Ammos Resource Management Pty Ltd

C/- Tattersall Lander Pty Ltd

Hydrogeological Assessment and Management Plan:

Proposed Sand Mine at 3631, 3679 & 3721 Nelson Bay, Bobs Farm, NSW

P1303897JR08V02
November 2020

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All enquiries regarding this project are to be directed to the Project Manager.

Executive Summary

Martens and Associates (MA) have prepared this hydrogeological assessment and management plan to document the findings of an updated groundwater assessment for a proposed sand mine at 3631, 3679 & 3721 Nelson Bay Road, Bobs Farm, NSW (the site). This report supersedes a previous groundwater management plan prepared by MA for the site (2015), and has been prepared to address agency comments provided for the Environmental Impact Statement (EIS). This updated assessment includes additional groundwater monitoring data and further groundwater modelling to address agency comments.

This assessment has:

1. Reviewed and analysed existing hydrogeological data for the site and surrounding area, including additional groundwater level and groundwater quality data.
2. Analysed results from site field investigations.
3. Prepared a conceptual groundwater (GW) model.
4. Prepared a numerical GW model for the pre-development and post-development conditions at the site.
5. Analysed the GW model results to determine long-term effects of the development on the local GW system.
6. Assessed any GW impacts in relation to the NSW Department of Primary Industries' Aquifer Interference Policy (2012).
7. Established baseline groundwater quality monitoring data.
8. Established groundwater quality and level monitoring locations, frequencies, analytes, and interim trigger values.
9. Established corrective actions to be taken in case of trigger value breach.
10. Commented on groundwater licensing.

Numerical modelling was able to accurately reproduce the monitored groundwater conditions using the MODFLOW package within the GMS graphical user interface.

Executive Summary

This assessment found that:

1. Modelled groundwater level changes do not impact high-priority groundwater dependent ecosystems mapped in the water sharing plan.

2. Modelled groundwater level changes do not impact nearby registered groundwater bores or affect basic landholder rights in respect of groundwater availability.

3. Impacts of changed groundwater levels on acid sulfate soils have been assessed and found to be negligible and able to be managed through the use of the groundwater management plan and ASS management plan.

4. Groundwater quality within the aquifer at the site is currently generally poor and, with the recommended engineering controls, risks to groundwater quality can be suitably managed.

5. The groundwater impacts of the proposed development have been assessed in relation to the NSW Aquifer Interference Policy and have been found to comply with the requirements.

6. A groundwater monitoring plan will be implemented which will manage the impact of the proposed development on groundwater levels and quality.

7. There is sufficient water share allocation available in the Stockton Groundwater Source to allow the purchase of additional share units needed for the operation of the proposed development.

Further, each of the agency comments relating to hydrogeology raised in response to the EIS have been addressed in this assessment.

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1 Introduction

1.1 Overview

Martens and Associates (MA) have prepared this hydrogeological assessment and management plan to document the findings of an updated groundwater assessment for a proposed sand mine at 3631, 3679 & 3721 Nelson Bay Road, Bobs Farm, NSW (the site). This report supersedes a previous groundwater management plan prepared by MA for the site (2015), and has been prepared to address agency comments provided for the Environmental Impact Statement (EIS). This updated assessment includes additional groundwater monitoring data and further groundwater modelling to address agency comments.

Refer to Attachment A for a plan of the proposed development.

This report should be read in conjunction with the MA 'Supplementary Acid Sulfate Soils Assessment' (REF: P1303897JR06V01, October 2020), hereafter the ASS Assessment.

1.2 Scope

Our work's scope included:

1. Review and analyse existing hydrogeological data for the site and surrounding area, including additional groundwater level and groundwater quality data.

2. Analyse results from site field investigations.

3. Prepare a conceptual groundwater (GW) model.

4. Prepare a numerical GW model for the pre-development and post-development conditions at the site.

5. Analyse the GW model results to determine long-term effects of the development on the local GW system.

6. Assess any GW impacts in relation to the NSW Department of Primary Industries' Aquifer Interference Policy (2012).

7. Establish baseline groundwater quality monitoring data.

8. Establish groundwater quality and level monitoring locations, frequencies, analytes, and interim trigger values.

9. Establish corrective actions to be taken in case of trigger value breach.

10. Comment on groundwater licensing.

1.3 Subject Site

Site information is summarised in Table 1. Site location and general surrounds are shown in Attachment B Map 1.

Table 1: Site background information.

Item	Description / Detail
Site Address	3631, 3679 & 3721 Nelson Bay Road, Bobs Farm, NSW
Lots and DPs	Lot 254 DP 753204, Lot 51 DP 1015671, and Lot 10 DP 1071458
Site Area	Approximately 53 ha
Local Government Area (LGA)	Port Stephens Council (PSC)
Current Zoning [1]	RU2 – Rural Landscape
Current Land Use	Approximately 19% of the site is currently used for agriculture (typically olive and fig plantations) with a small proportion of this area occupied by farm sheds, a farm hand residence and a master residence. Approximately 67% of the site's area is forested and undeveloped apart from vehicle tracks. The remaining 14% of the site is cleared and occupied by sheds, residences and plant (Lot 10 DP1071458). This area is in the north east of the site and aside from the cleared area surrounding the dwelling on Lot 51 DP 1015671, mining operations are not proposed in this region. An above ground electricity easement (poles and wires) cuts across the southern corner of the site.
Surrounding Land Uses	Rural residential allotments border the site to the north, west, south west, and north east. Nelson Bay Road borders the site to the south east, with Worimi National Park located on the southern side of the road. The Australian Shark and Ray Centre is located along the western end of the northern site boundary.
Topography	The majority of the site slopes towards the east, however, some portions of the site slope to the north, west and south west. Slopes are low (typically 0-5%) in the eastern portion of the site and are higher (typically 10-50%) over the remainder of the site on dune knolls. Site elevation ranges from approximately 35 mAHD at a knoll in the north west to approximately 2 mAHD at a depression in the site's north. Refer Attachment B Map 2 for a shaded relief of the area.
Surface Hydrology	No watercourses, drainage features or surface ponding are present onsite. The majority of the site drains east into Worimi National Park. The north west portion drains north west into a large dam on the neighbouring Shark and Ray Centre property or into the drainage network of Tilligerry Creek, located approximately 1km north west of the site.

Item	Description / Detail
Geology	Quaternary beach sand and alluvial deposits consisting of marine and freshwater deposits of gravel, sand, silt and clay overlying Gilmore and Nerong Carboniferous Volcanics (Newcastle 1:250 000 Geological Sheet SI 56-2). Refer to Attachment B Map 5 for local area geology.

Notes:

1. NSW Planning Portal.

1.4 Proposed Development Overview

We understand that the proposed development comprises the construction and operation of a sand mine with a maximum annual yield of 750,000 tonnes.

A site survey, preliminary site extraction works plan and proposed mine cross sections are provided in Attachment A.

We understand extraction is proposed to occur over the majority of the site excluding a 15 m vegetated buffer to site boundaries and a powerline easement, dedicated processing and administration area, mapped Groundwater Dependent Ecosystem (GDE) area in north western corner of site and an area with no proposed mining in the north eastern corner of the site.

Based on information from Quarry Mining Systems (2013), VGT & Quarry Mining Systems (2013), the proposed works are likely to include:

- Preliminary works: construction of access roads and an intersection with Nelson Bay Road; demolition of existing structures; construction of screening operations, loading ramp and storage shed; and construction of the main exit road onto the existing bitumen sealed road within Lot 10 DP 1071458.
- Clearing works: stockpiling of topsoil for future rehabilitation works.
- Stage 1 extraction: excavation of aeolian sands to 3 m Australian Height Datum (mAHD), using conventional excavation / extraction techniques, and stockpiling for later use for various purposes. Rehabilitation for stage 1 works will occur prior to the commencement of Stage 2 works.
- Stage 2 extraction: excavation of aeolian sands to 1 mAHD, using specialised excavation / extraction techniques, and stockpiling for later use for various purposes. Rehabilitation for stage 2 works will occur prior to the commencement of Stage 3 works.

- Stage 3 extraction: excavation of predominantly marine sand from 1 mAHD to -15 mAHD, by dredging techniques and stockpiling for later use for various purposes.

Sand extraction will involve processing to separate fines from the feed material via vibrating wet screen (Stages 1 – 3) with:

- Classifying tank (Stages 2 – 3 only); and / or
- Sand screen to sieve product (Stages 1 – 3).

Process waste water and fines shall be discharged to a settling pond.

Refer to Attachment A for the proposed development plan (Tattersall Lander).

1.5 Methodology Overview

In summary, the assessment methodology consisted of:

1. Installing 4 new monitoring wells on the site and collecting additional groundwater data for the site across 9 (in total) monitoring wells.
2. Developing a groundwater model for the existing, pre-development site conditions and calibrating to all field data collected to date.
3. Developing a post-development groundwater model through modifying the pre-development model to simulate the completed mining conditions.
4. Comparing pre-development and post-development groundwater conditions, and determining the resulting impacts.
5. Analysing collected groundwater quality data to establish base line levels.
6. Determining appropriate trigger values for groundwater levels and quality.

1.6 Abbreviations

AIP	Aquifer Interference Policy
ASS	Acid sulfate soils
BH	Borehole

BoM	Bureau of Meteorology
EC	Electrical Conductivity
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ET	Evapotranspiration
GDE	Groundwater Dependent Ecosystem
GW	Groundwater
HWC	Hunter Water Corporation
LIDAR	Light Detection and Ranging
LPI	Land and Property Information
K_{sat}	Saturated hydraulic conductivity
K_h, K_x, K_y	Horizontal hydraulic conductivity
K_v, K_z	Vertical hydraulic conductivity
NOx	Nitrogen oxide
MA	Martens and Associates
mAHD	Metres above the Australian Height Datum
mBGL	Metres below ground level
MHL	Manly Hydraulics Laboratory
MW	Monitoring Well
OEH	Office of Environment and Heritage
PQL	Practical Quantitation Limit
RMS	Residual Mean Squared
SEARS	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TP	Total Phosphorous
WSP	Water Sharing Plan

2 Statutory and Regulatory Requirements

2.1 Agency Responses to the Environmental Impact Statement

Agency comments received in response to the EIS relating to hydrogeology have been listed in Table 2 with the corresponding section of this report that addresses the comment.

Table 2: Agency Responses to the EIS relating to hydrogeology.

Groundwater Assessment Requirements	Section(s) of Report
Environmental Protection Authority	
'A detailed consideration of maintenance of an adequate buffer between all excavations and the highest predicted groundwater table' *as required by the revised SEAR's issued in April 2017 and the superseded Director General's Requirements from 2014.*	This assessment shows that extraction below the groundwater table is acceptable and that a buffer is not required – see Section 6.7.
A revised hydrogeological cross section (figure 7.12 of the EIS) to allow conceptual analysis of site location. A more concise and clearer cross section would help in determining groundwater behaviour across the project site.	See Section 4.1 and Attachment G for revised conceptual groundwater model. Cross sections of model results are provided in Attachment B Map 14 and Map 21.
Details of where or how the proponent will gain the additional entitlement sought to capture the amount of predicted water taken over the life of the mine. Water NSW data indicates that the project property currently holds a water access licence with a 40 ML share component.	This assessment has reviewed the relevant water sharing plan and found that adequate water allocation is available through either Water NSW or from other licensees – see Section 8.
Updated baseline groundwater data, and its interpretation. Data collection should continue and more recent sampling investigations and analysis should be provided. The data provided is limited to sampling events taken from 2013 to 2015. As the baseline data is limited to a 2-year timeframe without any continuality or updating, distinguishing the natural variance in the water table is restricted to dry climate rainfall events. Despite the report of onsite data loggers, no new groundwater level or quality data was provided in the EIS submission.	Four additional groundwater monitoring wells were installed for this assessment. 18 additional weeks of continuous monitoring and two groundwater quality sampling rounds were carried out across a total of nine wells in 2020 – see Sections 3.6 and 3.7.
Revised groundwater flow assessment. Groundwater characteristics of the project site were determined from the sampling results mentioned above. A crude schematic diagram was provided to determine the direction of flow across the site, which reveals a hydraulic gradient with groundwater flows to the north of the proposed quarry. It was determined that the hydraulic gradient, using the standing water levels from all five on-site monitoring bores, was in fact westerly to south westerly (see above below). Further groundwater sampling events and updates from the on-site loggers would be beneficial in determining the groundwater characteristics of the project site.	All data to date was used to develop a revised numerical groundwater model to characterise the existing conditions and determine the impact of the proposal on the local groundwater regime. See Sections 3.6 and 3.7 for further data. See Section 4 for revised groundwater modelling and Attachment B Map 12, Map 13, and Map 14 for pre-development conditions results.

Groundwater Assessment Requirements	Section(s) of Report
Further detail regarding the offset bore planned to be installed. Of the existing network of five monitoring bores currently around the project site, four are to be removed to accommodate the mine workings.	Additional wells were installed for this assessment outside of the proposal's extents – see Attachment B Map 3 for well locations and Section 7.3 for details of wells to be retained for the life of the project.
The locations of each new bore should be shown on a map and advice should be provided about when the new bores are to be drilled, or if an overlap between the installation and removal of bores will exist to ensure the development of each new bore, and its provided data, is adequate to capture and maintain suitable groundwater information. Given some of these bores are on the boundary of the project site, ongoing monitoring is needed to determine and capture boundary characteristics (flows in or out of the proposed quarry).	New monitoring bores have been installed in 2019 and monitoring was conducted over 4 months in 2020. See Attachment B Map 3 for monitoring well locations and Sections 3.6 & 3.7 for monitoring data. No additional new bores are proposed.
Assessment of an adequate buffer between the quarry and the local water table, which has been applied to other quarries in the area, prevents the formation of ASS across the regional landscape.	This assessment shows that extraction below the groundwater table is acceptable and that a buffer is not required – see Sections 6.3 and 6.7.
Sufficient information regarding the extent and management of Potential Acid Sulphate Soil (PASS) or ASS for the proposed dredging operation as outlined below:	Refer to the MA 'Supplementary Acid Sulfate Soils Assessment' (2020).
o *A significant groundwater monitoring plan including a metal assay with dedicated monitoring of the dredge pond.*	A detailed groundwater monitoring plan has been developed for this assessment - see Section 7.
Hunter Water Corporation	
In regards to best management practice, we note that the proposal to extract sand below the water table to -15 metres AHD is inconsistent with current best practice and the approval of other sand extraction operations in the area, which have limits on the depth of extraction imposed upon them in order to protect groundwater sources. For example, sand extraction at Sibelco's Tanilba Northern Dune operation, Sibelco's Anna Bay operation, the Cabbage Tree Road Quarry (SSD 6125, yet to commence), Salt Ash Sand Quarry (07_0094) and the Fullerton Cove Sand Quarry (07_0145) all have extraction depth limits imposed upon them to safeguard groundwater sources. Measures to protect groundwater sources are related to both pollution risk and the loss of valuable water supplies through drainage and evaporation.	This assessment shows that extraction below the groundwater table is acceptable and that a buffer is not required – see Section 6.7.
Hunter Water considers that, with Port Stephens only a short distance away, the suggested future water-based uses for the site are implausible and without sound basis. Hunter Water therefore recommends that the dredging proposal not be approved. Instead, if extractive operations are approved, they should be limited in depth to protect the underlying groundwater source and so the site can be rehabilitated in a way that ensures land use, compatible with the surrounding land.	This assessment shows that extraction below the groundwater table is acceptable and that a buffer is not required – see Sections 6.2 and 6.7.

Groundwater Assessment Requirements	Section(s) of Report
Hunter Water considers that extractive operations can be feasibly undertaken without adversely impacting on water quality, provided suitable operational management controls are developed and implemented to safeguard against aquifer pollution or contamination risks and an appropriate monitoring program is undertaken to assess this during the life of the operation.	A detailed groundwater monitoring plan has been developed for this assessment - see Section 7.
In order to ensure suitable operational management controls are in place, a Groundwater Management Plan should be required for approval prior to the commencement of operations. The Plan should include a monitoring program that describes the parameters to be measured, sampling locations, sampling frequency and details of action to be undertaken in the event of unexpected results, such as detected contamination.	A detailed groundwater monitoring plan has been developed for this assessment - see Section 7.
The proposed groundwater monitoring described in the EIS is generally considered acceptable, although more detailed consideration of the program may be required prior to approval of the Plan to identify all of the relevant monitoring requirements for the site. In particular, we recommend that event-based monitoring be added to the monitoring frequency (with event triggers to be determined from consultation during preparation of the plan) in order to accurately determine the hydrological characteristics of the site, which will not be established from the proposed quarterly monitoring.	A detailed groundwater monitoring plan has been developed for this assessment - see Section 7.
Operational performance should be reported annually in an Annual Environmental Management Report (AEMR) that reviews the matters described in the EMP.	A detailed groundwater monitoring plan has been developed for this assessment - see Section 7.
The storage and management of fuels and other chemicals used on site should comply with relevant standards and be undertaken in a way that protects the aquifer from the risk of contamination. Spills of any such materials should be cleaned up immediately and disposed of at an appropriately licenced facility. These matters should be documented in the EMP and include a spill management procedure (including remedial action to be implemented in the event of a spill incident).	A detailed groundwater monitoring plan has been developed for this assessment and a site Environment Manage Plan is to be developed at the detailed design stage - see Sections 6.5.2 & 7.
Department of Planning and Environment	
The groundwater assessment needs to consider the following potential impacts to groundwater resources:	
o *Impacts to the Ride Water Park Company's proposed recreational water park at 781 Marsh Road, Bobs Farm. Please address the matters raised in the company's submission;*	This assessment found that there would be negligible impact to groundwater at 781 Marsh Rd - see Sections 6.2 and 6.5, and Attachment B Map 22
o *Impacts to users of groundwater for agricultural and domestic use near the proposed sand mine;*	Offsite groundwater level changes caused by the proposal were found to be acceptable and risks to groundwater quality can be effectively managed by appropriate monitoring and management strategies – see Sections 6.2, 6.5, 6.6, & 7.

Groundwater Assessment Requirements	Section(s) of Report
o *Impacts to the adjacent Hunter Water Corporation's Special Area for drinking water supply;*	Offsite groundwater level changes caused by the proposal were found to be acceptable and risks to groundwater quality can be effectively managed by appropriate monitoring and management strategies – see Sections 6.2, 6.5, 6.6, & 7, & Attachment B Map 22.
o *Impacts to groundwater quality due to exposure of the sediment column to oxygen. Consideration must be given to the oxidation of Acid Sulfate Soils (ASS) and metals such as iron and arsenic that have been noted following mineral sand mining operations in the Port Stephens area. The impact of potential lowering pH and increase in metal concentrations on current and approved groundwater users must also be assessed; and*	The risk of impacts to groundwater quality due to changing groundwater levels interacting with potential acid sulfate soils has been examined by this assessment and found to be minimal – see Section 6.3.
o *Impacts of changed water quality on oyster farming in Tilligerry Creek must be assessed, including the matters set out in the submission of Joy-Lynne Redmayne.*	Risks to water quality in Tilligerry Creek were assessed to be minimal – see Section 6.5.
Port Stephens Council	
Local land holders have approached Council raising significant concerns with the potential impact of the proposed sand mine on the ground water. The ground water is likely to be affected by the mining activity which could threaten the quality and flow of the aquifer. The importance of the groundwater at the proposed site is due to its location within the Stockton Sandbed Aquifer. This aquifer is important in supporting local agriculture and vegetation, and also provides a backup water source for the supply of Grahamstown Dam in the event of future water shortages. This groundwater aquifer has potential interactions with the neighbouring Tomago Sandbed Aquifer, which supplies 20% of the lower Hunter's drinking water.	Offsite groundwater level and quality impacts caused by the proposal were found to be acceptable and can be effectively managed by appropriate monitoring and management strategies – see Sections 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, & 7, & Attachment B Map 22.
Further it is understood that potential acid sulfate soils have been recorded on site. Considering the proposed interaction with groundwater that is connected to the drinking water catchment, extractive activities that interact with the groundwater are considered to have a high risk of potentially serious impacts. This could impact on the viability of the surrounding rural land uses and is not acceptable.	The risk of impacts to groundwater quality due to changing groundwater levels interacting with potential acid sulfate soils has been examined by this assessment and found to be minimal – see Section 6.3.
Department of Industry	
Sand extraction should be limited to a 1 m buffer above the highest predicted water table.	This assessment shows that extraction below the groundwater table is acceptable and that a buffer is not required – see Section 6.7.

Groundwater Assessment Requirements	Section(s) of Report
The proponent must comply with the regulatory licensing requirements of the WMA 2000 for water take.	This assessment has reviewed the relevant water sharing plan and found that adequate water allocation is available through either Water NSW or from other licensees – see Section 8.
Detailed groundwater assessment should be provided prior to determination for review by DoI Water.	This report is considered to fulfil this requirement.
The water monitoring strategy should be expanded to include additional long-term observation sites that will not be impacted by mining, with an emphasis along the southern and northern boundary. Detailed baseline monitoring of water levels and a comprehensive water quality suite is required prior to excavation.	Four additional wells were installed for this assessment outside of the proposal's extents – see Attachment B Map 3 for well locations and Section 7.3 for details of wells to be retained for the life of the project. 18 additional weeks of continuous monitoring and two groundwater quality sampling rounds were carried out across a total of nine wells in 2020 – see Sections 3.6 and 3.7.
Define the site boundary groundwater level and water quality impact thresholds from the baseline data. A remedial response program should be defined for any exceedance of the impact thresholds.	All collected groundwater data was used to devise trigger values for groundwater levels and quality, a monitoring action plan has been proposed should any exceedances be detected - see Sections 7.3, 7.4, and 7.6.
DPI Fisheries has concerns with groundwater quality and movement from the site, these concerns can be addressed by meeting the recommendations outlined above by DoI Water.	Risks to water quality in Tilligerry Creek were assessed to be minimal – see Section 6.5 and above responses.

2.2 Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources 2016

The study area is located within the Stockton Groundwater Source as identified by the Water Sharing Plan (WSP) for the North Coast Coastal Sands Groundwater Sources (2016).

Any additional groundwater licencing required for the development will be required to comply with the rules of this plan.

2.3 Aquifer Interference Policy

The NSW Aquifer Interference Policy (AIP) details the role and requirements of the Minister administering the Water Management Act 2000 in regards to water licencing and assessment processes for aquifer interference activities under the Act.

The AIP applies to all activities that penetrate, interfere with, obstruct, abstract water from, or dispose of water to an aquifer.

The AIP requires that proponents demonstrate that the minimal impact considerations specified under the AIP can be met. An assessment of the proposal's compliance with the AIP is provided in Attachment H and is based on the groundwater modelling reported in Sections 4 and 5.

The groundwater source category at the site is defined as being a 'less productive alluvial groundwater source' due to poor water quality within the aquifer at the site as specified by the AIP (see Section 3.11 for further information).

3 Hydrogeological Data

3.1 Overview

3.1.1 Site Data

The following site data set was collected for the purposes of this investigation:

1. 26 boreholes were drilled between 2013 and 2019, terminating between -17.5 mAHD and 17 mAHD.

2. Five previously installed groundwater monitoring wells (MW1 – MW5).

3. Four new site groundwater monitoring wells were installed (MW101 – MW104).

4. 15-minute interval groundwater level observations at MW1 – MW3 between 22/08/2013 and 13/10/2014 (59 weeks) and at MW4 – MW5 between 22/08/2013 and 09/01/2014 (20 weeks). This is hereafter referred to as the first monitoring period throughout this report.

5. 15-minute interval groundwater level observations at MW1 – MW5 and MW101 – MW104, between 21/02/2020 and 25/06/2020 (18 weeks). This is hereafter referred to as the second monitoring period throughout this report.

6. Falling head slug tests from MW1 to MW5 to estimate hydraulic conductivity for the site.

7. Four rounds of groundwater quality sampling at MW1-MW5 between 2014 and 2015.

8. Two rounds of groundwater quality sampling at all monitoring wells in 2020.

Site testing locations are provided in Attachment B Map 3.

3.1.2 Regional Data

A review of available literature incorporated the following documents, all of which were utilised to some degree in this assessment:

1. Public domain bore data (Australian Government Bureau of Meteorology Groundwater Explorer, 2020 –

http://www.bom.gov.au/water/groundwater/explorer/map.shtml). Refer to Attachment B Map 4 for registered bore locations.

2. Newcastle 1:250,000 Geological Sheet (NSW Department of Mines, 1966). Refer to Attachment B Map 5 for local geology map.

3. Newcastle 1:100,000 Soil Landscape Sheet (NSW Department of Land and Water Conservation, 1995). Refer to Attachment A Map 6 for local soil landscapes map.

4. Port Stephens 1:100,000 Soil Landscape Sheet (NSW Department of Land and Water Conservation, 1995). Refer to Attachment A Map 6 for local soil landscapes map.

3.2 Regional Geology and Soils

There is only one geological unit identified within the study area by the Newcastle 1:250,000 Geological Map (Attachment B Map 5) which is Qa – Quaternary deposits: Gravel, sand, silt, clay, "Waterloo Rock", Marine and Freshwater deposits.

The Newcastle and Port Stephens 1:100,000 Soil Landscape Sheets (Attachment A Map 6) identifies seven soil profiles in the study area:

1. bf – Bobs Farm: organic loams, saturated estuarine clays and sandy clay loams.

2. bt – Boyces Track: loose loamy, grey, mottled, and yellow-orange sands.

3. fc – Fullerton Cove: saturated saline organic muds, loams, and coarse sands.

4. hn – Hawks Nest: loose loamy, bleached, mottled, and greyish yellow-brown sands.

5. lp – Lower Pindimar: loose brownish-black loamy, bleached, and coarse smelly brown sands, coffee rock.

6. sb – Shoal Bay: brownish-grey, bleached grey, coherent and iron stained, and dull yellow-orange loose sands.

7. sk – Stockton Beach: loose coarse shelly greyish yellow-brown marine sand and loose fine- to medium-grained aeolian sand.

3.3 Borehole Data

Borehole depth and elevation data is provided in Table 3. With the exception of an intermittent clay / high organics layer located in the vicinity of the water table (summarised in Table 4), borehole excavations generally revealed fine to medium grained sand to investigation levels.

Clay / high organics layer thickness varied from 0.2 to 2.4 m. The top of the clay / high organics layer varied from 1.46 m above the water table level (at two boreholes) to 4.61 m below the water table (at most boreholes). At the 12 boreholes drilled by MA (BH101-BH108 and MW101-MW104), the clay / high organics layer was only observed at BH102 and MW104, and comprised clayey sand with sandy clay layers. Detailed borehole logs are provided in Attachment C.

Based on laboratory testing documented in VGT & Quarry Mining Systems (2013), site sands are generally subrounded to rounded with moderately high sphericity.

Table 3: Summary of borehole investigations levels.

BH	Ground Level (mAHD)	BH Depth (m)	BH Base Level (mAHD)
1	5.82	19.0	-13.18
2	11.72	26.5	-14.78
3	15.48	26.5	-11.02
4	9.45	24.0	-14.55
5	18.25	26.5	-8.25
101	11 [1]	13.0	-2
102	6 [1]	10.0	-4
103	9 [1]	10.0	-1
104	27 [1]	10.0	17
105	15 [1]	10.0	5
106	20 [1]	10.0	10
107	6 [1]	10.0	-4
108	6 [1]	13.0	-7
401	16 [1]	18.5	-2.5
402	13 [1]	30.0	-17.0
403	10 [1]	18.0	-8.0
404	6 [1]	21.0	-15.0
405	11 [1]	26.0	-15.0
406	17 [1]	15.5	1.5
407	15 [1]	14.5	0.5
408	23 [1]	38.0	-15.0
409	7 [1]	24.5	-17.5
MW101	6.77	17.65	-10.88
MW102	25.63	28.70	-3.07
MW103	31.35	37.37	-6.02
MW104	11.83	25.40	-13.57

Notes:

1. Interpolated from survey plan (Attachment A). BH location not surveyed therefore levels indicative.

Table 4: Summary of clay / high organics layer levels and groundwater levels.

BH	Top of Clay / Organic Layer (mAHD)	Bottom of Clay / Organic Layer (mAHD)	Groundwater Level (mAHD)
1	1.52	1.32	2.41 [1]
2	1.22	-0.28	2.28 [1]
3	0.88	-0.12	2.18 [1]
4	3.65	3.25	1.84 [1]
5	-1.75	-4.15	2.67 [1]
101	NE	NE	0.00 [2]
102	1.10	-0.50	2.50 [2]
103	NE	NE	2.20 [2]
104	NE	NE	NE
105	NE	NE	NE
106	NE	NE	NE
107	NE	NE	1.50 [2]
108	NE	NE	2.50 [2]
401	2.5	0.7	2.5 [2]
402	NE	NE	2.5 [2]
403	NE	NE	0.6 [2]
404	0.75	0.25	0.75 [2]
405	NE	NE	1.7 [2]
406	NE	NE	2.1 [2]
407	NE	NE	4.1 [2]
408	NE	NE	Not recorded
409	NE	NE	2 [2]
MW101	NE	NE	1.67 [1]
MW102	NE	NE	2.49 [1]
MW103	NE	NE	2.33 [1]
MW104	2.60	1.60	1.03 [1]

Notes:

1. Mean of groundwater levels observed during monitoring.
2. Based on groundwater level observed during borehole drilling – indicative.
3. NE = not encountered.

3.4 Surrounding Licensed Groundwater Users

According to the Bureau of Meteorology's (BoM) 'Australian Groundwater Explorer' (2020) website there are 18 registered groundwater wells within 2.0 km of the proposed development area.

Registered well locations are shown in Attachment B Map 4 and available data is summarised in Table 5. None of the registered wells in the study area have available water level data.

Table 5: Registered wells within 2.0 km of the proposed development.

Well ID	Well Depth (m)	Drilled Date	Purpose	Status
GW080296	Unknown	6/09/2002	Irrigation	Unknown
GW078621	3.03	Unknown	Water Supply	Unknown
GW078618	10	Unknown	Water Supply	Unknown
GW064363	4	1/01/1919	Water Supply	Unknown
GW079402	Unknown	Unknown	Unknown	Unknown
GW079677	Unknown	Unknown	Unknown	Unknown
GW056098	13.3	1/01/1982	Irrigation	Unknown
GW067296	8	5/04/1991	Water Supply	Functioning
GW080277	8	Unknown	Unknown	Unknown
GW078478	11	Unknown	Water Supply	Unknown
GW079401	Unknown	Unknown	Unknown	Unknown
GW079396	Unknown	Unknown	Unknown	Unknown
GW079425	Unknown	Unknown	Unknown	Unknown
GW079354	Unknown	Unknown	Unknown	Unknown
GW062123	4	1/01/1938	Unknown	Unknown
GW062124	4	1/01/1938	Unknown	Unknown
GW062125	4	1/01/1938	Unknown	Unknown
GW080269	Unknown	16/08/2002	Stock and Domestic	Unknown

3.5 Climate and Sea Level Data

3.5.1 Rainfall and Evapotranspiration

The nearest rainfall station is Nelson Bay Rainfall Station (BoM station 58007, 1881-2020), approximately 16 km north east of the site. Mean annual rainfall at Nelson Bay is 1,344 mm. The nearest station with pan evaporation data is Williamtown RAAF Base (BoM station 061078, 1974-2016), approximately 15 km south-west of the site. Average annual pan evaporation at Williamtown RAAF Base is 1,737 mm. This can be converted to evapotranspiration with a pan coefficient for Williamtown of 82.1% (McMahon) which gives 1,424 mm. A summary of mean monthly rainfall, evapotranspiration data and calculated surplus / deficit is shown below in Table 6.

Table 6: Rainfall data for Nelson Bay (BOM Station 061054) and evapotranspiration data from Williamtown RAAF (061078) and calculated surplus / deficit.

Month	Mean Monthly Rainfall (mm)	Mean Monthly Evapotranspiration (mm)	Rainfall Surplus Rainfall – Evap. (mm)
January	99.8	175.6	-75.8
February	112.5	142.5	-30.0
March	117.7	127.3	-9.6
April	129.3	93.6	35.7
May	149.6	68.7	80.9
June	159.0	61.6	97.4
July	135.6	66.2	69.4
August	101.5	91.6	9.9
September	89.6	115.8	-26.2
October	77.9	142.5	-64.6
November	79.6	155.2	-75.6
December	92.0	183.2	-91.2
Annual	**1344.1**	**1423.8**	**-79.7**

Monthly rainfall data collected since January 2013 to date (which includes both monitoring periods) and average monthly rainfall for the corresponding months are shown in Attachment D Figure 4.

3.5.2 Cumulative Residual Rain

Historical annual rainfall and cumulative annual residual rainfall plots are provided in Attachment D Figure 3. Cumulative residual rainfall is the running total of recorded rainfall minus average rainfall. Analysed over preceding months and years, cumulative residual rainfall indicates whether the conditions leading up to monitoring are average, drier than average or wetter than average. Recorded and average monthly rainfall and cumulative monthly residual rainfall since January 2013 to date (which includes both monitoring periods) is provided in Attachment C Figure 4.

Over the 2013-2014 monitoring period, the recorded rainfall generally corresponds to the long-term average indicating average conditions. Over the 2019-2020 monitoring period, the recorded rainfall is generally less than the long-term average indicating drier-than-average conditions. In February 2020, much higher than average rainfall occurred. These trends are also demonstrated by the cumulative monthly residual rainfall graph, staying steady in 2013-2014, falling in 2019, and recovering in early 2020.

3.5.3 Sea Level

The Manly Hydraulics Laboratory (MHL, NSW government) operates a tidal gauge at Port Stephens, approximately 17 km north east of the site. Harmonic analysis of data from 1990-2010 (NSW OEH, 2012) shows that the mean high-water level is typically between 0.43 and 0.51 mAHD, with mean low-water level typically between -0.59 and -0.51 mAHD. Mean sea level is typically between -0.08 and 0.00 mAHD with the long-term average equal to -0.04 mAHD. The typical diurnal tidal range is approximately 1.02 m.

3.6 Groundwater Levels

3.6.1 General Borehole Assessment

Time series plots of groundwater levels for monitored bores and daily rainfall for both monitoring periods are provided in Attachment D Figure 5 and Figure 6.

In the first monitoring period, groundwater levels remain relatively stable through the entire monitoring period with no long-term increase or decline. This can be attributed to rainfall being generally in line with the long-term average as shown in Figure 4. In the first monitoring period, wells MW1 and MW2 show large and more rapid responses to rainfall events while MW3, MW4 and MW5 have a more subdued response.

In the second monitoring period, similar to the first monitoring period, MW1, MW2 and MW101 show rapid responses to rainfall events while the other wells exhibit more subdued responses. The difference in response to rainfall events is likely due to relative surface elevation at each well but may indicate variability in the soil material. Towards the end of the monitoring period all wells are generally rising in response to increased rainfall in May and June 2020.

Following retrieval of data from MW3 in April 2020, excessive root growth in the well made groundwater monitoring impossible. Given that rectification works had already been carried out in February, and that significant data already existed for this well from the first monitoring period, further monitoring of this well was suspended.

3.6.2 Data Logger Groundwater Level Observations

Statistical summaries of groundwater levels recorded by data loggers for the first monitoring period (22/08/2013 to 13/10/2014) are provided in Table 7, for the second monitoring period (21/02/2020 to 25/06/2020) in Table 8, and for the two periods combined in Table 9.

Table 7: Statistical summary of monitoring well water levels for the first monitoring period (22/08/2013 to 13/10/2014).

Bore I.D.	Ground Level (mAHD)	Groundwater Levels						
		Min. (mAHD)	25 %-ile (mAHD)	Median (mAHD)	Mean (mAHD)	75 %-ile (mAHD)	Max. (mAHD)	Fluctuation Range (Max – Min, m)
MW1	5.82	2.29	2.45	2.54	2.57	2.65	3.10	0.81
MW2	11.72	1.94	2.08	2.28	2.27	2.45	2.64	0.71
MW3	15.48	2.07	2.11	2.19	2.21	2.30	2.40	0.33
MW4	9.45	1.95	2.05	2.10	2.09	2.15	2.21	0.26
MW5	18.25	2.68	2.76	2.84	2.83	2.90	2.95	0.27

Table 8: Statistical summary of monitoring well water levels for the second monitoring period (21/02/2020 to 25/06/2020).

Bore I.D.	Ground Level (mAHD)	Groundwater Levels						
		Min. (mAHD)	25 %-ile (mAHD)	Median (mAHD)	Mean (mAHD)	75 %-ile (mAHD)	Max. (mAHD)	Fluctuation Range (Max – Min, m)
MW1	5.82	1.65	1.75	1.81	1.85	1.90	2.23	0.57
MW2	11.72	2.10	2.25	2.29	2.30	2.36	2.50	0.39
MW3	15.48	1.45	1.87	1.88	1.87	1.89	1.92	0.47
MW4	9.45	1.48	1.52	1.54	1.56	1.59	1.96	0.48
MW5	18.25	2.22	2.45	2.47	2.49	2.52	2.61	0.40
MW101	6.77	1.49	1.59	1.63	1.67	1.74	1.96	0.47
MW102	25.63	2.39	2.46	2.50	2.49	2.51	2.57	0.18
MW103	31.35	2.27	2.31	2.32	2.33	2.34	2.39	0.13
MW104	11.83	0.88	0.99	1.02	1.03	1.08	1.15	0.27

Table 9: Statistical summary of monitoring well water levels for both monitoring periods.

Bore I.D.	Ground Level (mAHD)	Groundwater Levels						
		Min. (mAHD)	25 %-ile (mAHD)	Median (mAHD)	Mean (mAHD)	75 %-ile (mAHD)	Max. (mAHD)	Fluctuation Range (Max – Min, m)
MW1	5.82	1.65	2.32	2.46	2.41	2.57	3.10	1.45
MW2	11.72	1.94	2.12	2.29	2.28	2.44	2.64	0.71
MW3	15.48	1.54	1.99	2.17	2.18	2.30	2.40	0.86
MW4	9.45	1.48	1.55	1.97	1.84	2.11	2.21	0.73
MW5	18.25	2.23	2.48	2.69	2.67	2.85	2.95	0.72
MW101	6.77	1.49	1.59	1.63	1.67	1.74	1.96	0.47
MW102	25.63	2.39	2.46	2.50	2.49	2.51	2.57	0.18
MW103	31.35	2.27	2.31	2.33	2.33	2.34	2.39	0.13
MW104	11.83	0.88	0.99	1.02	1.03	1.08	1.15	0.27

3.6.3 Groundwater Model Level Data

Average groundwater levels from each well for both monitoring periods combined (Table 9) were used to calibrate the pre-development conditions modelling scenario.

3.7 Groundwater Quality Data

Groundwater quality samples were taken from wells MW1 to MW5 on 22/08/2013, 16/10/2014, 30/01/2015, and 01/05/2015, and for all monitoring wells on 21/02/2020, and 14/05/2020 and submitted to a laboratory for analysis. Key analytes are summarised in Table 10 with laboratory reports for the complete suite of analytes in Attachment F. A statistical summary of groundwater quality major analytes is provided in Table 11. We note:

1. Site groundwater is acidic. Minimum and maximum pH values were 3.5 and 6.7 respectively.

2. Groundwater had a 90th percentile salinity concentration of 478 mg/L but one maximum of 1,200 mg/L. Groundwater is therefore generally fresh with saline intrusion possible.

3. Total Nitrogen (TN) had mean and median concentrations of 14.2 mg/L and 5.6 mg/L respectively. The mean concentration was strongly influenced by elevated oxidised nitrogen concentrations at MW1, MW2, and MW101 (maximum concentration of 43.00 mg/L). The elevated oxidised nitrogen concentrations at these bores may be due to application of fertilisers or some other agricultural source (geese are kept near MW1), or a combination of both.

4. Total Phosphorus (TP) had mean and median concentrations of 0.41 mg/L and 0.07 mg/L respectively. The mean concentration was strongly influenced by elevated concentrations at MW1 and MW101 (maximum concentration of 5.3 mg/L). Again, these elevated concentrations may be due to application of fertilisers or some other agricultural source.

