APPENDIX D

HYDROGEOLOGICAL IMPACT ASSESSMENT

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

HYDROGEOLOGICAL IMPACT ASSESSMENT, STOCKTON SAND QUARRY DREDGING, COXS LANE, FULLERTON COVE, NSW

BORAL RESOURCES (NSW) PTY LTD

19 FEBRUARY 2020
717041
VERSION 4

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

19 February 2020

Element Environment
PO Box 1563
Warriewood NSW 2120

Attention: **Luke Farrell**
Senior Environmental Consultant

Dear Luke

Hydrogeological Impact Assessment at Stockton Sand Quarry Dredging, Fullerton Cove, NSW

Please find enclosed a copy of our report entitled as above. Thank you for the opportunity to undertake this work.

Should you have any queries, please do not hesitate to contact us on (02) 9922 1777.

For and on behalf of
Environmental Earth Sciences NSW

Project Manager / Author
Elin Griffiths
Associate Environmental Scientist

Project Director / Internal Reviewer
Mark Stuckey
Principal Hydrogeologist and Soil Scientist

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EXECUTIVE SUMMARY

Introduction and objectives

Boral Resources (NSW) Pty Ltd (Boral) owns and operates the Stockton Sand Quarry (hereafter referred to as the 'site' or the 'quarry'), a long standing operation that currently extracts sand from the windblown (transgressive) sand dunes of Stockton Bight and transports up to 500,000 tonnes per annum (tpa) of sand product for use in the building, landscaping and construction markets.

Due to current and future demand for sand in the Hunter and Sydney regions, Boral is seeking approval for continued and expanded operations at the site through a State Significant Development (SSD) application. The proposed development (hereafter referred to as the 'Project') involves the extraction of sand from the inland vegetated dunes by front-end loader/ excavator to a depth of 4 metres (m) Australian Height Datum (AHD) in Stage 1 and subsequent dredging from 4 m AHD to 15 m below sea level (-15 m AHD) in Stages 2-6. The SSD application seeks a sitewide increase on the dispatch limit to 750,000 tpa (i.e. the windblown sand extraction area and the Project operations combined) to 2028 after which the sitewide limit would reduce to a maximum 500,000 tpa. The Project would be for a period of up to 25 years.

The objective of this report is to assess potential groundwater impacts during the establishment, operation and decommissioning of the proposed sand extraction area.

Conceptual site model

The site is situated on the Stockton Sandbeds Aquifer; a shallow aquifer that overlies the eastern extremity of the deeper Tomago Sandbeds Aquifer. There is a groundwater divide which runs in a northeast to southwest direction to the southeast of the windblown sand extraction area. Groundwater is inferred to flow towards the coast to the southeast and to Fullerton Cove to the southwest of the site.

Mean annual rainfall recorded at Stockton exceeds average monthly evaporation rates, suggesting high groundwater recharge rates. High rainfall infiltration will raise the water table, increasing the hydraulic gradient between the recharge and discharge area.

Aquifer testing confirms that the unconfined aquifer beneath the site is very permeable (hydraulic conductivity (K) values between 6 and 55 metres per day and transmissivity values up to between 50 and 4,627 m^2/day), but that due to the low hydraulic gradients (0.002 metres per metre (m/m) or 0.2%), groundwater velocities are relatively low (12.6 – 116 metres per year). Groundwater flux through the area of the proposed extraction area has been estimated at 600 m^3/day (219 megalitres (ML) per annum). This equates to a groundwater flux of approximately 18 ML/month.

Collection of physical information from the site is supported by chemical data. West of the groundwater divide, the shallow Stockton Sands aquifer is predominantly Sodium-Chloride (Na-Cl) dominated, whilst the deeper Tomago Sandbeds Aquifer is Calcium-Bicarbonate

($Ca\text{-}HCO_3$). East of the groundwater divide the groundwater is $Ca\text{-}HCO_3$ and Na-Cl dominated, likely reflective of increasingly marine influence.

The aquifer beneath the site has a generally acidic pH and is fresh, with low concentrations of dissolved salts and metals. It is noted that ambient dissolved metals concentrations (Aluminium, Iron and Zinc in particular) are occasionally outside water quality criteria. However, these elevated levels of dissolved metals were considered as background concentrations due to the previous mineral sands operation and the depositional environment of the aquifer.

No per- or poly-fluoro-alkyl substances (PFAS) were recorded above the laboratory limit of reporting (LOR) for the monitoring period (January – June 2018), which supports the conceptual site model (CSM) for the site that it lies in a separate groundwater (and surface water) catchment to the Williamtown RAAF Base. In addition, concentrations of potentially radioactive elements such as radium, uranium and thorium were not recorded above the LOR or water quality criteria.

Based on the results of the analytical testing, groundwater in the alluvial aquifer is broadly suitable for all uses. Concentrations of dissolved aluminium, iron and zinc are considered either false positives (associated with suspended sediment) or naturally occurring. The dissolved concentration of arsenic exceeded drinking water criteria in bore MWX6 but may also be considered a natural occurrence.

Impact assessment summary

Potential impacts to the environment are likely to arise through the establishment of the project, extraction of sand via dredging operations over approximately a 25 year period.

As groundwater movement accounts for less than 0.5% of catchment drainage even in the driest recorded years, excavation of the aquifer sediments should have no discernible effect on catchment hydrology other than increasing the area available for water storage and direct recharge to the Stockton Sandbeds Aquifer on the site.

Mitigation and monitoring

Soil

An Acid Sulfate Soils Impact Assessment (Environmental Earth Sciences, 2019) concluded a low probability for acid sulfate soils at the site. High alkalinity and acid buffering capacity exists within the boreholes examined. However as one localised occurrent reported a moderate risk for potential acid sulfate soils (ASS), an Acid Sulfate Soil Management Plan is recommended.

Groundwater

Groundwater monitoring and mitigation requirements will be included in an update to the existing Groundwater Monitoring and Management Plan (GMMP) which is prepared in accordance with Condition 3(12) for Development Consent 140-6-2005 (Mod 2). The GMMP describes the objectives of the groundwater management and monitoring and detail the proposed types and locations of monitoring.

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1 INTRODUCTION

1.1 Background

Boral Resources (NSW) Pty Ltd (Boral) owns and operates the Stockton Sand Quarry (hereafter referred to as the 'site' or the 'quarry'), a long standing operation that currently extracts sand from the windblown (transgressive) sand dunes of Stockton Bight and transports up to 500,000 tonnes per annum (tpa) of sand product for use in the building, landscaping and construction markets.

Due to current and future demand for sand in the Hunter and Sydney regions, Boral is seeking approval for continued and expanded operations at the site through a State significant development (SSD) application. The proposed development (hereafter referred to as the 'Project') involves the extraction of sand from the inland vegetated dunes by front-end loader/excavator to a depth of 4 metres (m) Australian Height Datum (AHD) in Stage 1 and subsequent dredging from 4 m AHD to 15 m below sea level (-15 m AHD) in Stages 2-6. The SSD application seeks a site wide increase on the dispatch limit to 750,000 tpa (i.e. the windblown sand extraction area and the Project operations combined) to 2028 after which the site wide limit would reduce to a maximum 500,000 tpa. The Project would be for a period of up to 25 years.

Sand extraction has taken place in various locations on the site since 1976 when G. Hawkins and Sons was initially granted consent.

Under Boral's ownership there have been two primary development consents granted, these include:

- DA 2010/94: The 'inland extraction area' (also known as pits 1 – 6) granted by Port Stephens Council in May 1996, and
- DA 140-6-2005: The 'windblown sand extraction area' (also known as the "windblown project" or pit 7) located on the transgressive dunes adjoining Stockton Beach granted by the Department of Planning in 2006.

The inland extraction operation on the vegetated dunes occurred above 5 m AHD and ceased in 2008 and rehabilitation has been ongoing. This former extraction area is generally consistent with the project site and is the focus of this development application.

The windblown sand extraction area started operations in 2008 and in accordance with Condition 5 of the development consent has 20 year life, due to cease in 2028.

The windblown sand extraction area is approximately 375 m south east of the project site and is approved to operate until 2028 and dispatch up to 500,000 tpa (refer to Condition 6 of DA 140-6-2005).

Boral propose to extract sand from a former sandpit in the inland extraction area (which has since replenished with windblown sand) via front-end loader and dredging.

The project would be located within a portion of land within Lot 1 DP1006399 and Lot 3 DP664552 (hereafter referred to as 'the project site'). The extraction area is designated

along the western dune ridge system of the Boral holding and is expected to disturb 37 hectares with a maximum dredge depth of 15 m below sea level (refer to **Figures 1 and 3**).

The project is for extractive industry with a production rate of up to 750,000 tpa and a targeted resource in excess of 9 million tonnes. Accordingly, the project is State Significant Development under the State Environmental Planning Policy (State & Regional Development) 2011.

Environmental Earth Sciences was commissioned by Element Environment, on behalf of Boral Resources NSW Pty Ltd (Boral), to undertake an assessment of hydrogeological conditions and an assessment of the potential impacts of the project.

2 OBJECTIVES

The objectives of this report are to describe the local hydrogeological setting within the areas of potential impact, to assess the potential impacts and recommend controls and mitigation measures.

An Acid Sulfate Soil Impact Assessment (ASS) has been provided by Environmental Earth Sciences (Environmental Earth Sciences, 2018). The results of this report are not duplicated herein. It is recommended that this report be read in conjunction with the ASS report.

3 SCOPE OF WORK

A significant amount of hydrogeological assessment and monitoring, including impact assessment, has been previously performed across the wider Tomago Sandbeds aquifer to the west of the project, including:

- installation of six (6) additional groundwater bores intersecting both aquifers (two deep, two shallow and two paired), which complements an existing network of 11 bores across the Boral site.
- monthly monitoring of existing bores since 2008 and new bores since 2017 within the Boral site, and
- groundwater modelling of the Tomago Sandbeds Aquifer and overlying Stockton Sandbeds Aquifer to the east has been performed at the neighbouring Williamtown RAAF base since 2015 (HydroSimulations, 2016).

3.1 Existing environment

The first component of works (review of existing data for the local aquifer) in the preparation of a Hydrogeological Impact Assessment report, is to be undertaken using an analytical approach to allow development of a water balance for the aquifer, and subsequent

assessment of the potential impacts associated with the proposed works under varying climatic conditions.

This has comprised the following works carried out by Environmental Earth Sciences:

- Review of existing data for the shallow and deep aquifer from:
    - Monthly monitoring data provided by Boral to assess changes in groundwater levels and chemistry over time under varying climactic conditions.
    - Hydrogeological works completed at the nearby Williamtown Royal Australian Air Force (RAAF) defence base, and
    - Collection of site-specific data for the project area (chemical and physical).
- Physical aquifer testing on installed bores to determine aquifer parameters.
- Chemical testing for chemicals of concern known to impact the neighbouring Tomago Sandbeds Aquifer, such as per- and poly-fluoro-alkyl substances (PFAS) including perflurooctaine sulfonate (PFOS) and perflurooctanoic acid (PFOA), and
- Installation of permanent groundwater pressure transducer loggers in select bores to assess groundwater level responses to climactic and tidal conditions.

3.2 Potential impacts

Once the existing environment is characterised, potential impacts as part of the proposed development can be assessed. These are likely to be associated with excavation of the sand resource to expose the aquifer to enhanced recharge and evaporative losses, which could result in changes to baseflow conditions and quality for other potential receptors (such as stock watering, irrigation and recreational water use).

Based on previous investigations, sand extraction activities have not adversely affected water levels. Previous reports carried out at adjacent sites are summarised in **Table 4**.

The characterisation of the existing environment is presented in Section 6. Assessment of potential impacts of the proposed development is presented in Section 9.

4 DESCRIPTION OF THE PROPOSAL

The sand within Boral's landholding comprises a fine to medium grained material suitable for use as a fine aggregate in concrete or as fill sand in construction. The existing windblown sand extraction operation located on the transgressive dunes, east of the project, provides sand principally for Boral's concrete batching plants on the Central Coast, in the lower Hunter Valley, Salamander Way, the Upper Hunter and New England. It is estimated that construction sand from Boral's holding represents approximately 30 %of fine sand produced in Stockton Bight and the Lower Hunter Region.

The project would involve establishment of the sand extraction site, extraction of sand by front-end loader and dredge and pumping it to the processing area for washing, stockpiling and dispatch.

5 LEGISLATIVE CONTEXT

5.1 Relevant legislation

Table 1 summaries the relevant legislation relevant to the project site.

Table 1: Summary of regulatory environment

Key legislation	
Water Management Act 2000	Key instruments of the Water Management Act are the designation of Water Sharing Plans, that ensure that water is provided for the environment and there is more secure access to water users, and the Aquifer Interference Policy, that outlines the approval and licencing process for prescribed aquifer interference activities
Water Sharing Plan (WSP)	**Groundwater:** The site falls within the Stockton Groundwater Source of the WSP for the North Coast Coastal Sands Groundwater Sources. The NSW Office of Water has classified the Stockton Groundwater Source (Coastal Sands) aquifer as a highly productive aquifer. **Surface Water:** The site falls within the Newcastle Water Source of the WSP for the Hunter Unregulated and Alluvial Water Sources. The WSP commenced on 1 August 2009 and continues until July 2020
Aquifer interference policy 2012	The NSW Aquifer Interference policy (2012) provides a framework for the assessment where a proposed activity will take water from an aquifer of connected surface water source and provides objective, measurable thresholds for considering the degree of impact an activity may have on the groundwater levels and quality. The project is likely to require an aquifer interference approval. However, the proposed works are not considered to be impacting on the overall catchment balance, as all groundwater that is abstracted will be recharged back into the aquifer via the dredge ponds.
Contaminated Land Management Act 1997	If activities undertaken at the site during the project works contaminate the land, it is the responsibility of the contaminators to notify NSW EPA in writing, in accordance with the Contaminated Land Management Act 1997.
Guidelines for Groundwater Protection in Australia (ARMCANZ and ANZECC 1995)	This guideline provides a framework for preventing groundwater contamination in Australia.
NSW State Groundwater Policy and Framework Document (NSW Department of Land and Water Conservation 1997)	The Framework document sets out the overall direction of groundwater management in NSW and provides broad objectives and principles to guide groundwater management.

Key legislation	
NSW State Groundwater Quantity Protection Policy (NSW Department of Land and Water Conservation 1998)	Builds on the concepts outlined in the framework document and provides more detail and guidance on how to manage and protect groundwater quantity.
NSW State Groundwater Quality Protection Policy (NSW Department of Land and Water Conservation 1998)	Builds on the concepts outlined in the framework document and provides more detail and guidance on how to manage and protect groundwater quality.
NSW State Groundwater Dependent Ecosystems Policy (NSW Department of Land and Water Conservation 2002)	This policy is specifically designed to protect valuable Groundwater Dependent Ecosystems (GDE's) which rely on groundwater for survival. It aims to maintain or restore the ecological processes and biodiversity of groundwater dependent ecosystems for the benefit of present and future generations.
Guidelines for Fresh and Marine Water Quality (ANZECC / ARMCANZ 2000)	These guidelines would be adopted to assess groundwater quality, potential beneficial use of groundwater at the Site, and to assess potential impacts to groundwater quality from operation of the proposed development.
Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales (NSW EPA 2003)	These guidelines would be adopted where sampling and analysis of groundwater samples is required as part of this assessment and during groundwater monitoring

5.2 Secretary's environmental assessment requirements (SEARs)

This hydrogeological impact assessment addresses the requirements of the Secretary's Environmental Assessment Requirements (SEARs) for the project. The SEARs in relation to groundwater are listed in **Table 2**.

Table 2: Issued SEARs – water

SEAR	Relevant section within this report
Detailed site water balance, including a description of site water demands and intakes, water disposal methods (inclusive of volume and frequency of any water discharges), water supply infrastructure and, water storage structures;	Section 8 (Conceptual Site Model)
Identification of any licensing requirements or other approvals under the Water Act 1912 and/or Water Management Act 2000;	Section 5.1
Demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP);	Section 8.6 (Estimated recharge rates and water balance)
A description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo;	Section 10 (Management and Mitigation)

SEAR	Relevant section within this report
An assessment of the likely impacts on the quality and quantity of existing surface and groundwater resources (including consideration of the Williamtown RAAF Base Contamination Broader Management Zone, any nearby drinking water catchments and other water users);	Section 9 (Impact Assessment)
Detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate potential surface and groundwater impacts.	Section 10 (Management and Mitigation)

6 EXISTING ENVIRONMENT

6.1 Introduction

Existing groundwater information is available around the site from registered bores and previously conducted groundwater investigation (including long-term on-going water quality and level monitoring). Information prior to the field works included a registered groundwater bore search for nearby bores within a 3 km radius of the site and review of previous studies carried out within the area surrounding the site.

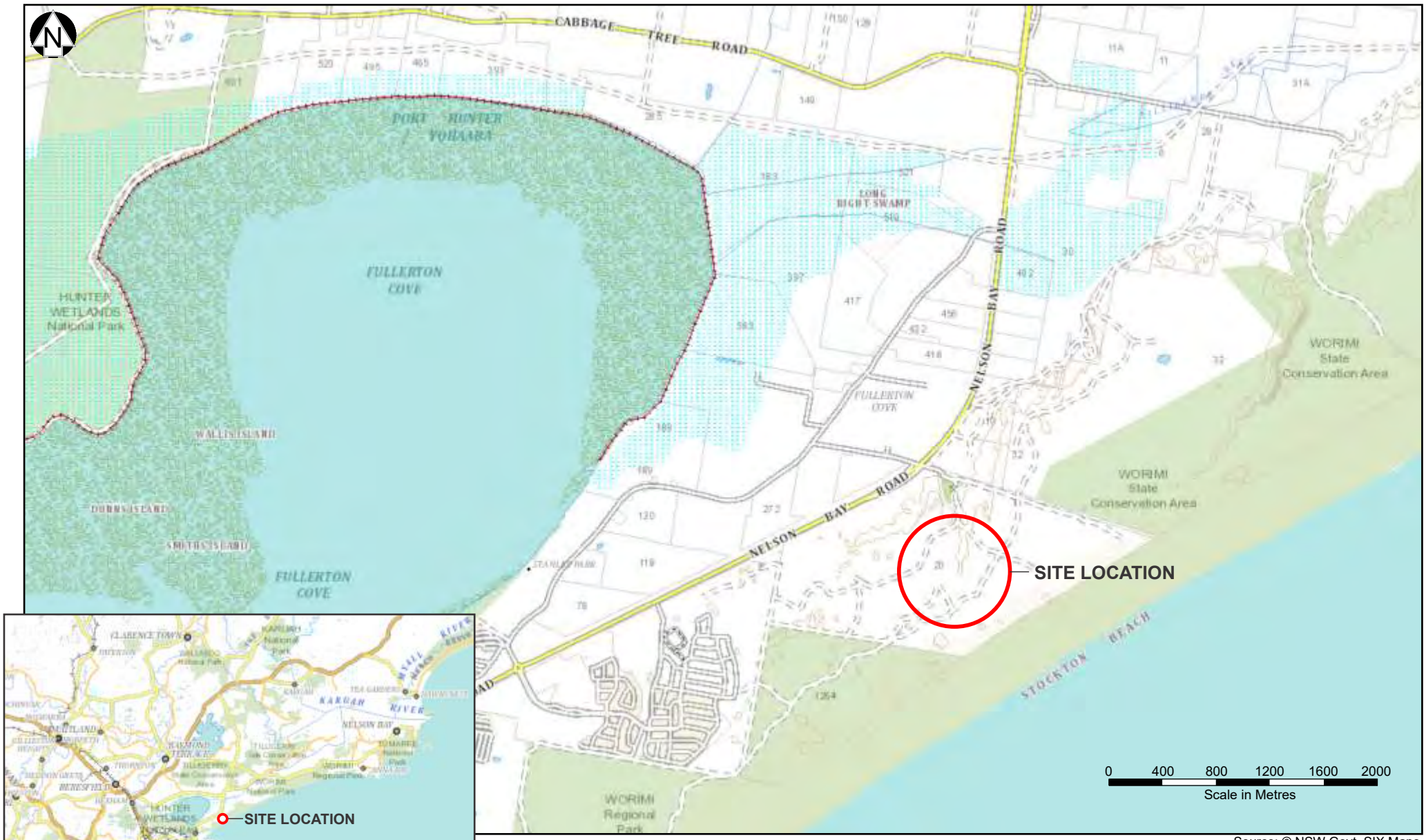
6.2 Site setting

6.2.1 Site locality and land uses

The site is located approximately 10 km north of Newcastle and is currently approved for windblown sand extraction from the Stockton transgressive dunes. **Table 3** below presents key identification features of the site. The site location and proposed extraction staging plan is illustrated in **Figure 1** and **Figure 2**, respectively.

Table 3: Site identification

Item	Details
Site Owner	Boral Resources (NSW) Pty Ltd
Address	Coxs Lane, Fullerton Cove, NSW 2318
Lot & Plan number	Part Lot 1 DP 1006399 Part Lot 3 DP 664552 Part Lot 7300 DP 1130730
Area	Approx. 37 ha
Zoning	RU2 – Rural Landscape; RE1 – Public Recreation (Crown Land)
Proposed land use	Extractive industry
Local Government Authority	Port Stephens Council



Source: © NSW Govt. SIX Maps

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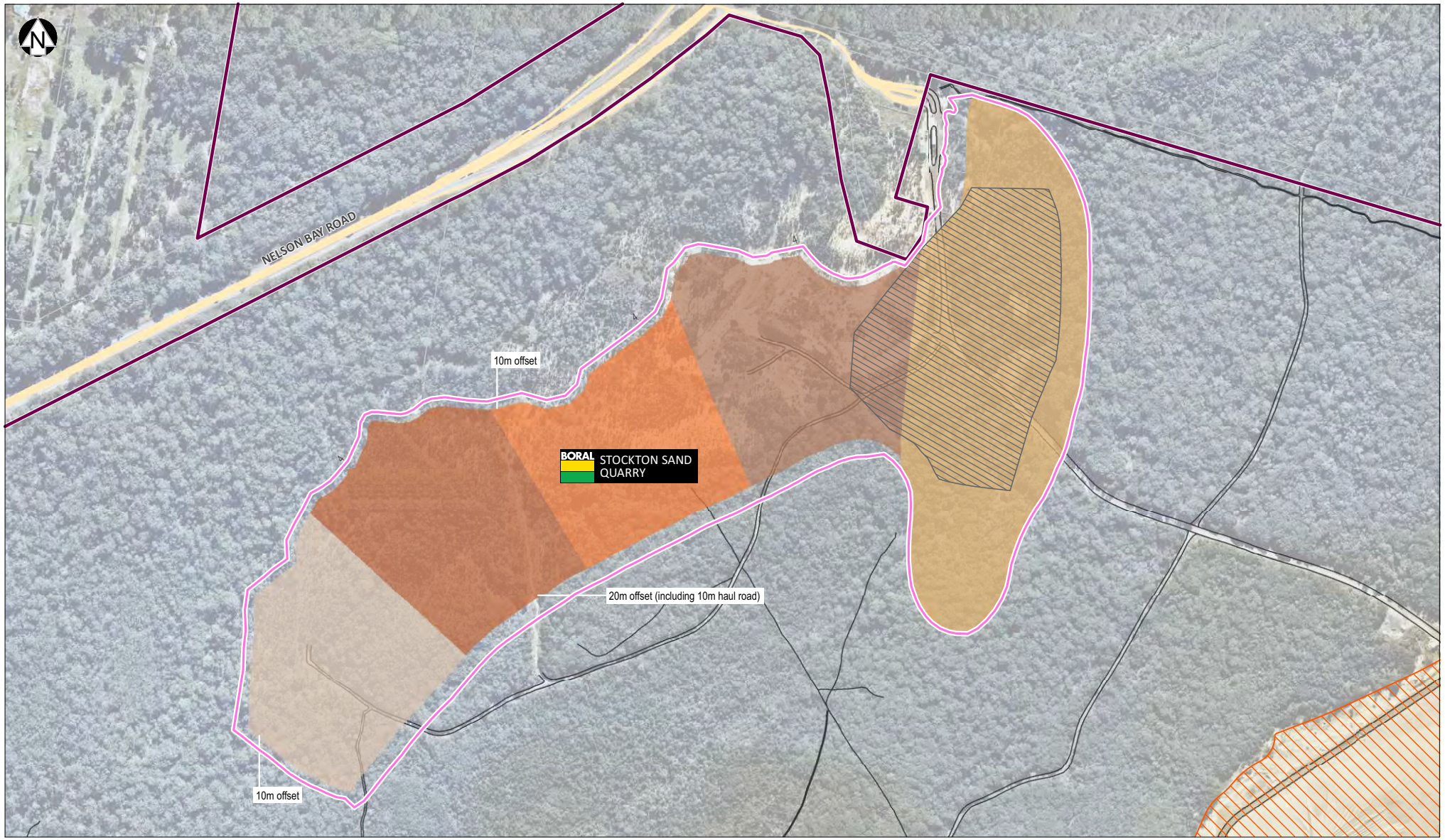
Title:	**Site Location**
Location:	**Nelson Bay Road, Fullerton Cove, NSW**
Client: **Boral Resources (NSW) Pty Ltd**	Job No: **717041**
Project Man: **EG**	Scale: **As shown**
Drawn By: **LB**	Date: **November 2018**
	Figure 1



Source: Element Environment

Stockton Sand Quarry boundary
Current windblown sand extraction area
Proposed clearance area
Access tracks

Extraction staging
Stage 1
Stage 2
Stage 3
Stage 4
Stage 5
Stage 6

0 50 100 150 200 250
Scale in Metres

ENVIRONMENTAL EARTH SCIENCES
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Title: **Extraction Staging Plan**

Location: **Nelson Bay Road, Fullerton Cove, NSW**

Client: **Boral Quarries**

Job No: **717041**

Project Man: **LL/AS**

Scale: **As shown**

Drawn By: **LB**

Date: **July 2019**

Figure 2

The Water Sharing Plan for the North Coast coastal sands groundwater sources (NSW DPI, 2016) classifies the Stockton groundwater source as located within the Worimi Conservation Lands which covers the Worimi National Park, Worimi State Conservation Area and Worimi Regional Park, with groundwater predominantly used for domestic purposes with some entitlement for irrigation and commercial purposes.

Land use surrounding the site is a mixture of rural, residential, public recreation and environmental conservation.

To the north west of Nelson Bay Road is the rural area of Fullerton Cove. This area comprises a mixture of small rural holdings and commercial premises. The main access for these properties is via Fullerton Cove Road and Coxs Lane to and from Nelson Bay Road.

These properties are separated from the site by Nelson Bay Road, with the closest approximately 480 metres (m) from the entrance to the quarry. A residential development at Fern Bay (Fern Bay Seaside Village) is approximately 1.5 km to the west south west of the site.

The majority of environmental conservation areas adjacent to the site are Worimi Conservation Land, Regional and National Park that extend along the Stockton Bight beach and dune system. The beach and dune areas of the wider aforementioned conservation areasare used for a variety of recreational purposes including fishing, four-wheel driving, quad bike riding, hiking and horse riding. There are no formal public access points through Boral's holding to Stockton Bight. Formal access to the dunes and beach is via Lavis Lane near Williamtown, and a new access within Seaside Estate at Fern Bay.

To the north-west of the Site is Williamtown RAAF base and associated waste station and waste treatment plant, landfill and sewage treatment plant.

The Worimi are the traditional owners of the Great Lakes and Port Stephens area between the Hunter and Manning Rivers. The area of the Stockton Bight has a special significance because it retains a large amount of cultural history. The Worimi people manage the environmental conservation areas of Stockton Bight adjacent to the site (known as the Worimi Conservation Lands) through a joint agreement with the NSW National Parks and Wildlife Services (NSW DPI 2016).

Boral Resources (NSW) Pty Ltd acknowledge the Traditional owners of the Great Lakes and Port Stephens area, including the Stockton Bight and recognise their continuing connection to land, water and community. Boral Resources (NSW) Pty Ltd pay respect to Elders past, present and emerging.

6.2.2 Site History

Sand extraction has taken place in various locations on the site since 1976 when G. Hawkins and Sons was initially granted consent.

Under Boral’s ownership there have been two primary development consents granted:

- DA 2010/94: The ‘inland extraction area’ (also known as pits 1 – 6) granted by Port Stephens Council in May 1996, and

- DA 140-6-2005: The 'windblown sand extraction area' (also known as the "windblown project" or pit 7) located on the transgressive dunes adjoining Stockton Beach granted by the Department of Planning in 2006.

The inland extraction operation on the vegetated dunes occurred above 5m AHD and ceased in 2008 and rehabilitation has been ongoing. This former extraction area is generally consistent with the project site and is the focus of this development application.

The windblown sand extraction area started in 2008 and is approximately 375 m south east of the proposed project site and is approved to operate until 2028 and dispatch up to 500,000 tpa (refer to Condition 6 of DA 140-6-2005).

6.2.3 Registered groundwater bore search

Registered Groundwater Bore database was searched on 15 May 2018 (BOM,2019). Bores were identified within an approximate 2.5 km radius of the site and were generally within the bounds of the Stockton Sandbeds Aquifer. A summary of the registered bore search is in **Appendix B** and discussed further in Section 8.5.5.

6.2.4 Sensitive groundwater users and groundwater dependent ecosystems (GDEs)

Further assessment of groundwater usage is provided in Section 8.8 of this report. As part of the desktop assessment for the project, investigations into the potential for the presence of GDEs in the vicinity of the site were undertaken. The closest potential GDEs are located to south-east (seaward) and north-west (inland) of the extraction area. Maps illustrating groundwater dependent ecosystems (BOM,2018) are provided in **Appendix C.**

The seaward GDEs comprise small ephemeral and mobile shallow deflation basin lakes vegetated with a variety of grasses, sedges and reeds. These lakes provide an ephemeral habitat for a number of invertebrates and other species (ERM, 2005).

The inland GDEs are primarily the swamp forests in the dune swales and the low-lying heath. These systems are up gradient (inland) of the extraction area. A previous groundwater assessment (ERM, 2005) noted that the risk of impacting these GDEs is very low given the sand extraction depth restrictions and low evaporation in times of high groundwater.

6.2.5 Review of previous reports and information

Environmental Earth Sciences was provided with the following reports pertaining to the site:

- ERM (1994). *Environmental Impact Statement for a Sand Extraction Operation on Boral Resources Freehold Property at Fern Bay, NSW*, ref. 1068/94573. Prepared for Boral Resources (Country) Pty Ltd.

- Umwelt (Australia) Pty Ltd (1995). *Review of Potential Hydraulic Impacts of Proposed Sand Extraction at Stockton Sand Pit, off Cox's Lane, Fern Bay*. Prepared for Boral Resources (Country) Pty Ltd.

- ERM (2005). *Environmental Impact Statement – Stockton Windblown Sand Extraction*, ref. 0027903 Final. Prepared for Boral Resources (Country) Pty Ltd.
- RPS (2016). *Boral Stockton Sand Quarry – Groundwater Gap Analysis*, ref. WS00256/003a. Prepared for Boral Quarries.
- Jacobs (2017). *Stockton Sand Quarry Groundwater Management Plan*, ref. IA147700_001b/B. Prepared for Boral Pty Ltd.

Table 4 provides a summary of pertinent information from previous investigations. Further sources of information are provided in Section 12 of this report.

Based on previous reports, groundwater beneath the wider Stockton area (prior to the current sand extraction plans for the site and those completed in 2008) follows a northeast-southwest orientated ridge line in the dune system with inferred groundwater flow split between the northwest to Fullerton Cove or southeast to the Pacific Ocean (Woolley *et al*. 1995).

No significant physical or chemical impact to groundwater as a result of sand extraction was identified during previous site investigations.

Table 4: Summary of relevant reports

Report	Key findings
ERM (1994)). *Environmental Impact Statement for a Sand Extraction Operation on Boral Resources Freehold Property at Fern Bay, NSW*, ref. 1068/94573. Prepared for Boral Resources (Country) Pty Ltd.	• The Inland Extraction Area consisted of dry sand extraction only, no excavations below the water table; and • Extraction estimated to lower the existing topography to a stabilised and revegetated landscape ~5 – 6 m AHD.
Umwelt (1995) *Review of Potential Hydraulic Impacts of Proposed Sand Extraction at Stockton Sand Pit, off Cox's Lane, Fern Bay*. Prepared for Boral Resources (Country) Pty Ltd.	Assuming that Boral extracts sand above 5 m AHD: • no alteration to the hydraulic conductivity of the aquifer; • no changes to surface or groundwater drainage conditions; • de-vegetation and extraction may increase infiltration rates in localised settings, however infiltration is naturally high; • the surface area of the aquifer to be disturbed at any one time considered miniscule; and, • provided >0.5 m of sand is above the water table, the proposed development will not significantly alter groundwater levels.
ERM (2005) *Environmental Impact Statement – Stockton Windblown Sand Extraction*, ref. 0027903 Final. Prepared for Boral Resources (Country) Pty Ltd.	• Groundwater monitoring of the landward side wells reported groundwater suitable for potable use if treated. • Windblown sand extraction considered to have a nett positive environmental impact.
RPS (2016) *Boral Stockton Sand Quarry – Groundwater Gap Analysis*, ref. WS00256/003a. Prepared for Boral Quarries.	• Conservatively calculates that for every 1 m decline in the water table the saltwater interface will rise by 40 m. • No high-priority groundwater dependant ecosystems identified near the site. • Boral Quarry is a significant distance upgradient of the Red Zone from the Williamtown RAAF Base • Highly unlikely that proposed dredging at site would change groundwater flow conditions or impact contaminant migration relating to the Red Zone. • No significant risk of inducing contaminant migration towards the site from proposed dredging activities. • Anticipates that the proposed dredging will meet the Level 1 Minimal Impact Considerations set by the NSW Aquifer Interference Policy.

Report	Key findings
Jacobs (2017) *Stockton Sand Quarry Groundwater Management Plan*, ref. IA147700_001b/B. Prepared for Boral Pty Ltd.	• Baseline groundwater data has been collected over Boral's monitoring network (2007 – 2017) with some intermittent lapses. • No groundwater impacts due to site operations have been identified to date (as all sand extraction has been above water table). • Groundwater results of monitoring wells (ID: MW1, 2, 5, 6, 7, 8, 9 and 11) considered indicative of natural background levels; • Aluminium (Al), Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury (Hg), Nickel (Ni), Zinc (Zn) and nitrate above ANZECC (2000) guidelines for 95% ecosystem protection.

7 FIELD STUDY

7.1 Field investigation

7.1.1 Bore installation

In conjunction with the assessment for acid sulfate soils (ASS) (Environmental Earth Sciences, 2018) four boreholes were drilled across the site to a maximum depth of 24.0m below ground level (bgl) between the dates of 13 and 14 March 2018.

Borehole locations for the ASS assessment (BH1 – BH4) along with existing groundwater monitoring bores are illustrated in **Figure 3**. Full details are provided in bore logs, **Appendix D**.

7.1.2 Ground conditions

The profiles of bores (BH1 – BH4) were typically described as fill comprising sand with chitter gravels of mixed lithology and coal.

This was underlain by natural granular material typically described as loose brown grey medium grained sand, further underlain locally by medium to coarse grained sand, with shell grit which extended beyond the maximum depth of investigation of 24 metres below ground level (m bgl). **Table 5** provides a summary of the stratigraphy encountered at the site.

Table 5: Stratigraphy summary

Strata	From (min/max)	To (min/max)	Min/max thickness	Groundwater (min/max)	Comments
Fill	Ground level	3.5/4.0 m bgl	3.5/4.0 m bgl	1.5/5.5 m bgl	Fill not present in BH2
Natural – Loose brown grey medium grain sand	3.5/4.0 m bgl	10.5/>24 m bgl	6.5/ >24 m bgl		Occasional localised layers of organic material present in BH2
Natural – Loose medium to coarse sand with shell grit	18/21 m bgl	Not encountered	Not applicable		

7.1.3 Groundwater levels

During drilling of BH1 – BH4, groundwater was encountered within all bores at depths between 1.5 and 5.5 m bgl. During these intrusive investigations, the standing water levels of existing surveyed groundwater monitoring bores (ID: MWX1; MWX2; MWX3; MWX4; MWX5 and MWX6) as well as the unsurveyed bore GW1 were recorded on 14 March 2018 within 1.5 hours of each other to reduce tidal variations on the data. **Table 6** provides a summary of observed static water levels (SWLs).

A hydrograph of SWLs from information provided by submersible data loggers, obtained by VGT on a monthly basis for the period of May 2017 to July 2018 is presented in **Chart 1** (**Appendix A).**

Table 6: Groundwater level results, 25 October 2018

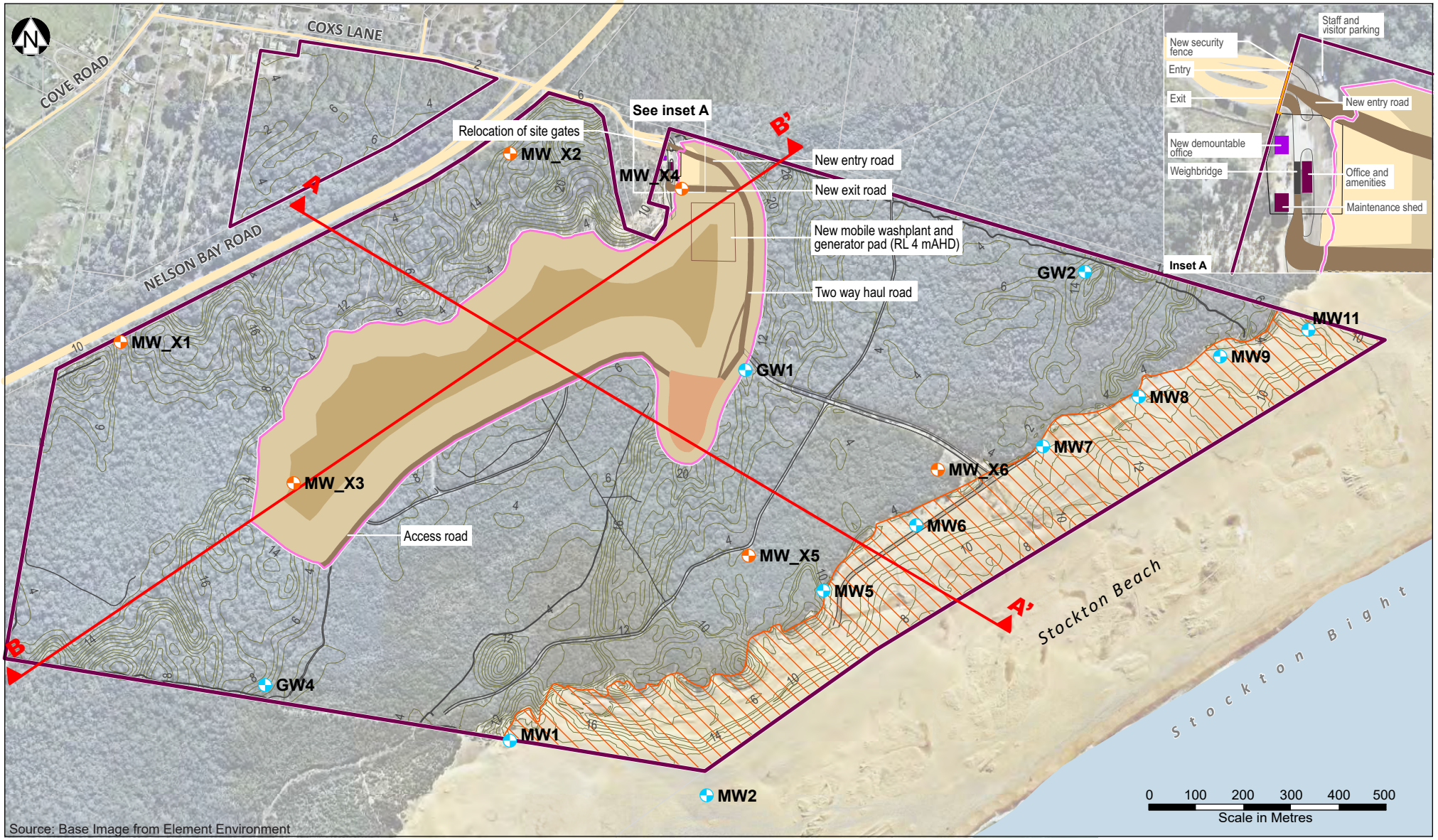
Sample	25 Oct 2018	
	Water Level (m) to Top of Casing (TOC)	Water Level (m AHD)
BH1	3.45	1.00
BH2	2.252	1.248
BH3	0.94	0.59
BH4	2.445	1.005
MWX1	3.813	5.64
MWX2		4.84
MWX3	1.37	5.12
MWX4	1.84	8.95
MWX5	4.295	2.64
MWX6		2.26

7.1.4 Sampling

On 13 March 2018, a water sample was obtained from nested bore MWX3 using a submersible pump.

To ensure that representative samples of groundwater were obtained, the following groundwater geochemical field parameters were collected during purging using a calibrated water quality meter (WQM):

- Oxygen Reduction Potential (ORP) – redox.
- pH.
- Dissolved oxygen (DO).
- Electrical conductivity (EC).
- Temperature.



LEGEND:

- Stockton Sand Quarry boundary
- Current windblown sand extraction area
- Contour (mAHD)
- Access tracks
- Additional groundwater monitoring location - installed April 2017
- Current groundwater monitoring location
- Cross section location (refer Figures 10 and 11)

PROJECT FEATURES:

- Proposed clearance area
- Access road
- Extraction base (RL -15mAHD)
- Batter
- Pad base (RL 4mAHD)

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Title: **Borehole and Groundwater Monitoring Well Locations**

Location: **Nelson Bay Road, Fullerton Cove, NSW**

Client: **Boral Quarries**

Job No: **717041**

Project Man: **EG**

Scale: **As shown**

Drawn By: **LB**

Date: **September 2019**

Figure 3

These field parameters were measured *ex-situ* within in-line flow cells, with the following stabilisation criteria indicating representative groundwater conditions suitable for sample collection:

- ± 10ppm DO when >1 ppm (no criteria for <1 ppm).
- ± 3% EC.
- ± 0.05 pH.
- ± 10mV ORP.

Following purging and stabilisation of field chemical parameters, samples were placed in appropriate containers and stored in ice-filled coolers prior to transportation to the laboratory for analysis. Refer to **Table 7** for a summary of field observations and refer to **Appendix E** for the Groundwater Field Sheets.

Table 7: Summary of SWL and field observations, March 2018.

Bore	Units	MWX3_S	MWX3_D
Date	-	13/03/2018	13/03/2018
Depth to Groundwater	m TOC	5.5	5.9
Depth of Bore	m	11.3	26
DO	ppm	0.13	0.14
EC	µS/cm	257	547
pH	-	6.02	7.01
Redox	mV	13	-104
Temperature	°C	20.1	20.1
Comments	-	Clear, no odour	Clear, no odour

7.1.5 Analytical schedule

Groundwater samples collected from bore MWX3 were sent to Sydney Analytical Laboratories (SAL), a NATA accredited laboratory and analysed for the following determinants:

- full ionic balance suite – pH, EC, total dissolved solids (TDS), cations (Na, Ca, Mg, K), anions (Cl, SO_4, HCO_3, PO_4, F) and nutrients (NH_3, NO_3 and NO_2), and
- dissolved metals / metalloids including aluminium (Al), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg) and zinc (Zn).

Results that have been used in the current assessment are provided in **Tables 16, 17 and 18** at the back of this report. Full details are attached in laboratory certificates, **Appendix F.**

7.1.6 Procedures for quality control and quality assurance

Quality control is achieved by using NATA registered laboratories using Australian Standards Materials Testing (ASTM) standard methods supported by internal duplicates, the checking of high, abnormal or otherwise anomalous results against background and other chemical results for the sample concerned.

Quality assurance is achieved by confirming that field results, or anticipated results based upon comparison with field observations, are consistent with laboratory results. Also, that sampling methods are uniform, and decontamination is thorough. In addition, the laboratory undertakes additional duplicate analysis as part of their internal quality assurance program on the basis of one duplicate analysis for every 20 samples analysed.

Field observations are compared with laboratory results when they are not as expected. Confirmation, re-sampling and re-analysis of a sample are undertaken if the results are not consistent with field observations and/or measurements. In addition, field duplicate sample results have to be within the acceptable range of reproducibility.

7.1.7 Hydraulic parameter testing

On 13 and 14 March 2018, 'slug-tests' were undertaken on the nested bore at MWX3 (MWX3_Shallow (MWX3S) and MWX3_Deep (MWX3D)). Slug (or falling head) tests require piezometers to have the screens fully submerged beneath the piezometric surface. This method was used to determine the *in*-situ hydraulic conductivity (K).

These tests involved causing an instantaneous change in water level in a section of the piezometer by introducing a known volume (i.e. a 'slug') and then measuring the recovery of the water level over time (after Fetter 2001). Using the data obtained from these tests, values for hydraulic conductivity (K), transmissivity (KD) and groundwater velocity (v) have been determined for the unconfined Quaternary aquifer.

The slug-tests were performed across the Site to determine the change in hydraulic properties of the water bearing sediments beneath the Site. The calculations and results of K determinations across the Site are provided in **Appendix G**, while values derived for K, KD and v have been summarised in **Table 8**. Local hydraulic gradients have been interpreted from **Figures 4 and 5**.

Results were found to be very responsive. As such, only the data from MW_X3S was analysed using the Bouwer-Rice (BR) and Hvorslev methods (after Fetter 2001 and Kruseman and de Ridder 2000). Literature values for hydraulic properties of the Stockton Sands (Hydrosimulations, 2016) record K values ranging between 10 and 20 m/day, specific yield (Sy) of 0.15 and porosity (n) between 0.3 and 0.33.

Data obtained from recent hydraulic testing agrees with literature values and confirms that the unconfined aquifer beneath the Site is very permeable (K values between 6 and 55 m/day and transmissivity values up to between 50 and 4627 m^2/day), but that due to the low hydraulic gradients (i), groundwater velocities are relatively low (12.6 - 116 m/year).

Table 8: Slug test results – March 2018

Bore	Screened interval	Aquifer	Test Date	Q	K	KD	Approximate Hydraulic Gradient (*i*)	Average linear velocity, (v)
	m BGL	-	-	m^3/day	m/day	m^2/day	m/m	m/year
MW_X3 Shallow	8.5 – 11.5	Stockton Sand Member (Holocene)	14/3/2018	600	25	243	0.002	61

Note(s):
1. K hydraulic conductivity; KD transmissivity; Q yield
2. v average linear velocity was calculated assuming effective porosity of 0.35 in medium grained sand (Freeze and Cherry, 1979, Kruseman and de Ridder, 2000)
3. all tests undertaken using the Hvorslev, Bouwer-Rice and Jacob Recovery test analysis methods, after Fetter 2001 and Kruseman and de Ridder, 2000

7.1.8 Long-term monitoring data

In addition to reviewing the data collected by Environmental Earth Sciences in March 2018, Environmental Earth Sciences was provided with groundwater chemical results collected from the MWX bore series on a monthly basis from October 2017 – June 2018. This was collected by VGT and subjected to laboratory analysis for:

- Full ionic balance suite - pH, EC, TDS, cations (Na, Ca, Mg, K), anions (Cl, SO_4, reactive P, F), total alkalinity as $CaCO_3$ and nutrients (NH_3, NO_3 and NO_2);
- dissolved metals / metalloids including aluminium (Al), arsenic (As), boron (B), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni) and zinc (Zn); and,
- Perfluorinated compounds including perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) monthly from January – June 2018 at limited locations (ID: MWX1, MWX2, MWX7 and GW4).

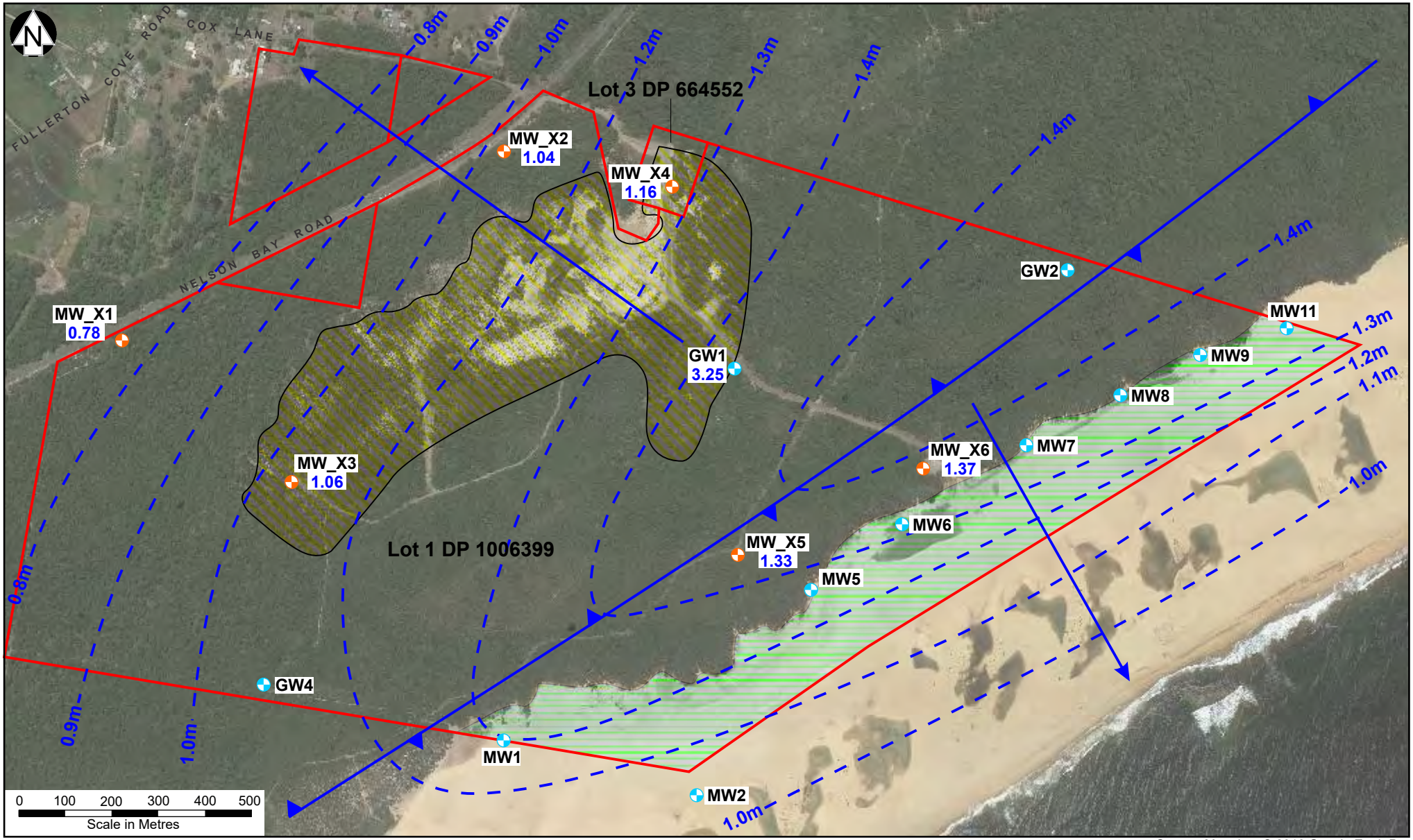
Data from the following borehole locations has been included within this assessment:

- GW1, MWX1; MWX2; MWX3 - nested; MWX4 - nested; MWX5 and MWX6.

7.2 Adequacy of field investigation

Based on the discussion above, it is considered that the information collected to date is appropriate (both physically and chemically) to assess the baseline conditions of the aquifer and provide an analytical assessment of potential impact from the site.

Assessment of water quality and physical groundwater conditions have occurred for a significant period of time (ERM [1994 and 2005], Umwelt [1995], RPS [2016] and Jacobs [2017]), see section 6.2.5, in addition to approximately 12 years' worth of data collected from selected bores. It is considered that whilst the addition of further analysis of groundwater in the lead up to commencement on site is unlikely to have a significant impact on the assessment of baseline conditions, it is recommended that on-going monitoring continue (as detailed in Section 10.2 below) to further enhance the temporal range and increase the robustness of the baseline data.



Source: Map data © 2016 Google Earth Pro

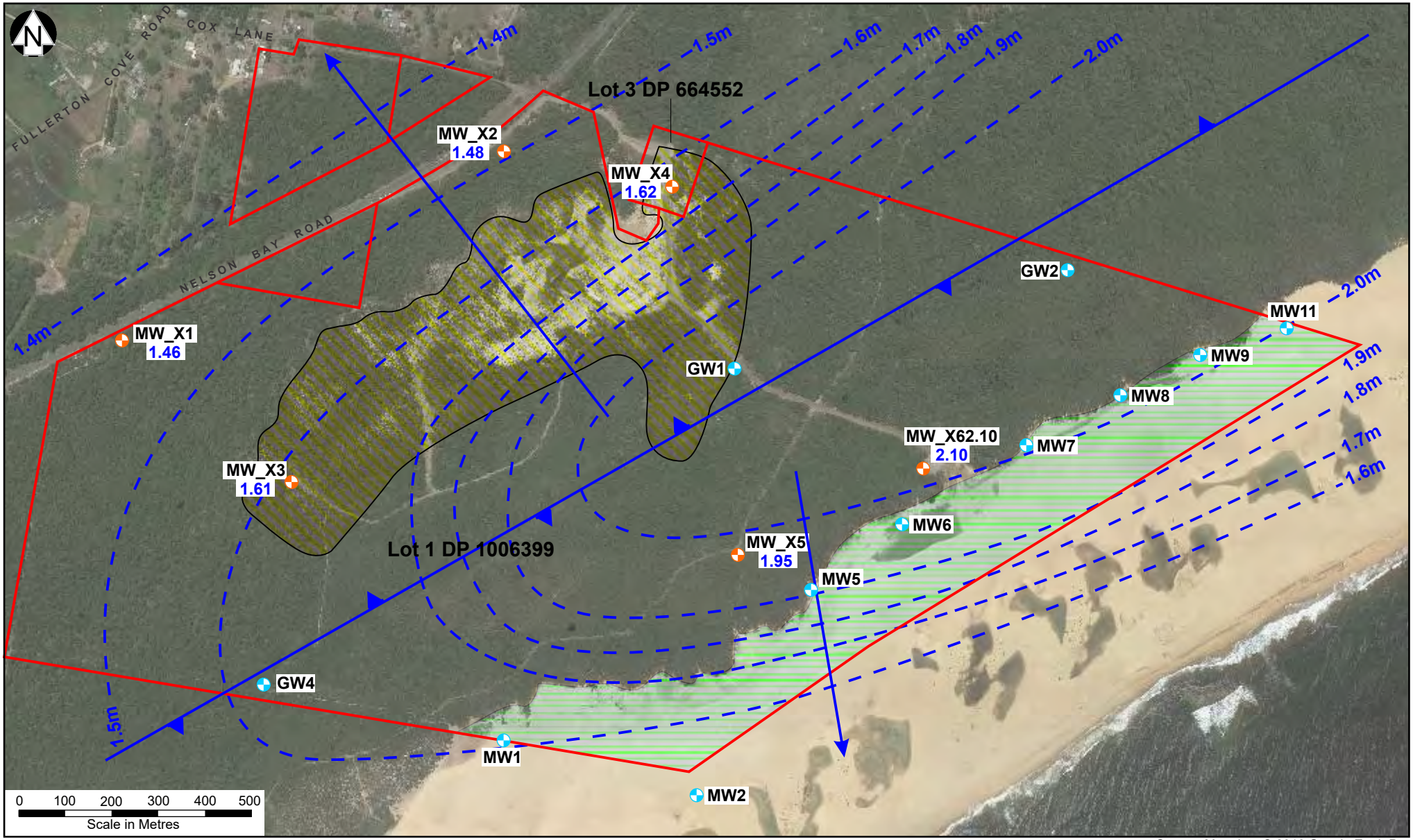
LEGEND:

- Lot area
- Windblown sand extraction area
- Inland extraction area
- Additional groundwater monitoring location - installed April 2017
- Current groundwater monitoring location
- Inferred groundwater level (mAHD)
- Inferred groundwater flow divide
- Inferred groundwater flow direction
- 1.33 Standing water level (mAHD)

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Title:	**Groundwater Levels Low Rainfall (14 March 2018)**
Location:	**Nelson Bay Road, Fullerton Cove, NSW**
Client: **Boral Resources (NSW) Pty Ltd**	Job No: **717041**
Project Man: **EG**	Scale: **As shown**
Drawn By: **LB**	Date: **November 2018**

Figure 4



Source: Map data © 2016 Google Earth Pro

LEGEND:

- Lot area
- Windblown sand extraction area
- Inland extraction area
- Additional groundwater monitoring location - installed April 2017
- Current groundwater monitoring location
- Inferred groundwater level (mAHD)
- Inferred groundwater flow divide
- Inferred groundwater flow direction
- 1.95 Standing water level (mAHD)

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Title:	**Groundwater Levels High Rainfall (20 June 2018)**
Location:	**Nelson Bay Road, Fullerton Cove, NSW**
Client: **Boral Resources (NSW) Pty Ltd**	Job No: **717041**
Project Man: **EG**	Scale: **As shown**
Drawn By: **LB**	Date: **November 2018**

Figure 5

8 CONCEPTUAL HYDROGEOLOGICAL MODEL (CSM)

8.1 Introduction

A CSM is a two- to three-dimensional interpretation of the soil, geology and hydrogeology relationships within a catchment. Information assessed and presented includes inferred soil/ rock weathering processes and groundwater/ surface water flow characteristics. The CSM aims to inform an exposure assessment of any impact (or potential for impact) identified by demarcating sources, pathways and receptors of the groundwater flow system. The CSM is one of the primary planning tools used to support decision making processes, organising available information about a site or issue in a clear structure that facilitates the identification of data and information gaps.

It is often presented using a variety of media, including text, maps, cross sections, two- or three-dimensional graphics, tables and other visual representations (including Piper, Durov, Stiff or Schoeller Plots, for example). This report includes text and tables, along with appended figures including 2D schematic cross sections of the investigation area (**Figures 7, 8 and 9**), data tables, Piper Diagrams and Schoeller Plots.

By gaining a greater understanding of the site, the model can also be used to assess which portions of the project may require further investigation or monitoring. The CSM presented herein is intended to help identify groundwater flow paths and environmental receptors using the available data. The CSM describes the existing hydrogeological environment and constraints.

8.2 Physical setting

8.2.1 Site locality

The site is located within the Stockton dune system of the Newcastle Bight, Aeolian sand dunes that span 32 km from Stockton to Anna Bay. The majority of the site comprises relatively stable and vegetated back dune and inter dune environments, whilst the south eastern property margin encompasses an un-vegetated and mobile foredune environment.

8.2.2 Landform and topography

Environmental Earth Sciences was provided with 3D contours of the site's topography for review. Topography within the project area forms the shape of a basin, reflective of former sand extraction in this area. Topography ranges from approximately 2.0 – 5.5 m AHD in the centre of the Project area and is encircled by higher topography ranging from a maximum of 29 m AHD (north), 8.8 m AHD (south), 27 m AHD (east) and 12 m AHD (west).

The Project area had been subjected to rehabilitation following an earlier sand extraction project ending in approximately 2008. This rehabilitation provides a degree of stability to the underlying sands situated along a crest in the dune fields.

Soil landscape information was sourced from eSPADE v2.0 published by the NSW Office of Environment & Heritage (2018) (espade.environment.nsw.gov.au/, verified 28 March 2018). The majority of the project area is underlain by the Boyces Track soil landscape group that typically exhibits a local relief of 10 – 30 m with slopes >25% and elevation ranging from 10 – 40 m. Refer to **Appendix H** for Soil Landscape Reports.

8.2.3 Climate

Regional meteorological data has been sourced from the Bureau of Meteorology (2018) (www.bom.gov.au, verified 28 March 2018) Williamtown RAAF weather station, approximately 5 km from site, and is summarised in **Figure 6**. Evaporation data is based on monthly averages from 2018.

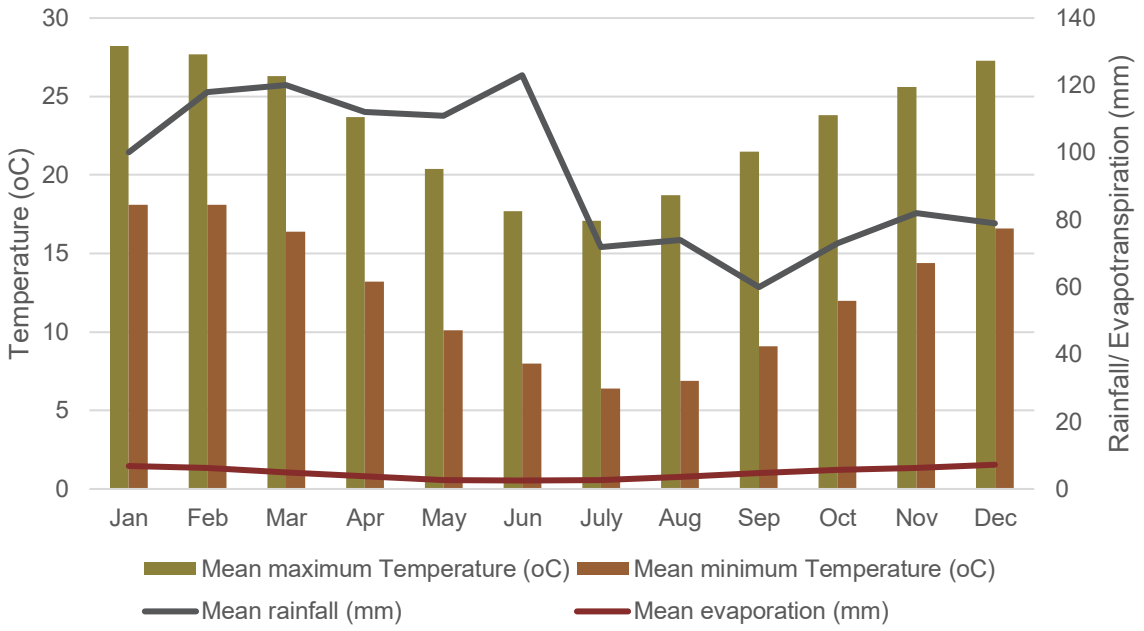


Figure 6: Average monthly climate data

Stockton's climate can be described as warm temperate with mild winters and warm summers. The temperature ranges from a mean daily maximum temperature of 17.1 °C in the coldest month of July, to warm summers with mean daily maximum temperatures of 28.2 °C in January. Minimum winter daily temperatures range from 6.4 – 8 °C and the area is rarely subjected to frosts and temperatures below 0 °C. A graph indicating monthly rainfall in relation to standing water levels (SWL) observed in all onsite wells between 2016 and June 2018 is presented in **Chart 1 (Appendix A)**.

Mean annual rainfall recorded at Stockton is 1,125 mm and the rainfall pattern has a late summer to autumn dominant trend. Monthly total evaporation rates are less than the average monthly rainfall (**Figure 6**), suggesting strong groundwater recharge rates of up to 70 – 80% of total rainfall for this system. Water loss as a result of evaporation is only likely to represent 5% of the total system, whilst transpiration is estimated to represent up to 15% of water loss.

8.3 Soil and geology

8.3.1 Geology

The local geology of the Newcastle Bight has been described as Qa – Quaternary Alluvium consisting of gravel, sand, silt, “Waterloo Rock” (i.e. indurated sand) with marine and freshwater deposits according to the Newcastle 1: 250 000 Geological Series Sheet S1 56-2 (1966).

The site’s geology consists specifically of Quaternary Holocene barrier dune (Qhbd). This is described as unconsolidated aeolian deposits of marine sand estimated to have formed between 9,500 – 6,500 years ago. This deposit ranges from 10 – 30 m thick and it is commonly referred to as the Stockton Sandbeds or the Stockton Sand Member.

The Tomago Sandbeds are Pleistocene-aged (circa 30,000 years) deposits that underlie the Stockton Sandbeds. Finally, the Stockton and Tomago Sandbeds are underlain by the Medowie Clay Member. A geological cross section of the area through the Tomago-Stockton Sandbeds, based on Thom *et al*. (1992) after Woolley *et al*. (1995) is presented in **Figure 7**.

8.3.2 Soil landscape

The dune sands represent a transgressive period of deposition and overly the beach and shore face, shelly sands that represent regressive beach barrier faces. Some localised organic-rich, peaty deposits may be present associated with interdunal swales. Total sediment thicknesses of the Stockton Sandbeds are known to range from between 10 m to 40 m.

The soil observed on the site is described in the Port Stephen Hydrologic Soil Group Map as ‘Group A’ soils (refer to **Appendix I** to view the Port Stephens Hydrologic Soil Group Map). A soil landscape is an area of land that has recognisable and specifiable topographies and soils.