Table 10: Groundwater quality sampling results for major analytes.

Bore	Sample date	pH	EC [1] µS/cm	TDS [2] mg/L	TKN [4] mg/L	NOx [5] mg/L	TN [6] mg/L	TP [7] mg/L
MW1	22/08/2013	5.3	500	310	1.90	16.00	17.90	0.10
	16/10/2014	5.2	570	490	0.70	43.00	43.70	0.80
	30/01/2015	5.8	410	240	2.10	7.80	9.90	<0.05
	1/05/2015	5.0	580	370	15.00	31.00	46.00	1.10
	21/02/2020	5.8	760	550	10.00	29.00	39.00	5.30
	14/05/2020	5.9	480	470	4.00	18.00	22.00	4.20
MW2	22/08/2013	5.4	490	270 [3]	2.30	21.00	23.30	<0.05
	16/10/2014	5.1	190	160	0.90	9.50	10.40	<0.05
	30/01/2015	5.5	390	210	1.30	19.00	20.30	<0.05
	1/05/2015	5.4	360	290	14.00	19.00	33.00	<0.05
	21/02/2020	6.1	400	300	1.00	11.00	12.00	<0.05
	14/05/2020	6.1	240	180	1.20	7.70	8.90	<0.05
MW3	22/08/2013	5.6	250	138 [3]	0.50	0.01	0.51	<0.05
	16/10/2014	3.5	390	210	0.30	0.10	0.40	<0.05
	30/01/2015	4.7	300	160	0.80	0.20	1.00	<0.05
	1/05/2015	4.9	280	150	11.00	0.08	11.08	0.20
	21/02/2020	5.8	240	140	7.96	0.04	0.80	0.06
	14/05/2020	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MW4	22/08/2013	5.2	190	105 [3]	0.30	<0.005	0.30	<0.05
	16/10/2014	4.7	150	120	1.60	0.02	1.62	<0.05
	30/01/2015	5.1	150	92	0.60	0.04	0.64	<0.05
	1/05/2015	5.4	220	140	40.00	<0.005	40.00	<0.05
	21/02/2020	5.7	150	120	0.20	<0.005	0.20	0.20
	14/05/2020	5.5	200	140	0.48	0.02	0.50	<0.05
MW5	22/08/2013	6.0	270	149 [3]	1.70	0.86	2.56	0.07
	16/10/2014	5.9	400	350	1.50	0.86	2.36	<0.05
	30/01/2015	5.6	430	280	1.50	0.81	2.31	<0.05
	1/05/2015	5.6	400	220	9.40	0.20	9.60	0.30
	21/02/2020	6.0	380	280	1.85	0.05	1.90	0.10
	14/05/2020	6.0	450	310	4.00	<0.005	4.00	0.09
MW101	21/02/2020	6.7	1500	1200	41.00	33.00	74.00	1.10
	14/05/2020	6.4	890	670	24.00	39.00	63.00	0.20

Bore	Sample date	pH	EC [1] µS/cm	TDS [2] mg/L	TKN [4] mg/L	NOx [5] mg/L	TN [6] mg/L	TP [7] mg/L
MW102	21/02/2020	6.5	440	300	4.10	<0.005	4.10	0.60
	14/05/2020	6.6	460	320	8.09	0.006	8.10	0.50
MW103	21/02/2020	6.3	650	420	2.09	0.007	2.10	0.10
	14/05/2020	6.3	650	400	1.80	<0.005	1.80	0.10
MW104	21/02/2020	6.2	260	160	0.60	<0.005	0.60	0.08
	14/05/2020	6.4	260	160	5.60	<0.005	5.60	0.08

Notes:

1. EC = electrical conductivity.
2. TDS = total dissolved solids.
3. Estimated from EC * 0.55 due to laboratory error.
4. TKN = total Kjeldahl nitrogen.
5. NOx = nitrogen oxide.
6. TN = total nitrogen.
7. TP = total phosphorous.

Table 11: Groundwater quality results statistical summary.

Statistic	pH	EC µS/cm	TDS mg/L	TKN mg/L	Nox mg/L	TN mg/L	TP mg/L
Minimum	3.50	150	92	0.20	<0.005 [1]	0.20	<0.05 [1]
10th Percentile	4.96	190	131	0.49	<0.005 [1]	0.51	<0.05 [1]
25th Percentile	5.30	250	150	0.90	0.007	1.62	<0.05 [1]
Median	5.70	390	240	1.85	0.20	5.60	0.07
Mean	5.65	414	286	6.09	8.31	14.20	0.41
75th Percentile	6.10	480	320	7.96	16.00	20.30	0.20
90th Percentile	6.40	650	478	14.40	29.80	41.48	0.92
Maximum	6.70	1500	1200	41.00	43.00	74.00	5.30
Range	3.20	1350	1108	40.80	43.00	73.80	5.30
Standard Deviation	0.63	249	202	9.68	12.50	18.59	1.08

Notes:

1. Where concentrations were below the practical quantitation limit (PQL), the value was taken as zero for analysis purposes. Any statistics equal to zero were then set to the PQL.

3.8 Hydraulic Conductivity

Saturated hydraulic conductivity (K_{sat}) testing was undertaken at the five original monitoring wells on 1 October 2013. Falling head slug tests were conducted with results provided in Table 12 below and calculation sheets provided in Attachment E.

Data indicates subsoil conditions are generally consistent with clean to silty sand. A median K_{sat} of around 6.8 m/day was estimated, although

we expect that this will vary say between 0.5 – 20 m/day depending on location within the aquifer.

Table 12: Result from site saturated hydraulic conductivity testing.

Borehole I.D.	Date	Hydraulic Conductivity K_{sat} (m/day)
MW1	01/10/2013	6.8
MW2	01/10/2013	17.2
MW3	01/10/2013	9.0
MW4	01/10/2013	2.4
MW5	01/10/2013	4.0

3.9 Groundwater Dependent Ecosystems (GDEs)

The project's ecological consultant, Wildthing Environmental Consultants (2013), have mapped three vegetation communities on the site which rely on groundwater to the north west and north east. These communities comprise 'Flooded Gum – Paperbark Swamp Forest', 'Paperbark Swamp Forest', and 'Freshwater Wetland'. See Attachment B Map 7 for a map of the GDEs.

The Water Sharing Plan (WSP) for the North Coast Coastal Sands Groundwater Sources 2016 identifies high-priority groundwater dependent ecosystems within the study area. These are the State Environment Planning Policy 14 (SEPP14) wetlands that are adjacent to Tilligerry Creek. See Attachment B Map 7 for a map of the SEPP14 coastal wetlands.

The Bureau of Meteorology's Groundwater Dependent Ecosystems Atlas (2020) identifies high-potential vegetation terrestrial GDEs around the site, generally correlating to the forested areas identified by Wildthing Environmental Consultants. Potential GDEs of the following types are identified:

- Coastal Dune Dry Sclerophyll Forests.
- Wallum Sand Heaths.

3.10 Groundwater Dependent Culturally Significant Sites

No groundwater dependent culturally significant sites are identified in the Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources 2016.

3.11 Groundwater System Productivity

The NSW Department of Primary Industries Office of Water NSW Aquifer Interference Policy (2012) defines groundwater systems as 'highly productive' or 'less productive', with highly productive groundwater systems characterised by:

1. Groundwater quality – total dissolved solids (TDS) < 1,500 mg/L: and

2. Groundwater supply – yield > 5 L/s.

In terms of groundwater supply, based on the measured hydraulic conductivities and the depth of the sand aquifer (typically greater than 20 m), 5 L/s abstraction from the aquifer is assessed to be possible.

One high salinity reading within the aquifer was observed at MW101 on 21/2/2020 (1,200 mg/L), all other TDS measurements were measured in an approximate range from 100 – 500 mg/L.

It is therefore assessed that this aquifer should be classified as 'highly productive' according to the AIP.

4 Pre-development Groundwater Model

4.1 Groundwater Model Conceptualisation

The conceptual hydrogeological model is provided in Attachment G. This has been developed through analysis of topography, geological maps, soil maps, local aerial photography, borehole information, as well as groundwater levels (measured and assumed) across the model domain. The data indicates:

1. A groundwater flow divide likely exists along the ridgeline north of the site and forms a groundwater ridge between Tilligerry Creek and the Pacific Ocean.

2. Hydraulic gradients are low with only a 1.64 m range in mean groundwater level between all site bores for the data logging periods.

3. Groundwater depth is highly variable due to varying land surface levels. Maximum groundwater depth likely is of the order of 32 mBGL below topographic divides, whilst minimum groundwater depth may be of the order of 0.5 to 1 mBGL in the far north of the site where land surface levels are 2 mAHD.

4. With the exception of a clay / high organics layer generally located just below the water table in some parts of the site, the investigation and soil profile generally comprise fine to medium grained sand that is subrounded to rounded with moderately high sphericity.

5. For all soil units, vertical conductivity is assumed to be lower than horizontal conductivity due to layering of strata and the likely presence of relatively low permeability interbeds.

6. Hydraulic conductivity for stable dune areas (including the site) is likely to frequently fall between say 0.5 – 20 m/day but may vary outside of this range. Hydraulic conductivity for the active dunes and beach sands south of the site are likely higher; and hydraulic conductivity for the silt, clay and estuarine sediments north of the site are likely lower.

7. Groundwater likely flows under unconfined conditions in the soil strata.

8. Groundwater is generally fresh in the site area.

9. Groundwater is recharged via rainfall, and exits the study area via throughflow to Tilligerry Creek and the ocean as well as evapotranspiration, particularly in well-established forested areas.

4.2 Software

The MODFLOW NWT Solver was utilised within the GMS 10.4.1 (2018) graphical user interface for this assessment.

4.3 Settings and Water Balance Error Criteria

The NWT solver options were kept at the recommended settings as per the USGS Online Guide (2018).

A model water balance error threshold of 1% was used which represents the typically adopted industry threshold value. This water balance error is the percentage difference between the total water coming into the model and the total amount of water leaving the model, and is a measure of the reliability of a groundwater model. If the error was above 1%, the model's convergence criteria (closure criterion) was reduced to ensure the model water balance error fell below 1%.

4.4 Model Extents and Grid Cell Configuration

A model domain of approximately 7 km by 5 km was used (Attachment B Map 8). Of this area approximately 75% comprised the active model area with the remaining portion being inactive. The active model domain was assigned to an area between Tilligerry Creek and the Pacific Ocean which were assumed to be constant head boundaries. The other boundaries were assigned as perpendicular lines between the ocean and Tilligerry Creek at an appropriate distance from the site. A 20 x 20 m grid cell size was used over the entire model domain. The grid was rotated approximately 15 degrees anti-clockwise from the north-south orientation to suit the domain. See Attachment B Map 8 for a map of the groundwater model domain.

4.5 Layers

The model soil units were represented using 2 layers. The top of layer 1 represents the existing topography and was defined using LIDAR data (NSW LPI, 2014) and survey information from site. The interface between layers 1 and 2 (bottom of layer 1, top of layer 2) was set to a constant value of -15 mAHD. The bottom of layer 2 was set to a constant value of -30 mAHD. These levels do not represent geological boundaries but were assessed to be acceptable for modelling given a minimum layer thickness of 15 m.

4.6 Boundary Conditions

4.6.1 Drain Boundaries

Multiple drain boundaries were defined to represent drains in low-lying areas in the model domain, particularly to the north of the site. Drain elevations were set to the surface level minus 0.25 m. Drain conductance was set to 3.0 m^2/day/m per meter length of drain and was calculated based on an average drain width (2 m) x K_h for silty sand (0.3 m/day based on final calibration, refer Section 4.8.2) divided by assumed creek sediment thickness (0.2 m). Refer to Attachment B Map 8 for a plan of the boundary conditions.

4.6.2 Constant Head Boundaries

Constant head boundaries were applied to all layers of the model along Stockton Beach and Tilligerry Creek. The constant heads at Stockton Beach and Tilligerry Creek were set to 0.0 mAHD (refer Section 3.5.3). Refer to Attachment B Map 8 for a plan of the boundary conditions.

4.7 Pre-Calibration Model Parameters

4.7.1 Hydraulic Conductivity

Further to the discussion in Section 4.1, the hydraulic conductivities in the model were adjusted within the upper and lower bounds in Table 13 to achieve calibration.

Table 13: Horizontal hydraulic conductivity calibration ranges.

Hydraulic Conductivity Zones	Range (m/day)
Active Dunes and Beach Sand	10 – 40
Stable Dunes – Fine to Medium Sand	5 – 20
Silt, Clay and Estuarine Sediments	0.2 – 2.0

A vertical anisotropy ratio (K_h / K_v) of 3 was used for all K-zones. Hydraulic conductivity zonation for both layers 1 and 2 was based on soil landscaping mapping (Attachment B Map 6) with some minor adjustments at the site based on hydraulic conductivity test results, and is shown in Attachment B Map 9.

4.7.2 Recharge

Recharge rates were adjusted within the upper and lower bounds in Table 14 to achieve calibration. Recharge area zonation was based on land uses from aerial photos and is shown in Attachment B Map 10.

Table 14: Recharge rate calibration ranges.

Recharge Zone	Range (mm/year)
Agricultural / Grassed Areas	250 – 500
Dunes	300 – 600
Forest below 10 mAHD	200 – 400
Forest higher than 10 mAHD	150 – 300
Swamp	250 – 550

4.7.3 Evapotranspiration

Evapotranspiration (ET) rates were adopted based on the annual average ET rate from BoM (1424 mm/day). ET extinction depths were adjusted within the upper and lower bounds in Table 15 to achieve calibration. ET depth zones are shown in Attachment B Map 11.

Table 15: Evapotranspiration depth calibration ranges.

Recharge Zone	Range (m)
Grassed / Agricultural Areas	0.5 – 2.0
Dunes	0.0 – 2.0
Forest below 10 mAHD	1.0 – 3.0
Forest higher than 10 mAHD	5.0 – 10.0
Swamp	0.5 – 1.5

4.8 Calibration

4.8.1 Calibration Period and Targets

The model was calibrated to the average groundwater levels for the whole monitoring period (Table 9) for each monitoring well across the model domain. No calibration data was available from registered bores in the model domain (refer Section 3.4). As part of the calibration procedure, a 'synthetic' monitoring well was created in MODFLOW at a low-lying pond north of the site. Being a low-lying pond, it is likely to be groundwater fed and therefore the water level in the pond is representative of local groundwater levels. The level of this synthetic well was set to the level of the LIDAR survey in the centre of the pond.

4.8.2 Calibration Procedure

Hydraulic conductivity, recharge, and evapotranspiration depth values were adjusted within the ranges identified in Section 4.7 to achieve calibration. At the completion of calibration, the model parameters were as presented in Table 16.

Table 16: Calibrated model parameters.

Calibration Parameter	Units	Calibrated Value
Hydraulic Conductivities		
Active Dunes and Beach Sand (K_H, K_V)	m/day	30, 10
Stable Dunes – Fine to Medium Sand (K_H, K_V)	m/day	18, 6
Silt, Clay, and Estuarine Sediments (K_H, K_V)	m/day	0.3, 0.1
Recharge Rates		
Agricultural / Grassed Areas	mm/year	400
Dunes	mm/year	535
Forest below 10 mAHD	mm/year	270
Forest higher than 10 mAHD	mm/year	200
Swamp	mm/year	470
Evapotranspiration Depths		
Grassed / Agricultural Areas	mBGL	1.5
Dunes	mBGL	0.5
Forest below 10 mAHD	mBGL	2.0
Forest higher than 10 mAHD	mBGL	8.0
Swamp	mBGL	1.0

4.8.3 Calibration Results

A calibration scatter plot of modelled and observed heads along with key calibration statistics is provided in Attachment D Figure 7. The model's absolute residual mean was 0.267 m and residual mean was 0.004 m which indicates a bias towards a very slight over-prediction of head. The mass balance discrepancy was -0.0006% and therefore acceptable being below the adopted threshold of 1.0%. Although the RMS was greater than the generally accepted threshold of 10% - largely due to the influence of MW101, overall, the predicted pre-development model closely replicates the observed GW level data and the model was considered satisfactory for predictive purposes.

4.9 Pre-Development Results

The calibrated heads for Layer 1 over the site for the pre-development model scenario are provided in Attachment B Map 12. The depth to groundwater over the site is provided in Attachment B Map 13. Cross-sections of the groundwater level through the model at the proposed development site is provided in Attachment B Map 14.

4.10 Model Confidence Level Classification

In accordance with the Australian Groundwater Modelling Guidelines (2012), the model is considered to generally represent a 'Class 2' model confidence level classification, suitable for impact assessment.

A 'Class 2' classification is justified on the basis of the following:

- Calibration statistics are generally reasonable.
- Mass balance error is less than 1.0% of total.
- Geotechnical data coverage is reasonable in the vicinity of the proposed development.
- Model parameters are generally consistent with conceptualisation.

5 Post-Development Conditions Groundwater Model

5.1 Model Modifications

For the impact assessment, the pre-development model was adjusted to simulate the final stage of mining operations, once the extraction pit is effectively fully excavated but assuming groundwater take due to dredging activities is ongoing. This was considered the situation which would cause the greatest impacts to the local groundwater system and therefore the most appropriate scenario for impact assessment.

To model the post-development groundwater impacts, changes were made to the pre-development model to simulate the window lake created by mining activities. For the post-development scenario model, the following changes were made:

1. The hydraulic conductivity within the flooded pit extents in layer 1 were set to 999 m/day to simulate the void created. Post-development groundwater model hydraulic conductivity zones are shown in Attachment B Map 16 based on final water level in pit. No change was made to layer 2 hydraulic conductivity zones.

2. The recharge over the pit area was set to the full amount of average annual rainfall plus runoff from the surrounding catchment assuming 30% of rainfall on this area would runoff to the pit, which results in a recharge rate of 1,344 mm/year. Post-development groundwater model recharge zones are shown in Attachment B Map 17.

3. The evapotranspiration rate over the flooded pit area was set to the annual average pan-evaporation rate from BoM for Williamtown RAAF Base with a pan coefficient applied of 82.1% for Williamtown (McMahon *et al*). The MODFLOW settings for evapotranspiration elevation and depth were adjusted in the area of the pit to ensure the full rate was applied to the free water surface. Post-development groundwater model evapotranspiration zones are shown in Attachment B Map 18.

4. Groundwater take from the pit due to ongoing operational losses was modelled by adding a synthetic 'extraction well' in the pit with an ongoing average daily extraction rate of 135 kL/day. This rate was adopted based on the project *Surface Water Management Plan* (MA, 2015) and includes losses from plant operation, dust suppression, and wheel washdown. This calculation assumed 19 working days per month and that the site

was operational 11 months a year. The modelled extraction well location is shown in Attachment B Map 15.

5.2 Post-Development Groundwater Levels

The groundwater heads for the post-development model scenario are provided in Attachment B Map 19 and show that water levels in the pit void range from 1.75 to 2.00 mAHD. The post-development depths to groundwater is provided in Attachment B Map 20. Cross sections of the post-development groundwater levels through the proposed development are provided in Attachment B Map 21. The resultant drawdown due to the proposed development is provided in Attachment B Map 22. Note that drawdown is calculated by subtracting the post-development GW levels from the pre-development GW levels hence, a negative drawdown indicates an increase in GW level.

Modelling predicts groundwater drawdown of up to 0.65 m on the site, and up to 0.35 m offsite. We note that during monitoring, groundwater levels have been recorded to vary by up to 1.45 m at a single well, and up to 2.22 m across different wells at the site (Section 3.6). The magnitude of the drawdown caused by the proposed development is therefore well within the range of the natural groundwater table fluctuation.

5.3 Post-Development Groundwater Flows

The groundwater flow balance for the pit area was calculated for both the pre-development and post-development groundwater models. Results from this analysis are presented below in Table 17. Refer to Attachment B Map 19 for the extents of the area over which the groundwater flow balance was calculated.

Table 17: Groundwater flow balance over the mine area for pre-development and post-development scenarios.

Flow Balance Parameter	Groundwater Flow Budget (ML/Year)	
	Pre-Development	Post-Development
Water In		
Recharge	101.3	487.1
Groundwater Flow In	82.5	113.4
Total Water In	183.8	600.5
Water Out		
Evapotranspiration	5.7	355.2
Groundwater Flow Out	178.1	196.1
Groundwater Extraction for Dredging Losses	0.0	45.1
Groundwater Extraction for Dust Suppression	0.0	2.5
Groundwater Extraction for Truck Washdown Losses	0.0	1.7
Total Water Out	183.8	600.6
Total Groundwater Balance (ML/year) (Total Water In minus Total Water Out)	**0.0**	**0.1**

6 Discussion and Groundwater Impact Assessment

6.1 Changed Groundwater Levels at Groundwater Dependant Ecosystems

Drawdown caused by the proposed development does not impact groundwater levels by more than ± 50 mm within 40 m of the SEPP14 wetlands identified as high-priority GDEs in the water sharing plan (Attachment B, Map 22).

Of the GDEs mapped by Wildthing Environmental Consultants which are reliant on groundwater, a maximum drawdown of -0.25 m (i.e. slight groundwater level increase) occurs at the flooded gum forest, north of the main extraction pit area (Attachment B Map 22). This groundwater level change dissipates over a small distance, returning to existing levels about 100 m from the extraction pit. A drawdown of approximately 150 mm occurs at the paperbark swamp forest on the north-east boundary of the site. Given the small magnitude and area over which these impacts occur, and the larger magnitude of natural groundwater level fluctuation, the groundwater level changes at these mapped GDEs is assessed to be unlikely to cause any impact.

6.2 Changed Groundwater Levels at Offsite Licenced Wells and Basic Landholder Rights

The drawdown map (Attachment B Map 22) shows that six registered wells are predicted to be impacted by drawdown greater than 0.05 m resulting from the proposed development. Of these wells, four are located in the forest to the east of the site which are predicted to drawdown by 0.05-0.15 m and have no known purpose or installation date and are most likely monitoring bores. One of the affected wells is an irrigation well installed in 1982 between the site and Nelson Bay Rd at the north east corner of the site which has a predicted drawdown of between 0.15 and 0.25 m due to the proposed development. The other well is an irrigation well installed in 2002 in Lot 1 DP 1251784 north west of the site which has a predicted drawdown of -0.05 m (i.e. GW level increased by 0.05 m).

None of these bores have drawdown greater than 2.0 m and therefore do not require any remediation work under the AIP. Further, the predicted change in groundwater level is less than the natural groundwater level fluctuation.

An objection to the proposed development citing groundwater impacts was submitted by the proposed Ride Water Park development to the north east of the site at 781 Marsh Road. The drawdown map (Attachment B, Map 22) shows that the proposed development will not

cause any drawdown ± 50 mm at the proposed Ride Water Park site. We note that the hydrogeological analysis submitted by Griffiths Investment Properties (the owners of the proposed Ride Water Park) and prepared by Coffey Environments Australia Pty Ltd, relies on limited site data and incorrect assumptions, notably that groundwater within the sand extraction pit would be drawn down to the base of excavation at -15 mAHD. This is clearly wrong because it assumes that the dredge pond is to be completely de-watered which is not practical or proposed. MA do not consider that the Coffey analysis diminishes or challenges the findings of this assessment. The groundwater impacts on the Ride Water Park site are modelled as being negligible and are therefore considered acceptable.

The Department of Planning and Environment has raised concerns regarding the proximity of Hunter Water Corporation's North Stockton Catchment Special Area to the proposed development. Attachment B Map 22 shows drawdown within this area is limited to 0.35 m in a very small section, but is generally less than 0.25 m. Given the size of the North Stockton Catchment area (> 50 km^2) and the small magnitude of predicted drawdown, especially with respect to the monitored natural groundwater level fluctuation, the predicted drawdown is assessed to have a negligible impact.

6.3 Acid Sulfate Soils Risks

6.3.1 Methodology

To assess the impact of changed groundwater levels on acid sulfate soils (ASS), each ASS sample taken from the approximate elevation of the groundwater table (±5 m) was assessed to determine whether:

1. The sample was taken from within the extents of the extraction pit;

2. An increase in groundwater level was predicted at the location where the sample was taken; and,

3. The sample recorded a net acidity less than 20 mole H+/tonne.

If the sample was taken from within the extents of the extraction pit, acid production is unlikely seeing as soil / sand from this area would be dredged and treated in accordance with the ASS management plan. If there is predicted to be an increase in the water level at the location of the sample, acid production is unlikely as there would be no risk of oxidising additional ASS. If the sample recorded a net acidity less than 20 mole H+/tonne, changes in groundwater level at that location have very little potential to produce significant acidity.

Depending on the answers to each question, a classification was assigned from 'A' to 'D' to each sample. Samples classified as 'D' would require further review to assess the level of risk posed by changes in groundwater levels to the production of ASS. This methodology has been represented in Figure 1.

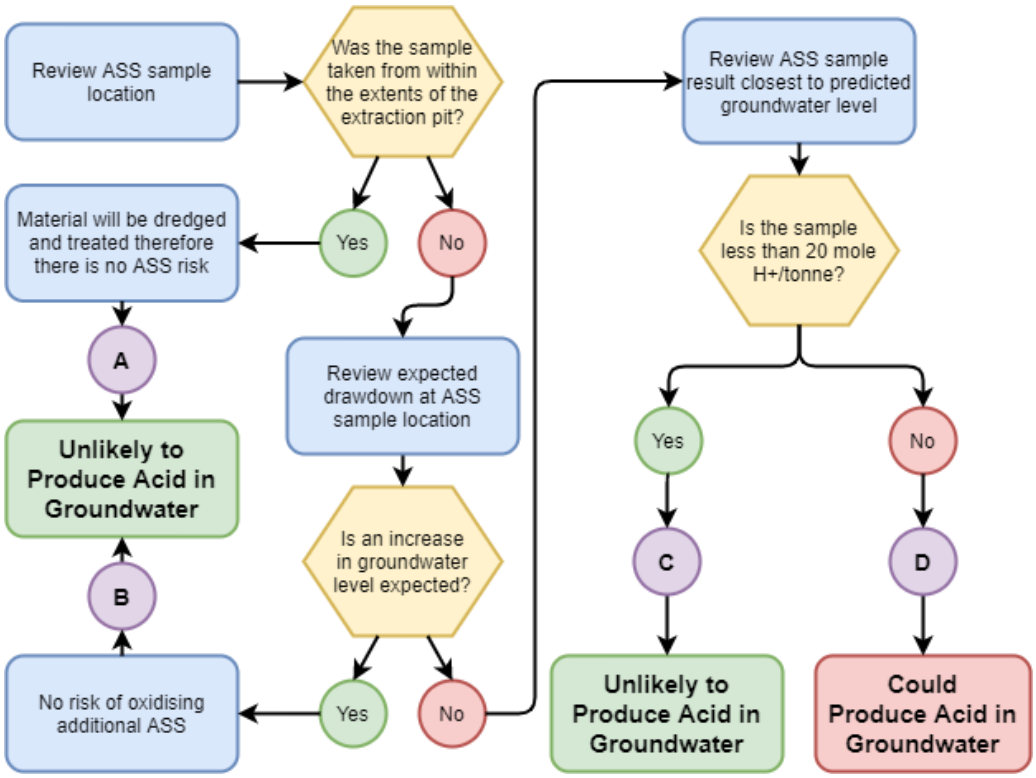

Figure 1: Groundwater - ASS impact assessment methodology.

6.3.2 *Analysis*

The ASS sample results from the approximate groundwater elevation have been mapped in Attachment B Map 23 and have been summarised in Table 18. The analysis and resulting classifications based on the methodology presented in Section 6.3.1 have also been summarised in Table 18.

Table 18: Summary of acid sulfate soils analysis results at the elevations where drawdown occurs.

Bore ID	In Pit?	Predicted Pre-development GW Level (mAHD)	Predicted Post-development GW Level (mAHD)	ASS Sample Level (mAHD)	Net Acidity (acidity units - mole H+/t)	Class.
BH 401	Yes	1.67	1.87 ↑	2.5	120	A
BH 402	Yes	1.87	1.88 ↑	5.5	<5	A
BH 403	Yes	2.07	1.90 ↓	1	<5	A
BH 404	Yes	2.42	1.90 ↓	0.5	180	A
BH 405	Yes	2.28	1.90 ↓	2.5	<5	A
BH 407	Yes	2.01	1.89 ↓	1.5	7	A
BH 408	Yes	2.29	1.91 ↓	1	<5	A
BH 409	Yes	2.42	1.92 ↓	1.5	<5	A
BH101	No	2.39	2.07 ↓	2.5	<10	C
BH102	Yes	2.37	1.92 ↓	2.5	12	A
BH103	No	2.08	1.92 ↓	1	35	D
BH105	Yes	2.02	1.90 ↓	2	<10	A
BH107	Yes	2.21	1.91 ↓	0.5	<10	A
BH108	Yes	2.06	1.90 ↓	3.5	10	A
BH3 / MW3	Yes	1.89	1.88 ↓	1	<10	A
BH4 / MW4	No	1.91	1.90 ↓	2.9	<10	C
BH5 / MW5	Yes	2.3	1.93 ↓	1	<10	A
MW101	No	2.38	1.92 ↓	2.5	<5	C
MW102	No	1.95	1.72 ↓	-3.5	<5	C
MW103	Yes	2.26	1.99 ↓	-2.5	<5	A
MW104	No	1.33	1.71 ↑	5	50	B

6.3.3 *Discussion*

The results above show that 15 of the 21 samples were taken from within the proposed pit extents and were hence assigned class 'A'. MW104 was outside of the pit extents however the groundwater table is expected to rise at this location so it was classified as 'B'. Of the remaining wells that were outside of the pit extents and are expected to experience a lowering of the groundwater table, four had net acidity values below the adopted threshold of 20 moles H+/t and were hence classified as 'C'. Only BH103 is outside of the pit extents, is expected to experience a lowering of the groundwater table, and had a net acidity value greater than 20 moles H+/t and was assigned a classification of 'D' and hence requires further consideration.

Groundwater modelling predicts that BH103 will experience a reduction in groundwater level of less than 20 cm which is within the range of

fluctuation which would normally occur due to variable climatic conditions. Furthermore, the net acidity value at BH103 at the level of the groundwater was 35 moles H+/t which despite being above the adopted threshold, is relatively small given the regional reading was almost 200 moles H+/t. Therefore, it is assessed that groundwater being lowered at BH103 will cause negligible acid production in the aquifer.

Further to the above discussion, the data shows that the majority of samples (14 out of 21) were below the practical quantification limit (PQL) for net acidity at the approximate elevation of groundwater drawdown.

This assessment has shown that the risk of generating acid of any material consequence is negligible and that any acidity caused by changes in the groundwater table can be dealt with by way of monitoring as excavation progresses and by the ASS management plan.

MA have reviewed the submission of Joy-Lynne Redmayne and consider that the concerns raised in relation to groundwater interaction with acid sulfate soils have been addressed by this assessment.

6.4 Dewatering Rates

Using a flow budget analysis in the MODFLOW package, total groundwater take for the proposed development was calculated to be 404.6 ML/year excluding recharge (see Section 5.3). It is noted that this is the maximum groundwater take which will occur in the final stages of sand extraction operations when the extraction pit and lake is near-complete and dredging activities are ongoing. Once dredging, truck washdown, and dust suppression activities cease, the ongoing dewatering rate will be 355.2 ML/year due to ongoing evapotranspiration however the net extraction will be zero once recharge is taken into account.

6.5 Groundwater Quality

6.5.1 Sources of Groundwater Contamination

Potential sources of groundwater contamination during the life of the proposed development include:

1. Chemicals from sand processing and agriculture;
2. Fuels and oils from sand processing equipment, farming equipment, and vehicles; and,
3. Effluent disposal.

MA note that the groundwater is already impacted by high levels of nutrient leaching from the ongoing agricultural use of the site as evidenced by the high TN and TP measurements (see Section 3.7).

6.5.2 Groundwater Quality Management Recommendations

The following recommendations are made to minimise the potential for contamination from the sand processing area:

1. Surface runoff from the sand processing area is to be directed to a water quality treatment device (sedimentation pond or similar) prior to discharging to the extraction pit.

2. Any fuel and chemical storage on site is to be appropriately bunded to prevent direct runoff to the sand extraction pit in the event of a spill.

3. Spill kits to be kept in fuel and chemical storages to be readily available in the event of a spill. Site staff to be trained in their use.

4. A site Environment Management Plan is to be developed at the detailed design stage which includes a spill management procedure.

5. A septic tank with an absorption trench with appropriate buffers is to be used for effluent disposal.

6. A management and monitoring plan for groundwater quality should be implemented (see Section 7).

Implementation of these recommendations will significantly reduce the risk of groundwater contamination. Furthermore, given the agricultural practices on the site will be ceased, the local groundwater quality may be improved as a result of the proposal.

6.5.3 Groundwater Quality Impacts on Tilligerry Creek

The impact of the proposal on water quality and oyster farming within Tilligerry Creek has been raised by Mrs. Joy-Lynne Redmayne. We consider that there will be no material impact on water quality and oyster farming operations in Tilligerry Creek since:

1. Risk of pollution of the aquifer is to be managed via the management methods previously described, therefore any potentially polluting events will be rare;

2. The proposal is approximately 1 km from Tilligerry Creek; and,

3. Hydraulic gradients from the proposal to Tilligerry Creek are very small (approximately 2m over 1 km) which means that groundwater travel time are in the order of decades.

We therefore assess that the risk of contamination from the site impacting Tilligerry Creek to be minimal.

6.6 Aquifer Interference Policy

The impacts of the proposed development were assessed against the minimal impact considerations for a 'highly-productive coastal sands groundwater source' in the AIP. The full assessment is shown in Attachment H but the following is noted:

- There is no variation in the water table 40 m from the SEPP14 wetlands which are identified in the water sharing plan;
- There is no 2.0 m decline in groundwater head at any groundwater supply work; and,
- The proposed development is not assessed to negatively impact local groundwater quality.

This assessment therefore demonstrates that the groundwater level impacts of the proposed development comply with the requirements of the AIP.

6.7 Extraction Below Water Table

Several of the agency comments (Section 2.1) state that extraction activities should not occur below the groundwater table level, and an adequate buffer should be maintained to the excavation base. This assessment has considered the potential impacts of extraction below the groundwater table level, which consist of:

1. Change to groundwater levels at groundwater dependant ecosystems.
2. Change to groundwater levels at offsite bores.
3. Change to groundwater levels at acid sulfate soils.
4. Change to groundwater quality.

Each of these potential impacts has been addressed in detail in each of the preceding sections. Modelling and assessment have demonstrated that there will be no material offsite impacts with respect to groundwater levels or groundwater quality. Further, the proposed development has

been assessed against the requirements of the AIP and has been found to comply.

We therefore consider that extraction activities can be safely undertaken below the groundwater table level, and a buffer above the groundwater table is not considered necessary.

7 Groundwater Management Plan

7.1 Groundwater Management Elements

Key surface / groundwater elements to be monitored include:

1. Groundwater levels in the monitoring wells.
2. Groundwater quality in the monitoring wells.
3. pH of water within the dredge lake, water exiting the washing plant, and of stockpile leachate.

7.2 Monitoring Locations

The existing monitoring well field comprises nine wells. Of these nine, MW4, MW101, MW102, and MW104 are outside of the proposed mining area and can be used for the life of the project. The remaining wells can be utilised for monitoring up to the point when they need to be removed however this will be prior to any excavation below the groundwater level so this will be of minimal value. See Attachment B Map 3 for monitoring well locations. Additional wells are not considered necessary to monitor local groundwater conditions.

7.3 Groundwater Level Monitoring

7.3.1 Monitoring Frequency

Groundwater levels should be dipped weekly with continuous monitoring at 15-minute intervals via data logger at MW4, MW101, MW102, MW104 and the dredge pit. Groundwater levels should also be dipped weekly at all wells that have not yet been removed as mining progresses. Continuous monitoring data should be downloaded every 3 months and compiled for reporting.

'Event-based sampling' dips should also be taken following any 24-hour period where rainfall is greater than 50 mm, which is approximately equivalent to a 3-month rainfall event.

7.3.2 Trigger Values

Trigger values for groundwater levels in each of the monitoring wells have been calculated by taking the predicted level from the MODFLOW numerical model and subtracting 0.2 m based on observed variance from the mean. Groundwater level trigger values are summarised below in Table 19.

Table 19: Groundwater level trigger values.

Well	Predicted Post-Development Groundwater Level (mAHD)	Trigger Level (mAHD)
MW4	1.50	1.30
MW101	1.50	1.30
MW102	1.49	1.29
MW104	1.43	0.88 [1]
Dredge Pit	1.49	1.29

Notes:

1. Groundwater level is predicted to increase at MW104 from the currently observed levels, hence the minimum reading from monitoring was utilised.

7.4 Groundwater Quality Monitoring

7.4.1 Monitoring Frequency

Groundwater quality should be routinely sampled quarterly throughout the life of the proposed development at wells MW4, MW101, MW102, MW104 and the dredge pit.

'Event-based sampling' groundwater quality samples should also be taken following any 24-hour period where rainfall is greater than 50 mm, which is approximately equivalent to a 3-month rainfall event.

7.4.2 Monitoring Well Sampling Methodology

Subject to bore-field maintenance, MW4, MW101, MW102 and MW104 are to be sampled using the following methodology:

1. Purging of the bore using dedicated bailers, to a minimum of three well volumes but preferably five well volumes.

2. After purging, samples shall be collected with the dedicated bailer for each bore.

Alternatively, pumps may be used for purging however if sampling from a pump, decontamination procedures should be followed between samples and between job sites.

To sample the dredge pit, water should be taken directly from the pit, preferably from the middle and at least 30 cm below the surface.

7.4.3 Analytes

Groundwater quality samples should be analysed for the following:

- pH

- Electrical Conductivity (EC)
- Total Dissolved Solids (TDS)
- Total Kjeldahl Nitrogen (TKN)
- Oxidised Nitrogen (NOx)
- Total Nitrogen (TN)
- Total Phosphorous (TP)
- Aluminium
- Iron
- Manganese
- Arsenic
- Chromium
- Cobalt
- Zinc
- Hydrocarbons

7.4.4 Interim Trigger Values

Interim trigger values for groundwater analytes are provided in Table 20. Values were established from previous monitoring events at the site where available by taking the median value and adding two standard deviations (or subtracting for pH). Where previous data was not available, trigger values were taken from the ANZG 2018 default guideline values for 95% species protection in marine environments.

A minimum of three samples taken prior to works commencing at the site to confirm trigger values for the analytes provided in Table 20.

We note that nominated trigger values are based on minimal sampling events and are statistically based. The trigger values are not considered to necessarily reflect unprecedented background values. Therefore, whilst exceedance of trigger values should incite some form of assessment, it is possible that certain trigger values will be exceeded as a result of natural variability.

Table 20: Interim trigger values for groundwater quality analytes.

Analyte	Units	Trigger Value	ANZG 2018 95% Species Protection Marine Water Default Guideline Value
pH	pH Units	4.4	N/A
EC	µS/cm	888	N/A
TDS	mg/L	644	N/A
TKN	mg/L	21.2	N/A
NOx	mg/L	25.2	N/A
TN	mg/L	42.8	N/A
TP	mg/L	2.2	N/A
Aluminium	µg/L	N/A	0.8 [1,2]
Iron	µg/L	N/A	300 [3]
Manganese	µg/L	N/A	80 [2]
Arsenic	µg/L	N/A	13 [1]
Chromium	µg/L	N/A	4.4
Cobalt	µg/L	N/A	1
Zinc	µg/L	N/A	15
Hydrocarbons	N/A	Any detection > PQL	N/A

Notes:

1. No default guideline value for marine water exists.
2. Default guideline value for freshwater used. Species protection level unknown.
3. ANZG 2018 does not list a default guideline value. Concentration taken from USEPA secondary drinking water regulations.

7.5 Bore-Field Maintenance

As part of routine bore-field inspections, the bore-field shall be maintained to ensure that collected groundwater samples are representative.

The following works should be completed during routine maintenance at each bore:

1. Visual inspection to confirm well and monument are in sound working order. Wells found to be damaged, lost or vandalised are to be rectified or replaced.

2. Purging the well until such time as groundwater quality being pumped is uniform.

3. Wells with an excessive algal matt build up are to be remediated with chlorine flushing and pumping, or if this is ineffective, replaced with a new groundwater well.

7.6 Monitoring Action Plan

Action will be required if trigger values are exceeded. Action will involve the following:

1. Re-test exceeded parameter/s.
2. Engage a suitably qualified consultant to review the data in light of environmental / climate conditions.
3. Consultant to determine if additional groundwater management strategies are required.
4. Consultant to update this groundwater monitoring plan in consultation with Council, EPA, and HWC.

This is represented diagrammatically in the action plan in Figure 2.

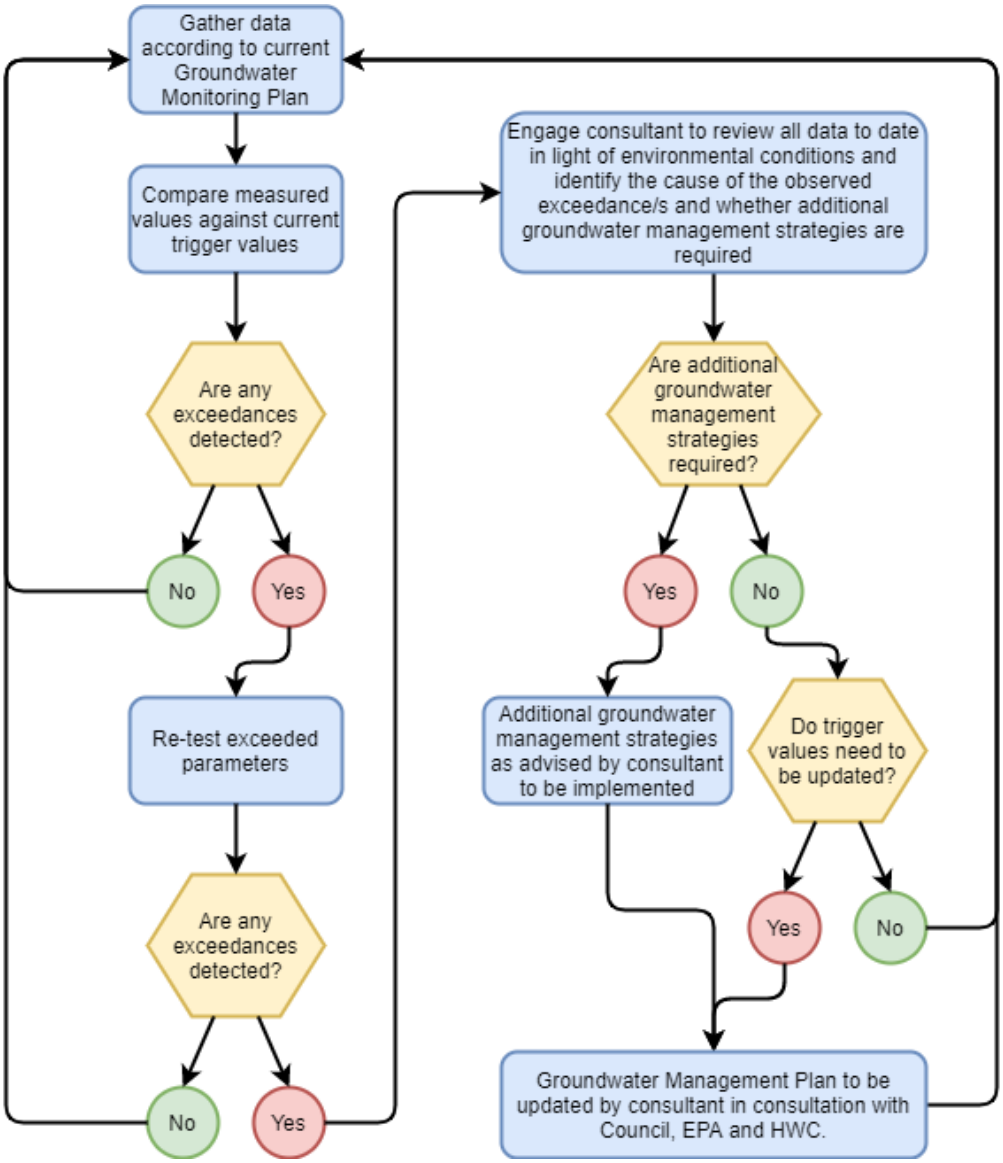

Figure 2: Groundwater Monitoring Action Plan.

7.7 Reporting

All monitoring data is to be graphed and assessed against trigger levels and presented in an annual report that will be forwarded to Council, EPA and HWC. Council, EPA and HWC are to be notified if results above trigger values are found at the time of monitoring.

Following the completion of the proposed development, the need to continue the water monitoring and the frequency of testing and reporting is to be assessed at the time of annual reporting. At a minimum, it is anticipated that monitoring will be required until at least 2 years following the completion of the proposed development.

8 Water Licencing

The proposed development is located within the Stockton Groundwater Source as identified by the Water Sharing Plan (WSP) for the North Coast Coastal Sands Groundwater Sources (2016). The grant of any groundwater Water Access Licence (WAL) and the management of allocation and share component which attach to it are bound by the rules within the *NSW Water Management Act 2000* (NSW) and this Water Sharing Plan.

As assessed previously in Sections 5.3 and 6.4, the total maximum groundwater take is 404.6 ML/year as set out in Table 21.

Table 21: Groundwater take calculation.

Component	Post-Development Groundwater Flow Budget (ML/Year)
Evaporation	355.2
Groundwater Extraction for Dredging Losses	45.1
Groundwater Extraction for Dust Suppression	2.5
Groundwater Extraction for Truck Washdown Losses	1.7
Total Groundwater Take	**404.6**

We note that the applicant already holds a licence for 40 ML/year under an existing licence, therefore an additional share of approximately 365 ML/year will need to be acquired for the proposed site. The additional share will not be required until extraction activities reach the water table, and will eventually grow to 365 ML/year by the end of extraction. Given the long-term average annual extraction limit for the Stockton Groundwater Source is 14,000 ML/year as stated in the WSP, and the total allocation currently licenced is 1037.5 ML/year, acquiring additional share components is assessed to be feasible either through application to Water NSW or through trading with other licensees.

9 Conclusions

This assessment has found that:

1. Modelled groundwater level changes do not impact high-priority groundwater dependent ecosystems mapped in the water sharing plan.

2. Modelled groundwater level changes do not impact nearby registered groundwater bores or affect basic landholder rights in respect of groundwater availability.

3. Impacts of changed groundwater levels on acid sulfate soils have been assessed and found to be negligible and able to be managed through the use of the groundwater management plan and ASS management plan.

4. Groundwater quality within the aquifer at the site is currently generally poor and, with the recommended engineering controls, risks to groundwater quality can be suitably managed.

5. The groundwater impacts of the proposed development have been assessed in relation to the NSW Aquifer Interference Policy and have been found to comply with the requirements.

6. A groundwater monitoring plan will be implemented which will manage the impact of the proposed development on groundwater levels and quality.

7. There is sufficient water share allocation available in the Stockton Groundwater Source to allow the purchase of additional share units needed for the operation of the proposed development.

Further, each of the agency comments relating to hydrogeology raised in response to the EIS have been addressed by this assessment.

10 References

ANZG (2018), *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, www.waterquality.gov.au/anz-guidelines

Australian Government Bureau of Meteorology (2020), *Climate Data Online*, http://www.bom.gov.au/climate/data/?ref=ftr

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11 Attachment A – Development Plan

LEGEND

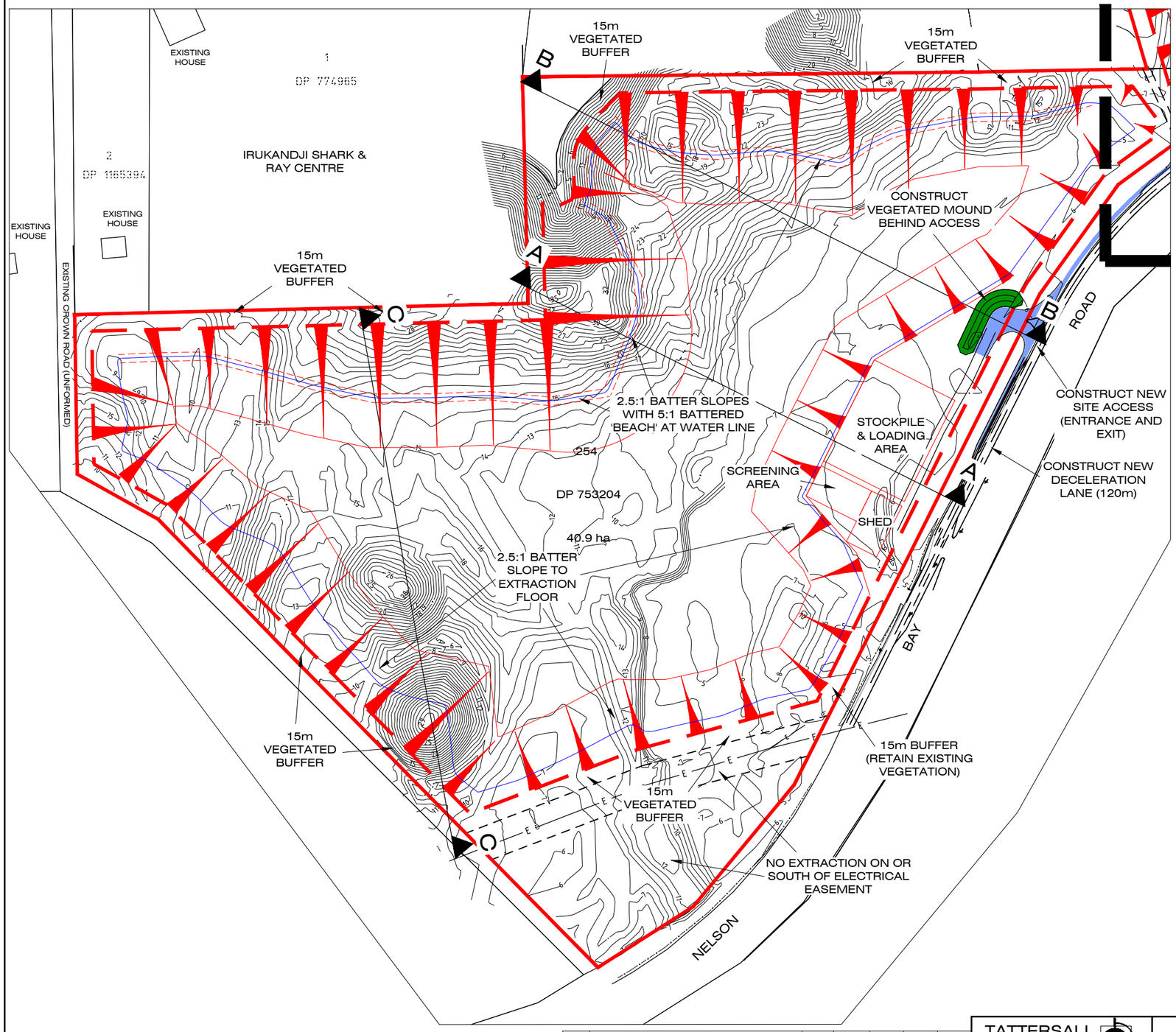
DENOTES PROPOSED SITE BOUNDARY

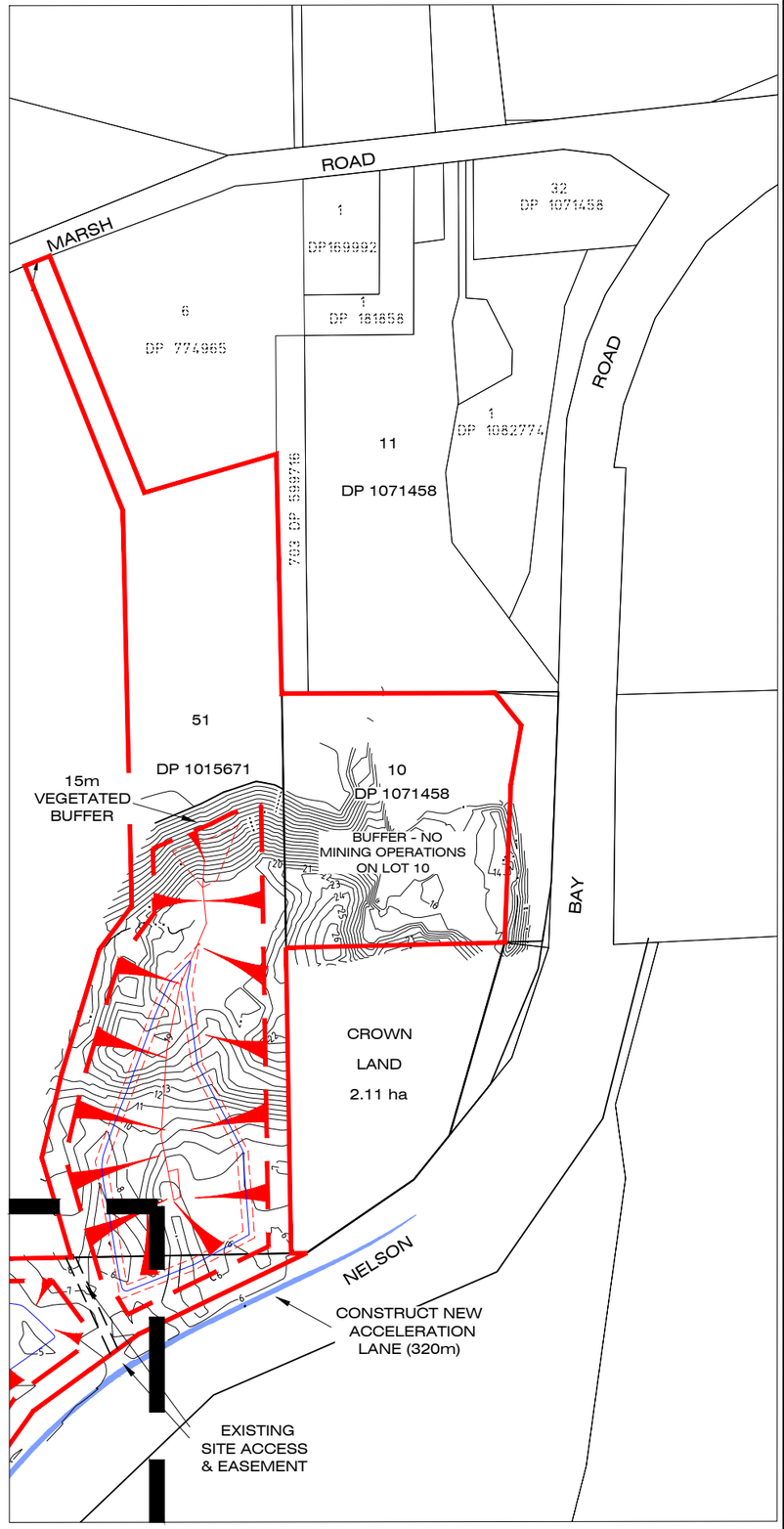
DENOTES PROPOSED EXTRACTION AREA - 36.07Ha
MAXIMUM EXCAVATION LEVEL -15.0m AHD

INDICATIVE VEHICLE HAUL ROUTE

EXISTING CONTOURS
1m INTERVALS

DENOTES INDICATIVE FINAL WATER BODY - 24.27Ha
ASSUMED 1.8m AHD





(1: 2000for A1 Size Plot)

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F	Lot 10 Buffer Included	AV	AV			
E	Site Extents and Entrance Revised	DS	DS			
D	Reduced Footprint - Additional Buffers Added	AV	AV			
C	Footprint Withdrawn from Electrical Easement	AV	AV			

* Denote the original signature and date when revision was issued.

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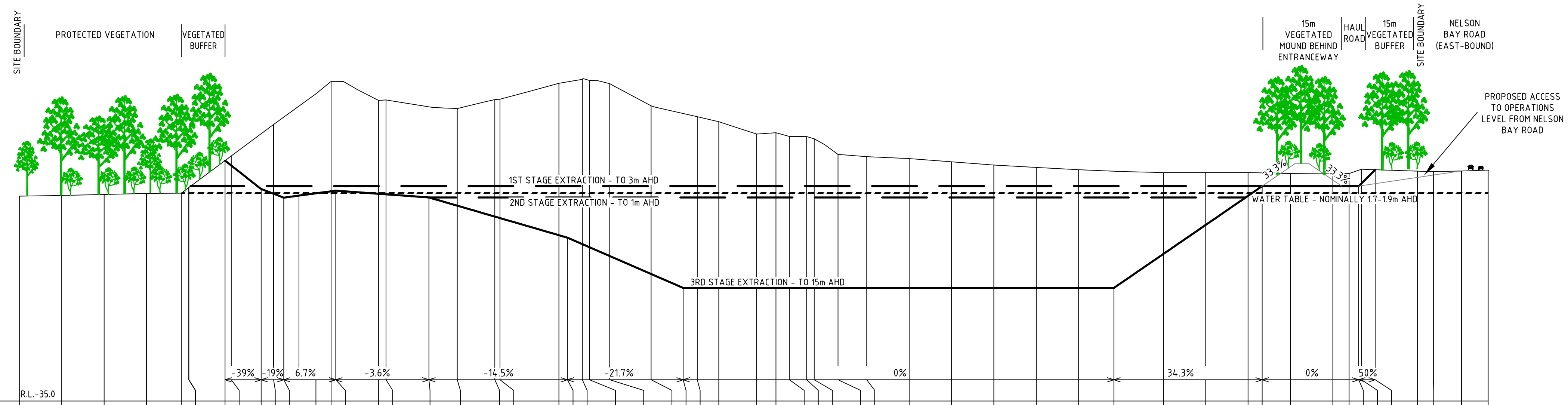
PLAN OF PROPOSED SAND MINE
LOT 254 DP 753204, LOT 51 DP 1015671, LOT 10 DP 1071458
NELSON BAY ROAD
BOBS FARM

COUNCIL: PORT STEPHENS	REFERENCE: 21400060
PARISH: TOMAREE	SHEET SIZE: A1
SCALE: 1:2000 on A1	SHEET No.: 1 of 3
DATE : Plotted 21/7/20 11:27 AM	
CLIENT: PATRA HOLDINGS PTY LTD	JOB No.: 212434
COMPUTER FILE : S:\Clients\2012\212434\Dwg\Layout Plan.dwg	



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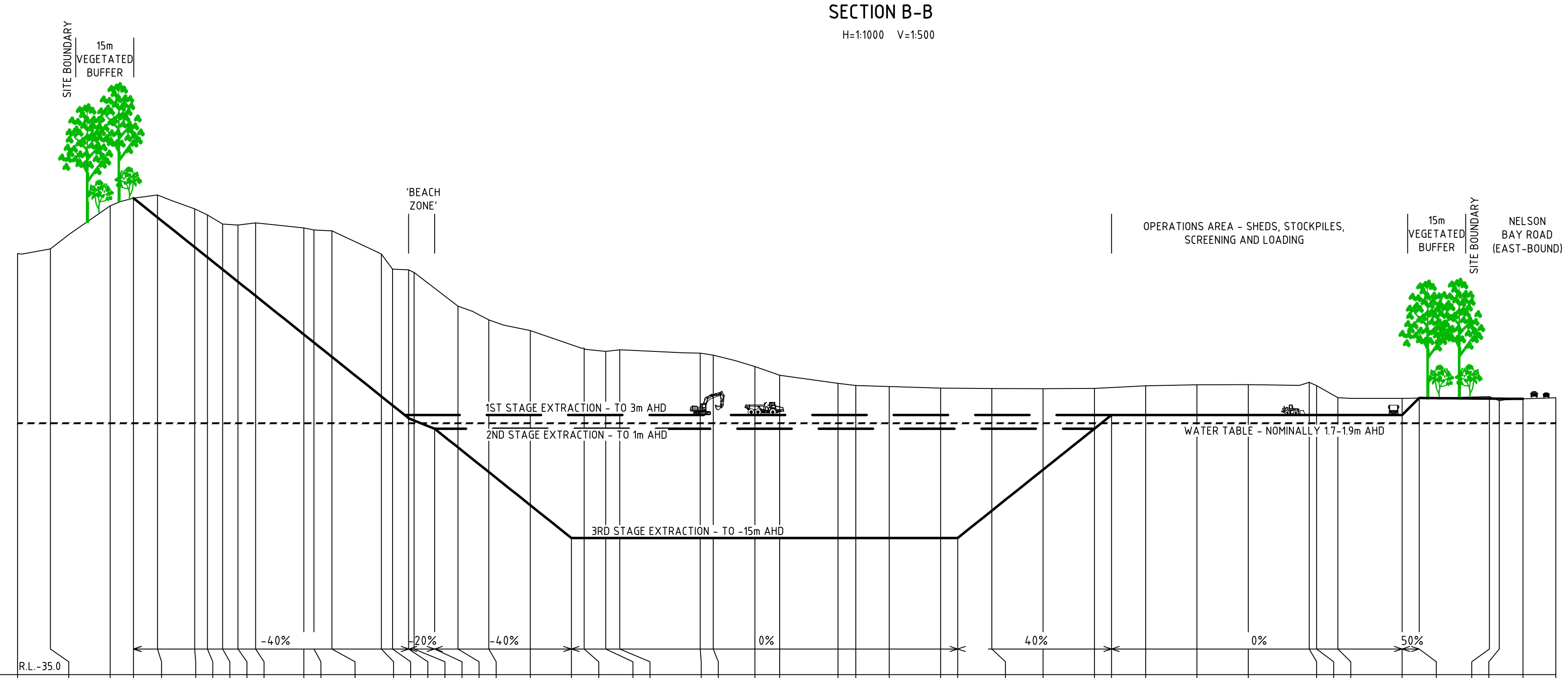
45		1.718
57.339		1.76
60		2.75
72.815	7.513	
75	6.655	8.332
85.6	2.493	
90	1.653	13.914
93.6	0.965	
105	1.73	19.328
110.387	2.092	21.527
112	2.2	
127.157	1.649	18.165
129.812	1.552	18.255
145	1	
155.028	-0.454	16.715
168.324	-2.382	18.313
170.152	-2.647	18.366
191.022	-5.673	21.184
194.029	-6.109	
199.305	-7.254	21.893
201.82	-7.8	21.708
208.994	-9.357	21.126
223.64	-12.535	17.205
235	-15	
240	-15	15.281
247.602	-15	14.387
261.022	-15	12.21
267.843	-15	12.448
272.609	-15	11.784
278.753	-15	11.776
281.405	-15	11.36
289.822	-15	8.622
300	-15	8.208
315	-15	7.876
330	-15	7.313
345	-15	6.726
360	-15	6.3
375	-15	5.906
387.5	-15	
405	-9	5.394
420	-3.857	5.396
435	1.286	5.393
440	3	
450	3	5.24
465	3	5.168
470.787	3	5.234
474.166	3	
475.153	3.494	5.986
480	5.917	5.917
495		5.662
500.64		5.559
510.55		5.685
520		

SECTION B-B

H=1:1000 V=1:500



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27.108		33.643
33.927	34.749	34.749
40.944	31.94	35.235
51.805	27.593	33.193
55.524	26.105	32.302
60	24.313	30.964
64.46	22.528	30.814
69.622	20.462	31.143
83.733	14.814	30.401
86.704	13.625	30.095
91.955	11.524	29.982
106.422	5.733	26.572
109.674	4.432	24.37
114.5	2.5	24.269
116.006	2.199	23.879
122	1	
128.837	-1.735	18.95
137.855	-5.342	16.942
150	-10.2	15.378
162	-15	
165.724	-15	12.779
172.059	-15	12.324
176.158	-15	12.56
199.686	-15	12.073
203.519	-15	11.764
215.711	-15	10.108
222.93	-15	8.822
240	-15	7.636
245.185	-15	7.336
255	-15	7.178
270	-15	6.942
275	-15	
285	-11	6.892
300	-5	6.863
315	1	6.906
320	3	
330	3	7.291
345	3	7.441
360	3	7.449
377.82	3	7.793
380.011	3	7.31
386.235	3	5.55
405	3	5.449
410	5.5	
430.547		5.693
433.412		5.104
440.364		5.372
450		

SECTION A-A

H=1:1000 V=1:500

INDICATIVE VOLUMES

STAGE 1	2,765,000m^3
STAGE 2	505,000m^3
STAGE 3	2,835,000m^3

REV	DETAILS OF AMENDMENT	DESIGNED	DRAWN	CHECKED	APPROVED	DATE
F	Lot 10 Buffer Included	AV	AV			
E	Site Extents and Entrance Revised	DS	DS			
D	Reduced Footprint - Additional Buffers Added	AV	AV			
C	Footprint Withdrawn from Electrical Easement	AV	AV			

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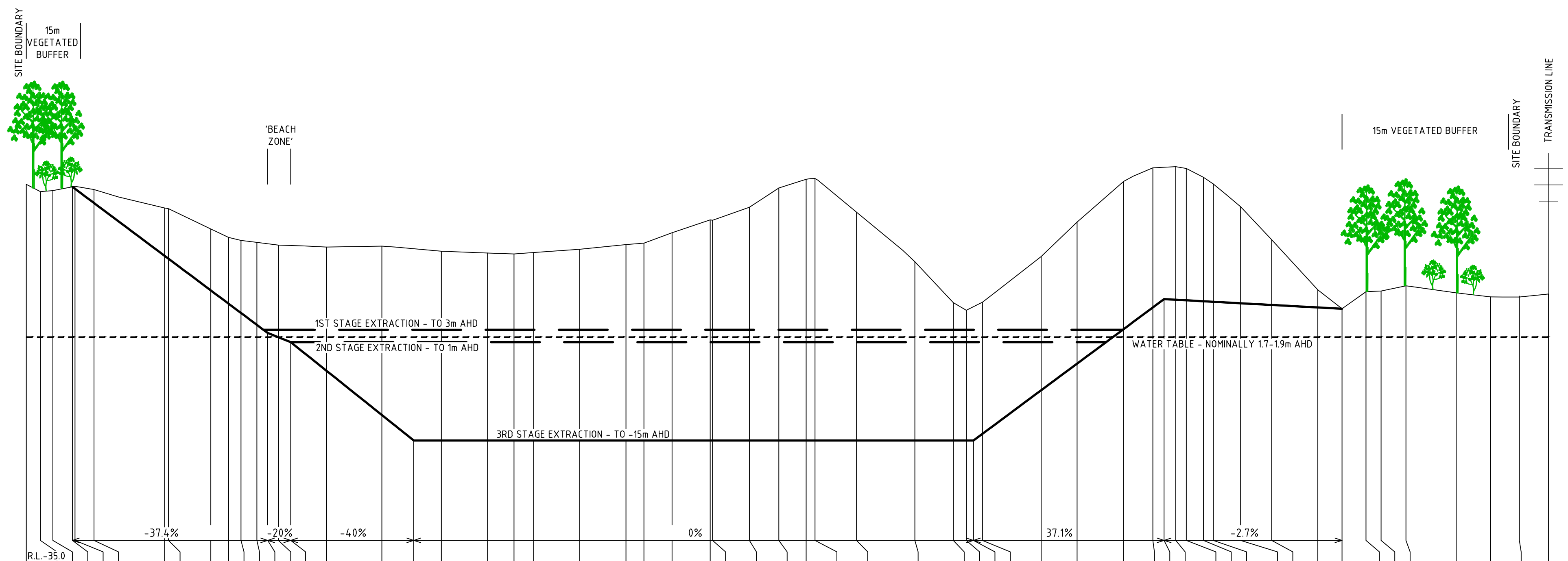
INDICATIVE CROSS SECTIONS
PROPOSED SAND MINE
NELSON BAY ROAD
BOBS FARM

COUNCIL: PORT STEPHENS	REFERENCE: 21400061
PARISH: TOMAREE	SHEET SIZE: A1
SCALE: 1:2000 on A1	SHEET No.: 2 of 3
DATE: Plotted 15/7/20 11:59 AM	

CLIENT: PATRA HOLDINGS PTY LTD | JOB No.: 212434 | COMPUTER FILE : S:\Clients\2012\212434\Dwg\Layout Plan.dwg



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4.583		25.489
8.662		25.668
15	26.27	26.27
15.849	25.952	26.35
22.017	23.643	25.824
45	15.04	22.83
46.245	14.574	22.714
60	9.425	19.421
65.82	7.247	18.028
69.82	5.749	17.557
75	3.81	17.231
78.5	2.5	
81.986	1.803	16.791
86	1	
97.619	-3.648	16.471
115.641	-10.856	16.61
126	-15	
135	-15	15.803
150	-15	15.508
158.614	-15	15.342
165	-15	15.592
180	-15	16.101
195	-15	16.868
200.843	-15	17.105
210	-15	18.803
222.415	-15	20.889
223.18	-15	20.824
235.143	-15	22.958
244.7	-15	26.072
253.616	-15	27.497
256.472	-15	27.629
270	-15	22.141
288.958	-15	14.087
301.434	-15	7.427
305.665	-15	6.191
308	-15	
310.912	-13.92	7.487
330	-6.839	14.931
341.705	-2.497	20.539
356.843	3.119	27.167
366.332	6.639	29.365
370	8	
373.81	7.897	29.553
377.208	7.805	29.247
382.822	7.652	27.82
386.006	7.566	26.734
394.894	7.325	23.038
405	7.051	17.65
420	6.645	9.504
427.84	6.432	6.432
435.655		9.221
440.551		9.324
448.646		10.16
465		9.023
476.13		8.363
485.515		8.334
495		8.82

SECTION C-C

H=1:1000 V=1:500

REV	DETAILS OF AMENDMENT	DESIGNED	DRAWN	CHECKED	APPROVED	DATE
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E	Site Extents and Entrance Revised	DS	DS			
D	Reduced Footprint - Additional Buffers Added	AV	AV			
C	Footprint Withdrawn from Electrical Easement	AV	AV			

* Denote the original signature and date when revision was issued.

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INDICATIVE CROSS SECTIONS
PROPOSED SAND MINE
NELSON BAY ROAD
BOBS FARM

COUNCIL	REFERENCE
PORT STEPHENS	21400062
PARISH	SHEET SIZE: A1
TOMAREE	
SCALE	SHEET No.
1:2000 on A1	3 of 3
DATE :	Plotted 15/7/20 12:00 PM

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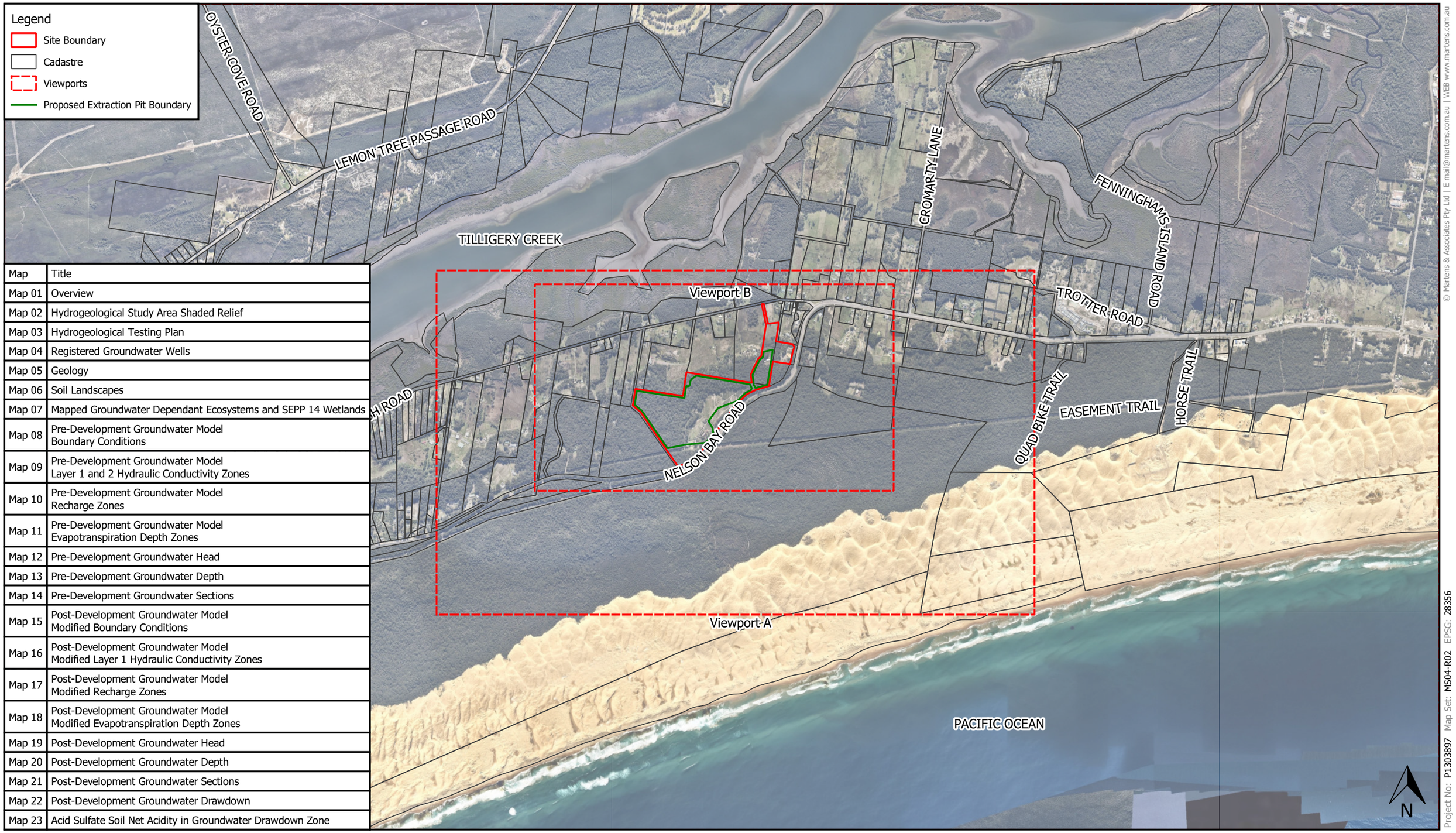
12 Attachment B – Maps



Map	Title
Map 01	Overview
Map 02	Hydrogeological Study Area Shaded Relief
Map 03	Hydrogeological Testing Plan
Map 04	Registered Groundwater Wells
Map 05	Geology
Map 06	Soil Landscapes
Map 07	Mapped Groundwater Dependant Ecosystems and SEPP 14 Wetlands
Map 08	Pre-Development Groundwater Model Boundary Conditions
Map 09	Pre-Development Groundwater Model Layer 1 and 2 Hydraulic Conductivity Zones
Map 10	Pre-Development Groundwater Model Recharge Zones
Map 11	Pre-Development Groundwater Model Evapotranspiration Depth Zones
Map 12	Pre-Development Groundwater Head
Map 13	Pre-Development Groundwater Depth
Map 14	Pre-Development Groundwater Sections
Map 15	Post-Development Groundwater Model Modified Boundary Conditions
Map 16	Post-Development Groundwater Model Modified Layer 1 Hydraulic Conductivity Zones
Map 17	Post-Development Groundwater Model Modified Recharge Zones
Map 18	Post-Development Groundwater Model Modified Evapotranspiration Depth Zones
Map 19	Post-Development Groundwater Head
Map 20	Post-Development Groundwater Depth
Map 21	Post-Development Groundwater Sections
Map 22	Post-Development Groundwater Drawdown
Map 23	Acid Sulfate Soil Net Acidity in Groundwater Drawdown Zone

0 300 600 900 1200 1500 m

1:30000 @ A3

Notes:
- Aerial from Nearmap (2020).
- Cadastre from site survey (Tattersall Lander, 2013) and NSW DFSI (2019).

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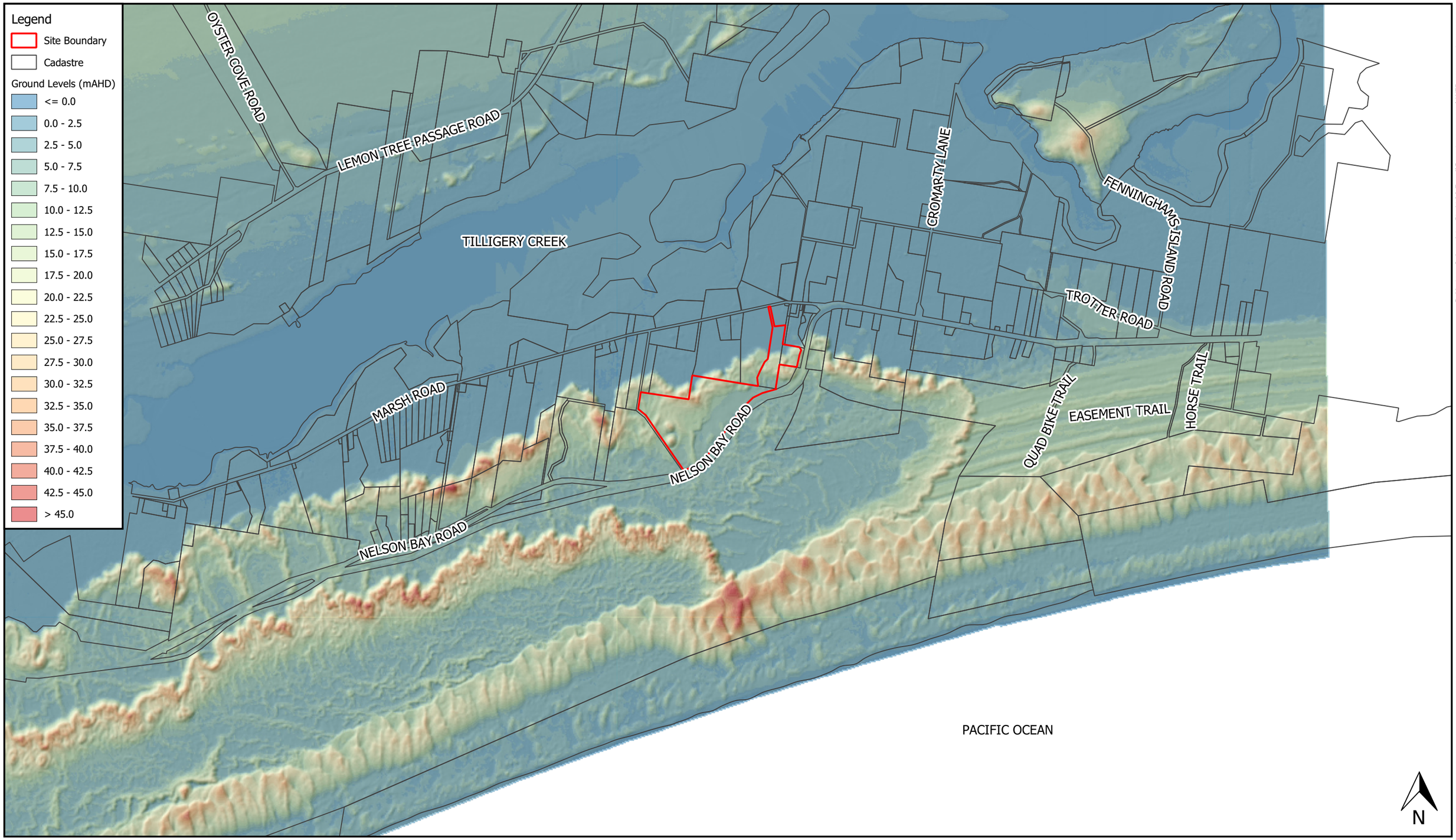
Project No: P1303897 Map Set: MS04-R02 EPSG: 28356

Map Title / Figure:
Overview

Map 01	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date



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Notes:
- Ground levels from site survey (Tattersall Lander, 2013) and 5m LIDAR (Geoscience Australia, 2015).
- Cadastre from site survey (Tattersall Lander, 2013) and NSW DFSI (2019).