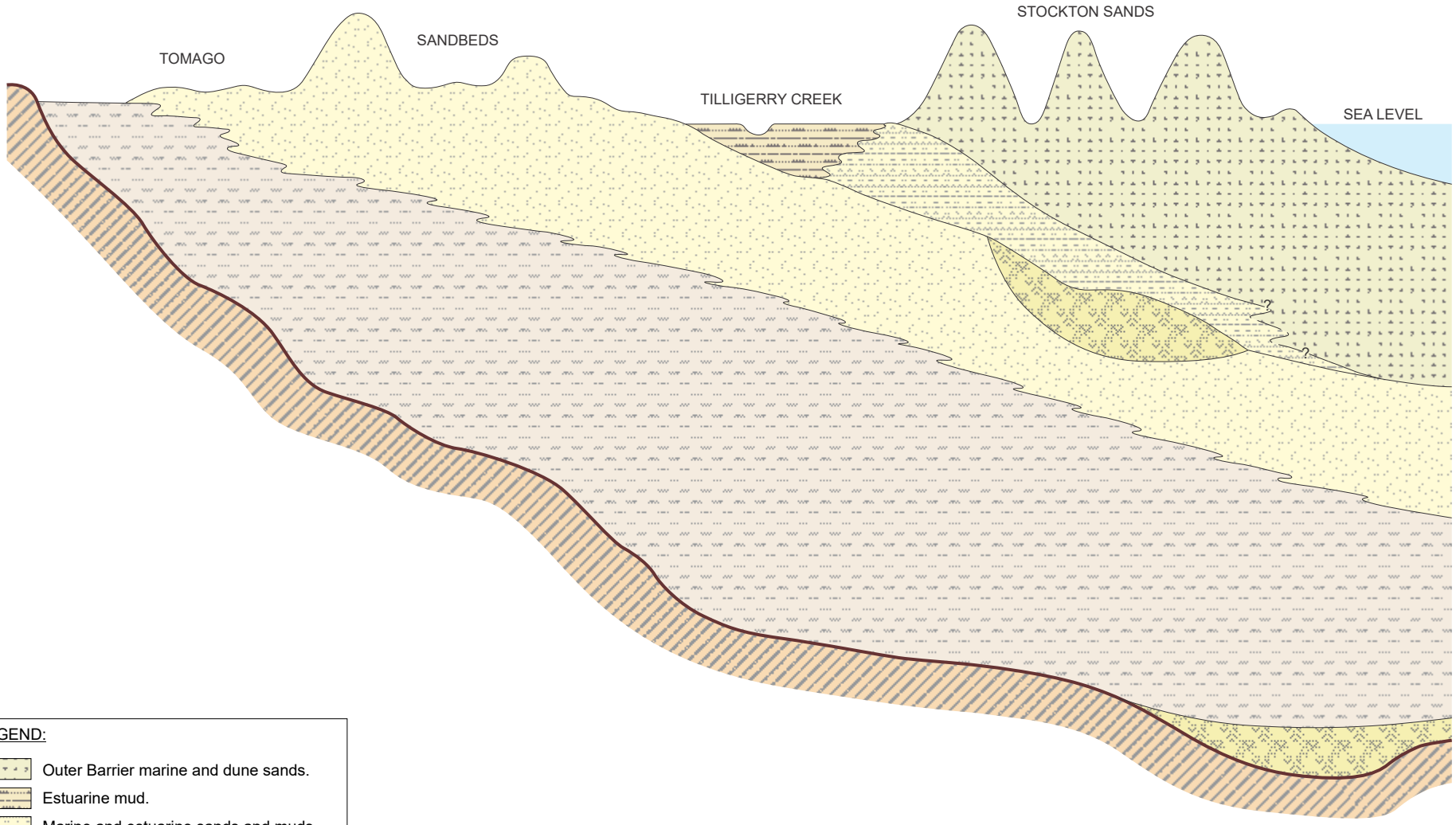
Two soil landscape groups were identified within the Project Area; predominantly Boyces Track with Hawks Nest along the southern Project Area boundary. Boyces Track are Holocene transgressive aeolian dunes with deep (>300 cm), well-draining and weakly developed podzol soils. Typically, these soils are acidic to neutral. Hawks Nest soil landscape are stable low Holocene sand sheets on low transgressive dunes with deep well-draining soils. They generally exhibit high water tables and a potential for acid sulfate soils (ASS) in low lying swampy swales. These soils may be strongly acid. Refer to **Appendix H** for Soil Landscape Reports.

8.3.3 Acid sulfate soils

The site was reviewed in the Port Stephens 1:50 000 Acid Sulfate Soils Map (1996) produced by NSW Department of Land and Water Conservation. The site is considered low probability for ASS in general. The southern boundary of the Project Area is considered low probability between 1 - 3 metres below ground surface (m BGS) whilst the remainder and majority of the Project Area is considered low probability for ASS >3 m BGS.

North West

South East



LEGEND:

- Outer Barrier marine and dune sands.
- Estuarine mud.
- Marine and estuarine sands and muds.
- Fluvial sand and gravel.
- Inner Barrier marine and dune sands.
- Estuarine-lagoonal mud; sand lenses.
- Unconformity.
- Bedrock.

Horizontal 0 1 2 Km

Vertical 0 10 20 30 m

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Title: **General Geological Cross Section**

Location: **Nelson Bay Road, Fullerton Cove, NSW**

Client: **Boral Resources (NSW) Pty Ltd**

Job No: **717041**

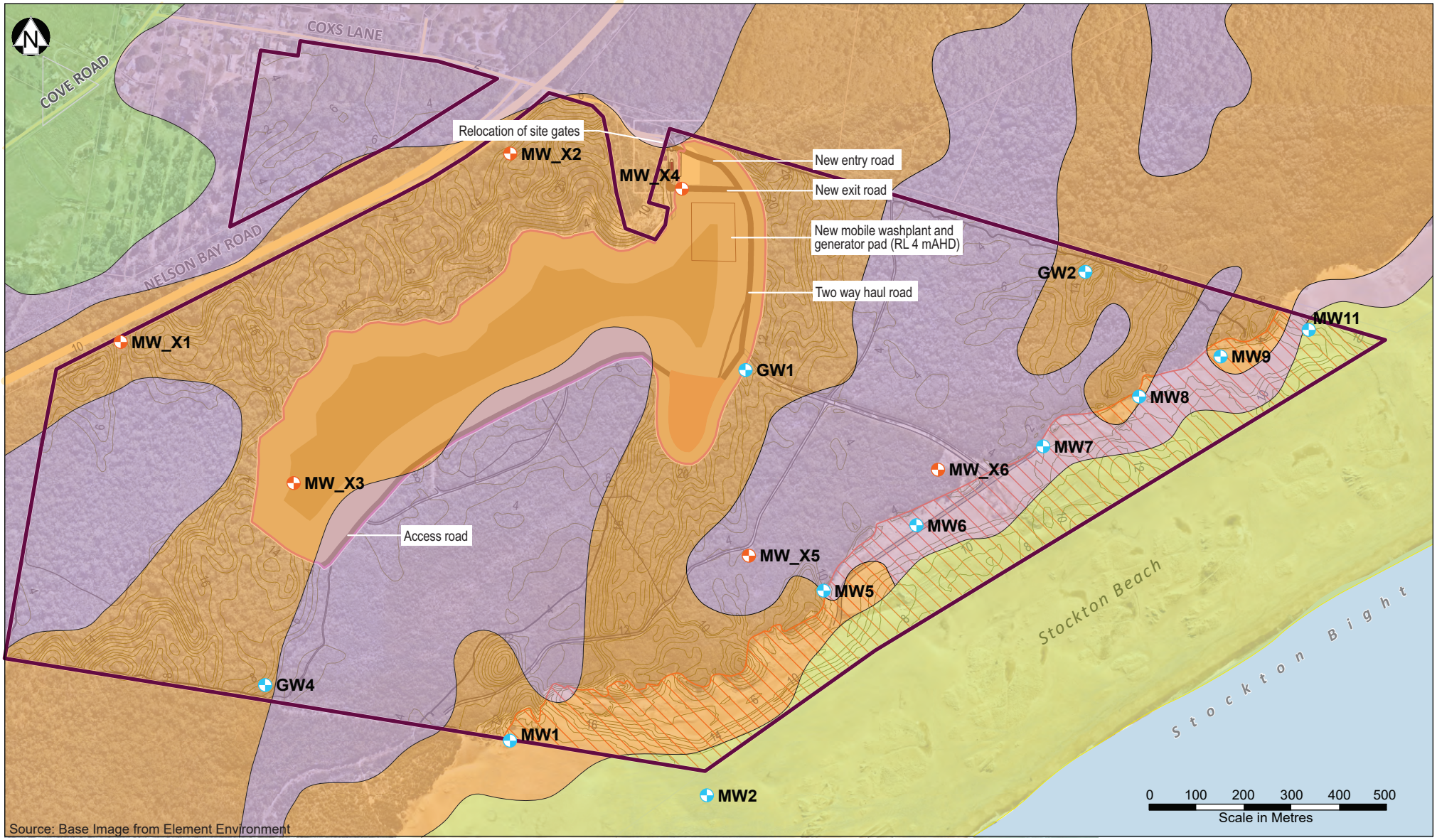
Project Man: **EG**

Scale: **As shown**

Drawn By: **LB**

Date: **November 2018**

Figure **7**

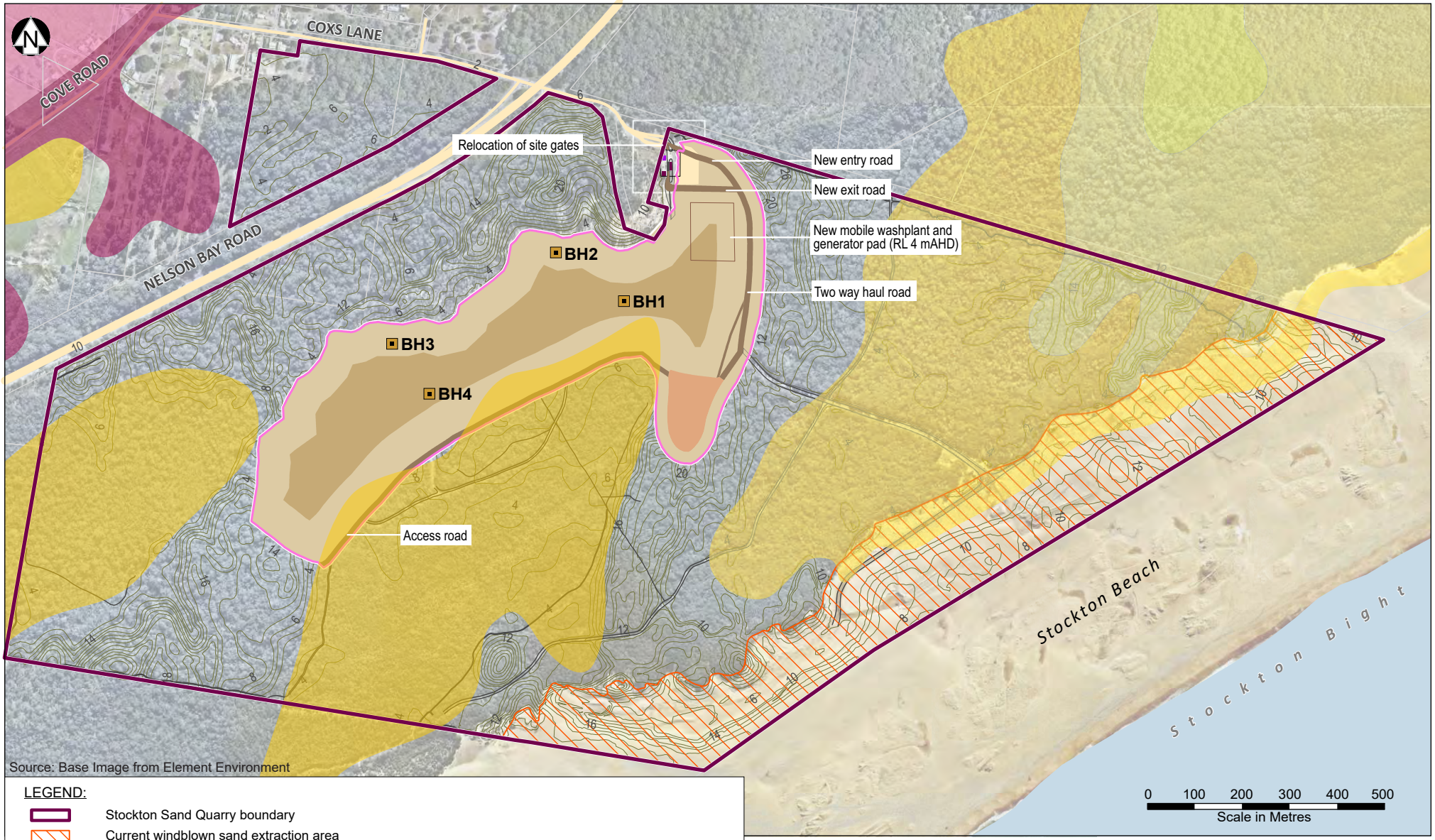


LEGEND:

- Stockton Sand Quarry boundary
- Current windblown sand extraction area
- Contour (mAHD)
- Access tracks
- Additional groundwater monitoring location - installed April 2017
- Current groundwater monitoring location
- Proposed clearance area
- Stockton Beach
- Bobs Farm
- Hawks Nest
- Boyces Track

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Title:	**Local Soil Landscapes**		
Location:	**Nelson Bay Road, Fullerton Cove, NSW**		
Client: **Boral Quarries**		Job No: **717041**	
Project Man: **EG**	Scale: **As shown**	**Figure 8**	
Drawn By: **LB**	Date: **September 2019**		



LEGEND:

- Stockton Sand Quarry boundary
- Current windblown sand extraction area
- Contour (mAHD)
- Access tracks
- Borehole location

PROJECT FEATURES:

- Proposed clearance area
- Access road
- Extraction base (RL -15mAHD)
- Batter
- Pad base (RL 4mAHD)

DEPTH TO ACID SULFATE SOIL MATERIALS:

HIGH PROBABILITY :

- Within 1 metre of the ground surface
- Between 1 and 3 metres below the ground surface

LOW PROBABILITY :

- Between 1 and 3 metres below the ground surface
- Greater than 3 metres below the ground surface

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Title:	**Acid Sulfate Soil Occurrence**
Location:	**Nelson Bay Road, Fullerton Cove, NSW**
Client: **Boral Quarries**	Job No: **717041**
Project Man: **EG**	Scale: **As shown**
Drawn By: **LB**	Date: **September 2019**
	Figure 9

An Acid Sulfate Soils (ASS) Assessment report by Environmental Earth Sciences (2018) corroborated the results of the desktop study, indicating a low probability for ASS at the site with high alkalinity and acid buffering capacity within the boreholes examined. One sample out of 25 tested, reported a moderate risk for potential ASS. Regular monitoring is recommended as part of an ASS Management Plan for a proactive monitoring regime to be employed so that early indications of localised acid generation could trigger appropriate management.

8.4 Hydrology

The site comprises the Stockton sand dunes, with no surface water features present within the Site.

There are no established drainage lines within the site due to the very high rate of infiltration to the sand substrate. Any runoff during high intensity rainfall would typically collect in interdunal swales, where infiltration would be dependent on the antecedent groundwater conditions.

The Pacific Ocean (Tasman Sea) lies directly to the south of the Stockton dunes. Tidally influenced Fullerton Cove and lower Hunter River are situated to the west of the project site and Port Stephens and Tilligerry Creek are tidal water bodies to the north east.

8.5 Hydrogeology

8.5.1 Background

The Stockton Sandbeds and transgressive sand dunes are the main aquifer at the site and comprise the Stockton Groundwater Source of the Water Sharing Plan (WSP) for the North Coast Coastal Sands Groundwater sources. Underlying these are the Tomago Sandbeds of the Tomago Groundwater.

The Stockton Sandbeds Aquifer is a shallow unconfined aquifer which overlies the eastern extremity of the deeper Tomago Sandbeds Aquifer. The sand extraction proposed for the project area is intended to be contained within the Stockton Sandbeds Aquifer.

8.5.2 Groundwater flow system

Groundwater flow is influenced by topography of the Stockton transgressive sand dunes and regional recharge/ discharge zones with water draining either to Fullerton Cove to the northwest of the site or Stockton Beach to the southeast. As a consequence, a northeast-southwest orientated groundwater drainage axis or flow divide exists along the length of the Stockton Sand Member. At the Boral site, the drainage axis is located approximately 1500 m inland from the coast and is centred approximately within the main body of the proposed extraction area.

Regional groundwater flow in the sand units is primarily horizontal with some downward flow due to the relatively high recharge rate. Groundwater is inferred to flow towards the coast to the southeast and to Fullerton Cove to the southwest of the site.

The Tomago Sandbeds Aquifer is situated to the west of the Stockton Sandbeds Aquifer and is separated by Tilligerry Creek and associated drainage network in this low-lying estuarine region. Groundwater from both the Tomago Sandbeds Aquifer and the Stockton Sandbeds Aquifer discharge into this low-lying region, that ultimately directs discharge on to Fullerton Cove (refer to **Figure 1**).

Regional groundwater within the Tomago Sandbeds Aquifer has been historically impacted by PFAS and PFOA associated with the RAAF Base, Williamtown. As a result, a NSW EPA Investigation Area has been nominated in the vicinity of the RAAF Base. The Risk Zone C boundary is drawn along the low-lying drainage area that both the Tomago and Stockton Sandbed Aquifers drain into. The Stockton Sandbeds Aquifer at the site is in a separate groundwater and surface water catchment to RAAF Base Williamtown.

8.5.3 Aquifers and aquitards

The deep marine sands of the Stockton Sandbeds constitute the primary aquifer. Review of borelogs from the site suggest the majority of the site is underlain by medium-grained sand with occasional coarse sands and shell grit. The deepest borelog available for review within the site (MWX6) generally recorded medium grained sand to the end of the bore (27.5 m bgl). The deepest bore investigation within the Project Area (BH2) similarly recorded medium-grained sand to the end of bore (24 m BGL). Refer to **Appendix D** for borelogs.

The sand beds overlie the Medowie Clay Member which is comprised of stiff grey clay or silt and acts as an aquitard for the Stockton and Tomago Sandbeds Aquifers. These clays separate the unconfined sand aquifers above from any fractured bedrock aquifers below.

8.5.4 Saline Interface

Given the coastal nature of the Stockton Sandbeds Aquifer, a saline interface will exist which marks the transition from predominantly fresh groundwater to predominantly saline groundwater.

The position of this interface is often approximated using the Ghyben-Herzberg equation. The equation is based on the density differential between fresh and saline groundwater and makes a number of simplifying assumptions such as the system being in hydraulic equilibrium (no flow), as well as a number of other assumptions, which cannot be met in reality. However, the method provides a useful approximation, and tells us that for every metre of fresh water above mean sea level there will be approximately 40 m of freshwater below it before the interface to saltwater.

In reality, the interface is likely to be a broad zone of dispersion and mixing that will also be dependent on the rate of flow through the aquifer.

In 2013, Geoscience Australia conducted a national review of the vulnerability of different groundwater aquifers to seawater intrusion (Ivkovic et al 2013, after NSW DPI 2016). Coastal sand aquifers were found to be particularly vulnerable to excessive pumping due to the low amounts of groundwater storage relative to rainfall recharge. It was reported that whilst water had migrated southwards to the Tomago, Tomaree and Stockton sand beds from Tilligerry Creek, as a result of an extensive drainage network on the southern banks of the estuary, no increase in salinity was observed at the seaward coastline.

As dewatering will not be performed for the project, the risks of saltwater intrusion are considered to be low (after RPS, 2016).

8.5.5 Results of registered bore search

Full groundwater bore search results are provided in **Appendix B**, whilst a summary of pertinent locations relative to the project site is provided in **Table 9**. Further summary is provided below.

A search of registered groundwater licenses surrounding the site indicates seven boreholes within a 3 km radius of the site that are registered for any purpose other than monitoring. Bores GW079378 and GW079736 are registered for domestic use and are located approximately 1.4 km and 1.5 km to the north and west of the site respectively. Bore GW200423 is located 3 km to the southwest and is registered for use as irrigation. Lithological data indicates a predominantly sand aquifer with minor interbedded clay horizons.

Table 9: Registered groundwater bore details

Bore ID	Distance from Site (km)	Depth (m)	Purpose	Lithology	SWL (m)	Salinity (mg/L)
GW078361	1.8 SSW	34.5	Extractive	Sand	2.0	280.0
GW078360	1.5 SW	35.0	Extractive	Sand 0 – 35	2.0	290.0
GW079736	1.5 W	20.0	Domestic	--	--	--
GW200423	3.0 SW	20.0	Irrigation	Sand 0 – 20 m	--	--
GW079378	1.4 N	--	Domestic	--	--	--
GW062439	1.5 NE	30.0	Extractive	Sand 0 – 30 m Clay 30 – 31 m	2.0	--
GW060459	2.0 NE	34.0	Extractive	Sand 0 – 9 m Clay/Sand 9 – 19 m Sand 19 – 33 m Clay 33 – 34 m	4.0	--

8.5.6 Potentiometric surface

Groundwater levels across the project site are presented in **Figures 4 and 5** which compares groundwater levels following periods of low and high rainfall, respectively.

The hydraulic gradient on the coastal side of the aquifer is estimated to range from approximately 0.2% during dry periods up to 0.36% in wet conditions (Umwelt,1995 after Mackie Martin and Associates, 1992 and Coffey, 1993). Hydraulic gradient for the Fullerton Cove side of the aquifer varies from approximately 0.1% during dry periods to approximately 0.2% during wet conditions (Umwelt, 1995).

Umwelt (1995) identified a secondary drainage pathway from the north eastern corner of the site to the south western corner which has a hydraulic gradient ranging from approximately

0.02 to 0.03%, equating to approximately one tenth of the hydraulic gradient compared to that of the coast in wet and dry conditions. Therefore, predominant groundwater movements at the site is toward either the coastline or Fullerton Cove.

The hydrograph of groundwater levels at the site between 2016 and June 2018 (**Chart 1, Appendix A**) indicates that the aquifer responds rapidly to rainfall. Particularly, that several rainfall events ≥40 mm occurring within a fortnight can raise SWL across all bores by approximately 0.5m.

Conceptual cross sections representing hydrogeological processes across the site are provided in **Figure 10** (north-west to south-east) and **Figure 11** (north-east to south-west). As well as predicted groundwater flow paths, these figures also show the proposed location of the sand extraction area.

Overall, the water-table surface is a subdued form of the topography, which is typical of all local and regional groundwater flow systems. Depths to groundwater are greatest in areas of groundwater recharge and shallowest in areas of groundwater discharge.

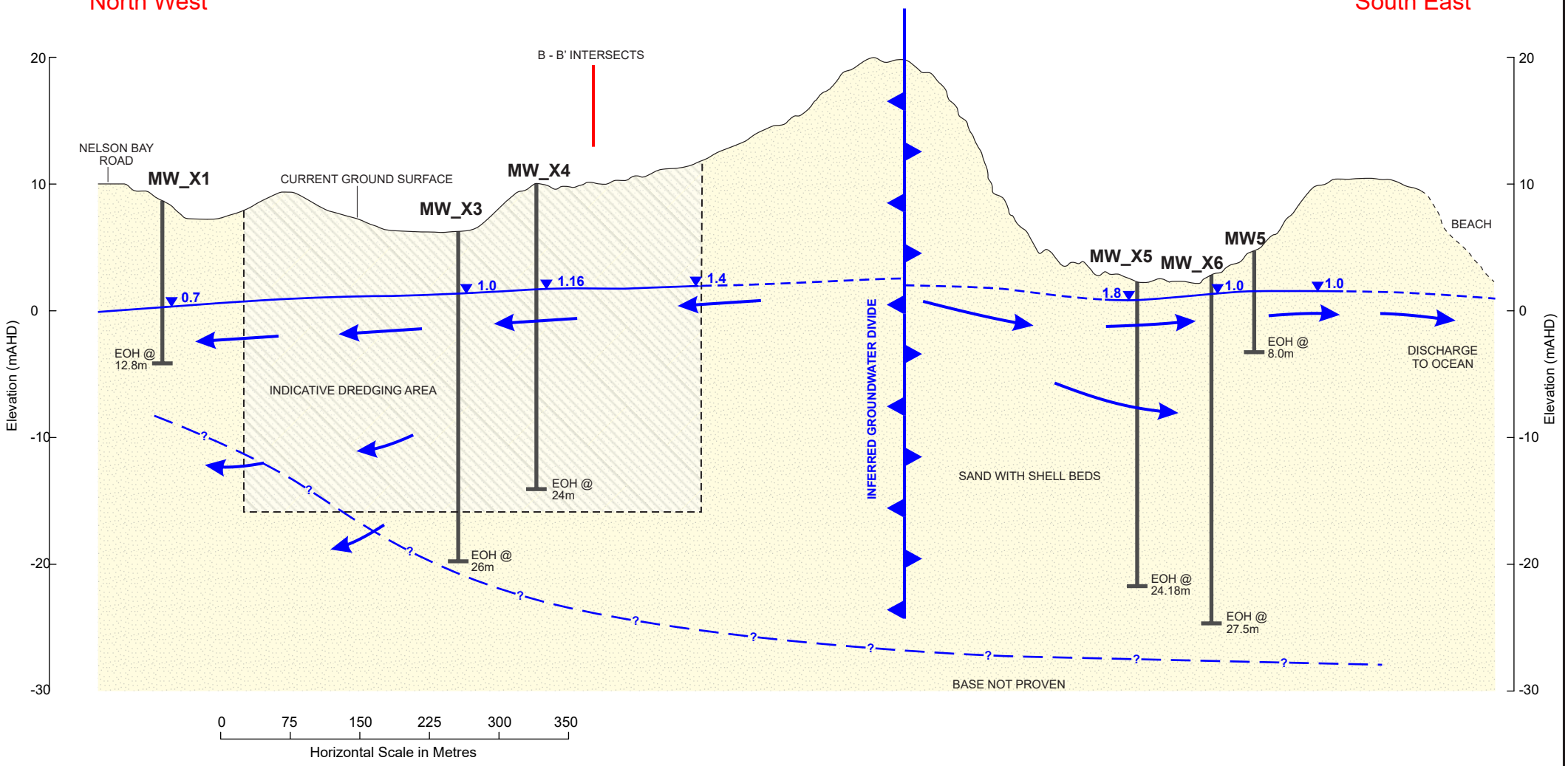
8.6 Estimated recharge rates and water balance

There is a groundwater divide which runs in a northeast to southwest direction to the southeast of the proposed windblown sand extraction area. Groundwater monitoring records identify two primary flow directions for groundwater, either to the north west towards Fullerton Cove, and the Tomago Groundwater Source, or to the south east towards Stockton Beach.

Sand extraction within the project area is conservatively estimated at 750,000 tpa for up to 25 years, with the product expected to contain 3% moisture content. This will result in 15 MLpa of water being 'taken' equating to approximately only 41 m^3/day or 0.5 L/sec. This amount is expected to be less than the natural aquifer recharge onto and discharge off the site towards the Pacific Ocean to the south and Fullerton Cove/ Long Bight Swamp/ Tilligerry Creek to the north (estimated to be around 600 m^3/day).

Crosbie *et al*. (2010b) state that, for the dominant soil type of the catchment (Podosols), recharge would be expected to be in the range of 100-1,000 mm/year, with a line of best fit of 386 mm (337 mm) for an annual rainfall of 1,100 mm on perennial (all) vegetation and Podosol soil types. This equates to 31% of rainfall recharging the aquifer, which is at the lower range of estimates for coastal alluvium provided by Crosbie *et al*. (2010a). The Water Sharing Plan (NSW DPI, 2016) for the area indicates total recharge for the Stockton Groundwater Area as 21,000 ML/yr, with an estimated infiltration rate of 22%.

The dominant recharge to the aquifer is via direct infiltration of rainfall. Recharge from rainfall is estimated at around 30% of total rainfall (taking into account evapotranspiration). However, localised recharge rates in dune environments with predominantly endoheric drainage are likely to be higher.



LEGEND:

- Inferred groundwater flow direction
- SWL March 2018

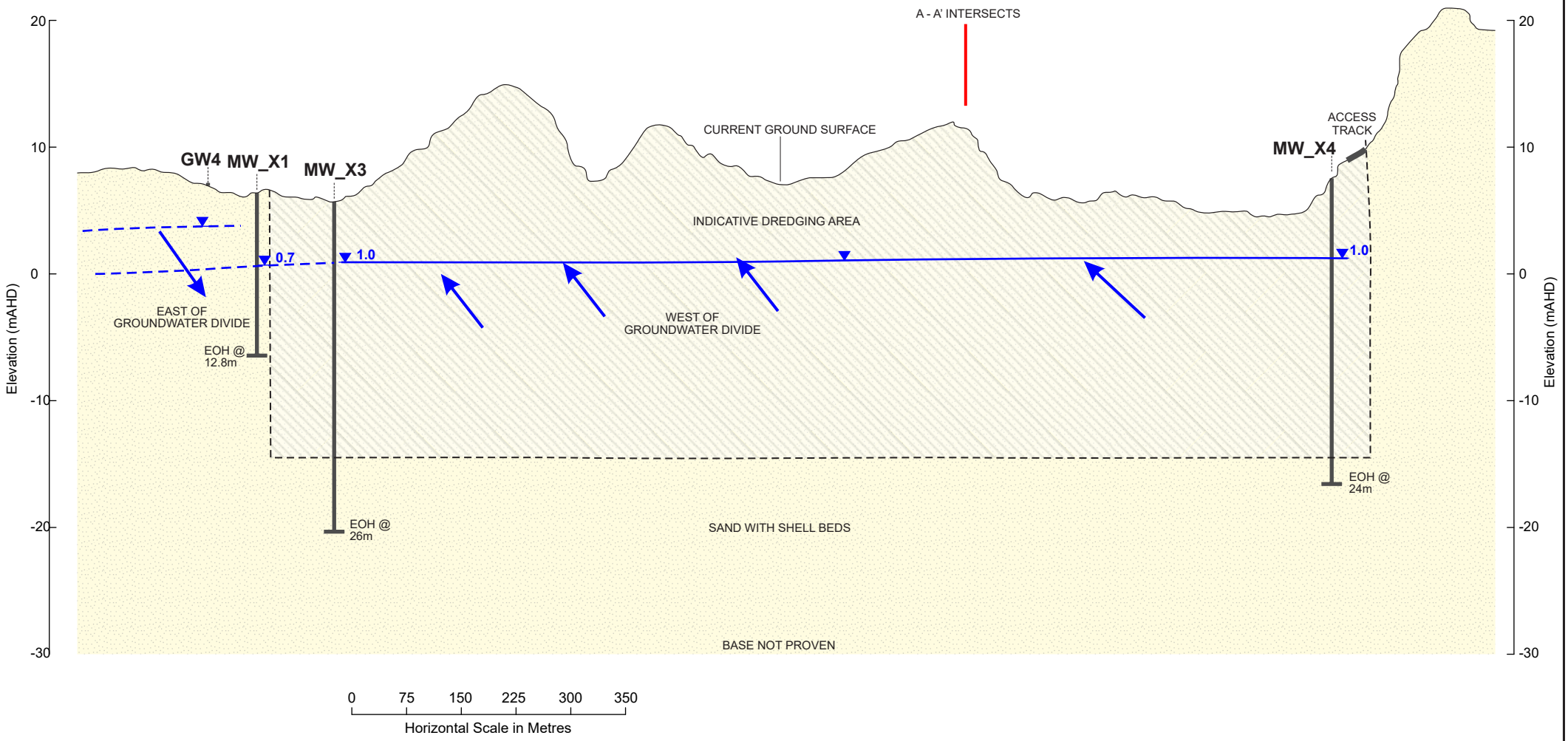
ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Title:	**Conceptual Cross Section A - A'**
Location:	**Nelson Bay Road, Fullerton Cove, NSW**
Client: **Boral Quarries**	Job No: **717041**
Project Man: **EG**	Scale: **Do not scale**
Drawn By: **LB**	Date: **September 2019**

Figure 10

B
South West

B'
North East



LEGEND:
- Inferred groundwater flow direction
- SWL March 2018

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Title:	**Conceptual Cross Section B - B'**
Location:	**Nelson Bay Road, Fullerton Cove, NSW**
Client: **Boral Quarries**	Job No: **717041**
Project Man: **EG**	Scale: **Do not scale**
Drawn By: **LB**	Date: **September 2019**

Figure 11

Total rainfall input to the site is estimated at 1.12 ML/d (407 MLpa). For the project area, recharge for the 37 ha site equates to 0.34 mpa x 370,000 m^2 = 126,170 m^3/y (126 MLpa) or 346 m^3/day or 4.0 L/sec. Evapotranspiration is estimated at 70% of recharge (88 MLpa, 242 m^3/day or 2.8 L/sec).

Under the lake scenario (which is expected to be 23.3 ha), recharge to the 137,000 m^2 non-lake area will be 47 MLpa, 128 m^3/day or 1.5 L/sec, and to the 233,000 m^2 lake will be 256 MLpa, 702 m^3/day or 8.1 L/sec, for a combined lake scenario recharge of 303 MLpa, 830 m^3/day or 9.6 L/sec. Evaporation from the lake is estimated at 1,382 mm, or 322 MLpa (882 m^3/day and 10.2 L/sec), and evapotranspiration from the non-lake area 33 MLpa, 90 m^3/day or 1.1 L/sec.

Discharge will be via through flow to the ocean to the southeast and also inland towards Fullerton Cove (south-west) and its associated drained estuarine flats.

Calculations indicate that the water take with the sand product contributes 4% of total groundwater outflows, which is being 'won' from natural groundwater discharge (outflow) from the site towards either the north or south. As half of this discharge is to the ocean, it is hard to see this as 'take' when it is recharging a marine water body. As the sand extraction proceeds, the above is expected to be altered gradually over time as recharge increases due to direct rainfall onto the dredge pond that is created, off-set by increased direct evaporation from the surface water body. A water balance has been presented in **Table 10**.

Table 10: Site Water Balance

Parameter	**Inflow (Pre-lake)**			**Outflow (Pre-lake)**		
Units	L/sec	m^3/d	ML/a	L/sec	m^3/d	ML/a
Recharge	4.0	346	126			
Groundwater inflow	6.9	600	219			
Evapotranspiration				2.8	242	88
Groundwater outflow				9.7	600	219
TOTAL	10.9	946	345	12.5	842	307
Parameter	**Inflow (Lake)**			**Outflow (Lake)**		
Units	L/sec	m^3/d	ML/a	L/sec	m^3/d	ML/a
Recharge	9.6	830	303			
Groundwater inflow	6.9	600	219			
Evaporation				10.2	882	322
Evapotranspiration				1.1	90	33
Sand Extraction				0.5	41	15
Groundwater outflow				6.9	600	219
TOTAL	16.5	1,430	522	18.7	1,613	589

8.7 Groundwater chemistry

8.7.1 Introduction

As part of this groundwater study, the inorganic chemistry of the unconfined aquifer identified beneath the site was assessed. Ionic balances and dissolved heavy metals including aluminium (Al), nickel (Ni), copper (Cu), lead (Pb), zinc (Zn), cadmium (Cd), chromium (Cr), iron (Fe), arsenic (As), magnesium (Hg) and manganese (Mn) were analysed on collected water samples by Environmental Earth Sciences during the investigation in March 2018 and monthly monitoring of all bores on site by VGT.

Hydrogeochemical characterisation of groundwater to support the development of the CSM, was undertaken using Schoeller plots and Piper diagrams. Schoeller plots express the concentration of ionic constituents in milli-equivalents (meq/L) plotted on logarithmic scale whilst Piper diagrams compare percentages of ionic constituents. Both diagrammatic methods help provide a visual indication of geochemical changes between locations, along flow paths, or to communicate temporal changes in water chemical characteristics.

Results of the field chemical assessment are provided in **Table 7** and **Appendix E** and correlate well with field observations and laboratory results. The chemical laboratory results of this analysis are also illustrated in **Figure 12, 13 and 14**. Full analytical results are in **Appendix F**.

8.7.2 Ionic balance

In brief, the summed total of anions against cations was less than 1% at all locations assessed, with an average difference of 0.2%. It was not possible to calculate the relative percentage difference (RPD) between field and laboratory pH as in most cases, Environmental Earth Sciences were only provided with laboratory data. On average, the relationship between laboratory determined TDS and field measured EC was 0.5 across the site. These results provide confidence in the data set obtained and allow reliance upon the chemical conclusions drawn.

Collection of physical information from the site has been supported by chemical data. Based on the results in **Tables 15 to 18** at the back of this report, the groundwater can be characterised on the basis of beneficial use protection and hydrogeochemical evolution.

Charts 2 – 10 (**Appendix A)** plot the ionic composition of the groundwater for bores GW1 and the MWX series bores on Schoeller diagrams. All bores have a data range of July 2017 – June 2018 for most ions. Data from 2013 – 2015 was also included in the Schoeller diagram for bore GW1 as it was available. These charts show the consistency of groundwater chemistry over time at each sampling location, providing an excellent background water chemistry signature.

From a water quality perspective, the data presented in **Figure 12 to 14** as well as **Table 15** indicate a distinction between the groundwaters within the south-east of the site (east of the groundwater divide) and in the north-west of the site (west of the groundwater divide). This is also evident on **Chart 11**, which shows pH at all bores between July 2017 – June 2018, with a distinction between the more acidic shallow bores to the north-west (bores G1, GW2,

GW4, MWX1, MWX2, MWX3S, MWX4S) and the more alkaline deeper bores and bores to the south-east (bores MWX3D, MWX4D, MWX5, MWX6, MW1, MW2 and MW5-MW11).

A summary of inorganics and metals recorded during the monitoring period July 2017 to June 2018 are illustrated in **Charts 12 to 25** in **Appendix A**.

Figure 12 illustrates the ionic balance in each of the monitoring bores to the west and east of the groundwater divide respectively, based on an average of data from 2017 presented on a Piper Diagram, whilst **Figure 13** illustrates the data recovered in June 2018 presented as a Schoeller Plot.

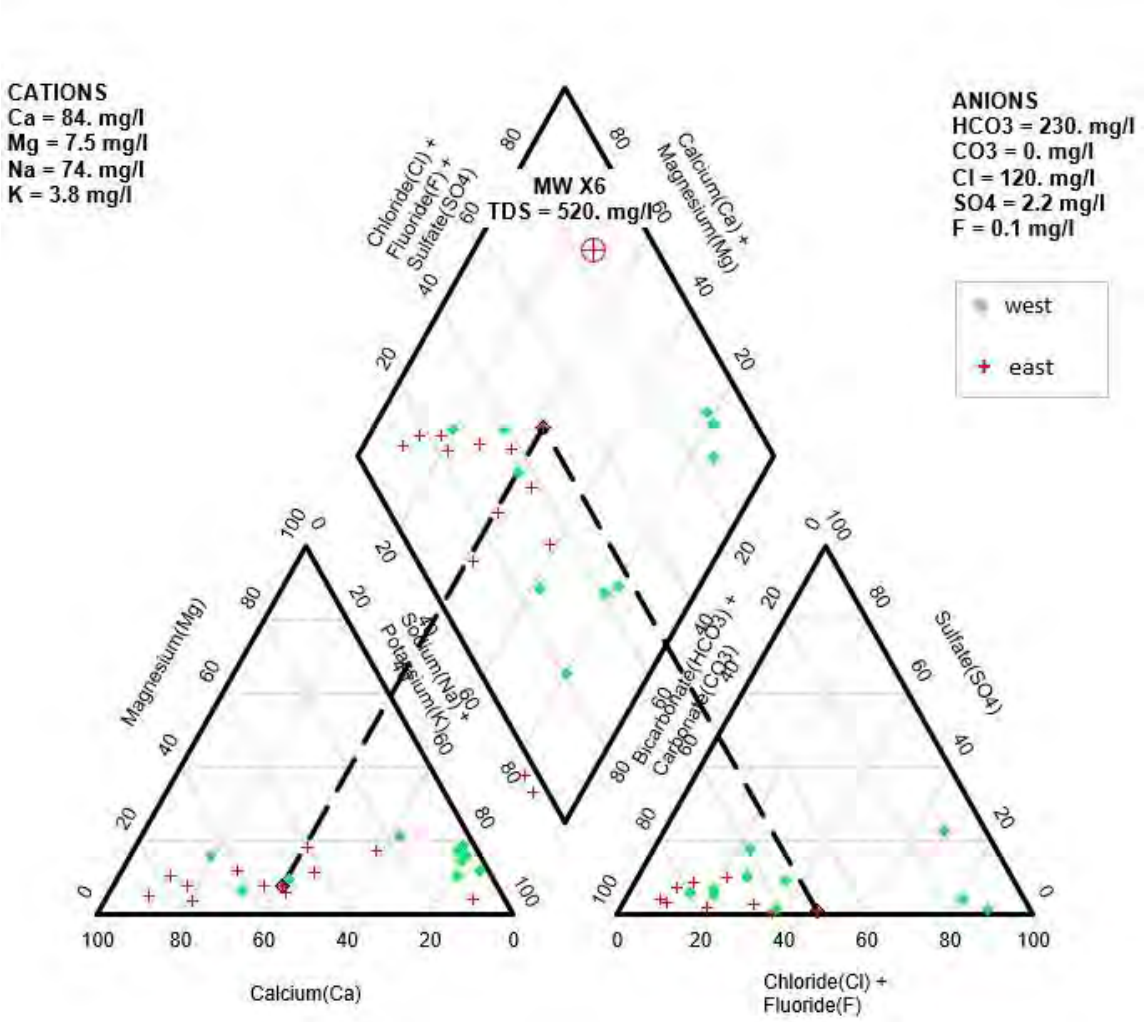


Figure 12: Piper diagram

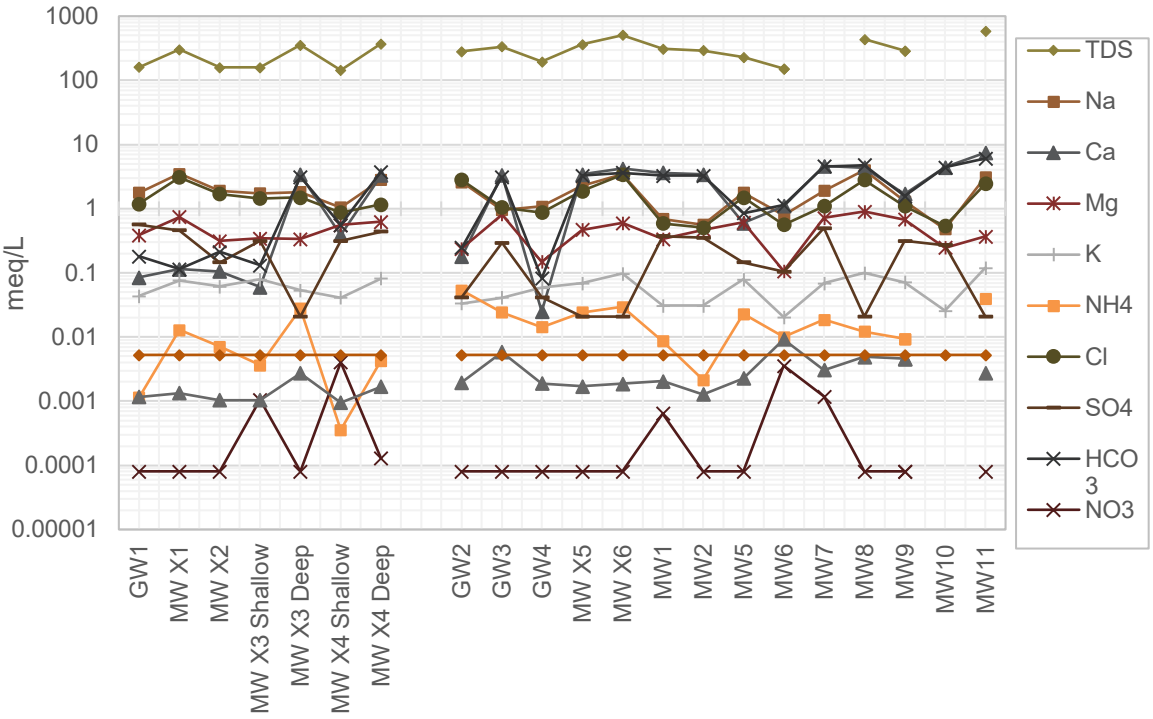


Figure 13: Schoeller Plot – groundwater chemistry, June 2018

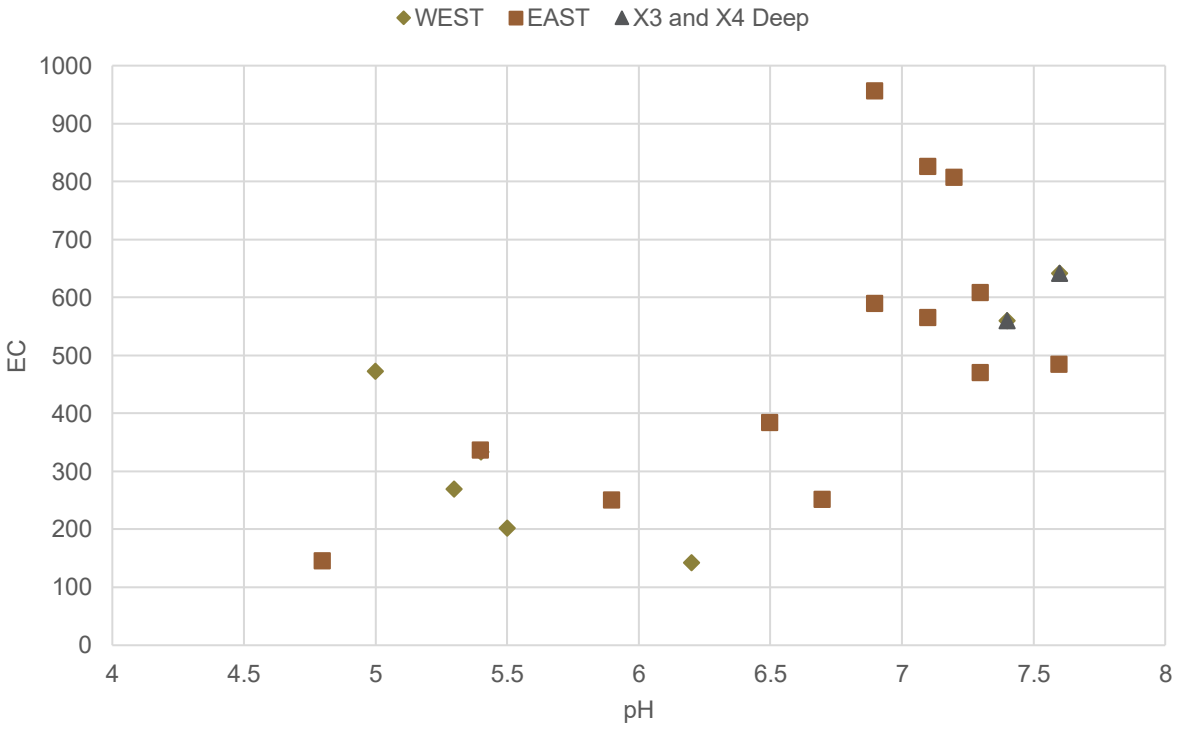


Figure 14: EC-pH summary

West of groundwater divide

To the west of the inferred groundwater flow divide (ID: GW1, GW2, GW4, MWX1, MWX2, MWX3S and MWX4S) the groundwater chemistry is sodium (Na) – chloride (Cl) dominant with the cations magnesium (Mg) and calcium (Ca) and anions sulfate (SO_4) and bicarbonate (HCO_3) sub-dominant. Refer to **Charts 2, 3, 4, 5 and 7** (**Appendix A**) for these individual Schoeller diagrams. These bores are typically more acidic with a pH range between 4.2 and 6.3, ranging between 5.0 and 6.2 during the June 2018 monitoring period. Refer to **Chart 11** for the Groundwater pH (**Appendix A)**.

The deeper of the nested bores (ID: MWX3D and MWX4D) reported groundwater chemistry that was Ca-HCO_3 >Na-Cl dominated. As these bores are screened from 23 – 26 m BGL and 21.5 – 24.5 m BGL respectively, they may potentially be reflective of groundwater chemistry at the deepest level of the Stockton Sandbeds Aquifer, generally assumed to be 20 m thick, or represent a mixing zone with the deeper Tomago Sandbeds Aquifer. Refer to **Charts 6 and 8** in the **Appendix A** for these Schoeller diagrams.

East of groundwater divide

A neutral to slightly alkaline pH range of 6.8 – 7.8 was reported for the deeper bores (MWX3D and MWX4D) and those easts of the groundwater divide. These bores typically reported a more Ca-HCO_3 dominant groundwater chemistry that would influence the pH.

East of the inferred groundwater flow divide (ID: MWX5 and MWX6) the groundwater chemistry was Ca-HCO_3 and Na-Cl dominated, likely reflective of increasingly marine influence. Refer to **Charts 9 and 10** (**Appendix A)** for these Schoeller diagrams.

A relationship exists between pH and salinity (EC) due to the presence of carbonate material (marine shells and other exoskeletons) in the aquifer matrix, resulting in higher pH's to the south-east and deeper in the aquifer, and subsequent higher dissolution rates of bicarbonate ($HCO_{3(aq)}$) rather than venting as $CO_{2(g)}$ in more acidic conditions. The higher HCO_3 results in higher Ca in equilibrium, and slightly higher salinity, as demonstrated on **Figure 13 and 14.**

Summary of hydrochemistry

Based on a review of monthly data, the following observations are surmised:

- Salinity, as EC, typically ranges from 200 to <1,000 µS/cm.
- Salinity between monitoring locations varies significantly, with average salinities ranging from 330 µS/cm at bore MW1 to 805 µS/cm at bore MW11.
- Salinity also varies significantly per location, with bore MW5 showing the greatest range of 796 µS/cm over the past three years (maximum – minimum).
- It is noted that the largest spikes in salinity occur following significant rainfall events and are inferred to be due to recharge flushing relict salt from above the water table.
- pH values are shown to typically range from pH 6.0 to 8.0. A few readings below pH 6 are noted at bores MW5 and MW9, and also bore MW1 in the past. pH values are generally relatively stable. A slight increasing trend over the last three years is noted at bores MW5 and MW9 (moving toward a more neutral pH).

8.7.3 Comparison of data to water quality criteria

In addition to analysis for inorganic chemicals, groundwater collected from the unconfined aquifer in the above-mentioned bores was analysed for a range of 11 heavy metals and PFAS compounds, as summarised in **Tables 17 and 18**. Please refer to **Appendix F** – Laboratory Transcripts for the full results.

The shallow bores to the east of the inferred groundwater flow divide reported acidic pH ranges that exceed the ANZG (2018) guideline values for 95% protection of freshwater aquatic ecosystems. As established in Section 4, acidic soil groups are a feature of the natural environment at the site and the groundwater results reflect this.

All concentrations of TDS across the monitoring network and data range reported TDS below the guidelines.

Arsenic (As) exceeded guidelines for drinking in bore MWX6, however this is considered a natural occurrence and this area is not within a drinking-water zone. Dissolved metals including aluminium, copper, zinc, arsenic and lead exceed guideline values for ecosystem protection (freshwater and marine).

Table 18 shows that all analyses for PFAS compounds at bores MWX1, MWX2, MWX7 and GW4 reported no concentrations above the laboratory LOR from the monitoring period (January – June 2018).

Analysis of two water samples was undertaken on 11 December 2018 by VGT Laboratories Pty Ltd, on behalf of Boral for radium, uranium and thorium. Analysis was undertaken by Envirolab and ALS, both NATA accredited laboratories. Neither sample recorded a positive result above the limit of reporting (LOR).

The groundwater quality results are generally considered to be representative of baseline groundwater quality in the project site and provides a good basis for comparison against results for monitoring throughout the life of the project and into closure.

8.8 Groundwater usage and receptors

8.8.1 Introduction

As the current predominant land use for the site and surrounding down-gradient areas is either industrial or passive recreational use, no extractive use of groundwater is expected. Despite this, the groundwater resource beneath the site is of relatively useful yield and quality (Section 8.5) and is therefore suitable for a number of potential beneficial uses. The search of the BOM registered groundwater bore database discussed in Section 8.5.5 indicates limited stock watering and domestic use in the area (**Appendix B**).

8.8.2 Potential beneficial users

Beneficial reuse of groundwater in NSW is governed by water quality objectives and associated criteria. Potential beneficial uses of an aquifer are directly associated with potential yield (sustainable or otherwise) and quality. All groundwater, regardless of yield or quality, is required to be protective of the natural ecosystem within which it resides and in particular discharges to, including any groundwater dependent ecosystems (GDEs).

In order to determine potential beneficial uses of an aquifer, a water quality and quantity assessment is undertaken, including:

- desk-top assessment of existing users and ecosystems (including GDEs), as well as any information on yield and quality.
- assessment of potential groundwater yields (quantity), including existing information and collection of additional physical data, and
- assessment of groundwater quality based on existing information, collection of field data and chemical analysis of collected groundwater samples.

A summary of each potential beneficial use of the aquifers beneath the site is provided in **Table 11.**

8.8.3 Summary of groundwater usage

Based on **Table 11**, the relevant beneficial users of groundwater (in order of priority and importance) are:

- the freshwater and marine ecosystems of local surface water features and nearby ephemeral creek systems.
- stock watering.
- recreational, direct contact and aesthetic use.
- possible irrigation, and
- project use (dust suppression).

Tables 15 to 18 list the relevant criteria values adopted, which have been derived to ensure water quality is protective of the relevant beneficial uses.

The local groundwater is not considered to have potential beneficial use as drinking water, while use for irrigation is not currently occurring and is considered unlikely.

Table 11: Potential beneficial use assessment

Potential beneficial use	Assessment
Drinking water	• The site is not situated in a catchment that is currently being used as a drinking water aquifer (Hunter Water, 2011). • An assessment of groundwater quality on the basis of TDS and EC, as well as Na, Cl and SO4 in particular has been undertaken, and has confirmed that groundwater is broadly suitable for human consumption, with the exception of arsenic at bore MWx6. However, given the depositional environment, it is considered that this may be a natural occurrence. • Thus, protection of groundwater for drinking supply is not a relevant beneficial use for this project, however as the average TDS is generally <2,000 mg/L drinking water criteria will still be cited in assessment of the data (as required by DEC 2007).
Recreation, direct contact and aesthetics	• Water-based recreational activities undertaken at Fullerton Cove include fishing and potentially water sports. As such, guidelines provided by NHMRC/ NRMMC (2008 and 2011) have been considered. • NHMRC/ NRMMC (2008) state that criteria for recreational/ direct contact quality can be derived from the values presented in NHMRC / NRMMC (2004, which was updated in 2011), by applying a multiplication factor of 10-20 for non-volatile chemicals. The reasoning for this is that the drinking water criteria are calculated based on the assumption that the average person consumes 2 L of water per day, and the rate of assumed incidental ingestion during a daily swimming session is 100-200 mL. • Drinking criteria and the consequent direct contact/ recreational criteria have been included in Tables 15 and 16. Also included in these tables are aesthetic criteria for certain chemicals relevant to the site that have potential odour, discolouration and taste issues (TDS, Na, Cl, NH_3, Mn and Fe).
Irrigation	• For reasons similar to the discussion above for drinking water quality, groundwater in the vicinity of the site is of marginal quality for use as irrigation water. For this reason (in addition to that of the limited area extent of the aquifer), groundwater is not utilised for irrigation in the catchment, based on field observations and discussions, and assessment of water quality data. • Further, iron concentrations in groundwater are also likely to limit potential groundwater use for irrigation (see Table 16). Additionally, analysis of data indicates that the groundwater hardness is on average 150 mg/L as $CaCO_3$. The saturation indices (Langelier and Ryzner) indicates that this water is corrosive.

Potential beneficial use	Assessment
Stock watering	• No groundwater bores within a 2.5 km radius of the site are registered for stock watering purposes (Appendix B). Criteria for stock watering are based on values provided in ANZG (2018), and default to NHMRC/ NRMMC (2011) where specific stock watering criteria are otherwise unavailable.
Discharge to surface water (ecosystem protection)	• The Hunter Wetlands National Park is located in and around Fullerton Cove, ≥2.5 km downgradient of the site. These wetlands support a wide range of aquatic and semi-aquatic flora and fauna in addition to migratory water birds. • Ecosystem protection is a primary beneficial use of the aquifer, as swamps and wetlands down gradient of the project area are receptors for groundwater discharge (see Figures 5 to 7). As such, water quality criteria for protection of 95% of species have been adopted from ANZG (2018).

Groundwater dependent ecosystems (GDE)	• The GDE map provided in Appendix C (after BOM, 2018) shows that the Project Area and vicinity contains a low to moderate potential for terrestrial GDEs, refer to Appendix C.
	• Review of the Stockton Sand Quarry Groundwater Management Plan (Jacobs, 2017) provides the following information pertaining to GDEs at and around the site from their review of previous reports (not sited by Environmental Earth Sciences):
	  • Potential GDEs south east of the Project Area (seaward) include mobile and ephemeral vegetated deflation basins consisting of a variety of reeds, grasses and sedges. This vegetation provides habitat to invertebrates.
	  • Swamp forests, dunes swales and low-lying heath are the primary GDEs north west (inland) of the Project Area. Given the sand extraction depth restrictions and low evaporation in times of high groundwater, the risk of the project operations impacting these GDEs was reported as very low.

Industry	• There are no industrial users of groundwater in the locality. The major reason for this is the relatively isolated location of the site away from the nearest industrial centres. As such, this potential beneficial use requires no further consideration.

9 IMPACT ASSESSMENT

This section presents an assessment of the potential physical and chemical impacts of the project, including consideration of the potential impacts to beneficial uses of the groundwater.

9.1 Assessment methodology

Potential impacts to groundwater beneficial users as a result of the project have been assessed in the context of the local hydrogeological setting, i.e. the CSM, and the relevant legislation and guidelines. The CSM was based on:

- a desktop study of existing information relating to the project and catchment hydrogeology.
- assessment of aquifer physical properties at existing individual locations, and
- assessment of aquifer chemical properties at existing individual locations.

The nature of the groundwater flow system, i.e. a local flow system discharging to the local surface water bodies and creeks, means that all potential impacts of the project are considered to be constrained. The area of potential impacts is constrained to the north and west by Fullerton Cove and associated drainage networks (≤2.5 km). It is constrained to the south and east by the Pacific Ocean (≤1.5 km).

The assessment of impacts is based on the CSM and on knowledge and experience of the authors of flow systems in similar environments and of similar projects. Where appropriate, calculations of groundwater flow velocity, volumetric groundwater flow rate (flux), and travel time are evaluated, based on Darcy's law (Freeze and Cherry, 1979).

Groundwater flow or transport modelling was not justifiable given that dewatering and associated drawdown will not be taking place. Groundwater extraction for use on the project area was not considered as it is understood that this will not be required, in part due to the current practice of sub-contracting dust suppression to an external contractor via water cart, where required.

The different components of the project are described in Section 5.2. The potential impacts associated with the components of the project are described in **Table 12**. Identified potential groundwater impacts are listed in a summary table (**Table 14**) in which the likelihood, consequence and the resulting potential risk associated with each potential impact is considered based on a risk matrix (**Table 13**).

9.2 Description of the proposal

It is understood that the project will encompass the following components:

9.2.1 Site preparation

Prior to commencement of extraction, stage one of the project area would be cleared of vegetation and topsoils stripped and stockpiled for future rehabilitation. All remaining revegetation within the project area would be stripped and stockpiled progressively as the dredge operation progressed.

9.2.2 Site works (excavation)

An estimated total area of 37 ha is expected to be disturbed, with dredging planned to a maximum depth of 15 m below sea level (-15m AHD). It is understood that sand and water pumped from the dredge extraction area will pass over an initial screen processing plant to separate oversize organic matter or debris and into a large wash tank to float out any fines (<75 µm). After washing, the sand will be pumped through a cyclone and stockpiled for further dewatering. Water removed through by the cyclone will be pumped back to the dredge pond. In the event of high turbidity, a silt curtain will be installed to create an in-water fines containment cell. Water pumped from the extraction areas will be returned via the pumping pipeline. Pumped water volumes will be recorded by a flow metre and the same volume of water will be returned to the extraction area to balance water extracted.

9.2.3 Site rehabilitation

Upon completion, it is understood that the area is to be left as a freshwater lake. Rehabilitation will be undertaken in accordance with Stockton Transgressive Dune Quarry Rehabilitation and Landscape Management Plan (Environmental Compliance Services, 2017) and the Environmental Earth Sciences (2019) *Rehabilitation Strategy for Stockton Sand Quarry Dredging, Cox Lane, Fullerton Cove, NSW, Boral Resources (NSW) Pty Ltd* (Ref: 717041_Rehabilitation V1.0, dated 2 September 2019).

There is no dewatering planned during the project operations because the method of sand excavation is via a suction dredge that will operate on the dredge pond that is to be created by the excavation extending below the water-table. Therefore, there is not expected to be any significant drawdown of groundwater levels associated with the project.

Across the site, negligible changes in groundwater levels are expected to occur throughout the life of the project and post-closure. The potential impacts of the project are described separately below in **Table 12** and summarised in **Table 14**.

Table 12: Summary of identified potential impacts

Potential physical impacts to groundwater	
Site preparation	• It is likely that once vegetation is cleared from the project area, recharge of the water table will increase via established high infiltration rates. This will potentially improve the mechanism for water table recharge (i.e. direct infiltration) which, along with reduced evapo-transpiration following vegetation removal, may result in localised water table elevations beneath the project and vicinity. The consequence of such an impact is minor to negligible (Table 12) and may even be beneficial by increasing groundwater flux rates from the project site to Fullerton Cove and low-lying swamps and wetlands north and west of the site.
Excavation	• Whilst the likelihood of any change in water table levels as a result of excavation and consequent alteration of recharge and discharge mechanisms for groundwater at the project area is "possible" (**Table 14**), the consequence is "minor". The actual groundwater inflows and outflows are not expected to alter significantly, primarily as proposed excavation works are not expected to alter the water-table gradient, the K or porosity of the sediments outside the mined area, hence flux will be stable. • Removal of the aquifer matrix by excavation is likely to have very little physical impact on the groundwater resource. This is because the Project area (37 ha to be disturbed) makes up a small proportion (<0.1%) of the overall 39,100-hectare (391 km^2) Stockton Sandbeds catchment. • Total rainfall input to the site is estimated at 1.2 ML/d, with potential evaporative loss estimated at around 50%. For the project area, this equates to approximately 1,125 mmpa which for the 37ha site equates to 0.35mpa x 370,000m^2 = 129,500 m^3/y (129.5 MLpa) or 355 m^3/day or 4.1 L/sec. • Calculations indicate that the water take with the sand product contributes 4% of total groundwater outflows, which is being 'won' from natural groundwater discharge (outflow) from the site towards either the north or south. As half of this discharge is to the ocean, it is hard to see this as 'take' when it is recharging a marine water body. As the sand extraction proceeds, the above is expected to be altered gradually over time as recharge increases due to direct rainfall onto the lake that is created, off-set by increased direct evaporation from the surface water body.
Reinstatement and rehabilitation	• Following completion of sand extraction, the area will remain as a lake. This would be expected to facilitate water table recharge and return to "natural" conditions. There is a "negligible" consequence of physical impact and therefore a "low" risk. • Further to the sand dredging operations taking minimal water from the excavation/ dredge area, combined with the creation of an enhanced groundwater recharge zone in the form of a lake, indicates that the water table will not be lowered in the dredge pond area and that the increased recharge rate will mean movement of groundwater away from the pond (including to the north towards Fullerton Cove, Cabbage Tree Road and the RAAF base).