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Map Title / Figure:

Hydrogeological Study Area Shaded Relief

Map 02	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

Project No: P1303897 Map Set: MS04-R02 EPSG: 28356

0 90 180 270 360 450 m

1:7500 @ A3

Viewport B

Notes:
- Aerial from Nearmap (2020).
- Monitoring wells surveyed by Tattersall Lander.
- Borehole locations are approximate.
- Cadastre from site survey (Tattersall Lander, 2013) and NSW DFSI (2019).

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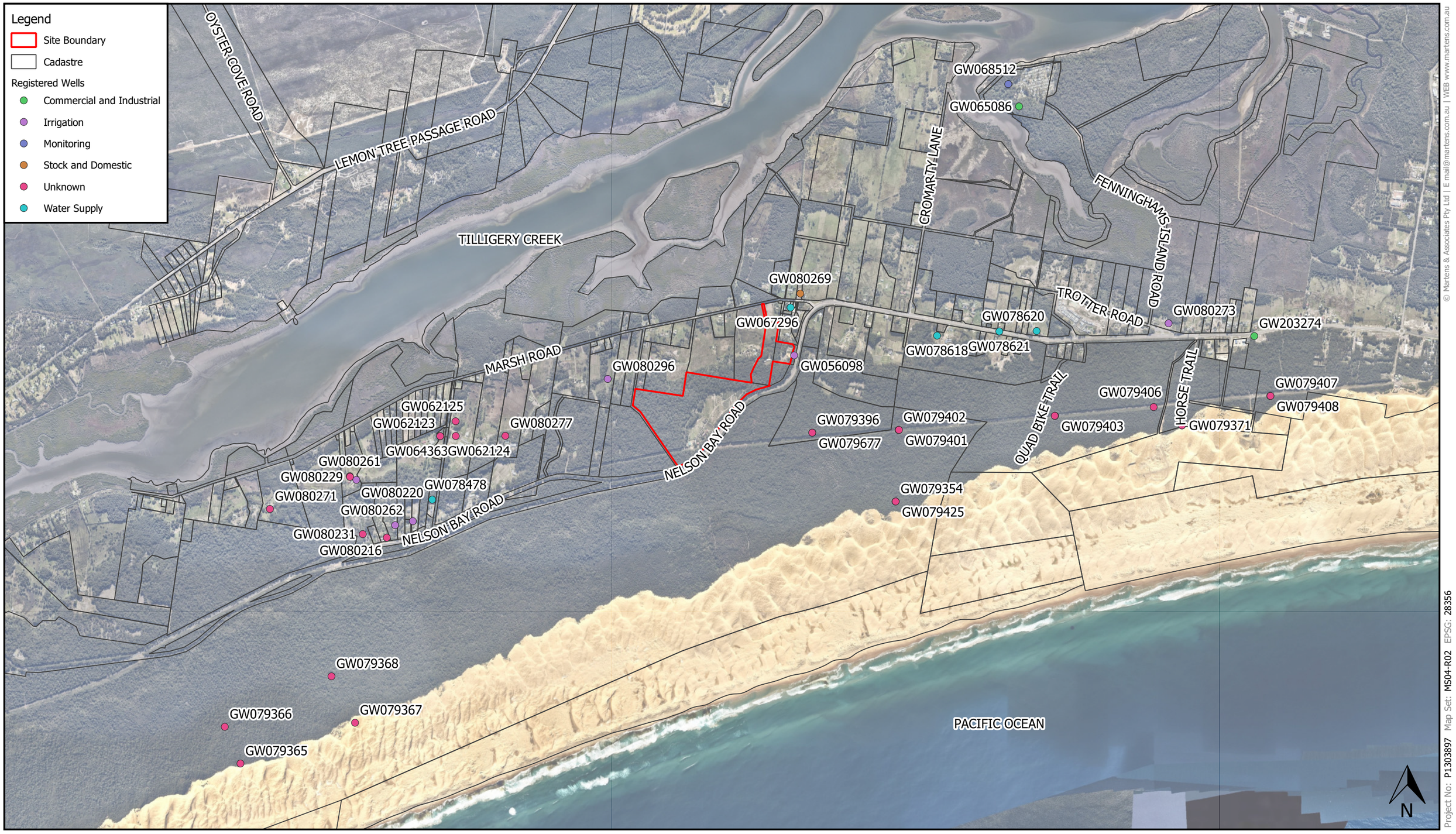
Map Title / Figure:

Hydrogeological Testing Plan

Map 03	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

Project No: P1303897 Map Set: MS04-R02 EPSG: 28356



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Notes:
- Aerial from Nearmap (2020).
- Registered well locations from BoM Groundwater Explorer (2020).
- Cadastre from site survey (Tattersall Lander, 2013) and NSW DFSI (2019).

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Map Title / Figure:

Registered Groundwater Wells

Map 04	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

Project No: P1303897 Map Set: MS04-R02 EPSG: 28356

0 300 600 900 1200 1500 m

1:30000 @ A3

Notes:
- Aerial from Nearmap (2020).
- Geology from NSW DPIE (2019).
- Cadastre from site survey (Tattersall Lander, 2013) and NSW DFSI (2019).

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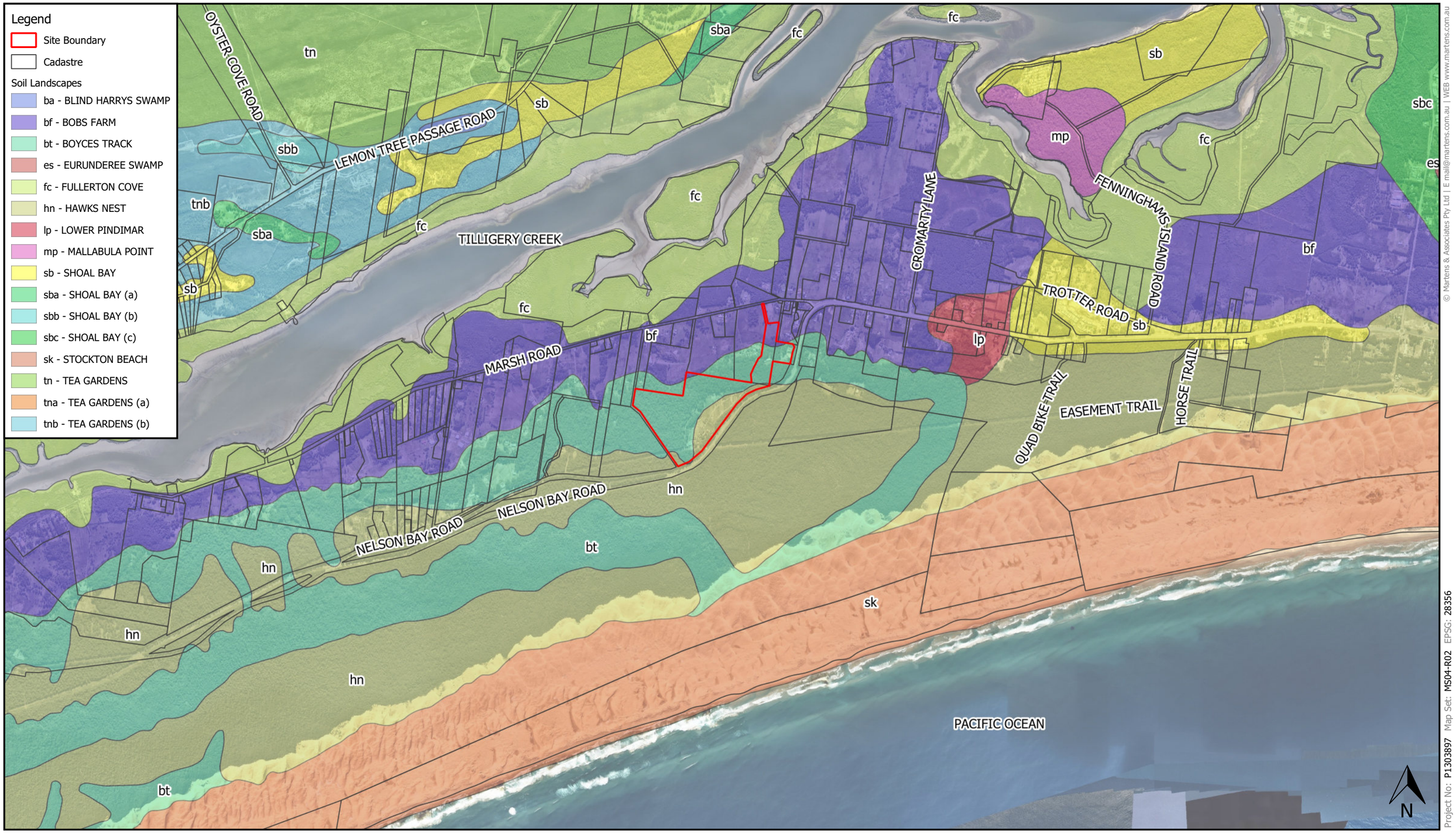
Map Title / Figure:
Geology

Map 05	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

Project No: P1303897 Map Set: MS04-R02 EPSG: 28356



Project No: P1303897 Map Set: MS04-R02 EPSG: 28356

0 300 600 900 1200 1500 m

1:30000 @ A3

Notes:
- Aerial from Nearmap (2020).
- Soil landscapes from NSW DPIE (2019).
- Cadastre from site survey (Tattersall Lander, 2013) and NSW DFSI (2019).

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Map Title / Figure:
Soil Landscapes

Map 06	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

0 300 600 900 1200 1500 m

1:30000 @ A3

Notes:
- Aerial from Nearmap (2020).
- SEPP14 Wetlands from OEH (2019).
- Mapped GDEs from Wildthing Environmental Consultants (2013).

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Map Title / Figure:

Mapped Groundwater Dependant Ecosystems and SEPP 14 Wetlands

Map 07	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

Project No: P1303897 Map Set: MS04-R02 EPSG: 28356

Legend

- Site Boundary
- Constant Head Boundaries
- Drain Boundaries
- Groundwater Model Domain

Project No: P1303897 Map Set: MS04-R02 EPSG: 28356

N

0 300 600 900 1200 1500 m

1:30000 @ A3

Notes:
- Aerial from Nearmap (2020).

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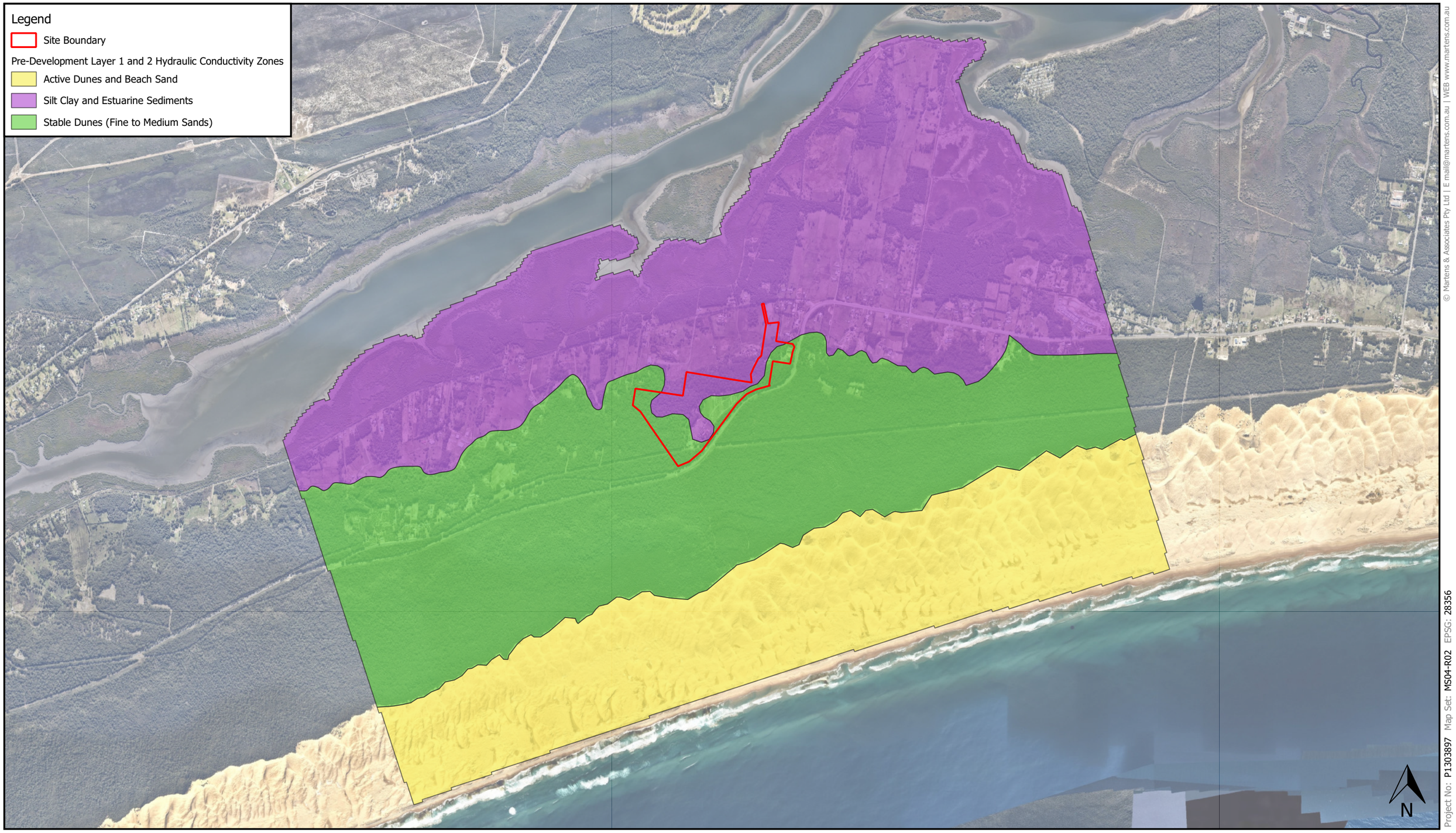
Map Title / Figure:

Pre-Development Groundwater Model Boundary Conditions

Map 08	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date



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Notes:
- Aerial from Nearmap (2020).

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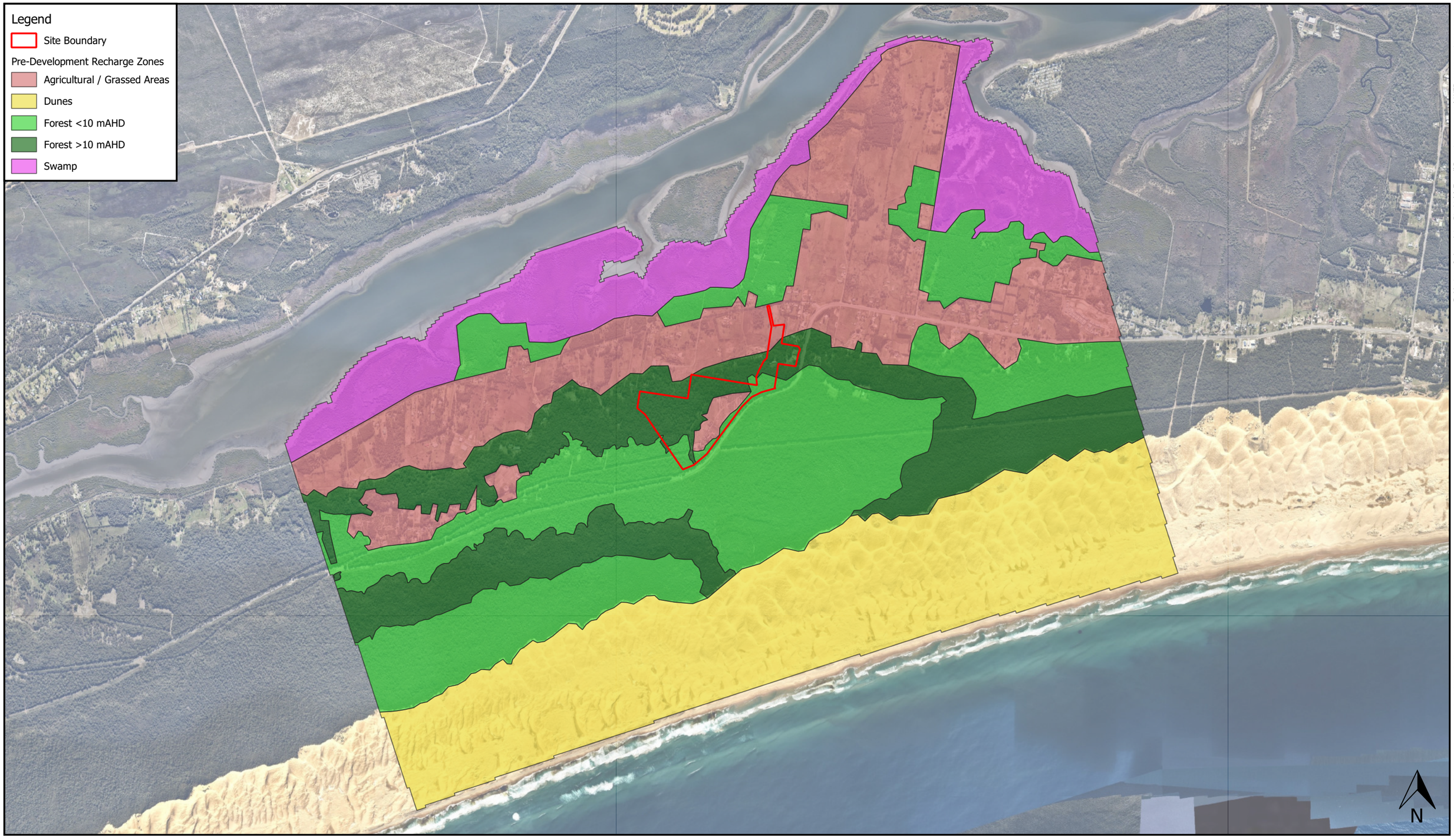
Map Title / Figure:

Pre-Development Groundwater Model
Layer 1 and 2 Hydraulic Conductivity Zones

Map 09	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

Project No: P1303897 Map Set: MS04-R02 EPSG: 28356



0 300 600 900 1200 1500 m

1:30000 @ A3

Notes:
- Aerial from Nearmap (2020).

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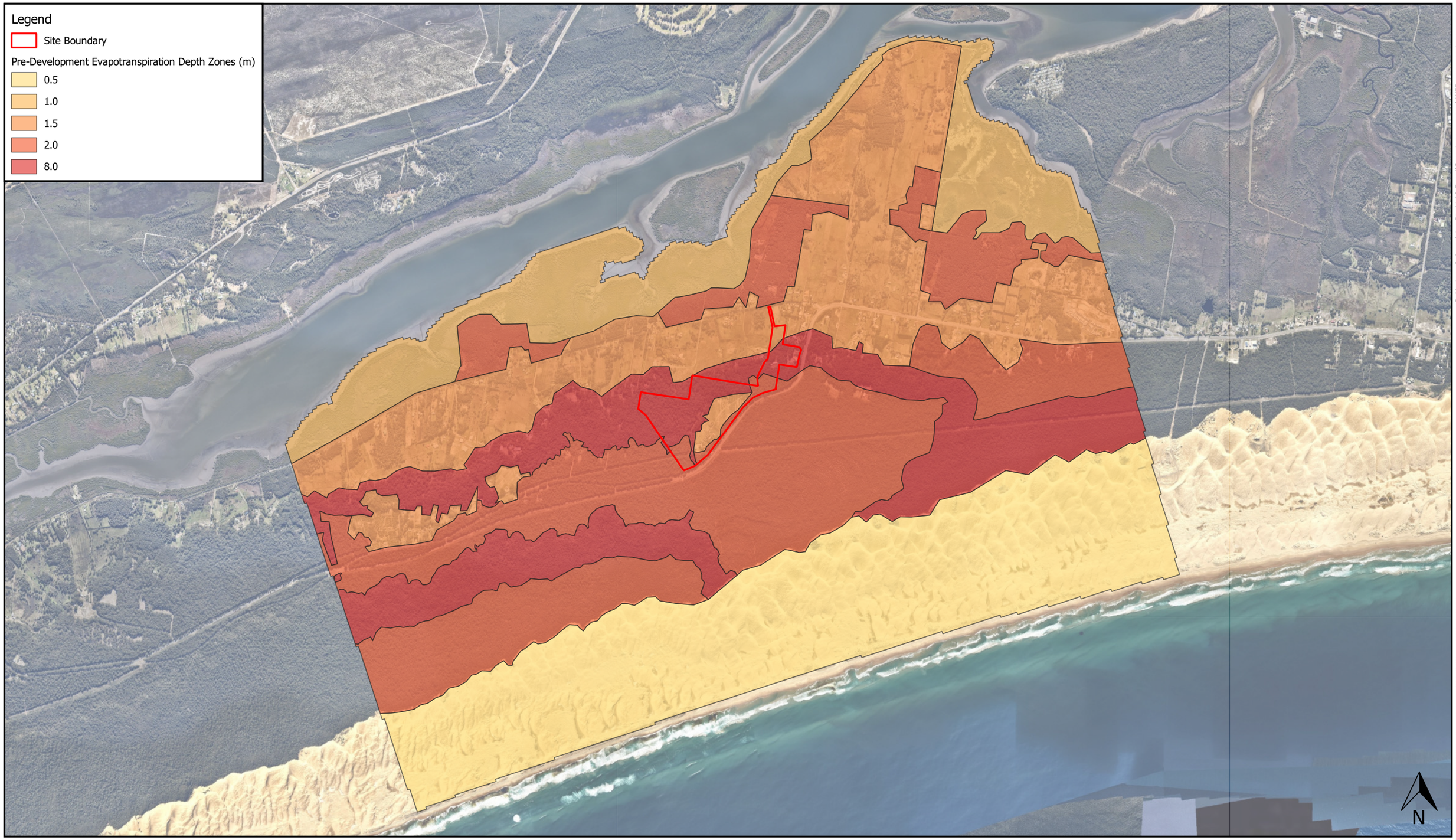
Map Title / Figure:

Pre-Development Groundwater Model Recharge Zones

Map 10	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

Project No: P1303897 Map Set: MS04-R02 EPSG: 28356



0 300 600 900 1200 1500 m

1:30000 @ A3

Notes:
- Aerial from Nearmap (2020).

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Map Title / Figure:

Pre-Development Groundwater Model Evapotranspiration Depth Zones

Map 11	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

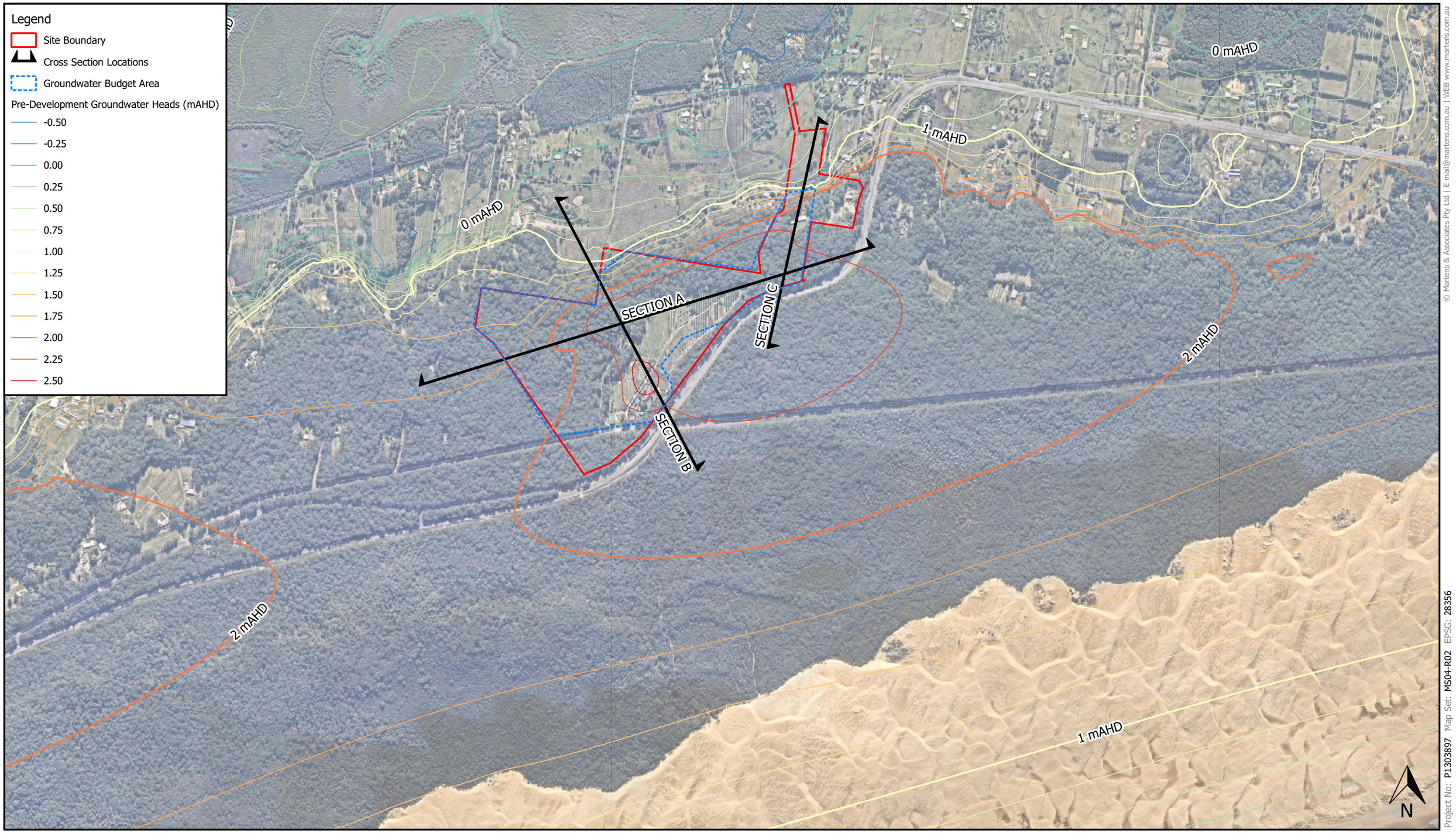
Project No: P1303897 Map Set: MS04-R02 EPSG: 28356

Legend

- Site Boundary
- Cross Section Locations
- Groundwater Budget Area

Pre-Development Groundwater Heads (mAHD)

- -0.50
- -0.25
- 0.00
- 0.25
- 0.50
- 0.75
- 1.00
- 1.25
- 1.50
- 1.75
- 2.00
- 2.25
- 2.50



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1:12500 @ A3

Viewport A

Notes:
- Aerial from Nearmap (2020).
- See Map 14 for sections.

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Environment | Water | Geotechnics | Civil | Projects

Project No: P1303897 Map Set: MS04-R02 EPSG: 28356

Map Title / Figure:

Pre-Development Groundwater Head

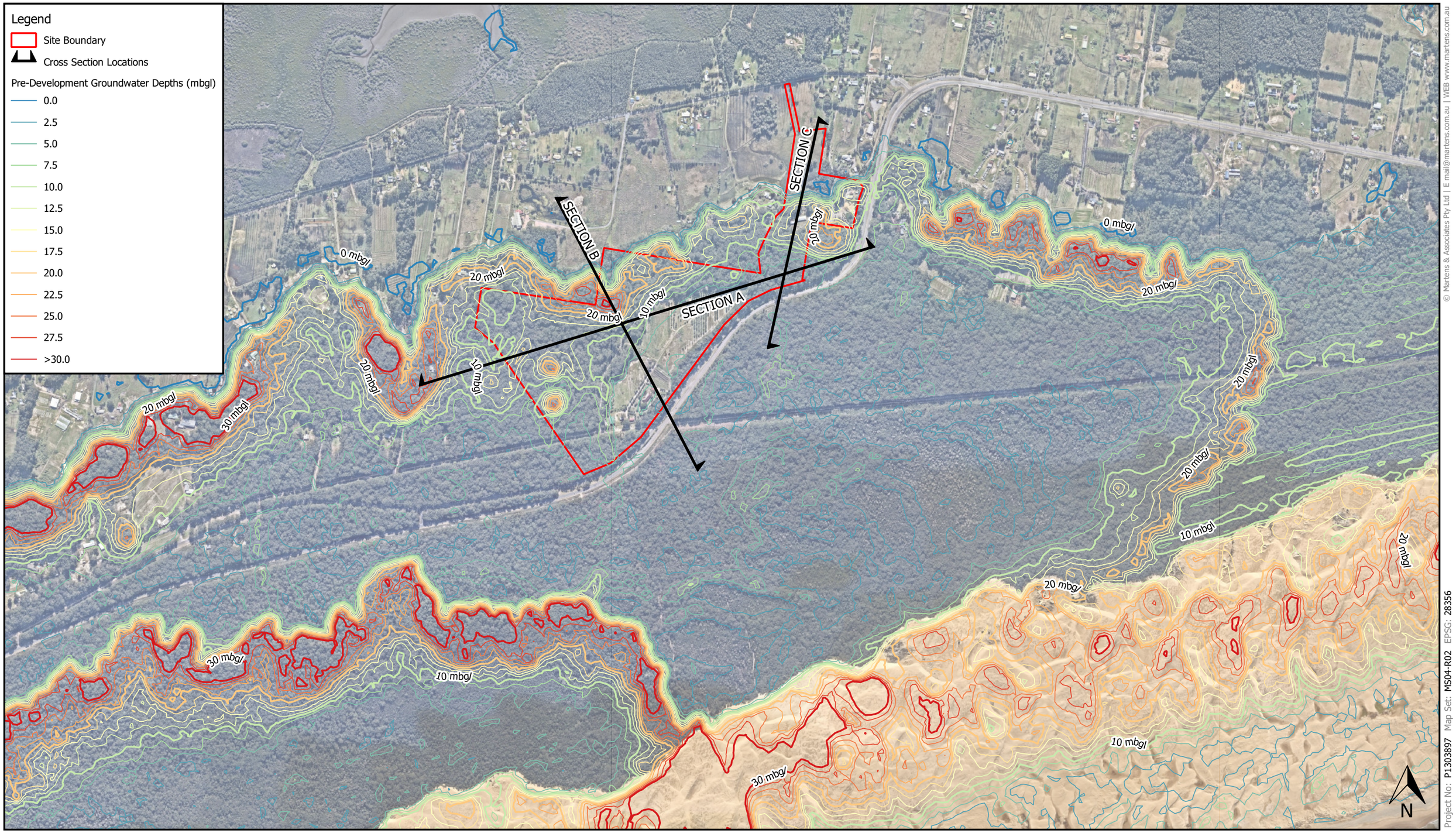
Map 12	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

Legend

- Site Boundary
- Cross Section Locations

Pre-Development Groundwater Depths (mbgl)

- 0.0
- 2.5
- 5.0
- 7.5
- 10.0
- 12.5
- 15.0
- 17.5
- 20.0
- 22.5
- 25.0
- 27.5
- >30.0



0 100 200 300 400 500 m

1:12500 @ A3

Viewport A

Notes:
- Aerial from Nearmap (2020).
- See Map 14 for sections.

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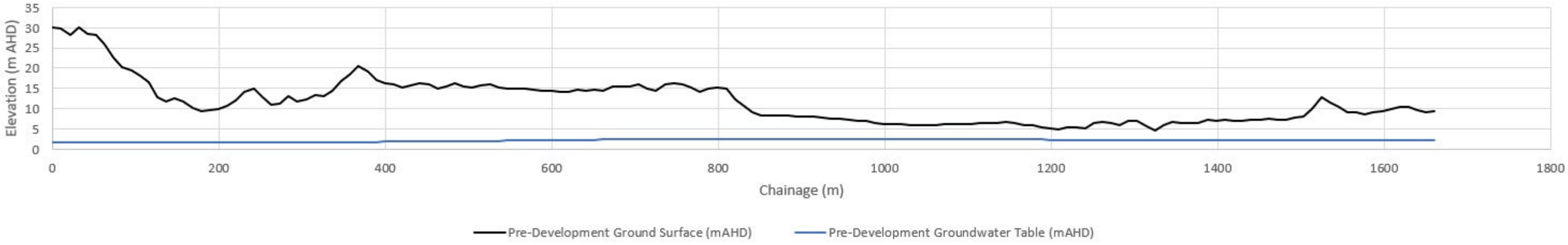
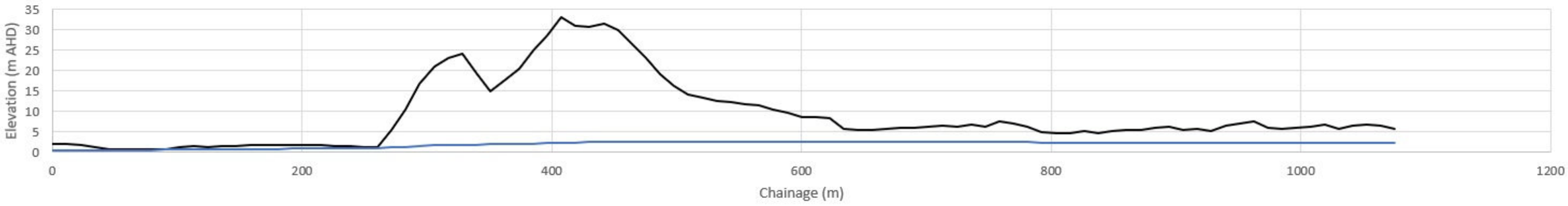
Map Title / Figure:

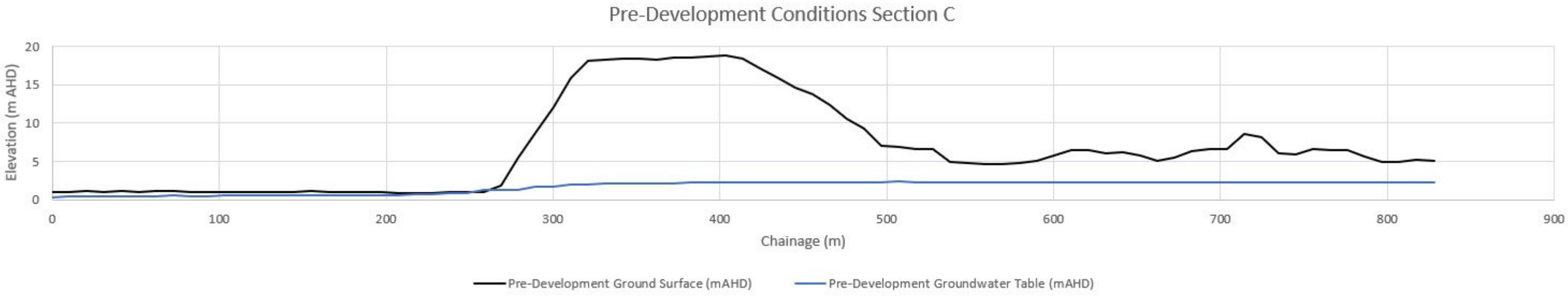
Pre-Development Groundwater Depth

Map 13	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

Project No: P1303897 Map Set: MS04-R02 EPSG: 28356







Project No: P1303897 Map Set: MS04-R02 EPSG: 28356

Map Title / Figure:

Pre-Development Groundwater Sections

Notes:
- See Map 12 and 13 for section locations.

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Map 14	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

Legend

- Site Boundary
- Extraction Well
- Proposed Extraction Pit Boundary
- Bottom of Extraction Pit Batter

N

0 100 200 300 400 500 m

1:12500 @ A3

Viewport A

Notes:
- Aerial from Nearmap (2020).

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Map Title / Figure:

Post-Development Groundwater Model Modified Boundary Conditions

Map 15	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

Project No: P1303897 Map Set: MS04-R02 EPSG: 28356

Legend

- Site Boundary
- Proposed Extraction Pit Boundary
- Bottom of Extraction Pit Batter

Post-Development Layer 1 Hydraulic Conductivity Zones

- Active Dunes and Beach Sand
- Silt Clay and Estuarine Sediments
- Stable Dunes (Fine to Medium Sands)
- Pit Void

N

0 100 200 300 400 500 m

1:12500 @ A3

Viewport A

Notes:
- Aerial from Nearmap (2020).

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Map Title / Figure:

Post-Development Groundwater Model
Modified Layer 1 Hydraulic Conductivity Zones

Map 16	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

Project No: P1303897 Map Set: MS04-R02 EPSG: 28356

Legend

- Site Boundary
- Proposed Extraction Pit Boundary
- Bottom of Extraction Pit Batter

Post-Development Recharge Zones

- Agricultural / Grassed Areas
- Dunes
- Forest <10 mAHD
- Forest >10 mAHD
- Pit Void
- Swamp

N

0 100 200 300 400 500 m

1:12500 @ A3

Viewport A

Notes:
- Aerial from Nearmap (2020).

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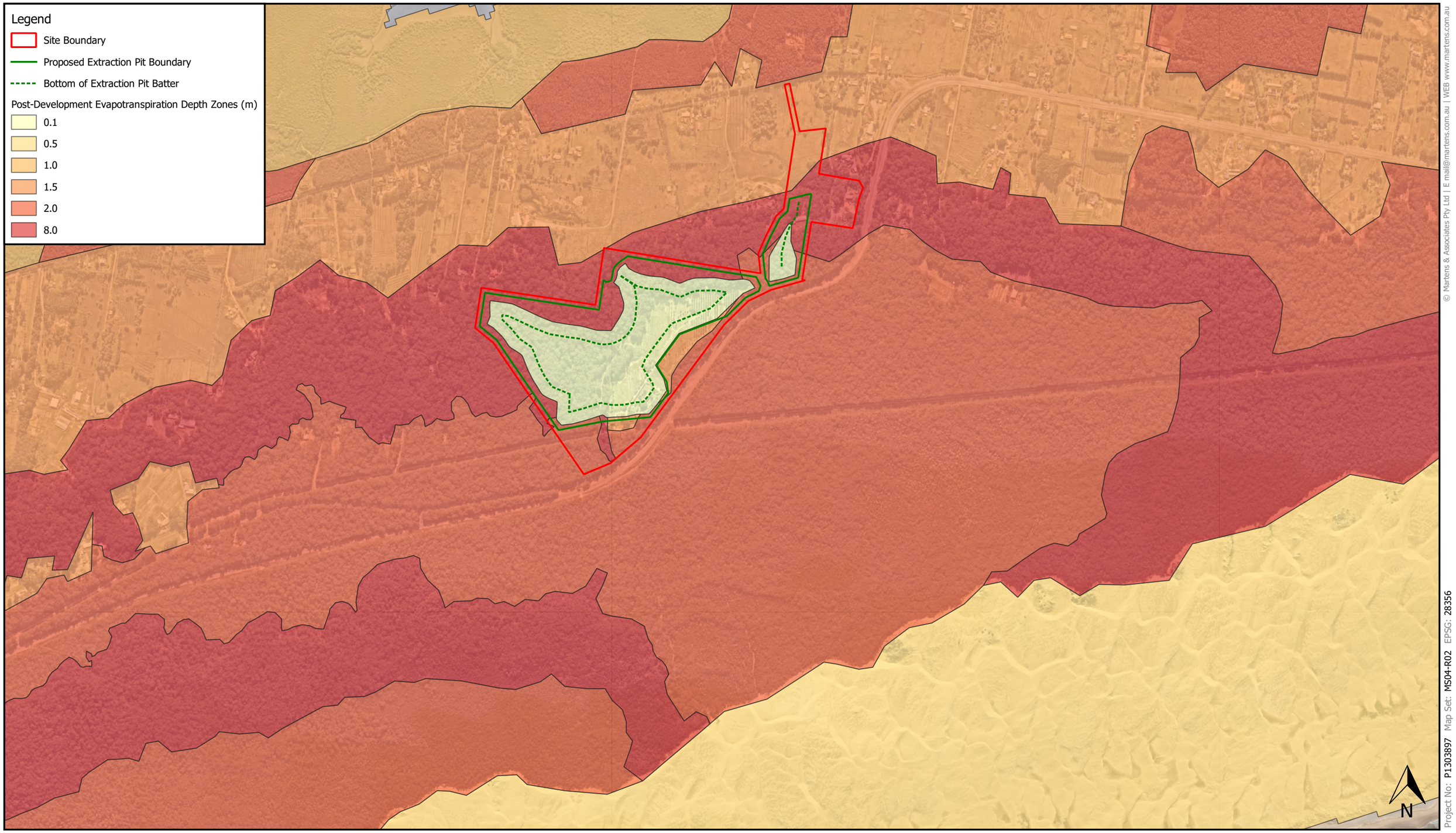
Map Title / Figure:

Post-Development Groundwater Model
Modified Recharge Zones

Map 17	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

Project No: P1303897 Map Set: MS04-R02 EPSG: 28356



0 100 200 300 400 500 m

1:12500 @ A3

Viewport A

Notes:
- Aerial from Nearmap (2020).