Potential chemical impact to groundwater	
Site preparation	• Reduced evapo-transpiration following vegetation removal may result in localised water table elevations beneath the Project Area, hence chemical impact as a result of site preparation is expected to be limited to potential increases in fresh water recharge to the aquifer. Any chemical "impact" is therefore likely to be beneficial.
Excavation	• Removal of the aquifer matrix by excavation has the potential to chemically impact on the groundwater resource. The likelihood of any change in water table levels as a result of excavation and consequent alteration of recharge and discharge mechanisms for groundwater at the Project Area is "unlikely" (**Table 12**). As dredging activities will see the majority of the water drain back into the dredge pond, there is low risk from the oxidation of potentially localised instances of PASS (Environmental Earth Sciences, 2018). Returning the water to the dredge pond prevents lowering of the groundwater table. Furthermore, recharge is rapid in the dune lithology, further preventing impacts to the groundwater table in the Project Area and across the site. • The contaminants of potential concern associated with regional groundwater impacts stem from the Williamtown RAAF base, chiefly PFOS/PFOA which are known to have impacted the Tomago Sandbeds aquifer. • As detailed in Section 4.5 above, it can be estimated from water balance calculations that the water table would not be expected to drop significantly. In addition, regional groundwater discharge zone of Tilligerry Creek/ Fourteen Foot Drain means movement of groundwater away from the pond (including to the north towards Fullerton Cove, Cabbage Tree Road and the RAAF base). • Therefore, the risk of chemical impacts to groundwater during excavation/dredging is considered "very unlikely".
Reinstatement and rehabilitation	• The wetland rehabilitation proposed for the area is considered to have a lower level of overall risk as the wetland would be expected to facilitate water table recharge and return to natural conditions. • The creation of an enhanced groundwater recharge zone in the form of a lake, in addition to the regional groundwater discharge zone of Tilligerry Creek/ Fourteen Foot Drain means movement of groundwater away from the pond (including to the north towards Fullerton Cove, Cabbage Tree Road and the RAAF base.

9.3 Comparison of risks

A summary of the primary potential groundwater impacts of the different components of the project, based on the above discussion, has been provided in **Table 12**. The individual impacts are considered separately in terms of their likelihood and consequence; scores are attributed to both likelihood and consequence on a scale from 1 to 5 in each case. The risk is, in turn, scored as the sum of the likelihood and consequence scores. The risk matrix is illustrated in **Table 13.**

Table 13: Risk matrix

		Likelihood				
Consequence		Very unlikely (5)	Unlikely (4)	Possible (3)	Likely (2)	Very Likely (1)
	Negligible (5)	10	9	8	7	6
	Minor (4)	9	8	7	6	5
	Moderate (3)	8	7	6	5	4
	Major (2)	7	6	5	4	3
	Critical (1)	6	5	4	3	2

Note(s):

Likelihood scale has five categories with scores from 5 to 1, i.e. Very Unlikely (5), Unlikely (4), Possible (3), Likely (2), Very Likely (1)

Consequence scale has five categories with scores from 5 to 1, i.e. Negligible (5), Minor (4), Moderate (3), Major (2), Critical (1)

Overall risk value = Consequence value + Likelihood value; consequence and likelihood are considered separately

Red denotes Extreme Risk (scores of 2-3), Orange denotes High Risk (scores of 4-5), Yellow denotes Moderate risk (scores of 6-7), Green denotes low risk (8-10)

9.4 Summary of impacts

As detailed in **Table 14**, all consequences associated with potential physical and chemical impacts are “minor” to “negligible”. This is primarily because the project site makes such a small contribution to the overall catchment water balance, and that there are no sensitive receptors to groundwater discharge down-gradient of the site.

The risk assessment as illustrated in **Table 14** concludes all potential physical and chemical impacts to groundwater are considered Low.

One category was classified initially as moderate as one location was identified with a moderate risk for potential ASS. However, this was a localised occurrence and was considered “no risk-nonreactive” (Environmental Earth Sciences, 2018). ASS issues on the project site will be managed by an acid sulfate soil management plan (ASSMP).

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Table 14: Qualitative impact assessment

Project Component	Aspect of Project Component	Potential Impacts to Groundwater	Likelihood of Impact	Consequence of Impact	Risk rating	Comments
Site Preparation	Vegetation Clearing	Physical Impact to Groundwater	Unlikely (4)	Minor (4)	**Low (8)**	Impacts: increased recharge, run-on, run-off and erosion
		Chemical Impact to Groundwater	Very Unlikely (5)	Moderate (3)	**Low (8)**	No mechanism for impact
		Ensuing Physical Impact to Ecosystems or Groundwater Users	Very Unlikely (5)	Negligible (5)	**Low (10)**	Ecosystem **not** heavily reliant on groundwater
		Ensuing Chemical Impact to Ecosystems or Groundwater Users	Very Unlikely (5)	Moderate (3)	**Low (8)**	No mechanism for impact
Excavation/dredging	Removal of Aquifer matrix	Physical Impact to Groundwater	Unlikely (4)	Minor (4)	**Low (8)**	Lowering of water table
		Chemical Impact to Groundwater	Very Unlikely (5)	Moderate (3)	**Low (8)**	PASS not considered a risk beneath site
		Ensuing Physical Impact to Ecosystems or Groundwater Users	Unlikely (4)	Minor (4)	**Low (8)**	Ecosystem **not** heavily reliant on groundwater
		Ensuing Chemical Impact to Ecosystems or Groundwater Users	Unlikely (4)	Minor (4)	**Low (8)**	No mechanism for impact
		Drawdown of water increasing plume of PFAS from RAAF base	Very Unlikely (5)	Moderate (3)	**Low (8)**	Site is in a separate groundwater and surface water catchment to the identified sources of PFAS in groundwater.

Project Component	Aspect of Project Component	Potential Impacts to Groundwater	Likelihood of Impact	Consequence of Impact	Risk rating	Comments
Rehabilitation (wetland and lake)	Wetland and lake formation	Physical Impact to Groundwater	Very Unlikely (5)	Negligible (5)	**Low (10)**	Risk decreasing over time
		Chemical Impact to Groundwater	Unlikely (4)	Minor (4)	**Low (6)**	Risk decreasing over time
		Ensuing Physical Impact to Ecosystems or Groundwater Users	Unlikely (4)	Negligible (5)	**Low (9)**	Ecosystem **not** heavily reliant on groundwater surface expression
		Ensuing Chemical Impact to Ecosystems or Groundwater Users	Unlikely (4)	Minor (4)	**Low (8)**	Regional groundwater flow to north-west and south-east

10 MANAGEMENT AND MITIGATION

10.1 Summary of soil mitigation and monitoring recommendations

The physical risk to groundwater from the project is very low.

Limited potential chemical risks were identified in an ASS assessment by Environmental Earth Sciences (2018) which reported a moderate risk for PASS in one location. However, high alkalinity and a high buffering capacity was reported throughout the borehole investigations within the Project Area.

Potential chemical risk during the operation of the project are considered to be mitigated by:

- excavation activities within the Project Area, while encountering the water bearing zone on site, are considered unlikely to change the groundwater level as water will be drained back into the dredge pond.
- proposed dredging activities include the sieving of material, so that fines (materials finer than sand) are separated on site and immediately returned below the water table.

Regular monitoring is therefore recommended as part of an ASS Management Plan for a proactive monitoring regime to be employed so that early indications of localised acid generation could trigger appropriate management.

10.2 Summary of groundwater monitoring recommendations

The following recommendations will be formalised in an update to the existing Groundwater Monitoring and Management Plan (GMMP) (Jacobs, 2017) to encompass the proposed extraction area. The GMMP forms a sub-plan to the Water Management Plan (WMP) prepared in accordance with DA 140-6-2005, Condition 3(12).

The GMMP describes the objectives of the groundwater management and monitoring and details the proposed types and locations of monitoring. It also describes the monitoring observations which would trigger actions, and the proposed action and/or mitigation should triggers be exceeded (Jacobs, 2017). The recommended monitoring program is intended to facilitate closure-focussed interpretation of the data.

10.2.1 Monitoring network

It is recommended that those boreholes outside the proposed extraction areas (7 total) form a monitoring network to be periodically sampled. They include bores MWX1, MWX2, MWX5, MWX6, MWX7, GW2, GW4 and MW2. Once extraction progresses below the water table, the dredge pond surface will need to be surveyed so that the relative height of water in the pond over time can be accurately measured.

All bores will need to be surveyed for relative height to Australian Height Datum (AHD) with at least 0.001 m accuracy, so that relative groundwater levels can be compared.

10.2.2 Physical assessment of groundwater and pond levels

Static groundwater levels (SWL) and pond water level will need to be measured monthly during dredging operations, and during rehabilitation works (bores only). Following rehabilitation, all bores will be incorporated into the quarterly groundwater monitoring program for the wider quarrying area.

10.2.3 Chemical assessment of groundwater and surface water

During excavation/dredging works, in additional to SWL and pond water level measurement, all seven bores and the pond will need to be tested for pH, on a monthly basis. It is recommended that pH measurement be performed in the field with a handheld electronic metre that is 2-point calibrated (calibration certificates to be provided).

In addition to the above recommended measurement for pH, all bores will be incorporated into the pre-existing groundwater management plan, which will be updated as a result of the determination.

Groundwater bores will be sampled on a monthly basis for static water levels (SWL) and pH, and tested quarterly for the following analytical suite:

- Field measurement of:
    - pH, electrolytic conductivity (EC), oxidation-reduction potential (ORP), static water levels (SWL), dissolved oxygen (DO) and temperature.
- Laboratory analysis for:
    - full ionic balance suite – pH, TDS, cations (Na, Ca, Mg, K), anions (Cl, SO_4, HCO_3, PO_4, F) and nutrients (NH_3, NO_3 and NO_2), and
    - dissolved metals / metalloids including aluminium (Al), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni) and zinc (Zn).

11 LIMITATIONS

This report has been prepared by Environmental Earth Sciences NSW ABN 109 404 006 in response to and subject to the following limitations:

1. The specific instructions received from client Element Environment;
2. The specific scope of works set out in PO717059 issued by Environmental Earth Sciences for and on behalf of Element Environment;
3. This report and all material contained within it is subject to Australian copyright law and is the property of Boral Limited. Other than in accordance with the *Copyright Act 1968* or the report, no material from the report may, in any form or by any means, be reproduced, distributed, stored in a retrieval system or transmitted, other than with the written consent of Boral Limited or its subsidiaries;

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5. This report comprises the formal report, documentation sections, tables, figures and appendices as referred to in the index to this report and must not be released to any third party or copied in part without all the material included in this report for any reason;

6. The report only relates to the site referred to in the scope of works being located at Stockton Sand Quarry, Fullerton Cove, NSW ("the site");

7. The report relates to the site as at the date of the report as conditions may change thereafter due to natural processes and/or site activities;

8. No warranty or guarantee is made in regard to any other use than as specified in the scope of works and only applies to the depth tested and reported in this report;

9. Fill, soil, groundwater and rock to the depth tested on the site may be fit for the use specified in this report. Unless it is expressly stated in this report, the fill, soil and/or rock may not be suitable for classification as clean fill if deposited off site; and

10. Our General Limitations set out at the back of the body of this report.

12 REFERENCES

Australian and New Zealand Governments (ANZG), 2018, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. National Water Quality Management Strategy.

Australian Government, Bureau of Meteorology (BoM), 2019, *Atlas of groundwater dependent ecosystems*. Accessed January 2019.

AECOM (2017). *RAAF Base Williamtown Off-Site Human Health Risk Assessment - RAAF Base Williamtown Stage 2B Environmental Investigation*, ref: 60527153 Revision 1 – Final, prepared for the Department of Defence. Available at: http://www.defence.gov.au/environment/pfas/Williamtown/publications.asp

Australian Soil Resources Information System (ASRIS) (2019). *Online soils mapping, acid sulfate soils*.

Beck, P and Mann, B. (2010). *A technical guide for demonstrating monitored natural attenuation of petroleum hydrocarbons in groundwater*. CRC Care Technical Report no. 15, September 2010.

Crosbie, R, S, Jolly, I D, Leaney, F W, Petheram, C and Wohling, D, 2010a, *Review of Australian groundwater recharge studies*. CSIRO: Water for a Healthy Country National Research Flagship, April 2010.

Crosbie, R, S, Jolly, I D, Leaney, F W and Petheram, C, 2010b, *Can the dataset of field based recharge estimates in Australia be used to predict recharge in data-poor areas?* Hydrology and Earth System Sciences 14 (2023-2038).

ERM (1994). *Environmental Impact Statement for a Sand Extraction Operation on Boral Resources Freehold Property at Fern Bay, NSW*, ref. 1068/94573. Prepared for Boral Resources (Country) Pty Ltd.

ERM (2005). *Environmental Impact Statement – Stockton Windblown Sand Extraction*, ref. 0027903 Final. Prepared for Boral Resources (Country) Pty Ltd.

Environmental Earth Sciences,2018. Acid sulfate soil impact assessment, Stockton sand quarry, Nelson Bay Road, NSW. Report number 714041_ASS

Fetter, C. W. (2001). *Applied hydrogeology*, 4th edition. Prentice Hall.

Freeze, R A and Cherry, J A, 1979, *Groundwater*. Prentice Hall.

Geological Survey of NSW (1966). *Newcastle 1:250,000 Geological series sheet S1 56-2*. NSW Department of Mines.

Hamon, R E, McLaughlin, M J, Gilkes, R J, Rate, A W, Zarcina, B, Robertson, A, Cozens, G, Radford, N, & Bettenay, L (2004). *Geochemical indices allow estimation of heavy metal background concentrations in soils*, Global Biogeochemical Cycles, vol. 18, GB1014.

Hem, J D (1985). *Study and interpretation of chemical characteristics of natural water*.

Hunter Water Corporation (HWC), 2011. *Catchment Management Plan*.

Hvorslev, M J (1951). *Time lag and soil permeability in ground-water observations*. U.S. Army Corps of Engineers, Waterways Experiment Station, Bulletin No. 36.

HydroSimulations, 2016, *RAAF Williamtown groundwater modelling. Report number AEC002/HC2016/09d*

Jacobs (2017). *Stockton Sand Quarry Groundwater Management Plan*, ref. IA147700_001b/B. Prepared for Boral Pty Ltd.

Kruseman G P and de Ridder N A, 2000, *Analysis and Evaluation of Pumping Test Data*. Second Edition. International Institute for Land Reclamation and Improvement.

Matthei L E (1995). *Soil Landscapes of the Newcastle 1:100,000 Sheet*. NSW Department of Land and Water Conservation, Sydney viewed on eSPADE v2.0 espade.environment.nsw.gov.au/ (viewed 28 March 2018).

National Environment Protection Council (NEPC) (2013). *National Environment Protection (Assessment of Site Contamination) Amendment Measure*, Adelaide, SA.

National Health and Medical Research Council (NHMRC)/ Natural Resource Management Ministerial Council (NRMMC) (2011). *Australian drinking water guidelines,* National Water Quality Management Strategy.

NHMRC & NRMMC (2008). *Guidelines for managing risks in recreational water.* Australian Government, February 2008.

National Uniform Drillers Licensing Committee (NUDLC) (2012). *Minimum Construction the Requirements for Water Bores in Australia*. 3rd Edition, Brisbane.

NSW Department of Environment and Conservation (DEC) (2007). *Contaminated sites: guidelines for the assessment and management of groundwater contamination*.

NSW Department of Primary Industries Office of Water (NOW) (2015). http://waterinfo.nsw.gov.au/gw/.

NOW, 2012, *Risk assessment guidelines for groundwater dependent ecosystems*. Volume 1 – The conceptual framework. May 2012.

NSW Department of Primary Industries (DPI) (2016). *Water sharing plan for the North Coast coastal sands groundwater sources background document.*

NSW Office of Environment & Heritage (OEH) (2011). *Contaminated sites: Guidelines for consultants reporting on contaminated sites*.

Parsons Brinckerhoff (PB), 2011, *Characterisation of hydrogeochemistry and risks to groundwater quality*. Report to NSW Office of Water, December 2011.

RPS (2016). *Boral Stockton Sand Quarry – Groundwater Gap Analysis*, ref. WS00256/003a. Prepared for Boral Quarries.

Standards Australia, 1998, *Water quality – sampling. Part 11: guidance on sampling of groundwaters* (AS/NZS 5667.11:1998). Standards Australia, Homebush, NSW.

Umwelt (Australia) Pty Ltd (1995). *Review of Potential Hydraulic Impacts of Proposed Sand Extraction at Stockton Sand Pit, off Cox's Lane, Fern Bay*. Prepared for Boral Resources (Country) Pty Ltd.

United States Environmental Protection Agency (USEPA) (1996). *Soil Screening Guidance, EPA/540/R-96/018, May 2006*, Office of Emergency and Remedial Response, United States Environment Protection Agency (USEPA), Washington DC.

Woolley, D, Mount, T and Gill, J (1995). *Tomago Tomaree Stockton Groundwater – Technical Review*. NSW Department of Water Resources, February 1995.

World Health Organisation (WHO) (2011). *Guidelines for drinking water quality*. 4th Edition

13 GLOSSARY OF TERMS

The following descriptions are of terms used in the text of this report.

Acid Sulfate Soil (ASS). A soil containing iron sulfides deposited during either the Pleistocene or Holocene geological epochs (Quaternary aged) as sea levels rose and fell.

Alluvial. Describes material deposited by, or in transit in, flowing water.

Anaerobic. Reducing or without oxygen.

Aquifer. A rock or sediment in a formation, group of formations, or part of a formation which is saturated and sufficiently permeable to transmit economic quantities of water to wells and springs.

Aquifer, confined. An aquifer that is overlain by a confining bed with significantly lower hydraulic conductivity than the aquifer.

Aquifer, perched. A region in the unsaturated zone where the soil is locally saturated because it overlies soil or rock of low permeability.

Background. The natural level of a property.

Baseline. An initial value of a measure.

Biodegradation. A biochemical process of microbial oxidation of complex organic compounds, to simpler chemical products. Micro-organisms derive the energy and cell carbon for growth from oxidation of organic compounds.

Bore. A hydraulic structure that facilitates the monitoring of groundwater level, collection of groundwater samples, or the extraction (or injection) of groundwater. Also known as a well, monitoring well or piezometer, although piezometers are typically of small diameter and only used for measuring the groundwater elevation or potentiometric surface.

Borehole. An uncased well drill hole.

Cation Exchange Capacity (CEC). The maximum positive charge required to balance the negative charge on colloids (clays and other charged particles). The units are milli-equivalents per 100 grams of material or centimoles of charge per kilogram of exchanger.

Clay. A soil material composed of particles finer than 0.002 mm. When used as a soil texture group such soils contain at least 35% clay.

Colluvial. Unconsolidated soil and rock material moved down-slope by gravity.

Confined Aquifer. An aquifer that is confined between two low-permeability aquitards. The groundwater in these aquifers is usually under hydraulic pressure, i.e. its hydraulic head is above the top of the aquifer.

Confining layer. A layer with low vertical hydraulic conductivity that is stratigraphically adjacent to one or more aquifers. A confining layer is an aquitard. It may lie above or below the aquifer.

Contaminant. Generally, any chemical species introduced into the soil or water. More particularly relates to those species that render soil or water unfit for beneficial use.

Contamination. Is considered to have occurred when the concentration of a specific element or compound is established as being greater than the normally expected (or actually quantified) background concentration.

Diffusion. A process by which species in solution move, driven by concentration gradients (from high to low).

Dilution. The mixing of a small volume of contaminated leachate with a large volume of uncontaminated water. The concentration of contaminants is reduced by the volume of the lower concentrated water. However the physical process of dilution often causes chemical disequilibria resulting in the destruction of ligand bonds, the alteration of solubility products

and the alteration of water pH. This usually causes precipitation by different chemical means of various species.

Discrete sample. Samples collected from different locations and depths that will not be composited but analysed individually.

Dispersion. A process by which species in solution mix with a second solution, thus reducing in concentration. In particular, relates to the reduction in concentration resulting from the movement of flowing groundwater.

Dissolved Oxygen (DO). Oxygen in the gaseous phase dissolved in water. Measured either as a concentration in mg/L or as a percentage of the theoretical saturation point, which is inversely related to temperature. At 19, 20 and 21 degrees Celsius, the oxygen concentrations in mg/L corresponding to 100% saturation are 9.4, 9.2 and 9.0 respectively.

Electrical Conductivity (EC). The EC of water is a measure of its ability to conduct an electric current. This property is related to the ionic content of the sample, which is in turn a function of the total dissolved (ionisable) solids (TDS) concentration. An estimate of TDS in fresh water can be obtained by multiplying EC by 0.65.

Flow path. The direction in which groundwater is moving.

Fluvial. A material deposited by, or in transit, in streams or watercourses.

Fracture. A break in the geological formation, e.g. a shear or a fault.

Gradational. The lower boundary between soil layers (horizons) has a gradual transition to the next layer. The solum (soil horizon) becomes gradually more clayey with depth.

Gradient. The rate of inclination of a slope. The degree of deviation from the horizontal; also refers to pressure.

Groundwater. The water held in the pores in the ground below the water table.

Groundwater Elevation. The elevation of the groundwater surface measured relative to a specified datum such as the Australian Height Datum (mAHD) or an arbitrary survey datum onsite, or “reduced level” (mRL).

Head space. The air space at the top of a soil or water sample.

Heavy Metals. All metallic elements whose atomic mass exceeds that of calcium (20) and includes lead (Pb), copper (Cu), Zinc (Zn), cadmium (Cd), and tin (Sn).

Heterogeneous. A condition of having different characteristics in proximate locations. Non-uniform. (Opposite of homogeneous).

Horizon. An individual soil layer, based on texture and colour, which differs from those above and below.

Hydraulic Conductivity (K). A coefficient describing the rate at which water can move through a permeable medium. It has units of length per time. The units for hydraulic conductivity are typically m3/day/m2 or m/day.

Hydraulic Gradient (i). The rate of change in total head per unit of distance of flow in a given direction – the direction is that which yields a maximum rate of decrease in head. Hydraulic Gradient is unit less.

Hydraulic Head (h). The sum of the elevation head and the pressure head at a point in an aquifer. This is typically reported as an elevation above a fixed datum, such as sea level.

Hydrocarbon. A molecule consisting of carbon and hydrogen atoms only, such as found in petroleum.

Hydrocarbon, volatile. A hydrocarbon with a low boiling point (high vapour pressure). Normally taken to mean those with ten (or less) carbon atoms per molecule.

Infiltration. The passage of water, under the influence of gravity, from the land surface into the subsurface.

Ionic Exchange. Adsorption occurs when a particle with a charge imbalance, neutralises this charge by the attraction (and subsequent adherence of) ions of opposite charge from solution. There are two types of such a charge: pH dependent; and pH independent or crystalline charge. Metal hydroxides and oxy-hydroxides represent examples of the former type, whilst clay minerals are representative of the latter and are normally associated with cation exchange.

Ions. An ion is a charged element or compound as a result of an excess or deficit of electrons. Positively charged ions are called cations, whilst negatively charged ions are called anions. Cations are written with superscript +, whilst anions use - as the superscript. The major aqueous ions are those that dominate total dissolved solids (TDS). These ions include: Cl-, SO42-, HCO3-, Na+, Ca2+, Mg2+, K+, NH4+, NO3-, NO2-, F-, PO43- and the heavy metals.

Lithic. Containing large amounts of fragments derived from previously formed rocks.

Mottled. Masses, blobs or blotches of sub-dominant, varying colours in the soil matrix.

Nodulation. Are hard, usually small, accumulation of precipitated iron and/or manganese in the soil profile, usually a result of past alternating periods of oxidation/reduction.

Nodule. A small, concretionary (hard) deposit, usually of iron and/or manganese.

Organics. Chemical compounds comprising atoms of carbon, hydrogen and others (commonly oxygen, nitrogen, phosphorous, sulfur). Opposite is inorganic, referring to chemical species not containing carbon.

Oxidation. Was originally referred only to the addition of oxygen to elements. However oxidation now encompasses the broader concept of the loss of electrons by electron transfer to other ions.

Perched Groundwater. Unconfined groundwater separated from an underlying main body of groundwater by an unsaturated zone. Perched groundwater typically occurs in discontinuous, often ephemeral, lenses, with unsaturated conditions both above and below.

Permeability (k). Property of porous medium relating to its ability to transmit or conduct liquid (usually water) under the influence of a driving force. Where water is the fluid, this is effectively the hydraulic conductivity. A function of the connectivity of pore spaces.

Piezometric or Potentiometric Surface. A surface that represents the level to which water will rise in cased bores. The water table is the potentiometric surface in an unconfined aquifer.

pH. A logarithmic index for the concentration of hydrogen ions in an aqueous solution, which is used as a measure of acidity.

Polycyclic aromatic Hydrocarbons (PAHs). Complex organic molecules which originate typically in the combustion of organic compounds.

Potential Acid Sulfate Soil (PASS). A soil that has the potential to become acidic if it is exposed to the atmosphere.

Porosity (n). The ratio of the volume of void spaces in a rock or sediment to the total volume of the rock or sediment. Typically given as a percentage.

Porosity, effective (ne). The volume of the void spaces through which water or other fluids can travel in a rock or sediment divided by the total volume of the rock or sediment.

Precipitation (chemical). There are two types of precipitation, pH dependent precipitation and solubility controlled precipitation. As the pH is raised beyond a threshold level the precipitation of metal cations such as oxy-hydroxides and hydroxides occur. As the pH is raised further precipitation continues until there are very few metal cations remaining in solution. This reaction is entirely reversible. Solubility controlled precipitation occurs between two ions when, at a given temperature and pressure, the concentration of one of the ions exceeds a certain level.

Profile. The solum. This includes the soil A and B horizons and is basically the depth of soil to weathered rock.

Purge (wells). The pumping out of well water to remove drilling debris or impurities; also conducted to bring fresh groundwater into the casing for sample collection. The later ensures that a more representative sample of an aquifer is taken.

QA/QC. Quality Assurance / Quality Control.

Recharge Area. Location of the replenishment of an aquifer by a natural process such as addition of water at the ground surface, or by an artificial system such as addition through a well

Recovery. The rate at which a water level in a well rises after pumping ceases.

Redox. REDuction-OXidation state of a chemical or solution.

Redox potential (Eh). The oxidation/reduction potential of the soil or water measured as milli-volt.

Reducing Conditions. Can be simply expressed as the absence of oxygen, though chemically the meaning is more complex. For more details refer to OXIDATION.

Remediation. The restoration of land or groundwater contaminated by pollutants, to a state suitable for other, beneficial uses.

Representative Sample. Assumed not to be significantly different than the population of samples available. In many investigations samples are often collected to represent the worst case situation.

Saturated Zone. A zone in which the rock or soil pores are filled (saturated) with water.

Shale. Fine-grained sedimentary rock formed by the compaction of silt, clay, or sand that accumulates in deltas and on lake and ocean bottoms. It is the most abundant of all sedimentary rocks.

Standing Water Level (SWL). The depth to the groundwater surface in a well or bore measured below a specific reference point – usually recorded as metres below the top of the well casing or below the ground surface.

Stratigraphy. A vertical sequence of geological units.

Subsoil. Subsurface material comprising the B and C horizons of soils with distinct profiles. They often have brighter colours and higher clay content than topsoils.

Texture. The size of particles in the soil. Texture is divided into six groups, depending on the amount of coarse sand, fine sand, silt and clay in the soil.

Topsoil. Part of the soil profile, typically the A1 horizon, containing material which is usually darker, more fertile and better structured than the underlying layers.

Total Dissolved Salts (TDS). The total dissolved salts comprise dissociated compounds and undissociated compounds, but not suspended material, colloids or dissolved gases.

Unsaturated Zone. The zone between the land surface and the water table, in which the rock or soil pores contain both air and water (water in the unsaturated zone is present at less than atmospheric pressure). It includes the root zone, intermediate zone and capillary fringe. Saturated bodies such as perched groundwater may exist in the unsaturated zone. Also referred to as the Vadose Zone.

Volatile. Having a low boiling or subliming pressure (a high vapour pressure).

Water table. Interface between the saturated zone and unsaturated zones. The surface in an aquifer at which pore water pressure is equal to atmospheric pressure.

Well. A hydraulic structure that facilitates the monitoring of groundwater level, collection of groundwater samples, or the extraction (or injection) of groundwater. Also known as a Bore.

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

ENVIRONMENTAL EARTH SCIENCES GENERAL LIMITATIONS

Scope of services
The work presented in this report is Environmental Earth Sciences response to the specific scope of works requested by, planned with and approved by the client. It cannot be relied on by any other third party for any purpose except with our prior written consent. Client may distribute this report to other parties and in doing so warrants that the report is suitable for the purpose it was intended for. However, any party wishing to rely on this report should contact us to determine the suitability of this report for their specific purpose.

Data should not be separated from the report
A report is provided inclusive of all documentation sections, limitations, tables, figures and appendices and should not be provided or copied in part without all supporting documentation for any reason, because misinterpretation may occur.

Subsurface conditions change
Understanding an environmental study will reduce exposure to the risk of the presence of contaminated soil and or groundwater. However, contaminants may be present in areas that were not investigated, or may migrate to other areas. Analysis cannot cover every type of contaminant that could possibly be present. When combined with field observations, field measurements and professional judgement, this approach increases the probability of identifying contaminated soil and or groundwater. Under no circumstances can it be considered that these findings represent the actual condition of the site at all points.

Environmental studies identify actual sub-surface conditions only at those points where samples are taken, when they are taken. Actual conditions between sampling locations differ from those inferred because no professional, no matter how qualified, and no sub-surface exploration program, no matter how comprehensive, can reveal what is hidden below the ground surface. The actual interface between materials may be far more gradual or abrupt than an assessment indicates. Actual conditions in areas not sampled may differ from that predicted. Nothing can be done to prevent the unanticipated. However, steps can be taken to help minimize the impact. For this reason, site owners should retain our services.

Problems with interpretation by others
Advice and interpretation is provided on the basis that subsequent work will be undertaken by Environmental Earth Sciences NSW. This will identify variances, maintain consistency in how data is interpreted, conduct additional tests that may be necessary and recommend solutions to problems encountered on site. Other parties may misinterpret our work and we cannot be responsible for how the information in this report is used. If further data is collected or comes to light we reserve the right to alter their conclusions.

Obtain regulatory approval
The investigation and remediation of contaminated sites is a field in which legislation and interpretation of legislation is changing rapidly. Our interpretation of the investigation findings should not be taken to be that of any other party. When approval from a statutory authority is required for a project, that approval should be directly sought by the client.

Limit of liability
This study has been carried out to a particular scope of works at a specified site and should not be used for any other purpose. This report is provided on the condition that Environmental Earth Sciences NSW disclaims all liability to any person or entity other than the client in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by any such person in reliance, whether in whole or in part, on the contents of this report. Furthermore, Environmental Earth Sciences NSW disclaims all liability in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by the client, or any such person in reliance, whether in whole or any part of the contents of this report of all matters not stated in the brief outlined in Environmental Earth Sciences NSW's proposal number and according to Environmental Earth Sciences general terms and conditions and special terms and conditions for contaminated sites.

To the maximum extent permitted by law, we exclude all liability of whatever nature, whether in contract, tort or otherwise, for the acts, omissions or default, whether negligent or otherwise for any loss or damage whatsoever that may arise in any way in connection with the supply of services. Under circumstances where liability cannot be excluded, such liability is limited to the value of the purchased service.

TABLES

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Table 15: Summary of Hydrogeochemistry, June 2018

		Ratios				Inorganics												Metals		
		Cl/SO4	Na/Ca	Na/Cl	Cl/HCO3	pH (Lab)	TDS	Sulfate as SO4 - Turbidimetric (Filtered)	Alkalinity (Bicarbonate as CaCO3) (mg/L)	Alkalinity (Carbonate as CaCO3) (mg/L)	Alkalinity (ResAlk) (mg/L)	Anions Total (meq/L)	Cation Total (meq/L)	Chloride (mg/L)	Fluoride (mg/L)	Ionic Balance (%)	Sodium (Filtered) (mg/L)	Calcium (Filtered) (mg/L)	Magnesium (Filtered) (mg/L)	Potassium (Filtered) (mg/L)
LOR						0.01	10	1	1	1	1	0.01	0.01	1	0.1	0.01	1	1	1	1
Location	**Date**																			
WEST																				
GW1	23/04/2018	1.4	30.9	0.9	3.4	5.5	129.0	26.0	11.0	2.8	23.6	3.7	8.6	0.2	0.1	71.0	34.0	1.1	3.5	1.4
MW-X1	24/04/2018	4.6	33.3	0.6	21.7	5.0	297.0	28.0	6.0	6.0	42.8	5.4	9.6	0.1	0.1	63.7	80.0	2.4	9.6	2.9
MW-X2	24/04/2018	8.1	19.6	0.6	8.1	5.4	212.0	11.0	11.0	6.8	20.9	4.2	7.7	0.2	0.1	127.7	53.0	2.7	5.1	2.8
MW-X3 shallow	24/04/2018	3.6	43.0	0.7	9.1	5.3	169.0	18.0	7.0	2.5	20.3	3.9	8.2	0.1	0.1	78.6	43.0	1.0	4.7	3.3
MW-X4 shallow	24/04/2018	2.4	2.3	0.6	1.1	6.2	88.0	10.0	21.0	15.3	47.4	1.5	7.4	0.6	0.1	60.9	14.0	6.1	3.3	1.2
MWX7	28/03/2018	0.67	12.77	2.61	0.27	7.1	1.11	68	170.66	24	205	5.532	6.0	46	0.2	0.041	120	9.4	2.8	2.8
Deep																				
MW-X3 deep	24/04/2018	65.0	0.6	0.6	0.3	7.4	333.0	1.0	190.0	175.0	186.5	1.3	9.7	3.1	0.1	161.4	42.0	70.0	4.1	2.1
MW-X4 deep	24/04/2018	1.8	1.0	1.3	0.2	7.6	377.0	28.0	240.0	167.5	195.9	2.0	12.0	3.8	0.1	193.3	67.0	67.0	8.5	3.3
EAST																				

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

		Ratios				Inorganics												Metals		
GW2	24/04/2018	46.5	15.6	0.6	18.6	5.4	283.0	2.0	5.0	8.5	20.9	5.7	0.0	0.2	0.1	120.1	53.0	3.4	3.9	1.0
GW4	24/04/2018	9.0	50.0	0.7	7.2	4.8	181.0	4.0	5.0	1.3	8.7	3.7	14.0	0.1	0.1	35.5	25.0	0.5	2.0	2.5
MW X5	24/04/2018	8.5	0.8	0.8	0.3	7.3	365.0	8.0	220.0	177.5	195.6	1.6	9.3	3.3	0.1	168.1	55.0	71.0	6.0	2.6
MW X6	24/04/2018	12.0	0.9	0.7	0.5	7.2	491.0	10.0	230.0	212.5	239.6	2.2	8.7	3.6	0.1	190.0	78.0	85.0	7.4	3.6
MW1	23/04/2018	0.8	0.2	0.9	0.1	7.3	293.0	23.0	180.0	192.5	199.0	0.5	5.2	3.3	0.2	188.9	17.0	77.0	4.1	1.6
MW2	23/04/2018	1.0	0.2	0.5	0.1	7.6	263.0	27.0	200.0	195.0	195.6	0.4	4.2	3.3	0.1	169.8	13.0	78.0	6.4	1.3
MW5	23/04/2018	7.5	3.1	0.7	1.1	5.9	175.0	6.0	41.0	25.0	60.4	2.3	10.6	0.9	0.1	118.4	31.0	10.0	5.6	2.4
MW6	23/04/2018	2.4	1.0	0.8	0.5	6.7	179.0	13.0	61.0	62.5	60.2	1.0	5.2	1.1	0.1	80.4	24.0	25.0	1.4	0.9
MW7	23/04/2018	0.6	0.4	1.2	0.1	6.9	385.0	50.0	230.0	212.5	265.3	1.2	8.2	4.6	0.1	264.5	38.0	85.0	11.0	2.6
MW8	23/04/2018	17.1	1.2	0.8	0.5	7.1	538.0	7.0	230.0	202.5	262.3	2.5	10.3	4.8	0.1	274.0	99.0	81.0	7.0	3.6
MW9	23/04/2018	1.9	0.4	0.5	0.3	6.5	261.0	20.0	120.0	127.5	118.6	1.2	11.3	1.6	0.1	129.6	18.0	51.0	6.7	2.1
MW11	6/11/2017	87.0	0.5	0.8	0.2	6.9	587.0	1.0	370.0	375.0	231.9	0.3	0.7	4.4	0.1	10.4	72.0	150.0	4.5	4.7

Notes:
- Not analysed / Not calculated
LOR = Limit of Reporting
Sample Type: Normal = Primary, Field_D = Intra-laboratory Duplicate, Interlab_D = Inter-laboratory Duplicate
ug/l = Micrograms per litre (ppb)
meq/L = miliequivalents per litre
mg/L = miligrams per litre

Table 16 DATA SUMMARY TABLE - INORGANIC CHEMISTRY

Criteria														
			Na	Ca	Mg	K	NH_4	Cl	SO_4	HCO_3	NO_3	PO_4	F	pH	TDS[2]
Drinking water - Health[3]			180*	-	-	-	0.5*	250*	500	-	50	-	1.5	-	600*
Recreation[4]			-	-	-	-	-	-	5000	-	500	-	15	6.5 -8.5	-
Ecological (fresh)[5]			-	-	-	-	0.9[A]	-	-	-	10.6^	-	-	-	-
Ecological (marine)[5]			-	-	-	-	0.91[A]	-	-	-		-	-	-	-
Livestock[4]			-	600	600	-	-	-	1000	-	400	-	2	-	4000
Irrigation[4]			115-460	-	-	-	5	175-700	-	-	20	-	1	6.0 -8.5	1500
		Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	-	mg/L
Sample	Date	Lab ID													
GW1	13/10/2017	4911/1	52	3.00	6.00	2.00	0.049	76	14.0	13.409	0.010	0.0306	<1	5.6	-
GW1	6/11/2017	4999/1	37	2.20	4.10	2.60	0.110	59	14.0	15.847	0.010	0.0153	<1	5.2	165
GW1	6/12/2017	5112/1	30	2.10	4.00	1.30	<0.005	45	16.0	11.000	0.005	0.0050	<1	5.7	125
GW1	29/01/2018	5321/1	39	2.90	5.30	2.00	0.047	51	23.0	8.000	0.010	0.0660	<1	5.3	162
GW1	28/02/2018	5424/1	29	1.70	3.80	1.90	0.042	44	26.0	10.000	<0.005	0.0670	<1	5.4	171
GW1	28/03/2018	5560/1	42	2.00	5.00	1.70	0.031	45	29.0	23.000	0.030	0.0430	<1	5.4	176
GW1	23/04/2018	5711/1	41	1.70	4.70	1.70	0.016	42	27.0	11.000	<0.005	0.0380	<1	5.5	161
GW1	21/05/2018	5858/1	35	1.70	3.80	1.90	0.042	44	26.0	11.000	<0.005	0.0370	<1	5.5	154
GW1	20/06/2018	6009/1	34	1.10	3.50	1.40	0.038	37	26.0	11.000	<0.005	0.0580	<1	5.5	129
MW X1	17/07/2017	4569/1	65	2.00	8.00	4.00	-	-	-	-	-	-	-	-	232
MW X1	11/10/2017	4910/4	76	2.00	10.00	4.00	0.270	120	21.0	7.320	<0.005	0.1530	<1	-	-
MW X1	7/11/2017	7998/4	73	2.10	9.40	3.90	0.270	130	26.0	6.100	<0.005	0.0153	<1	5.2	339
MW X1	7/12/2017	5113/4	90	2.80	15.00	4.50	0.260	160	25.0	6.000	<0.005	0.0050	<1	4.9	391
MW X1	30/01/2018	5322/4	89	2.80	12.00	3.70	0.190	130	25.0	5.000	<0.005	0.0850	<1	4.8	315
MW X1	1/03/2018	5425/4	62	2.90	9.80	3.90	0.270	120	25.0	10.000	<0.005	0.0540	<1	5.1	297
MW X1	29/03/2018	5561/4	75	2.40	9.00	3.50	0.270	110	22.0	19.000	<0.005	0.0450	<1	5.1	297
MW X1	24/04/2018	5715/4	81	2.30	9.00	3.00	0.180	110	22.0	7.000	<0.005	0.0440	<1	4.8	303
MW X1	22/05/2018	5859/4	82	2.20	8.80	2.80	0.150	120	24.0	6.000	<0.005	0.0410	<1	4.9	309
MW X1	21/06/2018	6010/4	80	2.40	9.60	2.90	0.170	130	28.0	6.000	<0.005	0.0550	<1	5	297
MW X2	17/07/2017	4569/2	53	5.00	5.00	3.00	-	-	-	-	-	-	-	-	178
MW X2	11/10/2017	4910/5	52	4.00	6.00	3.00	0.110	92	4.0	14.640	<0.005	0.0306	<1	-	-
MW X2	7/11/2017	4998/5	53	3.40	5.10	2.80	0.110	93	7.0	13.420	<0.005	0.0153	<1	5.3	351
MW X2	7/12/2017	5113/5	54	3.30	5.50	3.00	0.100	91	7.0	12.000	0.009	0.0050	<1	5.4	225
MW X2	30/01/2018	5322/5	54	3.00	5.40	3.10	0.110	85	6.0	11.000	<0.005	0.0630	<1	5.3	171
MW X2	1/03/2018	5425/5	39	2.70	4.40	2.80	0.110	73	7.0	16.000	<0.005	0.0420	<1	5.5	158
MW X2	29/03/2018	5561/5	46	2.30	4.10	2.40	0.110	66	7.0	25.000	<0.005	0.0430	<1	5.4	166
MW X2	24/04/2018	5715/5	44	2.10	3.80	2.40	0.099	60	7.0	13.000	<0.005	0.0340	<1	5.3	158
MW X2	22/05/2018	5859/5	46	2.00	3.80	2.40	0.100	64	9.0	13.000	<0.005	0.0330	<1	5.4	184
MW X2	21/06/2018	6010/5	53	2.70	5.10	2.80	0.110	89	11.0	11.000	<0.005	0.0440	<1	5.4	212
MW X3 Shallow	17/07/2017	4569/3	39	1.00	3.00	3.00	-	-	-	-	-	-	-	-	114
MW X3 Shallow	11/10/2017	4910/6	36	2.00	3.00	2.00	0.034	45	18.0	19.520	0.062	0.1836	<1	-	-
MW X3 Shallow	7/11/2017	4998/6	34	1.10	4.00	2.70	0.035	51	17.0	12.200	0.020	0.0153	<1	5.3	152
MW X3 Shallow	7/12/2017	5113/6	34	2.20	4.70	2.90	0.015	47	19.0	14.000	0.075	0.0050	<1	5.6	147
MW X3 Shallow	30/01/2018	5322/6	38	1.30	4.70	3.10	0.038	52	18.0	7.000	0.010	0.0590	<1	5.2	134
MW X3 Shallow	1/03/2018	5425/6	31	1.30	4.40	3.10	0.073	54	15.0	12.000	0.005	0.0390	<1	5.3	182
MW X3 Shallow	13/03/18	-	38	3.00	4.50	4.40	<0.1	58	19.0	9.000	<0.1	<0.1	<1	5.6	135
MW X3 Shallow	29/03/2018	5561/6	41	1.70	4.40	2.90	0.053	52	17.0	21.000	0.040	0.0370	<1	5.3	148
MW X3 Shallow	24/04/2018	5715/6	40	1.20	4.20	3.10	0.051	51	15.0	8.000	0.065	0.0340	<1	5.3	158
MW X3 Shallow	22/05/2018	5859/6	44	1.20	4.10	3.20	0.050	55	20.0	8.000	0.130	0.0270	<1	5.4	139
MW X3 Shallow	21/06/2018	6010/6	43	1.00	4.70	3.30	0.080	64	18.0	7.000	0.040	0.0420	<1	5.3	169
MW X3 Deep	17/07/2017	4569/4	41	70.00	4.00	2.00	-	-	-	-	-	-	-	-	350
MW X3 Deep	11/10/2017	4910/7	39	74.00	5.00	2.00	0.400	61	<1	231.800	<0.005	0.1530	<1	-	-
MW X3 Deep	7/11/2017	4998/7	38	66.00	3.90	2.10	0.130	40	14.0	183.000	0.120	0.0580	<1	7.1	306
MW X3 Deep	7/12/2017	5113/7	38	72.00	4.40	2.20	0.340	57	1.0	190.000	<0.005	0.0500	<1	7.7	341
MW X3 Deep	30/01/2018	5322/7	41	74.00	4.60	2.40	0.370	59	<1	200.000	<0.005	0.1700	<1	7.4	323
MW X3 Deep	1/03/2018	5425/7	33	73.00	4.30	2.30	0.330	55	5.0	190.000	0.030	0.0820	<1	7.3	341
MW X3 Deep	13/03/18	-	26	75.00	4.70	3.70	0.400	60	2.0	215.000	<0.1	<0.1	<1	6.9	285
MW X3 Deep	29/03/2018	5561/7	41	68.00	4.10	2.10	0.380	54	2.0	200.000	<0.005	0.0850	<1	7.5	331
MW X3 Deep	24/04/2018	5715/7	42	68.00	4.10	2.10	0.390	53	1.0	190.000	<0.005	0.0890	<1	7.6	355
MW X3 Deep	22/05/2018	5859/7	42	64.00	3.90	2.10	0.370	57	<1	180.000	<0.005	0.0890	<1	7.6	344
MW X3 Deep	21/06/2018	6010/7	42	70.00	4.10	2.10	0.380	65	<1	190.000	<0.005	0.0960	<1	7.4	333
MW X4 Shallow	17/07/2017	4569/5	19	3.00	3.00	2.00	-	-	-	-	-	-	-	-	93
MW X4 Shallow	11/10/2017	4910/8	17	3.00	2.00	2.00	0.083	24	13.0	61.000	<0.005	0.3366	<1	-	-
MW X4 Shallow	7/11/2017	4998/8	14	3.10	2.00	1.20	<0.005	28	7.0	13.420	0.057	0.0306	<1	5.4	87
MW X4 Shallow	7/12/2017	5113/8	18	6.40	3.50	1.60	<0.005	28	10.0	21.000	0.110	0.0090	<1	6.2	113
MW X4 Shallow	30/01/2018	5322/8	19	2.10	3.10	1.70	0.005	33	8.0	7.000	0.075	0.0560	<1	5.7	84
MW X4 Shallow	1/03/2018	5425/8	17	1.80	3.00	1.50	<0.005	30	8.0	11.000	0.059	0.0320	<1	5.6	73
MW X4 Shallow	29/03/2018	5561/8	14	1.40	2.60	1.20	0.008	22	6.0	21.000	0.099	0.0350	<1	5.8	66
MW X4 Shallow	24/04/2018	5715/8	24	7.80	6.80	1.60	0.005	31	15.0	34.000	0.250	0.0310	<1	6.3	144
MW X4 Shallow	22/05/2018	5859/8	23	9.80	4.90	1.80	<0.005	30	15.0	37.000	0.230	0.0290	<1	6.3	141
MW X4 Shallow	21/06/2018	6010/8	14	6.10	3.30	1.20	0.025	24	10.0	21.000	0.200	0.0400	<1	6.2	88
MW X4 Deep	17/07/2017	4569/6	66	67.00	8.00	3.00	-	-	-	-	-	-	-	-	388
MW X4 Deep	11/10/2017	4910/9	61	72.00	8.00	3.00	0.049	45	28.0	292.800	<0.005	0.0612	<1	-	-

Criteria														
			Na	Ca	Mg	K	NH_4	Cl	SO_4	HCO_3	NO_3	PO_4	F	pH	TDS[2]
Drinking water - Health[3]			180*	-	-	-	0.5*	250*	500	-	50	-	1.5	-	600*
Recreation[4]			-	-	-	-	-	-	5000	-	500	-	15	6.5 -8.5	-
Ecological (fresh)[5]			-	-	-	-	0.9[A]	-	-	-	10.6^	-	-	-	-
Ecological (marine)[5]			-	-	-	-	0.91[A]	-	-	-		-	-	-	-
Livestock[4]			-	600	600	-	-	-	1000	-	400	-	2	-	4000
Irrigation[4]			115-460	-	-	-	5	175-700	-	-	20	-	1	6.0 -8.5	1500
		Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	-	mg/L
Sample	Date	Lab ID													
MW X4 Deep	7/11/2017	4998/9	64	68.00	7.30	3.30	0.063	46	28.0	293.000	<0.005	0.0796	<1	7	356
MW X4 Deep	7/12/2017	5113/9	62	72.00	8.00	3.40	0.055	44	26.0	250.000	<0.005	0.0220	<1	7.7	391
MW X4 Deep	30/01/2018	5322/9	68	74.00	8.50	3.60	0.059	45	26.0	250.000	<0.005	0.0980	<1	7.6	364
MW X4 Deep	1/03/2018	5425/9	52	70.00	8.10	3.30	0.063	45	24.0	250.000	<0.005	0.0780	<1	7.7	375
MW X4 Deep	29/03/2018	5561/9	65	65.00	8.10	3.30	0.087	43	22.0	250.000	<0.005	0.0670	<1	7.8	375
MW X4 Deep	24/04/2018	5715/9	65	66.00	7.60	3.20	0.060	41	21.0	230.000	0.008	0.0550	<1	7.7	370
MW X4 Deep	22/05/2018	5859/9	67	63.00	7.50	3.20	0.069	45	23.0	240.000	<0.005	0.0500	<1	7.7	392
MW X4 Deep	21/06/2018	6010/9	67	67.00	8.50	3.30	0.096	51	28.0	240.000	<0.005	0.0570	<1	7.6	377
MW X5	17/07/2017	4569/7	52	69.00	6.00	3.00	-	-	-	-	-	-	-	-	341
MW X5	11/10/2017	4910/10	47	72.00	6.00	3.00	0.340	79	<1	231.800	<0.005	0.1224	<1	-	-
MW X5	7/11/2017	4998/10	49	69.00	5.30	2.70	0.360	78	<1	231.800	<0.005	0.0029	<1	7.4	351
MW X5	7/12/2017	5113/10	48	71.00	5.80	2.70	0.320	72	<1	200.000	<0.005	0.0080	<1	7.7	348
MW X5	30/01/2018	5322/10	52	73.00	6.10	3.00	0.320	76	<1	200.000	<0.005	0.0780	<1	7.5	362
MW X5	1/03/2018	5425/10	40	71.00	5.80	2.70	0.330	75	<1	200.000	<0.005	0.0620	<1	7.7	373
MW X5	29/03/2018	5561/10	51	68.00	5.60	2.50	0.330	70	<1	210.000	<0.005	0.0820	<1	7.7	375
MW X5	24/04/2018	5715/10	52	69.00	5.70	2.70	0.340	67	<1	200.000	<0.005	0.0560	<1	7.7	364
MW X5	22/05/2018	5859/10	52	64.00	5.50	2.70	0.310	71	<1	200.000	<0.005	0.0750	<1	7.6	368
MW X5	21/06/2018	6010/10	55	71.00	6.00	2.60	0.300	68	8.0	220.000	<0.005	0.0480	<1	7.3	365
MW X6	17/07/2017	4569/8	77	84.00	7.00	4.00	-	-	-	-	-	-	-	-	467
MW X6	11/10/2017	4910/11	69	89.00	8.00	4.00	0.420	130	<1	244.000	<0.005	0.1224	<1	-	-
MW X6	7/11/2017	4998/11	71	80.00	6.90	3.50	0.420	130	<1	266.200	0.005	0.0796	<1	7.1	483
MW X6	7/12/2017	5113/11	74	85.00	8.00	4.00	0.440	120	<1	210.000	<0.005	0.0050	<1	7.5	490
MW X6	30/01/2018	5322/11	82	90.00	8.30	4.30	0.410	130	<1	220.000	<0.005	0.0800	<1	7.5	497
MW X6	1/03/2018	5425/11	58	85.00	7.40	3.70	0.390	120	<1	220.000	<0.005	0.0680	<1	7.5	463
MW X6	29/03/2018	5561/11	77	84.00	7.50	3.70	0.410	120	<1	230.000	<0.005	0.0600	<1	7.5	524
MW X6	24/04/2018	5715/11	79	84.00	7.30	3.80	0.410	120	<1	220.000	<0.005	0.0610	<1	7.5	505
MW X6	22/05/2018	5859/11	78	78.00	7.20	3.70	0.390	120	3.0	210.000	<0.005	0.0510	<1	7.5	496
MW X6	21/06/2018	6010/11	78	85.00	7.40	3.60	0.370	120	10.0	230.000	<0.005	0.0650	<1	7.2	491

Note(s): 1. all table entries in mg/L other than pH (field measurement)

2. TDS total dissolved salts; Na sodium; Ca calcium; Mg magnesium; K potassium; NH_4 ammonium; Cl chloride; SO_4 sulfate; HCO_3 bicarbonate (alkalinity); NO_3 nitrate; PO_4 phosphate; F , fluoride.

3. Health – Australian Drinking Water Guidelines (ADWG, 2011)

4. Recreational and primary industries water quality - ANZECC (2000)

5. 95% species protection – ANZECC / ARMCANZ (2000)

Table 17 DATA SUMMARY TABLE - DISSOLVED METALS IN GROUNDWATER

Criteria			Al	As	B	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Se	Zn	Hg
Drinking water - Health[2]			-	0.01	4	0.002	0.05	2	-	0.5	0.02	0.01	0.01	-	3
Recreation[3]			0.2	0.05	1	0.005		1	0.3	0.1	0.1	0.05		5	0.001
Ecological (fresh)[4]			0.055	0.024	0.37	0.0002	0.001	0.0055	-	1.9	0.011	0.0034	0.011	0.031	0.0006
Ecological (marine)[4]			-	-	-	0.0055	0.0044	0.0013	-	-	0.07	0.0044	-	0.015	0.0004
Livestock[3]			5	0.5	5	0.01	1	0.4	-	-	1	0.1	0.02	20	0.002
Irrigation[3]				0.1	0.5		0.1	0.2	0.2	0.2	0.2	2		2	
		Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Sample	Date	Lab ID													
GW1	13/10/2017	4911/1	0.07	0.003	0.1	<0.001	<0.001	<0.001	0.34	0.001	<0.001	<0.001	<0.001	0.021	<0.00005
GW1	21/11/2017	4999/1	0.07	0.002	0.07	<0.001	<0.001	<0.001	0.03	0.005	<0.001	<0.001	<0.001	0.019	<0.00005
GW1	6/12/2017	5112/1	0.1	0.003	0.03	<0.001	<0.001	<0.001	0.37	0.005	<0.001	<0.001	<0.001	0.005	<0.00005
GW1	29/01/2018	5321/1	0.11	0.005	0.1	<0.001	<0.001	<0.001	0.51	0.005	0.001	<0.001	<0.001	0.035	<0.00005
GW1	28/02/2018	5424/1	0.16	0.006	0.09	<0.001	<0.001	<0.001	0.41	0.005	<0.001	0.002	<0.001	0.029	<0.00005
GW1	28/03/2018	5560/1	0.12	0.005	0.2	<0.001	<0.001	<0.001	0.53	0.008	<0.001	<0.001	<0.001	0.047	<0.00005
GW1	23/04/2018	5711/1	0.1	0.005	0.1	<0.001	<0.001	<0.001	0.45	0.005	0.001	<0.001	<0.001	0.025	<0.00005
GW1	21/05/2018	5858/1	0.12	0.004	0.1	<0.001	<0.001	<0.001	0.4	0.005	0.001	<0.001	<0.001	0.035	<0.00005
GW1	20/06/2018	6009/1	0.23	0.006	0.1	<0.001	<0.001	<0.001	0.29	0.005	<0.001	<0.001	<0.001	0.036	<0.00005
MW_X1	17/07/2017	4569/1	0.71	<0.001	0.03	<0.001	<0.001	<0.001	0.18	-	<0.001	<0.001	<0.001	0.005	<0.00005
MW_X1	13/10/2017	4910/4	0.73	<0.001	0.03	<0.001	<0.001	<0.001	1.1	0.018	0.003	<0.001	<0.001	0.006	<0.00005
MW_X1	7/11/2017	7998/4	0.67	<0.001	0.06	<0.001	<0.001	<0.001	1.2	0.021	<0.001	<0.001	<0.001	0.013	<0.00005
MW X1	7/12/2017	5113/4	0.86	<0.001	0.04	<0.001	<0.001	<0.001	1.7	0.022	<0.001	<0.001	<0.001	0.012	<0.00005
MW X1	30/01/2018	5322/4	0.84	<0.001	0.04	<0.001	<0.001	<0.001	1.2	0.016	<0.001	<0.001	<0.001	0.021	<0.00005
MW X1	1/03/2018	5425/4	0.72	<0.001	0.07	<0.001	<0.001	0.002	1.2	0.034	<0.001	<0.001	<0.001	0.025	<0.00005
MW X1	29/03/2018	5561/4	0.7	<0.001	0.1	<0.001	<0.001	<0.001	1.3	0.029	<0.001	<0.001	<0.001	0.021	<0.00005
MW X1	24/04/2018	5715/4	0.76	<0.001	0.09	<0.001	<0.001	<0.001	1.1	0.017	<0.001	<0.001	<0.001	0.01	<0.00005
MW X1	22/05/2018	5859/4	0.71	<0.001	0.08	<0.001	<0.001	<0.001	0.91	0.012	<0.001	<0.001	<0.001	0.016	<0.00005
MW X1	21/06/2018	6010/4	0.6	<0.001	0.09	<0.001	<0.001	<0.001	1	0.02	<0.001	<0.001	<0.001	0.017	<0.00005
MW_X2	17/07/2017	4569/2	0.07	0.006	0.03	<0.001	<0.001	<0.001	0.57	-	<0.001	<0.001	<0.001	0.006	<0.00005
MW_X2	13/10/2017	4910/5	0.09	<0.001	0.03	<0.001	<0.001	<0.001	0.44	0.02	<0.001	<0.001	<0.001	0.004	<0.00005
MW_X2	7/11/2017	4998/5	0.08	<0.001	0.06	<0.001	<0.001	<0.001	0.47	0.021	0.002	<0.001	<0.001	0.018	<0.00005
MW X2	7/12/2017	5113/5	0.09	<0.001	0.03	<0.001	<0.001	<0.001	0.51	0.017	0.002	<0.001	<0.001	0.008	<0.00005
MW X2	30/01/2018	5322/5	0.08	<0.001	0.03	<0.001	<0.001	0.001	0.43	0.014	<0.001	<0.001	<0.001	0.017	<0.00005
MW X2	1/03/2018	5425/5	0.08	<0.001	0.08	<0.001	<0.001	<0.001	0.52	0.019	<0.001	<0.001	<0.001	0.037	<0.00005
MW X2	29/03/2018	5561/5	0.08	<0.001	0.07	<0.001	<0.001	<0.001	<0.01	0.016	<0.001	<0.001	<0.001	0.029	<0.00005
MW X2	24/04/2018	5715/5	0.08	<0.001	0.09	<0.001	<0.001	<0.001	0.41	0.013	<0.001	<0.001	<0.001	0.024	<0.00005
MW X2	22/05/2018	5859/5	0.08	<0.001	0.08	<0.001	<0.001	<0.001	0.4	0.012	<0.001	<0.001	<0.001	0.023	<0.00005
MW X2	21/06/2018	6010/5	0.06	<0.001	0.07	<0.001	<0.001	<0.001	0.46	0.014	<0.001	<0.001	<0.001	0.022	<0.00005
MW_X3 Deep	17/07/2017	4569/3	0.02	0.001	0.02	<0.001	<0.001	<0.001	3.5		<0.001	<0.001	<0.001	0.005	<0.00005
MW_X3 Deep	13/10/2017	4910/6	0.01	<0.001	<0.00	<0.001	<0.001	<0.001	3.8	0.034	<0.001	<0.001	<0.001	0.002	<0.00005
MW_X3 Deep	7/11/2017	4998/6	0.02	<0.001	0.09	<0.001	<0.001	0.011	3.3	0.03	0.004	<0.001	<0.001	0.044	<0.00005
MW X3 Deep	7/12/2017	5113/6	0.01	<0.001	<0.001	<0.001	<0.001	0.003	4.2	0.036	<0.001	<0.001	<0.001	0.005	<0.00005
MW X3 Deep	30/01/2018	5322/6	0.01	<0.001	0.02	<0.001	<0.001	<0.001	4	0.033	<0.001	<0.001	<0.001	0.006	<0.00005
MW X3 Deep	1/03/2018	5425/6	0.02	<0.001	0.06	<0.001	<0.001	<0.001	4.1	0.038	<0.001	<0.001	<0.001	0.022	<0.00005
MW X3 Deep	13/03/18	-	<0.1	<0.01	-	<0.0002	<0.01	<0.001	3.4	0.04	-	<0.001	<0.001	0.002	<0.00005
MW X3 Deep	29/03/2018	5561/6	0.02	<0.001	0.07	<0.001	<0.001	<0.001	3.5	0.033	<0.001	<0.001	<0.001	0.032	<0.00005
MW X3 Deep	24/04/2018	5715/6	0.01	<0.001	0.07	<0.001	<0.001	<0.001	3.8	0.035	<0.001	<0.001	<0.001	0.022	<0.00005
MW X3 Deep	22/05/2018	5859/6	0.02	<0.001	0.05	<0.001	<0.001	<0.001	3.8	0.034	<0.001	<0.001	<0.001	0.03	<0.00005
MW X3 Deep	21/06/2018	6010/6	0.02	<0.001	0.05	<0.001	<0.001	<0.001	3.4	0.033	<0.001	<0.001	<0.001	0.015	<0.00005
MW_X3 Shallow	17/07/2017	4569/4	0.27	0.002	0.03	<0.001	<0.001	<0.001	0.41		<0.001	<0.001	<0.001	0.006	<0.00005
MW_X3 Shallow	13/10/2017	4910/7	0.35	0.002	0.02	<0.001	<0.001	0.005	0.33	0.014	<0.001	<0.001	<0.001	0.004	<0.00005
MW_X3 Shallow	7/11/2017	4998/7	0.2	0.001	0.08	<0.001	<0.001	<0.001	0.31	0.016	<0.001	<0.001	<0.001	0.031	<0.00005
MW X3 Shallow	7/12/2017	5113/7	0.22	0.001	0.02	<0.001	<0.001	0.003	0.26	0.016	<0.001	<0.001	<0.001	0.015	<0.00005
MW X3 Shallow	30/01/2018	5322/7	0.24	0.002	0.03	<0.001	<0.001	0.002	0.42	0.011	<0.001	<0.001	<0.001	0.024	<0.00005
MW X3 Shallow	1/03/2018	5425/7	0.28	0.003	0.08	<0.001	<0.001	<0.001	0.6	0.015	<0.001	<0.001	<0.001	0.031	<0.00005
MW X3 Shallow	13/03/18	-	<0.1	<0.01	-	<0.0002	<0.01	<0.001	0.48	0.01	-	<0.001	<0.001	0.004	<0.00005
MW X3 Shallow	29/03/2018	5561/7	0.25	0.001	0.1	<0.001	<0.001	<0.001	0.24	0.013	<0.001	<0.001	<0.001	0.045	<0.00005
MW X3 Shallow	24/04/2018	5715/7	0.22	0.001	0.07	<0.001	<0.001	<0.001	0.26	0.01	<0.001	<0.001	<0.001	0.017	<0.00005
MW X3 Shallow	22/05/2018	5859/7	0.19	0.001	0.07	<0.001	<0.001	<0.001	0.22	0.012	<0.001	<0.001	<0.001	0.038	<0.00005
MW X3 Shallow	21/06/2018	6010/7	0.19	0.001	0.07	<0.001	<0.001	<0.001	0.3	0.012	<0.001	<0.001	<0.001	0.051	<0.00005
MW_X4 Deep	17/07/2017	4569/5	0.02	0.004	0.06	<0.001	<0.001	<0.001	0.17	-	<0.001	<0.001	<0.001	0.003	<0.00005
MW_X4 Deep	13/10/2017	4910/8	0.02	0.003	0.05	<0.001	<0.001	<0.001	0.21	0.017	<0.001	<0.001	<0.001	0.001	<0.00005
MW_X4 Deep	7/11/2017	4998/8	0.01	0.003	0.08	<0.001	<0.001	<0.001	0.22	0.018	<0.001	<0.001	<0.001	0.01	<0.00005
MW X4 Deep	7/12/2017	5113/8	0.02	0.003	0.06	<0.001	<0.001	<0.001	0.24	0.016	<0.001	<0.001	<0.001	0.001	<0.00005
MW X4 Deep	30/01/2018	5322/8	0.02	0.003	0.06	<0.001	<0.001	<0.001	0.24	0.015	<0.001	<0.001	<0.001	0.003	<0.00005
MW X4 Deep	1/03/2018	5425/8	0.02	0.004	0.09	<0.001	<0.001	<0.001	0.3	0.019	<0.001	<0.001	<0.001	0.019	<0.00005
MW X4 Deep	29/03/2018	5561/8	0.01	0.004	0.1	<0.001	<0.001	<0.001	0.33	0.022	<0.001	<0.001	<0.001	0.018	<0.00005
MW X4 Deep	24/04/2018	5715/8	0.01	0.004	0.1	<0.001	<0.001	<0.001	0.43	0.022	0.003	<0.001	<0.001	0.019	<0.00005
MW X4 Deep	22/05/2018	5859/8	0.01	0.004	0.08	<0.001	<0.001	<0.001	0.5	0.024	<0.001	<0.001	<0.001	0.019	<0.00005
MW X4 Deep	21/06/2018	6010/8	0.01	0.004	0.09	<0.001	<0.001	<0.001	0.53	0.033	<0.001	<0.001	<0.001	0.024	<0.00005
MW_X4 Shallow	17/07/2017	4569/6	0.02	<0.001	<0.02	<0.001	<0.001	<0.001	0.03	-	<0.001	<0.001	<0.001	0.008	<0.00005
MW_X4 Shallow	13/10/2017	4910/9	0.02	<0.001	<0.00	<0.001	<0.001	0.003	0.06	0.001	<0.001	<0.001	<0.001	0.004	<0.00005

Criteria														
			Al	As	B	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Se	Zn	Hg
Drinking water - Health[2]			-	0.01	4	0.002	0.05	2	-	0.5	0.02	0.01	0.01	-	3
Recreation[3]			0.2	0.05	1	0.005		1	0.3	0.1	0.1	0.05		5	0.001
Ecological (fresh)[4]			0.055	0.024	0.37	0.0002	0.001	0.0014	-	1.9	0.011	0.026	0.011	0.008	0.0006
Ecological (marine)[4]			-	-	-	0.0055	0.0044	0.0013	-	-	0.07	0.0044	-	0.015	0.0004
Livestock[3]			5	0.5	5	0.01	1	0.4	-	-	1	0.1	0.02	20	0.002
Irrigation[3]				0.1	0.5		0.1	0.2	0.2	0.2	0.2	2		2	
		Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Sample	Date	Lab ID													
MW_X4 Shallow	7/11/2017	4998/9	0.01	<0.001	0.06	<0.001	<0.001	0.004	0.02	0.005	<0.001	<0.001	<0.001	0.025	<0.00005
MW X4 Shallow	7/12/2017	5113/9	0.02	<0.001	<0.001	<0.001	<0.001	0.001	0.05	0.005	<0.001	<0.001	<0.001	0.005	<0.00005
MW X4 Shallow	30/01/2018	5322/9	0.02	<0.001	<0.02	<0.001	<0.001	0.002	0.03	0.005	<0.001	<0.001	<0.001	0.01	<0.00005
MW X4 Shallow	1/03/2018	5425/9	0.02	<0.001	0.06	<0.001	<0.001	0.004	0.03	0.005	<0.001	<0.001	<0.001	0.036	<0.00005
MW X4 Shallow	29/03/2018	5561/9	0.02	<0.001	0.09	<0.001	<0.001	0.002	0.03	0.005	<0.001	<0.001	<0.001	0.031	<0.00005
MW X4 Shallow	24/04/2018	5715/9	0.01	<0.001	0.08	<0.001	<0.001	0.006	0.01	0.005	<0.001	<0.001	<0.001	0.023	<0.00005
MW X4 Shallow	22/05/2018	5859/9	0.02	<0.001	0.06	<0.001	<0.001	0.007	0.01	0.005	<0.001	<0.001	<0.001	0.024	<0.00005
MW X4 Shallow	21/06/2018	6010/9	0.02	<0.001	0.06	<0.001	<0.001	0.004	0.02	0.005	<0.001	<0.001	<0.001	0.024	<0.00005
MW_X5	17/07/2017	4569/7	0.02	0.004	0.03	<0.001	<0.001	<0.001	0.72	-	<0.001	<0.001	<0.001	0.003	<0.00005
MW_X5	13/10/2017	4910/10	0.02	0.004	0.02	<0.001	<0.001	0.036	0.71	0.05	0.002	0.004	<0.001	0.026	<0.00005
MW_X5	7/11/2017	4998/10	0.02	0.004	0.09	<0.001	<0.001	<0.001	1.1	0.048	<0.001	0.001	<0.001	0.037	<0.00005
MW X5	7/12/2017	5113/10	0.01	0.004	0.03	<0.001	<0.001	<0.001	1.3	0.048	<0.001	<0.001	<0.001	0.002	<0.00005
MW X5	30/01/2018	5322/10	0.02	0.004	0.03	<0.001	<0.001	<0.001	1.2	0.051	<0.001	<0.001	<0.001	0.004	<0.00005
MW X5	1/03/2018	5425/10	0.02	0.004	0.07	<0.001	<0.001	<0.001	1.3	0.059	<0.001	<0.001	<0.001	0.024	<0.00005
MW X5	29/03/2018	5561/10	0.01	0.004	0.05	<0.001	<0.001	<0.001	1.1	0.044	<0.001	<0.001	<0.001	0.018	<0.00005
MW X5	24/04/2018	5715/10	0.01	0.004	0.07	<0.001	<0.001	<0.001	1.1	0.046	<0.001	<0.001	<0.001	0.018	<0.00005
MW X5	22/05/2018	5859/10	0.01	0.003	0.06	<0.001	<0.001	<0.001	1	0.045	<0.001	<0.001	<0.001	0.022	<0.00005
MW X5	21/06/2018	6010/10	0.02	0.003	0.1	<0.001	<0.001	<0.001	0.98	0.041	<0.001	<0.001	<0.001	0.027	<0.00005
MW_X6	17/07/2017	4569/8	<0.01	0.022	0.03	<0.001	<0.001	<0.001	3.1	-	<0.001	<0.001	<0.001	0.002	<0.00005
MW_X6	13/10/2017	4910/11	<0.01	0.022	0.02	<0.001	<0.001	<0.001	2.7	0.34	<0.001	<0.001	<0.001	0.002	<0.00005
MW_X6	7/11/2017	4998/11	<0.01	0.022	0.06	<0.001	<0.001	<0.001	2.9	0.35	<0.001	<0.001	<0.001	0.017	<0.00005
MW X6	7/12/2017	5113/11	<0.01	0.022	0.03	<0.001	<0.001	<0.001	3.8	0.39	<0.001	<0.001	<0.001	0.003	<0.00005
MW X6	30/01/2018	5322/11	0.01	0.02	0.03	<0.001	<0.001	<0.001	3.9	0.39	<0.001	<0.001	<0.001	0.006	<0.00005
MW X6	1/03/2018	5425/11	<0.01	0.023	0.02	<0.001	<0.001	<0.001	3.4	0.43	<0.001	<0.001	<0.001	0.004	<0.00005
MW X6	29/03/2018	5561/11	<0.01	0.026	0.06	<0.001	<0.001	<0.001	3	0.38	<0.001	<0.001	<0.001	0.022	<0.00005
MW X6	24/04/2018	5715/11	<0.01	0.026	0.06	<0.001	<0.001	<0.001	3	0.37	<0.001	<0.001	<0.001	0.017	<0.00005
MW X6	22/05/2018	5859/11	<0.01	0.024	0.07	<0.001	<0.001	<0.001	2.8	0.34	<0.001	<0.001	<0.001	0.023	<0.00005
MW X6	21/06/2018	6010/11	<0.01	0.023	0.07	<0.001	<0.001	<0.001	2.7	0.37	<0.001	<0.001	<0.001	0.02	<0.00005

Note(s):
1. all table entries in mg/L other than pH (field measurement)
2. Health – Australian Drinking Water Guidelines (ADWG, 2011)
3. Recreational and primary industries water quality - ANZECC (2000)
4. 95% species protection – ANZECC / ARMCANZ (2000)

Table 18 DATA SUMMARY TABLE - PFAS IN GROUNDWATER

Criteria						
		PFHxS	PFOS	PFOA	6:2 Fluorotelomer sulfonate	8:2 Fluorotelomer sulfonate
Tolerable Daily Intake (TDI)[2] [ug/kg_{bw}/d]		0.02	0.02	0.16	-	-
Drinking water - Health[2]		0.07	0.07	0.56	-	-
Recreational water[2]		0.7	0.7	5.6	-	-
Freshwater[3]		-	0.13	220	-	-
Interim marine[3]		-	0.13	220	-	-
	Units	ug/L	mg/L	mg/L	mg/L	mg/L
Sample	Date					
GW2	1/10/2015	-	<0.02	<0.02	<0.1	<0.1
GW4	1/03/2018	<0.01	<0.01	<0.01	<0.01	<0.01
GW4	1/03/2018	<0.01	<0.01	<0.01	<0.01	<0.01
GW4	29/03/2018	<0.01	<0.01	<0.01	<0.01	<0.01
GW4	24/04/2018	<0.01	<0.01	<0.01	<0.01	<0.01
GW4	22/05/2018	<0.01	<0.01	<0.01	<0.01	<0.01
GW4	21/06/2018	<0.01	<0.01	<0.01	<0.01	<0.01
MW X1	1/03/2018	<0.01	<0.01	<0.01	<0.01	<0.01
MW X1	1/03/2018	<0.01	<0.01	<0.01	<0.01	<0.01
MW X1	29/03/2018	<0.01	<0.01	<0.01	<0.01	<0.01
MW X1	24/04/2018	<0.01	<0.01	<0.01	<0.01	<0.01
MW X1	22/05/2018	<0.01	<0.01	<0.01	<0.01	<0.01
MW X1	21/06/2018	<0.01	<0.01	<0.01	<0.01	<0.01
MW X2	1/03/2018	<0.01	<0.01	<0.01	<0.01	<0.01
MW X2	1/03/2018	<0.01	<0.01	<0.01	<0.01	<0.01
MW X2	29/03/2018	<0.01	<0.01	<0.01	<0.01	<0.01
MW X2	24/04/2018	<0.01	<0.01	<0.01	<0.01	<0.01
MW X2	22/05/2018	<0.01	<0.01	<0.01	<0.01	<0.01
MW X2	21/06/2018	<0.01	<0.01	<0.01	<0.01	<0.01
MW X7	29/03/2018	<0.01	<0.01	<0.01	<0.01	<0.01
MW X7	24/04/2018	<0.01	<0.01	<0.01	<0.01	<0.01
MW X7	22/05/2018	<0.01	<0.01	<0.01	<0.01	<0.01
MW X7	21/06/2018	<0.01	<0.01	<0.01	<0.01	<0.01

Note(s): 1. all table entries in ug/L

2. Health based guidance values – Table 1 NEMP (2018)

3. 95% species protection (slightly to moderately disturbed systems)– Table 5 NEMP (2018)

APPENDIX A: CHARTS

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Chart 2 - Schoeller Diagram GW1

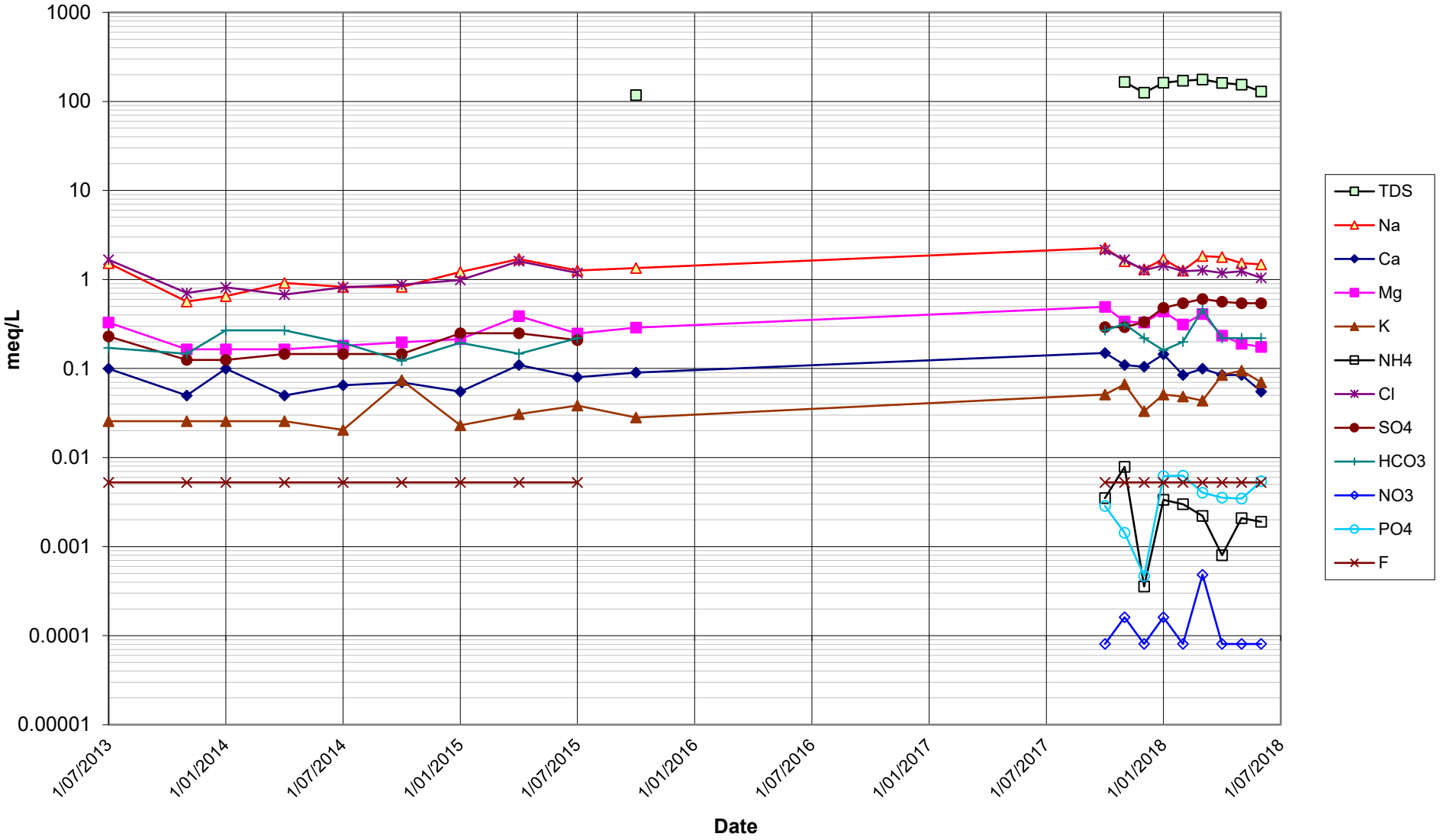


Chart 2

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Chart 3 - Schoeller Diagram MWx1

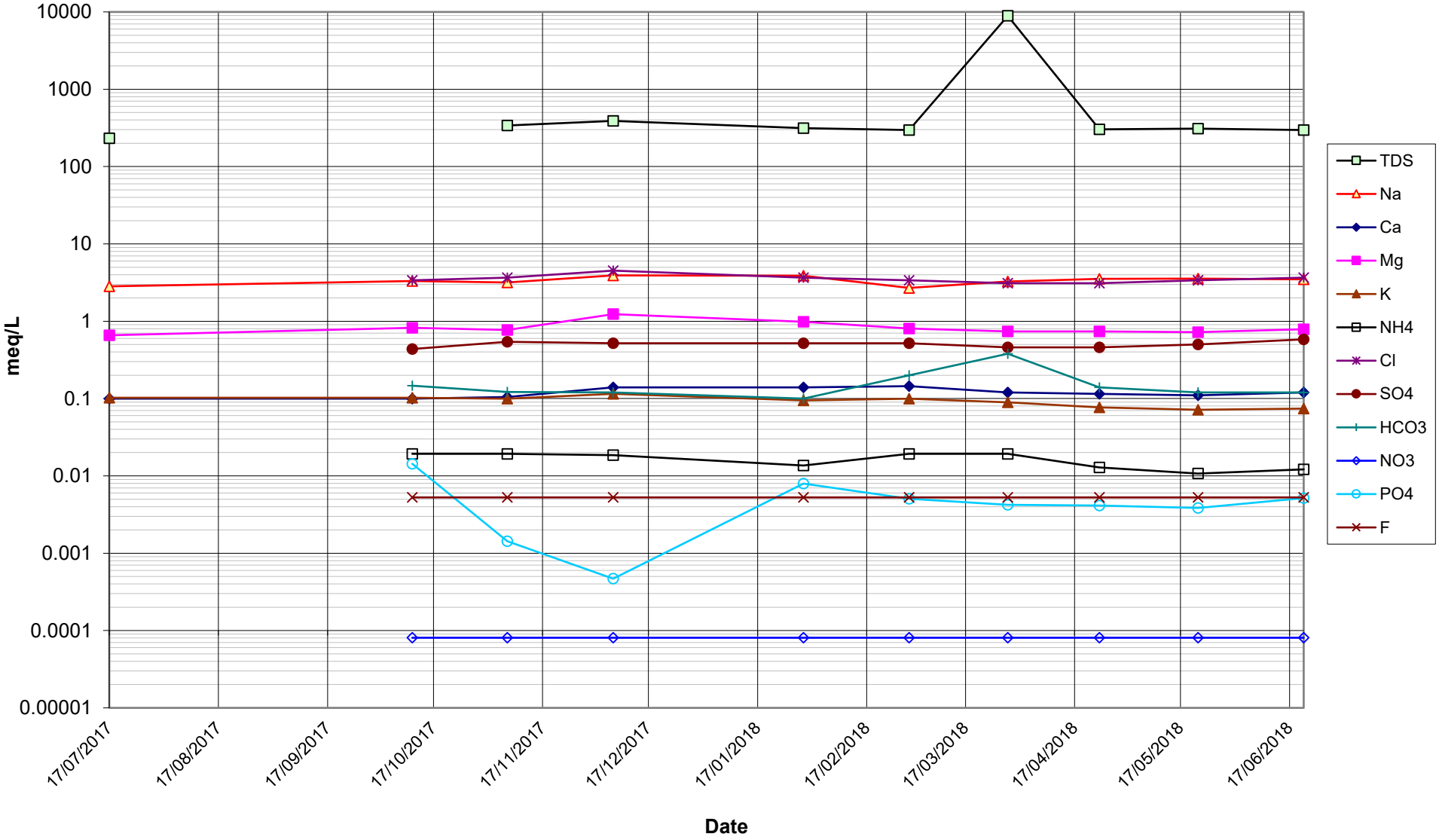


Chart 3

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Chart 4 - Schoeller Diagram MWx2

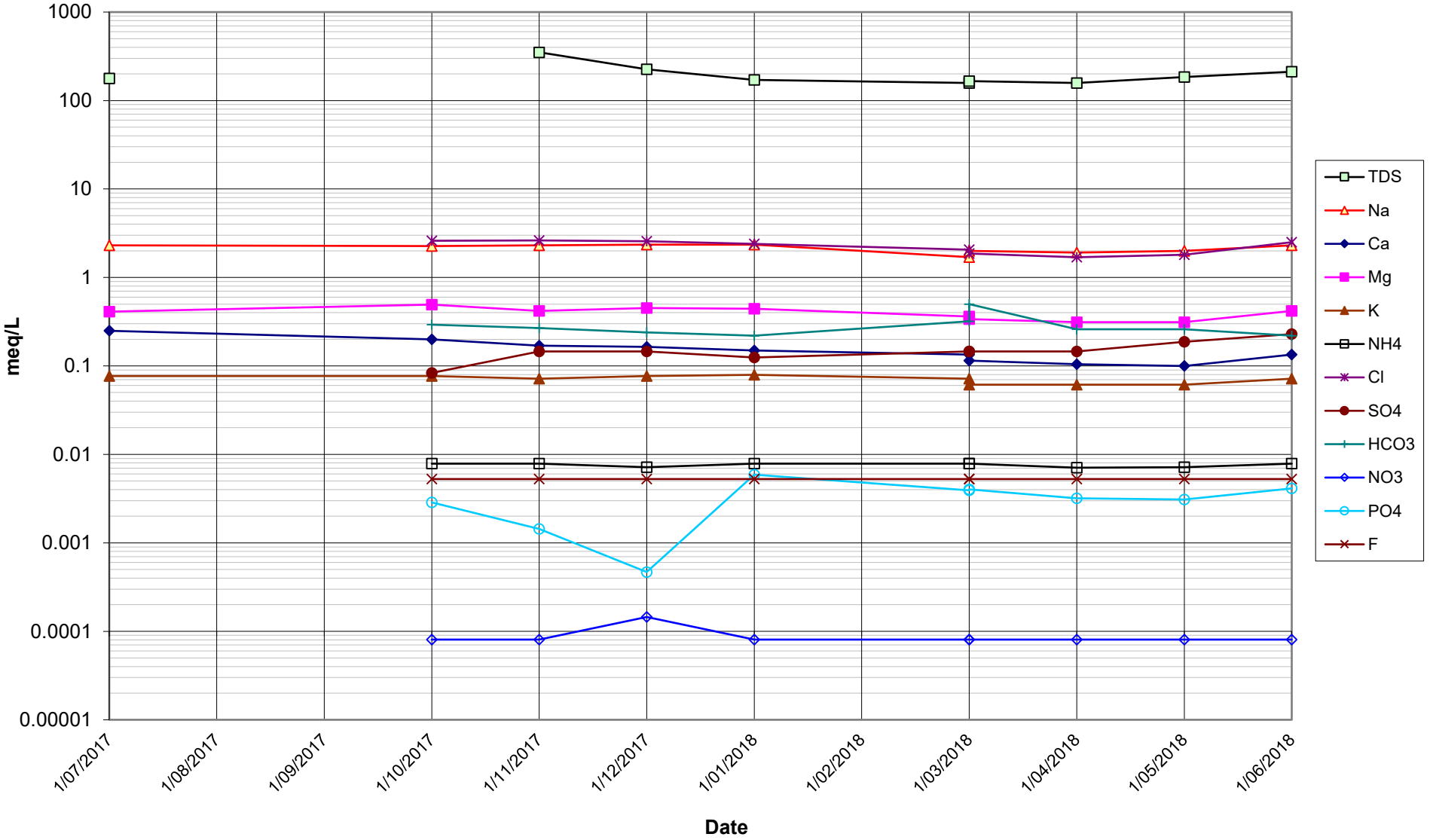


Chart 4

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Chart 5 - Schoeller Diagram MWx3_Shallow

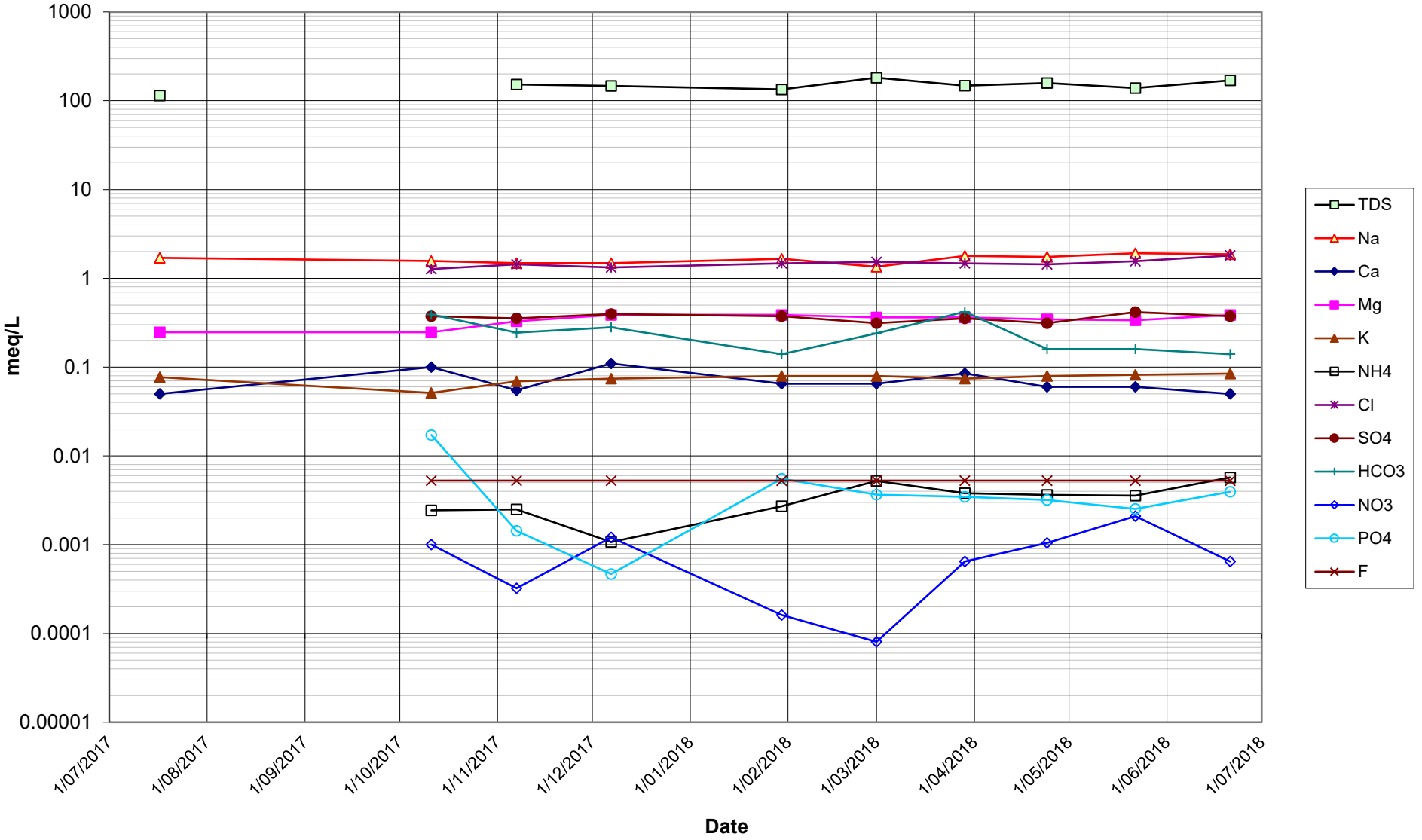


Chart 5

Chart 6 - Schoeller Diagram MWx3_Deep

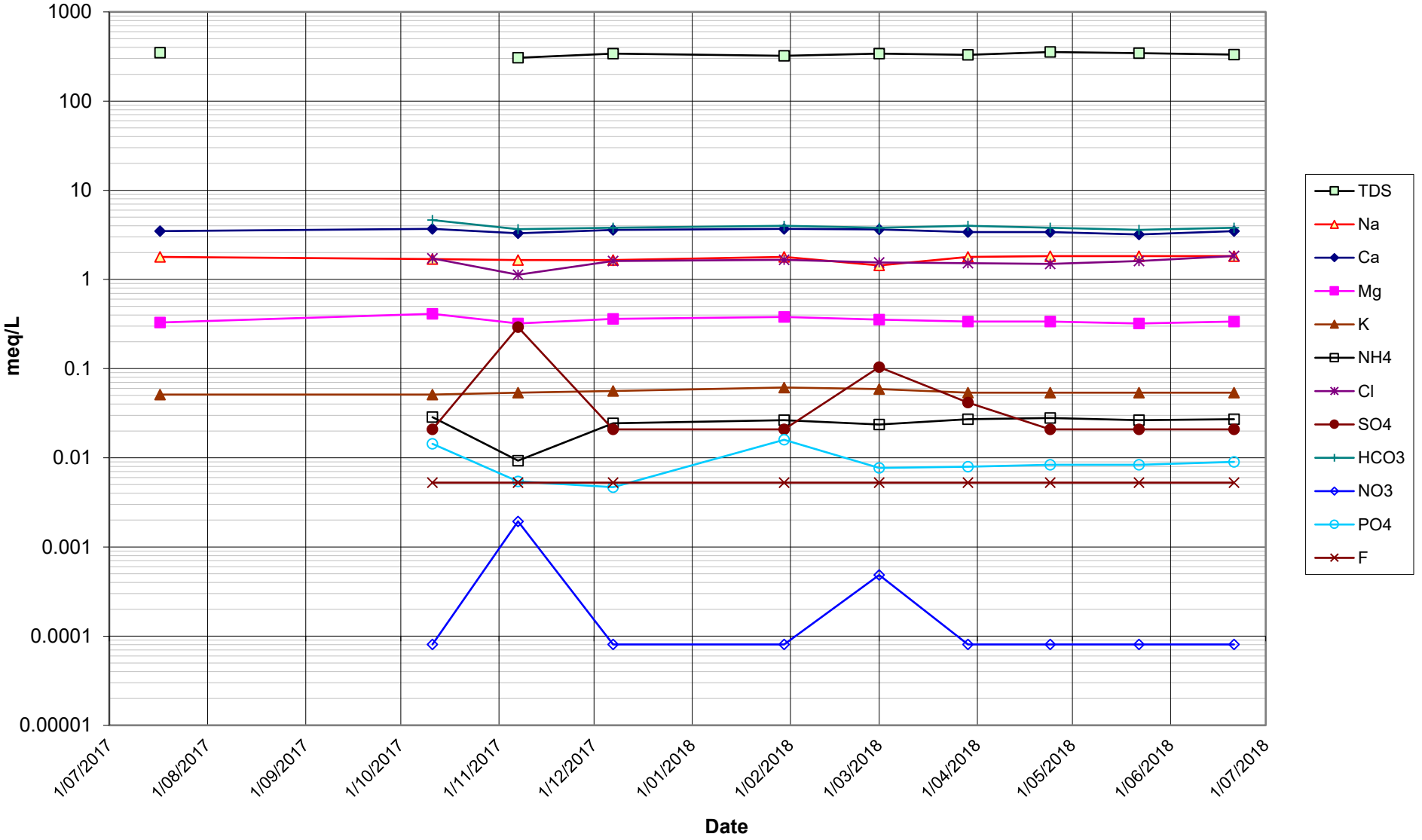
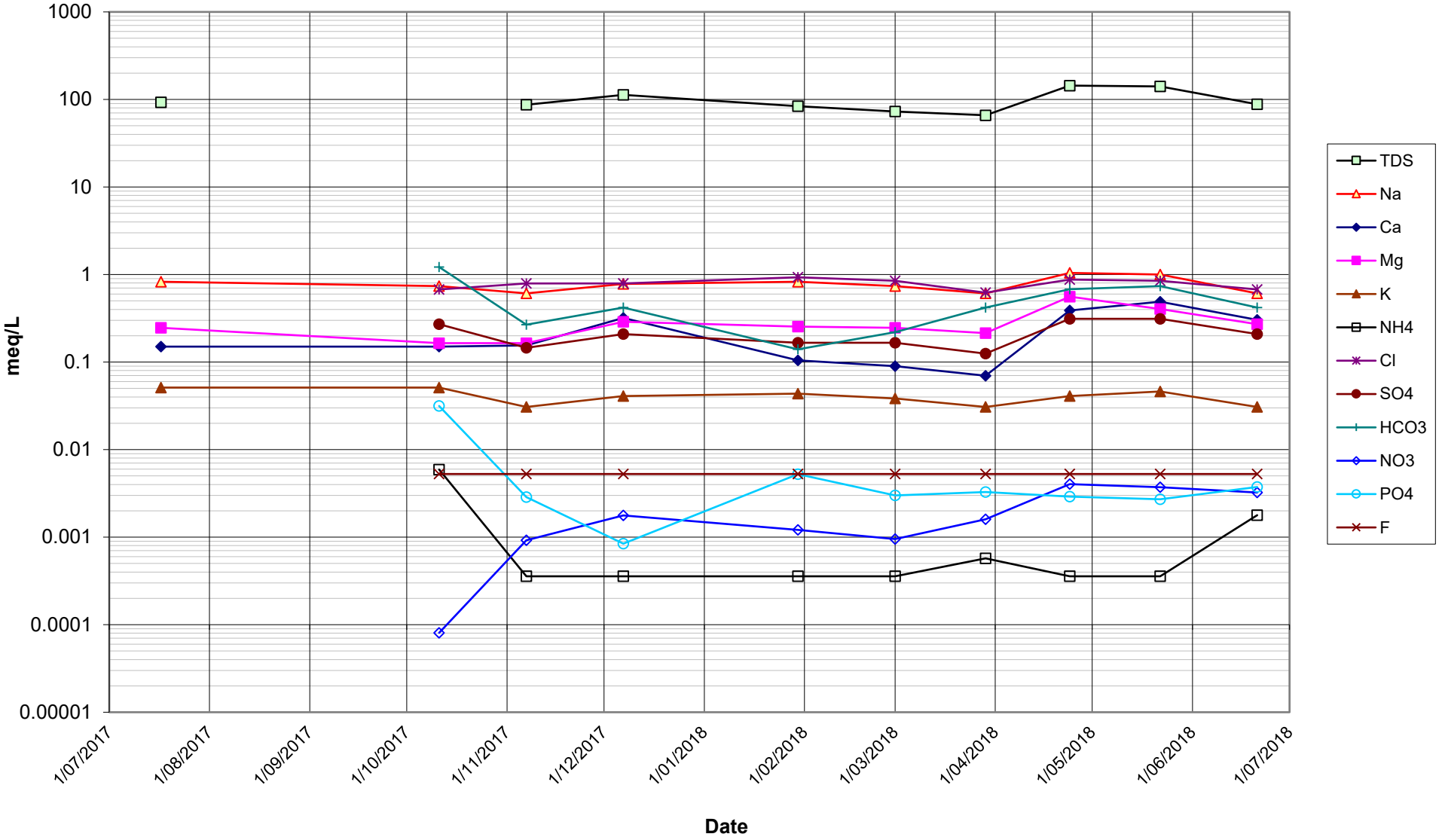
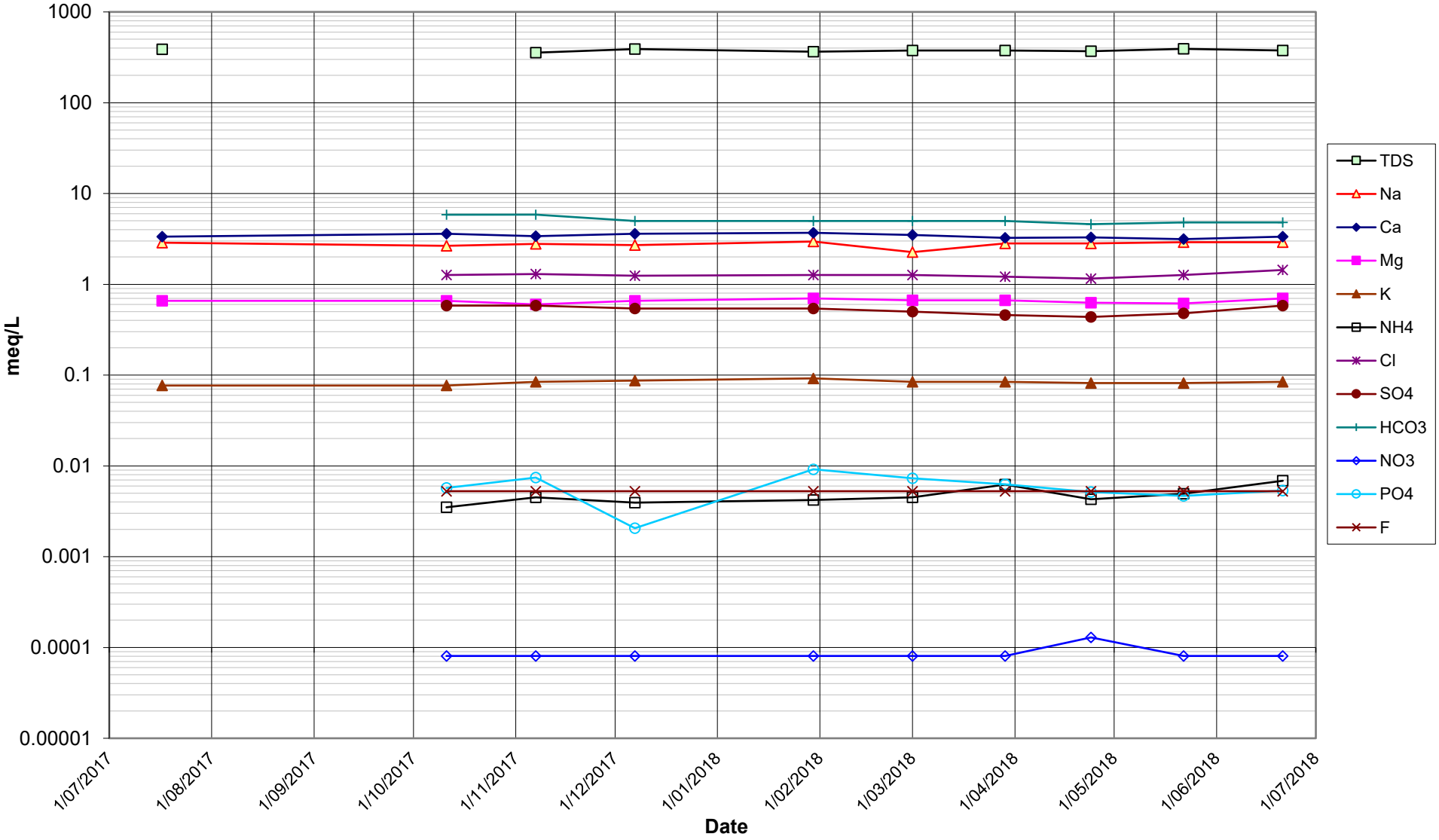


Chart 7 - Schoeller Diagram MWx4_Shallow



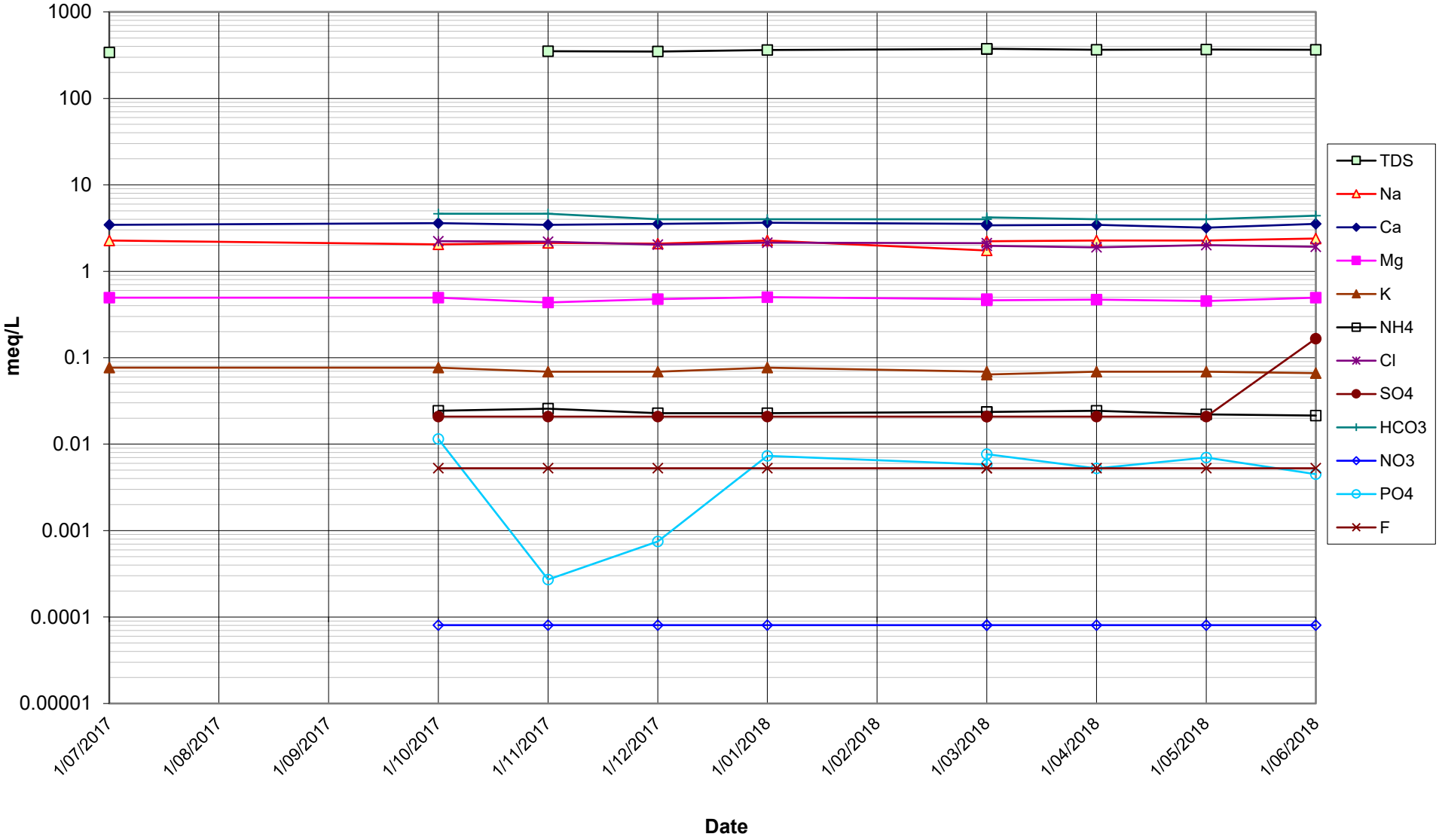
ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Chart 8 - Schoeller Diagram MWx4_Deep



ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Chart 9 - Schoeller Diagram MWx5



ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Chart 10 - Schoeller Diagram MWx6