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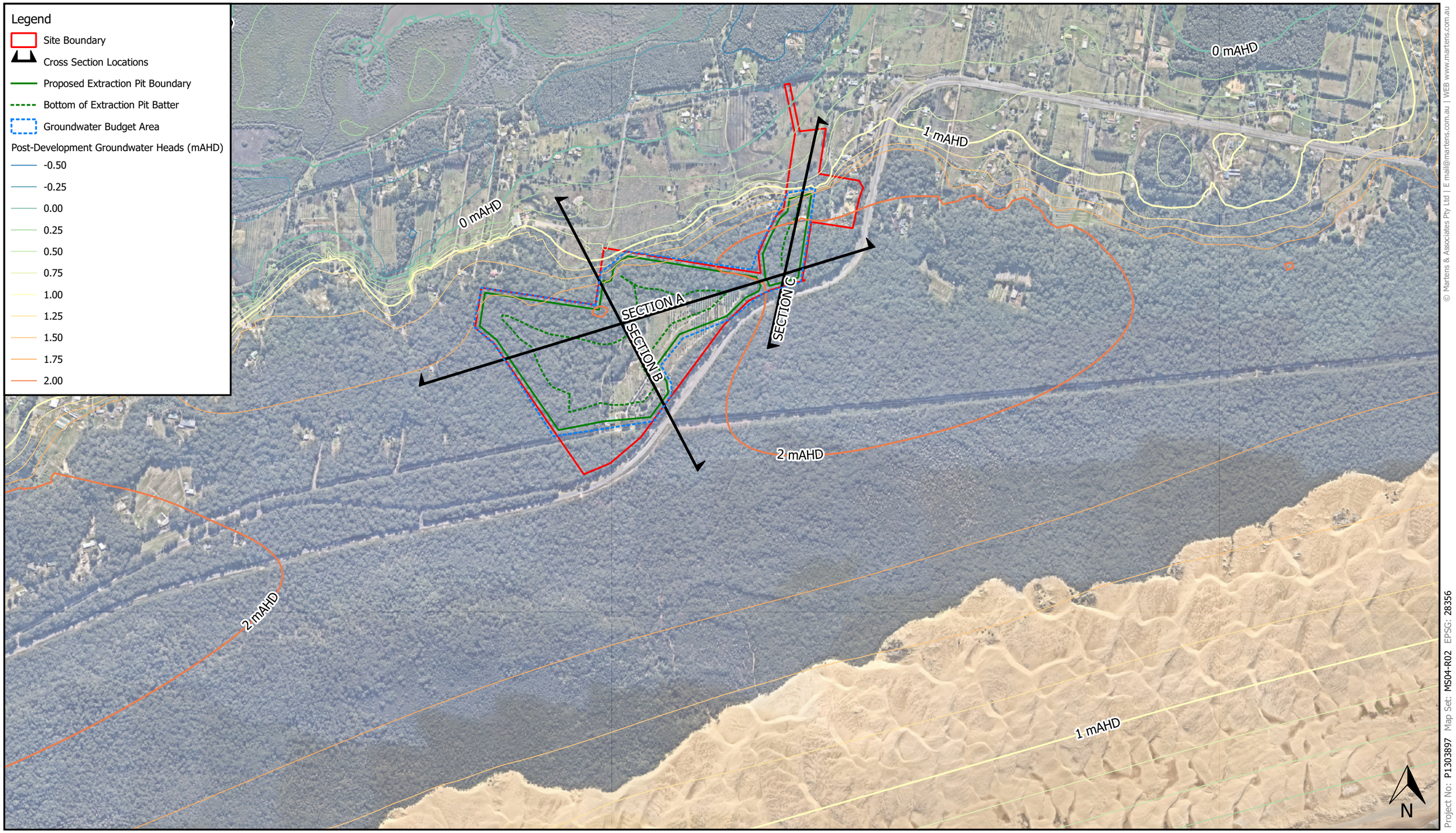
Map Title / Figure:

Post-Development Groundwater Model
Modified Evapotranspiration Depth Zones

Map 18	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

Project No: P1303897 Map Set: MS04-R02 EPSG: 28356



0 100 200 300 400 500 m

1:12500 @ A3

Viewport A

Notes:
- Aerial from Nearmap (2020).
- See Map 21 for sections.

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Map Title / Figure:

Post-Development Groundwater Head

Map 19	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

Project No: P1303897 Map Set: MS04-R02 EPSG: 28356

Legend

- Site Boundary
- Cross Section Locations
- Proposed Extraction Pit Boundary
- Bottom of Extraction Pit Batter

Post-Development Groundwater Depths (mbgl)

- 0.0
- 2.5
- 5.0
- 7.5
- 10.0
- 12.5
- 15.0
- 17.5
- 20.0
- 22.5
- 25.0
- 27.5
- >30.0

SECTION A
SECTION B
SECTION C
0 mbgl
10 mbgl
20 mbgl
30 mbgl
N

0 100 200 300 400 500 m

1:12500 @ A3

Viewport A

Notes:
- Aerial from Nearmap (2020).
- See Map 21 for sections.

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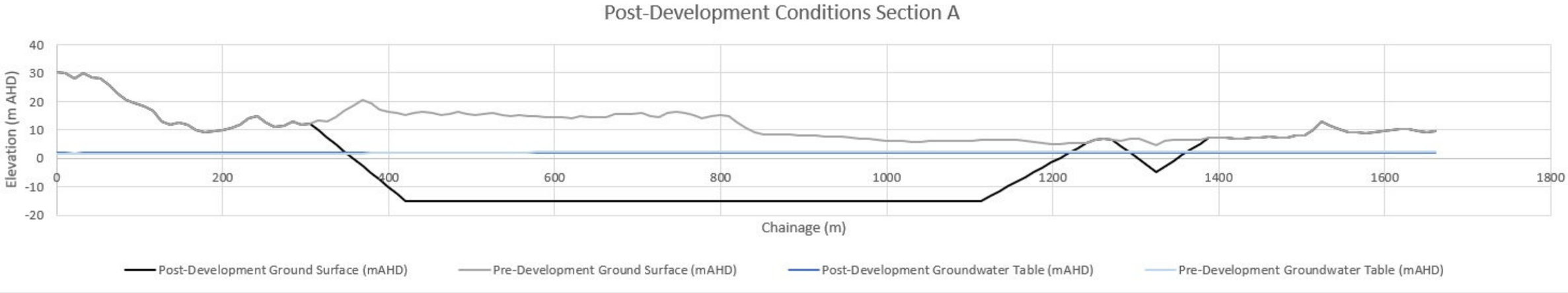
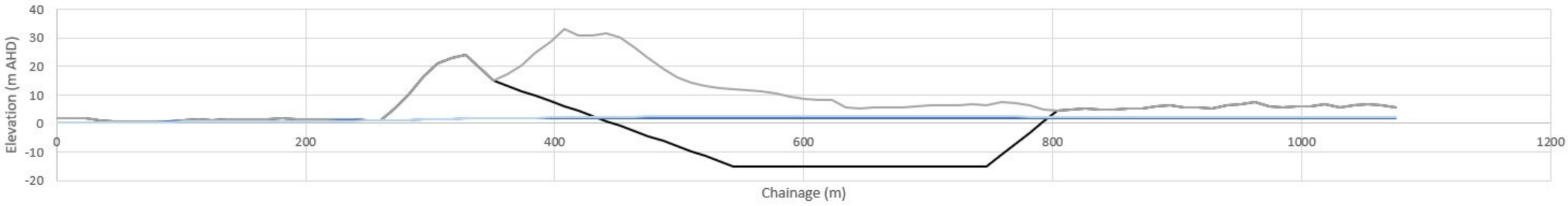
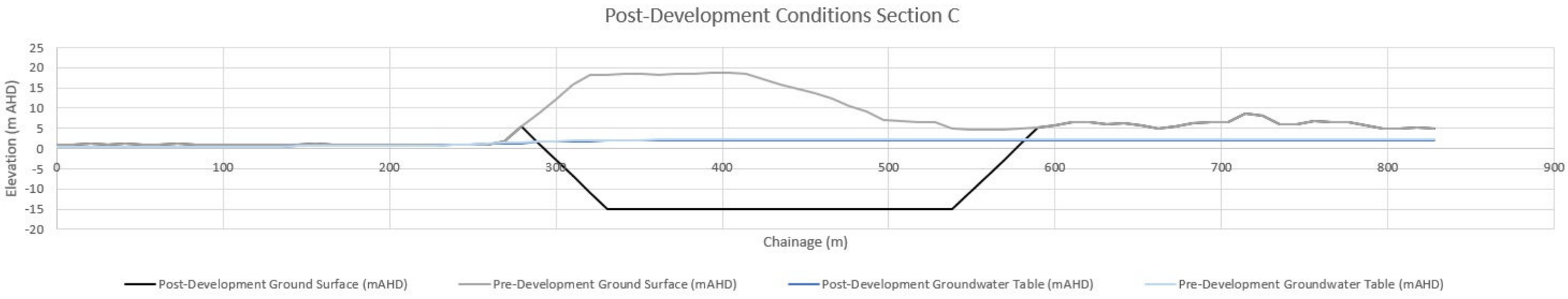
Map Title / Figure:
Post-Development Groundwater Depth

Map 20	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

Project No: P1303897 Map Set: MS04-R02 EPSG: 28356







Project No: P1303897 Map Set: MS04-R02 EPSG: 28356

Map Title / Figure:

Post-Development Groundwater Sections

Notes:
- See Map 19 and 20 for section locations.

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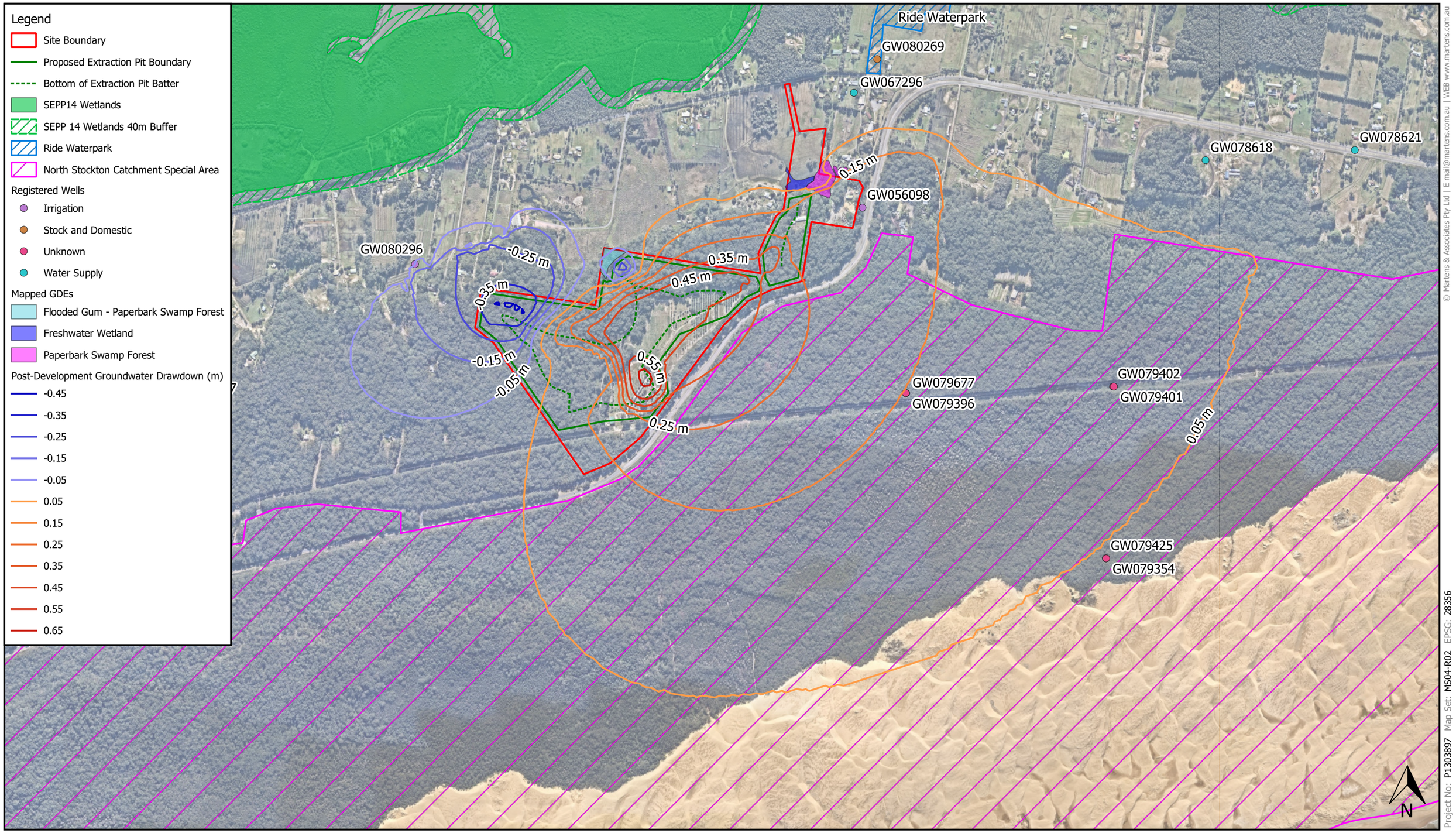
Map 21	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date



Project No: P1303897 Map Set: MS04-R02 EPSG: 28356

1:12500 @ A3

Viewport A

Notes:
- Aerial from Nearmap (2020).
- Drawdown is calculated by subtracting the post-development head from the pre-development head hence, negative drawdown indicates a predicted increase in groundwater level.
- SEPP14 Wetlands from OEH (2019).
- Mapped GDEs from Wildthing Environmental Consultants (2013).

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Map Title / Figure:

Post-Development Groundwater Drawdown

Map 22	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

Legend

- Site Boundary
- Proposed Extraction Pit Boundary
- Bottom of Extraction Pit Batter

Net Acidity at GW Table (mole H+/t)

- <5
- 5 - 10
- 10 - 20
- 20 - 40
- 40 - 80
- 80 - 160
- 160 - 200

BH101
MW102
BH5/MW5
MW104
BH 408
BH 409
BH102
MW103
BH 401
BH3/MW3
MW101
BH 407
BH 405
BH 402
BH 404
BH105
BH108
BH4/MW4
BH 403
BH107
BH103

N

0 90 180 270 360 450 m

1:7500 @ A3

Viewport B

Notes:
- Aerial from Nearmap (2020).
- Acid sulfate soil results taken from Supplementary Acid Sulfate Soil Assessment (Martens and Associates, 2020).

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Map Title / Figure:

Acid Sulfate Soil Net Acidity in Groundwater Drawdown Zone

Map 23	Map
3631, 3679 & 3721 Nelson Bay Rd, Bobs Farm, NSW	Site
Proposed Sand Mine	Project
Hydrogeological Assessment & Management Plan	Sub-Project
Ammos Resource Management P/L	Client
05/11/2020	Date

Project No: P1303897 Map Set: MS04-R02 EPSG: 28356

13 Attachment C – Borehole Logs

Plan of:	Bobs Farm Quarry BH-1	***Location:***	Bobs Farm	***Projection:***	N/A	***Date:***	26/11/2013	***Version:***	A
				Contour Interval:	N/A	***Sheet:***	2 of 2	***Survey:***	N/A
						Plan By:	TC	***Source:***	VGT Pty Ltd
Figure:	ONE	***Council:***	Port Stephens Council			***Project Manager:***	GVT		
Client:	EMS	***Scale:***				***Office:***	Thornton	***Our Ref:***	V:\Jobs_EMS Quarry\Bobs Farm\BFBH1 drill log

vgt
Environmental Compliance Solutions

Drill Hole Number: BH 1

Project: Bobs Farm
Drilling Co: Total Drill
Date: August 2013
Job Number: QMS
Logged By: G THOMSON
Hole Depth: 19m
Hole Dia: 4.5 inch

Description	Depth	Graphic Log	Heavy Mineral		Remarks
Ground Surface					
SAND - Cloud grey with roots, mg	0				Solid flight augers
SAND - Pearl grey, mg					GR 406691; 6373153, rl 5.8m
SAND - Tan, mg	1				Colours from AS 2700- 1985
					medium grained (mg)
	2				
	3				Water Table 3.0m Moist samples Minor heavy mineral?
Water Table 3.5m					
SAND -Black, mg, Sulphur smell	4				Sulphur smell
PALEOSOL - Black, cricket pitch?					
SAND - Dark earth, mg	5				Sulphur smell
SAND - Mixed sample. dark earth, mcg	6				Hollow flight augers
					Could not retrieve samples
	7				Sampled from top of hole
					As part of hole cleaning up augers
	8				
	9				
	10				
SAND - Mixed sample. dark earth, mcg					
	11				
	12				
	13				
	14				
	15				
	16				
	17				
	18				
	19				
	20				

BH1-BL-AWT
0.6 to 3.5m

Above Water Table

Water Table 3.5m

Not Tested

Below Water Table

BH1-BL-G2
4.2 to 12m

BH1-BL-G1
12 to 19m

Plan of:	Bobs Farm Quarry BH-2	***Location:***	Bobs Farm	***Projection:***	N/A	***Date:***	26/11/2013	***Version:***	A
				Contour Interval:	N/A	***Sheet:***	2 of 2	***Survey:***	N/A
						Plan By:	TC	***Source:***	VGT Pty Ltd
Figure:	TWO	***Council:***	Port Stephens Council			***Project Manager:***	GVT		
Client:	EMS	***Scale:***				***Office:***	Thornton	***Our Ref:***	V:\Jobs_EMS Quarry\Bobs Farm\BFBH1 drill log

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Environmental Compliance Solutions

Drill Hole Number: BH 2

Project: Bobs Farm
Drilling Co: Total Drill
Date: August 2013
Job Number: QMS
Logged By: G THOMSON
Hole Depth: 26.5 m
Hole Dia: 4.5 inch

Description	Depth	Graphic Log	Heavy Mineral		Remarks
Ground Surface					
SAND - Oyster, mg	0				Minor Organics
	1				GR 406592; 6373286 RL 11.7
SAND - Lead grey, vegetation matter.	2				
SAND - Koala grey, mg					
SAND - Oyster, mg	3				
SAND - Chocolate, mg.	4				
SAND - Wombat, mg					
SAND - Buff, mg	5				
	6				
	7				
	8				
	9				
	10				Water Table 10.0m
Water Table 10.2m					
SAND - Buff, mg					
CLAY - Black, silty, firm, wet	11				Cores retrived from drill
	12				
SAND- Cloud grey, with black fleck, <1% medium coarse grained (mcg)	13				(mcg) medium coarse grained
	14				
	15				
	16				
	17				
	18				
SAND - Koala Grey, 1-3% black fleck	19				
	20				
SAND - Koala Grey, 1-3% black fleck	21				
	22				
	23				
	24				
	25				
	26				
	27				

Not Tested
Too Variable

BH2-BL-B
4.2 to 9.5m

Water Table 10.2m

10.5 to 12.0m

13.5 to 14.0m

17.5 to 18.5m

26.0 to 26.5m

Above Water Table

Below Water Table

Plan of:	Bobs Farm Quarry BH-3	***Location:***	Bobs Farm	***Projection:***	N/A	***Date:***	26/11/2013	***Version:***	A
				Contour Interval:	N/A	***Sheet:***	2 of 2	***Survey:***	N/A
						Plan By:	TC	***Source:***	VGT Pty Ltd
Figure:	THREE	***Council:***	Port Stephens Council			***Project Manager:***	GVT		
Client:	EMS	***Scale:***				***Office:***	Thornton	***Our Ref:***	V:\Jobs_EMS Quarry\Bobs Farm\BFBH1 drill log

vgt
Environmental Compliance Solutions

Drill Hole Number: BH 3

Project: Bobs Farm
Drilling Co: Total Drill
Date: August 2013

Job Number: QMS
Logged By: G THOMSON

Hole Depth: 26.5
Hole Dia: 4.5 inch

Description	Depth	Graphic Log	Heavy Mineral		Remarks
Ground Surface					
SANDY LOAM SOIL - Koala Grey, mg					GR 406297; 6373318; rl 15.4
SAND - Pearl grey, mg					
SAND - Wombat, mg					
SAND- Tan, mg					
SAND - Buff, mg					
SAND - Raffia, mg					
SAND - Raffia, mg					
Water Table 13.2m					
SAND - Pearl grey, mcg, moist					
CLAY - Back, dark grey, silty					
SAND - Lead grey, with 5% black spec					
SAND -Koala grey, cg, 5% black fleck					
SAND -Koala grey, cg, 5% black fleck					

Not Tested
Too Variable

BH3-BL-B1
4.0 to 10.0m(~6m Bench)

BH3-BL-B2
10.0 to 14.6m

Water Table 13.2m

Not Tested
Too Variable

17.0 to 17.5m

26.0 to 26.5m

Above Water Table

Below Water Table

Plan of:	Bobs Farm Quarry BH-4	***Location:***	Bobs Farm	***Projection:***	N/A	***Date:***	26/11/2013	***Version:***	A
				Contour Interval:	N/A	***Sheet:***	2 of 2	***Survey:***	N/A
						Plan By:	TC	***Source:***	VGT Pty Ltd
Figure:	FOUR	***Council:***	Port Stephens Council			***Project Manager:***	GVT		
Client:	EMS	***Scale:***				***Office:***	Thornton	***Our Ref:***	V:\Jobs_EMS Quarry\Bobs Farm\BFBH1 drill log

vgt
Environmental Compliance Solutions

Drill Hole Number: BH 4

Project: Bobs Farm
Drilling Co: Total Drill
Date: August 2013
Job Number: QMS
Logged By: G THOMSON
Hole Depth: 24 m
Hole Dia: 4.5 inch

Description	Depth	Graphic Log	Heavy Mineral	Remarks
Ground Surface				
SAND - Koala grey, mg, sandy loam soil.				
SAND - Tan, mg				GR 406260; 6373082 rl 9.4
SAND- Rafia, mg, minor buff mottles				
SAND - Oyster / black, mg				
SAND - Black, silty high organcs?				
SAND - Driftwood, mg				
Water Table 7.3m				
SAND - Tan, mg				
SAND - Buff, mg				
SAND - Driftwood, mcg				
SAND- Cloud grey, mcg, 2-4% black speck				

Not Tested

BH4-BL-B
1.5 to 5.8m

5.6 to 5.8m

Water Table 7.3m

Not Tested

8.5 to 11.0m

11.5 to 24.0m

Above Water Table

Below Water Table

Plan of:	Bobs Farm Quarry BH-5	***Location:***	Bobs Farm	***Projection:***	N/A	***Date:***	26/11/2013	***Version:***	A
				Contour Interval:	N/A	***Sheet:***	2 of 2	***Survey:***	N/A
						Plan By:	TC	***Source:***	VGT Pty Ltd
Figure:	FIVE	***Council:***	Port Stephens Council			***Project Manager:***	GVT		
Client:	EMS	***Scale:***				***Office:***	Thornton	***Our Ref:***	V:\Jobs_EMS Quarry\Bobs Farm\BFBH1 drill log

vgt
Environmental Compliance Solutions

Drill Hole Number: BH 5

Project: Bobs Farm
Drilling Co: Total Drill
Date: August 2013
Job Number: QMS
Logged By: G THOMSON
Hole Depth: 26.5 m
Hole Dia: 4.5 inch

Description	Depth	Graphic Log	Heavy Mineral	Remarks
Ground Surface				
SAND - Koala grey, darker at top, mg organic at top and sitly at base.	0			GR 406803; 6373515; rl 18.2
SAND - Tan / buff, mg, sitly in part	1			
SAND - Buff, mg	2			
	3			
	4			
	5			
SAND - Raffia, mg, no silt	6			
	7			
	8			
	9			
	10			
SAND - Raffia, mg, no silt	11			
	12			
	13			
	14			
SAND -Pale Ochre, mc	15			
Water Table 15.4m	16			
	17			
SAND-Cloud grey, minor pale ochre, mcg	18			
	19			
SAND-Cloud grey, with 5-10% black fleck	20			
CLAY - Black , shell common	21			
	22			
SAND - Lead grey, shells	23			
SAND-Light grey, 1-2% black speck minor shell grit, mcg	24			
	25			
	26			
	27			

Not Tested

BH5-BL-B
5.5 to 14.5m

Water Table 15.4m

Not Tested

BH5-BL-M
20.0 to 22.0m

BH5-BL-G
23.0 to 25.65m

Above Water Table | Below Water Table

CLIENT	Ammos Resource Management Pty Ltd	COMMENCED	29/07/14	COMPLETED	29/07/14	**REF**	**BH101**
PROJECT	Acid Sulphate Soils & Geotechnical Assessment	LOGGED	GMT/BR	CHECKED	RE	Sheet	1 of 1
SITE	3631, 3679 & 3721 Nelson Bay Rd & 774 Marsh Rd, Bobs Farm, NSW	GEOLOGY	Aeolian Sand	VEGETATION	NA	PROJECT NO.	P1303897
EQUIPMENT	4WD Truck Mounted Hydraulic Auger	EASTING	NA	RL SURFACE	Approx 11m AHD		
EXCAVATION DIMENSIONS	Ø95mm X 13.0m depth	NORTHING	NA	ASPECT	South South West	SLOPE	5%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	MATERIAL DESCRIPTION (SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.)	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	M	0.2			SP	SAND - Medium grained, light grey/grey, with minor organics, rootlets.		VL			- TOPSOIL - AEOLIAN
				1.0			SP	SAND - Medium grained, light yellow/white.		VL			1.0
				1.5				Grading to					- AEOLIAN
				2.0									2.0
											A	2.5	3897/101/ 2.5
				3.0			SP	light brown/orange/ light yellow.		L			3.0
				4.0									4.0
				4.5				Grading to					- AEOLIAN
				5.0						MD			5.0
											A	5.5	3897/101/ 5.5
				6.0									6.0
V	Nil	N	M	7.0									7.0
				8.0									8.0
											A	8.5	3897/101/ 8.5
				9.0			SP	light yellow/white.		L			9.0
				10.0							A	10.0	3897/101/ 10.0
		11.0 ▽		11.0									- Groundwater at ~11.0m.
		Y	W	12.0									12.0
				13.0							A	13.0	3897/101/ 13.0
								Borehole terminated at 13.0m in sand.					
				14.0									14.0
				15.0									15.0
				16.0									16.0
				17.0									17.0
				18.0									18.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
▽ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	Ammos Resource Management Pty Ltd	**COMMENCED**	29/07/14	**COMPLETED**	29/07/14	**REF**	**BH102**
PROJECT	Acid Sulphate Soils & Geotechnical Assessment	**LOGGED**	GMT/BR	**CHECKED**	RE	**Sheet**	1 of 1
SITE	3631, 3679 & 3721 Nelson Bay Rd & 774 Marsh Rd, Bobs Farm, NSW	**GEOLOGY**	Aeolian Sand	**VEGETATION**	NA	**PROJECT NO.**	P1303897
EQUIPMENT	4WD Truck Mounted Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	Approx 6m AHD		
EXCAVATION DIMENSIONS	Ø95mm X 10.0m depth	**NORTHING**	NA	**ASPECT**	South East	**SLOPE**	2%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	MATERIAL DESCRIPTION SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	M	0.3			SP	SAND - Medium grained, grey/black, minor organics and rootlets.		VL			- TOPSOIL
													- AEOLIAN
V	Nil	N	M	1.0			SP	SAND - Medium grained, light grey/yellow/white.		L	A	1.5	3897/102/ 1.5
				2.0									- AEOLIAN
							SP	Grading to orange/brown.		L	A	2.5	3897/102/ 2.5
				3.0									
		3.5 ▽		3.5									- Groundwater at ~3.5m.
								Grading to					- AEOLIAN
				4.0							A	4.0	3897/102/ 4.0
V	Nil	Y	W				SP	yellow/white.		VL			
				4.9									
				5.0							A/B	5.0	3897/102/ 5.0 - MARINE
V	Nil	Y	W	6.0			SC	Clayey SAND - Medium grained, grey with sandy clay layers, dark grey.		MD			
				6.5									- MARINE
				7.0							A/B	7.0	3897/102/ 7.0
											A	7.5	3897/102/ 7.5
				8.0									
V	Nil	Y	W				SP	SAND - Medium grained, light grey, inferred dense.		D			
											A	8.5	3897/102/ 8.5
				9.0									
				10.0							A	10.0	3897/102/ 10.0
								Borehole terminated at 10.0m in sand.					
				11.0									
				12.0									
				13.0									
				14.0									
				15.0									
				16.0									
				17.0									
				18.0									

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
▽ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	Ammos Resource Management Pty Ltd	**COMMENCED**	29/07/14	**COMPLETED**	29/07/14	**REF**	**BH103**
PROJECT	Acid Sulphate Soils & Geotechnical Assessment	**LOGGED**	GMT/BR	**CHECKED**	RE	**Sheet**	1 of 1
SITE	3631, 3679 & 3721 Nelson Bay Rd & 774 Marsh Rd, Bobs Farm, NSW	**GEOLOGY**	Aeolian Sand	**VEGETATION**	NA	**PROJECT NO.**	P1303897
EQUIPMENT	4WD Truck Mounted Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	Approx 9m AHD		
EXCAVATION DIMENSIONS	Ø95mm X 10.0m depth	**NORTHING**	NA	**ASPECT**	East	**SLOPE**	2%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	MATERIAL DESCRIPTION SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	M	0.2			SP	SAND - Medium grained, dark grey, some organics, rootlets.		VL			- TOPSOIL
				0.9			SP			L	A/B	0.5	3897/103/ 0.5 - AEOLIAN
				1.0				SAND - Medium grained, light grey.					- AEOLIAN 1.0
								Grading to		L	A/B	1.5	3897/103/ 1.5
				2.0									2.0
											A	2.5	3897/103/ 2.5
				3.0			SP	yellow/orange.		MD			3.0
V	Nil	N	M	4.0							A	4.0	3897/103/ 4.0 4.0
				4.8									
				5.0				Grading to					- AEOLIAN 5.0
											A	5.5	3897/103/ 5.5
				6.0									6.0
		6.8					SP	yellow/white.		L			- Groundwater at 6.8m.
				7.0							A/B	7.0	3897/103/ 7.0 7.0
		Y	W								A	7.5	3897/103/ 7.5
				8.0							A	8.0	3897/103/ 8.0 8.0
V	Nil	Y	W				SP	SAND - With minor organics, medium grained, inferred medium dense, dark brown.		MD			- MARINE
				8.5									- MARINE
				9.0									9.0
V	Nil	Y	W				SP	SAND - Medium grained, inferred medium dense, brown/light brown.		MD			
				10.0							A/B	10.0	3897/103/ 10.0 10.0
								Borehole terminated at 10.0m in sand.					
				11.0									11.0
				12.0									12.0
				13.0									13.0
				14.0									14.0
				15.0									15.0
				16.0									16.0
				17.0									17.0
				18.0									18.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	Ammos Resource Management Pty Ltd	**COMMENCED**	30/07/14	**COMPLETED**	30/07/14	**REF**	**BH104**
PROJECT	Acid Sulphate Soils & Geotechnical Assessment	**LOGGED**	GMT/BR	**CHECKED**	RE	**Sheet**	1 of 1
SITE	3631, 3679 & 3721 Nelson Bay Rd & 774 Marsh Rd, Bobs Farm, NSW	**GEOLOGY**	Aeolian Sand	**VEGETATION**	NA	**PROJECT NO.**	P1303897
EQUIPMENT	4WD Truck Mounted Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	27m AHD		
EXCAVATION DIMENSIONS	Ø95mm X 10.0m depth	**NORTHING**	NA	**ASPECT**	South South West	**SLOPE**	2%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	MATERIAL DESCRIPTION SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	M	0.2			SP	SAND - Medium grained, dark grey/grey, minor organics.		MD			- TOPSOIL
							SP	SAND - Medium grained, light grey/grey.		L	A	0.5	3897/104/ 0.5 - AEOLIAN
				1.0									1.0
				1.2				Grading to					- AEOLIAN
				2.0									2.0
							SP	orange/brown.		L	A	2.5	3897/104/ 2.5
				3.0									3.0
				3.5				Grading to					- AEOLIAN
				4.0									4.0
V	Nil	N	M										
				5.0			SP	yellow/brown.		L	A	5.5	3897/104/ 5.5
				6.0									6.0
				7.0				Grading to					- AEOLIAN 7.0
				8.0									8.0
							SP	light yellow white.		L			
				9.0									9.0
										MD			
				10.0							A	10.0	3897/104/ 10.0 10.0
								Borehole terminated at 10.0m in sand.					
				11.0									11.0
				12.0									12.0
				13.0									13.0
				14.0									14.0
				15.0									15.0
				16.0									16.0
				17.0									17.0
				18.0									18.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	Ammos Resource Management Pty Ltd	**COMMENCED**	30/07/14	**COMPLETED**	30/07/14	**REF**	**BH105**
PROJECT	Acid Sulphate Soils & Geotechnical Assessment	**LOGGED**	GMT/BR	**CHECKED**	RE	**Sheet**	1 of 1
SITE	3631, 3679 & 3721 Nelson Bay Rd & 774 Marsh Rd, Bobs Farm, NSW	**GEOLOGY**	Aeolian Sand	**VEGETATION**	NA	**PROJECT NO.**	P1303897
EQUIPMENT	4WD Truck Mounted Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	Approx 15m AHD		
EXCAVATION DIMENSIONS	Ø95mm X 10.0m depth	**NORTHING**	NA	**ASPECT**	East	**SLOPE**	2-4%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	MATERIAL DESCRIPTION SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	M	0.3			SP	SAND - Medium grained, dark grey, minor organics.		L			- TOPSOIL
											A	0.5	3897/105/ 0.5 - AEOLIAN
				1.0			SP	SAND - Medium grained, light grey/orange.		L			1.0
				1.5				Grading to					- AEOLIAN
				2.0						L			2.0
							SP	brown/orange.					
										VL	A	2.5	3897/105/ 2.5
				3.0				Grading to					- AEOLIAN
				4.0									4.0
V	Nil	N	M	5.0									5.0
											A	5.5	3897/105/ 5.5
				6.0									6.0
							SP	light yellow/white.		VL			
				7.0									7.0
				8.0									8.0
				9.0									9.0
				10.0							A	10.0	3897/105/ 10.0 10.0
								Borehole terminated at 10.0m in sand.					
				11.0									11.0
				12.0									12.0
				13.0									13.0
				14.0									14.0
				15.0									15.0
				16.0									16.0
				17.0									17.0
				18.0									18.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
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Engineering Log - Borehole

CLIENT	**Ammos Resource Management Pty Ltd**	**COMMENCED**	30/07/14	**COMPLETED**	30/07/14	**REF**	**BH106**
PROJECT	**Acid Sulphate Soils & Geotechnical Assessment**	**LOGGED**	GMT/BR	**CHECKED**	RE	**Sheet**	**1 of 1**
SITE	**3631, 3679 & 3721 Nelson Bay Rd & 774 Marsh Rd, Bobs Farm, NSW**	**GEOLOGY**	Aeolian Sand	**VEGETATION**	NA	**PROJECT NO.**	P1303897
EQUIPMENT	4WD Truck Mounted Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	Approx 20m AHD		
EXCAVATION DIMENSIONS	Ø95mm X 10.0m depth	**NORTHING**	NA	**ASPECT**	South South West	**SLOPE**	2%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	MATERIAL DESCRIPTION SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	M	0.3			SP	SAND - Medium grained, beige.		VL			- TOPSOIL
										L	A	0.5	3897/106/0.5 - AEOLIAN
				1.0									
				1.5						MD			
				2.0									
											A	2.5	3897/106/2.5
				3.0						L			
				4.0									
V	Nil	N	M	5.0			SP	SAND - Medium grained, yellow tending to light yellow between 2.5m trace mineral bands <5mm thick, dark grey		MD			
											A	5.5	3897/106/5.5
				6.0									
				7.0									
				8.0									
				9.0									
				10.0							A	10.0	3897/106/10.0
								Borehole terminated at 10.0m in sand.					
				11.0									
				12.0									
				13.0									
				14.0									
				15.0									
				16.0									
				17.0									
				18.0									

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
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Engineering Log - Borehole

Quality Sheet No. 4

CLIENT	Ammos Resource Management Pty Ltd	**COMMENCED**	30/07/14	**COMPLETED**	30/07/14	**REF**	**BH107**
PROJECT	Acid Sulphate Soils & Geotechnical Assessment	**LOGGED**	GMT/BR	**CHECKED**	RE	**Sheet**	1 of 1
SITE	3631, 3679 & 3721 Nelson Bay Rd & 774 Marsh Rd, Bobs Farm, NSW	**GEOLOGY**	Aeolian Sand	**VEGETATION**	NA	**PROJECT NO.**	P1303897
EQUIPMENT	4WD Truck Mounted Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	Approx 6m AHD		
EXCAVATION DIMENSIONS	Ø95mm X 10.0m depth	**NORTHING**	NA	**ASPECT**	South East	**SLOPE**	2%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	MATERIAL DESCRIPTION SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	M	0.2			SP	SAND - Medium grained, minor organics and rootlets.		VL			- TOPSOIL - AEOLIAN
				1.0									1.0
				2.0			SP	SAND - Medium grained, light brown/yellow/orange.		L			2.0
				3.0									3.0
		N	M	4.0									4.0
		4.5 ▽						Grading to					- MARINE - Hole collapsed groundwater back to 4.5m.
V	Nil	Y	W	5.0							A/B	5.5	3897/107/5.5 5.0
				6.0						L			6.0
				7.0			SP	yellow/light grey.			A	7.0	3897/107/7.0 7.0
				8.0									8.0
											A	8.5	3897/107/8.5
				9.0						MD			9.0
				10.0							A	10.0	3897/107/10.0 10.0
								Borehole terminated at 10.0m in sand.					
				11.0									11.0
				12.0									12.0
				13.0									13.0
				14.0									14.0
				15.0									15.0
				16.0									16.0
				17.0									17.0
				18.0									18.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
▽ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
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EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	**Ammos Resource Management Pty Ltd**	**COMMENCED**	29/07/14	**COMPLETED**	29/07/14	**REF**	**BH108**
PROJECT	**Acid Sulphate Soils & Geotechnical Assessment**	**LOGGED**	GMT/BR	**CHECKED**	RE	**Sheet**	**1 of 1**
SITE	**3631, 3679 & 3721 Nelson Bay Rd & 774 Marsh Rd, Bobs Farm, NSW**	**GEOLOGY**	Aeolian Sand	**VEGETATION**	NA	**PROJECT NO.**	P1303897
EQUIPMENT	4WD Truck Mounted Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	Approx 6m AHD		
EXCAVATION DIMENSIONS	Ø95mm X 13.0m depth	**NORTHING**	NA	**ASPECT**	East	**SLOPE**	0-2%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	MATERIAL DESCRIPTION SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	M	0.4			SP	SAND - Medium grained, grey/light grey, minor organics.		VL			- TOPSOIL
							SP	SAND - Medium grained, light grey.		VL	A	0.5	3897/108/0.5 - AEOLIAN
				1.0				Grading to					- AEOLIAN
				2.0			SP	light grey and brown.		L			
											A	2.5	3897/108/2.5
		3.5		3.0									
				3.5									- Groundwater at 3.5m.
								Grading to					- MARINE
				4.0			SP	brown.		MD			
				5.0							A	5.5	3897/108/5.5
				6.0				Grading to					- MARINE
V	Nil	Y	W	7.0						L			
				8.0							A	8.5	3897/108/8.5
				9.0			SP	grey.					
				10.0									
				11.0						MD			
				12.0									
				13.0							A	13.0	3897/108/13.0
								Borehole terminated at 13.0m in sand.					
				14.0									
				15.0									
				16.0									
				17.0									
				18.0									