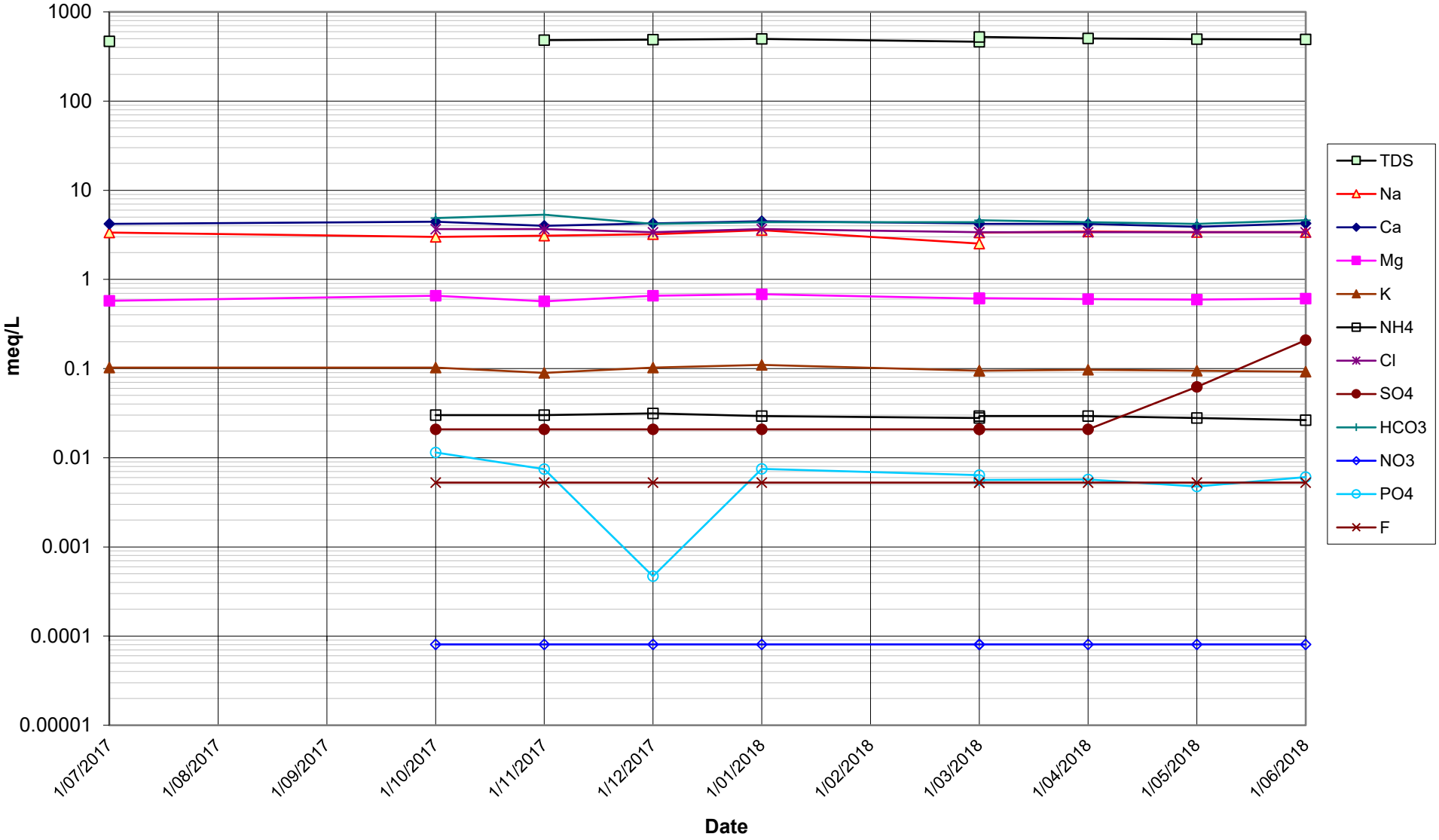


Chart 10

Chart 11 - Groundwater pH

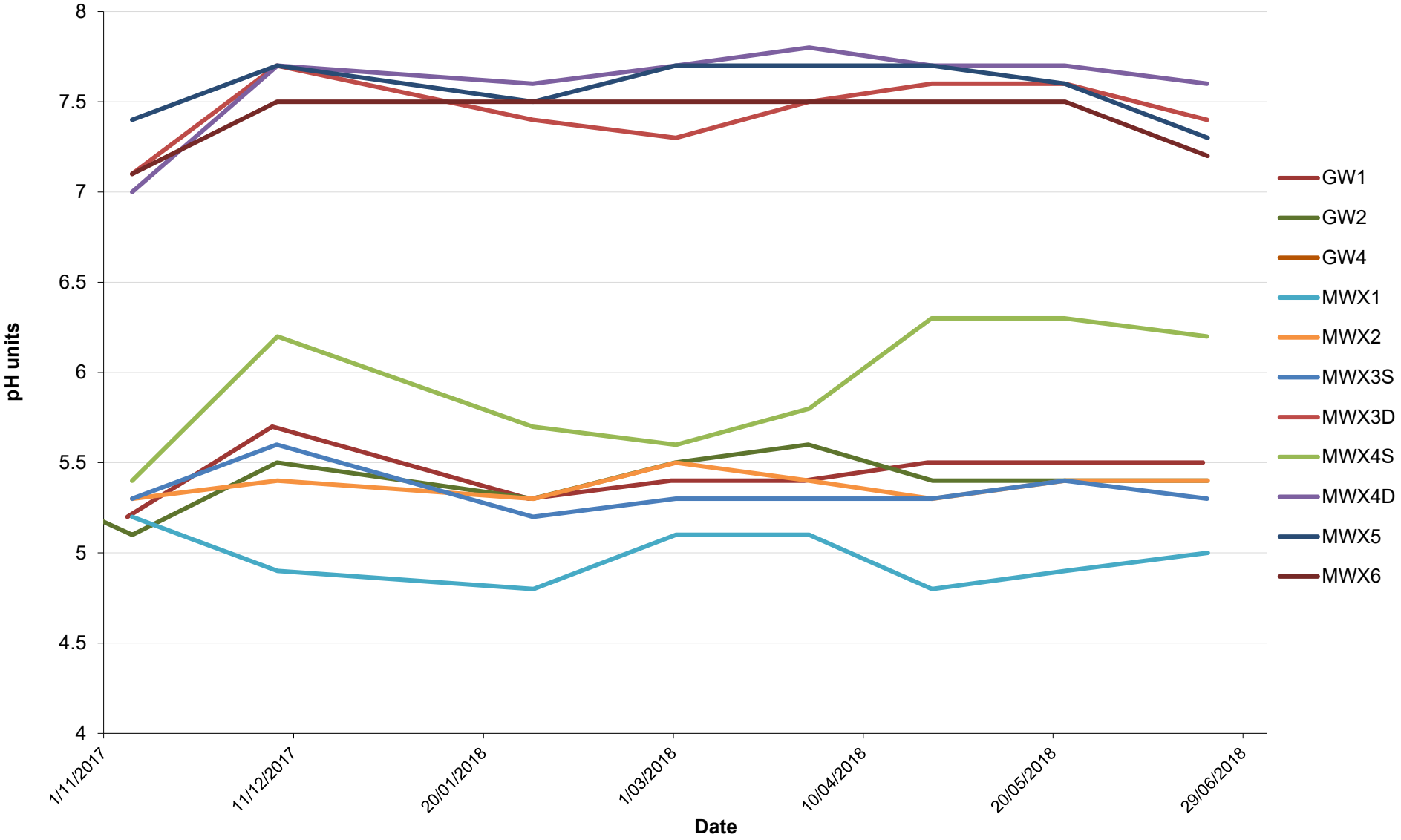


Chart 11

Chart 12 - Aluminium concentrations in groundwater

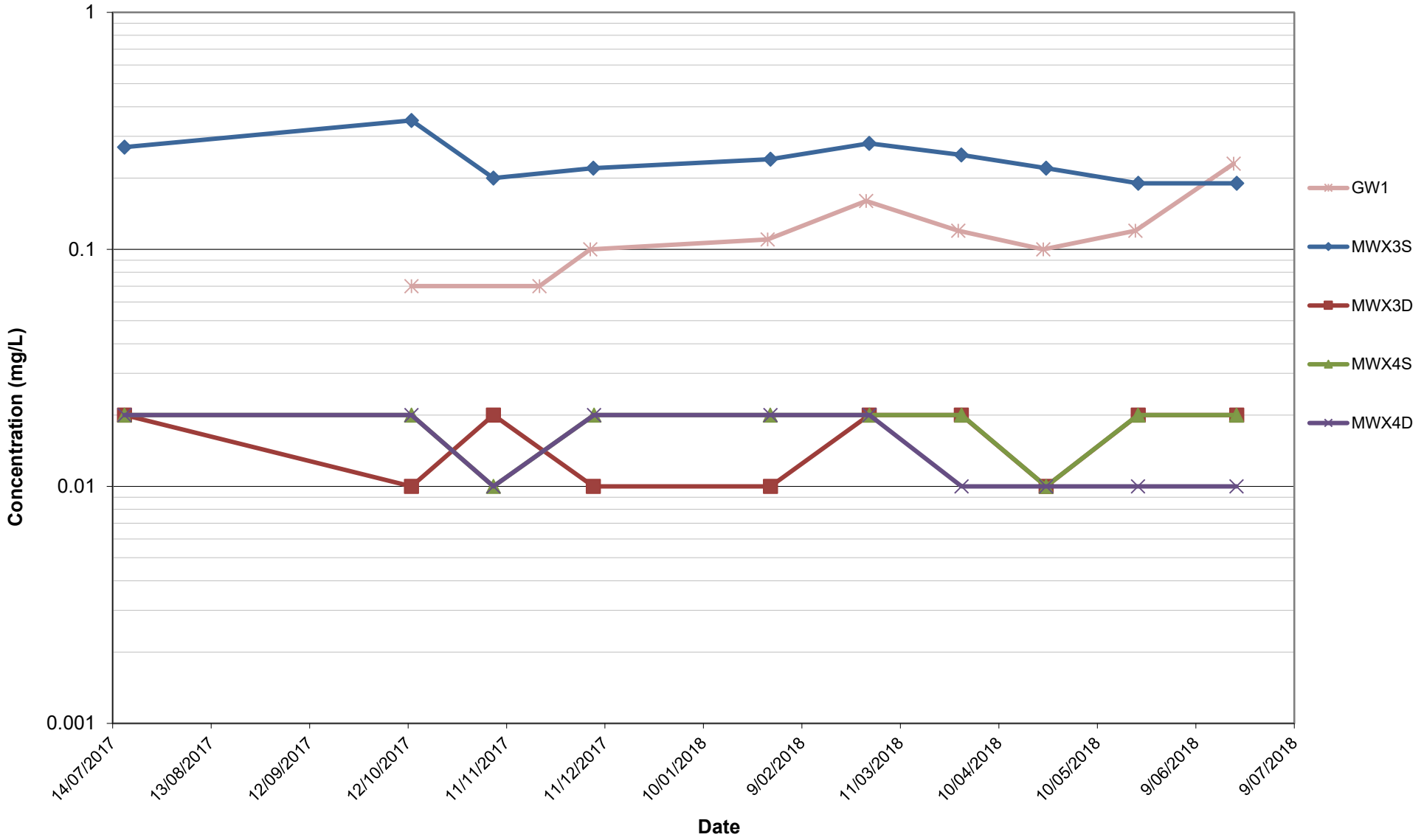


Chart 13 - Calcium concentrations in groundwater

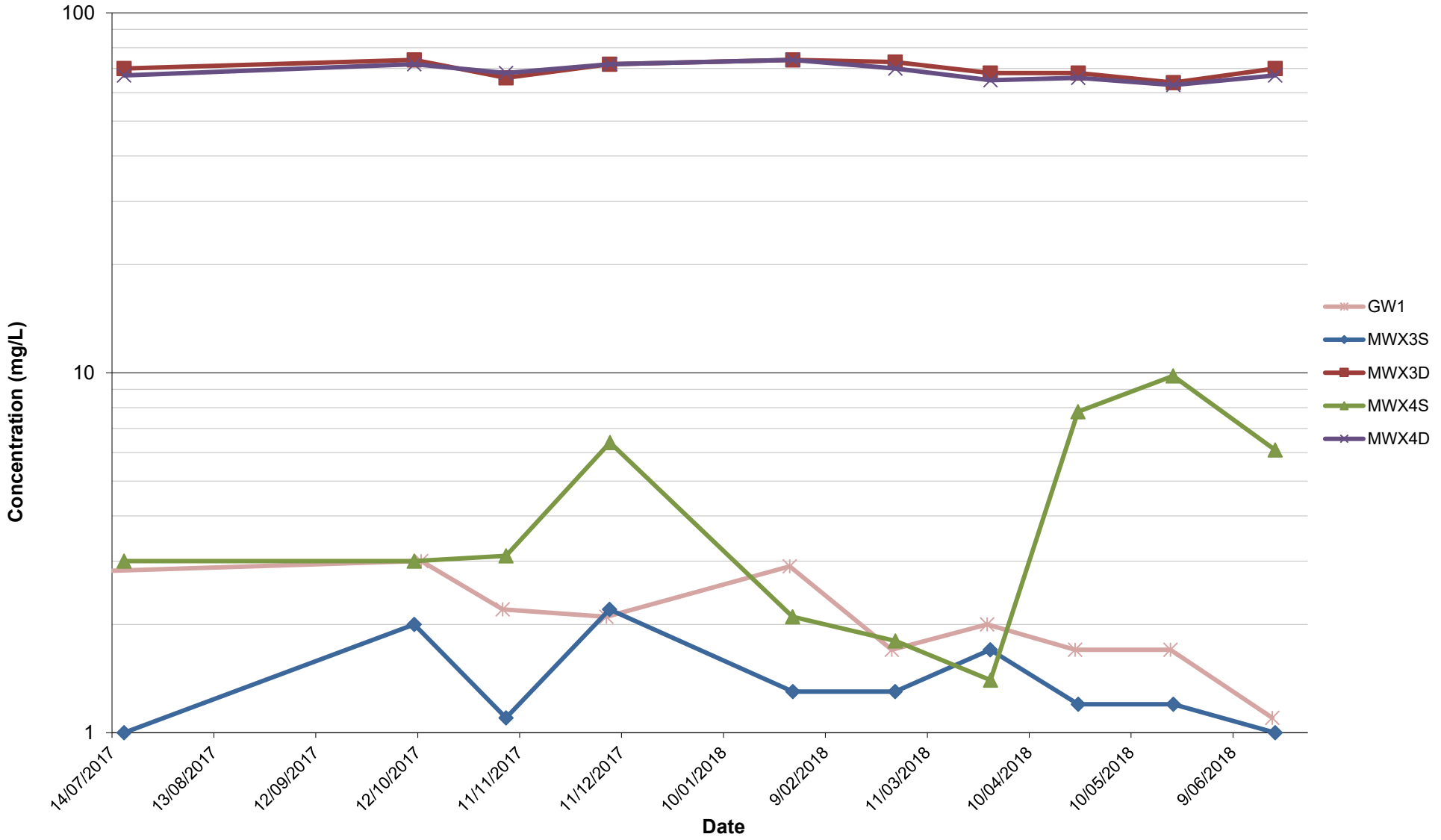


Chart 13

Chart 14 - Copper concentrations in groundwater

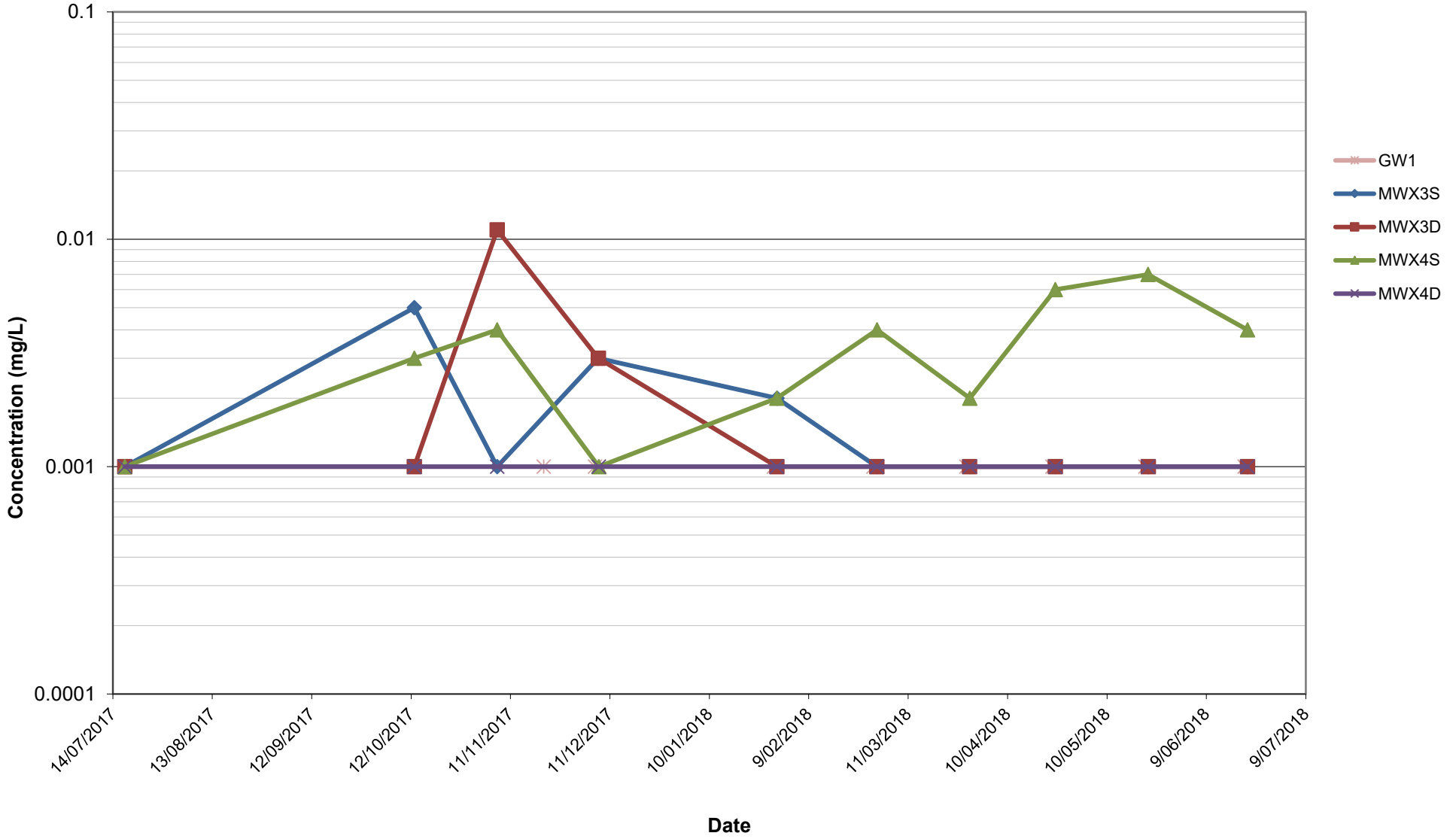


Chart 14

Chart 15 - Iron concentrations in groundwater

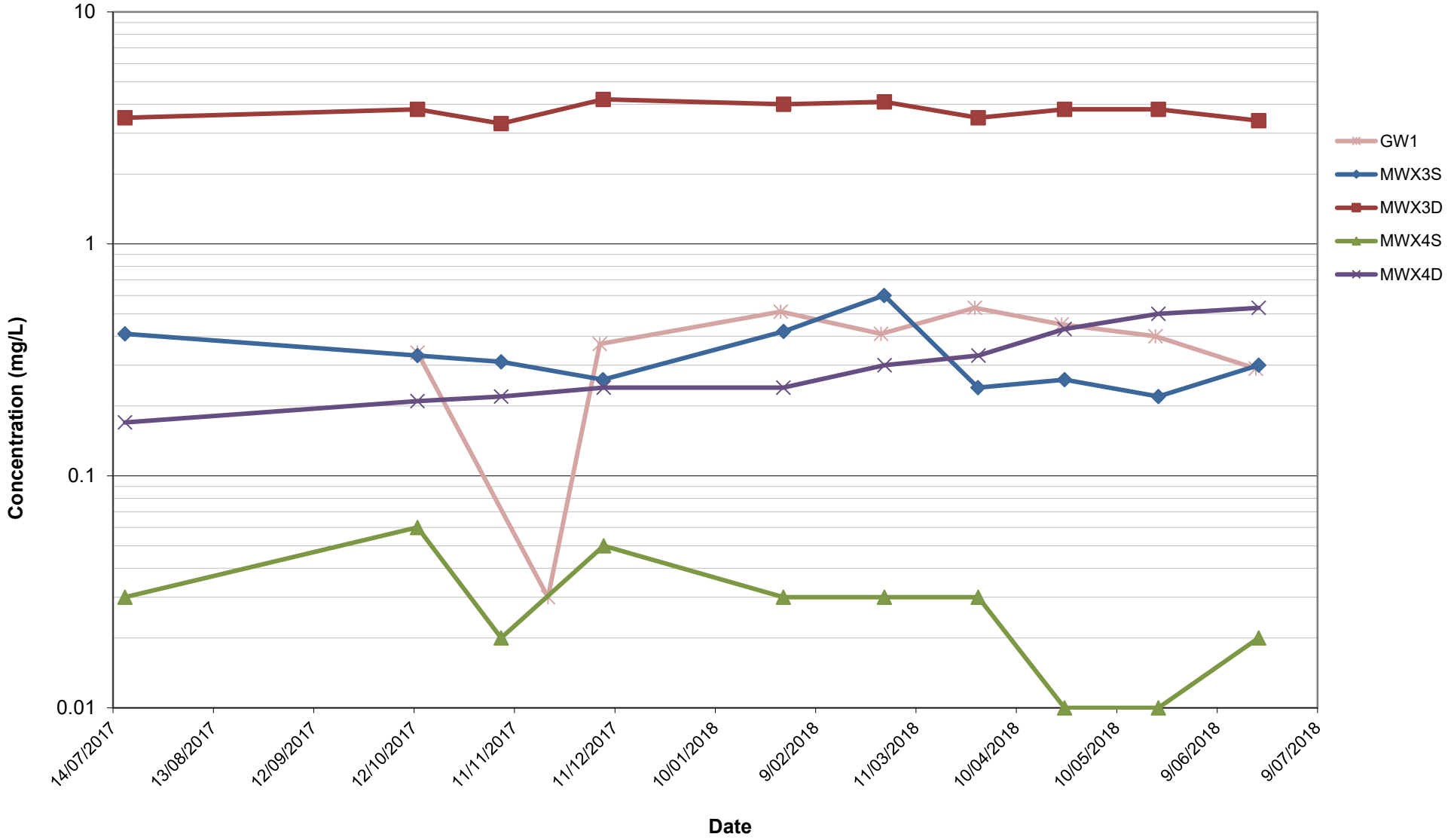


Chart 15

Chart 16 - Lead concentrations in groundwater

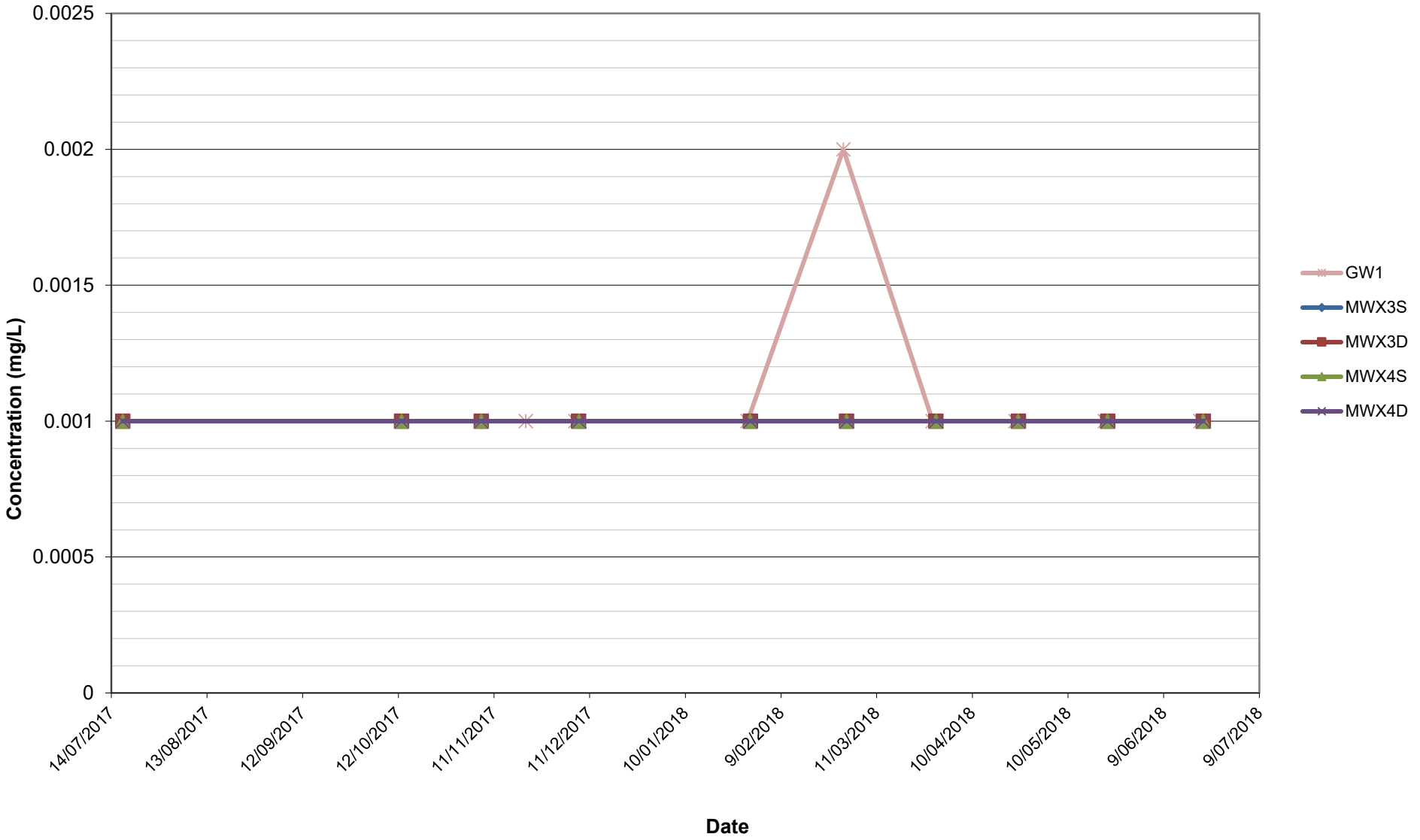


Chart 17 - Magnesium concentrations in groundwater

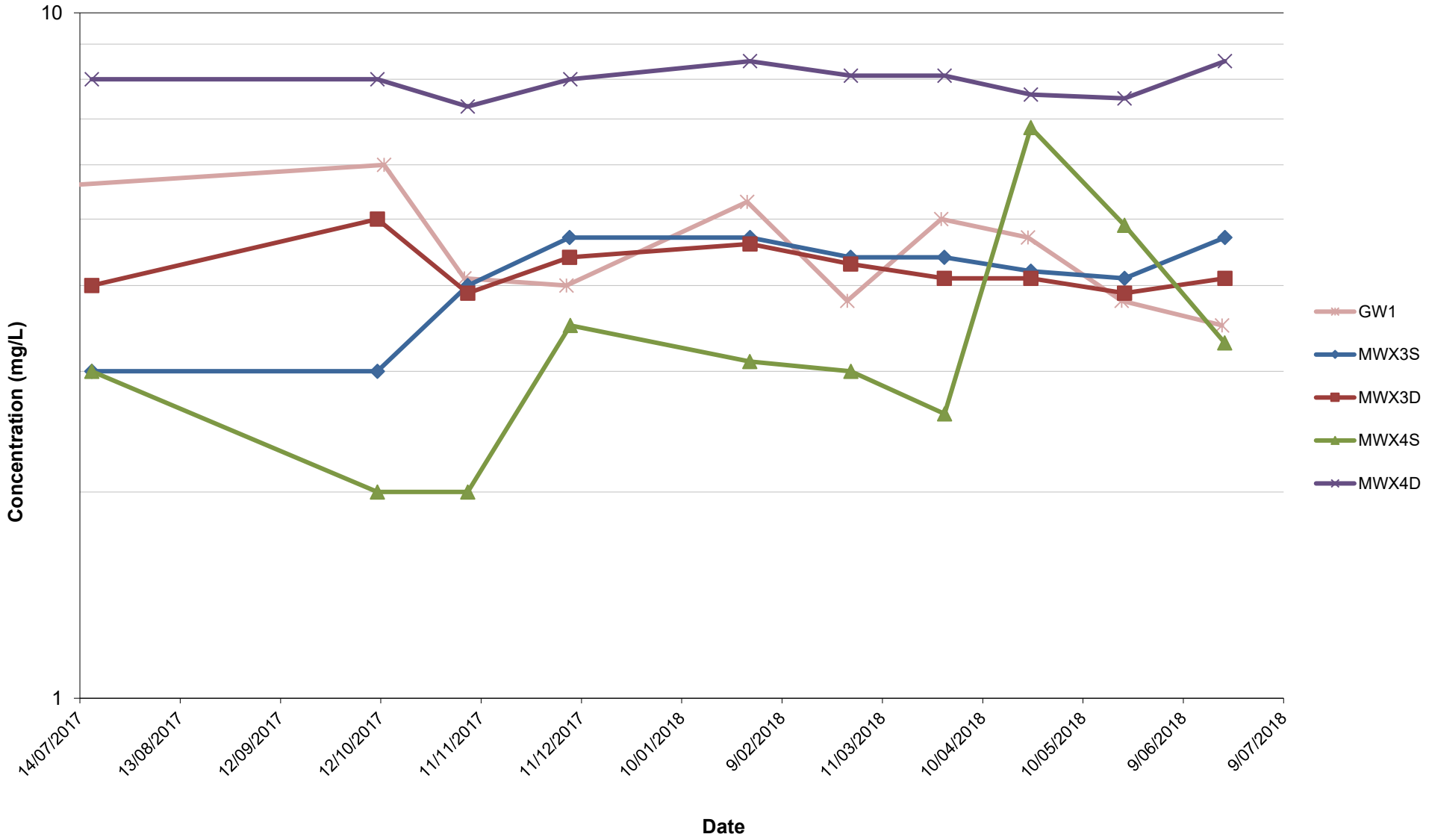


Chart 17

Chart 18 - Potassium concentrations in groundwater

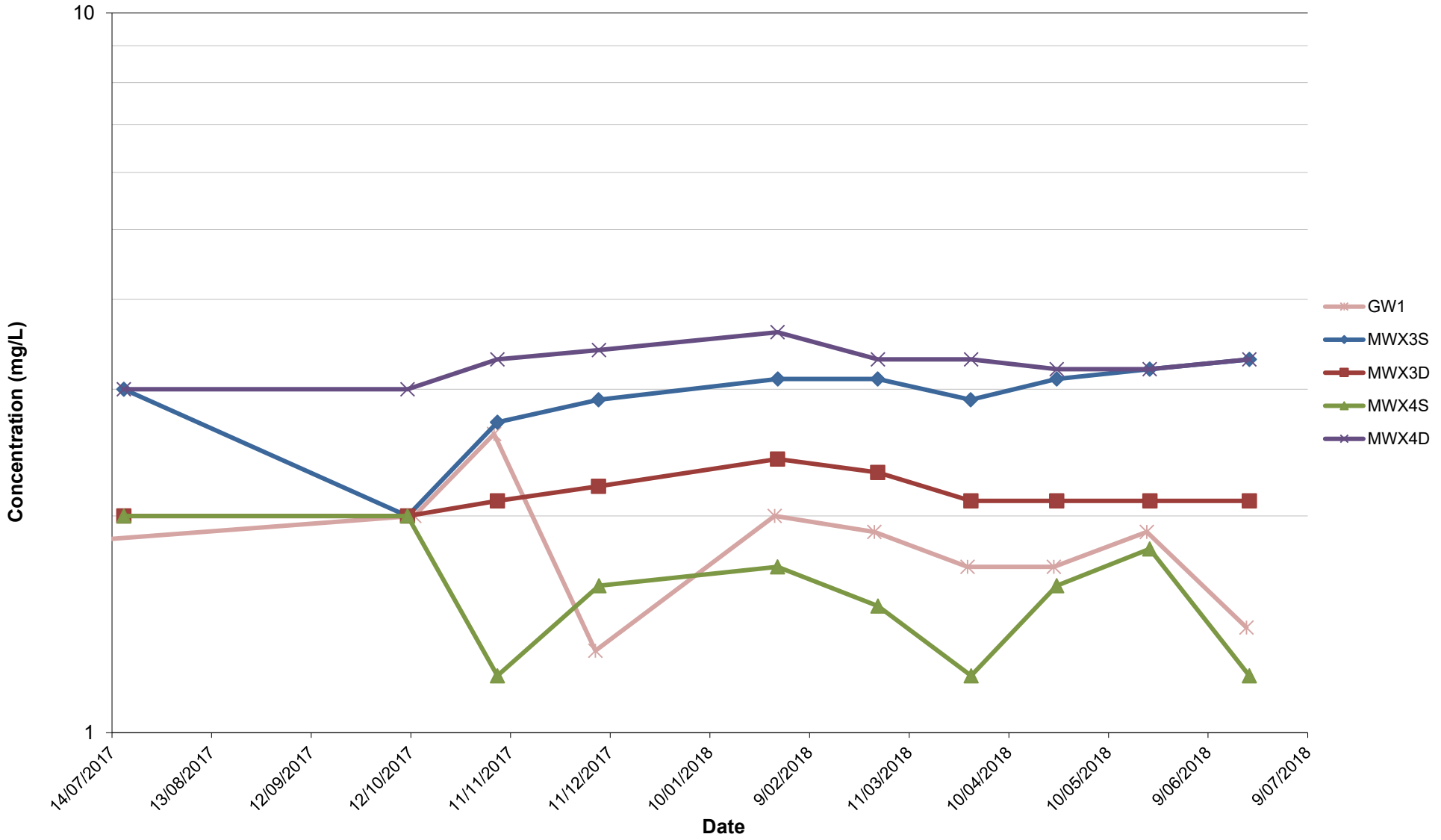


Chart 19 - Chloride concentrations in groundwater

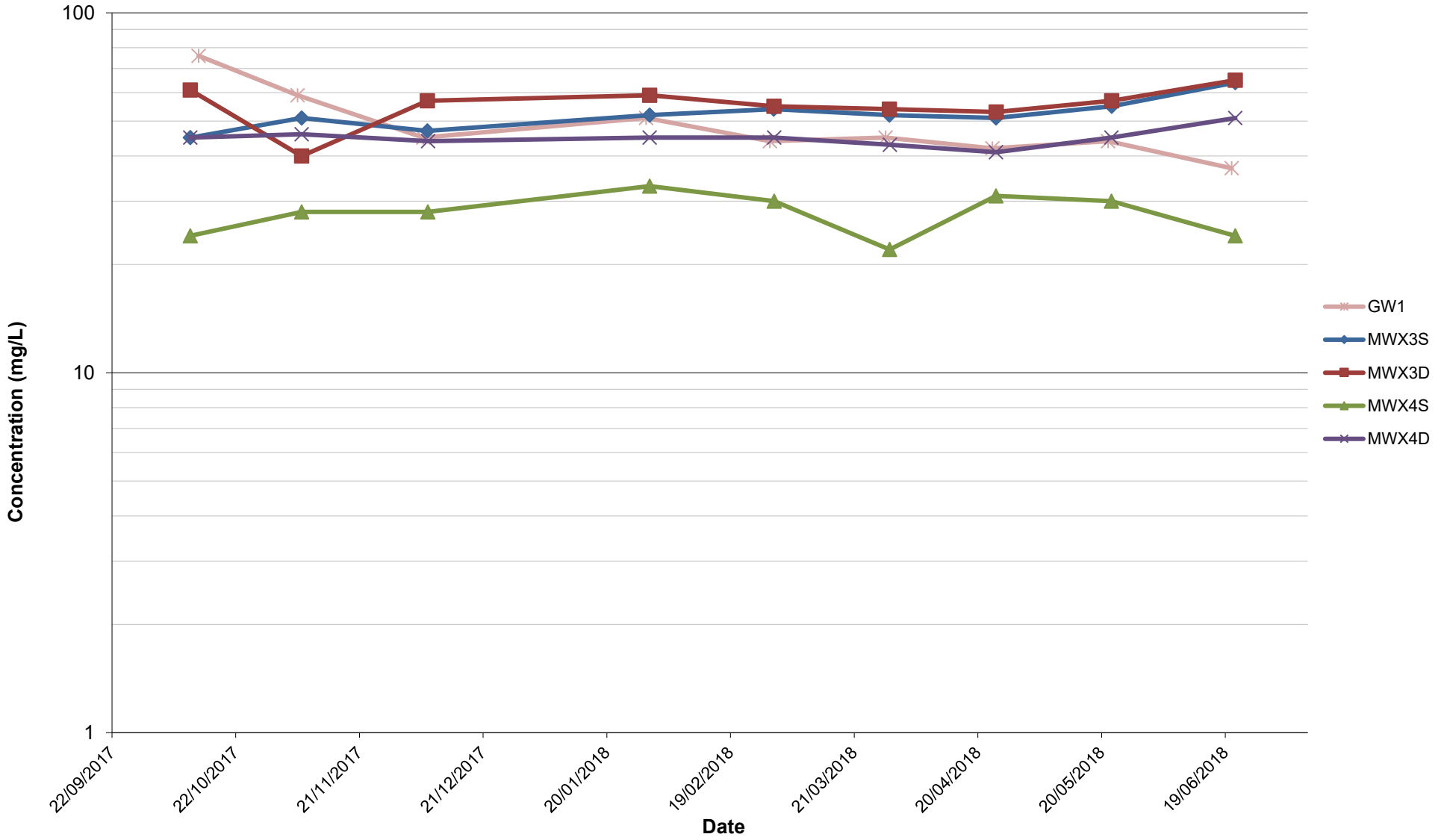


Chart 19

Chart 20 - Nitrate concentrations in groundwater

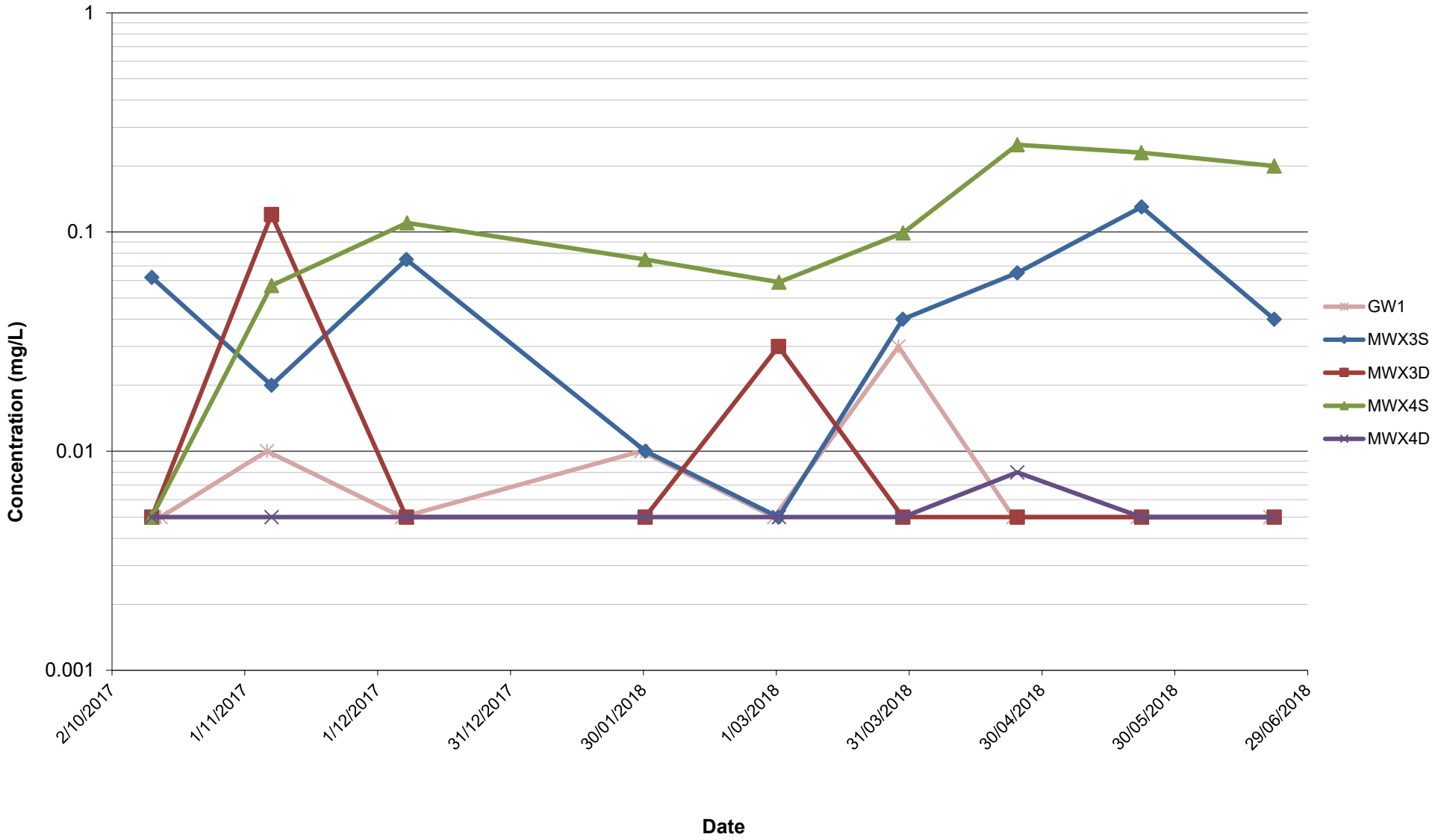


Chart 21 - Phosphate concentrations in groundwater

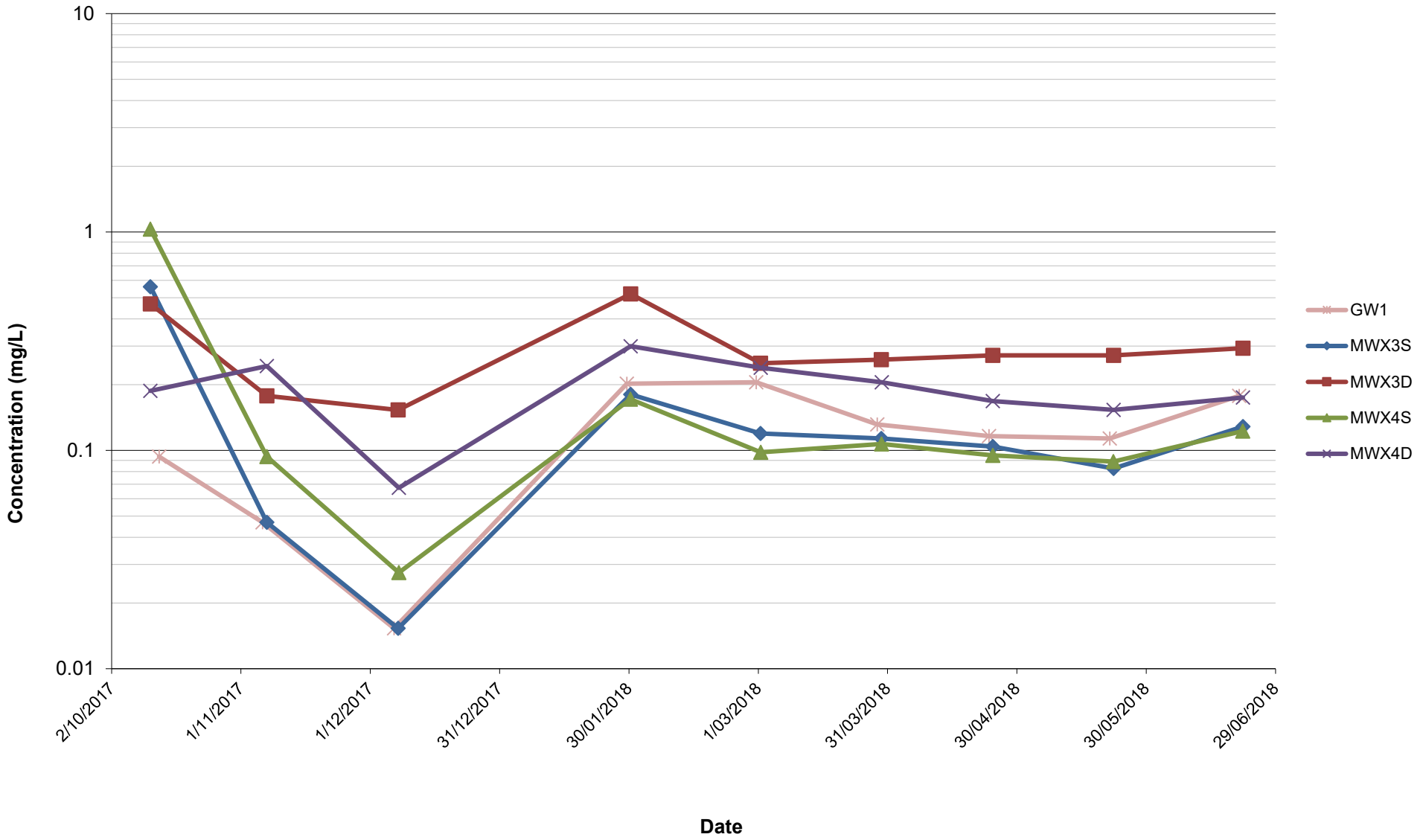


Chart 21

Chart 22 - Sulfate concentrations in groundwater

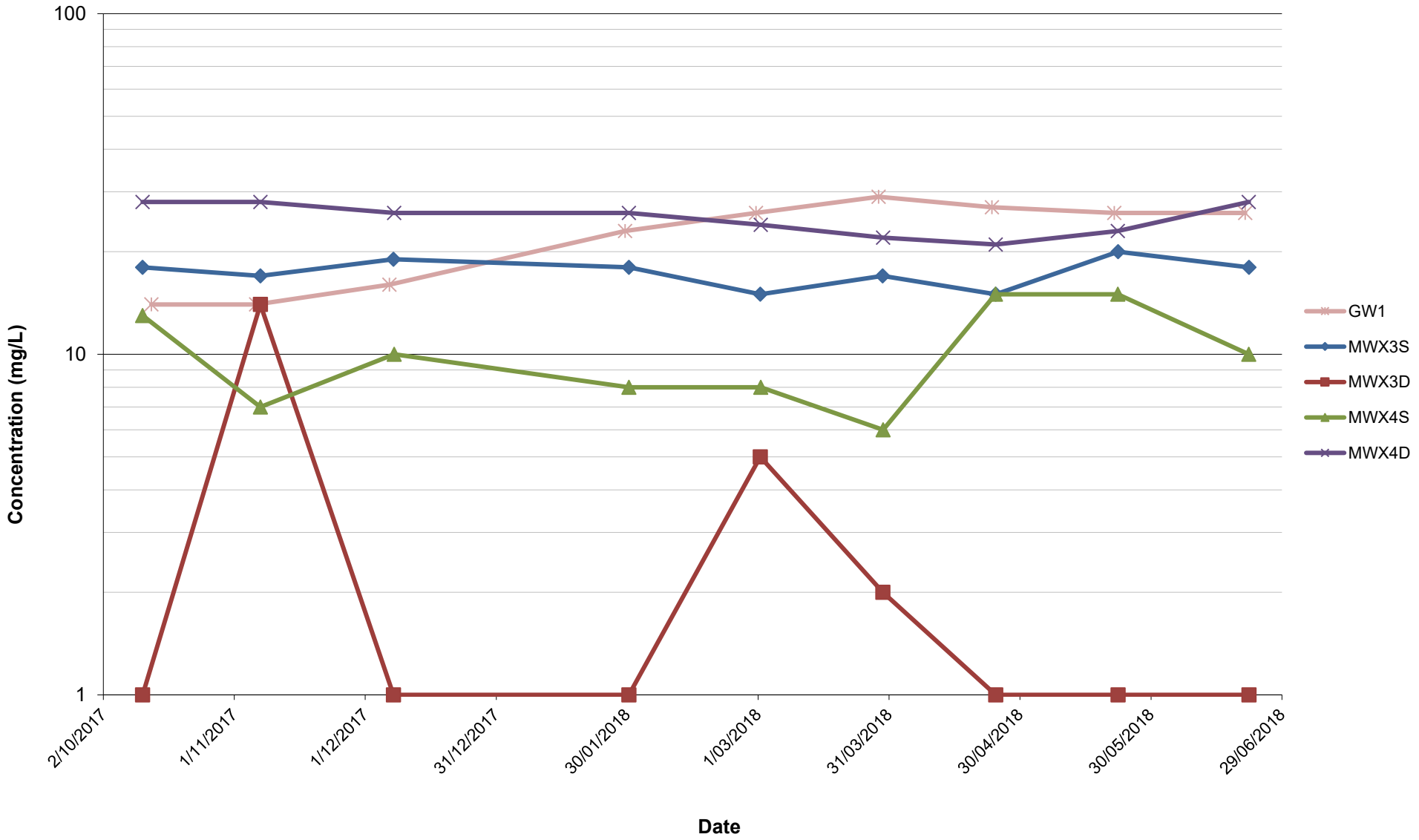


Chart 21

Chart 23 - Bicarbonate concentrations in groundwater

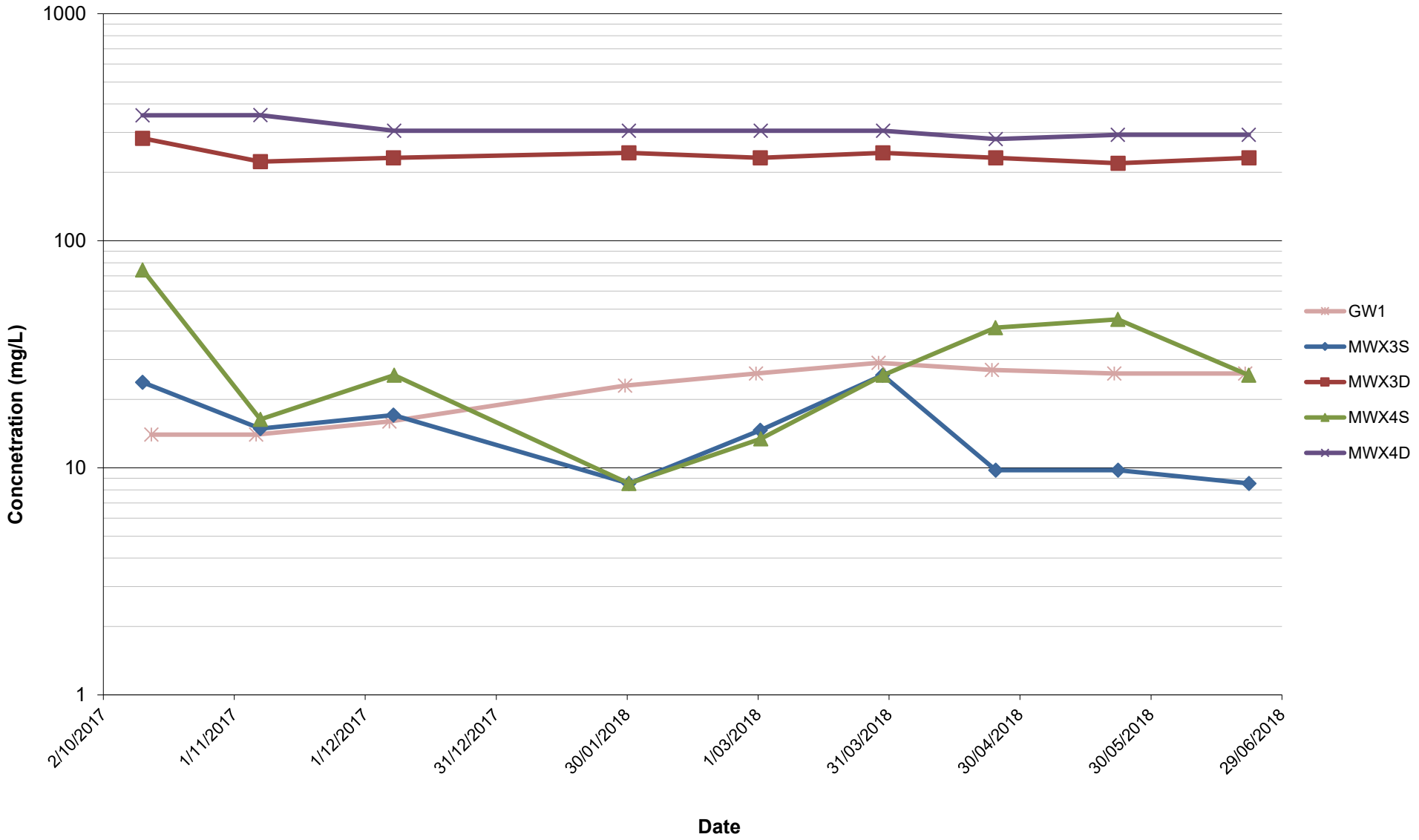


Chart 24 - Ammonia concentrations in groundwater

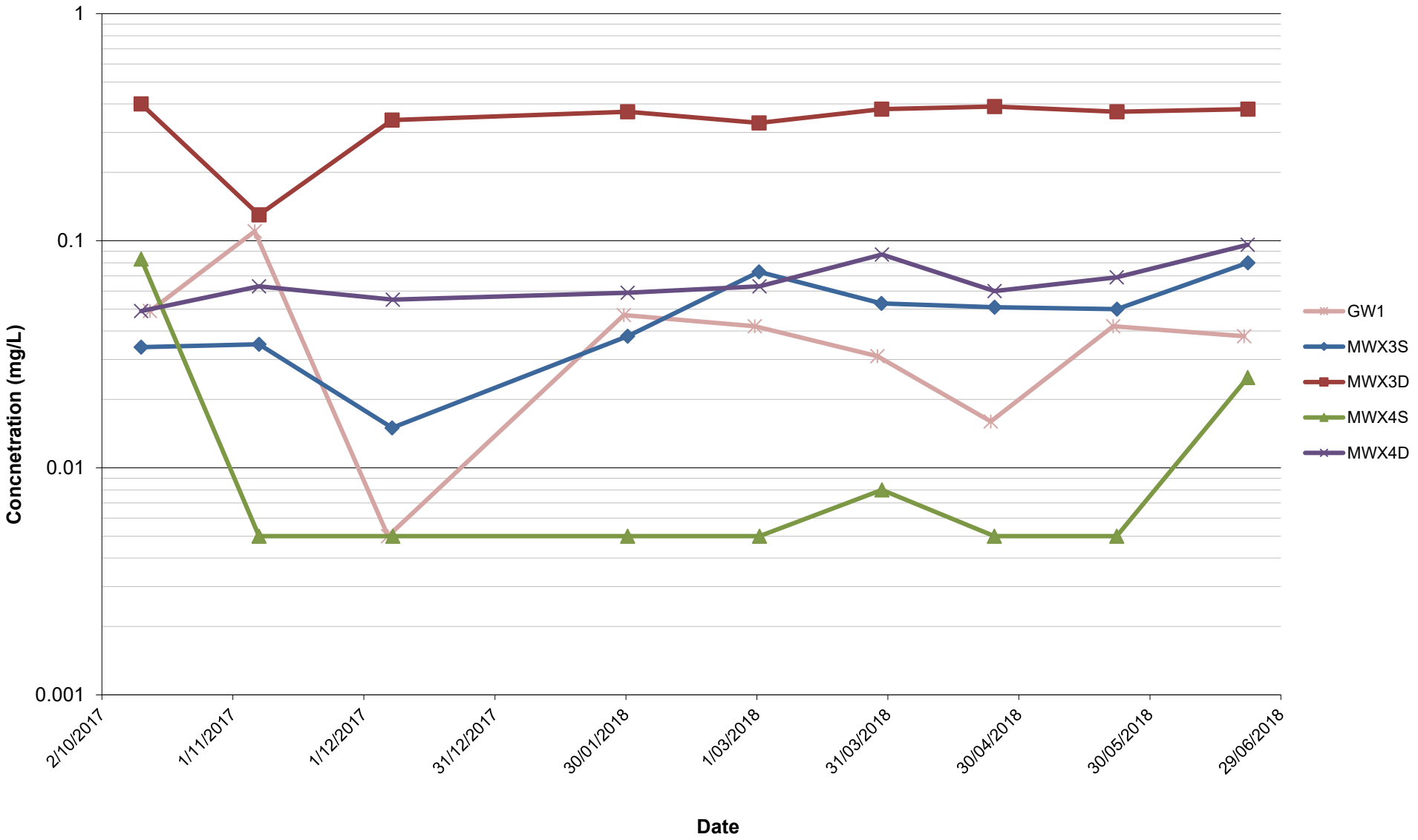
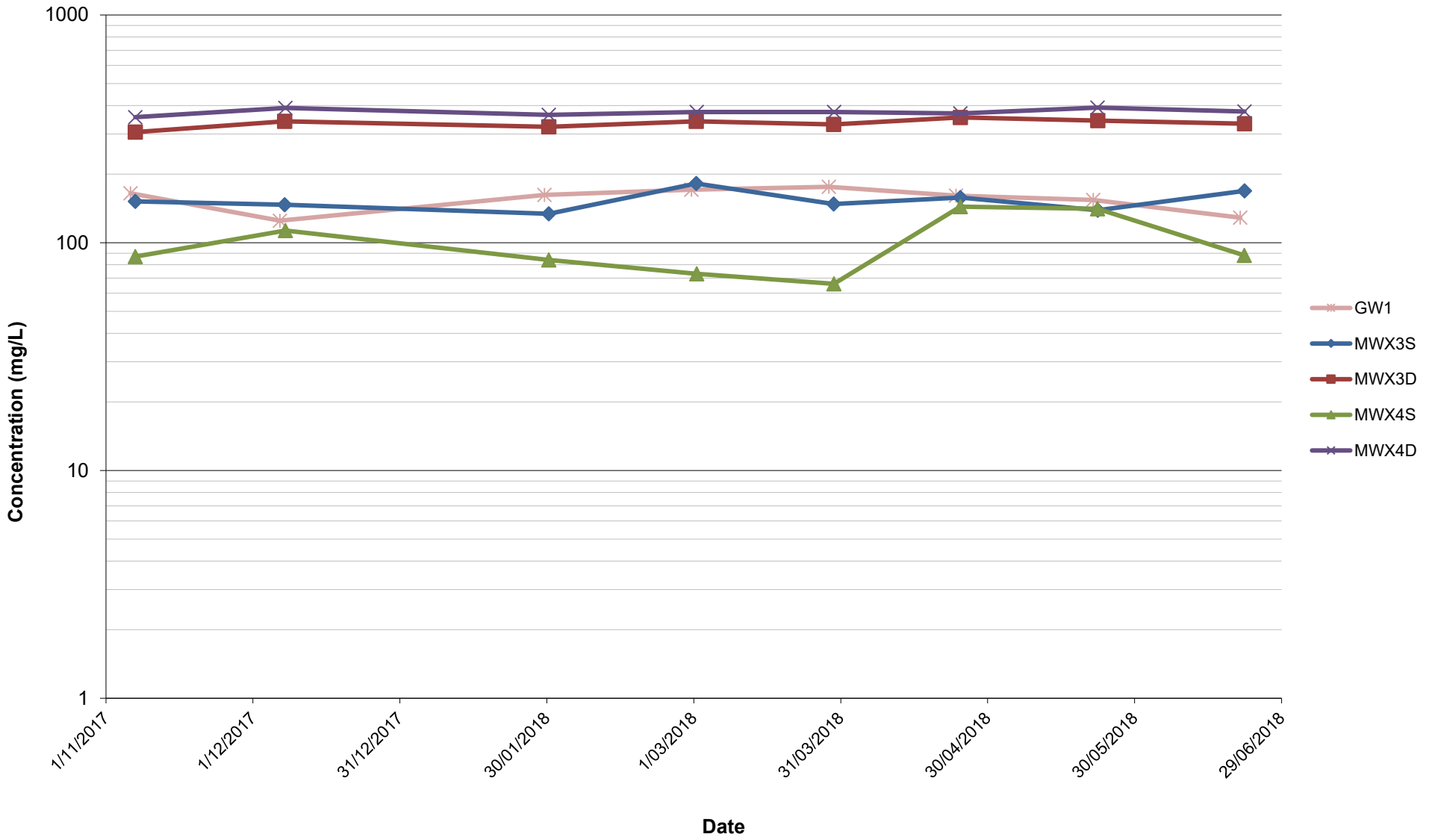


Chart 25 - Total Dissolved Solids concentrations in groundwater



APPENDIX B: GROUNDWATER BORE SEARCH RESULTS

NSW Office of W ater
Work Summary

GW060459

Licence: 20BL134880
Licence Status: LAPSED

Authorised Purpose(s): MINING
Intended Purpose(s): MINING

Work Type: Bore
Work Status:
Construct.Method: Rotary Mud
Owner Type: Private

Commenced Date:
Completion Date: 01/11/1986
Final Depth: 30.00 m
Drilled Depth: 34.00 m

Contractor Name:
Driller: Garry Stanley Strudwick
Assistant Driller:

Property: N/A NSW
GWMA: -
GW Zone: -
Standing W ater Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	GLOUC	GLOUC.040	173
Licensed:	GLOUCESTER	STOWELL	Whole Lot //

Region: 20 - Hunter
River Basin: 210 - HUNTER RIVER
Area/District:
CMA Map: 9232-2N
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6366133.0
Easting: 392401.0
Latitude: 32°50'15.3"S
Longitude: 151°51'01.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Annulus	(Unknown)	10.00	34.00	400			Graded
1		Backfill	Backfill	31.00	34.00				
1	1	Casing	Welded Steel	-0.50	20.00	220			Seated on Bottom
1	1	Opening	Screen	20.00	29.00	220		1	Stainless Steel, A: 0.75mm
1	1	Casing	Welded Steel	29.00	31.00	220			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
20.00	29.00	9.00	Unconsolidated	4.00		43.00			

Geologists Log

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.00	1.00	Sand Yellow	Sand	
1.00	2.00	1.00	Sand White	Sand	

2.00	4.00	2.00	Sand Light Brown	Sand	
4.00	6.00	2.00	Sand Grey Fine	Sand	
6.00	9.00	3.00	Sand Grey Coarse	Sand	
9.00	19.00	10.00	Sand Grey Coarse Some Clay	Sand	
19.00	23.00	4.00	Sand Light Brown Coarse Shell Water Supply	Sand	
23.00	30.00	7.00	Sand Grey Coarse Some Small Gravel Water Supply	Sand	
30.00	32.00	2.00	Sand Light Yellow Coarse Some Small Gravel	Sand	
32.00	33.00	1.00	Sand Yellow	Sand	
33.00	34.00	1.00	Clay Grey	Clay	

Remarks

18/08/1988: BACKFILL IS GRAVEL

*** End of GW060459 ***

NSW Office of W ater
Work Summary

GW062439

Licence: 20BL136178
Licence Status: CONVERTED

Authorised Purpose(s): MINING
Intended Purpose(s): MINING

Work Type: Bore
Work Status:
Construct.Method: Rotary Mud
Owner Type: Private

Commenced Date:
Completion Date: 01/04/1989
Final Depth: 30.00 m
Drilled Depth: 31.00 m

Contractor Name:
Driller: Garry Stanley Strudwick
Assistant Driller:

Property: NOT KNOWN 28 LAVIS LANE WILLIAMTOWN 2318 NSW
GWMA: 025 - TOMAGO TOMAREE STOCKTON
GW Zone: 003 - STOCKTON
Standing W ater Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	GLOUC	GLOUC.040	173
Licensed:	GLOUCESTER	STOWELL	Whole Lot 911//1008362

Region: 20 - Hunter
River Basin: 210 - HUNTER RIVER
Area/District:
CMA Map: 9232-2N
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6366008.0
Easting: 392246.0
Latitude: 32°50'19.3"S
Longitude: 151°50'55.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Annulus	(Unknown)	1.00	31.00	400			Graded
1	1	Casing	Steel	-1.00	20.00	220			Seated on Bottom
1	1	Opening	Screen	20.00	29.00	220		1	Stainless Steel, A: 0.75mm
1	1	Casing	Steel	29.00	30.00	220			Seated on Bottom

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
2.00	30.00	28.00	Unconsolidated	2.00		15.00			

Geologists Log

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	3.00	3.00	Sand Yellow Water Supply	Sand	

3.00	5.00	2.00	Sand Light Brown Water Supply	Sand	
5.00	10.00	5.00	Clay Grey Veined Water Supply	Clay	
10.00	12.00	2.00	Sand Grey Silty Water Supply	Sand	
12.00	20.00	8.00	Sand Light Grey Medium Water Supply	Sand	
20.00	27.00	7.00	Sand Light Grey Coarse Water Supply	Sand	
27.00	29.00	2.00	Sand Dark Grey Coarse Water Supply	Sand	
29.00	30.00	1.00	Sand Grey Silty Water Supply	Sand	
30.00	31.00	1.00	Clay Grey	Clay	

Remarks

*** End of GW062439 ***

NSW Office of W ater
Work Summary

GW078360

Licence: 20WA202361
Licence Status: CANCELLED
Authorised Purpose(s): MINING
Intended Purpose(s):
Work Type: Bore
Work Status:
Construct.Method: Rotary Mud
Owner Type:
Commenced Date:
Completion Date: 08/04/1997
Final Depth: 35.00 m
Drilled Depth: 35.00 m
Contractor Name: INTERTEC DRILLING SERVICES
Driller: Colin Leslie Barden
Assistant Driller:
Property: FULLERTON COVE - MLA 7 OFF LAVIS LANE WILLIAMTOWN 2301
GWMA: 025 - TOMAGO TOMAREE STOCKTON
GW Zone: 003 - STOCKTON
Standing W ater Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	GLOUC	GLOUC.040	LOT 20 DP 828848
Licensed:	GLOUCESTER	STOWELL	Whole Lot 20//828848

Region: 20 - Hunter
River Basin: - Unknown
Area/District:
CMA Map:
Grid Zone:
Scale:
Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6363612.0
Easting: 390011.0
Latitude: 32°51'36.3"S
Longitude: 151°49'28.1"E
GS Map: -
MGA Zone: 0
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	35.00	350			Rotary Mud
1		Annulus	Crushed Aggregate	0.00	9.00				Graded, Q:0.600m3
1		Annulus	Crushed Aggregate	9.00	27.60				Graded, Q:1.200m3
1	1	Casing	Steel	0.70	27.60	219			Suspended in Clamps, Welded
1	1	Opening	Screen	17.00	26.40	219		1	Stainless Steel, Welded, A: 0.90mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
3.00	35.00	32.00	Unknown	2.00		20.00	16.50	01:00:00	290.00

Geologists Log

Drillers Log

From	To	Thickness	Drillers Description	Geological Material	Comments

(m)	(m)	(m)			
0.00	2.10	2.10	dark grey coarse grain sand	Sand	
2.10	12.30	10.20	sand	Sand	
12.30	17.70	5.40	crushed shell/sand red	Sand	
17.70	26.30	8.60	brown coarse grain sand	Sand	
26.30	33.40	7.10	crushed shell/sand red	Sand	
33.40	35.00	1.60	light brown coarse grain sand	Sand	

Remarks

*** End of GW078360 ***

NSW Office of W ater
Work Summary

GW078361

Licence: 20WA202361
Licence Status: CANCELLED

Authorised Purpose(s): MINING
Intended Purpose(s):

Work Type: Bore
Work Status:
Construct.Method: Rotary Mud
Owner Type:

Commenced Date:
Completion Date: 05/04/1997
Final Depth: 34.50 m
Drilled Depth: 34.50 m

Contractor Name: INTERTEC DRILLING SERVICES
Driller: Colin Leslie Barden
Assistant Driller:

Property: FULLERTON COVE - MLA 7 OFF LAVIS LANE WILLIAMTOWN 2301
GWMA: 025 - TOMAGO TOMAREE STOCKTON
GW Zone: 003 - STOCKTON
Standing W ater Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	GLOUC	GLOUC.040	LOT 20 DP 828848
Licensed:	GLOUCESTER	STOWELL	Whole Lot 20//828848

Region: 20 - Hunter
River Basin: - Unknown
Area/District:
CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6363736.0
Easting: 390139.0
Latitude: 32°51'32.3"S
Longitude: 151°49'33.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	34.50	350			Rotary Mud
1		Annulus	Waterworn/Rounded	0.00	14.00				Graded, Q:0.840m3
1		Annulus	Waterworn/Rounded	14.00	30.00				Graded, Q:1.200m3
1	1	Casing	Steel	0.70	30.00	219			Suspended in Clamps, Welded
1	1	Opening	Screen	19.50	28.90	219		1	Stainless Steel, Welded, A: 0.90mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
3.00	34.50	31.50	Unknown	2.00		20.00	19.00	01:00:00	280.00

Geologists Log

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.30	1.30	grey coarse grain sand	Sand	

1.30	2.40	1.10	dark grey coarse grain sand	Sand	
2.40	9.00	6.60	indurated sand	Sand	
9.00	13.70	4.70	shell/sand layer	Sand	
13.70	21.00	7.30	brown coarse grey sand	Sand	
21.00	29.30	8.30	crushed shell/sand bed	Sand	
29.30	34.50	5.20	light brown coarse grain sand	Sand	

Remarks

*** End of GW078361 ***

NSW Office of W ater
Work Summary

GW079736

Licence: 20BL167158
Licence Status: CONVERTED

Authorised Purpose(s): DOMESTIC
Intended Purpose(s): DOMESTIC

Work Type: Bore
Work Status:
Construct.Method:
Owner Type:

Commenced Date:
Completion Date:
Final Depth:
Drilled Depth:

Contractor Name:
Driller:
Assistant Driller:

Property: N/A 220 FULLERTON COVE ROAD FULLERTON COVE 2318
GWMA: 025 - TOMAGO TOMAREE STOCKTON
GW Zone: 003 - STOCKTON
Standing W ater Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	GLOUC	GLOUC.039	PORTION 19)
Licensed:	GLOUCESTER	STOCKTON	Whole Lot 343//719242

Region: 20 - Hunter
River Basin: - Unknown
Area/District:
CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6365083.0
Easting: 389396.0
Latitude: 32°50'48.3"S
Longitude: 151°49'05.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments

Remarks

30/11/2009: Reviewed data - nothing to update.

*** End of GW079736 ***

NSW Office of W ater
Work Summary

GW079778

Licence: | Licence Status:

Authorised Purpose(s):
Intended Purpose(s):

Work Type: Bore
Work Status:
Construct.Method:
Owner Type:

Commenced Date: | Final Depth:
Completion Date: | Drilled Depth:

Contractor Name:
Driller:
Assistant Driller:

Property: | Standing W ater Level (m):
GWMA: | Salinity Description:
GW Zone: | Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	GLOUC	GLOUC.040	LTPT3 DP753192
Licensed:			

Region: 20 - Hunter | CMA Map:
River Basin: - Unknown | Grid Zone: | Scale:
Area/District:

Elevation: 0.00 m (A.H.D.) | Northing: 6364173.0 | Latitude: 32°51'18.3"S
Elevation Source: (Unknown) | Easting: 390628.0 | Longitude: 151°49'52.1"E

GS Map: - | MGA Zone: 0 | Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments

Remarks

10/12/1999: Form A Remarks:
Boral Country Fullerton Cove Monitoring Bores, stockton beach Newcastle
Bore No GW4
30/11/2009: Reviewed data - nothing to update.

*** End of GW079778 ***

NSW Office of W ater
Work Summary

GW200423

Licence: 20CA203259
Licence Status: CURRENT

Authorised Purpose(s): IRRIGATION
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status: New Bore
Construct.Method: Auger - Hollow Flight
Owner Type: Private

Commenced Date:
Completion Date: 24/08/2005
Final Depth: 20.00 m
Drilled Depth: 20.00 m

Contractor Name: KF & BL GIGGINS PTY. LTD.
Driller: Kenneth Frank Giggins
Assistant Driller:

Property: N/A 85 NELSON BAY ROAD FERN BAY NSW
GWMA: 025 - TOMAGO TOMAREE STOCKTON
GW Zone: 003 - STOCKTON
Standing W ater Level: 3.000
Salinity:
Yield:

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	GLOUC	GLOUC.39	16//258848
Licensed:	GLOUCESTER	STOCKTON	Whole Lot 1//270466

Region: 20 - Hunter
River Basin: - Unknown
Area/District:
CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6363887.0
Easting: 388749.0
Latitude: 32°51'26.9"S
Longitude: 151°48'39.7"E

GS Map: -
MGA Zone: 0
Coordinate Source: GPS - Global Positioning System

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	20.00	250			Auger - Hollow Flight
1		Annulus	Waterworn/Rounded	10.00	18.00				Graded, Q:172.000m3, PL:Poured/Shovelled
1	1	Casing	Pvc Class 9	-0.50	18.00	162	150		Seated on Bottom, Glued
1	1	Opening	Slots - Horizontal	12.00	18.00	162		1	Casing - Machine Slotted, PVC Class 9, Glued, SL: 32.0mm, A: 0.25mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
6.00	18.00	12.00	Unknown	3.00				01:00:00	

Geologists Log

Drillers Log

From	To	Thickness	Drillers Description	Geological Material	Comments

(m)	(m)	(m)			
0.00	1.00	1.00	Top sand fill	Topsoil	
1.00	6.00	5.00	Dark clayey sand	Clayey Sand	
6.00	18.00	12.00	Light grey sand med to coarse	Sand	
18.00	20.00	2.00	Light grey fine sand	Sand	

Remarks

08/06/2011: Karla Abbs, 8-Jun-2011: Corrected Rock Types in Drillers Log

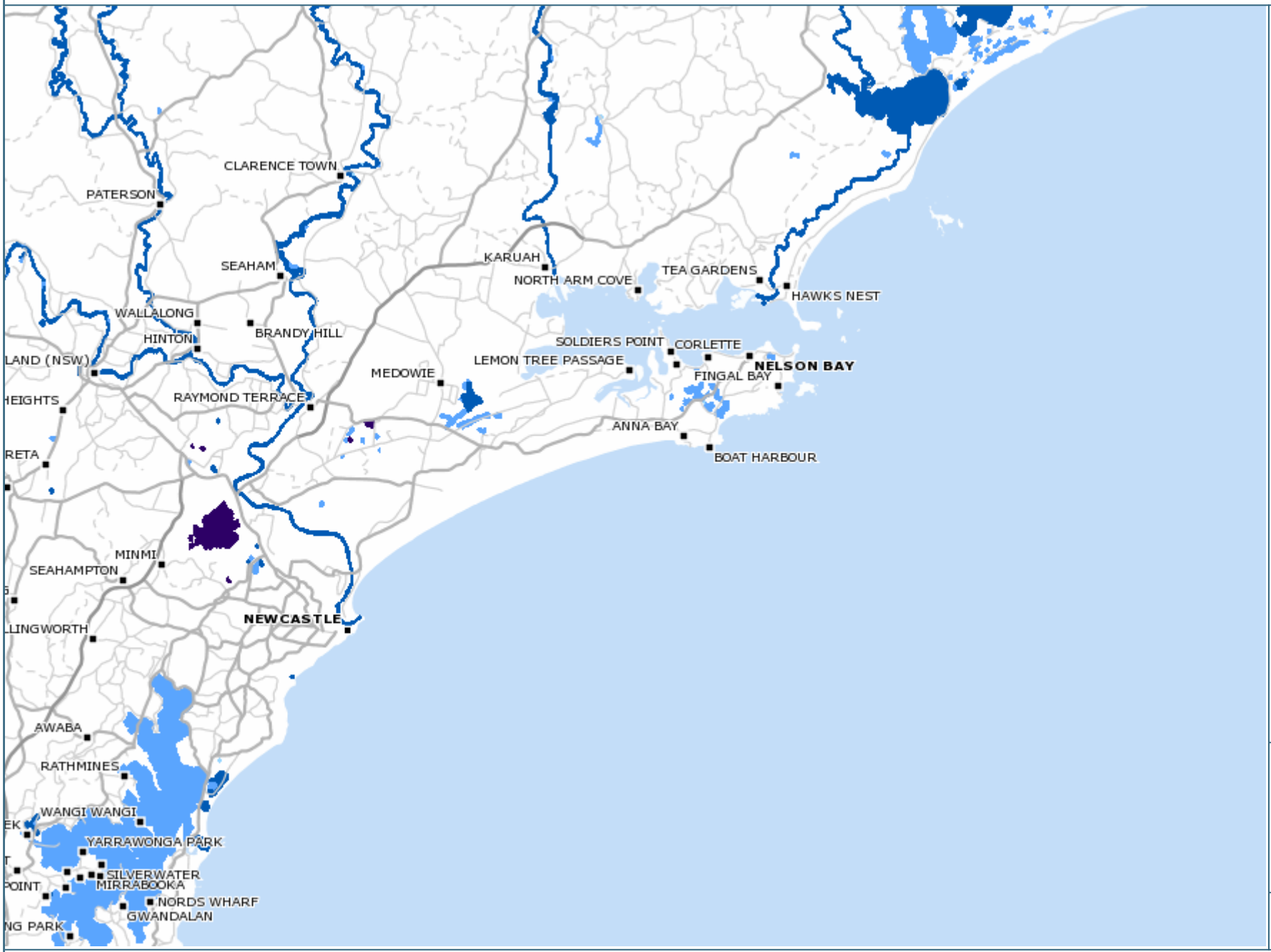
*** End of GW200423 ***

APPENDIX C: GROUNDWATER DEPENDENT ECOSYSTEMS MAP REPORTS

Australian Government
Bureau of Meteorology

Groundwater Dependent Ecosystems Atlas

717041 Aquatic GDEs



Aquatic Inflow Dependent Ecosystem (IDE), reliant on water in addition to rainfall

- Highly likely to be an IDE
- Likely to be an IDE

Aquatic GDE

- Known GDE - from regional s
- High potential GDE - from r
- Moderate potential GDE - fr
- Low potential GDE - from re
- Unclassified potential GDE
- High potential GDE - from n
- Moderate potential GDE - fr
- Low potential GDE - from na
- Unclassified potential GDE

Aquatic Inflow Dependent Ecosystem (IDE), reliant on water in addition to rainfall

- Highly likely to be an IDE
- Likely to be an IDE

Aquatic Inflow Dependent

N

1:539,698

Kilometres 10 20

Data Source: Bureau of Meteorology, Geoscience Australia and State/Territory lead water agencies. Refer to metadata for further information: Click here

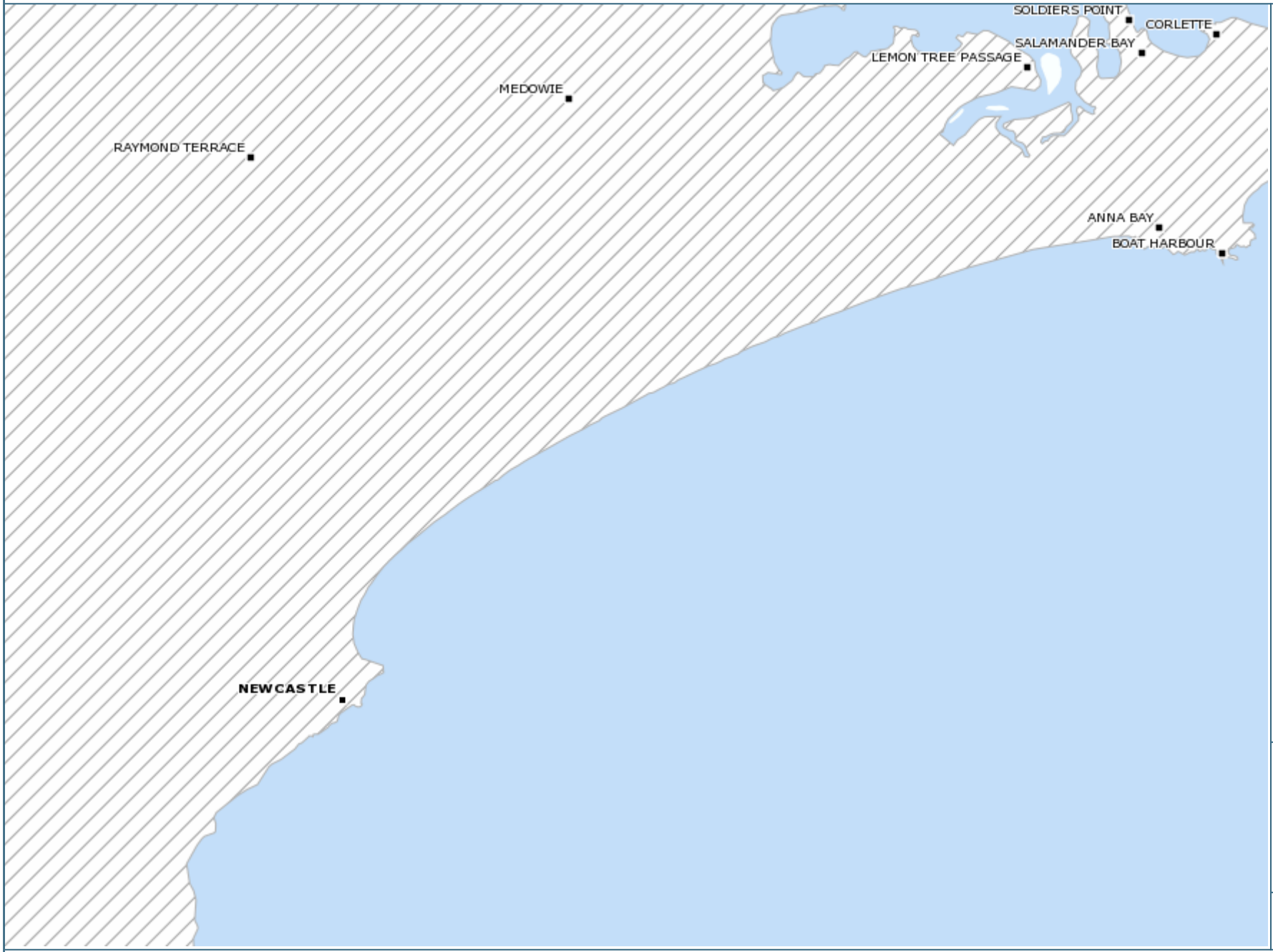
Australian Albers GDA94

Date: 4 February, 2018

Australian Government
Bureau of Meteorology

Groundwater Dependent Ecosystems Atlas

717041 Subterranean GDEs



Subterranean GDE (no data)

No ecosystems analysed

Subterranean GDE

Known GDE - from regional s
High potential GDE - from r
Moderate potential GDE - fr
Low potential GDE - from re
Unclassified potential GDE

N

1:222,406

Kilometres 5

Data Source: Bureau of Meteorology, Geoscience Australia and State/Territory lead water agencies. Refer to metadata for further information: Click here

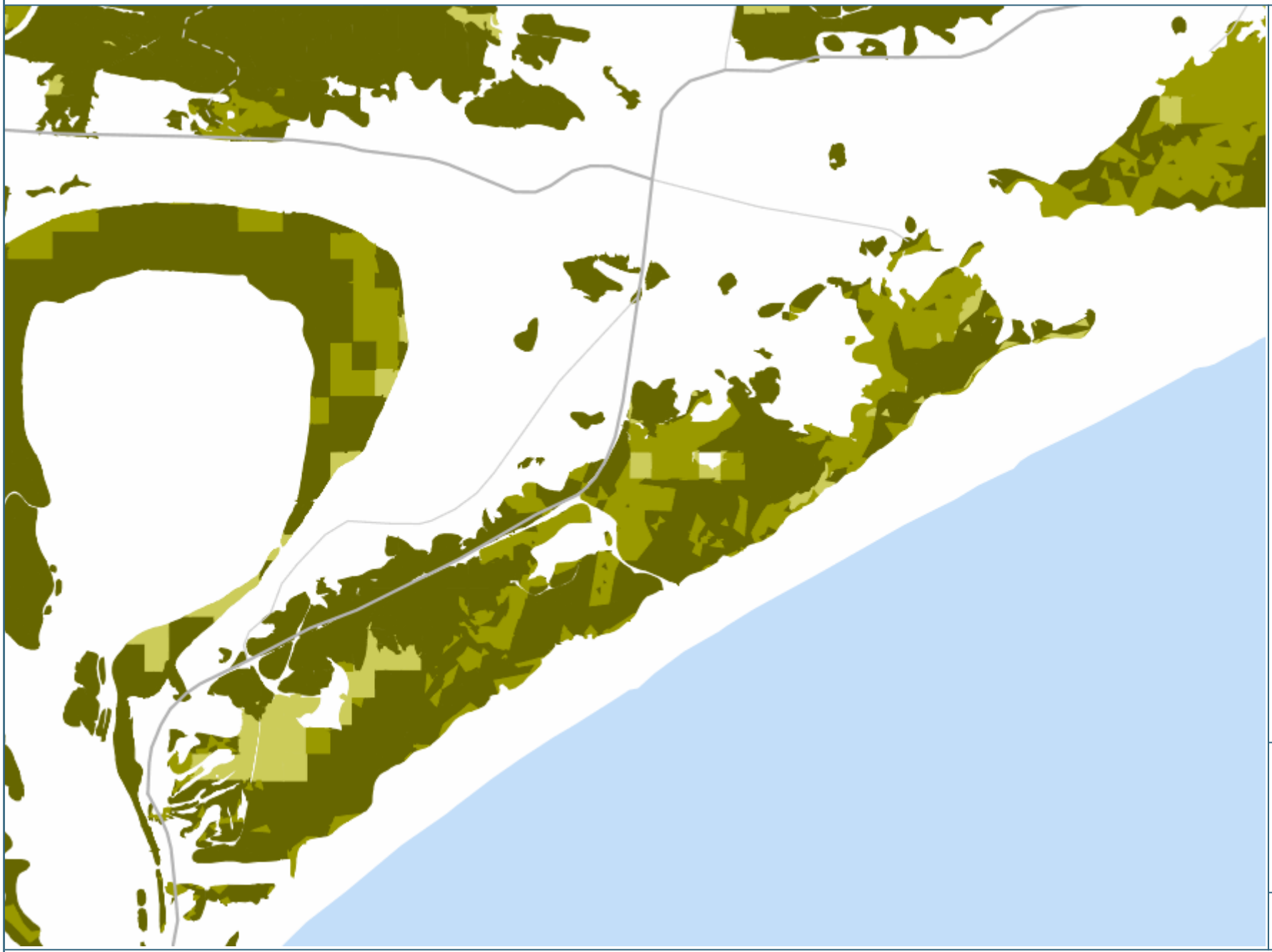
Australian Albers GDA94

Date: 4 February, 2018

Australian Government
Bureau of Meteorology

Groundwater Dependent Ecosystems Atlas

717041 Terrestrial GDEs



Data Source: Bureau of Meteorology, Geoscience Australia and State/Territory lead water agencies. Refer to metadata for further information: Click here

Australian Albers GDA94

Date: 4 February, 2018

APPENDIX D: BORELOGS

LOCATION:	Fullerton Cove	JOB No.	717041	TRENCH NUMBER:	BH1	LOGGED BY:
EASTING:		DRILL TYPE:	Sonic Drill			LV
NORTHING:		DATE STARTED:	12/03/18	CLIENT:	Element Environment	APPROVED:
ELEVATION:		DATE FINISHED:	12/03/18			LV

Water Level
▼ Water level
▽ Potential water level range
Moisture
D=Dry M=Moist MS=Moist Saturated S=Saturated

PAGE #: 1 / 1

Depth (metres).	STRATIGRAPHY	GRAPHIC LOG	SAMPLES: Sample Interval	Moisture	pH Field	pH FOX	Water Level	COMMENTS
0	FILL: Loose grey-brown SAND with chitter gravels of mixed lithology and coal.			D	6.9	5.7		
1				M	7.2	6.1		
	FILL: Loose, faun SAND of homogeneous medium grain size.			MS	6.8	3.7	▼	
2	FILL: Loose, dark brown SAND of homogeneous medium grain size.			MS	6.5	4.9		
3	FILL: Loose, faun SAND of medium - coarse grain size.			MS	6.5	3.6		
4	FILL: Loose brown SAND of medium - coarse grain size with chitter.			MS	6.2	3.7		
5	NATURAL: Loose, faun - brown SAND of medium grain size.							
6								
7	NATURAL: Loose, light brown - grey SAND of medium grain size.			MS	5.4	3.2		
8								
9								
10								
11	NATURAL: Loose, light grey SAND with medium - coarse grain size, shell grit present.			MS	6.3	6.1		
12	NATURAL: Loose, grey SAND of medium grain size, minor shell grit present.			MS	7.8	6.1		
13								
14								
15								
16	NATURAL: Loose, grey SAND of medium - coarse grain size, shell grit present.			MS	8.3	6.1		
17								
18								
19	End of core @ 18.0m (> 16m below the water table).							

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION:	Fullerton Cove	JOB No.	717041	TRENCH NUMBER:	BH2	LOGGED BY:
EASTING:		DRILL TYPE:	Sonic Drill			LV
NORTHING:		DATE STARTED:	13/03/18	CLIENT:	Element Environment	APPROVED:
ELEVATION:		DATE FINISHED:	13/03/18			LV

Water Level
▼ Water level
▽ Potential water level range
Moisture
D=Dry M=Moist MS=Moist Saturated S=Saturated

PAGE #: 1 / 1

Depth (metres)	STRATIGRAPHY	GRAPHIC LOG	SAMPLES: Sample Interval	Moisture	pH Field	pH FOX	Water Level	COMMENTS
0	NATURAL: Loose, light brown SAND.			D	8.7	6.6		
1	NATURAL: Loose, cream - light brown SAND of medium grain size. Both chitter gravels and brick present.							
2				M	5.0	1.3	▽	
3	NATURAL: Loose, dark brown - black SAND of medium grain size. Organic layer present.			M	6.5	2.8		
4	NATURAL: Loose, light brown - grey SAND of medium coarse grain size.			M	6.4	5.2		
5	NATURAL: Loose cream - light brown SAND of medium - coarse grain size.							
6	Minor presence of organics.			MS	6.2	5.6	▽	
7								
8								
9	NATURAL: Loose, light brown - brown SAND of medium grain size.			MS	6.4	3.1		
10								
11								
12	NATURAL: Loose, cream SAND of medium grain size.			MS	6.9	5.8		
13								
14								
15								
16	NATURAL: Loose, light grey SAND of medium grain size.			MS	6.5	5.5		
17								
18								
19								
20	Grading to grey mottle.			MS	6.0	6.4		
21								
22								
23								
24				MS	6.6	6.1		
25	End of core @ 24.0m (> 16m below the water table).							

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION:	Fullerton Cove	JOB No.	717041	TRENCH NUMBER:	BH3	LOGGED BY:
EASTING:		DRILL TYPE:	Sonic Drill			LV
NORTHING:		DATE STARTED:	13/03/18	CLIENT:	Element Environment	APPROVED:
ELEVATION:		DATE FINISHED:	13/03/18			LV

Water Level
▼ Water level
▽ Potential water level range
Moisture
D=Dry M=Moist MS=Moist Saturated S=Saturated

PAGE #: 1 / 1

Depth (metres)	STRATIGRAPHY	GRAPHIC LOG	SAMPLES: Sample Interval	Moisture	pH Field	pH FOX	Water Level	COMMENTS
0	FILL: Loose, grey SAND of medium grain size.			D	7.2	6.9		
3	FILL: Loose, dark brown, loamy SAND of fine - medium grain size. Both chitter gravels and organics present.			DM	7.4	6.5		
				DM	7.7	5.9		
4				DM	7.4	5.7		
	NATURAL: Loose, cream SAND of medium grain size with brown mottle.							
5	NATURAL: Loose, cream SAND of medium grain size.						▽	
6				MS	7.0	5.8	▽	
8	Becoming medium - coarse grain size.			MS	7.1	5.7		
9	NATURAL: Loose, grey- brown SAND of medium grain size.			MS	6.9	2.6		
12	NATURAL: Loose, light grey SAND of medium grain size. Shell grit and fine gravels present.			MS	7.4	6.3		
15	Grading to dark grey mottle.			MS	8.2	6.2		
16	NATURAL: Loose, grey SAND with minor shell grit present.							
18	NATURAL: Loose, yellow - grey SAND of medium grain size.			MS	6.8	5.9		
21	End of core @ 21.0m (> 16m below the water table).							
22								

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Stockton	JOB No. 717041	TRENCH NUMBER: BH4	LOGGED BY:
EASTING:	DRILL TYPE: Sonic Drill		LV
NORTHING:	DATE STARTED: 14/03/18	CLIENT: Element Environment	APPROVED:
ELEVATION:	DATE FINISHED: 14/03/18		LV

Water Level
▼ Water level
▽ Potential water level range
Moisture
D=Dry M=Moist MS=Moist Saturated S=Saturated

PAGE #: 1 / 1

Depth (metres)	STRATIGRAPHY	GRAPHIC LOG	SAMPLES: Sample Interval	Moisture	pH Field	pH FOX	Water Level	COMMENTS
0	FILL: Loose, grey SAND of medium grain size. Gravels and organics present.			D	7.2	5.5		
1								
2	FILL: Loose, grey SAND with chitter and gravels present.			DM	7.3	5.1		
3								
4	NATURAL: Loose, coffee SAND of medium grain size.			MS	7.5	4.8	▽ ▽	
5	NATURAL: Loose, milk - coffee SAND of medium grain size.			MS	7.4	5.0		
6	NATURAL: Loose, light brown SAND of medium grain size.			MS	7.3	3.0		
7								
8								
9				MS	7.0	2.6		
10								
11								
12	NATURAL: Loose, grey SAND of medium grain size.			MS	7.4	4.6		
13								
14								
15	NATURAL: Loose, brown SAND of medium grain size.			MS	7.2	3.9		
16	NATURAL: Loose, light grey SAND of medium grain size.			MS	7.2	2.6		
				MS	7.5	6.1		
17	NATURAL: Loose, dark grey SAND of medium - coarse grain size. Shell grit present.			MS	8.7	5.6		
18	NATURAL: Loose, light brown - grey SAND of medium grain size.							
19								
20								
21	NATURAL: Loose, white- light grey SAND of fine - medium grain size.			MS	8.8	6.1		
22	End of core @ 21.0m (> 16m below the water table).							

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Department of Primary Industries Water

Form A Particulars of completed work

Driller's Licence No:	1772	1
Class of Licence:	4	
Driller's Name:	Peter Stewart	
Assistant Driller:	BLAKE Stewart	
Contractor:	Port Stephens Drilling	
New bore		Replacement bore
Deepened		Enlarged
Reconditioned		Other (specify)
Final Depth	12.18 m	Monitoring Well 12.18

Work Licence No:	MW x 1	2
Name of Licensee:	Coal Resources PTY LTD	
Intended Use:	Monitoring Wells	
Completion Date:	5-5-17	

DRILLING DETAILS 3

From (m)	To (m)	Hole Diameter (mm)	Drilling Method See Code 3
0	12.18	101	1

WATER BEARING ZONES 4

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method See Code 4		D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)
5.46	12.18	6.72	5.46									

CASING / LINER DETAILS 5

Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code 5
8	60.33	5.02		12.18	5

Casing support method — See Code 5: 2

Type of casing bottom — See Code 5: 2

Centralisers installed (Yes/No): NO (indicate on sketch)

Sump installed (Yes/No): NO From m To m

Pressure cemented (Yes/No): NO From m To m

Casing Protector cemented in place

WATER ENTRY DESIGN 6

General Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Opening type See Code 6	Fixing See Code 5	Screen Aperture (mm)	Slot Details Length (mm)	Width (mm)	Alignment See Code 6
8	60.33	5.02	12.18	9.18	5	5	0.5	3000	60.33	H

GRAVEL PACK 7

Type		Grade		Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres	Quantity m^3
Rounded		Graded	/	8	16	12.18	3.18	180	
Crushed		Ungraded				3.18	2.18		
Bentonite/Grout seal (Yes/No)	Yes								
Method of placement of Gravel Pack		See Code 7	2						

For Departmental use only: G W

Department of Primary Industries Water

Form A Particulars of completed work

Work Licence No: MW-X1

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud (Yes/No) NO Name: Base Resources PTY LTD

Method	Bailing/Surging	Jetting	Airlifting	Backwashing	Pumping	Other:
Duration	hrs	hrs	hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical(s) used	Quantity applied (Litres)	Method of application
Decon 90	5 LTRS	Sprayed on

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level m Test Method See Code 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: m Is work partly backfilled: (Yes/No)

Is work abandoned: (Yes/No) Method of abandonment: Backfilled Plugged Capped

Has any casing been left in the work (Yes/No) From m To m

Sealing / fill type (See Code 11)	From depth (m)	To depth (m)	Sealing / fill type (See Code 11)	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist Geologist Driller Diviner Client Other 12

13

Lot No 1 DP No 1006399

Work Location Co ordinates Easting Northing Zone 54

GPS: (Yes/No) >> AMG/AGD or MGA/GDA (See explanation)

Longitude Latitude

Please mark the work site with "X" on the CLID provided map.

Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: Date: 5-5-17

Licensee: Date: 5-5-17

Department of Primary Industries Water

Form A Particulars of completed work

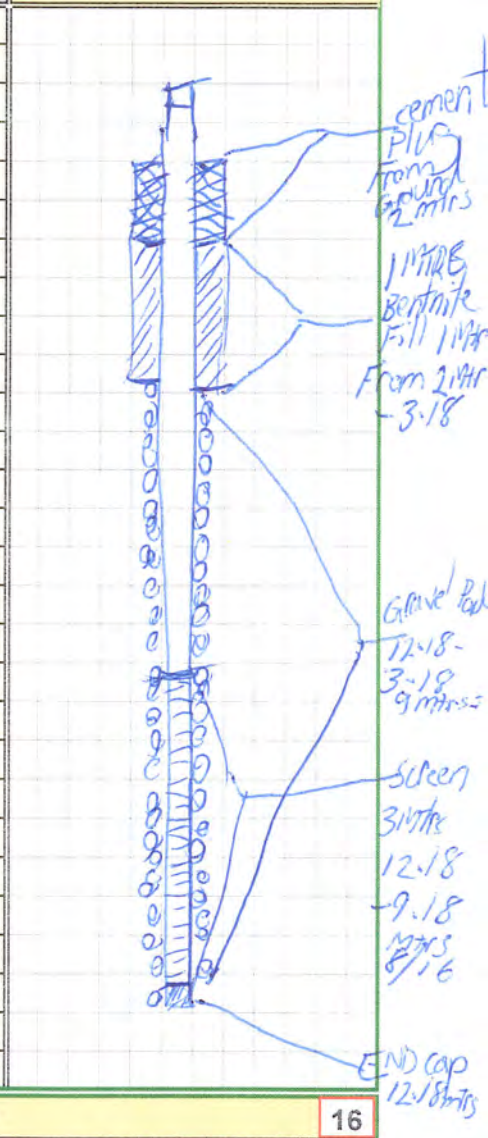
Work Licence No:

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY)

15

Depth From (m)	Depth To (m)	Description (See Code 15)
0		
0	.5	Black - Amber Sand
.5	5.5	Amber sand Medium grain
5.5	12.18	Amber sand Course to Medium Grain

WORK CONSTRUCTION SKETCH



WORK NOT CONSTRUCTED BY DRILLING RIG

16

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

Please attach copies of the following if available

17

Geologist log	(Yes/No) ☐	Laboratory analysis of water Sample	(Yes/No) ☐	Pumping test(s)	(Yes/No) ☐
Geophysical log	(Yes/No) ☐	Sieve analysis of aquifer material	(Yes/No) ☐	Installed Pump details	(Yes/No) ☐

Department of Primary Industries Water — Form A Particulars of completed work

1

Driller's Licence No: 1772
Class of Licence: 4
Driller's Name: Peter Stewart
Assistant Driller: Blake Stewart
Contractor: Port Stephens Drilling

New bore		Replacement bore	
Deepened		Enlarged	
Reconditioned		Other (specify)	/

Final Depth: 26.04 m — Monitoring well 26.04

2

Work Licence No: MW3
Name of Licensee: Boral Resources PTY LTD
Intended Use: Monitoring well
Completion Date: 6-5-19

DRILLING DETAILS — 3

From (m)	To (m)	Hole Diameter (mm)	Drilling Method See Code 3
0	26.04	101	1

WATER BEARING ZONES — 4

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method See Code 4	D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)
5.31	26.04	20.73	5.31	/	/	/	/	/	/	/	/

CASING / LINER DETAILS — 5

Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code 5
8	60.53	5.02		26.04	5

Casing support method — See Code 5: 2
Type of casing bottom — See Code 5: 2
Centralisers installed (Yes/No): NO (indicate on sketch)
Sump installed (Yes/No): NO — From m To m
Pressure cemented (~~Yes~~/No): N/A — From m To m
Casing Protector cemented in place

WATER ENTRY DESIGN — 6

General: Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Opening type See Code 6	Fixing See Code 5	Screen Aperture (mm)	Slot Details: Length (mm)	Width (mm)	Alignment See Code 6
8	60.53	5.02	5.31	26.04	5	5	0.5	3000	60.53	H

GRAVEL PACK — 7

Type		Grade		Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres	Quantity m^3
Rounded		Graded	/	8/16		3.4	26.4	920	
Crushed		Ungraded							
Bentonite/Grout seal (Yes/No): YES						2.4	~~2.4~~ 3.4	~~2.4~~ 23	~~20~~
Method of placement of Gravel Pack — See Code 7: 2									

For Departmental use only: G W

Department of Primary Industries Water

Form A Particulars of completed work

Work Licence No: MW-X3

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud (Yes/No) NO Name: Bore Resources PTY LTD

Method	Bailing/Surging	Jetting	Airlifting	Backwashing	Pumping	Other:
Duration	hrs	hrs	hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical(s) used	Quantity applied (Litres)	Method of application
Decon 90	5 LTRS	SPRAYED ON

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level m Test Method See Code 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: m Is work partly backfilled: (Yes/No)

Is work abandoned: (Yes/No) Method of abandonment: Backfilled Plugged Capped

Has any casing been left in the work (Yes/No) From m To m

Sealing / fill type (See Code 11)	From depth (m)	To depth (m)	Sealing / fill type (See Code 11)	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist Geologist Driller Diviner Client / Other 12

13

Lot No 1 DP No 1006399

Work Location Co ordinates Easting Northing Zone 54

GPS: (Yes/No) >> AMG/AGD or MGA/GDA (See explanation)

Longitude Latitude

Please mark the work site with "X" on the CLID provided map.

Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: Peter Stewart

Date: 5-5-17

Licensee:

Date: 5-5-17

Department of Primary Industries Water

Form A Particulars of completed work

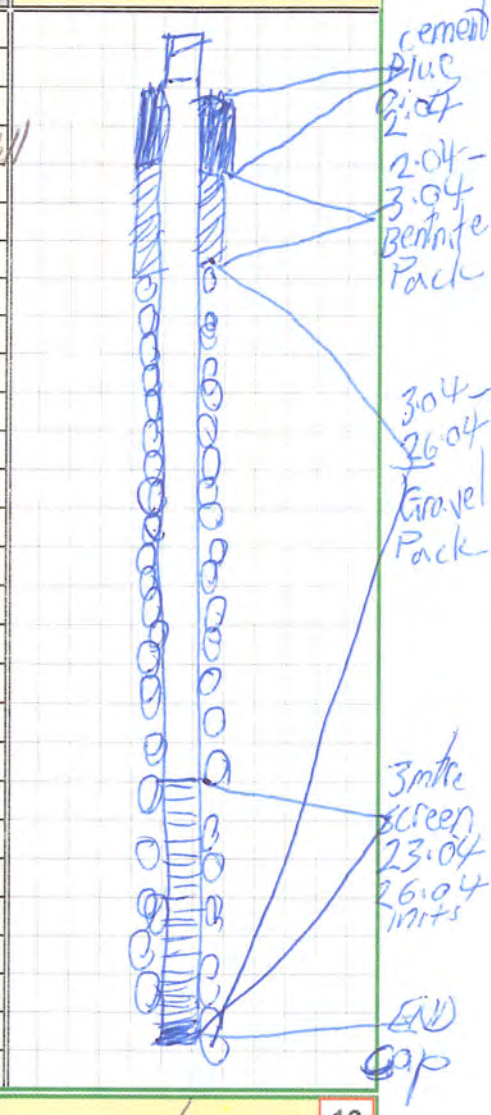
Work Licence No: MW-X3

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY)

15

Depth From (m)	Depth To (m)	Description (See Code 15)
0	3	Amber Sand Medium Grain
3	12.9	Amber Sand Medium to Coarse Grain
12.9	14.9	Grey Sand with Shell Fragments
14.9	24	Grey Sand with Fine Gravel Stone
24	26.9	Grey Sand Medium Sand

WORK CONSTRUCTION SKETCH



WORK NOT CONSTRUCTED BY DRILLING RIG

16

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other ☐

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

Please attach copies of the following if available

17

Geologist log	(Yes/No) ☐	Laboratory analysis of water Sample	(Yes/No) ☐	Pumping test(s)	(Yes/No) ☐
Geophysical log	(Yes/No) ☐	Sieve analysis of aquifer material	(Yes/No) ☐	Installed Pump details	(Yes/No) ☐

NSW GOVERNMENT | Department of Primary Industries Water

Form A Particulars of completed work

1

Driller's Licence No: 1772
Class of Licence: 4
Driller's Name: Peter Stewart
Assistant Driller: Blake Stewart
Contractor:

New bore		Replacement bore	
Deepened		Enlarged	
Reconditioned		Other (specify)	

Final Depth: 11.44 m — Monitoring well

2

Work Licence No: MW-X3
Name of Licensee: Boca Resources PTY LTD
Intended Use: Monitoring Well
Completion Date: 6-5-17

DRILLING DETAILS **3**

From (m)	To (m)	Hole Diameter (mm)	Drilling Method See Code 3
0	11.44	101	1

WATER BEARING ZONES **4**

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method See Code 4		D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)
4.92	11.44	6.52	4.92									

CASING / LINER DETAILS **5**

Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code 5
8	60.53	5.02	0	11.44	5

Casing support method — See Code 5: 2
Type of casing bottom — See Code 5: 2
Centralisers installed {Yes/No}: NO (indicate on sketch)
Sump installed {Yes/No}: NO From m To m
Pressure cemented {Yes/No}: NO From m To m
Casing Protector cemented in place

WATER ENTRY DESIGN **6**

General: Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Opening type See Code 6	Fixing See Code 5	Screen Aperture (mm)	Slot Details: Length (mm)	Width (mm)	Alignment See Code 6
8	60.53	5.02	8.44	11.44	5	5	0.5	3000	60.53	H

GRAVEL PACK **7**

Type		Grade		Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres	Quantity m^3
Rounded		Graded	✓	8	16	2.44	11.44	180	
Crushed		Ungraded							

Bentonite/Grout seal (Yes/No): YES
Method of placement of Gravel Pack — See Code 7: 2

For Departmental use only: GW

Department of Primary Industries Water

Form A Particulars of completed work

Work Licence No:

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud (Yes/No)		Name:									
Method	Bailing/Surging		Jetting		Airlifting		Backwashing		Pumping		Other
Duration		hrs		hrs		hrs		hrs		hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical(s) used	Quantity applied (Litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level ____ m Test Method ____ See Code 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: ____ m Is work partly backfilled: (Yes/No) ____

Is work abandoned: (Yes/No) ____ Method of abandonment: Backfilled ____ Plugged ____ Capped ____

Has any casing been left in the work (Yes/No) ____ From ____ m To ____ m

Sealing / fill type (See Code 11)	From depth (m)	To depth (m)	Sealing / fill type (See Code 11)	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist ____ Geologist ____ Driller ____ Diviner ____ Client ✓ Other ____ 12

13

Lot No 1 DP No 1006399

Work Location Co ordinates Easting ____ Northing ____ Zone 54

GPS: (Yes/No) ____ >> AMG/AGD ____ or MGA/GDA ____ (See explanation)

Longitude ____ Latitude ____

Please mark the work site with "X" on the CLID provided map.

Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: Peter Stewart **Licensee:** [signature]

Date: 6-5-17 **Date:** 6-5-17

Please submit forms to water.gds@dpi.nsw.gov.au or to the local NSW Office of Water agency

Department of Primary Industries Water

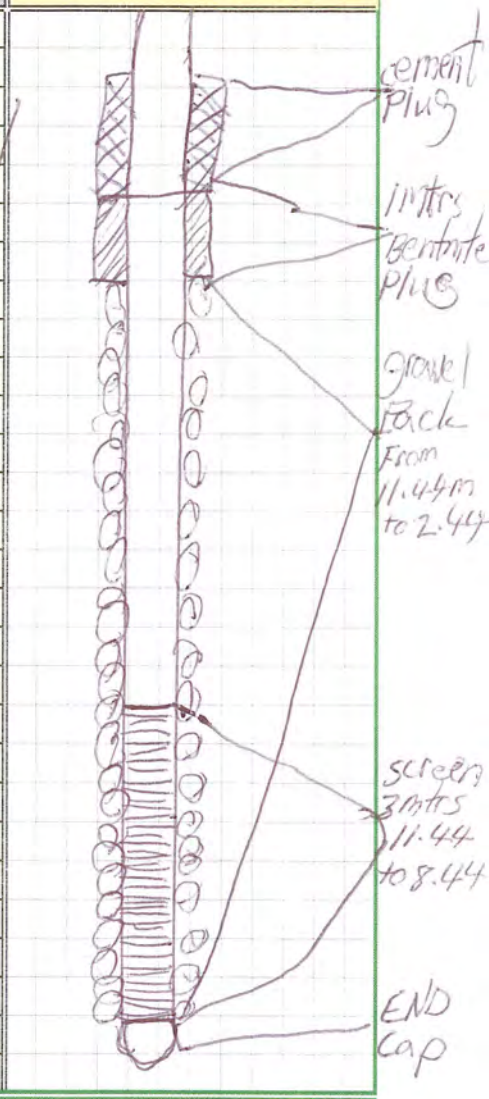
Form A Particulars of completed work

Work Licence No:

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY)

Depth From (m)	Depth To (m)	Description (See Code 15)
0	5	MG Amber Sand
5	8	MG/CG Amber Sand
8	10	CG/F Fine Gravel Grey Colour
10	11.44	Amber CG sand with fine Gravel

15 WORK CONSTRUCTION SKETCH



WORK NOT CONSTRUCTED BY DRILLING RIG — 16

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

Please attach copies of the following if available — 17

Geologist log	(Yes/No) ☐	Laboratory analysis of water Sample	(Yes/No) ☐	Pumping test(s)	(Yes/No) ☐
Geophysical log	(Yes/No) ☐	Sieve analysis of aquifer material	(Yes/No) ☐	Installed Pump details	(Yes/No) ☐

Department of Primary Industries
Water

Form A Particulars of completed work

1

Driller's Licence No: 1772
Class of Licence: 4
Driller's Name: Peter Stewart
Assistant Driller: Blake Stewart
Contractor: Port Stephens Drilling

New bore		Replacement bore	
Deepened		Enlarged	
Reconditioned		Other (specify)	Monitoring well

Final Depth: 12.10 m

2

Work Licence No: MW-X14
Name of Licensee: Boral Resources PTY LTD
Intended Use: Monitoring well
Completion Date: 19-5-17

DRILLING DETAILS **3**

From (m)	To (m)	Hole Diameter (mm)	Drilling Method See Code 3
0	12.10		1

WATER BEARING ZONES **4**

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method See Code 4	D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)
8.90	12.10	3.2	8.90								

CASING / LINER DETAILS **5**

Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code 5
8	60.33	5.02		12.10	

Casing support method: See Code 5: 2
Type of casing bottom: See Code 5: 2
Centralisers installed {Yes/No}: NO (indicate on sketch)
Sump installed {Yes/No}: NO From m To m
Pressure cemented {Yes/No}: NO From m To m
Casing Protector cemented in place

WATER ENTRY DESIGN **6**

General Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Opening type See Code 6	Fixing See Code 5	Screen Aperture (mm)	Slot Details Length (mm)	Width (mm)	Alignment See Code 6
8	60.33	5.02	8.90	12.10	5	5	0.5	3000	60.33	H

GRAVEL PACK **7**

Type	Grade	Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres	Quantity m^3
Rounded	Graded	8	16	2	12.10	180	
Crushed	Ungraded						
Bentonite/Grout seal (Yes/No): YES				2	3	30	
Method of placement of Gravel Pack: See Code 7: 1							

For Departmental use only: G W

Department of Primary Industries Water

Form A Particulars of completed work

Work Licence No: MW-[illegible]

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud (Yes/No) No Name: Boral Resources PTY LTD

Method	Bailing/Surging	Jetting	Airlifting	Backwashing	Pumping	Other:
Duration	hrs	hrs	hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical(s) used	Quantity applied (Litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level m Test Method See Code 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: m Is work partly backfilled: (Yes/No)

Is work abandoned: (Yes/No) Method of abandonment: Backfilled Plugged Capped

Has any casing been left in the work (Yes/No) From m To m

Sealing / fill type (See Code 11)	From depth (m)	To depth (m)	Sealing / fill type (See Code 11)	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist Geologist Driller Diviner Client Other 12

13

Lot No 1 DP No 1006399

Work Location Co ordinates Easting Northing Zone 54

GPS: (Yes/No) >> AMG/AGD or MGA/GDA (See explanation)

Longitude Latitude

Please mark the work site with "X" on the CLID provided map.

Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: [signature] Licensee: ----------

Date: 19-5-17 Date: ----------

Department of Primary Industries Water

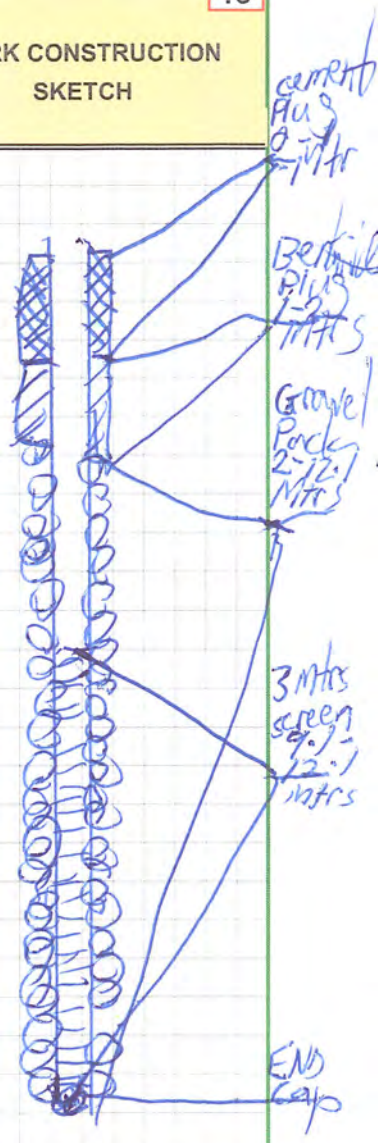
Form A Particulars of completed work

Work Licence No: MW-24

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY) — 15

Depth From (m)	Depth To (m)	Description (See Code 15)
0	4	Amber sand MG
4	7	Amber Sand MG with FG
7	10	Amber sand CG with Traces of Shell
10	12.1	Amber Sand CG

WORK CONSTRUCTION SKETCH



WORK NOT CONSTRUCTED BY DRILLING RIG — 16

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other ☐

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

Please attach copies of the following if available — 17

Geologist log	(Yes/No) ☐	Laboratory analysis of water Sample	(Yes/No) ☐	Pumping test(s)	(Yes/No) ☐
Geophysical log	(Yes/No) ☐	Sieve analysis of aquifer material	(Yes/No) ☐	Installed Pump details	(Yes/No) ☐

Department of Primary Industries Water

Form A Particulars of completed work

1

Driller's Licence No: 1772
Class of Licence: 4
Driller's Name: Peter Stewart
Assistant Driller: Blake Stewart
Contractor: Port Stephens Drilling

New bore		Replacement bore	
Deepened		Enlarged	
Reconditioned		Other (specify)	Monitoring well

Final Depth 24.48 m

2

Work Licence No: MW-X4
Name of Licensee: Boral Resources PTY LTD
Intended Use: Monitoring well
Completion Date: 18-5-17

DRILLING DETAILS **3**

From (m)	To (m)	Hole Diameter (mm)	Drilling Method See Code 3
0	24.48	101	1

WATER BEARING ZONES **4**

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method See Code 4	D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)
8.74	24.48	15.74	8.74								

CASING / LINER DETAILS **5**

Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code 5
8	60.53	5.07		24.48	5

Casing support method See Code 5: 2
Type of casing bottom See Code 5: 2
Centralisers installed {Yes/No}: NO (indicate on sketch)
Sump installed {Yes/No}: NO From m To m
Pressure cemented {Yes/No}: NO From m To m
Casing Protector cemented in place

WATER ENTRY DESIGN **6**

General Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Opening type See Code 6	Fixing See Code 5	Screen Aperture (mm)	Slot Details Length (mm)	Width (mm)	Alignment See Code 6
8	60.53	5.07	8.74	24.48	5	5	0.5	3000	60.53	A

GRAVEL PACK **7**

Type		Grade		Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres	Quantity m^3
Rounded		Graded	✓	8	16	3	24.48	360	
Crushed		Ungraded							

Bentonite/Grout seal (Yes/No)
Method of placement of Gravel Pack See Code 7

For Departmental use only: G W

Department of Primary Industries Water

Form A Particulars of completed work

Work Licence No: MW-X64

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud (Yes/No) No Name: Bore Resources PTY LTD

Method	Bailing/Surging	Jetting	Airlifting	Backwashing	Pumping	Other:
Duration	hrs	hrs	hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical(s) used	Quantity applied (Litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level m Test Method See Code 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: m Is work partly backfilled: (Yes/No)

Is work abandoned: (Yes/No) Method of abandonment: Backfilled Plugged Capped

Has any casing been left in the work (Yes/No) From m To m

Sealing / fill type (See Code 11)	From depth (m)	To depth (m)	Sealing / fill type (See Code 11)	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist Geologist Driller Diviner Client Other 12

13

Lot No 1 DP No 1006399

Work Location Co ordinates Easting Northing Zone 54

GPS: (Yes/No) >> AMG/AGD or MGA/GDA (See explanation)

Longitude Latitude

Please mark the work site with "X" on the CLID provided map.

Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: Peter Stewart Licensee:

Date: 18-5-17 Date:

Department of Primary Industries Water

Form A Particulars of completed work

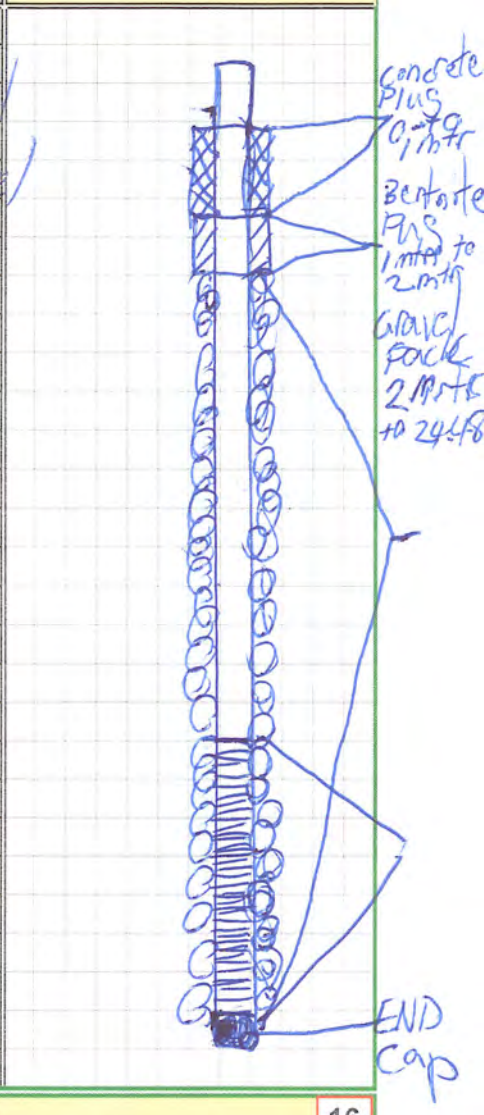
Work Licence No: MW- X4

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY)

15

Depth From (m)	Depth To (m)	Description (See Code 15)
0	4	Amber Sand ~~Fine~~ MG
4	12	Amber CG
12	15	Amber sand CG with Fine Gravel
15	17	Gray Sand MG with Shell
17	24	Gray sand CG with Fine Gravel

WORK CONSTRUCTION SKETCH



WORK NOT CONSTRUCTED BY DRILLING RIG

16

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other ☐

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

Please attach copies of the following if available

17

Geologist log	(Yes/No) ☐	Laboratory analysis of water Sample	(Yes/No) ☐	Pumping test(s)	(Yes/No) ☐
Geophysical log	(Yes/No) ☐	Sieve analysis of aquifer material	(Yes/No) ☐	Installed Pump details	(Yes/No) ☐

Department of Primary Industries Water

Form A Particulars of completed work

1

Driller's Licence No: 1772
Class of Licence: 4
Driller's Name: Peter Stewart
Assistant Driller: Blake Stewart
Contractor: Bot Stephens Drilling

New bore		Replacement bore	
Deepened		Enlarged	
Reconditioned		Other (specify)	-

Final Depth 24.18 m Monitoring well

2

Work Licence No: MW25
Name of Licensee: Boral Resources Pty LTD
Intended Use: Monitoring well
Completion Date: 6-5-17

DRILLING DETAILS **3**

From (m)	To (m)	Hole Diameter (mm)	Drilling Method See Code 3
0	24.18		1

WATER BEARING ZONES **4**

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method See Code 4	D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)
2.45	24.18	21.73	2.45								

CASING / LINER DETAILS **5**

Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code 5
8	60.53	5.02	~~21.18~~ 2.45	24.18	8

Casing support method See Code 5: 2
Type of casing bottom See Code 5: 2
Centralisers installed {Yes/No}: No (indicate on sketch)
Sump installed {Yes/No}: No From m To m
Pressure cemented {Yes/No}: No From m To m
Casing Protector cemented in place

WATER ENTRY DESIGN **6**

General Material Code 5	General OD (mm)	General Wall Thickness (mm)	General From (m)	General To (m)	General Opening type See Code 6	General Fixing See Code 5	Screen Aperture (mm)	Slot Details Length (mm)	Slot Details Width (mm)	Slot Details Alignment See Code 6
~~8~~	~~60.53~~	5.02	~~21.18~~ 2.45	24.18	5	5	.05	2000	60.53	H

GRAVEL PACK **7**

Type		Grade		Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres	Quantity m^3
Rounded		Graded	1	8/16		3.18	24.18	375	
Crushed		Ungraded							

Bentonite/Grout seal (Yes/No): Yes
Method of placement of Gravel Pack: See Code 7: 1

For Departmental use only: G W

Department of Primary Industries Water

Form A Particulars of completed work

Work Licence No: MW-X5

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud (Yes/No) [ ] Name: Bore Resources PTY LTD

Method	Bailing/Surging	Jetting	Airlifting	Backwashing	Pumping	Other:
Duration	hrs	hrs	hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical(s) used	Quantity applied (Litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level [ ] m Test Method [ ] See Code 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: [ ] m Is work partly backfilled: (Yes/No) [ ]

Is work abandoned: (Yes/No) [ ] Method of abandonment: Backfilled [ ] Plugged [ ] Capped [ ]

Has any casing been left in the work (Yes/No) [ ] From [ ] m To [ ] m

Sealing / fill type (See Code 11)	From depth (m)	To depth (m)	Sealing / fill type (See Code 11)	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist [ ] Geologist [ ] Driller [ ] Diviner [ ] Client [ ] Other [ ] 12

13

Lot No 1 DP No 1006399

Work Location Co ordinates Easting [ ] Northing [ ] Zone 54

GPS: (Yes/No) [ ] >> AMG/AGD [ ] or MGA/GDA [ ] (See explanation)

Longitude [ ] Latitude [ ]

Please mark the work site with "X" on the CLID provided map.

Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: [signature] Licensee: ----------

Date: 6-5-17 Date: ----------

Please submit forms to water.gds@dpi.nsw.gov.au or to the local NSW Office of Water agency

Department of Primary Industries Water

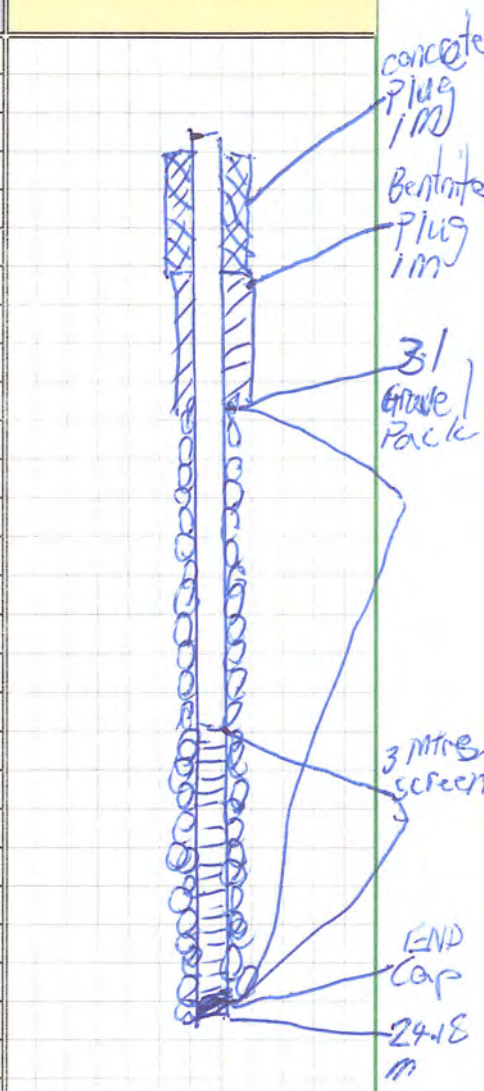
Form A Particulars of completed work

Work Licence No:

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY) — 15

Depth From (m)	Depth To (m)	Description (See Code 15)
0		
0	8	Amber sand MG
8	15	Amber sand MG with FG
15	19	Grey Sand with Shell
19	24.18	Grey Sand MG

WORK CONSTRUCTION SKETCH



WORK NOT CONSTRUCTED BY DRILLING RIG — 16

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other ☐

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

Please attach copies of the following if available — 17

Geologist log	(Yes/No) ☐	Laboratory analysis of water Sample	(Yes/No) ☐	Pumping test(s)	(Yes/No) ☐
Geophysical log	(Yes/No) ☐	Sieve analysis of aquifer material	(Yes/No) ☐	Installed Pump details	(Yes/No) ☐

CODE TABLES

DRILLING METHOD 3

1	Auger - Hollow Flight	9	Rotary - Percussion - (Down Hole Hammer)
2	Auger - Solid Flight	10	Rotary - Percussion - Foam injection
3	Cable Tool - Drill and Drive Casing	11	Rotary - Reverse circulation - Air
4	Cable Tool - Mud stabilised	12	Rotary - Reverse circulation - Mud
5	Rotary Air	13	Rotary - Coring
6	Rotary - Air/foam	14	Jetted - Air
7	Rotary - Mud	15	Jetted - Water
8	Rotary - Water	16	Other - See page 2, N0 11

WATER BEARING ZONE 4

TEST METHOD

1	Airlift	6	Pump - Helical Roto
2	Bailer	7	Pump - Jet
3	Pump - Centrifugal	8	Pump - Turbine
4	Pump - Cylinder	9	Freeflow
5	Pump - Electric submersib		

FLOW MEASURING DEVICE

A	Container of known volum	F	Weir - Rectangular
B	Flow meter	G	Weir - V Notch - 60°
C	Flume	H	Weir - V Notch - 90°
D	Orifice, plate & manomete	I	Other
E	Ultra sonic meter		

CASING / LINER DETAILS 5

MATERIAL

1	A.B.S.	6	PVC - Class 12	11	Steel - Stainless
2	Aluminium	7	PVC - Class 15	12	Steel - Stainless 304
3	Concrete cylinder	8	PVC - Class 18	13	Steel - Stainless 316
4	Fibre glass (FRP)	9	Steel - ERW	14	Other
5	PVC - Class 9	10	Steel - Galvanised		

METHOD OF FIXING

1	Glued	6	Welded - Butt
2	Kwik-lock	7	Welded - Colla
3	Packer	8	Other
4	Riveted		
5	Screwed		

CASING SUPPORT METHOD

1	Driven into small hole	5	Held in clamp
2	Seated on bottom	6	Other
3	Seated on backfill		
4	Cemented		

TYPE OF CASING BOTTOM

1	Open end	5	Casing shoe
2	End cap	6	Wash down shoe
3	Plug - concrete	7	Cementing shoe
4	Plug - wood	8	Other

WATER ENTRY DESIGN 6

OPENING TYPE

1	Casing - Bridge slot	7	Casing - Plasma-cut slot
2	Casing - Drilled holes	8	Casing - Perforated in hole
3	Casing - Hand sawn slot	9	Screen - gauze / mesh
4	Casing - Louvre slot	10	Screen - round wire
5	Casing - Machine slotted	11	Screen - wedge wire
6	Casing - Oxy cut slot		

SLOT ALIGNMENT

D	Diagonal
H	Horizontal
V	Vertical

For MATERIAL and FIXING Codes Please refer to CASING DETAILS code table

GRAVEL PACK - METHOD OF PLACEMENT 7

1	Poured or shovelled into annulu	2	Placed through tremie pipe	3	Reverse circulated

WORK PARTLY BACKFILLED OR ABANDONED - SEALING MATERIAL 11

1	Cement grout	3	Bentonite	5	Clay	7	Gravel
2	Concrete	4	Drilled cuttings	6	Sand	8	Coarse stone

DRILLER'S ROCK STRATA DESCRIPTION 15

Reporting sequence	1 Rock type	2 Colour	3 Grain size	4 Texture
Example	Sandstone	Dk Grey	mg	Fractured

To save confusion, write the *full name of colour and abbreviate th following:* light = lt, dark = dk, fine grained = fg, medium grained = mg, coarse grained = cg. *Texture can relate t* weathered, fractured, broken, hard, soft etc.

Department of Primary Industries Water — Form A Particulars of completed work

1

Driller's Licence No: 1772
Class of Licence: 4
Driller's Name: Peter Stewart
Assistant Driller: Blake Stewart
Contractor: Port Stephens Drilling

New bore		Replacement bore	
Deepened		Enlarged	
Reconditioned		Other (specify)	✓

Final Depth: 27.58 m — monitoring well

2

Work Licence No: MW36
Name of Licensee: Boral Resources PTY LTD
Intended Use: Monitoring well
Completion Date: 5-5-17

DRILLING DETAILS — 3

From (m)	To (m)	Hole Diameter (mm)	Drilling Method See Code 3
0	27.58		1

WATER BEARING ZONES — 4

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method See Code 4		D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)
2.45	27.58	25.13	2.45									

CASING / LINER DETAILS — 5

Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code 5
8	60.53	5.02	0	27.58	5

Casing support method — See Code 5: 2
Type of casing bottom — See Code 5: 2
Centralisers installed {Yes/No}: No (indicate on sketch)
Sump installed {Yes/No}: No — From m To m
Pressure cemented {Yes/No}: No — From m To m
Casing Protector cemented in place

WATER ENTRY DESIGN — 6

General Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Opening type See Code 6	Fixing See Code 5	Screen Aperture (mm)	Slot Details Length (mm)	Width (mm)	Alignment See Code 6
8	60.53	5.02	14.58	27.58	5	5	.05	3000	60.53	H

GRAVEL PACK — 7

Type		Grade		Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres	Quantity m^3
Rounded		Graded	✓	8/16		3	27.	450	
Crushed		Ungraded							
Bentonite/Grout seal (Yes/No)									
Method of placement of Gravel Pack		See Code 7	1						

For Departmental use only: G W

Department of Primary Industries Water

Form A Particulars of completed work

Work Licence No: MW-X6

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud (Yes/No) | Name: Boral Resources PTY LTD

Method	Bailing/Surging	Jetting	Airlifting	Backwashing	Pumping	Other:
Duration	hrs	hrs	hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical(s) used	Quantity applied (Litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level ____ m | Test Method ____ | See Code 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: ____ m | Is work partly backfilled: (Yes/No) ____

Is work abandoned: (Yes/No) ____ | Method of abandonment: Backfilled ____ Plugged ____ Capped ____

Has any casing been left in the work (Yes/No) ____ | From ____ m To ____ m

Sealing / fill type (See Code 11)	From depth (m)	To depth (m)	Sealing / fill type (See Code 11)	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist ____ Geologist ____ Driller ____ Diviner ____ Client ____ Other ____ 12

13

Lot No 1 | DP No 100 6399

Work Location Co ordinates Easting ____ Northing ____ Zone 54

GPS: (Yes/No) ____ >> AMG/AGD ____ or MGA/GDA ____ (See explanation)

Longitude ____ Latitude ____

Please mark the work site with "X" on the CLID provided map.

Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: ____ **Licensee:** ____

Date: 5-5-17 **Date:** ____

Please submit forms to water.gds@dpi.nsw.gov.au or to the local NSW Office of Water agency

Department of Primary Industries Water

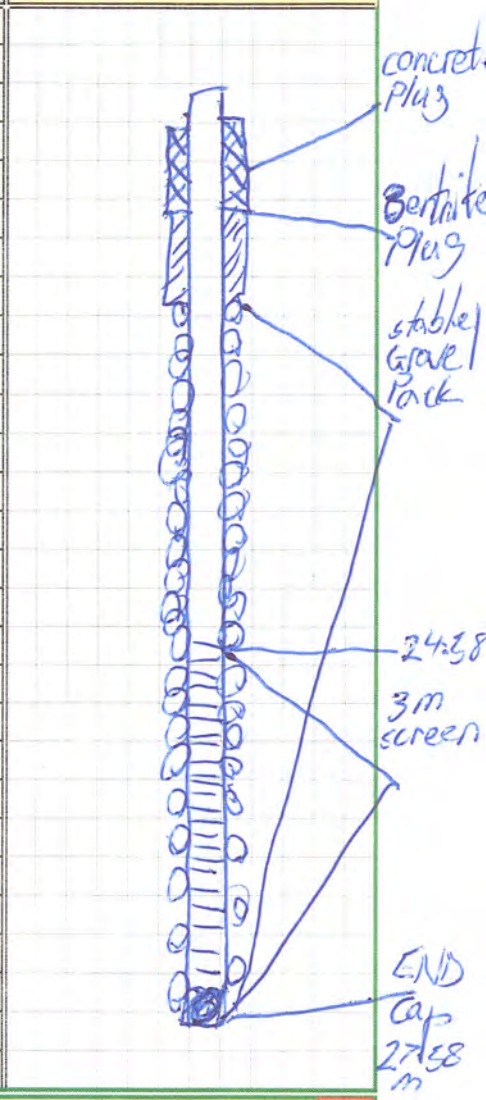
Form A Particulars of completed work

Work Licence No: MW-X6

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY) — 15

Depth From (m)	Depth To (m)	Description (See Code 15)
0	10	Amber Sand MG
10	15	Amber Sand MG with Fine Gravel
15	20	Amber Sand CG with Organics
20	27.58	Gray sand MG with shell fragments

WORK CONSTRUCTION SKETCH



WORK NOT CONSTRUCTED BY DRILLING RIG — 16

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other ☐

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

Please attach copies of the following if available — 17

Geologist log	(Yes/No) ☐	Laboratory analysis of water Sample	(Yes/No) ☐	Pumping test(s)	(Yes/No) ☐
Geophysical log	(Yes/No) ☐	Sieve analysis of aquifer material	(Yes/No) ☐	Installed Pump details	(Yes/No) ☐

CODE TABLES

DRILLING METHOD 3

1	Auger - Hollow Flight	9	Rotary - Percussion - (Down Hole Hammer)
2	Auger - Solid Flight	10	Rotary - Percussion - Foam injection
3	Cable Tool - Drill and Drive Casing	11	Rotary - Reverse circulation - Air
4	Cable Tool - Mud stabilised	12	Rotary - Reverse circulation - Mud
5	Rotary Air	13	Rotary - Coring
6	Rotary - Air/foam	14	Jetted - Air
7	Rotary - Mud	15	Jetted - Water
8	Rotary - Water	16	Other - See page 2, N0 11

WATER BEARING ZONE 4

TEST METHOD				FLOW MEASURING DEVICE			
1	Airlift	6	Pump - Helical Rotc	A	Container of known volum	F	Weir - Rectangular
2	Bailer	7	Pump - Jet	B	Flow meter	G	Weir - V Notch - 60°
3	Pump - Centrifugal	8	Pump - Turbine	C	Flume	H	Weir - V Notch - 90°
4	Pump - Cylinder	9	Freeflow	D	Orifice, plate & manomete	I	Other
5	Pump - Electric submersib			E	Ultra sonic meter		

CASING / LINER DETAILS 5

MATERIAL						METHOD OF FIXING			
1	A.B.S.	6	PVC - Class 12	11	Steel - Stainless	1	Glued	6	Welded - Butt
2	Aluminium	7	PVC - Class 15	12	Steel - Stainless 304	2	Kwik-lock	7	Welded - Colla
3	Concrete cylinder	8	PVC - Class 18	13	Steel - Stainless 316	3	Packer	8	Other
4	Fibre glass (FRP)	9	Steel - ERW	14	Other	4	Riveted		
5	PVC - Class 9	10	Steel - Galvanised			5	Screwed		

CASING SUPPORT METHOD				TYPE OF CASING BOTTOM			
1	Driven into small hole	5	Held in clamp	1	Open end	5	Casing shoe
2	Seated on bottom	6	Other	2	End cap	6	Wash down shoe
3	Seated on backfill			3	Plug - concrete	7	Cementing shoe
4	Cemented			4	Plug - wood	8	Other

WATER ENTRY DESIGN 6

OPENING TYPE				SLOT ALIGNMENT	
1	Casing - Bridge slot	7	Casing - Plasma-cut slot	D	Diagonal
2	Casing - Drilled holes	8	Casing - Perforated in hole	H	Horizontal
3	Casing - Hand sawn slot	9	Screen - gauze / mesh	V	Vertical
4	Casing - Louvre slot	10	Screen - round wire		
5	Casing - Machine slotted	11	Screen - wedge wire		
6	Casing - Oxy cut slot				

For MATERIAL and FIXING Codes Please refer to CASING DETAILS code table

GRAVEL PACK - METHOD OF PLACEMENT 7

1	Poured or shovelled into annul	2	Placed through tremie pipe	3	Reverse circulated

WORK PARTLY BACKFILLED OR ABANDONED - SEALING MATERIAL 11

1	Cement grout	3	Bentonite	5	Clay	7	Gravel
2	Concrete	4	Drilled cuttings	6	Sand	8	Coarse stone

DRILLER'S ROCK STRATA DESCRIPTION 15

Reporting sequence	1 Rock type	2 Colour	3 Grain size	4 Texture
Example	Sandstone	Dk Grey	mg	Fractured

To save confusion, write the *full name of colour and abbreviate th following:* light = lt, dark = dk, fine grained = fg, medium grained = mg, coarse grained = cg. *Texture can relate t* weathered, fractured, broken, hard, soft etc.

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A 28/2/2013
PARTICULARS OF COMPLETED WORK

Work Licence No: B L

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud No [x] Yes [ ] Name:

Method	Bailing/Surging [ ]	Jetting	Airlifting [ ]	Backwashing [ ]	Pumping [ ]	Other:
Duration	hrs	hrs	hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical/s used	Quantity applied (litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery		
								Water level (m)	Time taken (hrs)	(mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level ____ m Test Method Code [ ] See Code Table 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: ____ metres Is work partly backfilled: No [x] Yes [ ]

Is work abandoned: No [x] Yes [ ] Method of abandonment: Backfilled [ ] Plugged [ ] Capped [ ]

Has any casing been left in the work No [x] Yes [ ] From m To m

Sealing / fill type Code	From depth (m)	To depth (m)	Sealing / fill type Code	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist [ ] Geologist [ ] Driller [ ] Diviner [ ] Client [x] Other ____ 12

13

Lot No DP No

Work Location Co ordinates Easting 392604.05 Northing 6364756.47 Zone ____

GPS: No [ ] Yes [ ] >> AMG/AGD [ ] or MGA/GDA [ ] (See explanation)

Please mark the work site with "X" on the DWE CLID map
indicate also the distances in metres from two (2) adjacent boundaries and attach the map to this Form A package

Signatures:

Driller: _____ **Licensee:** _____

Date: 24/04/2013 **Date:** _____

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A .....
PARTICULARS OF COMPLETED WORK

Work Licence No: ..... B L .....

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY)

15

Depth From (m)	Depth To (m)	Description	WORK CONSTRUCTION SKETCH
0	15	Sand medium to course - Dry	
15	21	Sand Medium to course - wet - saturated	

WORK NOT CONSTRUCTED BY DRILLING RIG

16

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other .....

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m

Please attach copies of the following if available

17

Geologist log No [x] Yes ☐ Laboratory analysis of water Sample No ☐ Yes ☐ Pumping test(s) No ☐ Yes ☐

Geophysical log No [x] Yes ☐ Sieve analysis of aquifer material No [x] Yes ☐ Installed Pump details No [x] Yes ☐

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A
PARTICULARS OF COMPLETED WORK

1

Driller's Licence No: DL2013
Class of Licence: Class 2
Driller's Name: Tim Tucker
Assistant Driller: Toby Osbourne
Contractor: Boral

New bore [ ] Replacement bore [X]
Deepened [ ] Enlarged [ ]
Reconditioned [ ] Other (specify)
Final Depth 18m m MW02

2

Work Licence No: B L
Name of Licensee: Boral Stockton
Intended Use: Water monitoring
Completion Date: 29/03/2013

3 DRILLING DETAILS

From (m)	To (m)	Hole Diameter (mm)	Drilling Method Code
0	18	200	1

4 WATER BEARING ZONES

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method Code	D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond. (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)

5 CASING / LINER DETAILS

Material Code	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code
6	60	5	0	12	5

Casing support method Code 2
Type of casing bottom Code 2
Centralisers installed No [X] Yes [ ] (indicate on sketch)
Sump installed No [X] Yes [ ] From m To m
Pressure cemented No [X] Yes [ ] From m To m
Casing Protector cemented in place No [X] Yes [ ]

6 WATER ENTRY DESIGN

General: Material Code	General: OD (mm)	General: Wall Thickness (mm)	General: From (m)	General: To (m)	General: Opening type Code	General: Fixing Code	Screen: Aperture (mm)	Slot Details: Length (mm)	Slot Details: Width (mm)	Slot Details: Alignment Code
6	60	5	12	18	5	5	0.04	45	50	H

7 GRAVEL PACK

Type	Grade	Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres or m³
Rounded [ ]	Graded [X]	1	2	12	18	
Crushed [ ]	Ungraded [ ]					

Bentonite/Grout seal No [ ] Yes [X]
Method of placement of Gravel Pack Code 1

For D W E use only: G W

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A 29/2/2013
PARTICULARS OF COMPLETED WORK

Work Licence No: B L

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud No [x] Yes [ ] Name:

Method	Bailing/Surging [ ]	Jetting	Airlifting [ ]	Backwashing [ ]	Pumping [ ]	Other:
Duration	hrs	hrs	hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical/s used	Quantity applied (litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level ____ m Test Method Code [ ] See Code Table 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: ____ metres Is work partly backfilled: No [x] Yes [ ]

Is work abandoned: No [x] Yes [ ] Method of abandonment: Backfilled [ ] Plugged [ ] Capped [ ]

Has any casing been left in the work No [x] Yes [ ] From m To m

Sealing / fill type Code	From depth (m)	To depth (m)	Sealing / fill type Code	From depth (m)	To depth (m)

12

Site chosen by: Hydrogeologist [ ] Geologist [ ] Driller [ ] Diviner [ ] Client [x] Other ____

13

Lot No DP No

Work Location Co ordinates Easting 392599.55 Northing 6364951.41 Zone ____

GPS: No [ ] Yes [ ] >> AMG/AGD [ ] or MGA/GDA [ ] (See explanation)

Please mark the work site with "X" on the DWE CLID map.
Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: ____ **Licensee:** ____

Date: 24/04/2013 **Date:** ____

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A
PARTICULARS OF COMPLETED WORK

Work Licence No: B L

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY) — 15

Depth From (m)	Depth To (m)	Description	WORK CONSTRUCTION SKETCH
0	12	Sand medium to course - Dry	
12	18	Sand Medium to course - wet - saturated	

WORK NOT CONSTRUCTED BY DRILLING RIG — 16

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other .....

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

Please attach copies of the following if available — 17

Geologist log	No [x]	Yes ☐	Laboratory analysis of water Sample	No ☐	Yes ☐	Pumping test(s)	No ☐ Yes ☐
Geophysical log	No [x]	Yes ☐	Sieve analysis of aquifer material	No [x]	Yes ☐	Installed Pump details	No [x] Yes ☐

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A
PARTICULARS OF COMPLETED WORK

1

Driller's Licence No: DL2013
Class of Licence: Class 2
Driller's Name: Tim Tucker
Assistant Driller: Toby Osbourne
Contractor: Boral

New bore [ ] Replacement bore [X]
Deepened [ ] Enlarged [ ]
Reconditioned [ ] Other (specify)

Final Depth 8m m MW3

2

Work Licence No: B L
Name of Licensee: Boral Stockton
Intended Use: Water monitoring
Completion Date: 1/03/2013

3 DRILLING DETAILS

From (m)	To (m)	Hole Diameter (mm)	Drilling Method Code
0	8	200	1

4 WATER BEARING ZONES

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method Code	D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond. (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)

5 CASING / LINER DETAILS

Material Code	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code
6	60	5	0	2	5

Casing support method Code 2
Type of casing bottom Code 2
Centralisers installed No [x] Yes [ ] (indicate on sketch)
Sump installed No [x] Yes [ ] From m To m
Pressure cemented No [x] Yes [ ] From m To m
Casing Protector cemented in place No [ ] Yes [ ]

6 WATER ENTRY DESIGN

General: Material Code	General: OD (mm)	General: Wall Thickness (mm)	General: From (m)	General: To (m)	General: Opening type Code	General: Fixing Code	Screen: Aperture (mm)	Slot Details: Length (mm)	Slot Details: Width (mm)	Slot Details: Alignment Code
6	60	5	2	8	5	5	0.04	45	50	H

7 GRAVEL PACK

Type	Grade	Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres	Quantity or m^3
Rounded [ ]	Graded [X]	1	2	2	8		
Crushed [ ]	Ungraded [ ]						

Bentonite/Grout seal No [ ] Yes [x]
Method of placement of Gravel Pack Code 1

For D W E use only: G W [ ][ ][ ][ ][ ][ ][ ]

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A 28/2/2013
PARTICULARS OF COMPLETED WORK

Work Licence No: B L

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud No ☐ Yes ☐ Name:

Method	Bailing/Surging ☐	Jetting	Airlifting ☐	Backwashing ☐	Pumping ☐	Other:
Duration	hrs	hrs	hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical/s used	Quantity applied (litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level ..... m Test Method Code ☐ See Code Table 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: ..... metres Is work partly backfilled: No ☐ Yes ☐

Is work abandoned: No ☐ Yes ☐ Method of abandonment: Backfilled ☐ Plugged ☐ Capped ☐

Has any casing been left in the work No ☐ Yes ☐ From m To m

Sealing / fill type Code	From depth (m)	To depth (m)	Sealing / fill type Code	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist ☐ Geologist ☐ Driller ☐ Diviner [x] Client ☐ Other 12

Lot No DP No 13

Work Location Co ordinates Easting 390480.16 Northing 6364597.62 Zone .....

GPS: No ☐ Yes ☐ >> AMG/AGD ☐ or MGA/GDA ☐ (See explanation)

Please mark the work site with "X" on the DWE CLID map.
Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: .....

Date: 24/04/2013

Licensee: .....

Date: .....

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A
PARTICULARS OF COMPLETED WORK

Work Licence No: ..... B L .....

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY)

15

Depth From (m)	Depth To (m)	Description
0	2	Sand medium to course - Dry
2	8	Sand Medium to course - wet - saturated

WORK CONSTRUCTION SKETCH

WORK NOT CONSTRUCTED BY DRILLING RIG

16

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other .....

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (n

Please attach copies of the following if available

17

Geologist log No ☐ Yes ☐ Laboratory analysis of water Sample No ☐ Yes ☐ Pumping test(s) No ☐ Yes ☐

Geophysical log No ☐ Yes ☐ Sieve analysis of aquifer material No ☐ Yes ☐ Installed Pump details No ☐ Yes ☐

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A
PARTICULARS OF COMPLETED WORK

1

Driller's Licence No: DL2013
Class of Licence: Class 2
Driller's Name: Tim Tucker
Assistant Driller: Toby Osbourne
Contractor: Boral

New bore [ ] Replacement bore [X]
Deepened [ ] Enlarged [ ]
Reconditioned [ ] Other (specify)
Final Depth m 8m MW4

2

Work Licence No: B L
Name of Licensee: Boral Stockton
Intended Use: Water monitoring
Completion Date: 28/03/2013

DRILLING DETAILS

3

From (m)	To (m)	Hole Diameter (mm)	Drilling Method Code
0	8	200	1

WATER BEARING ZONES

4

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method Code	D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond. (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)

CASING / LINER DETAILS

5

Material Code	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code
6	60	5	0	2	5

Casing support method Code 2
Type of casing bottom Code 2
Centralisers installed No [x] Yes [ ] (indicate on sketch)
Sump installed No [x] Yes [ ] From m To m
Pressure cemented No [x] Yes [ ] From m To m
Casing Protector cemented in place No [ ] Yes [ ]

WATER ENTRY DESIGN

6

General Material Code	General OD (mm)	General Wall Thickness (mm)	General From (m)	General To (m)	General Opening type Code	General Fixing Code	Screen Aperture (mm)	Slot Details Length (mm)	Slot Details Width (mm)	Slot Details Alignment Code
6	60	5	2	8	5	5	0.04	45	50	H

GRAVEL PACK

7

Type	Grade	Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres or m^3
Rounded [ ]	Graded [X]	1	2	2	8	
Crushed [ ]	Ungraded [ ]					
Bentonite/Grout seal No [ ] Yes [x]						
Method of placement of Gravel Pack Code 1						

For D W E use only: G W

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A 28/2/2013
PARTICULARS OF COMPLETED WORK

Work Licence No: B L

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud No ☐ Yes ☐ Name:

Method	Bailing/Surging ☐	Jetting	Airlifting ☐	Backwashing ☐	Pumping ☐	Other:
Duration	hrs	hrs	hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical/s used	Quantity applied (litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level ..... m Test Method Code ☐ See Code Table 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: ..... metres Is work partly backfilled: No ☐ Yes ☐

Is work abandoned: No ☐ Yes ☐ Method of abandonment: Backfilled ☐ Plugged ☐ Capped ☐

Has any casing been left in the work No ☐ Yes ☐ From m To m

Sealing / fill type Code	From depth (m)	To depth (m)	Sealing / fill type Code	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist ☐ Geologist ☐ Driller ☐ Diviner x Client ☐ Other 12

13

Lot No DP No

Work Location Co ordinates Easting 392242.69 Northing 6364807.51 Zone .....

GPS: No ☐ Yes ☐ >> AMG/AGD ☐ or MGA/GDA ☐ (See explanation)

Please mark the work site with "X" on the DWE CLID map,
indicate also the distances in metres from two (2) adjacent boundaries and attach the map to this Form A package

Signatures:

Driller: .....

Date: 24/04/2013

Licensee: .....

Date: .....

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A .....
PARTICULARS OF COMPLETED WORK

Work Licence No: ..... B L .....

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY)

15

Depth From (m)	Depth To (m)	Description
0	2	Sand medium to course - Dry
2	8	Sand Medium to course - wet - saturated

WORK CONSTRUCTION SKETCH

WORK NOT CONSTRUCTED BY DRILLING RIG

16

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other .....