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	Ammos Resource Management Pty Ltd	COMMENCED	01/10/2019	COMPLETED	01/10/2019	**REF BH401**	
PROJECT	Supplementary Acid Sulfate Soils Assessment	LOGGED	DI	CHECKED	JF	Sheet 1 OF 2	
SITE	3631 Nelson Bay Road, Bobs Farm, NSW	GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.999298	RL SURFACE	16.11 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 18.50 m depth	NORTHING	-32.774238	ASPECT	Northeast	SLOPE	<5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	L		1 2 3 4 5 6 7 8 9	16.11 *1.20* 14.91 *2.80* 13.31 *3.80* 12.31 *4.60* 11.51	3897/BH401/0.0-0.2/S/1 D 0.00 m 3897/BH401/0.4-0.6/S/1 D 0.40 m 3897/BH401/0.9-1.1/S/1 D 0.90 m 3897/BH401/1.4-1.6/S/1 D 1.40 m 3897/BH401/1.9-2.1/S/1 D 1.90 m 3897/BH401/2.4-2.6/S/1 D 2.40 m 3897/BH401/2.9-3.1/S/1 D 2.90 m 3897/BH401/3.4-3.6/S/1 D 3.40 m 3897/BH401/3.9-4.1/S/1 D 3.90 m 3897/BH401/4.8-5.2/S/1 D 4.80 m 3897/BH401/5.8-6.2/S/1 D 5.80 m 3897/BH401/6.8-7.2/S/1 D 6.80 m 3897/BH401/7.8-8.2/S/1 D 7.80 m 3897/BH401/8.8-9.2/S/1 D 8.80 m 3897/BH401/9.8-10.2/S/1 D 9.80 m			SP	SAND; fine to medium grained; dark grey and grey; with silt. Dark brown and brown. Brown, no silt. Pale brown and brown. Pale brown.	D - M		AEOLIAN DEPOSITS

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Engineering Log - BOREHOLE

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	01/10/2019	COMPLETED	01/10/2019	**REF BH401**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	DI	CHECKED	JF	Sheet 2 OF 2
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	151.999298	RL SURFACE	16.11 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 18.50 m depth	NORTHING	-32.774238	ASPECT	Northeast	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	L	01/10/19	11	11.40 4.71	3897/BH401/10.8-11.2/S/1 D 10.80 m			SP	SAND; fine to medium grained; dark grey and grey; with silt.			AEOLIAN DEPOSITS
			12		3897/BH401/11.8-12.2/S/1 D 11.80 m				Pale brown and orange.	D - M		
			13	12.60 3.51	3897/BH401/12.8-13.2/S/1 D 12.80 m				Pale brown and pale grey.	M		
			14	13.60 2.51	3897/BH401/13.8-14.2/S/1 D 13.80 m			CL	Sandy CLAY; low plasticity; dark grey; fine to medium grained sand.	M (>PL)		MARINE DEPOSITS 13.60: H2S odour.
			15		3897/BH401/14.8-15.2/S/1 D 14.80 m							
			16	15.40 0.71 16.00 0.11	3897/BH401/15.8-16.2/S/1 D 15.80 m			SP	SAND; fine to medium grained; dark grey, grey and pale yellow; trace clay.			
			17		3897/BH401/17.0/S/1 D 17.00 m			SP	SAND; fine to medium grained; grey.	W		
			18	18.50	3897/BH401/18.0/S/1 D 18.00 m							
			19						Hole Terminated at 18.50 m (Target depth reached)			

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Engineering Log - BOREHOLE

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	01/10/2019	COMPLETED	01/10/2019	**REF BH402**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	WB	CHECKED	JF	Sheet 1 OF 3
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	151.998852	RL SURFACE	12.92 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 30.00 m depth	NORTHING	-32.775189	ASPECT	East	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
				12.92	3897/BH402/0.0-0.2/S/1 D 0.00 m			SP	TOPSOIL: SAND; fine to medium grained; dark grey and grey; with silt.			TOPSOIL
					3897/BH402/0.4-0.6/S/1 D 0.40 m							
				0.60 12.32					SAND; fine to medium grained; dark grey, grey and pale grey; trace silt.			AEOLIAN DEPOSITS
				12.22					Pale brown and grey.			
			1		3897/BH402/0.9-1.1/S/1 D 0.90 m							
				1.20 11.72					Dark brown and brown; with silt.			
					3897/BH402/1.4-1.6/S/1 D 1.40 m							
				1.80 11.12					Brown, dark brown and orange.			
			2		3897/BH402/1.9-2.1/S/1 D 1.90 m							
					3897/BH402/2.4-2.6/S/1 D 2.40 m							
				2.70 10.22					Brown and pale brown; trace silt.			
			3		3897/BH402/2.9-3.1/S/1 D 2.90 m							
					3897/BH402/3.4-3.6/S/1 D 3.40 m							
				3.80 9.12					Pale brown; no silt.			
			4		3897/BH402/3.9-4.1/S/1 D 3.90 m							
AD/V	L		5		3897/BH402/4.8-5.2/S/1 D 4.80 m					D - M		
			6		3897/BH402/5.8-6.2/S/1 D 5.80 m							
			7		3897/BH402/6.8-7.2/S/1 D 6.80 m							
				7.50 5.42					Pale brown and pale yellow.			
			8		3897/BH402/7.8-8.2/S/1 D 7.80 m							
			9		3897/BH402/8.8-9.2/S/1 D 8.80 m							
					3897/BH402/9.8-10.2/S/1 D 9.80 m							

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Engineering Log - BOREHOLE

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	01/10/2019	COMPLETED	01/10/2019	**REF BH402**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	WB	CHECKED	JF	Sheet 2 OF 3
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	151.998852	RL SURFACE	12.92 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 30.00 m depth	NORTHING	-32.775189	ASPECT	East	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V									SAND; fine to medium grained; dark grey, grey and pale grey; trace silt.	D - M		AEOLIAN DEPOSITS
				10.40 2.52				SP	SAND; fine to medium grained; dark grey; with clay.			MARINE DEPOSITS
			11		3897/BH402/10.8-11.2/S/1 D 10.80 m							
					3897/BH402/11.2-12.2/S/1 D 11.20 m							
			12									
			13		3897/BH402/12.8-13.2/S/1 D 12.80 m							
WB												13.20: Mud drilling started.
			14	*14.00* -1.08				SP	SAND; fine to medium grained; grey; trace clay; trace grey seam.			
	L				3897/BH402/14.15/S/1 D 14.15 m							
			15							M - W		
					3897/BH402/15.5-15.65/S/1 D 15.50 m							
			16									
			17	*17.00* -4.08	3897/BH402/17.0-17.15/S/1 D 17.00 m			SP	SAND; fine to medium grained; grey.			
			18									
					3897/BH402/18.5-18.65/S/1 D 18.50 m							
			19									

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Engineering Log - BOREHOLE

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	01/10/2019	COMPLETED	01/10/2019	**REF BH402**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	WB	CHECKED	JF	Sheet 3 OF 3
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	151.998852	RL SURFACE	12.92 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 30.00 m depth	NORTHING	-32.775189	ASPECT	East	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
				20.50 -7.58	3897/BH402/20.5/S/1 D 20.50 m			SP	SAND; fine to medium grained; grey. Trace coarse grained quartz minerals; trace clay seam.			
			21									
			22		3897/BH402/22.0/S/1 D 22.00 m							
			23									
				23.50 -10.58	3897/BH402/23.5/S/1 D 23.50 m			SP	SAND; fine to medium grained; grey; trace quartz minerals.			
			24									
WB	L		25	*25.00* -12.08	3897/BH402/25.0/S/1 D 25.00 m			SP	SAND; fine to medium grained; grey.	M - W		
			26									
					3897/BH402/26.5/S/1 D 26.50 m							
			27									
			28	*28.00* -15.08	3897/BH402/28.0/S/1 D 28.00 m				Trace subrounded gravels.			
			29									
				30.00	3897/BH402/29.8-30/S/1 D 29.80 m				Hole Terminated at 30.00 m (Target depth reached)			

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	02/10/2019	COMPLETED	02/10/2019	**REF BH403**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	DI	CHECKED	JF	Sheet 1 OF 2
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	152.001559	RL SURFACE	10 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 18.00 m depth	NORTHING	-32.776706	ASPECT	East	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	L		0	10.00	3897/BH403/0.0-0.2/S/1 D 0.00 m			SP	TOPSOIL: SAND; fine to medium grained; grey; trace roots and silt.			TOPSOIL
				0.30 9.70	3897/BH403/0.4-0.6/S/1 D 0.40 m			SP	SAND; fine to medium grained; grey and pale grey.			AEOLIAN DEPOSITS
			1	*0.90* 9.10	3897/BH403/0.9-1.1/S/1 D 0.90 m				Grey and pale brown.			
				1.30 8.70	3897/BH403/1.4-1.6/S/1 D 1.40 m				Dark brown and brown; with silt.			
			2		3897/BH403/1.9-2.1/S/1 D 1.90 m							
					3897/BH403/2.4-2.6/S/1 D 2.40 m							
				2.70 7.30					Brown; trace silt.			
			3		3897/BH403/2.9-3.1/S/1 D 2.90 m							
					3897/BH403/3.4-3.6/S/1 D 3.40 m							
			4		3897/BH403/3.9-4.1/S/1 D 3.90 m					D - M		
			5		3897/BH403/4.8-5.2/S/1 D 4.80 m							
				5.60 4.40					Brown and pale brown; no silt.			
			6		3897/BH403/5.8-6.2/S/1 D 5.80 m							
				6.50 3.50				SP	SAND; fine to medium grained; dark grey and black; with silt; trace organic matter.			MARINE DEPOSITS
			7		3897/BH403/6.8-7.2/S/1 D 6.80 m							
				7.60 2.40					Dark brown and grey.			
			8		3897/BH403/7.8-8.2/S/1 D 7.80 m							8.50: Mud drilling started.
			9		3897/BH403/8.8-9.2/S/1 D 8.80 m							
		▽		*9.40* 0.60					Dark brown.	M - W		
					3897/BH403/9.8-10.2/S/1 D 9.80 m							

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Engineering Log - BOREHOLE

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	02/10/2019	COMPLETED	02/10/2019	**REF BH403**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	DI	CHECKED	JF	Sheet 2 OF 2
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	152.001559	RL SURFACE	10 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 18.00 m depth	NORTHING	-32.776706	ASPECT	East	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
WB	L		11	*11.00* -1.00				SP	SAND; fine to medium grained; dark grey and black; with silt; trace organic matter.	M - W		MARINE DEPOSITS
					3897/BH403/11.5/S/1 D 11.50 m			SP	SAND; fine to medium grained; grey; no silt.			
			12									
			13		3897/BH403/13.0/S/1 D 13.00 m							
			14									
					3897/BH403/14.5/S/1 D 14.50 m							
			15									
			16		3897/BH403/16.0/S/1 D 16.00 m							
			17									
					3897/BH403/17.5/S/1 D 17.50 m							
			18	*18.00*					Hole Terminated at 18.00 m (Target depth reached)			
			19									

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	25/09/2019	COMPLETED	25/09/2019	**REF BH404**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	WX	CHECKED	JF	Sheet 1 OF 3
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	151.999298	RL SURFACE	5.55 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 21.00 m depth	NORTHING	-32.774238	ASPECT	West	SLOPE <2%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V				5.55	3897/BH404/0.0-0.2/S/1 D 0.00 m			SP	SAND; fine to medium grained; grey and dark grey.			AEOLIAN DEPOSITS
				0.40 5.15	3897/BH404/0.5/S/1 D 0.50 m				Grey.			
				0.80 4.75					Pale grey.			
			1		3897/BH404/1.0/S/1 D 1.00 m							
				1.20 4.35					Grey brown.			
					3897/BH404/1.5/S/1 D 1.50 m							
				1.80 3.75					Brown.			
			2		3897/BH404/2.0/S/1 D 2.00 m					D		
					3897/BH404/2.5/S/1 D 2.50 m							
			3	*3.00* 2.55	3897/BH404/3.0/S/1 D 3.00 m				Yellow dark brown.			
				3.50 2.05	3897/BH404/3.5/S/1 D 3.50 m				Yellow brown.			
			4	*4.00* 1.55	3897/BH404/4.0/S/1 D 4.00 m				Grey brown.			
					3897/BH404/4.5/S/1 D 4.50 m							
				4.80 0.75				CI-CH	Silty CLAY; medium to high plasticity; dark grey; with sand.	M (>PL)		ALLUVIUM
	L		5		3897/BH404/5.0/S/1 D 5.00 m							
				5.30 0.25				SP	SAND; fine to medium grained; dark grey.			MARINE DEPOSITS
					3897/BH404/5.5/S/1 D 5.50 m							
WB			6		3897/BH404/6.0/S/1 D 6.00 m							
			7									
				7.50 -1.95	3897/BH404/7.5/S/1 D 7.50 m			SP	SAND; fine to medium grained; grey.	W		
			8									
			9		3897/BH404/9.0/S/1 D 9.00 m							

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	25/09/2019	COMPLETED	25/09/2019	**REF BH404**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	WX	CHECKED	JF	Sheet 2 OF 3
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	151.999298	RL SURFACE	5.55 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 21.00 m depth	NORTHING	-32.774238	ASPECT	West	SLOPE <2%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
					3897/BH404/10.5/S/1 D 10.50 m			SP	SAND; fine to medium grained; grey.			
			11									
				12.00 -6.45								
			12		3897/BH404/12.0/S/1 D 12.00 m			SP	SAND; medium grained; grey.			
			13									
					3897/BH404/13.5/S/1 D 13.50 m							
			14									
				15.00 -9.45								
WB	L		15		3897/BH404/15.0/S/1 D 15.00 m			SP	SAND; fine to medium grained; grey.	W		
			16									
					3897/BH404/16.5/S/1 D 16.50 m							
			17									
			18		3897/BH404/18.0/S/1 D 18.00 m							
			19									
				19.50 -13.95	3897/BH404/19.5/S/1 D 19.50 m			SP	SAND; fine to medium grained; brown and pale grey.			

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Engineering Log - BOREHOLE

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	25/09/2019	COMPLETED	25/09/2019	**REF BH404**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	WX	CHECKED	JF	Sheet 3 OF 3
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	151.999298	RL SURFACE	5.55 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 21.00 m depth	NORTHING	-32.774238	ASPECT	West	SLOPE <2%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
WB	L		21	***21.00*** -15.45	3897/BH404/20.9-21.0/S71 D 20.90 m			SP	SAND; fine to medium grained; brown and pale grey.	W		
									Pale grey and pale brown. Hole Terminated at 21.00 m (Target depth reached)			
			22									
			23									
			24									
			25									
			26									
			27									
			28									
			29									

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Engineering Log - BOREHOLE

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	27/09/2019	COMPLETED	27/09/2019	**REF BH405**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	WX	CHECKED	JF	Sheet 1 OF 3
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	152.001997	RL SURFACE	10.7 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 26.00 m depth	NORTHING	-32.7748957	ASPECT	East	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
				10.70				SM	TOPSOIL: Silty SAND; fine grained; grey and dark grey; trace roots.			TOPSOIL
				0.30 10.40	3897/BH405/0.2/S/1 D 0.20 m			SP	SAND; fine grained; grey and dark grey.			AEOLIAN DEPOSITS
					3897/BH405/0.5/S/1 D 0.50 m							
			1		3897/BH405/1.0/S/1 D 1.00 m							
				1.30 9.40				SP	SAND; fine grained; grey and brown.			
					3897/BH405/1.5/S/1 D 1.50 m							
			2	*2.00* 8.70	3897/BH405/2.0/S/1 D 2.00 m			SP	SAND; fine grained; brown.			
					3897/BH405/2.5/S/1 D 2.50 m							
			3		3897/BH405/3.0/S/1 D 3.00 m							
					3897/BH405/3.5/S/1 D 3.50 m							
			4		3897/BH405/4.0/S/1 D 4.00 m							
					3897/BH405/4.5/S/1 D 4.50 m							
	L		5		3897/BH405/5.0/S/1 D 5.00 m					M		
			6	*6.00* 4.70	3897/BH405/6.0/S/1 D 6.00 m				Fine grained, brown and pale brown.			
			7		3897/BH405/7.0/S/1 D 7.00 m							
			8	*8.00* 2.70	3897/BH405/8.0/S/1 D 8.00 m				Yellow brown, pale brown.			
			9	*9.00* 1.70	3897/BH405/9.0/S/1 D 9.00 m			SP	SAND; fine grained; brown and pale grey.			
WB												

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Engineering Log - BOREHOLE

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	27/09/2019	COMPLETED	27/09/2019	**REF BH405**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	WX	CHECKED	JF	Sheet 2 OF 3
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	152.001997	RL SURFACE	10.7 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 26.00 m depth	NORTHING	-32.7748957	ASPECT	East	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
					3897/BH405/10.5/S/1 D 10.50 m			SP	SAND; fine grained; brown and pale grey.			
			11									
			12		3897/BH405/12.0/S/1 D 12.00 m							
			13	*13.00* -2.30				SP	SAND; fine to medium grained; grey; coarse grained sand; some quartz;			MARINE DEPOSITS
					3897/BH405/13.5/S/1 D 13.50 m							
			14									
WB	L		15	*15.00* -4.30	3897/BH405/15.0/S/1 D 15.00 m			SP	SAND; fine to coarse grained; grey; subrounded quartz grained; well graded.	M		
			16									
			17									
					3897/BH405/17.5/S/1 D 17.50 m							
			18									
			19		3897/BH405/19.0/S/1 D 19.00 m							

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CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	27/09/2019	COMPLETED	27/09/2019	**REF BH405**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	WX	CHECKED	JF	Sheet 3 OF 3
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	152.001997	RL SURFACE	10.7 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 26.00 m depth	NORTHING	-32.7748957	ASPECT	East	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
				20.50				SP	SAND; fine to coarse grained; grey; subrounded quartz grained; well graded.			
				-9.80	3897/BH405/20.5/S/1 D 20.50 m			SP	SAND; fine to coarse grained; subrounded to rounded; grey; including quartz and possible volcanic material/igneous gravels.			
			21									
			22		3897/BH405/22.0/S/1 D 22.00 m							
WB	L		23							M		
			24									
			25		3897/BH405/25.0/S/1 D 25.00 m							
			26	*26.00*					Hole Terminated at 26.00 m (Target depth reached)			
			27									
			28									
			29									

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CLIENT	Ammos Resource Management Pty Ltd	COMMENCED	01/10/2019	COMPLETED	01/10/2019	**REF BH406**	
PROJECT	Supplementary Acid Sulfate Soils Assessment	LOGGED	DI	CHECKED	JF	Sheet 1 OF 2	
SITE	3631 Nelson Bay Road, Bobs Farm, NSW	GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.99946	RL SURFACE	16.7 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 15.50 m depth	NORTHING	-32.773773	ASPECT	South	SLOPE	5-10%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	L		0	16.70	3897/BH406/0.0-0.2/S/1 D 0.00 m			SP	TOPSOIL: SAND; fine to medium grained; grey and dark grey; with silt; trace organic material.			TOPSOIL
					3897/BH406/0.4-0.6/S/1 D 0.40 m							
				0.70 16.00				SP	SAND; fine to medium grained; pale brown and grey; predominantly quartz; subrounded to rounded grained.			AEOLIAN DEPOSITS
			1		3897/BH406/0.9-1.1/S/1 D 0.90 m							
				1.20 15.50					Brown and pale brown.			
					3897/BH406/1.4-1.6/S/1 D 1.40 m							
				1.80 14.90					Dark brown and brown; trace silt.			
			2		3897/BH406/1.9-2.1/S/1 D 1.90 m							
				2.20 14.50					Dark brown, brown and trace orange.			
					3897/BH406/2.4-2.6/S/1 D 2.40 m							
			3		3897/BH406/2.9-3.1/S/1 D 2.90 m							
					3897/BH406/3.4-3.6/S/1 D 3.40 m							
			4		3897/BH406/3.9-4.1/S/1 D 3.90 m							
				4.40 12.30					Brown and pale brown; no silt.			
			5		3897/BH406/4.8-5.2/S/1 D 4.80 m					D - M		
			6		3897/BH406/5.8-6.2/S/1 D 5.80 m							
				6.60 10.10					Pale brown.			
			7		3897/BH406/6.8-7.2/S/1 D 6.80 m							
				7.40 9.30					Pale brown and yellow.			
			8		3897/BH406/7.8-8.2/S/1 D 7.80 m							
			9		3897/BH406/8.8-9.2/S/1 D 8.80 m							
					3897/BH406/9.8-10.2/S/1 D 9.80 m							

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CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	01/10/2019	COMPLETED	01/10/2019	**REF BH406**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	DI	CHECKED	JF	Sheet 2 OF 2
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	151.99946	RL SURFACE	16.7 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 15.50 m depth	NORTHING	-32.773773	ASPECT	South	SLOPE 5-10%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	L		11		3897/BH406/10.8-11.2/S71 D 10.80 m			SP	SAND; fine to medium grained; pale brown and grey; predominantly quartz; subrounded to rounded grained.	D - M		AEOLIAN DEPOSITS
			12		3897/BH406/11.8-12.2/S71 D 11.80 m							
			13		3897/BH406/12.8-13.2/S71 D 12.80 m							
			14		3897/BH406/13.8-14.2/S71 D 13.80 m							
				14.60 2.10					Pale brown, yellow and pale grey.			
			15		3897/BH406/14.8-15.2/S71 D 14.80 m					M		
				15.50					Hole Terminated at 15.50 m (Target depth reached)			
			16									
			17									
			18									
			19									

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CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	01/10/2019	COMPLETED	01/10/2019	**REF BH407**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	DI	CHECKED	JF	Sheet 1 OF 2
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	Shrubs	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	151.999882	RL SURFACE	16.7 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 14.50 m depth	NORTHING	-32.774472	ASPECT	Southeast	SLOPE 5-10%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	L		1	16.70	3897/BH407/0.0-0.2/S/1 D 0.00 m			SP	TOPSOIL: SAND; medium grained; grey and dark grey; trace shrubs and roots. From 0.3m: No roots.			TOPSOIL
				0.30 16.40	3897/BH407/0.4-0.6/S/1 D 0.40 m			SP	SAND; medium grained; grey and dark grey.			AEOLIAN DEPOSITS
				0.70 16.00	3897/BH407/0.9-1.1/S/1 D 0.90 m				Pale grey; fine to medium grained.			
			2	*1.30* 15.40	3897/BH407/1.4-1.6/S/1 D 1.40 m				Dark brown and yellow brown.			
				2.20 14.50	3897/BH407/1.9-2.1/S/1 D 1.90 m				Yellow and pale brown.			
			3		3897/BH407/2.4-2.6/S/1 D 2.40 m							
					3897/BH407/2.9-3.1/S/1 D 2.90 m							
			4		3897/BH407/3.4-3.6/S/1 D 3.40 m							
				4.40 12.30	3897/BH407/3.9-4.1/S/1 D 3.90 m				Pale yellow and pale brown; majority of sand is subrounded to rounded quartz grained.			
			5		3897/BH407/4.8-5.2/S/1 D 4.80 m					D - M		
			6		3897/BH407/5.8-6.2/S/1 D 5.80 m							
			7		3897/BH407/6.8-7.2/S/1 D 6.80 m							
			8		3897/BH407/7.8-8.2/S/1 D 7.80 m							
			9		3897/BH407/8.8-9.2/S/1 D 8.80 m							
					3897/BH407/9.8-10.2/S/1 D 9.80 m							

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CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	01/10/2019	COMPLETED	01/10/2019	**REF BH407**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	DI	CHECKED	JF	Sheet 2 OF 2
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	Shrubs	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	151.999882	RL SURFACE	16.7 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 14.50 m depth	NORTHING	-32.774472	ASPECT	Southeast	SLOPE 5-10%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	L		11		3897/BH407/10.8-11.2/S71 D 10.80 m			SP	SAND; medium grained; grey and dark grey.	D - M		AEOLIAN DEPOSITS
			12		3897/BH407/11.8-12.2/S71 D 11.80 m							
				12.60 4.10					Grey.			12.60: Possible marine.
			13		3897/BH407/12.8-13.2/S71 D 12.80 m					M		
			14	*14.00* 2.70	3897/BH407/13.8-14.2/S71 D 13.80 m				Grey, yellow grey, with brown; trace silt.			14.00: Organic odour.
				14.50					Hole Terminated at 14.50 m (Target depth reached)			
			15									
			16									
			17									
			18									
			19									

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CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	25/09/2019	COMPLETED	25/09/2019	**REF BH408**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	HN/WB	CHECKED	JF	Sheet 1 OF 4
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	152.002581	RL SURFACE	23.11 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 38.00 m depth	NORTHING	-32.773177	ASPECT	Southeast	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
				23.11				SM	TOPSOIL: Silty SAND; fine grained; dark grey; trace roots.			TOPSOIL
					3897/BH408/0.2-0.3/S/1 D 0.20 m							
				0.50								
				22.61	3897/BH408/0.5-0.6/S/1 D 0.50 m				Brown and grey.			
				0.70								
				22.41				SP	SAND; fine grained; brown.			AEOLIAN DEPOSITS
			1		3897/BH408/1.0-1.1/S/1 D 1.00 m							
					3897/BH408/1.5-1.6/S/1 D 1.50 m							
			2		3897/BH408/2.0-2.1/S/1 D 2.00 m							
					3897/BH408/2.5-2.6/S/1 D 2.50 m							
			3		3897/BH408/3.0-3.1/S/1 D 3.00 m							
					3897/BH408/3.5-3.6/S/1 D 3.50 m							
			4		3897/BH408/4.0-4.1/S/1 D 4.00 m							
					3897/BH408/4.5-4.6/S/1 D 4.50 m							
AD/V	L			*5.00*								
			5	18.11	3897/BH408/5.0-5.1/S/1 D 5.00 m				Pale brown.			
					3897/BH408/5.5-5.6/S/1 D 5.50 m							
			6		3897/BH408/6.0-6.1/S/1 D 6.00 m							
			7		3897/BH408/7.0-7.1/S/1 D 7.00 m							
			8		3897/BH408/8.0-8.1/S/1 D 8.00 m							
				9.00	3897/BH408/8.9-9.0/S/1							
			9	14.11	D 8.90 m			SP	SAND; fine grained; pale brown, yellow brown.			
					3897/BH408/9.9-10.0/S/1							

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	25/09/2019	COMPLETED	25/09/2019	**REF BH408**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	HN/WB	CHECKED	JF	Sheet 2 OF 4
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	152.002581	RL SURFACE	23.11 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 38.00 m depth	NORTHING	-32.773177	ASPECT	Southeast	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
					D 9.90 m			SP	SAND; fine grained; pale brown, yellow brown.			
AD/V			11		3897/BH408/10.9-11.0/S71 D 10.90 m							
												11.50: Mud drilling started on 26/09/2019.
			12									
				12.50 10.61	3897/BH408/12.5-12.7/S71 D 12.50 m				Yellow brown.			
			13									
				14.00 9.11	3897/BH408/14.0-14.2/S71 D 14.00 m				Pale yellow brown.			
WB	L		15									
					3897/BH408/15.5-15.7/S71 D 15.50 m							
			16									
				17.00 6.11	3897/BH408/17.0-17.2/S71 D 17.00 m				Dark yellow.			
			18									
					3897/BH408/18.5-18.7/S71 D 18.50 m							
			19									

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Engineering Log - BOREHOLE

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	25/09/2019	COMPLETED	25/09/2019	**REF BH408**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	HN/WB	CHECKED	JF	Sheet 3 OF 4
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	152.002581	RL SURFACE	23.11 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 38.00 m depth	NORTHING	-32.773177	ASPECT	Southeast	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
WB	L		21		3897/BH408/20.5-20.7/S71 D 20.50 m			SP	SAND; fine grained; pale brown, yellow brown.			
			22		3897/BH408/22.0-22.2/S71 D 22.00 m							
			23		3897/BH408/23.5-23.7/S71 D 23.50 m							
			24									
			25		3897/BH408/25.0-25.2/S71 D 25.00 m							
			26	*26.00* -2.89					Pale grey.			
			27		3897/BH408/26.5-26.7/S71 D 26.50 m							
			28		3897/BH408/28.0-28.2/S71 D 28.00 m							
			29		3897/BH408/29.5-29.7/S71 D 29.50 m							

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Engineering Log - BOREHOLE

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	25/09/2019	COMPLETED	25/09/2019	**REF BH408**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	HN/WB	CHECKED	JF	Sheet 4 OF 4
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	152.002581	RL SURFACE	23.11 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 38.00 m depth	NORTHING	-32.773177	ASPECT	Southeast	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			31		3897/BH408/31.0-31.2/S/1 D 31.00 m			SP	SAND; fine grained; pale brown, yellow brown.			
			32	*32.00* -8.89	3897/BH408/32.5-32.7/S/1 D 32.50 m			SP	SAND; fine grained; grey.			MARINE DEPOSITS
			33									
WB	L		34	*34.00* -10.89	3897/BH408/34-34.2/S/1 D 34.00 m				Fine grained; grey.			
			35									
				35.70 -12.59	3897/BH408/35.5-37.7/S/1 D 35.50 m				Fine to medium grained (mostly fine grained); grey.			
			36									
			37									
				37.50 -14.39					Fine to medium grained (mostly medium grained); trace shell fragments.			
			38	*38.00*	3897/BH408/37.8-38.0/S/1 D 37.80 m				Hole Terminated at 38.00 m (Target depth reached)			
			39									

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Engineering Log - BOREHOLE

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	20/09/2019	COMPLETED	20/09/2019	**REF BH409**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	WX	CHECKED	JF	Sheet 1 OF 3
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	152.004581	RL SURFACE	7.32 m	DATUM AHD
EXCAVATION DIMENSIONS		24.50 m depth	NORTHING	-32.773304	ASPECT	Southeast	SLOPE <2%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/T				7.32	3897/BH409/0.0-0.1/S/1 D 0.00 m			SP	SAND; medium grained; grey brown.			AEOLIAN DEPOSITS
					3897/BH409/0.5/S/1 D 0.50 m							
			1		3897/BH409/1.0/S/1 D 1.00 m							
					3897/BH409/1.5/S/1 D 1.50 m							
				1.90 5.42								
			2		3897/BH409/2.0/S/1 D 2.00 m				Brown.			
				2.20 5.12					Orange brown.			
					3897/BH409/2.5/S/1 D 2.50 m					D		
				2.80 4.52					Dark orange brown.			
			3		3897/BH409/3.0/S/1 D 3.00 m							
					3897/BH409/3.5/S/1 D 3.50 m							
			4	*4.10* 3.22	3897/BH409/4.0/S/1 D 4.00 m				Orange brown.			
					3897/BH409/4.5/S/1 D 4.50 m							
	L		5									
		20/09/19		*5.50* 1.82					Pale grey yellow.			
			6		3897/BH409/6.0-6.2/S/1 D 6.00 m							
				6.50 0.82				SC	Clayey SAND; fine to medium grained; dark grey.			MARINE DEPOSITS
WB			7									
					3897/BH409/7.5-7.7/S/1 D 7.50 m					W		
			8	*8.50* -1.18				SP	SAND; fine to medium grained; grey.			
			9		3897/BH409/9.0-9.2/S/1 D 9.00 m							
				10.00								

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Engineering Log - BOREHOLE

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	20/09/2019	COMPLETED	20/09/2019	**REF BH409**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	WX	CHECKED	JF	Sheet 2 OF 3
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	152.004581	RL SURFACE	7.32 m	DATUM AHD
EXCAVATION DIMENSIONS		24.50 m depth	NORTHING	-32.773304	ASPECT	Southeast	SLOPE <2%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
				-2.68				SP	SAND; fine to medium grained; grey.			
									Pale grey.			
					3897/BH409/10.5-10.7/S/1 D 10.50 m							
			11									
					3897/BH40912-12.2/S/1 D 12.00 m							
			12									
			13									
					3897/BH409/13.5-13.7/S/1 D 13.50 m							
			14									
WB	L		15		3897/BH409/15-15.2/S/1 D 15.00 m					W		
			16									
					3897/BH409/16.5-16.7/S/1 D 16.50 m							
			17									
				18.00								
			18	-10.68	3897/BH409/18-18.2/S/1 D 18.00 m				Medium to coarse grained.			
			19									
					3897/BH409/19.5-19.7/S/1 D 19.50 m							

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Engineering Log - BOREHOLE

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	20/09/2019	COMPLETED	20/09/2019	**REF BH409**
PROJECT	Supplementary Acid Sulfate Soils Assessment		LOGGED	WX	CHECKED	JF	Sheet 3 OF 3
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	152.004581	RL SURFACE	7.32 m	DATUM AHD
EXCAVATION DIMENSIONS		24.50 m depth	NORTHING	-32.773304	ASPECT	Southeast	SLOPE <2%

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
WB	L		21	*21.00* -13.68	3897/BH409/21-21.2/S/1 D 21.00 m			SP	SAND; fine to medium grained; grey.			
			22						Grey.	W		
					3897/BH409/22.5-22.7/S/1 D 22.50 m							
			23									
			24		3897/BH409/24-24.2/S/1 D 24.00 m							
				24.50					Hole Terminated at 24.50 m (Target depth reached)			
			25									
			26									
			27									
			28									
			29									

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Engineering Log - BOREHOLE

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	18/09/2019	COMPLETED	18/09/2019	**REF MW101**
PROJECT	Acid Sulfate Soils Assessment		LOGGED	WX	CHECKED		Sheet 1 OF 2
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	7.1 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 17.95 m depth	NORTHING		ASPECT	Northeast	SLOPE <2%

Drilling | **Sampling** | **Field Material Description**

METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS
AD/T	L	19/09/19	0	0.10 7.00	3897/MW101/0.0-0.1/S/1 D 0.00 m			SP SP	TOPSOIL: SAND; medium grained; grey black; trace organics and rootlets. SAND; medium grained; pale grey.			ID MW101 (Static Water Level)
					3897/MW101/0.5/S/1 D 0.50 m							
			1	0.90 6.20	3897/MW101/1.0/S/1 D 1.00 m				Dark orange brown.			
				1.50 5.60	3897/MW101/1.5/S/1 D 1.50 m				Orange brown.			
			2	1.90 5.20	3897/MW101/2.0/S/1 D 2.00 m				Orange yellow brown.	D		
				2.30 4.80	3897/MW101/2.5/S/1 D 2.50 m				Yellow-brown.			
			3	3.00 4.10	3897/MW101/3.0/S/1 D 3.00 m				Brown.			
				3.50 3.60	3897/MW101/3.5/S/1 D 3.50 m				Yellow-brown.			
			4		3897/MW101/4.0/S/1 D 4.00 m							
				4.70 2.40	3897/MW101/4.5/S/1 D 4.50 m				Dark yellow-brown.	M		
			5	5.00 2.10					Dark grey.			Casing
					SPT 5.70-5.85 m 8							
			6		3897/MW101/5.7-6.0/S/1 D 5.70 m							
			7	7.00 0.10					Grey.			
					3897/MW101/7.3-7.5/S/1 D 7.30 m					W		
			8									
				8.50 -1.40					Pale grey.			
			9		3897/MW101/8.8-9.0/S/1 D 8.80 m							Sand
				10.00								

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Engineering Log - TEST

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	18/09/2019	COMPLETED	18/09/2019	**REF MW101**
PROJECT	Acid Sulfate Soils Assessment		LOGGED	WX	CHECKED		Sheet 2 OF 2
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	7.1 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 17.95 m depth	NORTHING		ASPECT	Northeast	SLOPE <2%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level
AD/T	L		11	-2.90	3897/MW101/10.3-10.5/S/1 D 10.30 m			SP	SAND; medium grained; pale grey. Pale grey white.			MW101
				11.50 -4.40					Pale grey.			Sand
			12		3897/MW101/11.8-12/S/1 D 11.80 m							Casing
			13									Screen
			14		3897/MW101/13.3-13.5/S/1 D 13.30 m					W		
			15		3897/MW101/14.8-15/S/1 D 14.80 m							
			16									
			17		3897/MW101/16.3-16.5/S/1 D 16.30 m							
			18	*17.95*					Hole Terminated at 17.95 m			
			19									

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Engineering Log - TEST

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	23/09/2019	COMPLETED	24/09/2019	**REF MW102**
PROJECT	Acid Sulfate Soils Assessment		LOGGED	HN	CHECKED		Sheet 1 OF 4
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 30.00 m depth	NORTHING		ASPECT	Northeast	SLOPE <2%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level
AD/T			0	0.50	3897/MW102/0.2-0.3/S/1 D 0.20 m			SM	Silty SAND; fine to medium grained; grey and dark grey; trace roots.			MW102
					3897/MW102/0.5-0.6/S/1 D 0.50 m			SP	SAND; fine to mediume grained; brown; trace silt; trace roots.			Concrete
			1	1.30	3897/MW102/1.0-1.1/S/1 D 1.00 m							Bentonite
				1.50	3897/MW102/1.5-1.6/S/1 D 1.50 m				Pale brown with some grey. No silt; no roots.	D / M		
			2	2.50	3897/MW102/2.0-2.1/S/1 D 2.00 m							
			3	3.50	3897/MW102/2.5-2.6/S/1 D 2.50 m				Brown and grey.			
					3897/MW102/3.0-3.1/S/1 D 3.00 m							
			4	4.00	3897/MW102/3.5-3.6/S/1 D 3.50 m				Brown.			Sand
					3897/MW102/4.0-4.1/S/1 D 4.00 m				Pale brown.			
					3897/MW102/4.5-4.6/S/1 D 4.50 m							
WB	L		5									
			6		SPT 5.50-5.95 m 0,0,0 N=0 3897/MW102/5.5-5.95/S/1 D 5.50 m					M		Casing
			7	7.00	SPT 7.00-7.45 m 0,0,0 N=0 3897/MW102/7.0-7.45/S/1 D 7.00 m				Brown and grey.			
			8									
			9	8.50	SPT 8.50-8.95 m 0,0,0 N=0 3897/MW102/8.5-8.95/S/1 D 8.50 m				Pale brown.			Screen

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Engineering Log - TEST

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	23/09/2019	COMPLETED	24/09/2019	**REF MW102**
PROJECT	Acid Sulfate Soils Assessment		LOGGED	HN	CHECKED		Sheet 2 OF 4
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 30.00 m depth	NORTHING		ASPECT	Northeast	SLOPE <2%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level MW102
WB	L		11		SPT 10.00-10.45 m 0,0,0 N=0 3897/MW102/10.0-10.45/S/1 D 10.00 m			SP	SAND; fine to mediume grained; brown; trace silt; trace roots.			
			12		SPT 11.50-11.95 m 0,0,0 N=0 3897/MW102/11.5-11.95/S/1 D 11.50 m							Screen
			13		SPT 13.00-13.45 m 0,0,0 N=0 3897/MW102/13.0-13.45/S/1 D 13.00 m							
			14									
			15		SPT 14.50-14.95 m 0,0,0 N=0 3897/MW102/14.5-14.95/S/1 14.50 m					M		Sand
			16		SPT 16.00-16.45 m 0,0,0 N=0 3897/MW102/16.0-16.45/S/1 D 16.00 m							
			17									
			18		SPT 17.50-17.95 m 0,0,0 N=0 3897/MW102/17.5-17.95/S/1 D 17.50 m							
			19		SPT 19.00-19.45 m 0,0,0 N=0 3897/MW102/19.0-19.45/S/1 D 19.00 m							