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

Please attach copies of the following if available

17

Geologist log No ☐ Yes ☐ Laboratory analysis of water Sample No ☐ Yes ☐ Pumping test(s) No ☐ Yes ☐

Geophysical log No ☐ Yes ☐ Sieve analysis of aquifer material No ☐ Yes ☐ Installed Pump details No ☐ Yes ☐

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A
PARTICULARS OF COMPLETED WORK

1

Driller's Licence No: DL2013
Class of Licence: Class 2
Driller's Name: Tim Tucker
Assistant Driller: Toby Osbourne
Contractor: Boral

New bore [ ] Replacement bore [X]
Deepened [ ] Enlarged [ ]
Reconditioned [ ] Other (specify)

Final Depth 8m m MW5

2

Work Licence No: B L
Name of Licensee: Boral Stockton
Intended Use: Water monitoring
Completion Date: 28/03/2013

DRILLING DETAILS 3

From (m)	To (m)	Hole Diameter (mm)	Drilling Method Code
0	8	200	1

WATER BEARING ZONES 4

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method Code	D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond. (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)

CASING / LINER DETAILS 5

Material Code	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code
6	60	5	0	2	5

Casing support method Code 2
Type of casing bottom Code 2
Centralisers installed No [X] Yes [ ] (indicate on sketch)
Sump installed No [X] Yes [ ] From m To m
Pressure cemented No [X] Yes [ ] From m To m
Casing Protector cemented in place No [ ] Yes [ ]

WATER ENTRY DESIGN 6

General: Material Code	General: OD (mm)	General: Wall Thickness (mm)	General: From (m)	General: To (m)	General: Opening type Code	General: Fixing Code	Screen: Aperture (mm)	Slot Details: Length (mm)	Slot Details: Width (mm)	Slot Details: Alignment Code
6	60	5	2	8	5	5	0.04	45	50	H

GRAVEL PACK 7

Type	Grade	Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres or m³
Rounded [ ]	Graded [X]	1	2	2	8	
Crushed [ ]	Ungraded [ ]					

Bentonite/Grout seal No [ ] Yes [X]
Method of placement of Gravel Pack Code 1

For D W E use only: G W [ ][ ][ ][ ][ ][ ]

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A 28/2/2013
PARTICULARS OF COMPLETED WORK

Work Licence No: B L

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud No ☐ Yes ☐ Name:

Method	Bailing/Surging ☐	Jetting	Airlifting ☐	Backwashing ☐	Pumping ☐	Other:
Duration	hrs	hrs	hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical/s used	Quantity applied (litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level ____ m Test Method Code ☐ See Code Table 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: ____ metres Is work partly backfilled: No ☐ Yes ☐

Is work abandoned: No ☐ Yes ☐ Method of abandonment: Backfilled ☐ Plugged ☐ Capped ☐

Has any casing been left in the work No ☐ Yes ☐ From m To m

Sealing / fill type Code	From depth (m)	To depth (m)	Sealing / fill type Code	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist ☐ Geologist ☐ Driller ☐ Diviner x Client ☐ Other ____ 12

13

Lot No DP No

Work Location Co ordinates Easting 392042.12 Northing 6364700.48 Zone

GPS: No ☐ Yes ☐ >> AMG/AGD ☐ or MGA/GDA ☐ (See explanation)

Please mark the work site with "X" on the DWE CLID map.
Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: _____ **Licensee:** _____

Date: 24/04/2013 **Date:** _____

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A
PARTICULARS OF COMPLETED WORK

Work Licence No: B L

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY)

15

Depth From (m)	Depth To (m)	Description
0	2	Sand medium to course - Dry
2	8	Sand Medium to course - wet - saturated

WORK CONSTRUCTION SKETCH

WORK NOT CONSTRUCTED BY DRILLING RIG

16

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other .....

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m

Please attach copies of the following if available

17

Geologist log No ☐ Yes ☐ Laboratory analysis of water Sample No ☐ Yes ☐ Pumping test(s) No ☐ Yes ☐

Geophysical log No ☐ Yes ☐ Sieve analysis of aquifer material No ☐ Yes ☐ Installed Pump details No ☐ Yes ☐

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A
PARTICULARS OF COMPLETED WORK

1

Driller's Licence No: DL2013
Class of Licence: Class 2
Driller's Name: Tim Tucker
Assistant Driller: Toby Osbourne
Contractor: Boral

New bore [ ] Replacement bore [X]
Deepened [ ] Enlarged [ ]
Reconditioned [ ] Other (specify)
Final Depth 8m m MW6

2

Work Licence No: B L
Name of Licensee: Boral Stockton
Intended Use: Water monitoring
Completion Date: 28/03/2013

DRILLING DETAILS

3

From (m)	To (m)	Hole Diameter (mm)	Drilling Method Code
0	8	200	1

WATER BEARING ZONES

4

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method Code	D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond. (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)

CASING / LINER DETAILS

5

Material Code	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code
6	60	5	0	2	5

Casing support method Code 2
Type of casing bottom Code 2
Centralisers installed No [X] Yes [ ] (indicate on sketch)
Sump installed No [X] Yes [ ] From m To m
Pressure cemented No [X] Yes [ ] From m To m
Casing Protector cemented in place No [ ] Yes [ ]

WATER ENTRY DESIGN

6

General: Material Code	General: OD (mm)	General: Wall Thickness (mm)	General: From (m)	General: To (m)	General: Opening type Code	General: Fixing Code	Screen: Aperture (mm)	Slot Details: Length (mm)	Slot Details: Width (mm)	Slot Details: Alignment Code
6	60	5	2	8	5	5	0.04	45	50	H

GRAVEL PACK

7

Type	Grade	Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres or m³
Rounded [ ]	Graded [X]	1	2	2	8	
Crushed [ ]	Ungraded [ ]					

Bentonite/Grout seal No [ ] Yes [x]
Method of placement of Gravel Pack Code 1

For D W E use only: G W [ ][ ][ ][ ][ ][ ]

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A ..... 28/2/2013 .....
PARTICULARS OF COMPLETED WORK

Work Licence No: ..... B L .....

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud No ☐ Yes ☐ Name:

Method	Bailing/Surging ☐	Jetting	Airlifting ☐	Backwashing ☐	Pumping ☐	Other:
Duration	hrs	hrs	hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical/s used	Quantity applied (litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level ..... m Test Method Code ☐ See Code Table 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: ..... metres Is work partly backfilled: No ☐ Yes ☐

Is work abandoned: No ☐ Yes ☐ Method of abandonment: Backfilled ☐ Plugged ☐ Capped ☐

Has any casing been left in the work No ☐ Yes ☐ From m To m

Sealing / fill type Code	From depth (m)	To depth (m)	Sealing / fill type Code	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist ☐ Geologist ☐ Driller ☐ Diviner [x] Client ☐ Other 12

Lot No DP No 13

Work Location Co ordinates Easting 391780.84 Northing 6364527.43 Zone .....

GPS: No ☐ Yes ☐ >> AMG/AGD ☐ or MGA/GDA ☐ (See explanation)

Please mark the work site with "X" on the DWE CUD map.
Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package

Signatures:

Driller: ..... **Licensee:** .....

Date: 24/04/2013 **Date:** .....

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A .....
PARTICULARS OF COMPLETED WORK

Work Licence No: B L .....

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY)

15

Depth From (m)	Depth To (m)	Description
0	2	Sand medium to course - Dry
2	8	Sand Medium to course - wet - saturated

WORK CONSTRUCTION SKETCH

WORK NOT CONSTRUCTED BY DRILLING RIG

16

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other .....

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m

Please attach copies of the following if available

17

Geologist log No ☐ Yes ☐ Laboratory analysis of water Sample No ☐ Yes ☐ Pumping test(s) No ☐ Yes ☐

Geophysical log No ☐ Yes ☐ Sieve analysis of aquifer material No ☐ Yes ☐ Installed Pump details No ☐ Yes ☐

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A
PARTICULARS OF COMPLETED WORK

1

Driller's Licence No: DL2013
Class of Licence: Class 2
Driller's Name: Tim Tucker
Assistant Driller: Toby Osbourne
Contractor: Boral

New bore [ ] Replacement bore [X]
Deepened [ ] Enlarged [ ]
Reconditioned [ ] Other (specify)

Final Depth 8m m MW7

2

Work Licence No: B L
Name of Licensee: Boral Stockton
Intended Use: Water monitoring
Completion Date: 28/03/2013

DRILLING DETAILS **3**

From (m)	To (m)	Hole Diameter (mm)	Drilling Method Code
0	8	200	1

WATER BEARING ZONES **4**

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method Code	D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond. (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)

CASING / LINER DETAILS **5**

Material Code	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code
6	60	5	0	2	5

Casing support method Code 2
Type of casing bottom Code 2
Centralisers installed No [X] Yes [ ] (indicate on sketch)
Sump installed No [X] Yes [ ] From m To m
Pressure cemented No [X] Yes [ ] From m To m
Casing Protector cemented in place No [ ] Yes [ ]

WATER ENTRY DESIGN **6**

General: Material Code	General: OD (mm)	General: Wall Thickness (mm)	General: From (m)	General: To (m)	General: Opening type Code	General: Fixing Code	Screen: Aperture (mm)	Slot Details: Length (mm)	Slot Details: Width (mm)	Slot Details: Alignment Code
6	60	5	2	8	5	5	0.04	45	50	H

GRAVEL PACK **7**

Type	Grade	Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres or m³
Rounded [ ]	Graded [X]	1	2	2	8	
Crushed [ ]	Ungraded [ ]					
Bentonite/Grout seal No [ ] Yes [X]						

Method of placement of Gravel Pack Code 1

For D W E use only: G W

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A 28/2/2013
PARTICULARS OF COMPLETED WORK

Work Licence No: B L

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud No ☐ Yes ☐ Name:

Method	Bailing/Surging ☐	Jetting	Airlifting ☐	Backwashing ☐	Pumping ☐	Other:
Duration	hrs	hrs	hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical/s used	Quantity applied (litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level ..... m Test Method Code ☐ See Code Table 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: ..... metres Is work partly backfilled: No ☐ Yes ☐

Is work abandoned: No ☐ Yes ☐ Method of abandonment: Backfilled ☐ Plugged ☐ Capped ☐

Has any casing been left in the work No ☐ Yes ☐ From m To m

Sealing / fill type Code	From depth (m)	To depth (m)	Sealing / fill type Code	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist ☐ Geologist ☐ Driller ☐ Diviner x Client ☐ Other 12

Lot No DP No 13

Work Location Co ordinates Easting 391588.88 Northing 6364388.16 Zone .....

GPS: No ☐ Yes ☐ >> AMG/AGD ☐ or MGA/GDA ☐ (See explanation)

Please mark the work site with "X" on the DWE CLID map.
Indicate also the distances in metres from two (2) adjacent boundaries and attach the map to this Form A package

Signatures:

Driller: .....

Date: 24/04/2013

Licensee: .....

Date: .....

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A .....
PARTICULARS OF COMPLETED WORK

Work Licence No: ..... B L .....

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY)

15

Depth From (m)	Depth To (m)	Description
0	2	Sand medium to course - Dry
2	8	Sand Medium to course - wet - saturated

WORK CONSTRUCTION SKETCH

WORK NOT CONSTRUCTED BY DRILLING RIG

16

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other .....

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (n

Please attach copies of the following if available

17

Geologist log No ☐ Yes ☐ Laboratory analysis of water Sample No ☐ Yes ☐ Pumping test(s) No ☐ Yes ☐

Geophysical log No ☐ Yes ☐ Sieve analysis of aquifer material No ☐ Yes ☐ Installed Pump details No ☐ Yes ☐

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A
PARTICULARS OF COMPLETED WORK

1

Driller's Licence No: DL2013
Class of Licence: Class 2
Driller's Name: Tim Tucker
Assistant Driller: Toby Osbourne
Contractor: Boral

New bore [ ] Replacement bore [X]
Deepened [ ] Enlarged [ ]
Reconditioned [ ] Other (specify)

Final Depth 25m m
MW8

2

Work Licence No: B L
Name of Licensee: Boral Stockton
Intended Use: Water monitoring
Completion Date: 28/03/2013

DRILLING DETAILS

3

From (m)	To (m)	Hole Diameter (mm)	Drilling Method Code
0	25	200	1

WATER BEARING ZONES

4

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method Code	D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond. (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)

CASING / LINER DETAILS

5

Material Code	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code
6	60	5	0	19	5

Casing support method Code 2
Type of casing bottom Code 2
Centralisers installed No [X] Yes [ ] (indicate on sketch)
Sump installed No [X] Yes [ ] From m To m
Pressure cemented No [X] Yes [ ] From m To m
Casing Protector cemented in place No [ ] Yes [ ]

WATER ENTRY DESIGN

6

General: Material Code	General: OD (mm)	General: Wall Thickness (mm)	General: From (m)	General: To (m)	General: Opening type Code	General: Fixing Code	Screen: Aperture (mm)	Slot Details: Length (mm)	Slot Details: Width (mm)	Slot Details: Alignment Code
6	60	5	19	25	5	5	0.04	45	50	H

GRAVEL PACK

7

Type	Grade	Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres or m^3
Rounded [ ]	Graded [X]	1	2	19	25	
Crushed [ ]	Ungraded [ ]					
Bentonite/Grout seal No [ ] Yes [X]						
Method of placement of Gravel Pack Code 1						

For D W E use only: G W

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A 28/2/2013
PARTICULARS OF COMPLETED WORK

Work Licence No: B L

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud No [x] Yes [ ] Name:

Method	Bailing/Surging [ ]	Jetting	Airlifting [ ]	Backwashing [ ]	Pumping [ ]	Other:
Duration	hrs	hrs	hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical/s used	Quantity applied (litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level ..... m Test Method Code [ ] See Code Table 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: ..... metres Is work partly backfilled: No [ ] Yes [ ]

Is work abandoned: No [ ] Yes [ ] Method of abandonment: Backfilled [ ] Plugged [ ] Capped [ ]

Has any casing been left in the work No [ ] Yes [ ] From m To m

Sealing / fill type Code	From depth (m)	To depth (m)	Sealing / fill type Code	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist [ ] Geologist [ ] Driller [ ] Diviner [x] Client [ ] Other 12

Lot No DP No 13

Work Location Co ordinates Easting 391428.28 Northing 6364224.74 Zone .....

GPS: No [ ] Yes [ ] >> AMG/AGD [ ] or MGA/GDA [ ] (See explanation)

Please mark the work site with "X" on the DWE CLID map.
Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: .....

Date: 24/04/2013

Licensee: .....

Date: .....

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A
PARTICULARS OF COMPLETED WORK

Work Licence No: 5BL

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY)

15

Depth From (m)	Depth To (m)	Description
0	2	Sand medium to course - Dry
2	8	Sand Medium to course - wet - saturated

WORK CONSTRUCTION SKETCH

WORK NOT CONSTRUCTED BY DRILLING RIG

16

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other .....

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

Please attach copies of the following if available

17

Geologist log No ☐ Yes ☐ Laboratory analysis of water Sample No ☐ Yes ☐ Pumping test(s) No ☐ Yes ☐

Geophysical log No ☐ Yes ☐ Sieve analysis of aquifer material No ☐ Yes ☐ Installed Pump details No ☐ Yes ☐

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A
PARTICULARS OF COMPLETED WORK

1

Driller's Licence No: DL2013
Class of Licence: Class 2
Driller's Name: Tim Tucker
Assistant Driller: Toby Osbourne
Contractor: Boral

New bore [ ] Replacement bore [X]
Deepened [ ] Enlarged [ ]
Reconditioned [ ] Other (specify)
Final Depth m 25m MW9

2

Work Licence No: B L
Name of Licensee: Boral Stockton
Intended Use: Water monitoring
Completion Date: 28/03/2013

DRILLING DETAILS

3

From (m)	To (m)	Hole Diameter (mm)	Drilling Method Code
0	25	200	1

WATER BEARING ZONES

4

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method Code	D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond. (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)

CASING / LINER DETAILS

5

Material Code	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code
6	60	5	0	19	5

Casing support method Code 2
Type of casing bottom Code 2
Centralisers installed No [X] Yes [ ] (indicate on sketch)
Sump installed No [X] Yes [ ] From m To m
Pressure cemented No [X] Yes [ ] From m To m
Casing Protector cemented in place No [ ] Yes [ ]

WATER ENTRY DESIGN

6

General Material Code	General OD (mm)	General Wall Thickness (mm)	General From (m)	General To (m)	General Opening type Code	General Fixing Code	Screen Aperture (mm)	Slot Details Length (mm)	Slot Details Width (mm)	Slot Details Alignment Code
6	60	5	19	25	5	5	0.04	45	50	H

GRAVEL PACK

7

Type	Grade	Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres or m^3
Rounded [ ]	Graded [X]	1	2	19	25	
Crushed [ ]	Ungraded [ ]					

Bentonite/Grout seal No [ ] Yes [X]
Method of placement of Gravel Pack Code 1

For D W E use only: G W [ ][ ][ ][ ][ ][ ]

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A .....28/2/2013.....
PARTICULARS OF COMPLETED WORK

Work Licence No: ..... B L .....

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud No [x] Yes [ ] Name:

Method	Bailing/Surging [ ]	Jetting	Airlifting [ ]	Backwashing [ ]	Pumping [ ]	Other:
Duration	hrs	hrs	hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical/s used	Quantity applied (litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level ..... m Test Method Code [ ] See Code Table 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: ..... metres Is work partly backfilled: No [ ] Yes [ ]

Is work abandoned: No [ ] Yes [ ] Method of abandonment: Backfilled [ ] Plugged [ ] Capped [ ]

Has any casing been left in the work No [ ] Yes [ ] From m To m

Sealing / fill type Code	From depth (m)	To depth (m)	Sealing / fill type Code	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist [ ] Geologist [ ] Driller [ ] Diviner [x] Client [ ] Other 12

Lot No DP No 13

Work Location Co ordinates Easting 390939.54 Northing 6364058.75 Zone .....

GPS: No [ ] Yes [ ] >> AMG/AGD [ ] or MGA/GDA [ ] (See explanation)

Please mark the work site with "X" on the DWE CLID map.
Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: ..... **Licensee:** .....

Date: 24/04/2013 **Date:** .....

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A
PARTICULARS OF COMPLETED WORK

Work Licence No: B L

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY)

Depth From (m)	Depth To (m)	Description
0	21	Sand medium to course - Dry
21	25	Sand Medium to course - wet - saturated

15 WORK CONSTRUCTION SKETCH

WORK NOT CONSTRUCTED BY DRILLING RIG

16

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other .....

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

Please attach copies of the following if available

17

Geologist log No ☐ Yes ☐ Laboratory analysis of water Sample No ☐ Yes ☐ Pumping test(s) No ☐ Yes ☐

Geophysical log No ☐ Yes ☐ Sieve analysis of aquifer material No ☐ Yes ☐ Installed Pump details No ☐ Yes ☐

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A
PARTICULARS OF COMPLETED WORK

1

Driller's Licence No: DL2013
Class of Licence: Class 2
Driller's Name: Tim Tucker
Assistant Driller: Toby Osbourne
Contractor: Boral

New bore [ ] Replacement bore [X]
Deepened [ ] Enlarged [ ]
Reconditioned [ ] Other (specify)

Final Depth 25m m MW10

2

Work Licence No: B L
Name of Licensee: Boral Stockton
Intended Use: Water monitoring
Completion Date: 28/03/2013

DRILLING DETAILS

3

From (m)	To (m)	Hole Diameter (mm)	Drilling Method Code
0	25	200	1

WATER BEARING ZONES

4

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method Code	D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond. (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)

CASING / LINER DETAILS

5

Material Code	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code
6	60	5	0	19	5

Casing support method Code 2

Type of casing bottom Code 2

Centralisers installed No [X] Yes [ ] (indicate on sketch)

Sump installed No [X] Yes [ ] From m To m

Pressure cemented No [X] Yes [ ] From m To m

Casing Protector cemented in place No [ ] Yes [ ]

WATER ENTRY DESIGN

6

General Material Code	General OD (mm)	General Wall Thickness (mm)	General From (m)	General To (m)	General Opening type Code	General Fixing Code	Screen Aperture (mm)	Slot Details Length (mm)	Slot Details Width (mm)	Slot Details Alignment Code
6	60	5	19	25	5	5	0.04	45	50	H

GRAVEL PACK

7

Type	Grade	Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres or m^3
Rounded [ ]	Graded [X]	1	2	19	25	
Crushed [ ]	Ungraded [ ]					

Bentonite/Grout seal No [ ] Yes [X]

Method of placement of Gravel Pack Code 1

For D W E use only: G W

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A 28/2/2013
PARTICULARS OF COMPLETED WORK

Work Licence No: B L

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud No [x] Yes [ ] Name:

Method	Bailing/Surging	Jetting	Airlifting	Backwashing	Pumping	Other:
	[ ]	[ ]	[ ]	[ ]	[ ]	
Duration	hrs	hrs	hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical/s used	Quantity applied (litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery		
								Water level (m)	Time taken (hrs)	(mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level ..... m Test Method Code [ ] See Code Table 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: ..... metres Is work partly backfilled: No [x] Yes [ ]

Is work abandoned: No [x] Yes [ ] Method of abandonment: Backfilled [ ] Plugged [ ] Capped [ ]

Has any casing been left in the work No [x] Yes [ ] From m To m

Sealing / fill type Code	From depth (m)	To depth (m)	Sealing / fill type Code	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist [ ] Geologist [ ] Driller [ ] Diviner [ ] Client [x] Other 12

Lot No DP No 13

Work Location Co ordinates Easting 391351.67 Northing 6363950.75 Zone .....

GPS: No [ ] Yes [ ] >> AMG/AGD [ ] or MGA/GDA [ ] (See explanation)

Please mark the work site with "X" on the DWE CLID map.
Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: ..... **Licensee:** .....

Date: 24/04/2013 **Date:** .....

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A
PARTICULARS OF COMPLETED WORK

Work Licence No: B L

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY)

Depth From (m)	Depth To (m)	Description
0	21	Sand medium to course - Dry
21	25	Sand Medium to course - wet - saturated

15 WORK CONSTRUCTION SKETCH

WORK NOT CONSTRUCTED BY DRILLING RIG

16

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other .....

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

Please attach copies of the following if available

17

Geologist log No [X] Yes ☐ Laboratory analysis of water Sample No ☐ Yes ☐ Pumping test(s) No ☐ Yes ☐

Geophysical log No [X] Yes ☐ Sieve analysis of aquifer material No [X] Yes ☐ Installed Pump details No [X] Yes ☐

APPENDIX E: GROUNDWATER FIELD SHEETS

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Groundwater - Well Sampling Data Form

JOB INFORMATION

Date:	13/3/18	Time:	12:00
Project Name:	Boral Stockton	Project Number:	717041
Site Location:	stockton	Sample:	MWx3 - shallow
Well ID:	MWx3 shallow	Weather:	sunny

EQUIPMENT

Water Quality Equipment: TPS90FL PH/TEM/CON/SAL/DO/TUR

Interface Probe Number: Solinist Water Level Meter 101

Purging Equipment:

(please circle)

Bailer type: Plastic Teflon Waterra

Pump type: Peristaltic Submersable Micro-purge Waterra

WELL GAUGING & PURGE VOLUME CALCULANTIONS

Casing Diameter	25mm	50mm	100mm	125mm	150mm	200mm
Conversion Factor (L/m)	0.98	1.96	7.85	31.4	49.1	70.7

Total Well Depth	(-)	Water Level	(=)	Water Column
11.3 (m)	(-)	5.5 (m)		5.8 (m)

Water Column	(x)	Conversion Factor	(=)	Well Volume (L)
5.8 (m)	(x)	_____	(=)	11.3 L

Volume of water in well
= Pr x r x h

P=3.14159
r = radius of well in cm
h = height of well in cm
V = volume in litres

Depth to Product	Product Thickness	Verified with bailer:
n/a (m)	n/a (m)	n/a (Y/N)

WATER QUALITY PARAMETERS

Beginning purge time: 12:24

Ending purge time: 3 x Well volume

Parameters

Litres	Time	pH	Temp (°C)	Cond	DO	DO	Redox	Comments
		6.83	20.4	260	0.29		-41.8	clear, no odor
		6.46	20.3	257.9	0.17		5.6	
		6.31	20.3	257.4	0.14		9.8	
		6.11	20.2	257.3	0.13		13.7	
		6.02	20.1	257.1	0.13		12.9	

pH, temp, EC readings not necessary if well is purged dry

Total Well Volume

Flow Rate (ml/minute)

Sample time: _____

Containers used: _____

Field parameters stabilise: (Y / N)

Well purge dry: _____ (Y / N)

FIELD QC CHECKS (circle)

Was clean sampling equipment used for sample collection?	Y	N	
Was clean sample equipment properly protected from contaminant?	Y	N	
Were air bubbles present in vials at the time of collection?	Y	N	N/A
Were metals field filtered prior to preservation?	Y	N	N/A
Duplicate sample collected? (if YES write Sample ID here)	Y	N	N/A
Rinsate blank collected?	Y	N	

ENVIRONMENTAL EARTH SCIENCES
"HE KNOW AND "HE HOW

Groundwater - Well Sampling Data Form

JOB INFORMATION

Date:	13/3/18	Time:	
Project Name:	717041	Project Number:	717041
Site Location:	Boral	Sample:	MW x3 - deep
Well ID:	MW x3 - Deep	Weather:	Sunny

EQUIPMENT

Water Quality Equipment: TPS90FL PH/TEM/CON/SAL/DO/TUR

Interface Probe Number: Solinist Water Level Meter 101

Purging Equipment:

(please circle)

Bailer type: Plastic Teflon Waterra

Pump type: Peristaltic Submersable Micro-purge Waterra

WELL GAUGING & PURGE VOLUME CALCULANTIONS

Casing Diameter	25mm	50mm	100mm	125mm	150mm	200mm
Conversion Factor (L/m)	0.98	1.96	7.85	31.4	49.1	70.7

Total Well Depth	(-)	Water Level	(=)	Water Column
26 (m)	(-)	5.9 (m)		20.1 (m)

Volume of water in well
= Pr x r x h

P =3.14159
r = radius of well in cm
h = height of well in cm
V = volume in litres

Water Column	(x)	Conversion Factor	(=)	Well Volume (L)
20.1 (m)	(x)	1.96	(=)	39.3 L

Depth to Product	Product Thickness	Verified with bailer:
n/a (m)	n/a (m)	n/a (Y/N)

WATER QUALITY PARAMETERS

Beginning purge time: 12:07 — Ending purge time: 3x well volume

Parameters: SPC µS

Litres	Time	pH	Temp (°C)	Cond	DO	DO	Redox	Comments
		7.23	20.1	518.1	0.82		+122.2	clear / Lbr.
		7.04	20.1	546.7	0.77		-106.1	no odour
		7.03	20.0	546.6	0.27		-106.9	
		7.02	20.0	546.4	0.18		-104.0	
		7.01	20.1	546.5	0.14		-103.6	

pH, temp, EC readings not necessary if well is purged dry

Total Well Volume

Flow Rate (ml/minute)

Sample time: _____

Containers used: _____

Field parameters stabilise: (Y) N

Well purge dry: _____ (Y / N)

FIELD QC CHECKS (circle)

Was clean sampling equipment used for sample collection?	(Y)	N	
Was clean sample equipment properly protected from contaminant?	(Y)	N	
Were air bubbles present in vials at the time of collection?	Y	(N)	N/A
Were metals field filtered prior to preservation?	Y	(N)	N/A
Duplicate sample collected? (if YES write Sample ID here)	Y	(N)	N/A
Rinsate blank collected?	Y	(N)	

Slug Test

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Job no: 717041 Date: 14/3/18 Tester name: LV

Well number: MWx3 shallow Site: Stockton Rising/Falling Test (circle): Both

Well Depth 11.317 (m) Depth to water (TOC): 5.525 (m) Stickup: 0.2 (m)

Casing and screen diameter (inner diameter): 50 (mm)

Construction comments (length of screen, position of screen etc): _____

Data logger type/brand/serial no: Van ESSEN

Method of communication with logger (direct read/pre-programmed) pre-programmed

Construction details (notes of construction, depth to seal etc):

Slug details (if known) (note a slug of 1L is 900m long by 37.5mm dia)

Length: 1.8 m Diameter: ~~900m~~ 37.5 Volume: ~~37.5mm~~ 2L

Test

Test time start: _____ Test time finish: _____

Test ID on computer: MWx3-shallow_V4 and _V5

Length of transducer cable to be used: ~~7.4~~ 8 (m)

- Measure length of rope/cable + Slug such that the base of slug is just above the water (depth to water minus the length of the slug): (7.4 (m))
- Measure length of rope/cable + slug such that slug will be fully submerged but not hitting transducer. (mark or tie off)

Other notes/comments

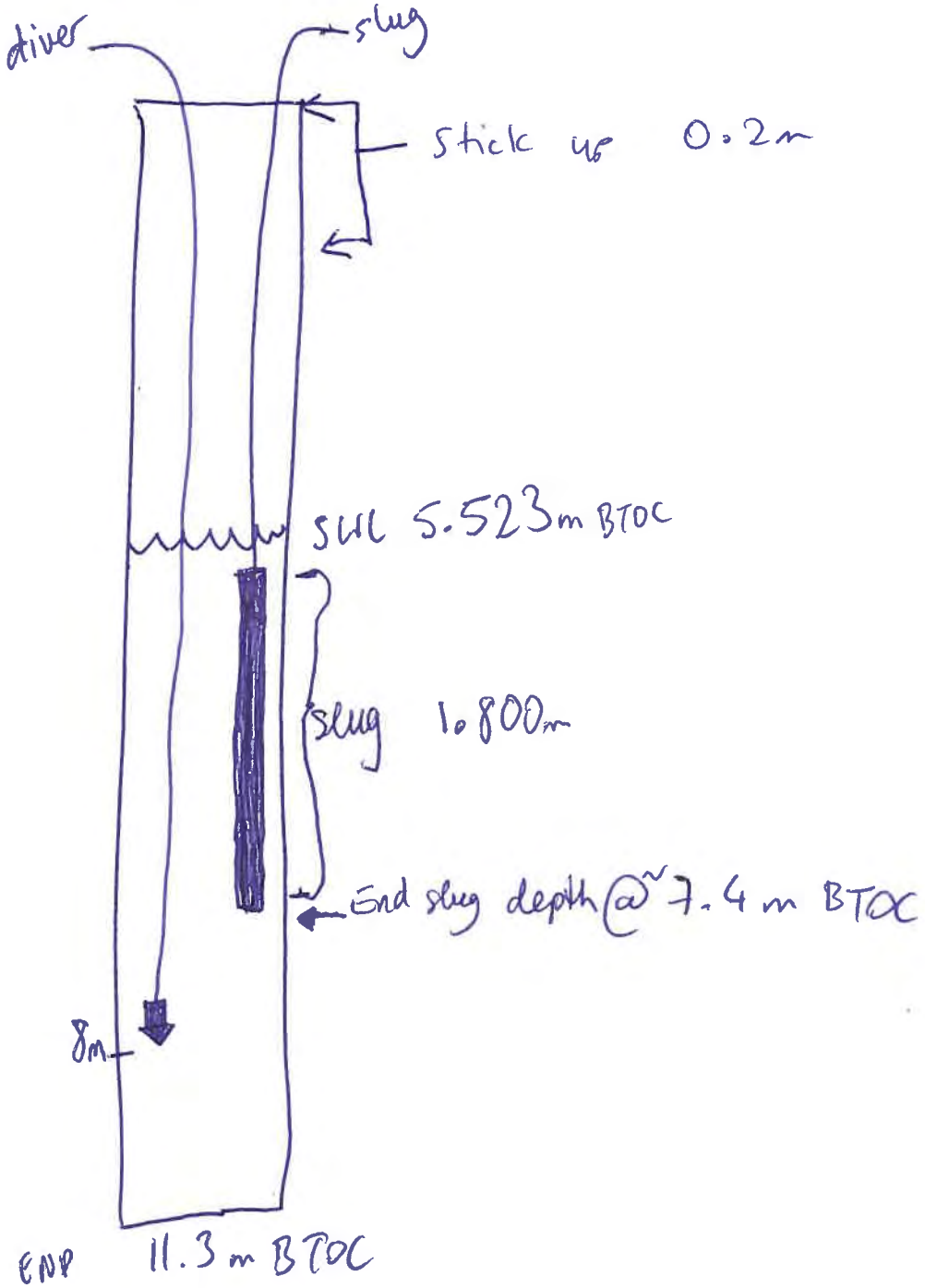
Diver in well for ~10 mins to equilibrate before inserting slug in V4, approx 5mins equilibrate for V5

SWL pre-start: 5.525 m ~~BTOC~~

SWL post-slug: 5.525

MW x 3 - shallow

SWL from ground surface
= 5.323m BGS



Well construction
total depth: 11.45m
Screen length: 3m
SWL : 4.92 m

Slug Test

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Job no: 717041 Date: 14/3/18 Tester name: CV

Well number: MWx3 deep Site: Stockton Rising/Falling Test (circle): Both

Well Depth 26 (m) Depth to water (TOC): 5.910 (m) Stickup: 0.51 (m)

Casing and screen diameter (inner diameter): 50 (mm)

Construction comments (length of screen, position of screen etc): _____

Data logger type/brand/serial no: Van Essen

Method of communication with logger (direct read/pre-programmed) pre programmed

Construction details (notes of construction, depth to seal etc):

Slug details (if known) (note a slug of 1L is 900m long by 37.5mm dia)

Length: 1.8 Diameter: 37.5 Volume: 2L

Test

Test time start: V4: 10mins Test time finish: _____

Test ID on computer: V2 + V3

Length of transducer cable to be used: 8 (m)

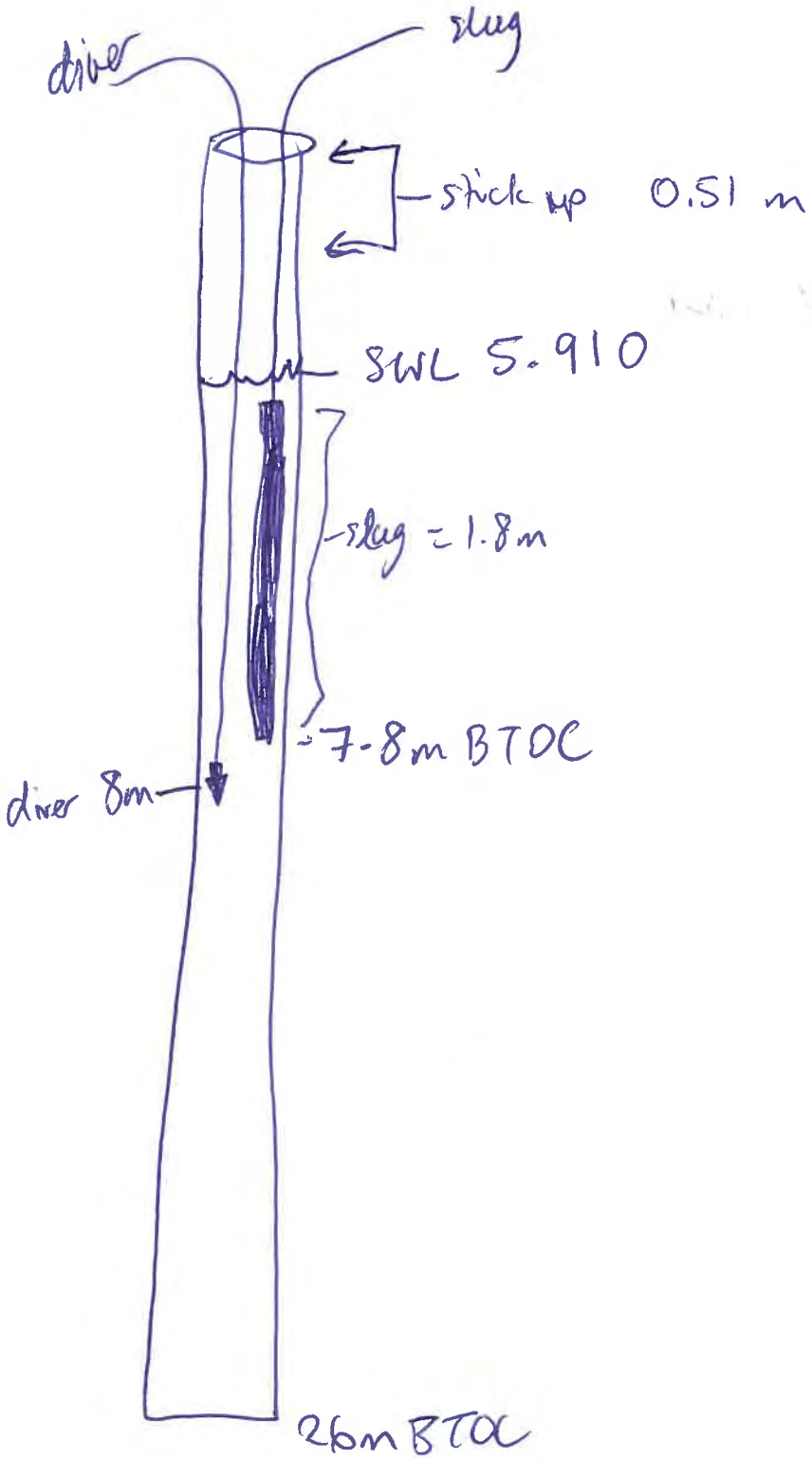
- Measure length of rope/cable + Slug such that the base of slug is just above the water (depth to water minus the length of the slug): (7.8 (m))
- Measure length of rope/cable + slug such that slug will be fully submerged but not hitting transducer. (mark or tie off)

Other notes/comments

SWL pre - slug : 5.910
SWL post - slug : 5.910
~5 mins equilibration time in well prior to slug test

MW x 3 - deep

SWL from ground surface
= 5.400m BGS



Well construction:
total depth: 26m BGL
screen length: 3m
SWL: 5.31

Rising
267 - 274

Falling
328 - 331

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

APPENDIX F: LABORATORY TRANSCRIPTS

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1807813**	Page	: 1 of 2
Client	: **ENVIRONMENTAL EARTH SCIENCES**	Laboratory	: Environmental Division Brisbane
Contact	: LORETTA VISINTIN	Contact	: Peter Ravlic
Address	:	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 02 99221777	Telephone	: +61-7-3243 7222
Project	: 717041	Date Samples Received	: 27-Mar-2018 10:19
Order number	:	Date Analysis Commenced	: 29-Mar-2018
C-O-C number	: ----	Issue Date	: 29-Mar-2018 10:54
Sampler	: LORETTA VISINTIN		
Site	: Boral Stockton		
Quote number	: EN/010/17		
No. of samples received	: 3		
No. of samples analysed	: 3		

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- **The samples in this work order have been re-batched from ES1807945.**
- ASS: EA033 (CRS Suite): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m3'.

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			Client sample ID	**BH2_2.0 ES1807945-013**	**BH4_6.0 ES1807945-037**	**BH4_9.0 ES1807945-038**	**----**	**----**
			Client sampling date / time	13-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB1807813-001**	**EB1807813-002**	**EB1807813-003**	**--------**	**--------**
				Result	Result	Result	----	----
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	**0.11**	**0.15**	**0.02**	**----**	**----**
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	**22**	**30**	<10	**----**	**----**
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	**0.03**	**0.05**	<0.01	**----**	**----**

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **EB1807813**	Page	: 1 of 3
Client	: **ENVIRONMENTAL EARTH SCIENCES**	Laboratory	: Environmental Division Brisbane
Contact	: LORETTA VISINTIN	Contact	: Peter Ravlic
Address	:	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 02 99221777	Telephone	: +61-7-3243 7222
Project	: 717041	Date Samples Received	: 27-Mar-2018
Order number	:	Date Analysis Commenced	: 29-Mar-2018
C-O-C number	: ----	Issue Date	: 29-Mar-2018
Sampler	: LORETTA VISINTIN		
Site	: Boral Stockton		
Quote number	: EN/010/17		
No. of samples received	: 3		
No. of samples analysed	: 3		

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA033-C: Acid Neutralising Capacity (QC Lot: 1532412)									
EB1807813-001	BH2_2.0 ES1807945-013	EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	0.11	0.15	35.3	0% - 50%
		EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	0.03	0.05	35.3	No Limit
		EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	22	31	35.3	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA033-C: Acid Neutralising Capacity (QCLot: 1532412)								
EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	<0.01	10 % CaCO3	99.0	70	130
EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	<10	----	----	----	----
EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	<0.01	----	----	----	----

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) or Matrix Spike Duplicate (MSD) Results are required to be reported.**

ALS Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EB1807813**	Page	: 1 of 4
Client	: **ENVIRONMENTAL EARTH SCIENCES**	Laboratory	: Environmental Division Brisbane
Contact	: LORETTA VISINTIN	Telephone	: +61-7-3243 7222
Project	: 717041	Date Samples Received	: 27-Mar-2018
Site	: Boral Stockton	Issue Date	: 29-Mar-2018
Sampler	: LORETTA VISINTIN	No. of samples received	: 3
Order number	:	No. of samples analysed	: 3

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA033-C: Acid Neutralising Capacity							
80* dried soil (EA033)							
BH2_2.0 - ES1807945-013	**13-Mar-2018**	**29-Mar-2018**	13-Mar-2019	✓	**29-Mar-2018**	27-Jun-2018	✓
80* dried soil (EA033)							
BH4_6.0 - ES1807945-037, BH4_9.0 - ES1807945-038	**14-Mar-2018**	**29-Mar-2018**	14-Mar-2019	✓	**29-Mar-2018**	27-Jun-2018	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Chromium Suite for Acid Sulphate Soils	EA033	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Chromium Suite for Acid Sulphate Soils	EA033	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Chromium Suite for Acid Sulphate Soils	EA033	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Chromium Suite for Acid Sulphate Soils	EA033	SOIL	In house: Referenced to Ahern et al 2004. This method covers the determination of Chromium Reducible Sulfur (SCR); pHKCl; titratable actual acidity (TAA); acid neutralising capacity by back titration (ANC); and net acid soluble sulfur (SNAS) which incorporates peroxide sulfur. It applies to soils and sediments (including sands) derived from coastal regions. Liming Rate is based on results for samples as submitted and incorporates a minimum safety factor of 1.5.

Preparation Methods	Method	Matrix	Method Descriptions
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EB1807813**

Client	: **ENVIRONMENTAL EARTH SCIENCES**	Laboratory	: Environmental Division Brisbane
Contact	: LORETTA VISINTIN	Contact	: Peter Ravlic
Address	:	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: lvisintin@environmentalearthsciences.com	E-mail	: peter.ravlic@alsglobal.com
Telephone	: +61 02 99221777	Telephone	: +61-7-3243 7222
Facsimile	: +61 02 99221010	Facsimile	: +61-7-3243 7218
Project	: 717041	Page	: 1 of 2
Order number	:	Quote number	: ES2015ENVEAR0001 (EN/010/17)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: Boral Stockton		
Sampler	: LORETTA VISINTIN		

Dates

Date Samples Received	: 27-Mar-2018 10:19	Issue Date	: 27-Mar-2018
Client Requested Due Date	: 04-Apr-2018	Scheduled Reporting Date	: **04-Apr-2018**

Delivery Details

Mode of Delivery	: Samples On Hand	Security Seal	: Not Available
No. of coolers/boxes	: ----	Temperature	: ----
Receipt Detail	: REBATCH	No. of samples received / analysed	: 3 / 3

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- **The samples in this work order have been re-batched from ES1807945.**
- Discounted Package Prices apply only when specific ALS Group Codes ('W', 'S', 'NT' suites) are referenced on COCs.
- Please direct any turn around / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (3 weeks), Solid (2 months) from receipt of samples.
- Analysis will be conducted by ALS Environmental, Brisbane, NATA accreditation no. 825, Site No. 818 (Micro site no. 18958).
- **Breaches in recommended extraction / analysis holding times (if any) are displayed overleaf in the Proactive Holding Time Report table.**

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exists.**

Any sample identifications that cannot be displayed entirely in the analysis summary table will be listed below.

EB1807813-001 : [13-Mar-2018] : BH2_2.0 - ES1807945-013
EB1807813-002 : [14-Mar-2018] : BH4_6.0 - ES1807945-037
EB1807813-003 : [14-Mar-2018] : BH4_9.0 - ES1807945-038

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.
If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **SOIL**

Laboratory sample ID	*Client sampling date / time*	*Client sample ID*	SOIL - EA033-C ANC ANC only from Chromium Suite Method
EB1807813-001	13-Mar-2018 00:00	BH2_2.0 ES1807945-0...	✓
EB1807813-002	14-Mar-2018 00:00	BH4_6.0 ES1807945-0...	✓
EB1807813-003	14-Mar-2018 00:00	BH4_9.0 ES1807945-0...	✓

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.

Requested Deliverables

ALL INVOICES MELB ADDRESS

- A4 - AU Tax Invoice (INV)	Email	accounts@eesigroup.com

LORETTA VISINTIN

- *AU Certificate of Analysis - NATA (COA)	Email	lvisintin@environmentalearthsciences.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	lvisintin@environmentalearthsciences.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	lvisintin@environmentalearthsciences.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	lvisintin@environmentalearthsciences.com
- Chain of Custody (CoC) (COC)	Email	lvisintin@environmentalearthsciences.com
- EDI Format - ENMRG (ENMRG)	Email	lvisintin@environmentalearthsciences.com
- EDI Format - ESDAT (ESDAT)	Email	lvisintin@environmentalearthsciences.com

MARK STUCKEY

- *AU Certificate of Analysis - NATA (COA)	Email	mstuckey@eesigroup.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	mstuckey@eesigroup.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	mstuckey@eesigroup.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	mstuckey@eesigroup.com
- Chain of Custody (CoC) (COC)	Email	mstuckey@eesigroup.com
- EDI Format - ENMRG (ENMRG)	Email	mstuckey@eesigroup.com
- EDI Format - ESDAT (ESDAT)	Email	mstuckey@eesigroup.com

From: Loretta Visintin [mailto:lvisintin@eesigroup.com]
Sent: Tuesday, 27 March 2018 10:19 AM
To: ALSEnviro Sydney <ALSEnviro.Sydney@ALSGlobal.com>
Cc: Mark Stuckey <mstuckey@eesigroup.com>
Subject: RE: RESULTS & EDD for ALS Workorder : ES1807945 | Your Reference: 717041

Hello,

We have an additional analysis request; we would like to schedule ANC titration (EA033-C) analysis on the following samples:

1 • BH2_2.0
2 • BH4_6.0
3 • BH4_9.0

Standard turnaround will suffice, thanks.

Kind regards, Loretta

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Loretta Visintin – Environmental Scientist
82-84 Dickson Ave Artarmon NSW 2064
P: +61 2 9922 1777
M: +61 488 339 151
lvisintin@eesigroup.com
www.eesigroup.com

Environmental Division
Brisbane
Work Order Reference
EB1807813

Telephone : +61-7-3243 7222

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1807945**	Page	: 1 of 8
Client	: **ENVIRONMENTAL EARTH SCIENCES**	Laboratory	: Environmental Division Sydney
Contact	: LORETTA VISINTIN	Contact	: Peter Ravlic
Address	:	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: +61 02 99221777	Telephone	: +61-2-8784 8555
Project	: 717041	Date Samples Received	: 15-Mar-2018 17:30
Order number	:	Date Analysis Commenced	: 24-Mar-2018
C-O-C number	: ----	Issue Date	: 26-Mar-2018 12:44
Sampler	: LV		
Site	: Boral Stockton		
Quote number	: EN/010/17		
No. of samples received	: 48		
No. of samples analysed	: 29		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ASS: EA033 (CRS Suite):Retained Acidity not required because pH KCl greater than or equal to 4.5
- ASS: EA033 (CRS Suite): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m3'.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1_1.5	BH1_3.0	BH1_4.0	BH1_7.0	BH1_15.5
			Client sampling date / time	12-Mar-2018 00:00	12-Mar-2018 00:00	12-Mar-2018 00:00	12-Mar-2018 00:00	12-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	ES1807945-003	ES1807945-005	ES1807945-006	ES1807945-007	ES1807945-010
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	5.6	6.0	5.5	6.1	9.5
Titratable Actual Acidity (23F)	----	2	mole H+ / t	2	<2	2	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	0.026	0.016	0.024	0.018	0.016
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	16	10	15	11	<10
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	----	----	----	----	1.21
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	----	----	----	----	241
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	----	----	----	----	0.39
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S	0.03	<0.02	0.03	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	18	10	17	11	<10
Liming Rate	----	1	kg CaCO3/t	1	<1	1	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	0.03	<0.02	0.03	<0.02	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	18	10	17	11	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t	1	<1	1	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH2_0.5	BH2_2.0	BH2_2.5	BH2_3.0	BH2_9.0
			Client sampling date / time	13-Mar-2018 00:00	13-Mar-2018 00:00	13-Mar-2018 00:00	13-Mar-2018 00:00	13-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	ES1807945-012	ES1807945-013	ES1807945-014	ES1807945-015	ES1807945-017
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**10.0**	**5.1**	**6.0**	**6.2**	**5.8**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	**42**	<2	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	**0.07**	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.010**	**0.099**	**0.026**	**0.009**	**0.020**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	**62**	**16**	<10	**12**
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	**3.28**	----	----	----	----
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	**656**	----	----	----	----
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	**1.05**	----	----	----	----
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	<0.02	**0.17**	**0.03**	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	**104**	**17**	<10	**12**
Liming Rate	----	1	kg CaCO3/t	<1	**8**	**1**	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	**0.17**	**0.03**	<0.02	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	**104**	**17**	<10	**12**
Liming Rate excluding ANC	----	1	kg CaCO3/t	<1	**8**	**1**	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH3_3.5	BH3_4.0	BH3_9.0	BH3_15.0	BH3_16.0
			Client sampling date / time	13-Mar-2018 00:00	13-Mar-2018 00:00	13-Mar-2018 00:00	13-Mar-2018 00:00	13-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	ES1807945-024	ES1807945-025	ES1807945-028	ES1807945-030	ES1807945-031
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**6.1**	**6.0**	**5.7**	**9.6**	**9.5**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.007**	**0.008**	**0.018**	**0.017**	**0.012**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	<10	**11**	**10**	<10
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	**----**	**----**	**----**	**4.84**	**0.65**
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	**----**	**----**	**----**	**967**	**130**
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	**----**	**----**	**----**	**1.55**	**0.21**
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	**12**	<10	<10
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	<10	**12**	**10**	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t	<1	<1	<1	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH4_2.0	BH4_3.5	BH4_5.0	BH4_6.0	BH4_9.0
			Client sampling date / time	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	ES1807945-034	ES1807945-035	ES1807945-036	ES1807945-037	ES1807945-038
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**10.2**	**6.6**	**6.2**	**5.3**	**5.4**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	**4**	**6**
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.050**	**0.007**	**0.007**	**0.027**	**0.030**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	**31**	<10	<10	**17**	**18**
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	**8.26**	**0.27**	----	----	----
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	**1650**	**54**	----	----	----
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	**2.65**	**0.09**	----	----	----
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	**0.03**	**0.04**
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	**21**	**24**
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	**2**	**2**
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.05**	<0.02	<0.02	**0.03**	**0.04**
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**31**	<10	<10	**21**	**24**
Liming Rate excluding ANC	----	1	kg CaCO3/t	**2**	<1	<1	**2**	**2**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH4_12.0	BH4_15.0	BH4_16.0	BH4_17.0	BH4_20.5
			Client sampling date / time	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	ES1807945-039	ES1807945-040	ES1807945-041	ES1807945-043	ES1807945-044
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**6.0**	**8.0**	**5.5**	**5.9**	**9.2**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.029**	**0.018**	**0.017**	**0.018**	**0.012**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	**18**	**11**	**11**	**11**	<10
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	**----**	**0.20**	**----**	**----**	**0.62**
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	**----**	**39**	**----**	**----**	**125**
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	**----**	**0.06**	**----**	**----**	**0.20**
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	**0.03**	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	**18**	<10	**12**	**11**	<10
Liming Rate	----	1	kg CaCO3/t	**1**	<1	<1	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.03**	<0.02	<0.02	<0.02	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**18**	**11**	**12**	**11**	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t	**1**	<1	<1	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	FD1	FD2	FD3	FD4	----
			Client sampling date / time	13-Mar-2018 00:00	12-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	----
Compound	CAS Number	LOR	Unit	ES1807945-045	ES1807945-046	ES1807945-047	ES1807945-048	--------
				Result	Result	Result	Result	----
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**8.6**	**9.3**	**6.3**	**5.6**	----
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	<2	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	----
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.014**	**0.016**	<0.005	**0.025**	----
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	<10	<10	**16**	----
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	**0.21**	**1.18**	----	----	----
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	**41**	**235**	----	----	----
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	**0.07**	**0.38**	----	----	----
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	----
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	**0.03**	----
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	**17**	----
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	**1**	----
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	**0.03**	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	<10	<10	**17**	----
Liming Rate excluding ANC	----	1	kg CaCO3/t	<1	<1	<1	**1**	----

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **ES1807945**	Page	: 1 of 3
Client	: **ENVIRONMENTAL EARTH SCIENCES**	Laboratory	: Environmental Division Sydney
Contact	: LORETTA VISINTIN	Contact	: Peter Ravlic
Address	:	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: +61 02 99221777	Telephone	: +61-2-8784 8555
Project	: 717041	Date Samples Received	: 15-Mar-2018
Order number	:	Date Analysis Commenced	: 24-Mar-2018
C-O-C number	: ----	Issue Date	: 26-Mar-2018
Sampler	: LV		
Site	: Boral Stockton		
Quote number	: EN/010/17		
No. of samples received	: 48		
No. of samples analysed	: 29		

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA033-A: Actual Acidity (QC Lot: 1516717)									
ES1807945-003	BH1_1.5	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.00	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	2	2	0.00	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	5.6	5.7	1.77	0% - 20%
ES1807945-024	BH3_3.5	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.00	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.00	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	6.1	6.3	3.22	0% - 20%
EA033-A: Actual Acidity (QC Lot: 1516718)									
ES1807945-039	BH4_12.0	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.00	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.00	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	6.0	6.1	1.65	0% - 20%
EA033-B: Potential Acidity (QC Lot: 1516717)									
ES1807945-003	BH1_1.5	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.026	0.024	6.25	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	16	15	0.00	No Limit
ES1807945-024	BH3_3.5	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.007	0.009	28.6	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	<10	0.00	No Limit
EA033-B: Potential Acidity (QC Lot: 1516718)									
ES1807945-039	BH4_12.0	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.029	0.026	9.93	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	18	16	9.93	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA033-A: Actual Acidity (QCLot: 1516717)								
EA033: pH KCl (23A)	----	----	pH Unit	----	4.6 pH Unit	100	70	130
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	17.7 mole H+ / t	96.6	70	130
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-A: Actual Acidity (QCLot: 1516718)								
EA033: pH KCl (23A)	----	----	pH Unit	----	4.6 pH Unit	100	70	130
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	17.7 mole H+ / t	108	70	130
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-B: Potential Acidity (QCLot: 1516717)								
EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	0.25483 % S	84.0	70	130
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----
EA033-B: Potential Acidity (QCLot: 1516718)								
EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	0.25483 % S	81.8	70	130
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----
EA033-C: Acid Neutralising Capacity (QCLot: 1516717)								
EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	<0.01	10 % CaCO3	100	70	130
EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	<10	----	----	----	----
EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	<0.01	----	----	----	----
EA033-C: Acid Neutralising Capacity (QCLot: 1516718)								
EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	<0.01	10 % CaCO3	100	70	130
EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	<10	----	----	----	----
EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	<0.01	----	----	----	----

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) or Matrix Spike Duplicate (MSD) Results are required to be reported.**

ALS Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **ES1807945**	Page	: 1 of 6
Client	: **ENVIRONMENTAL EARTH SCIENCES**	Laboratory	: Environmental Division Sydney
Contact	: LORETTA VISINTIN	Telephone	: +61-2-8784 8555
Project	: 717041	Date Samples Received	: 15-Mar-2018
Site	: Boral Stockton	Issue Date	: 26-Mar-2018
Sampler	: LV	No. of samples received	: 48
Order number	:	No. of samples analysed	: 29

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA033-A: Actual Acidity							
Snap Lock Bag - frozen (EA033)							
BH1_1.5, BH1_3.0, BH1_4.0, BH1_7.0, BH1_15.5, FD2	**12-Mar-2018**	**24-Mar-2018**	12-Mar-2019	✓	**24-Mar-2018**	22-Jun-2018	✓
Snap Lock Bag - frozen (EA033)							
BH2_0.5, BH2_2.0, BH2_2.5, BH2_3.0, BH2_9.0, BH3_3.5, BH3_4.0, BH3_9.0, BH3_15.0, BH3_16.0, FD1	**13-Mar-2018**	**24-Mar-2018**	13-Mar-2019	✓	**24-Mar-2018**	22-Jun-2018	✓
Snap Lock Bag - frozen (EA033)							
BH4_2.0, BH4_3.5, BH4_5.0, BH4_6.0, BH4_9.0, BH4_12.0, BH4_15.0, BH4_16.0, BH4_17.0, BH4_20.5, FD3, FD4	**14-Mar-2018**	**24-Mar-2018**	14-Mar-2019	✓	**24-Mar-2018**	22-Jun-2018	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA033-B: Potential Acidity							
Snap Lock Bag - frozen (EA033) BH1_1.5, BH1_3.0, BH1_4.0, BH1_7.0, BH1_15.5, FD2	**12-Mar-2018**	**24-Mar-2018**	12-Mar-2019	✓	**24-Mar-2018**	22-Jun-2018	✓
Snap Lock Bag - frozen (EA033) BH2_0.5, BH2_2.0, BH2_2.5, BH2_3.0, BH2_9.0, BH3_3.5, BH3_4.0, BH3_9.0, BH3_15.0, BH3_16.0, FD1	**13-Mar-2018**	**24-Mar-2018**	13-Mar-2019	✓	**24-Mar-2018**	22-Jun-2018	✓
Snap Lock Bag - frozen (EA033) BH4_2.0, BH4_3.5, BH4_5.0, BH4_6.0, BH4_9.0, BH4_12.0, BH4_15.0, BH4_16.0, BH4_17.0, BH4_20.5, FD3, FD4	**14-Mar-2018**	**24-Mar-2018**	14-Mar-2019	✓	**24-Mar-2018**	22-Jun-2018	✓
EA033-C: Acid Neutralising Capacity							
Snap Lock Bag - frozen (EA033) BH1_1.5, BH1_3.0, BH1_4.0, BH1_7.0, BH1_15.5, FD2	**12-Mar-2018**	**24-Mar-2018**	12-Mar-2019	✓	**24-Mar-2018**	22-Jun-2018	✓
Snap Lock Bag - frozen (EA033) BH2_0.5, BH2_2.0, BH2_2.5, BH2_3.0, BH2_9.0, BH3_3.5, BH3_4.0, BH3_9.0, BH3_15.0, BH3_16.0, FD1	**13-Mar-2018**	**24-Mar-2018**	13-Mar-2019	✓	**24-Mar-2018**	22-Jun-2018	✓
Snap Lock Bag - frozen (EA033) BH4_2.0, BH4_3.5, BH4_5.0, BH4_6.0, BH4_9.0, BH4_12.0, BH4_15.0, BH4_16.0, BH4_17.0, BH4_20.5, FD3, FD4	**14-Mar-2018**	**24-Mar-2018**	14-Mar-2019	✓	**24-Mar-2018**	22-Jun-2018	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA033-D: Retained Acidity							
Snap Lock Bag - frozen (EA033) BH1_1.5, BH1_3.0, BH1_4.0, BH1_7.0, BH1_15.5, FD2	**12-Mar-2018**	**24-Mar-2018**	12-Mar-2019	✓	**24-Mar-2018**	22-Jun-2018	✓
Snap Lock Bag - frozen (EA033) BH2_0.5, BH2_2.0, BH2_2.5, BH2_3.0, BH2_9.0, BH3_3.5, BH3_4.0, BH3_9.0, BH3_15.0, BH3_16.0, FD1	**13-Mar-2018**	**24-Mar-2018**	13-Mar-2019	✓	**24-Mar-2018**	22-Jun-2018	✓
Snap Lock Bag - frozen (EA033) BH4_2.0, BH4_3.5, BH4_5.0, BH4_6.0, BH4_9.0, BH4_12.0, BH4_15.0, BH4_16.0, BH4_17.0, BH4_20.5, FD3, FD4	**14-Mar-2018**	**24-Mar-2018**	14-Mar-2019	✓	**24-Mar-2018**	22-Jun-2018	✓
EA033-E: Acid Base Accounting							
Snap Lock Bag - frozen (EA033) BH1_1.5, BH1_3.0, BH1_4.0, BH1_7.0, BH1_15.5, FD2	**12-Mar-2018**	**24-Mar-2018**	12-Mar-2019	✓	**24-Mar-2018**	22-Jun-2018	✓
Snap Lock Bag - frozen (EA033) BH2_0.5, BH2_2.0, BH2_2.5, BH2_3.0, BH2_9.0, BH3_3.5, BH3_4.0, BH3_9.0, BH3_15.0, BH3_16.0, FD1	**13-Mar-2018**	**24-Mar-2018**	13-Mar-2019	✓	**24-Mar-2018**	22-Jun-2018	✓
Snap Lock Bag - frozen (EA033) BH4_2.0, BH4_3.5, BH4_5.0, BH4_6.0, BH4_9.0, BH4_12.0, BH4_15.0, BH4_16.0, BH4_17.0, BH4_20.5, FD3, FD4	**14-Mar-2018**	**24-Mar-2018**	14-Mar-2019	✓	**24-Mar-2018**	22-Jun-2018	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Chromium Suite for Acid Sulphate Soils	EA033	3	29	**10.34**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Chromium Suite for Acid Sulphate Soils	EA033	2	29	**6.90**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Chromium Suite for Acid Sulphate Soils	EA033	2	29	**6.90**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Chromium Suite for Acid Sulphate Soils	EA033	SOIL	In house: Referenced to Ahern et al 2004. This method covers the determination of Chromium Reducible Sulfur (SCR); pHKCl; titratable actual acidity (TAA); acid neutralising capacity by back titration (ANC); and net acid soluble sulfur (SNAS) which incorporates peroxide sulfur. It applies to soils and sediments (including sands) derived from coastal regions. Liming Rate is based on results for samples as submitted and incorporates a minimum safety factor of 1.5.