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Engineering Log - TEST

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	23/09/2019	COMPLETED	24/09/2019	**REF MW102**
PROJECT	Acid Sulfate Soils Assessment		LOGGED	HN	CHECKED		Sheet 3 OF 4
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 30.00 m depth	NORTHING		ASPECT	Northeast	SLOPE <2%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID MW102 Static Water Level
WB	L		21		SPT 20.50-20.95 m 0,0,0 N=0 3897/MW102/20.5-20.95/S/1 D 20.50 m			SP	SAND; fine to mediume grained; brown; trace silt; trace roots.			
			22		SPT 22.00-22.45 m 0,0,0 N=0 3897/MW102/22.0-22.45/S/1 D 22.00 m							Screen
			23		SPT 23.50-23.95 m 0,0,0 N=0 3897/MW102/23.5-23.95/S/1 D 23.50 m							
			24									Sand
			25		SPT 25.00-25.45 m 0,0,0 N=0 3897/MW102/25.0-25.45/S/1 D 25.00 m					M		
			26									
			27	*26.90*	SPT 26.50-26.95 m 0,0,0 N=0 3897/MW102/26.5-26.95/S/1 D 26.50 m				Dark grey.			
				27.50				SC	Clayey SAND; fine to medium grained; dark grey.			
			28		SPT 28.00-28.45 m 0,0,0 N=0 3897/MW102/28.0-28.45/S/1 D 28.00 m							
			29									
				30.00	SPT 29.50-29.95 m 0,0,0 N=0 3897/MW102/29.5-29.95/S/1				Hole Terminated at 30.00 m			

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	23/09/2019	COMPLETED	24/09/2019	**REF MW102**
PROJECT	Acid Sulfate Soils Assessment		LOGGED	HN	CHECKED		Sheet 4 OF 4
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 30.00 m depth	NORTHING		ASPECT	Northeast	SLOPE <2%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level MW102
					D 29.50 m							
			31									
			32									
			33									
			34									
			35									
			36									
			37									
			38									
			39									

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CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	27/09/2019	COMPLETED	30/09/2019	**REF MW103**
PROJECT	Acid Sulfate Soils Assessment		LOGGED	WB	CHECKED		Sheet 1 OF 4
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	29.66 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 38.00 m depth	NORTHING		ASPECT	Northeast	SLOPE <2%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level
AD/T			0	29.66				SP	TOPSOIL: SAND; fine grained; dark grey; trace roots.			MW103
				0.20 29.46	3897/MW103/0.2/S/1 D 0.20 m			SP	SAND; fine grained; dark grey.			Concrete
					3897/MW103/0.5/S/1 D 0.50 m							
			1	*1.00* 28.66	3897/MW103/1.0/S/1 D 1.00 m				Grey.			
				1.30 28.36					Brown and some grey.			
					3897/MW103/1.5/S/1 D 1.50 m							
			2	*1.80* 27.86					Brown.			
					3897/MW103/2.0/S/1 D 2.00 m							
					3897/MW103/2.5/S/1 D 2.50 m							
			3		3897/MW103/3.0/S/1 D 3.00 m							
				3.50 26.16	3897/MW103/3.5/S/1 D 3.50 m				Brown; trace roots.			
			4	*4.00* 25.66	3897/MW103/4.0/S/1 D 4.00 m				Brown and yellow-brown.			
					3897/MW103/4.5/S/1 D 4.50 m							
			5							M		Casing
					3897/MW103/5.5/S/1 D 5.50 m							
			6									
					3897/MW103/6.5/S/1 D 6.50 m							
			7									
				7.50 22.16	3897/MW103/7.5/S/1 D 7.50 m				Pale brown and yellow-brown.			
			8									
					3897/MW103/8.5/S/1 D 8.50 m							
			9									
					3897/MW103/9.5/S/1 D 9.50 m							Backfill Cuttings

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CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	27/09/2019	COMPLETED	30/09/2019	**REF MW103**
PROJECT	Acid Sulfate Soils Assessment		LOGGED	WB	CHECKED		Sheet 2 OF 4
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	29.66 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 38.00 m depth	NORTHING		ASPECT	Northeast	SLOPE <2%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level
AD/T			11		3897/MW103/10.5/S/1 D 10.50 m			SP	SAND; fine grained; dark grey.			MW103
			12		3897/MW103/11.5/S/1 D 11.50 m							Backfill Cuttings
			13		3897/MW103/13.5/S/1 D 13.50 m							
			14		3897/MW103/14.5/S/1 D 14.50 m							
			15							M		
			16		3897/MW103/16/S/1 D 16.00 m							
			17									
				17.50 12.16	3897/MW103/17.5/S/1 D 17.50 m				Pale brown, yellow-brown, some dark grey.			
			18									
			19	*19.00* 10.66	3897/MW103/19/S/1 D 19.00 m				Pale brown and yellow-brown.			Bentonite

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Engineering Log - TEST

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	27/09/2019	COMPLETED	30/09/2019	**REF MW103**
PROJECT	Acid Sulfate Soils Assessment		LOGGED	WB	CHECKED		Sheet 3 OF 4
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	29.66 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 38.00 m depth	NORTHING		ASPECT	Northeast	SLOPE <2%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level
AD/T								SP	SAND; fine grained; dark grey.	M		MW103
				20.50 9.16	3897/MW103/20.4-20.5/S/1 D 20.40 m				Pale brown and grey.			
			21									
				21.50 8.16				SP	SAND; fine grained; pale brown, yellow-brown and some grey.			
					3897/MW103/21.7/S/1 D 21.70 m							
			22									
			23									
					3897/MW103/23.2/S/1 D 23.20 m							
			24									Sand
					3897/MW103/24.7/S/1 D 24.70 m							
			25							W		
				26.00 3.66				SP	SAND; fine grained; brown, yellow-brown and pale brown.			
			26		3897/MW103/26.2/S/1 D 26.20 m							
			27									
					3897/MW103/27.7/S/1 D 27.70 m							
			28									
			29									Sand
					3897/MW103/29.2/S/1 D 29.20 m							Screen

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Engineering Log - TEST

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	27/09/2019	COMPLETED	30/09/2019	**REF MW103**
PROJECT	Acid Sulfate Soils Assessment		LOGGED	WB	CHECKED		Sheet 4 OF 4
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	29.66 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 38.00 m depth	NORTHING		ASPECT	Northeast	SLOPE <2%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level
AD/T				*30.50* -0.84				SP	SAND; fine grained; brown, yellow-brown and pale brown.			MW103
					3897/MW103/30.7/S/1 D 30.70 m			SP	SAND; fine grained; pale brown, yellow-brown and some pale grey; trace organics (wood fragments in pale grey material).			
			31	*31.00* -1.34				SC	Clayey SAND; fine grained; grey; trace shell fragments.			
			32		3897/MW103/32.2/S/1 D 32.20 m							
			33									Sand
				33.70 -4.04	3897/MW103/33.7/S/1 D 33.70 m			SP	SAND; fine to medium grained; grey.	W		Screen
			34									
			35	*35.20* -5.54	3897/MW103/35.2/S/1 D 35.20 m			SP	SAND; fine grained; grey.			
			36									
					3897/MW103/36.7/S/1 D 36.70 m							
			37									
			38	*38.00*					Hole Terminated at 38.00 m			
			39									

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Engineering Log - TEST

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	30/09/2019	COMPLETED	01/10/2019	**REF MW104**
PROJECT	Acid Sulfate Soils Assessment		LOGGED	WX	CHECKED		Sheet 1 OF 3
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	15.36 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 26.00 m depth	NORTHING		ASPECT	South	SLOPE 5-10%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level MW104
AD/T			0	15.36	3897/MW104/0.1-0.2/S/1 D 0.00 m			SP	TOPSOIL: SAND; fine to medium subrounded to rounded grained; dark grey and grey; with silt; trace organic material.	D - M		Concrete
					3897/MW104/0.4-0.5/S/1 D 0.40 m							
			1		3897/MW104/0.1-0.2/S/1 D 1.00 m							
				1.20 14.16				SP	SAND; fine to medium grained; brown, grey and dark grey; no organics; trace silt.			
					3897/MW104/1.5/S/1 D 1.50 m							
			2		3897/MW104/2.0/S/1 D 2.00 m							
				2.20 13.16					Dark grey and dark brown; with silt.			
					3897/MW104/2.5/S/1 D 2.50 m							
				2.80 12.56					Dark brown.			
			3		3897/MW104/3.0/S/1 D 3.00 m							
					3897/MW104/3.5/S/1 D 3.50 m							
				3.70 11.66					Orange-dark brown; trace silt.			
			4		3897/MW104/4.0/S/1 D 4.00 m							
				4.20 11.16					Orange and pale brown, no silt.			
					3897/MW104/4.5/S/1 D 4.50 m							
			5		3897/MW104/5.0/S/1 D 5.00 m					M		
					3897/MW104/5.5/S/1 D 5.50 m							
			6									
				6.20 9.16					Pale brown and yellow.			
					3897/MW104/6.5/S/1 D 6.50 m							
			7									Backfill Cuttings
					3897/MW104/7.5/S/1 D 7.50 m							
			8									
					3897/MW104/8.5/S/1 D 8.50 m							Casing
			9	*9.10* 6.26					Pale grey.	W		
				9.40 5.96				CI	Sandy Silty CLAY; medium plasticity; dark brown; fine to medium grained sand; trace organic material.	M (>PL)		
					3897/MW104/9.5/S/1 D 9.50 m							

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Engineering Log - TEST

CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	30/09/2019	COMPLETED	01/10/2019	**REF MW104**
PROJECT	Acid Sulfate Soils Assessment		LOGGED	WX	CHECKED		Sheet 2 OF 3
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	15.36 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 26.00 m depth	NORTHING		ASPECT	South	SLOPE 5-10%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level
AD/T				*10.20* 5.16				CI				MW104
								SP	SAND; fine to medium grained; grey.			
					3897/MW104/10.5/S/1 D 10.50 m							
			11									Backfill Cuttings
					3897/MW104/11.5/S/1 D 11.50 m							
			12									
					3897/MW104/12.5/S/1 D 12.50 m							
			13									
					3897/MW104/14.0-14.5/S/1 D 14.00 m							Bentonite
			14									
			15							W		
					3897/MW104/15.75-16.27/S/1 D 15.75 m							
			16									
			17									Screen
					3897/MW104/17.25/S/1 D 17.25 m							
			18									Sand
					3897/MW104/18.75/S/1 D 18.75 m							
			19									

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CLIENT	Ammos Resource Management Pty Ltd		COMMENCED	30/09/2019	COMPLETED	01/10/2019	**REF MW104**
PROJECT	Acid Sulfate Soils Assessment		LOGGED	WX	CHECKED		Sheet 3 OF 3
SITE	3631 Nelson Bay Road, Bobs Farm, NSW		GEOLOGY	Quaternary	VEGETATION	None	PROJECT NO. P1303897
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	15.36 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 26.00 m depth	NORTHING		ASPECT	South	SLOPE 5-10%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level
AD/T			21		3897/MW104/20.25/S/1 D 20.25 m			SP	SAND; fine to medium grained; grey.			MW104 Sand
				21.75 -6.39	3897/MW104/21.75/S/1 D 21.75 m			SP	SAND; fine grained; grey.			
			22									
			23		3897/MW104/23.25/S/1 D 23.25 m					W		Screen
			24									
			25		3897/MW104/24.75/S/1 D 24.75 m							
			26	*26.00*					Hole Terminated at 26.00 m			
			27									
			28									
			29									

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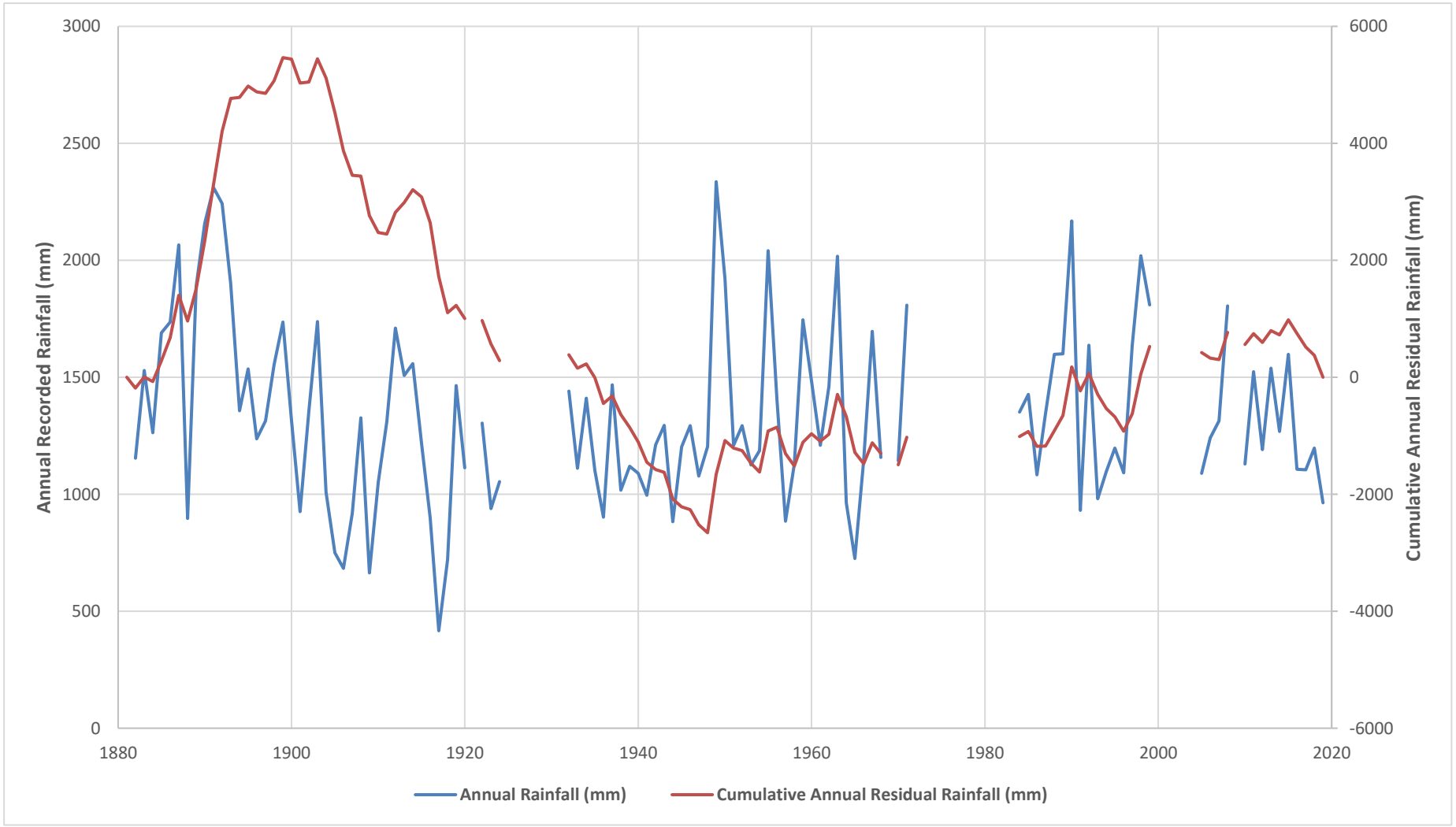
Engineering Log - TEST

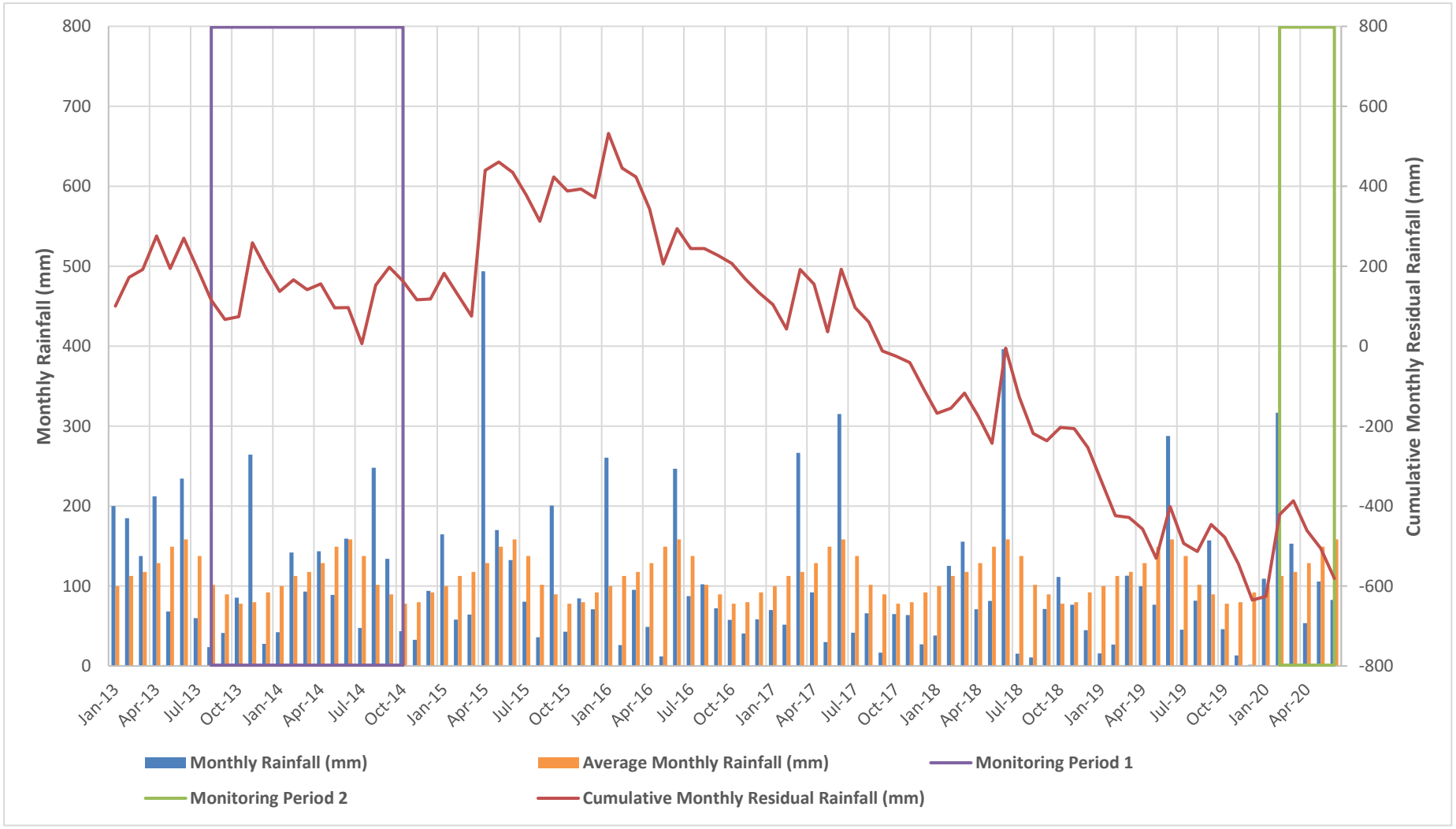
14 Attachment D – Figures



NOTES:

- Cumulative annual residual rainfall is the running total of recorded annual rainfall minus average annual rainfall.

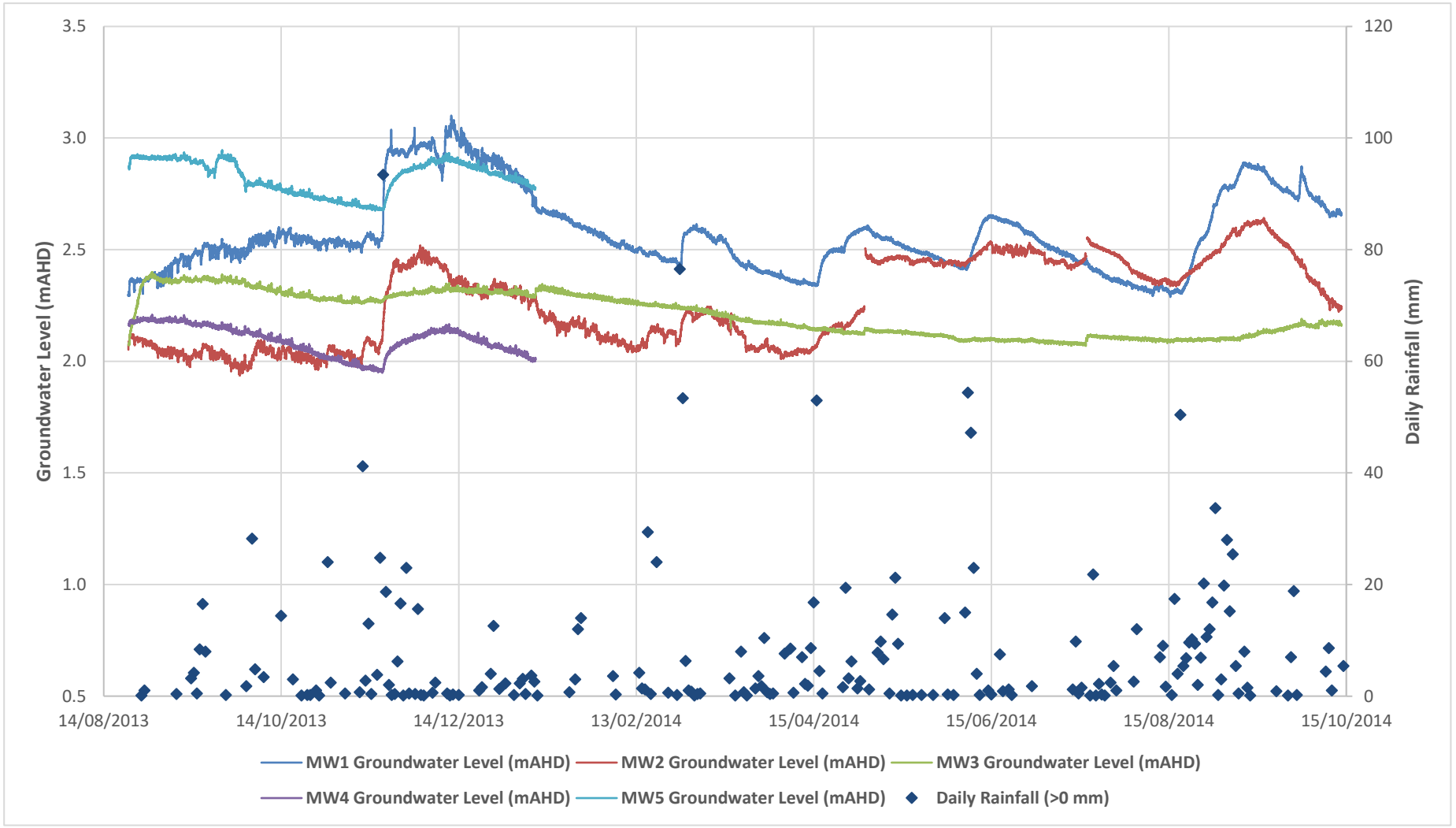
Martens & Associates Pty Ltd		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	JCF	**Figure 3:** Historical Annual Rainfall and Cumulative Annual Residual Rainfall at Nelson Bay (BoM Station 061054).	Report: P1303897JR08V02
Approved:	DM		
Date:	05/11/2020		Page 144



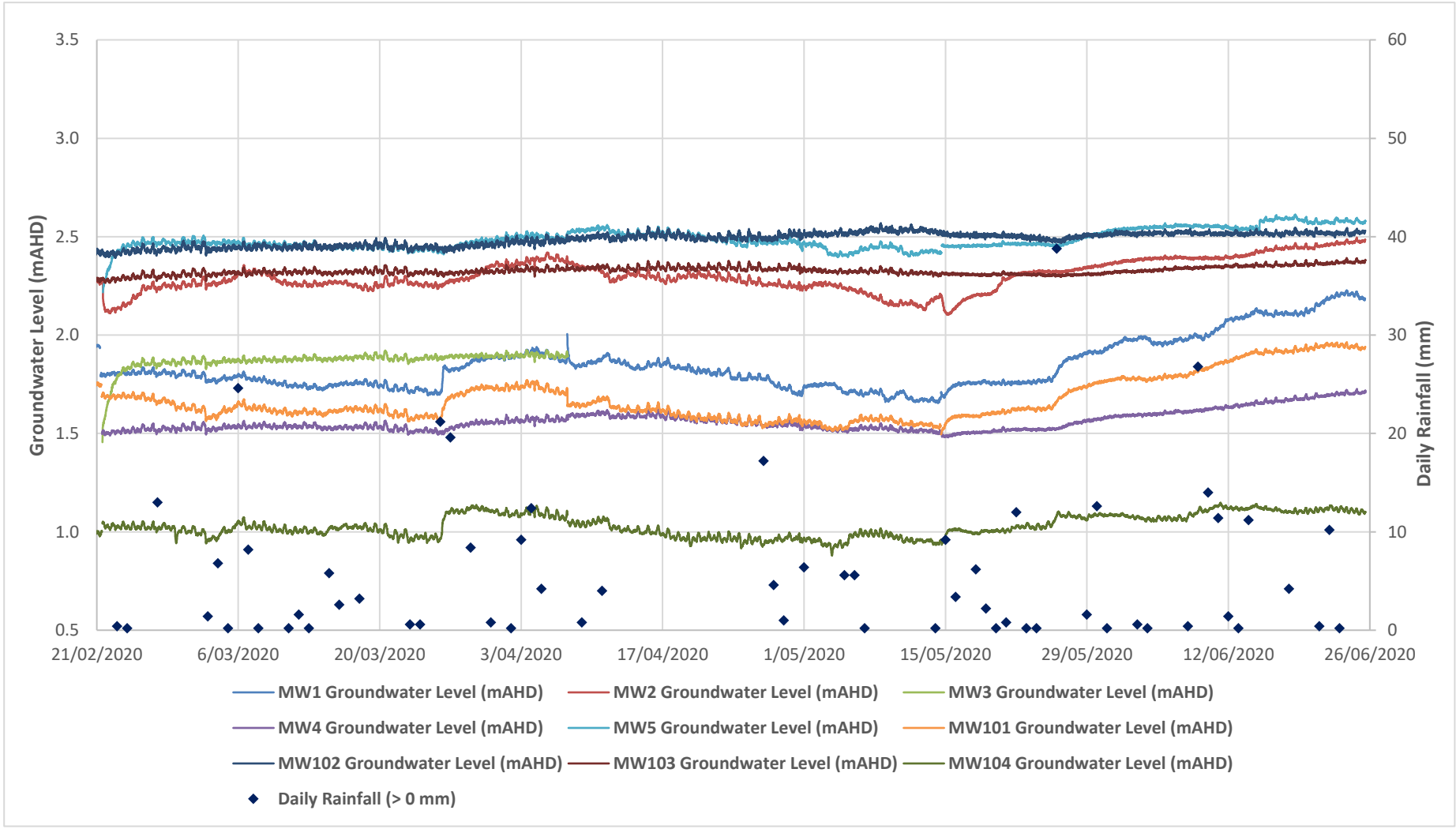
NOTES:

- Cumulative monthly residual rainfall is the running total of recorded monthly rainfall minus average monthly rainfall.

Martens & Associates Pty Ltd	**Environment | Water | Wastewater | Geotechnical | Civil | Management**
Drawn: JCF	**Figure 4:** Recorded and Average Monthly Rainfall, and Cumulative Monthly Residual Rainfall for the Year Preceding Groundwater Monitoring.
Approved: DM	Report: P1303897JR08V02
Date: 05/11/2020	Page 145

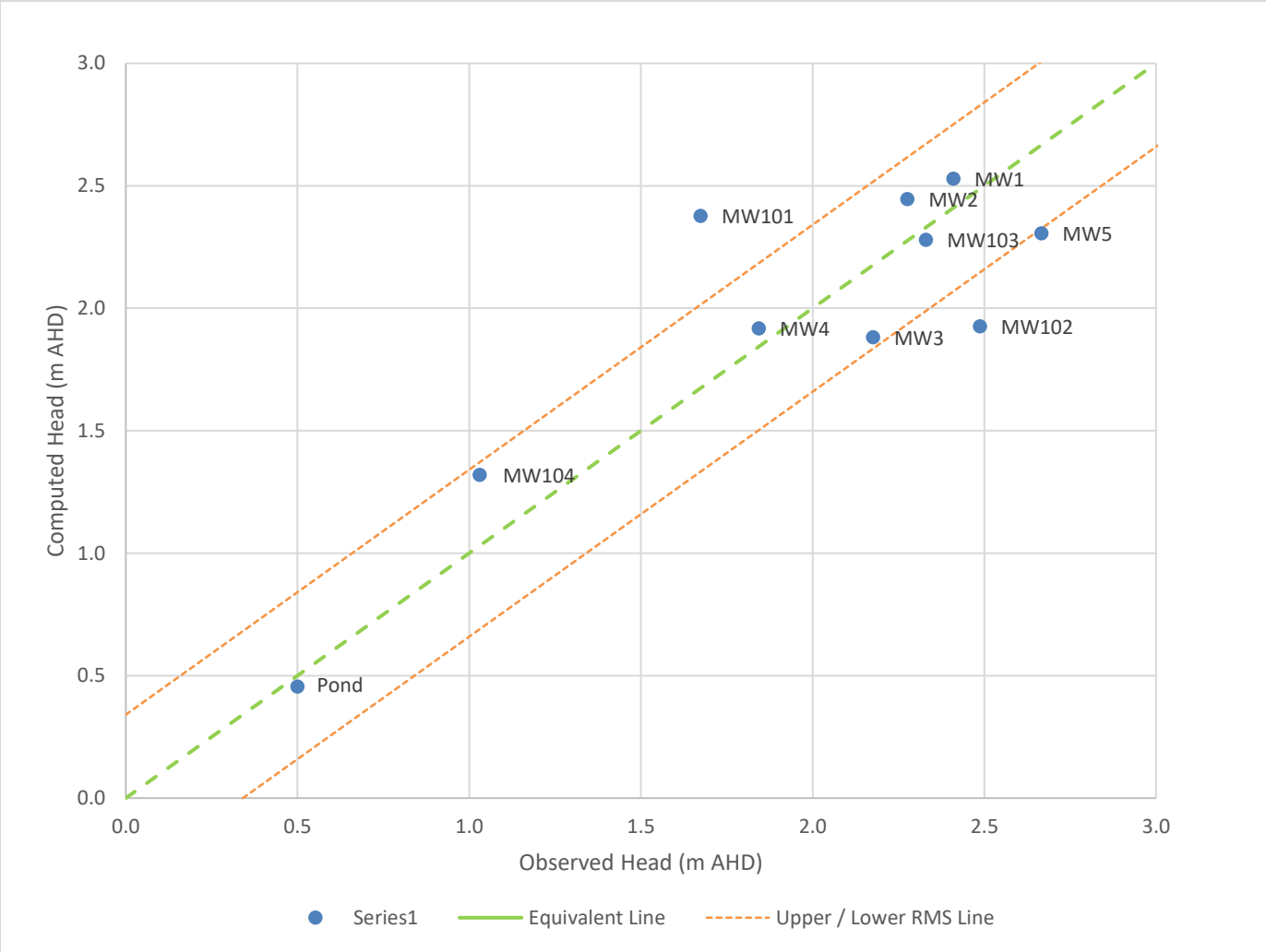


	Martens & Associates Pty Ltd		**Environment | Water | Wastewater | Geotechnical | Civil | Management**
	Drawn:	JCF	**Figure 5:** Groundwater Levels and Daily Rainfall for the first monitoring period.
	Approved:	DM	Report: P1303897JR08V02
	Date:	05/11/2020	Page 146



	Martens & Associates Pty Ltd		**Environment | Water | Wastewater | Geotechnical | Civil | Management**
	Drawn:	JCF	**Figure 6:** Groundwater Levels and Daily Rainfall for the second monitoring period.
	Approved:	DM	Report: P1303897JR08V02
	Date:	05/11/2020	Page 147

No. of Data Points	10
Mean Residual (m)	0.004
Mean Absolute Residual (m)	0.267
Root Mean Squared Residual (m)	0.341



	Martens & Associates Pty Ltd	**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
	Drawn: JCF	**Figure 7**: Pre-development Conditions Model Calibration Results.	Report: P1303897JR08V02
	Approved: DM		
	Date: 05/11/2020		Page 148

15 Attachment E – Slug Test Results

Single Bore Slug Test (Rising or Falling)

Method ST-13 Revised 7.3.2007

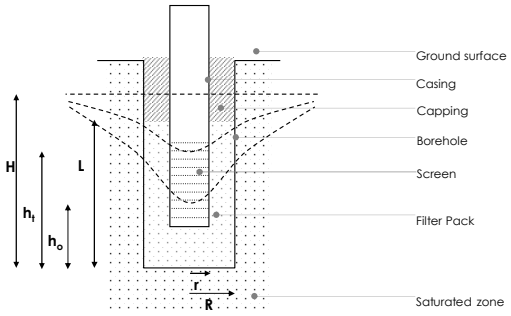
martens consulting engineers

PROJECT DETAILS

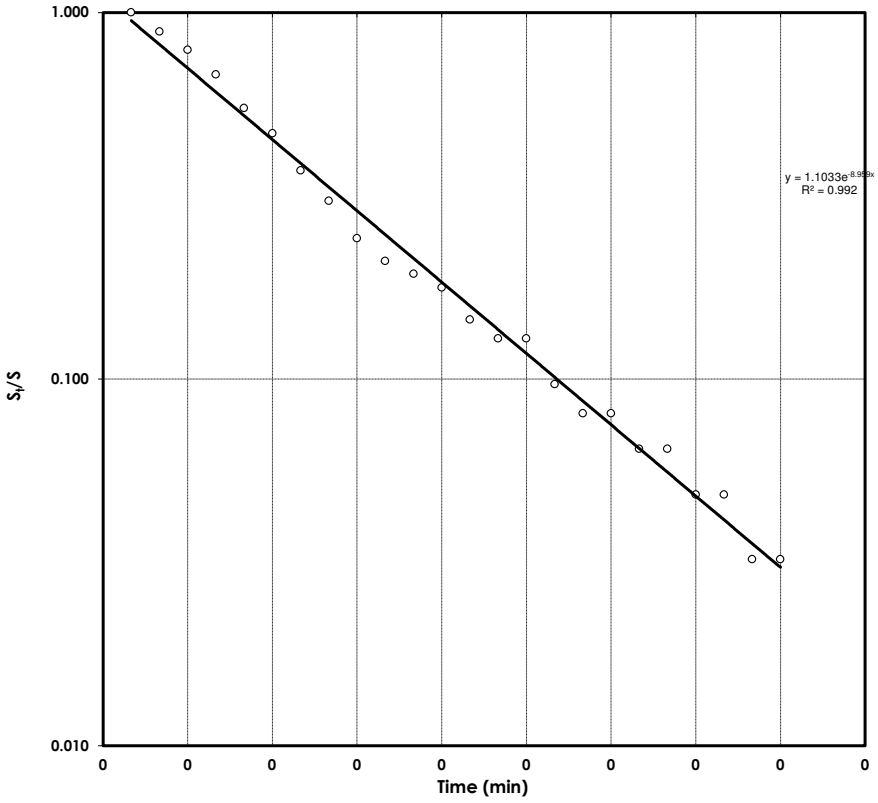
Project	P1303897	Test Date	01.10.2013
Project Ref	P1303897JS03V03	Field Testing	B.Rose
Borehole Ref	MW1	Data Analysis	B.Rose
Method	Hvorslev (1981)	Reviewed	D.Martens

FIELD TEST DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	18.63	m
h_o - Water level reading at time = 0 (depth)	19.25	m
r - Casing radius	0.025	m
R - Bore radius	0.050	m
L - Length of open screen	2.00	m
T_o - Length of characteristic time	0.12	minutes
K_{sat} - Saturated hydraulic conductivity	6.81	m/d



DATA PLOT



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Single Bore Slug Test (Rising or Falling)

Method ST-13 Revised 7.3.2007

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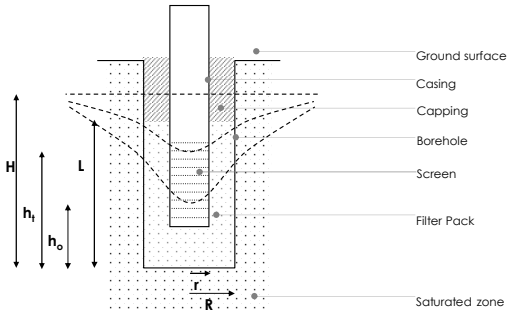
PROJECT DETAILS

Project	P1303897	Test Date	01.10.2013
Project Ref	P1303897JS03V03	Field Testing	B.Rose
Borehole Ref	MW2	Data Analysis	B.Rose
Method	Hvorslev (1981)	Reviewed	D.Martens

FIELD TEST DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	13.32	m
h_o - Water level reading at time = 0 (depth)	13.86	m
r - Casing radius	0.025	m
R - Bore radius	0.050	m
L - Length of open screen	2.00	m
T_o - Length of characteristic time	0.05	minutes
K_{sat} - Saturated hydraulic conductivity	17.21	m/d



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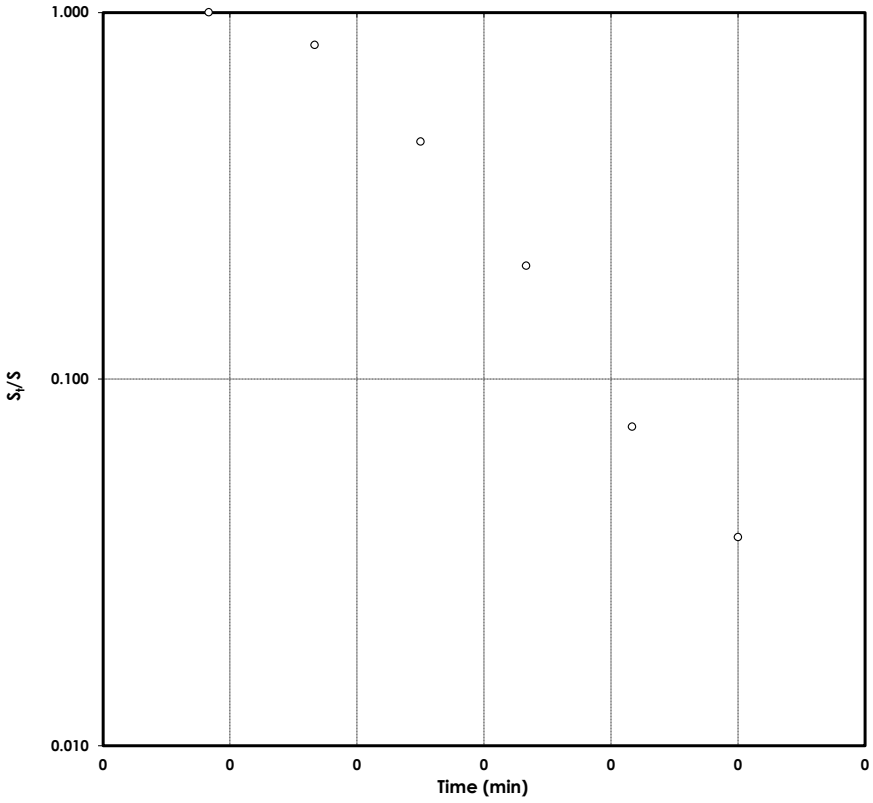

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Single Bore Slug Test (Rising or Falling)

Method ST-13 Revised 7.3.2007

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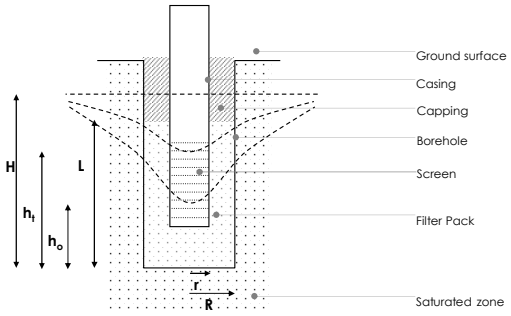
PROJECT DETAILS