Preparation Methods	Method	Matrix	Method Descriptions
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house

CHAIN OF CUSTODY - ANALYSIS REQUEST FORM

Project Manager: Loretta Visintin | Sampler: LV | Job No: 717041 | Site Location: Boral Stockton | Laboratory: ALS | Sheet: 1 of 1

No. of samples	Sample ID/ Depth	Field pH water	Date sampled	Field Test: Difference pHFOX	Sample Matrix			Analysis Required													Sample-specific instructions/ notes
					Soil	Water	Sediment	EA033 (Cr suite complete)	HOLD												
1	BH1_0.3	6.9	12/03/2018	1.2	X				x												
2	BH1_1.0	7.2	12/03/2018	1.1	X				x												
3	BH1_1.5	6.8	12/03/2018	3.1	X			x													
4	BH1_2.0	6.2	12/03/2018	1.6	X				x												
5	BH1_3.0	6.5	12/03/2018	2.9	X			x													
6	BH1_4.0	6.2	12/03/2018	2.5	X			x													
7	BH1_7.0	5.4	12/03/2018	2.2	X			x													
8	BH1_10.5	6.3	12/03/2018	0.2	X				x												
9	BH1_12.0	7.8	12/03/2018	1.7	X				x												
10	BH1_15.5	8.3	12/03/2018	2.2	X			x													
11	BH2_0.25	6.8	13/03/2018	0.8	X				x												
12	BH2_0.5	8.7	13/03/2018	2.1	X			x													
13	BH2_2.0	5	13/03/2018	3.7	X			x													
14	BH2_2.5	6.5	13/03/2018	3.7	X			x													
15	BH2_3.0	6.4	13/03/2018	1.2	X			x													
16	BH2_6.0	6.2	13/03/2018	0.6	X				x												
17	BH2_9.0	6.4	13/03/2018	3.3	x			x													
	TOTAL																				

Turn Around *(circle)*: **NORMAL** / **3 DAYS** / **48 HRS** / **24 HRS** *(confirm with lab in advance if quick turn-around is required)*

Comments/ Instructions:

Lab Quotation No. *(if applicable)*:

Send report to *(email address)*: lvisintin@environmentalearthsciences.com

Cc: report to *(email address)*: mstuckey@eesigroup.com

Cc: invoice to *(email address)*: accounts@eesigroup.com

	Name	Signature	Date	Time
Sent off Site/Office by:	Loretta Visintin		15-Mar-18	
Receiving Lab:	Scanned	yes	15/3/18	1730 ork
Receiving Lab:				

Phone: (02) 9922 1777
Fax: (02) 9922 1010
PO Box 380 North Sydney NSW 2059
Email: eesnsw@environmentalearthsciences.com

ENVIRONMENTAL EARTH SCIENCES

Gibson Forward Lab / Split WO
Lab / Analysis: Brisbane / Cr suite EA033
Organised By / Date: _____
Relinquished By / Date: _____
Courier / Courier: _____
WO No: _____
Attach By PO / Internal Sheet: _____

Environmental Division
Sydney
Work Order Reference
ES1807945

Telephone : + 61-2-8784 8555

CHAIN OF CUSTODY - ANALYSIS REQUEST FORM

Project Manager: Loretta Visintin | Sampler: LV | Job No: 717041 | Site Location: Boral Stockton | Laboratory: ALS | Sheet: 1 of 1

No. of samples	Sample ID/ Depth	Field pH water	Date sampled	Field Test: Difference pHFOX	Sample Matrix			Analysis Required												Sample-specific instructions/ notes
					Soil	Water	Sediment	EA033 (Cr suite complete)	HOLD											
18	BH2_12.0	6.9	13/03/2018	1.1	X				x											
19	BH2_16.0	6.5	13/03/2018	1	X				x											
20	BH2_19.5	6	13/03/2018	0.4	X				x											
21	BH2_24.0	6.6	13/03/2018	0.5	X				x											
22	BH3_0.5	7.2	13/03/2018	0.3	X				x											
23	BH3_2.75	7.4	13/03/2018	0.9	X				x											
24	BH3_3.5	7.7	13/03/2018	1.8	X			x												
25	BH3_4.0	7.4	13/03/2018	1.7	X			x												
26	BH3_6.0	7	13/03/2018	1.2	X				x											
27	BH3_8.0	7.1	13/03/2018	1.4	X				x											
28	BH3_9.0	6.9	13/03/2018	4.3	X			x												
29	BH3_12.0	7.4	13/03/2018	1.1	X				x											
30	BH3_15.0	8.2	13/03/2018	2	X			x												
31	BH3_16.0	8.6	13/03/2018	2.5	X			x												
32	BH3_18.0	6.8	13/03/2018	0.9	X				x											
33	BH4_0.5	7.2	14/03/2018	1.7	X				x											
34	BH4_2.0	7.3	14/03/2018	2.2	X			x												
	TOTAL																			

Turn Around *(circle)*: **NORMAL** / **3 DAYS** / **48 HRS** / **24 HRS** *(confirm with lab in advance if quick turn-around is required)*

Comments/ Instructions:

Lab Quotation No. *(if applicable)*:

Send report to *(email address)*: lvisintin@environmentalearthsciences.com

Cc: report to *(email address)*: mstuckey@eesigroup.com

Cc: Invoice to *(email address)*: accounts@eesigroup.com

	Name	Signature	Date	Time
Sent off Site/Office by:	Loretta Visintin		15-Mar-18	
Receiving Lab:	[illegible]		15/3/18	1730 OK
Receiving Lab:				

Phone: (02) 9922 1777
Fax: (02) 9922 1010
PO Box 380 North Sydney NSW 2059
Email: eesnsw@environmentalearthsciences.com

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

CHAIN OF CUSTODY - ANALYSIS REQUEST FORM

Project Manager: Loretta Visintin | Sampler: LV | Job No: 717041 | Site Location: Boral Stockton | Laboratory: ALS | **Sheet:** 1 **of** 1

No. of samples	Sample ID/ Depth	Field pH water	Date sampled	Field Test: Difference pHFOX	Sample Matrix: Soil	Water	Sediment	Analysis Required: EA033 (Cr suite complete)	HOLD											Sample-specific instructions/ notes
35	BH4_3.5	7.5	14/03/2018	2.7	X			x												
36	BH4_5.0	7.4	14/03/2018	2.4	X			x												
37	BH4_6.0	7.3	14/03/2018	4.3	X			x												
38	BH4_9.0	7	14/03/2018	4.4	X			x												
39	BH4_12.0	7.4	14/03/2018	2.8	X			x												
40	BH4_15.0	7.2	14/03/2018	3.3	X			x												
41	BH4_16.0	7.2	14/03/2018	4.6	X			x												
42	BH4_16.5	7.5	14/03/2018	1.4	X				x											
43	BH4_17.0	8.7	14/03/2018	3.1	X			x												
44	BH4_20.5	8.8	14/03/2018	2.7	X			x												
45	FD1		13/03/2018		X			x												
46	FD2		12/03/2018		X			x												
47	FD3		14/03/2018		X			x												
48	FD4		14/03/2018		x			x												
	TOTAL		48					29	19											

Turn Around *(circle)*: **NORMAL** / **3 DAYS** / **48 HRS** / **24 HRS** *(confirm with lab in advance if quick turn-around is required)*

Lab Quotation No. *(if applicable)*:

Comments/ Instructions:

Send report to *(email address)*: lvisintin@environmentalearthsciences.com

Cc: report to *(email address)*: mstuckey@eesigroup.com

Cc: invoice to *(email address)*: accounts@eesigroup.com

	Name	Signature	Date	Time
Sent off Site/Office by:	Loretta Visintin		15-Mar-18	
Receiving Lab:	Soils Lab	AJS.	15/3/18	1730 O/C
Receiving Lab:				

Phone: (02) 9922 1777
Fax: (02) 9922 1010
PO Box 380 North Sydney NSW 2059
Email: eesnsw@environmentalearthsciences.com

ENVIRONMENTAL EARTH SCIENCES

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

INTERIM REPORT 207744

Client Details

Client	VGT Laboratories Pty Ltd
Attention	Administration Email
Address	PO Box 2335, Greenhills, NSW, 2323

Sample Details

Your Reference	**6740**
Number of Samples	2 water
Date samples received	11/12/2018
Date completed instructions received	11/12/2018

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	18/12/2018
Interim Report Date	18/12/2018

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Radioactivity Analysis report			
Our Reference		207744-1	207744-2
Your Reference	UNITS	6740/2	6740/4
Date Sampled		06/12/2018	06/12/2018
Type of sample		water	water
Date prepared	-		
Date analysed	-		
Radium-226	Bq/L		
Radium-228	Bq/L		

HM in water - total			
Our Reference		207744-1	207744-2
Your Reference	UNITS	6740/2	6740/4
Date Sampled		06/12/2018	06/12/2018
Type of sample		water	water
Date prepared	-	12/12/2018	12/12/2018
Date analysed	-	12/12/2018	12/12/2018
Uranium-Total	µg/L	<0.5	<0.5
Thorium-Total	µg/L	<0.5	<0.5

Method ID	Methodology Summary
Ext-041	Analysed by Australian Government - Australian Radiation Protection and Nuclear Safety Agnency. VIC. Radium 226 is determined by liquid scintiallation counting. Radium 228 is measured by high resolution gamma-ray spectrometry.
Metals-022	Determination of various metals by ICP-MS.

QUALITY CONTROL: HM in water - total						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Date prepared	-			12/12/2018	[NT]	[NT]	[NT]	[NT]	12/12/2018	[NT]
Date analysed	-			12/12/2018	[NT]	[NT]	[NT]	[NT]	12/12/2018	[NT]
Uranium-Total	µg/L	0.5	Metals-022	<0.5	[NT]	[NT]	[NT]	[NT]	105	[NT]
Thorium-Total	µg/L	0.5	Metals-022	<0.5	[NT]	[NT]	[NT]	[NT]	110	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

CHAIN OF CUSTODY - Client

ENVIROLAB GROUP - National phone number 1300 42 43 44

Sydney Lab - Envirolab Services
12 Ashley St, Chatswood, NSW 2067
Ph 02 9910 6200 / sydney@envirolab.com.au

Perth Lab - MPL Laboratories
16-18 Hayden Crt Myaree, WA 6154
Ph 08 9317 2505 / lab@mpl.com.au

Melbourne Lab - Envirolab Services
1A Dalmore Drive Scoresby VIC 3179
Ph 03 9763 2500 / melbourne@envirolab.com.au

Brisbane Office - Envirolab Services
20a, 10-20 Depot St, Banyo, QLD 4014
Ph 07 3266 9532 / brisbane@envirolab.com.au

Adelaide Office - Envirolab Services
7a The Parade, Norwood, SA 5067
Ph 0406 350 706 / adelaide@envirolab.com.au

Client: VGT Pty Ltd

Contact Person: Lisa Thomson / Anthony Crane

Project Mgr:

Sampler:

Address:
Delivery: 4/30 Glenwood Dr, Thornton NSW 2322
Postal: PO Box 2335, Greenhills, NSW 2323

Phone: 4028 6412 **Mob:** 0427 334471

Email: Results: lab@vgt.com.au Invoice: mail@vgt.com.au

Client Project Name / Number / Site etc (ie report title): 6740

PO No.:

Envirolab Quote No. : 2016_C3 (No $25 Admin Fee, No Min $100)

Date results required:

Or choose: standard

Note: Inform lab in advance if urgent turnaround is required - surcharges apply

Report format: esdat / equis /

Lab Comments:

Sample information					Tests Required														Comments
Envirolab Sample ID	Client Sample ID or information	second Desc	Date sampled	Type of sample	Gross Alpha and Beta	Uranium/Thorium													Provide as much information about the sample as you can
1	6740/2		6/12/18	GW	X	X													
2	6740/4		6/12/18	GW	X	X													

ENVIROLAB
Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200

Job No: 207744

Date Received: 11/12

Time Received: 10:42

Received By: AZ

Temp: Cool/Ambient

Cooling: Ice/Icepack

Security: Intact/Broken/None

Relinquished by (Company): VGT Pty Ltd

Print Name: Athony Crane

Date & Time: 10/12/2018

Signature: AJC

Received by (Company): ELS

Print Name: Andy Zhang

Date & Time: 11/12 10:42

Signature: AZ

Lab use only:

Samples Received: Cool or Ambient (circle one)

Temperature Received at: **(if applicable)**

Transported by: Hand delivered / courier

White - Lab copy / Blue - Client copy / Pink - Retain in Book

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 207744

Client Details

Client	VGT Laboratories Pty Ltd
Attention	Administration Email
Address	PO Box 2335, Greenhills, NSW, 2323

Sample Details

Your Reference	**6740**
Number of Samples	2 water
Date samples received	11/12/2018
Date completed instructions received	11/12/2018

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	18/12/2018
Date of Issue	16/01/2019
Reissue Details	This report replaces R00 created on 16/01/2019 due to: Sample ID Amended (Client Request)

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Results Approved By
Jaimie Loa-Kum-Cheung, Senior Chemist
Nancy Zhang, Assistant Lab Manager

Authorised By

Jacinta Hurst, Laboratory Manager

Radioactivity Analysis report			
Our Reference		207744-1	207744-2
Your Reference	UNITS	MW2	MW7
Date Sampled		06/12/2018	06/12/2018
Type of sample		water	water
Radium-226	Bq/L	#	#
Radium-228	Bq/L	#	#

HM in water - total			
Our Reference		207744-1	207744-2
Your Reference	UNITS	MW2	MW7
Date Sampled		06/12/2018	06/12/2018
Type of sample		water	water
Date prepared	-	12/12/2018	12/12/2018
Date analysed	-	12/12/2018	12/12/2018
Uranium-Total	µg/L	<0.5	<0.5
Thorium-Total	µg/L	<0.5	<0.5

Method ID	Methodology Summary
Ext-041	Analysed by Australian Government - Australian Radiation Protection and Nuclear Safety Agency. VIC. Radium 226 is determined by liquid scintiallation counting. Radium 228 is measured by high resolution gamma-ray spectrometry.
Metals-022	Determination of various metals by ICP-MS.

QUALITY CONTROL: HM in water - total						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Date prepared	-			12/12/2018	[NT]	[NT]	[NT]	[NT]	12/12/2018	[NT]
Date analysed	-			12/12/2018	[NT]	[NT]	[NT]	[NT]	12/12/2018	[NT]
Uranium-Total	µg/L	0.5	Metals-022	<0.5	[NT]	[NT]	[NT]	[NT]	105	[NT]
Thorium-Total	µg/L	0.5	Metals-022	<0.5	[NT]	[NT]	[NT]	[NT]	110	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
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RPD	Relative Percent Difference
LCS	Laboratory Control Sample
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NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Report Comments

Gross Alpha and Beta analysed by ALS, report no CA1807626.
see report atatched.

ALS Water

CERTIFICATE OF ANALYSIS

Work Order	: **CA1807626**	Page	: 1 of 2
Amendment	: **1**		
Client	: **Envirolab Services**	Laboratory	: ALS Water Resources Group
Contact	: Results Envirolab	Contact	: Client Services
Address	: 12 Ashley Street Chatswood NSW 2067	Address	: 16B Lithgow Street Fyshwick ACT Australia 2609
Telephone	: 0299106200	Telephone	: +61 2 6202 5404
Project	: —	Date Samples Received	: 13-Dec-2018 11:20
Order number	:	Date Analysis Commenced	: 18-Dec-2018
C-O-C number	: —	Issue Date	: 16-Jan-2019 13:48
Sampler	: —		
Site	: —		
Quote number	: —		
No. of samples received	: 2		
No. of samples analysed	: 2		

Accreditation No. 992
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Titus Vimalasiri	Metals Teamleader	Radionuclides, Fyshwick, ACT

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- **For samples collected by ALS WRG, sampling was carried out in accordance with Procedure EN67**

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)				Client sample ID	— **MW2**	— **MW7**	—	—	—
				Client sampling date / time	12-Dec-2018 00:00	12-Dec-2018 00:00	--–	––	–--
Compound	*CAS Number*	*LOR*	*Unit*		**CA1807626-001**	**CA1807626-002**	——–	——-	–——–
					Result	Result	---	––	-–
EA250CA: Gross Alpha and Beta Activity									
Gross alpha	––	0.05	Bq/L		<0.05	<0.05	––	—	—
Gross beta	––	0.10	Bq/L		<0.10	<0.10	––	—	—
Gross beta activity - 40K	––	0.10	Bq/L		<0.10	<0.10	––	—	—

APPENDIX G: SLUG TEST RESULTS

stockton *717041*

slug test 13/14 March 208

MW06

Parameters		Jacob Approximation		Hvorslev			Bouwer & Rice					
							Lw=h		***h>Lw***			
Test 1		***T = 2.3Q/4*pi*delta s***		***To=(ln(0,37/E)/F***								
Depth (m)	11.4	slope	0.135	E	0.8012		Le/R	60.0	A	3		
Static (m)	5.5			F	-1.168		C	2	B	0.6		
Hydraulic gradient (m/m)	0.002						Ho	0.169	ln (Re/R)	3.1451		
Aquifer thickness (b,m)	6.0	**delta S**	0.3108		checked by hand		Ht	0.018				
Le (m)	3	**S**	3.00E-05	To	0.661		t	1.5				
Lw (m)	5.9	**KD (m2/d)**	353.281	**KD (m2/d)**	334.243							
R (m)	0.05	**K (m/d)**	**58.8801**	**K (m/d)**	**55.7071**	**6.91**	**KD (m2/d)**	305.496	**KD (m2/d)**	253.5700		
Porosity	0.35	**v (m/d)**	0.336458	**v (m/d)**	0.318326		**K (m/d)**	**50.9160**	**K (m/d)**	**42.2617**		
		v (m/year)	122.807	**v (m/year)**	116.189		**v (m/d)**	0.290949	**v (m/d)**	0.24150		
Q (m3/d)	**600.000**						**v (m/year)**	106.196	**v (m/year)**	88.1458		
Water (m)	5.9											

	Average	SD	CV
KD	311.65	43.42	0.14
K	49.63	4.01	0.08
v	0.297	0.04	0.14
	108.33	15.09	0.14

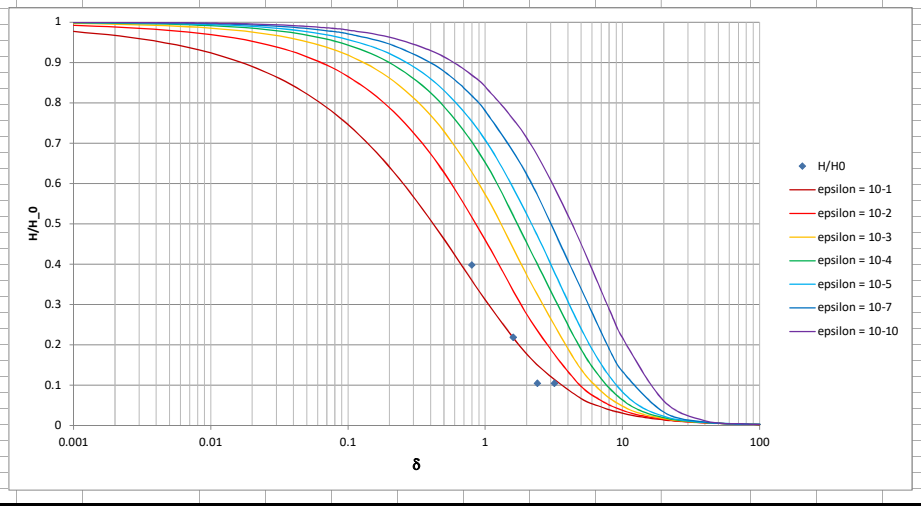
Cooper, Bredehoft, and Papadopulos (1967) slug test analysis for well screens below the water table and dominated by horizontal flow. Insert your observed t vs. H/H_0 data, then enter model data in the yellow row and adjust K_r to achieve a match to one of the curves. Then enter the best-fit alpha (blue cell) to get an estimated Ss. All data must be in one consistent set of time and length units (e.g. day, meter). The parameters are defined as follows: H=deviation of head from static, H_0 = initial H, at t=0, t=time, r_s=effective radius of the screen, r_c=effective radius of the casing, B=length of the well screen or formation thickness for fully-penetrating well, K=horizontal hydraulic conductivity, S_s=specific storage, ε (epsilon)= S_s b(r_s/r_c)^2, δ=Kbt/(r_c)^2.

Cooper, H. H., J. D. Bredehoeft, and I. S. Papadopulos. 1967. Response of a finite diameter well to an instantaneous charge of water. *Water Resources Research*, 3, 263--269.

Papadapulos, I. S., Bredehoeft, J. D., and H. H. Cooper. 1973. On the analysis of "slug test" data. *Water Resources*

r_s [L]	r_c [L]	b [L]	K [L/T]		Best fit epsilon [ ]		S
0.05	0.05	10	4.0E-04	m/s	1.0E-01		1.0E-01
			3.5E+01	m/d	S_s [1/L] computed from best fit epsilon		
MW1			3.5E+02	m2/d	1.0E-02		

t	H/H0	δ
0	1	0
0.5	0.397929	0.8
1	0.218935	1.6
1.5	0.10503	2.4
2	0.10503	3.2
		0
		0
		0
		0
		0
		0
		0



APPENDIX H: SOIL LANDSCAPE REPORTS

bt BOYCES TRACK

Landscape—steep Quaternary Holocene sand dunes on the Tomago Coastal Plain. Local relief 10–30 m, slopes >25%, elevation 10–40 m. Uncleared tall open-forest.

Soils—deep (>300 cm), well-drained weakly developed Podzols (Uc2.2).

Qualities and Limitations—wind erosion hazard, steep slopes, mass movement hazard (if disturbed), ground water pollution hazard, non-cohesive acid soils of low fertility.

LOCATION

Steep stable Holocene dunes on the Tomago Coastal Plain between North Stockton and Bobs Farm. Type location is along Boyces Track (Area reference 4**01****E, 63 **70****N).

LANDSCAPE

Geology and Regolith

Holocene transgressive aeolian dunes.

Topography

Steep stable Holocene transgressive dunes. Two long walled ridges, parallel to the shoreline, form the major part of this landscape (Thom *et al*. 1992). These ridges are separated by a low relief sand plain (see Hawks Nest **(hn)** soil landscape). Local relief 10–20 m, slope gradients often >30 %, elevation 10–40 m. Windward slopes are generally longer and more gently inclined than leeward slopes which are shorter and steeper, often having formed at the angle of repose of the sand.

Vegetation

Predominantly uncleared tall open-forest containing *Eucalyptus pilularis* (blackbutt), *Angophora costata* (smooth-barked apple), *Banksia serrata* (old man banksia), *Acacia longifolia* (sydney golden wattle) with an understorey of *Persoonia* spp. (geebung), *Pteridium esculentum* (bracken) and *Imperata cylindrica* (blady grass).

Land Use

Predominantly bushland. Some areas are being sand mined.

Existing Land Degradation

This landscape is often being buried on the seaward side by large encroaching unstable transgressive dunes.

SOILS

Dominant Soil Materials

bt1—Speckled loose loamy sand (topsoil—A_1 horizon)

Colour	commonly brownish grey (10YR 4/1)
Texture	coarse loamy sand
Structure	loose
Fabric	sandy
Field pH	moderately to slightly acid (pH 5.0–6.0)
Coarse fragments	few charcoal fragments
Roots	common fine, few coarse
Exposed condition	loose
Permeability	high
Type location	Boyces Track on top of dune 500 m south of Nelson Bay Road (Grid Ref. 4 **01**10*E, 63 **70**40*N). *Soil Landscapes of the Port Stephens 1:100 000 Sheet* Soil Data System card 25, 0–40 cm

bt2—Bleached loose sand (topsoil—A_2 horizon)

Colour	greyish yellow brown (10YR 5/2) to light grey (10YR 7/1, 10YR 8/1). Dry colours usually bleached light grey (10YR 7/1, 10YR8/1)
Texture	sand
Structure	loose

Fabric	sandy
Field pH	slightly acid to neutral (pH 6.0–7.0)
Coarse fragments	few charcoal fragments
Roots	few fine, few coarse
Exposed condition	loose
Permeability	high
Type location	Boyces Track on top of dune 500 m south of Nelson Bay Road (Grid Ref. 4 **01**10*E, 63 **70**40*N). *Soil Landscapes of the Port Stephens 1:100 000 Sheet* Soil Data System card 25, 40–140 cm

bt3—Faintly mottled sand (topsoil—weak Bhs horizon)

Colour	mixture of dark brown (10YR 4/3) or brown (10YR 4/4) mottles in a background colour of dull yellow orange (10YR 6/4)
Texture	sand
Structure	loose
Fabric	sandy
Field pH	slightly acid to neutral (pH 6.0–7.0)
Coarse fragments	absent
Roots	few fine, few coarse
Exposed condition	loose
Permeability	high
Type location	Boyces Track on top of dune 500 m south of Nelson Bay Road (Grid Ref. 4 **01**10*E, 63 **70**40*N). *Soil Landscapes of the Port Stephens 1:100 000 Sheet* Soil Data System card 25, 140–180 cm

bt4—Loose dull yellow orange sand (parent material—C horizon)

Colour	dull yellow orange (10YR 6/4)
Texture	sand
Structure	loose
Fabric	sandy
Field pH	slightly acid to neutral (pH 6.0–7.0)
Coarse fragments	absent
Roots	absent
Exposed condition	loose
Permeability	high
Type location	Boyces Track on top of dune 500 m south of Nelson Bay Road (Grid Ref. 4 **01**10*E, 63 **70**40*N). *Soil Landscapes of the Port Stephens 1:100 000 Sheet* Soil Data System card 25, >180 cm

Occurrence and Relationships

Generally. Up to 40 cm of speckled loose loamy sand **(bt1)** overlies up to 100 cm of bleached loose light grey sand **(bt2)**, which overlies up to a 50 cm of faintly mottled sand **(bt3)** and >500 cm of loose dull yellow orange sand **(bt4)** [well-drained weakly developed Podzols (Uc2.2)]. Boundaries are clear except for **bt3/bt4** which is diffuse. Total soil depth >300 cm.

QUALITIES AND LIMITATIONS

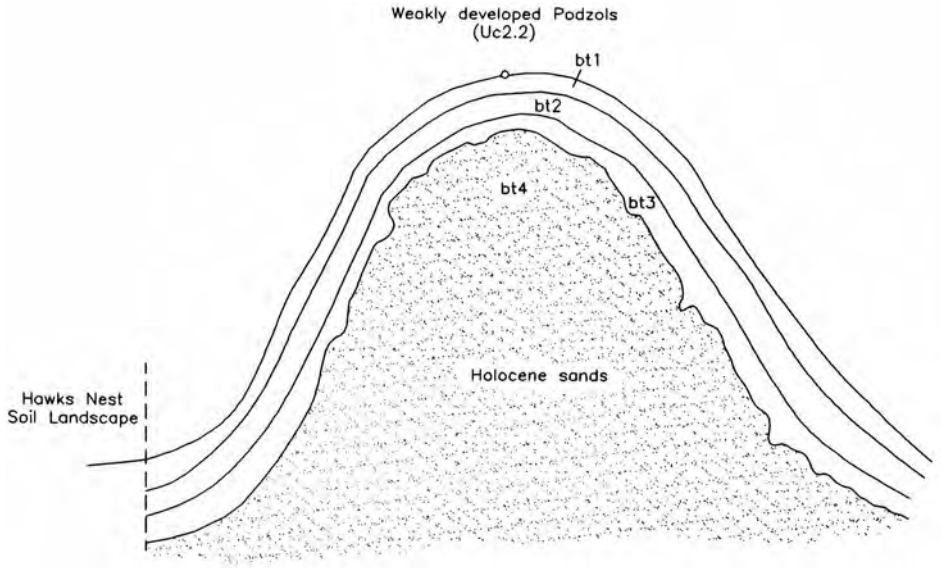
Landscape Limitations

High wind erosion hazard
Mass movement hazard (if disturbed)
Steep slopes (localised)
Non-cohesive soils
Foundation hazard
Ground water pollution hazard

Soil Limitations

bt1
High erodibility
High permeability
Very strong acidity
Low fertility
Low available water-holding capacity

bt2
High erodibility
High permeability
Strong acidity
Very low fertility
Very low available water-holding capacity



■ ***Schematic cross-section of Boyces Track soil landscape illustrating the occurrence and relationship of the dominant soil materials.***

bt3 High erodibility
High permeability
Strong acidity
Very low fertility
Very low available water-holding capacity

bt4 High erodibility
High permeability
Very low fertility
Very low available water-holding capacity

Fertility

Soil Materials as Plant Growth Media. Soil material suitability as growth media is generally low, due to strongly acid soils, high permeability, low fertility and very low available water-holding capacity.

Soil Profile Fertility. Soil profile suitability is generally low to moderate for deep, well-drained Podzols.

Erodibility

	K factor	Non-concentrated flows	Concentrated flows	Wind
bt1	0.000	very low	high	moderate
bt2	0.000	very low	very high	high
bt3	0.000	very low	high	high
bt4	0.000	very low	high	high

Erosion Hazard

	Non-concentrated flows	Concentrated flows	Wind
grazing	slight	high	V high
cultivation	slight	high	extreme
urban	slight	very high	V high

Foundation Hazard

High foundation hazard due to steep slopes and localised mass movement hazard.

Urban Capability

Generally high to severe limitations for urban development.

Rural Capability

Generally severe limitations for cultivation and high limitations for grazing. This landscape is best left undisturbed and retained under native vegetation.

Sustainable Land Management Recommendations

To prevent wind erosion it is important to maintain sufficient ground cover. Fertilisers may be necessary to establish good cover. Protective fences around critical vegetated areas and weed control may also be necessary.

Soil Conservation Earthworks

Not suitable, due to highly pervious soil materials.

hn HAWKS NEST

Landscape—low Holocene sandsheets and low transgressive dunes on the Tomago Coastal Plain. Local relief <3 m, slope gradients <10%, elevation 3–12 m. Dry scrubland, woodland and tall open-forest.

Soils—deep (>300 cm), well-drained Podzols (Uc2.3) and Siliceous Sands/Podzols (Uc2.21) on dunes, deep (>200 cm), poorly drained Humus Podzols (Uc5.1) on sandsheets.

Qualities and Limitations—wind erosion hazard, high watertables (localised), seasonal waterlogging (localised), permanent waterlogging (localised), non-cohesive, potential acid sulphate soils, ground water pollution hazard.

LOCATION

Stable low Holocene sandsheets and low transgressive dunes on the Tomago Coastal Plain from North Stockton to Bobs Farm (Area reference Salt Ash 4 **00**5**E, 63 **70**6**N).

LANDSCAPE

Geology and Regolith

Holocene quartz sandsheets and beach ridges.

Topography

Stable, gently undulating, Holocene, sandsheets and low transgressive dunes. Local relief <3 m, slope gradients <10%, elevation 3–12 m ASL. Low sandy dunes and swales are the dominant landform elements. The area is generally well drained apart from isolated, small, shallow swamps which occur in low lying, poorly drained swales and depressions.

Vegetation

Predominantly uncleared woodland and tall open-forest. Common species include *Angophora costata* (smooth-barked apple), *Eucalyptus pilularis* (blackbutt), *Eucalyptus gummifera* (red bloodwood), *Banksia serrata* (old man banksia), with an understorey of *Pteridium esculentum* (bracken), *Imperata cylindrica* (blady grass), *Actinotus helianthi* (flannel flower), *Persoonia* spp. (geebung), *Acacia longifolia* (sydney golden wattle).

Land Use

The main land use is bushland.

Existing Land Degradation

None identified.

SOILS

Dominant Soil Materials

hn1—Loose speckled grey brown loamy sand (topsoil—A_1 horizon)

Colour	brownish grey (10YR 4/1), occasionally brownish black in moist areas
Texture	loamy sand
Structure	single-grained
Fabric	sandy
Field pH	moderately acid (pH 5.5)
Coarse fragments	few charcoal fragments
Roots	fine common, few to common coarse
Exposed condition	loose
Permeability	very high
Type location	Boyces Track 300 m south of Nelson Bay Road (Grid Ref. 4 **00**850*E, 63 **70**80*N). *Soil Landscapes of the Port Stephens 1: 100 000 Sheet* Soil Data System card 246, 0–45 cm

hn2—Loose bleached sand (subsoil—A_2 horizon)

Colour	dull yellow orange (10YR 7/2), bleached
Texture	sand **Structure** single-grained
Fabric	sandy
Field pH	moderately acid (pH 5.5)

Coarse fragments	absent
Roots	few
Exposed condition	loose
Permeability	very high
Type location	Boyces Track 300 m south of Nelson Bay Road (Grid Ref. 4 **00**850*E, 63 **70**80*N). *Soil Landscapes of the Port Stephens 1:100 000 Sheet* Soil Data System card 246, 45–150 cm

hn3—Coloured mottled sand (subsoil—Bhs horizon)

Colour	organic staining; dark brown (10YR 3/4), brown (10YR 4/4) , organic/iron staining dull yellow orange (10YR 6/4) to dull yellow brown (10YR 5/4) with pale brown mottles
Texture	sand
Structure	single-grained
Fabric	sandy
Field pH	moderately to slightly acid (pH 5.5–6.0)
Coarse fragments	absent
Roots	fine common, few to common coarse
Exposed condition	loose to slightly hardsetting
Permeability	high
Type location	Boyces Track 300 m south of Nelson Bay Road (Grid Ref. 4 **00**850*E, 63 **70**80*N). *Soil Landscapes of the Port Stephens 1:100 000 Sheet* Soil Data System card 246, 150–270 cm

hn4—Greyish yellow brown sand (C horizon)

Colour	commonly greyish yellow brown (10YR 6/2)
Texture	sand
Structure	single-grained
Fabric	sandy
Field pH	moderately acid to neutral (pH 5.5–7.0)
Coarse fragments	absent
Roots	absent
Exposed condition	loose
Permeability	very high
Type location	Boyces Track 300 m south of Nelson Bay Road (Grid Ref. 4 **00**850*E, 63 **70**80*N). *Soil Landscapes of the Port Stephens 1:100 000 Sheet* Soil Data System card 246, 270–>300 cm

Occurrence and Relationships

Soil type is dependent on the age of the sand body. Along the coastal fringe lie the youngest aged dunes, and soil development is very poor apart from some organic matter build-up on the surface and minor development of a Bhs horizon. Further inland the dunes become progressively older and consequently the soils become more strongly developed with increasing age. It must be noted that the poorly developed soils of the seaward dunes very slowly become more developed as one travels landward.

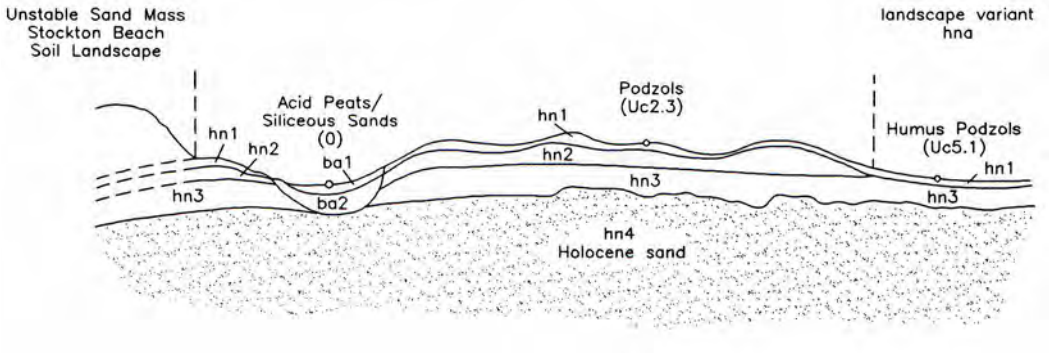
Dunes. Up to 40 cm of **hn1** overlies 10–150 cm of bleached loose sand **(hn2)**. **hn2** overlies 30–>100 cm of coloured mottled sand **(hn3)** and over 300 cm of greyish yellow brown sand **(hn4)** [well-drained Siliceous Sand/Podzol intergrades (Uc2.21) on the seaward fringe, Podzols (Uc2.3) occur landward]. Total soil depth is >300 cm and the boundaries between the soil materials are clear except for the boundary between **hn3** and **hn4** which is often diffuse.

Swampy swales. Small areas Acid Peats (O) occur in low lying, poorly drained swales with up to 10 cm **ba1** overlying >100 cm **ba2** [very poorly drained Acid Peat/Siliceous Sand intergrades]. (See Blind Harrys Swamp **(ba)** soil landscape.)

QUALITIES AND LIMITATIONS

Landscape Limitations

Wind erosion hazard
Non-cohesive soil
High watertables (localised, swales)
Seasonal waterlogging (localised, swales)
Permanent waterlogging (localised, swamps)
Ground water pollution hazard



■ ***Schematic cross-section of Hawks Nest soil landscape illustrating the occurrence and relationship of the dominant soil materials.***

Soil Limitations

hn1 High permeability
Strong acidity
Low fertility
Low available water-holding capacity

hn2 High erodibility
High permeability
Very low fertility
Very low available water-holding capacity

hn3 High erodibility
High permeability
Very low fertility
Very low available water-holding capacity

hn4 High erodibility
High permeability
Strong acidity
Very low fertility
Very low available water-holding capacity
Potential acid sulphate soil (localised)

Fertility

Soil Materials as Plant Growth Media. Soil material suitability is generally low due to very low nutrient and moisture retention capacities, low exchangeable cations and high permeability.

Soil Profile Fertility. Generally low suitability for deep, poorly drained Humus Podzols and deep, well-drained Podzols and Siliceous Sands/Podzols.

Erodibility

	K factor	Non-concentrated flows	Concentrated flows	Wind
hn1	0.000	very low	high	high
hn2	0.000	very low	high	high
hn3	0.000	very low	high	high
hn4	0.000	very low	high	high

Erosion Hazard

	Non-concentrated flows	Concentrated flows	Wind
grazing	slight	high	high
cultivation	slight	high	V high
urban	slight	very high	high

Foundation Hazard

Generally low, except for swampy swales which have a high foundation hazard due to high watertables.

Urban Capability

Exposed areas, swamps, and poorly drained sand flats have high limitations for urban development. Sheltered areas have moderate limitations for urban development.

Rural Capability

Due to the highly sensitive nature of the dunes which are easily predisposed to wind erosion, there is generally a high limitation for both cultivation and grazing. The area is best retained under native timber.

Sustainable Land Management Recommendations

To prevent wind erosion, it is important to maintain sufficient ground cover. Fertilisers may be necessary to establish good cover. Protective fences around critical vegetated areas and weed control may be necessary.

Soil Conservation Earthworks

Not suitable, due to highly pervious soil materials.

APPENDIX I: HYDROLOGICAL SOIL GROUP MAPPING

Port Stephens Hydrologic Soil Group Mapping

PORT STEPHENS COUNCIL

Hydrologic Soil Group Map - Sheet HSG_004

Hydrologic Soil Group

- A
- B
- C
- D
- Not Assessed
- Water

Cadastre

Cadastre 24/01/2017 © Land and Property Information (LPI)

NOTES

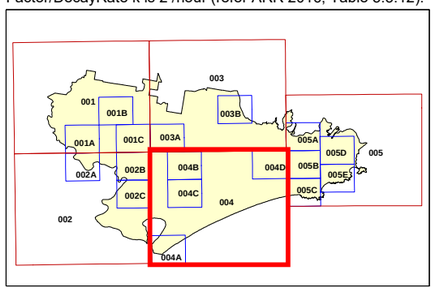
This map provides an estimation of Hydrologic Groups of Soils in NSW according to the four class system. The map was released by the NSW Government 11 October 2016. The map uses the best available soils mapping coverage and was derived by linking a Hydrologic Group class to a particular Great Soil Group.

Group A— soils having high infiltration rates, even when thoroughly wetted and consisting chiefly of deep, well to excessively-drained sands or gravels.These soils have a high rate of water transmission. For design purposes, it is assumed that the Antecedent Moisture Condition is "Rather wet" (refer to Australian Rainfall and Runoff (ARR) 2016, Table 5.3.11) and the Horton Maximum (Initial) Infiltration Rate is 83.6 mm/hr, the Minimum (Final) Infiltration Rate is 25 mm/hr and the Shape Factor/Decay Rate k is 2 /hour (refer ARR 2016, Table 5.3.12).

Group B— soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission. For design purposes it is assumed that the Antecedent Moisture Condition is "Rather wet" (refer to ARR 2016, Table 5.3.11) and the Horton Maximum (Initial) Infiltration Rate is 66.3 mm/hr, the Minimum (Final) Infiltration Rate is 13 mm/hr and the Shape Factor/Decay Rate k is 2 /hour (refer ARR 2016, Table 5.3.12).

Group C— soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of transmission. For design purposes, it is assumed that the Antecedent Moisture Condition is "Rather wet" (refer to ARR 2016, Table 5.3.11) and the Horton Maximum (Initial) Infiltration Rate is 33.7 mm/hr, the Minimum (Final) Infiltration Rate is 6 mm/hr and the Shape Factor/Decay Rate k is 2 /hour (refer ARR 2016, Table 5.3.12).

Group D— soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a high water table, soils with a clay layer, and shallow soils over nearly impervious material. These soils have a very slow rate of transmission. For stormwater design purposes, it is assumed that the Antecedent Moisture Condition is "Rather wet" (refer to ARR 2016, Table 5.3.11) and the Horton Maximum (Initial) Infiltration Rate is 7.4 mm/hr, the Minimum (Final) Infiltration Rate is 3 mm/hr and the Shape Factor/DecayRate k is 2 /hour (refer ARR 2016, Table 5.3.12).



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MGA Zone 56

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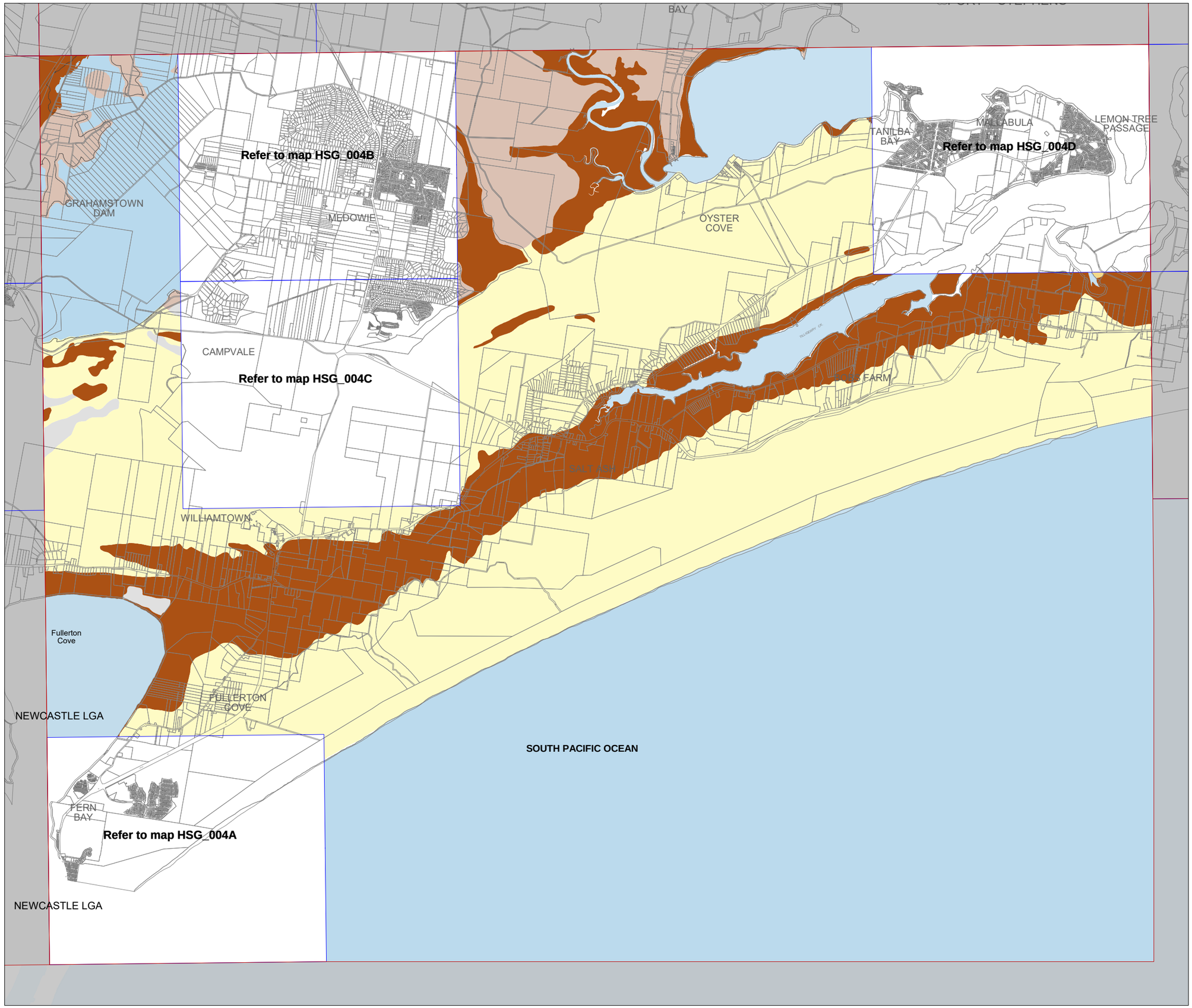
Scale: 1:80000 A3

Map identification number :
HSG_004_080_20170124



Port Stephens Hydrologic Soil Group Mapping

Hydrologic Soil Group Map - Sheet HSG_004A

Hydrologic Soil Group

- A
- B
- C
- D
- Not Assessed
- Water

Cadastre

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NOTES

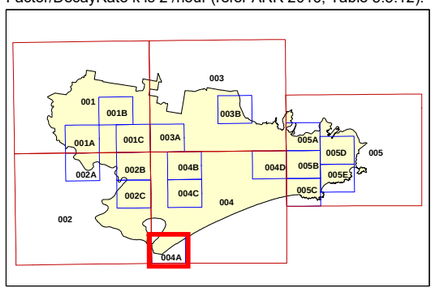
This map provides an estimation of Hydrologic Groups of Soils in NSW according to the four class system. The map was released by the NSW Government 11 October 2016. The map uses the best available soils mapping coverage and was derived by linking a Hydrologic Group class to a particular Great Soil Group.

Group A— soils having high infiltration rates, even when thoroughly wetted and consisting chiefly of deep, well to excessively-drained sands or gravels.These soils have a high rate of water transmission. For design purposes, it is assumed that the Antecedent Moisture Condition is "Rather wet" (refer to Australian Rainfall and Runoff (ARR) 2016, Table 5.3.11) and the Horton Maximum (Initial) Infiltration Rate is 83.6 mm/hr, the Minimum (Final) Infiltration Rate is 25 mm/hr and the Shape Factor/Decay Rate k is 2 /hour (refer ARR 2016, Table 5.3.12).

Group B— soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission. For design purposes, it is assumed that the Antecedent Moisture Condition is "Rather wet" (refer to ARR 2016, Table 5.3.11) and the Horton Maximum (Initial) Infiltration Rate is 66.3 mm/hr, the Minimum (Final) Infiltration Rate is 13 mm/hr and the Shape Factor/Decay Rate k is 2 /hour (refer ARR 2016, Table 5.3.12).

Group C— soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of transmission. For design purposes, it is assumed that the Antecedent Moisture Condition is "Rather wet" (refer to ARR 2016, Table 5.3.11) and the Horton Maximum (Initial) Infiltration Rate is 33.7 mm/hr, the Minimum (Final) Infiltration Rate is 6 mm/hr and the Shape Factor/Decay Rate k is 2 /hour (refer ARR 2016, Table 5.3.12).

Group D— soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a high water table, soils with a clay layer, and shallow soils over nearly impervious material. These soils have a very slow rate of transmission. For stormwater design purposes, it is assumed that the Antecedent Moisture Condition is "Rather wet" (refer to ARR 2016, Table 5.3.11) and the Horton Maximum (Initial) Infiltration Rate is 7.4 mm/hr, the Minimum (Final) Infiltration Rate is 3 mm/hr and the Shape Factor/DecayRate k is 2 /hour (refer ARR 2016, Table 5.3.12).



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GDA 1994
MGA Zone 56

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Scale: 1:20000 A3

Map identification number :
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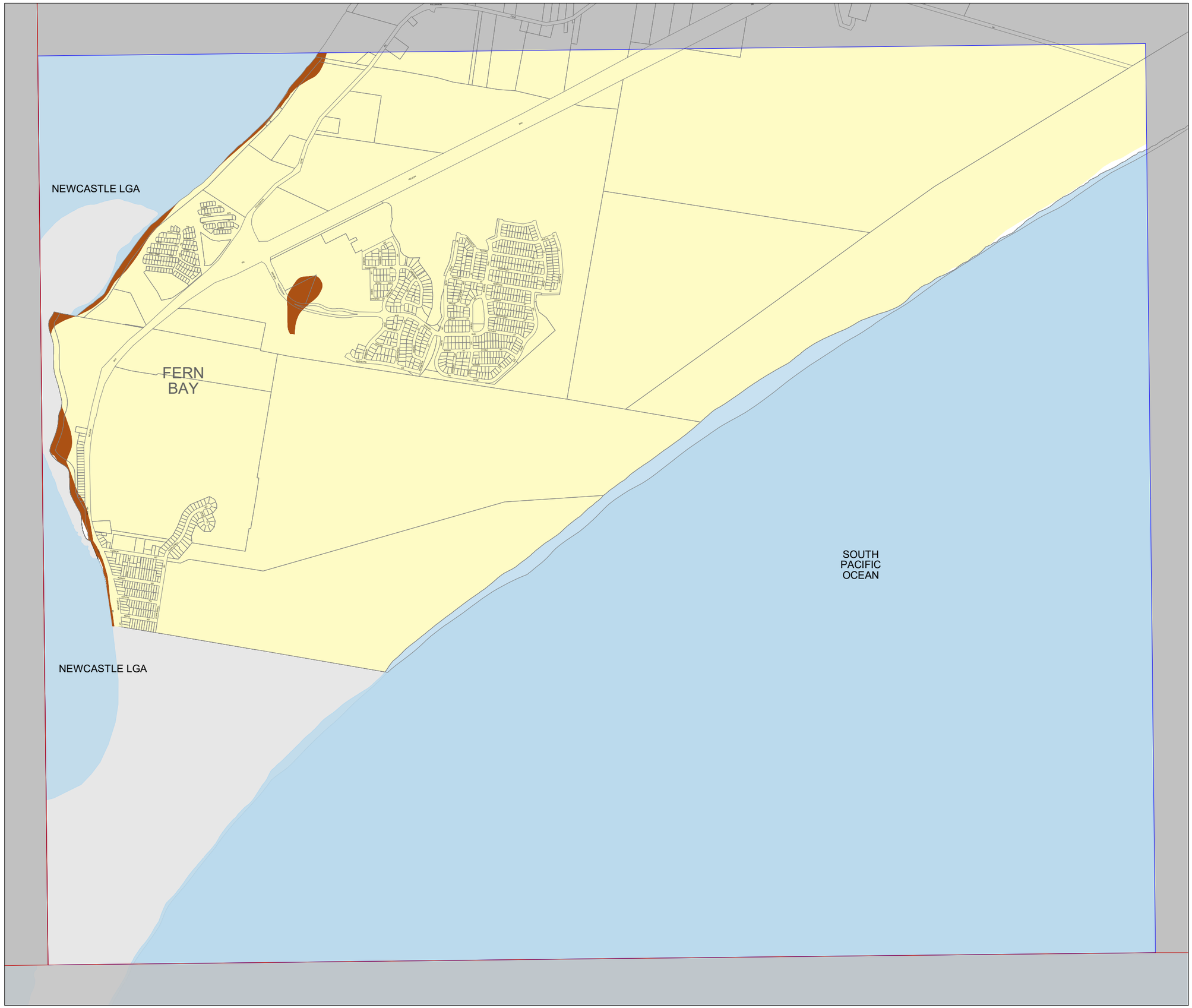

Port Stephens Hydrologic Soil Group Mapping

Hydrologic Soil Group Map - Sheet HSG_004B

Hydrologic Soil Group

- A
- B
- C
- D
- Not Assessed
- Water

Cadastre

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NOTES

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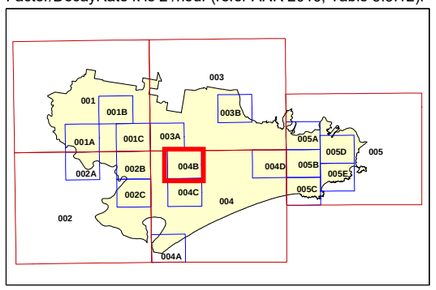
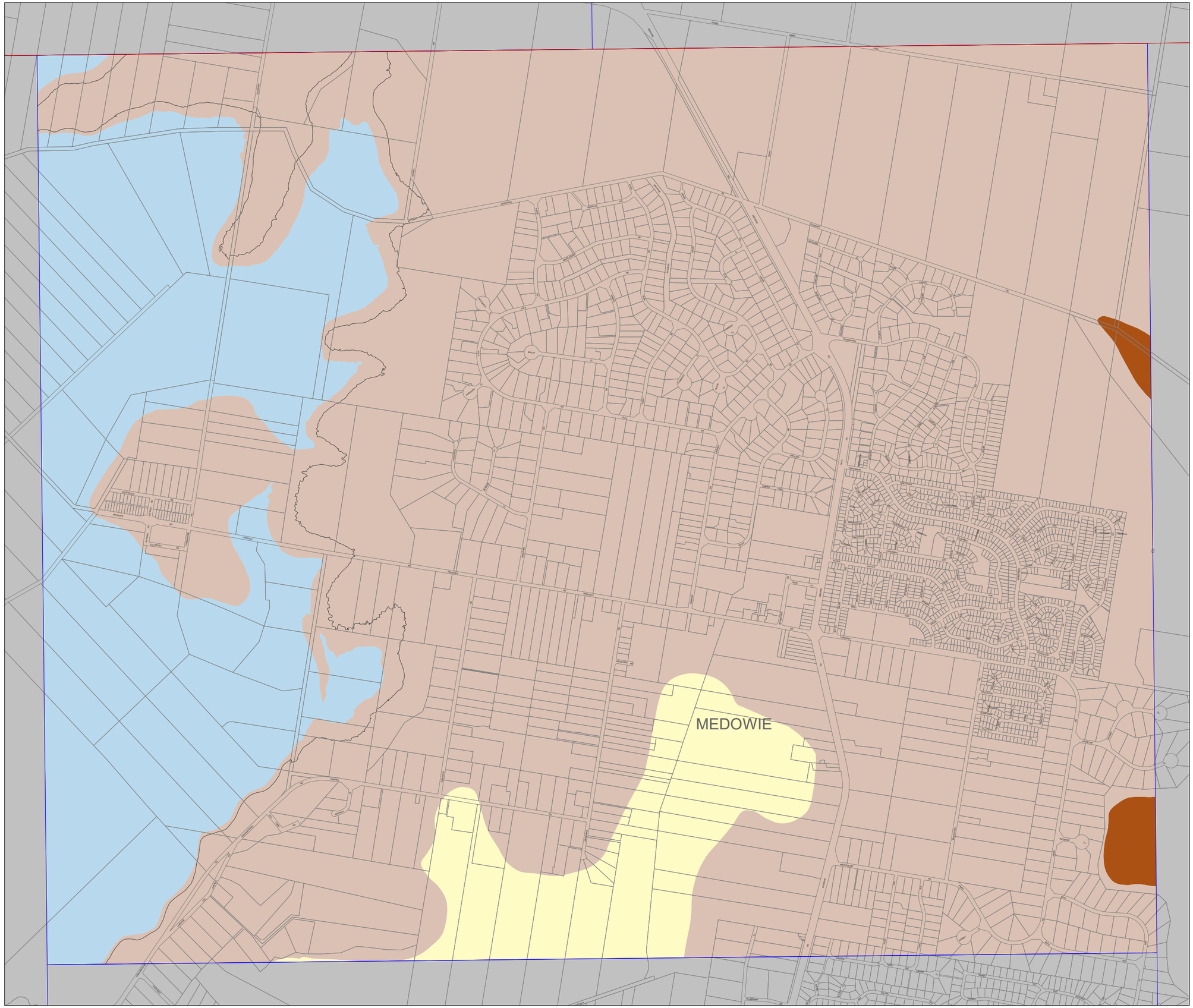
Group B— soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission. For design purposes, it is assumed that the Antecedent Moisture Condition is "Rather wet" (refer to ARR 2016, Table 5.3.11) and the Horton Maximum (Initial) Infiltration Rate is 66.3 mm/hr, the Minimum (Final) Infiltration Rate is 13 mm/hr and the Shape Factor/Decay Rate k is 2 /hour (refer ARR 2016, Table 5.3.12).

Group C— soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of transmission. For design purposes, it is assumed that the Antecedent Moisture Condition is "Rather wet" (refer to ARR 2016, Table 5.3.11) and the Horton Maximum (Initial) Infiltration Rate is 33.7 mm/hr, the Minimum (Final) Infiltration Rate is 6 mm/hr and the Shape Factor/Decay Rate k is 2 /hour (refer ARR 2016, Table 5.3.12).

Group D— soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a high water table, soils with a clay layer, and shallow soils over nearly impervious material. These soils have a very slow rate of transmission. For stormwater design purposes, it is assumed that the Antecedent Moisture Condition is "Rather wet" (refer to ARR 2016, Table 5.3.11) and the Horton Maximum (Initial) Infiltration Rate is 7.4 mm/hr, the Minimum (Final) Infiltration Rate is 3 mm/hr and the Shape Factor/DecayRate k is 2 /hour (refer ARR 2016, Table 5.3.12).





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GDA 1994
MGA Zone 56

0 400 metres

Scale: 1:20000 A3

Map identification number :
HSG_004B_020_20170124

Port Stephens Hydrologic Soil Group Mapping

Hydrologic Soil Group Map - Sheet HSG_004C

Hydrologic Soil Group

- A
- B
- C
- D
- Not Assessed
- Water

Cadastre

Cadastre 24/01/2017 © Land and Property Information (LPI)

NOTES

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Group B— soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission. For design purposes, it is assumed that the Antecedent Moisture Condition is "Rather wet" (refer to ARR 2016, Table 5.3.11) and the Horton Maximum (Initial) Infiltration Rate is 66.3 mm/hr, the Minimum (Final) Infiltration Rate is 13 mm/hr and the Shape Factor/Decay Rate k is 2 /hour (refer ARR 2016, Table 5.3.12).

Group C— soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of transmission. For design purposes, it is assumed that the Antecedent Moisture Condition is "Rather wet" (refer to ARR 2016, Table 5.3.11) and the Horton Maximum (Initial) Infiltration Rate is 33.7 mm/hr, the Minimum (Final) Infiltration Rate is 6 mm/hr and the Shape Factor/Decay Rate k is 2 /hour (refer ARR 2016, Table 5.3.12).

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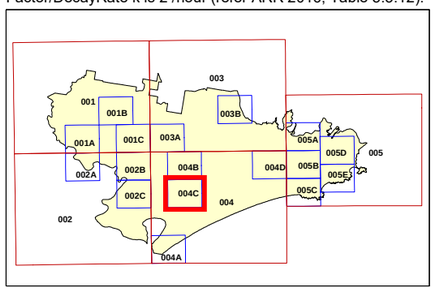

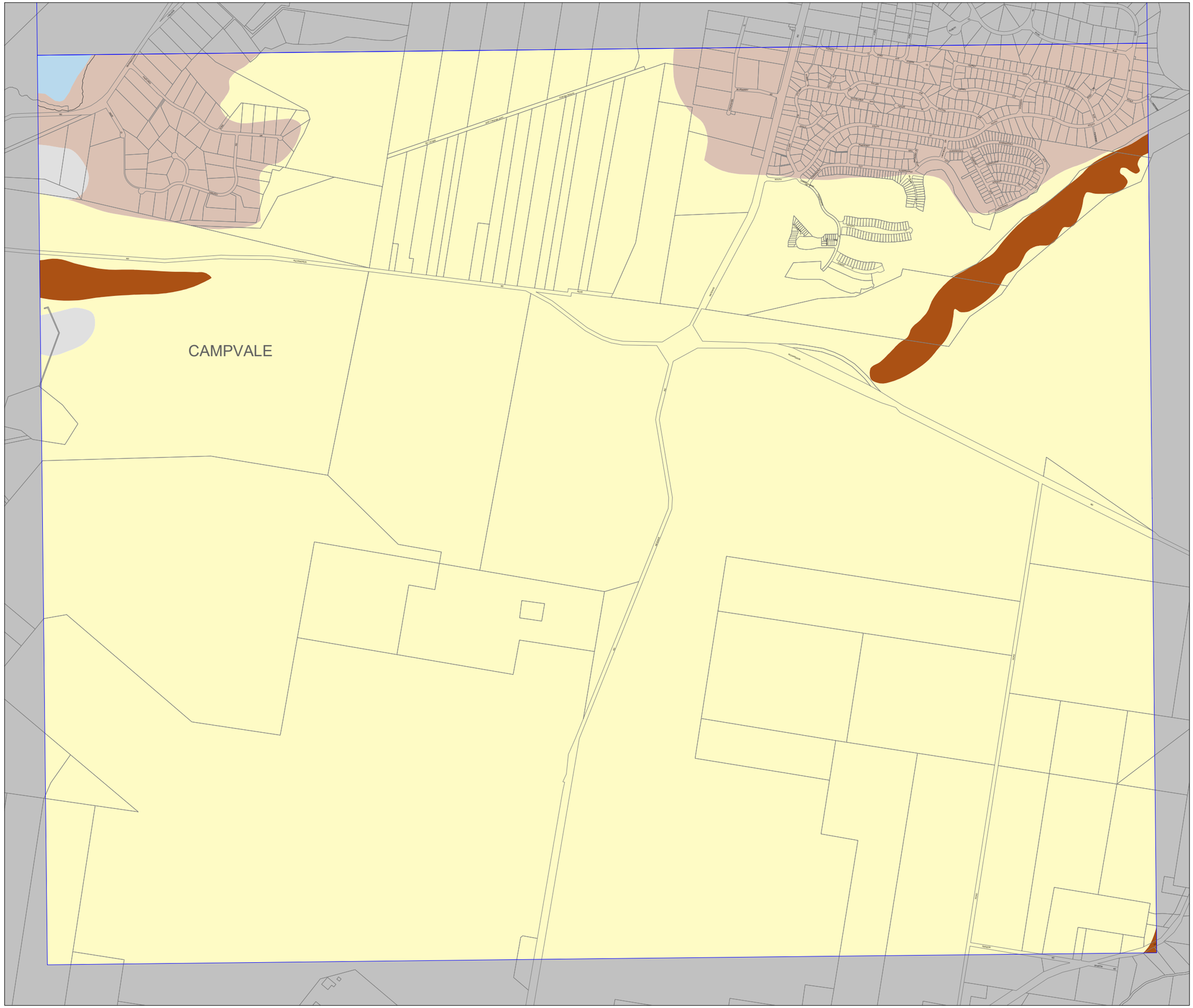

N

GDA 1994
MGA Zone 56

0 400 metres

Scale: 1:20000 A3

Map identification number :
HSG_004C_020_20170124

Port Stephens Hydrologic Soil Group Mapping

PORT STEPHENS COUNCIL

Hydrologic Soil Group Map - Sheet HSG_004D

Hydrologic Soil Group

- A
- B
- C
- D
- Not Assessed
- Water

Cadastre

Cadastre 24/01/2017 © Land and Property Information (LPI)

NOTES

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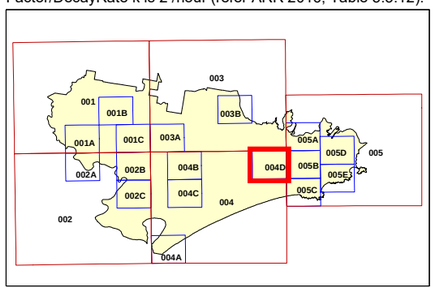

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GDA 1994
MGA Zone 56

0 400 metres

Scale: 1:20000 A3

Map identification number :
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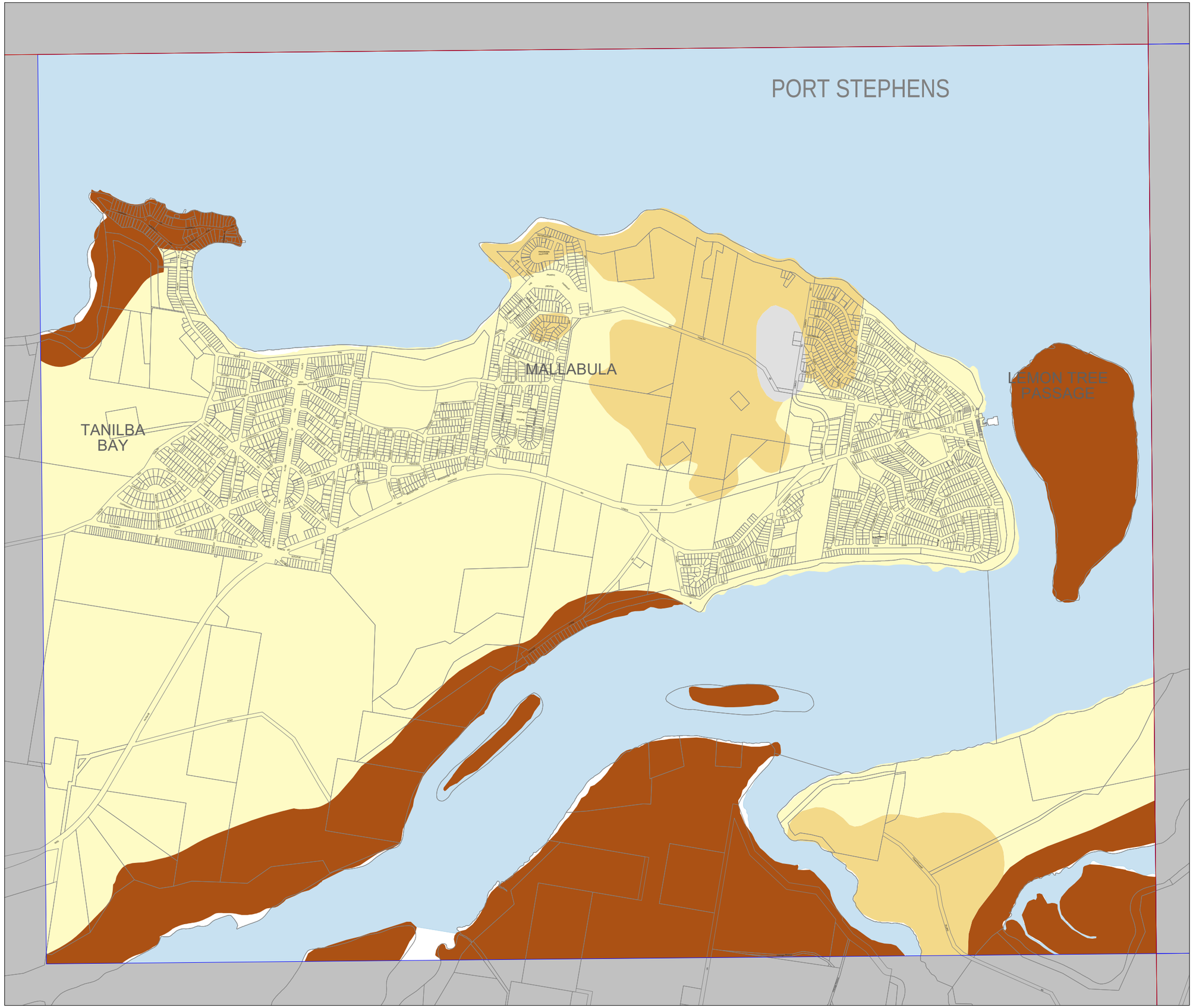

APPENDIX J: PHOTO PLATES


1. View south from access road


2. View north centre of site


3. Centre of site


4. Ridge system


5. Soil samples in liners (on-site PASS testing)