Project	P1303897	Test Date	01.10.2013
Project Ref	P1303897JS03V03	Field Testing	B.Rose
Borehole Ref	MW3	Data Analysis	B.Rose
Method	Hvorslev (1981)	Reviewed	D.Martens

FIELD TEST DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	14.79	m
h_o - Water level reading at time = 0 (depth)	15.13	m
r - Casing radius	0.025	m
R - Bore radius	0.050	m
L - Length of open screen	2.00	m
T_o - Length of characteristic time	0.09	minutes
K_{sat} - Saturated hydraulic conductivity	9.00	m/d



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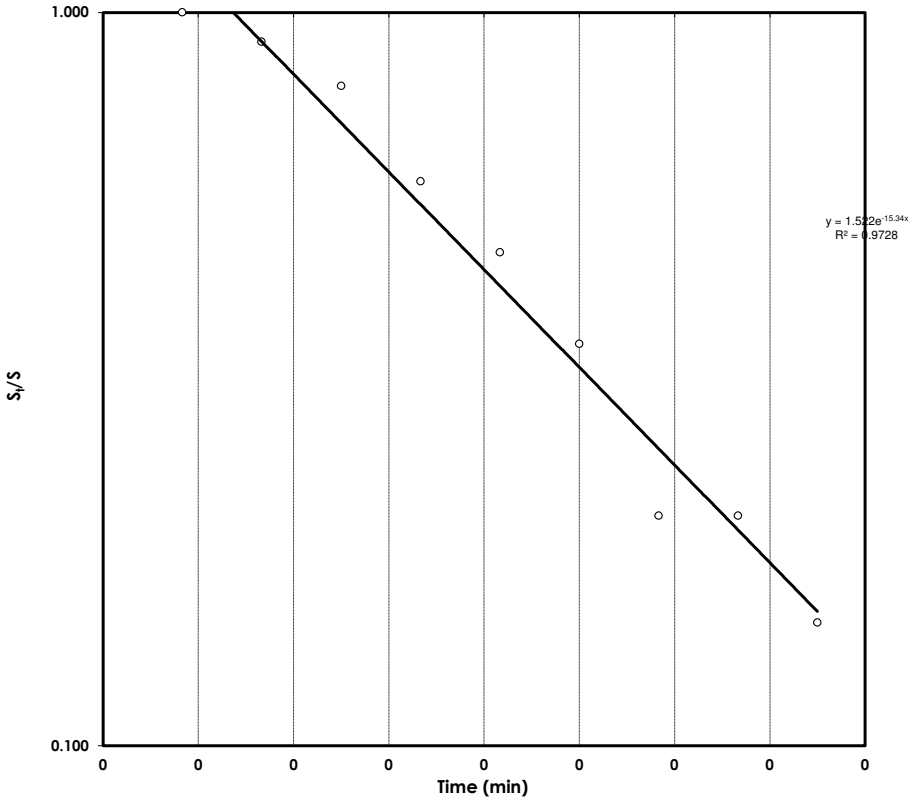

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Single Bore Slug Test (Rising or Falling)

Method ST-13 Revised 7.3.2007

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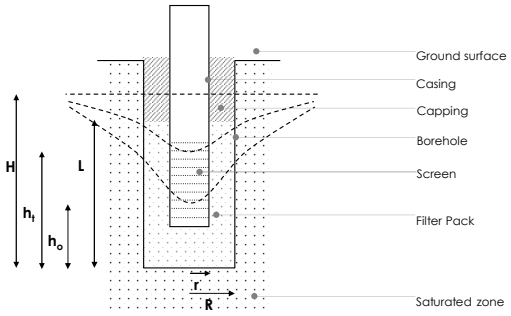
PROJECT DETAILS

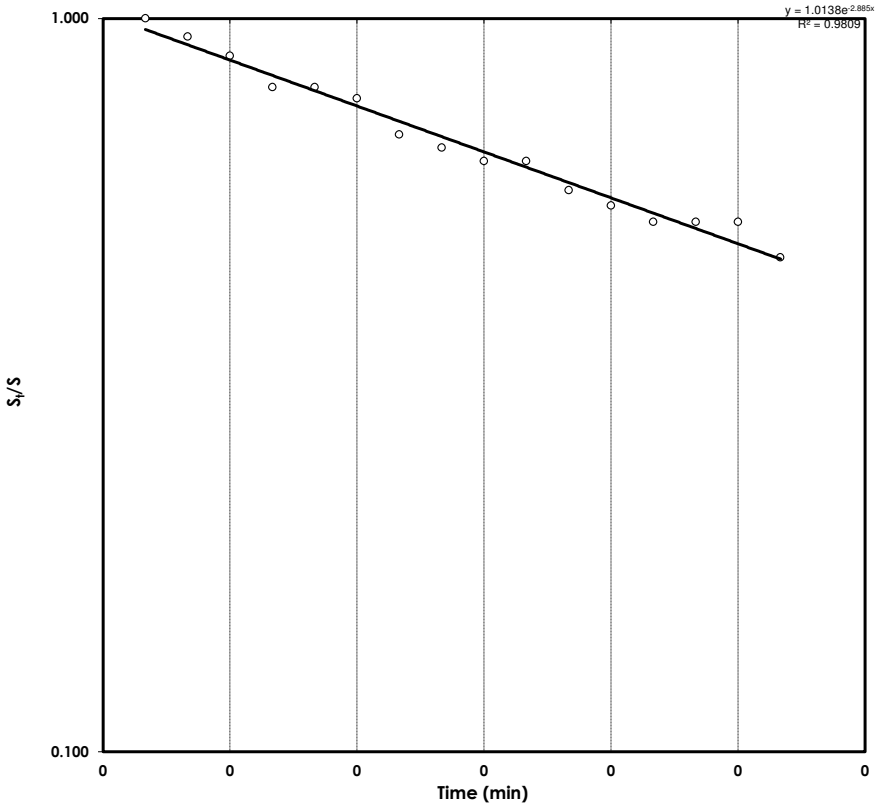
Project	P1303897	Test Date	01.10.2013
Project Ref	P1303897JS03V03	Field Testing	B.Rose
Borehole Ref	MW4	Data Analysis	B.Rose
Method	Hvorslev (1981)	Reviewed	D.Martens

FIELD TEST DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	12.76	m
h_o - Water level reading at time = 0 (depth)	13.12	m
r - Casing radius	0.025	m
R - Bore radius	0.050	m
L - Length of open screen	2.00	m
T_o - Length of characteristic time	0.35	minutes
K_{sat} - Saturated hydraulic conductivity	2.38	m/d



DATA PLOT



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Single Bore Slug Test (Rising or Falling)

Method ST-13 Revised 7.3.2007

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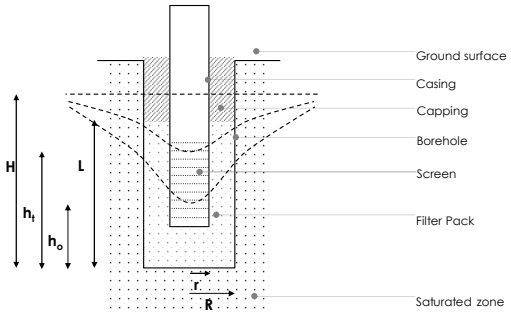
PROJECT DETAILS

Project	P1303897	Test Date	01.10.2013
Project Ref	P1303897JS03V03	Field Testing	B.Rose
Borehole Ref	MW5	Data Analysis	B.Rose
Method	Hvorslev (1981)	Reviewed	D.Martens

FIELD TEST DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	16.43	m
h_o - Water level reading at time = 0 (depth)	16.86	m
r - Casing radius	0.025	m
R - Bore radius	0.050	m
L - Length of open screen	2.00	m
T_o - Length of characteristic time	0.21	minutes
K_{sat} - Saturated hydraulic conductivity	3.95	m/d



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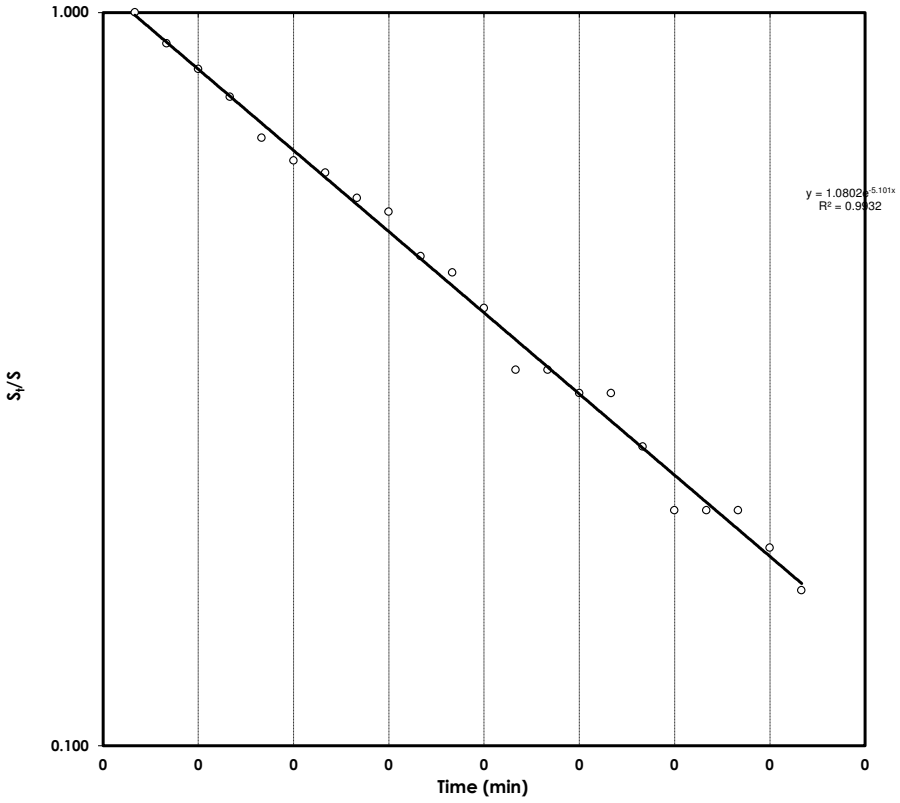

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16 Attachment F – Groundwater Quality Results

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12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
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CERTIFICATE OF ANALYSIS 96132

Client:

Martens & Associates Pty Ltd
6/37 Leighton Place
Hornsby
NSW 2077

Attention: Ben Rose, Gray Taylor

Sample log in details:

Your Reference:	**P1303897, Bobs Farm**		
No. of samples:	5 waters		
Date samples received / completed instructions received	23/08/13	/	23/08/13

This report replaces the previous R00 report due to the addition of pH results

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: / Issue Date:	30/08/13	/	8/01/14
Date of Preliminary Report:	Not issued		

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Accredited for compliance with ISO/IEC 17025. **Tests not covered by NATA are denoted with *.**

Results Approved By:

Jacinta Hurst
Laboratory Manager

Ion Balance Our Reference: Your Reference Date Sampled Type of sample	UNITS ---------- ----------	96132-1 3897/GMB01 22/08/2013 water	96132-2 3897/GMB02 22/08/2013 water	96132-3 3897/GMB03 22/08/2013 water	96132-4 3897/GMB04 22/08/2013 water	96132-5 3897/GMB05 22/08/2013 water
Date prepared	-	24/08/2013	24/08/2013	24/08/2013	24/08/2013	24/08/2013
Date analysed	-	24/08/2013	24/08/2013	24/08/2013	24/08/2013	24/08/2013
Calcium - Dissolved	mg/L	20	13	1.9	1.0	7.3
Potassium - Dissolved	mg/L	47	57	2.2	1.6	9.7
Sodium - Dissolved	mg/L	28	23	32	26	22
Magnesium - Dissolved	mg/L	16	13	4.0	3.2	7.8
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	7	7	8	<5	19
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	7	7	8	<5	19
Sulphate, SO4	mg/L	77	57	11	9	25
Chloride, Cl	mg/L	88	37	54	43	40
Ionic Balance	%	6.1	27	-1.3	1.9	4.4

Miscellaneous Inorganics						
Our Reference:	UNITS	96132-1	96132-2	96132-3	96132-4	96132-5
Your Reference	----------	3897/GMB01	3897/GMB02	3897/GMB03	3897/GMB04	3897/GMB05
Date Sampled	----------	22/08/2013	22/08/2013	22/08/2013	22/08/2013	22/08/2013
Type of sample		water	water	water	water	water
Date prepared	-	24/08/2013	24/08/2013	24/08/2013	24/08/2013	24/08/2013
Date analysed	-	24/08/2013	24/08/2013	24/08/2013	24/08/2013	24/08/2013
pH	pH Units	5.3	5.4	5.6	5.2	6.0
Electrical Conductivity	µS/cm	500	490	250	190	270
Total Dissolved Solids (grav)	mg/L	310	[NA]	[NA]	[NA]	[NA]
Total Suspended Solids	mg/L	32	[NA]	[NA]	[NA]	[NA]
NOx as N in water	mg/L	16	21	0.01	<0.005	0.86
TKN in water	mg/L	1.9	2.3	0.5	0.3	1.7
Ammonia as N in water	mg/L	0.24	0.78	0.45	0.064	0.65
Nitrate as N in water	mg/L	16	21	0.015	<0.005	0.85

Metals in Water - Dissolved						
Our Reference:	UNITS	96132-1	96132-2	96132-3	96132-4	96132-5
Your Reference	----------	3897/GMB01	3897/GMB02	3897/GMB03	3897/GMB04	3897/GMB05
Date Sampled	----------	22/08/2013	22/08/2013	22/08/2013	22/08/2013	22/08/2013
Type of sample		water	water	water	water	water
Date digested	-	26/08/2013	26/08/2013	26/08/2013	26/08/2013	26/08/2013
Date analysed	-	26/08/2013	26/08/2013	26/08/2013	26/08/2013	26/08/2013
Phosphorus - Dissolved	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05

Metals in Waters - Acid extractable						
Our Reference:	UNITS	96132-1	96132-2	96132-3	96132-4	96132-5
Your Reference	----------	3897/GMB01	3897/GMB02	3897/GMB03	3897/GMB04	3897/GMB05
Date Sampled	----------	22/08/2013	22/08/2013	22/08/2013	22/08/2013	22/08/2013
Type of sample		water	water	water	water	water
Date prepared	-	26/08/2013	26/08/2013	26/08/2013	26/08/2013	26/08/2013
Date analysed	-	27/08/2013	27/08/2013	27/08/2013	27/08/2013	27/08/2013
Phosphorus - Total	mg/L	0.1	<0.05	<0.05	<0.05	0.07

Method ID	Methodology Summary
Metals-020 ICP-AES	Determination of various metals by ICP-AES.
Inorg-006	Alkalinity - determined titrimetrically in accordance with APHA 22nd ED, 2320-B.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA 22nd ED, 4110 -B.
Inorg-041	Gravimetric determination of the total solids content of water using APHA 22nd ED 2540B.
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA 22nd ED, 4500-H+.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell and dedicated meter, in accordance with APHA 22nd ED 2510 and Rayment & Lyons.
Inorg-018	Total Dissolved Solids - determined gravimetrically. The solids are dried at 180+/-5oC.
Inorg-019	Suspended Solids - determined gravimetrcially by filtration of the sample, in accordance with APHA 22nd ED, 2540-D. The samples are dried at 104+/-5oC.
Inorg-055	Nitrate - determined colourimetrically based on EPA353.2 and APHA 22nd ED NO3- F. Soils are analysed following a water extraction.
Inorg-062	TKN - determined colourimetrically based on APHA 22nd ED 4500 Norg.
Inorg-057	Ammonia - determined colourimetrically based on EPA350.1 and APHA 22nd ED 4500-NH3 F, Soils are analysed following a KCl extraction.

QUALITY CONTROL Ion Balance	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			26/08/2013	96132-5	24/08/2013 || 24/08/2013	LCS-W3	26/08/2013
Date analysed	-			26/08/2013	96132-5	24/08/2013 || 24/08/2013	LCS-W3	26/08/2013
Calcium - Dissolved	mg/L	0.5	Metals-020 ICP-AES	<0.5	96132-5	7.3 || 7.2 || RPD: 1	LCS-W3	93%
Potassium - Dissolved	mg/L	0.5	Metals-020 ICP-AES	<0.5	96132-5	9.7 || 9.8 || RPD: 1	LCS-W3	96%
Sodium - Dissolved	mg/L	0.5	Metals-020 ICP-AES	<0.5	96132-5	22 || 23 || RPD: 4	LCS-W3	93%
Magnesium - Dissolved	mg/L	0.5	Metals-020 ICP-AES	<0.5	96132-5	7.8 || 7.8 || RPD: 0	LCS-W3	94%
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006	<5	96132-5	<5 || [N/T]	[NR]	[NR]
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	96132-5	19 || [N/T]	[NR]	[NR]
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	96132-5	<5 || [N/T]	[NR]	[NR]
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	96132-5	19 || [N/T]	LCS-W3	104%
Sulphate, SO4	mg/L	1	Inorg-081	<1	96132-5	25 || [N/T]	LCS-W3	99%
Chloride, Cl	mg/L	1	Inorg-081	<1	96132-5	40 || [N/T]	LCS-W3	90%
Ionic Balance	%		Inorg-041	[NT]	96132-5	4.4 || [N/T]	[NR]	[NR]

QUALITY CONTROL Miscellaneous Inorganics	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			24/08/2013	96132-1	24/08/2013 || 24/08/2013	LCS-W1	24/08/2013
Date analysed	-			24/08/2013	96132-1	24/08/2013 || 24/08/2013	LCS-W1	24/08/2013
pH	pH Units		Inorg-001	[NT]	96132-1	5.3 || 5.3 || RPD: 0	LCS-W1	102%
Electrical Conductivity	µS/cm	1	Inorg-002	<1	96132-1	500 || 490 || RPD: 2	LCS-W1	102%
Total Dissolved Solids (grav)	mg/L	5	Inorg-018	<5	96132-1	310 || [N/T]	LCS-W1	95%
Total Suspended Solids	mg/L	5	Inorg-019	<5	96132-1	32 || [N/T]	LCS-W1	95%
NOx as N in water	mg/L	0.005	Inorg-055	<0.005	96132-1	16 || 15 || RPD: 6	LCS-W1	90%
TKN in water	mg/L	0.1	Inorg-062	<0.1	96132-1	1.9 || 1.9 || RPD: 0	LCS-W1	96%
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	96132-1	0.24 || 0.23 || RPD: 4	LCS-W1	116%
Nitrate as N in water	mg/L	0.005	Inorg-055	<0.005	96132-1	16 || 15 || RPD: 6	LCS-W1	90%

QUALITY CONTROL Metals in Water - Dissolved	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date digested	-			26/08/2013	96132-5	26/08/2013 || 26/08/2013	LCS-W3	26/08/2013
Date analysed	-			26/08/2013	96132-5	26/08/2013 || 26/08/2013	LCS-W3	26/08/2013
Phosphorus - Dissolved	mg/L	0.05	Metals-020 ICP-AES	<0.05	96132-5	<0.05 || <0.05	LCS-W3	91%

QUALITY CONTROL Metals in Waters - Acid extractable	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			26/08/2013	[NT]	[NT]	LCS-W1	26/08/2013
Date analysed	-			26/08/2013	[NT]	[NT]	LCS-W1	26/08/2013
Phosphorus - Total	mg/L	0.05	Metals-020 ICP-AES	<0.05	[NT]	[NT]	LCS-W1	97%

QUALITY CONTROL Ion Balance	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD
Date prepared	-	96132-1	24/08/2013 || 24/08/2013
Date analysed	-	96132-1	24/08/2013 || 24/08/2013
Calcium - Dissolved	mg/L	96132-1	20 || [N/T]
Potassium - Dissolved	mg/L	96132-1	47 || [N/T]
Sodium - Dissolved	mg/L	96132-1	28 || [N/T]
Magnesium - Dissolved	mg/L	96132-1	16 || [N/T]
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	96132-1	<5 || <5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	96132-1	7 || 7 || RPD: 0
Carbonate Alkalinity as $CaCO_3$	mg/L	96132-1	<5 || <5
Total Alkalinity as $CaCO_3$	mg/L	96132-1	7 || 7 || RPD: 0
Sulphate, SO4	mg/L	96132-1	77 || [N/T]
Chloride, Cl	mg/L	96132-1	88 || [N/T]
Ionic Balance	%	96132-1	6.1 || [N/T]

Report Comments:

Sample#2:The mass inbalance may be caused by other ions that have not been measured.

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NA: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

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.

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: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics and 10-140% for SVOC 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.

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12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

CERTIFICATE OF ANALYSIS 117694

Client:

Martens & Associates Pty Ltd
6/37 Leighton Place
Hornsby
NSW 2077

Attention: Ben Rose, Gray Taylor

Sample log in details:

Your Reference:	**P1303897, Bobs Farm**
No. of samples:	5 waters
Date samples received / completed instructions received	16/10/2014 / 16/10/2014

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: / Issue Date:	23/10/14 / 23/10/14
Date of Preliminary Report:	Not issued

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Results Approved By:

Jacinta Hurst
Laboratory Manager

Ion Balance Our Reference: Your Reference Date Sampled Type of sample	UNITS ---------- ----------	117694-1 3897/PH1 13/10/2014 water	117694-2 3897/PH2 13/10/2014 water	117694-3 3897/PH3 13/10/2014 water	117694-4 3897/PH4 13/10/2014 water	117694-5 3897/PH5 13/10/2014 water
Date prepared	-	16/10/2014	16/10/2014	16/10/2014	16/10/2014	16/10/2014
Date analysed	-	16/10/2014	16/10/2014	16/10/2014	16/10/2014	16/10/2014
Calcium - Dissolved	mg/L	40	3.3	1.9	1.0	13
Potassium - Dissolved	mg/L	45	11	2.9	1.6	14
Sodium - Dissolved	mg/L	33	11	44	22	39
Magnesium - Dissolved	mg/L	19	8.0	4.4	3.1	10
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	6	<5	<5	<5	20
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	6	<5	<5	<5	20
Sulphate, SO4	mg/L	56	11	36	16	58
Chloride, Cl	mg/L	48	19	68	26	66
Ionic Balance	%	40	36	-4.8	9.7	1.5

Miscellaneous Inorganics						
Our Reference:	UNITS	117694-1	117694-2	117694-3	117694-4	117694-5
Your Reference	----------	3897/PH1	3897/PH2	3897/PH3	3897/PH4	3897/PH5
Date Sampled	----------	13/10/2014	13/10/2014	13/10/2014	13/10/2014	13/10/2014
Type of sample		water	water	water	water	water
Date prepared	-	16/10/2014	16/10/2014	16/10/2014	16/10/2014	16/10/2014
Date analysed	-	16/10/2014	16/10/2014	16/10/2014	16/10/2014	16/10/2014
pH	pH Units	5.2	5.1	3.5	4.7	5.9
Electrical Conductivity	µS/cm	570	190	390	150	400
Total Dissolved Solids (grav)	mg/L	490	160	210	120	350
Total Suspended Solids	mg/L	54	21	<5	430	810
NOx as N in water	mg/L	43	9.5	0.1	0.02	0.86
TKN in water	mg/L	0.7	0.9	0.3	1.6	1.5
Ammonia as N in water	mg/L	0.062	<0.005	0.056	<0.005	0.028
Nitrate as N in water	mg/L	43	9.5	0.10	0.025	0.86

Metals in Water - Dissolved						
Our Reference:	UNITS	117694-1	117694-2	117694-3	117694-4	117694-5
Your Reference	----------	3897/PH1	3897/PH2	3897/PH3	3897/PH4	3897/PH5
Date Sampled	----------	13/10/2014	13/10/2014	13/10/2014	13/10/2014	13/10/2014
Type of sample		water	water	water	water	water
Date digested	-	17/10/2014	17/10/2014	17/10/2014	17/10/2014	17/10/2014
Date analysed	-	17/10/2014	17/10/2014	17/10/2014	17/10/2014	17/10/2014
Phosphorus - Dissolved	mg/L	0.8	<0.05	<0.05	<0.05	<0.05

Metals in Waters - Acid extractable						
Our Reference:	UNITS	117694-1	117694-2	117694-3	117694-4	117694-5
Your Reference	----------	3897/PH1	3897/PH2	3897/PH3	3897/PH4	3897/PH5
Date Sampled	----------	13/10/2014	13/10/2014	13/10/2014	13/10/2014	13/10/2014
Type of sample		water	water	water	water	water
Date prepared	-	20/10/2014	20/10/2014	20/10/2014	20/10/2014	20/10/2014
Date analysed	-	20/10/2014	20/10/2014	20/10/2014	20/10/2014	20/10/2014
Phosphorus - Total	mg/L	0.6	<0.05	<0.05	0.1	0.8

Method ID	Methodology Summary
Metals-020 ICP-AES	Determination of various metals by ICP-AES.
Inorg-006	Alkalinity - determined titrimetrically in accordance with APHA latest edition, 2320-B.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B.
Inorg-041	Gravimetric determination of the total solids content of water based on APHA latest edition 2540B.
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-018	Total Dissolved Solids - determined gravimetrically. The solids are dried at 180+/-5oC.
Inorg-019	Suspended Solids - determined gravimetrcially by filtration of the sample. The samples are dried at 104+/-5oC.
Inorg-055	Nitrate - determined colourimetrically. Soils are analysed following a water extraction.
Inorg-062	TKN - determined colourimetrically based on APHA latest edition 4500 Norg.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Soils are analysed following a KCl extraction.

QUALITY CONTROL Ion Balance	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			16/10/2014	117694-1	16/10/2014 || 16/10/2014	LCS-W1	16/10/2014
Date analysed	-			16/10/2014	117694-1	16/10/2014 || 16/10/2014	LCS-W1	16/10/2014
Calcium - Dissolved	mg/L	0.5	Metals-020 ICP-AES	<0.5	117694-1	40 || 39 || RPD: 3	LCS-W1	103%
Potassium - Dissolved	mg/L	0.5	Metals-020 ICP-AES	<0.5	117694-1	45 || 46 || RPD: 2	LCS-W1	112%
Sodium - Dissolved	mg/L	0.5	Metals-020 ICP-AES	<0.5	117694-1	33 || 34 || RPD: 3	LCS-W1	115%
Magnesium - Dissolved	mg/L	0.5	Metals-020 ICP-AES	<0.5	117694-1	19 || 19 || RPD: 0	LCS-W1	105%
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006	<5	117694-1	<5 || <5	[NR]	[NR]
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	117694-1	6 || 6 || RPD: 0	[NR]	[NR]
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	117694-1	<5 || <5	[NR]	[NR]
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	117694-1	6 || 6 || RPD: 0	LCS-W1	101%
Sulphate, SO4	mg/L	1	Inorg-081	<1	117694-1	56 || 56 || RPD: 0	LCS-W1	115%
Chloride, Cl	mg/L	1	Inorg-081	<1	117694-1	48 || 44 || RPD: 9	LCS-W1	101%
Ionic Balance	%		Inorg-041	[NT]	117694-1	40 || 41 || RPD: 2	[NR]	[NR]

QUALITY CONTROL Miscellaneous Inorganics	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			16/10/2014	117694-1	16/10/2014 || 16/10/2014	LCS-W1	16/10/2014
Date analysed	-			16/10/2014	117694-1	16/10/2014 || 16/10/2014	LCS-W1	16/10/2014
pH	pH Units		Inorg-001	[NT]	117694-1	5.2 || 5.2 || RPD: 0	LCS-W1	101%
Electrical Conductivity	µS/cm	1	Inorg-002	<1	117694-1	570 || 670 || RPD: 16	LCS-W1	102%
Total Dissolved Solids (grav)	mg/L	5	Inorg-018	<5	117694-1	490 || 490 || RPD: 0	LCS-W1	97%
Total Suspended Solids	mg/L	5	Inorg-019	<5	117694-1	54 || 56 || RPD: 4	LCS-W1	94%
NOx as N in water	mg/L	0.005	Inorg-055	<0.005	117694-1	43 || 43 || RPD: 0	LCS-W1	98%
TKN in water	mg/L	0.1	Inorg-062	<0.1	117694-1	0.7 || 0.7 || RPD: 0	LCS-W1	96%
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	117694-1	0.062 || 0.063 || RPD: 2	LCS-W1	92%
Nitrate as N in water	mg/L	0.005	Inorg-055	<0.005	117694-1	43 || 43 || RPD: 0	LCS-W1	94%

QUALITY CONTROL Metals in Water - Dissolved	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date digested	-			16/10/2014	117694-1	17/10/2014 || 17/10/2014	LCS-W2	17/10/2014
Date analysed	-			16/10/2014	117694-1	17/10/2014 || 17/10/2014	LCS-W2	17/10/2014
Phosphorus - Dissolved	mg/L	0.05	Metals-020 ICP-AES	<0.05	117694-1	0.8 || 0.8 || RPD: 0	LCS-W2	113%

QUALITY CONTROL Metals in Waters - Acid extractable	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			20/10/2014	117694-2	20/10/2014 || 20/10/2014	LCS-W1	20/10/2014
Date analysed	-			20/10/2014	117694-2	20/10/2014 || 20/10/2014	LCS-W1	20/10/2014
Phosphorus - Total	mg/L	0.05	Metals-020 ICP-AES	<0.05	117694-2	<0.05 || <0.05	LCS-W1	107%

QUALITY CONTROL Ion Balance	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	117694-2	16/10/2014
Date analysed	-	[NT]	[NT]	117694-2	16/10/2014
Calcium - Dissolved	mg/L	[NT]	[NT]	117694-2	92%
Potassium - Dissolved	mg/L	[NT]	[NT]	117694-2	94%
Sodium - Dissolved	mg/L	[NT]	[NT]	117694-2	82%
Magnesium - Dissolved	mg/L	[NT]	[NT]	117694-2	90%
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	[NT]	[NT]	[NR]	[NR]
Bicarbonate Alkalinity as $CaCO_3$	mg/L	[NT]	[NT]	[NR]	[NR]
Carbonate Alkalinity as $CaCO_3$	mg/L	[NT]	[NT]	[NR]	[NR]
Total Alkalinity as $CaCO_3$	mg/L	[NT]	[NT]	[NR]	[NR]
Sulphate, SO4	mg/L	[NT]	[NT]	[NR]	[NR]
Chloride, Cl	mg/L	[NT]	[NT]	[NR]	[NR]
Ionic Balance	%	[NT]	[NT]	[NR]	[NR]

QUALITY CONTROL Metals in Water - Dissolved	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date digested	-	[NT]	[NT]	117694-2	17/10/2014
Date analysed	-	[NT]	[NT]	117694-2	17/10/2014
Phosphorus - Dissolved	mg/L	[NT]	[NT]	117694-2	101%
QUALITY CONTROL Metals in Waters - Acid extractable	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	117694-3	20/10/2014
Date analysed	-	[NT]	[NT]	117694-3	20/10/2014
Phosphorus - Total	mg/L	[NT]	[NT]	117694-3	110%

Report Comments:

Sample #1 and 2:The mass inbalance may be caused by other ions that have not been measured.

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NA: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

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.

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: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics and 10-140% for SVOC 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.

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CERTIFICATE OF ANALYSIS 122756

Client:

Martens & Associates Pty Ltd
6/37 Leighton Place
Hornsby
NSW 2077

Attention: Ben Rose

Sample log in details:

Your Reference:	**P1303897, Bob's Farm**		
No. of samples:	5 waters		
Date samples received / completed instructions received	30/01/15	/	30/01/15

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: / Issue Date:	6/02/15	/	6/02/15
Date of Preliminary Report:	Not issued		

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Accredited for compliance with ISO/IEC 17025. **Tests not covered by NATA are denoted with *.**

Results Approved By:

Jacinta Hurst
Laboratory Manager

Ion Balance Our Reference: Your Reference Date Sampled Type of sample	UNITS ---------- ----------	122756-1 3897/PH1 29/01/2015 water	122756-2 3897/PH2 29/01/2015 water	122756-3 3897/PH3 29/01/2015 water	122756-4 3897/PH4 29/01/2015 water	122756-5 3897/PH5 29/01/2015 water
Date prepared	-	30/01/2015	30/01/2015	30/01/2015	30/01/2015	30/01/2015
Date analysed	-	30/01/2015	30/01/2015	30/01/2015	30/01/2015	30/01/2015
Calcium - Dissolved	mg/L	15	11	2.1	0.9	17
Potassium - Dissolved	mg/L	28	35	2.9	1.3	15
Sodium - Dissolved	mg/L	30	18	46	25	39
Magnesium - Dissolved	mg/L	9.3	11	4.5	2.1	11
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	21	13	<5	5	15
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	21	13	<5	5	15
Sulphate, SO4	mg/L	60	40	20	10	96
Chloride, Cl	mg/L	48	31	74	35	55
Ionic Balance	%	8.3	23	1.0	0.70	-0.52

Miscellaneous Inorganics						
Our Reference:	UNITS	122756-1	122756-2	122756-3	122756-4	122756-5
Your Reference	----------	3897/PH1	3897/PH2	3897/PH3	3897/PH4	3897/PH5
Date Sampled	----------	29/01/2015	29/01/2015	29/01/2015	29/01/2015	29/01/2015
Type of sample		water	water	water	water	water
Date prepared	-	30/01/2015	30/01/2015	30/01/2015	30/01/2015	30/01/2015
Date analysed	-	30/01/2015	30/01/2015	30/01/2015	30/01/2015	30/01/2015
pH	pH Units	5.8	5.5	4.7	5.1	5.6
Electrical Conductivity	µS/cm	410	390	300	150	430
Total Dissolved Solids (grav)	mg/L	240	210	160	92	280
Total Suspended Solids	mg/L	38	19	220	13	310
NOx as N in water	mg/L	7.8	19	0.2	0.04	0.81
TKN in water	mg/L	2.1	1.3	0.8	0.6	1.5
Ammonia as N in water	mg/L	0.21	<0.005	0.081	0.041	0.060
Nitrate as N in water	mg/L	7.8	19	0.20	0.045	0.79

Metals in Water - Dissolved						
Our Reference:	UNITS	122756-1	122756-2	122756-3	122756-4	122756-5
Your Reference	----------	3897/PH1	3897/PH2	3897/PH3	3897/PH4	3897/PH5
Date Sampled	----------	29/01/2015	29/01/2015	29/01/2015	29/01/2015	29/01/2015
Type of sample		water	water	water	water	water
Date digested	-	02/02/2015	02/02/2015	02/02/2015	02/02/2015	02/02/2015
Date analysed	-	02/02/2015	02/02/2015	02/02/2015	02/02/2015	02/02/2015
Phosphorus - Dissolved	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05

Metals in Waters - Acid extractable						
Our Reference:	UNITS	122756-1	122756-2	122756-3	122756-4	122756-5
Your Reference	----------	3897/PH1	3897/PH2	3897/PH3	3897/PH4	3897/PH5
Date Sampled	----------	29/01/2015	29/01/2015	29/01/2015	29/01/2015	29/01/2015
Type of sample		water	water	water	water	water
Date prepared	-	02/02/2015	02/02/2015	02/02/2015	02/02/2015	02/02/2015
Date analysed	-	02/02/2015	02/02/2015	02/02/2015	02/02/2015	02/02/2015
Phosphorus - Total	mg/L	0.06	<0.05	0.1	<0.05	0.5

Method ID	Methodology Summary
Metals-020 ICP-AES	Determination of various metals by ICP-AES.
Inorg-006	Alkalinity - determined titrimetrically in accordance with APHA latest edition, 2320-B.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B.
Inorg-041	Gravimetric determination of the total solids content of water based on APHA latest edition 2540B.
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-018	Total Dissolved Solids - determined gravimetrically. The solids are dried at 180+/-5oC.
Inorg-019	Suspended Solids - determined gravimetrcially by filtration of the sample. The samples are dried at 104+/-5oC.
Inorg-055	Nitrate - determined colourimetrically. Soils are analysed following a water extraction.
Inorg-062	TKN - determined colourimetrically based on APHA latest edition 4500 Norg.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Soils are analysed following a KCl extraction.

QUALITY CONTROL Ion Balance	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			30/01/2015	122756-1	30/01/2015 || 30/01/2015	LCS-W2	30/01/2015
Date analysed	-			30/01/2015	122756-1	30/01/2015 || 30/01/2015	LCS-W2	30/01/2015
Calcium - Dissolved	mg/L	0.5	Metals-020 ICP-AES	<0.5	122756-1	15 || [N/T]	LCS-W2	98%
Potassium - Dissolved	mg/L	0.5	Metals-020 ICP-AES	<0.5	122756-1	28 || [N/T]	LCS-W2	102%
Sodium - Dissolved	mg/L	0.5	Metals-020 ICP-AES	<0.5	122756-1	30 || [N/T]	LCS-W2	103%
Magnesium - Dissolved	mg/L	0.5	Metals-020 ICP-AES	<0.5	122756-1	9.3 || [N/T]	LCS-W2	97%
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006	<5	122756-1	<5 || <5	[NR]	[NR]
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	122756-1	21 || 21 || RPD: 0	[NR]	[NR]
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	122756-1	<5 || <5	[NR]	[NR]
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	122756-1	21 || 21 || RPD: 0	LCS-W2	100%
Sulphate, SO4	mg/L	1	Inorg-081	<1	122756-1	60 || 60 || RPD: 0	LCS-W2	108%
Chloride, Cl	mg/L	1	Inorg-081	<1	122756-1	48 || 47 || RPD: 2	LCS-W2	103%
Ionic Balance	%		Inorg-041	[NT]	122756-1	8.3 || [N/T]	[NR]	[NR]

QUALITY CONTROL Miscellaneous Inorganics	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			30/01/2015	122756-1	30/01/2015 || 30/01/2015	LCS-W1	30/01/2015
Date analysed	-			30/01/2015	122756-1	30/01/2015 || 30/01/2015	LCS-W1	30/01/2015
pH	pH Units		Inorg-001	[NT]	122756-1	5.8 || 5.8 || RPD: 0	LCS-W1	102%
Electrical Conductivity	µS/cm	1	Inorg-002	<1	122756-1	410 || 410 || RPD: 0	LCS-W1	106%
Total Dissolved Solids (grav)	mg/L	5	Inorg-018	<5	122756-1	240 || [N/T]	LCS-W1	96%
Total Suspended Solids	mg/L	5	Inorg-019	<5	122756-1	38 || [N/T]	LCS-W1	97%
NOx as N in water	mg/L	0.005	Inorg-055	<0.005	122756-1	7.8 || 7.7 || RPD: 1	LCS-W1	96%
TKN in water	mg/L	0.1	Inorg-062	<0.1	122756-1	2.1 || 2.0 || RPD: 5	LCS-W1	101%
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	122756-1	0.21 || 0.21 || RPD: 0	LCS-W1	100%
Nitrate as N in water	mg/L	0.005	Inorg-055	<0.005	122756-1	7.8 || 7.7 || RPD: 1	LCS-W1	94%

QUALITY CONTROL Metals in Water - Dissolved	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date digested	-			02/02/2015	[NT]	[NT]	LCS-W2	02/02/2015
Date analysed	-			02/02/2015	[NT]	[NT]	LCS-W2	02/02/2015
Phosphorus - Dissolved	mg/L	0.05	Metals-020 ICP-AES	<0.05	[NT]	[NT]	LCS-W2	99%
QUALITY CONTROL Metals in Waters - Acid extractable	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			02/02/2015	[NT]	[NT]	LCS-W2	02/02/2015
Date analysed	-			02/02/2015	[NT]	[NT]	LCS-W2	02/02/2015
Phosphorus - Total	mg/L	0.05	Metals-020 ICP-AES	<0.05	[NT]	[NT]	LCS-W2	116%

QUALITY CONTROL Miscellaneous Inorganics	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD
Date prepared	-	122756-2	30/01/2015 || 30/01/2015
Date analysed	-	122756-2	30/01/2015 || 30/01/2015
Total Dissolved Solids (grav)	mg/L	122756-2	210 || 200 || RPD: 5
Total Suspended Solids	mg/L	122756-2	19 || 20 || RPD: 5

QUALITY CONTROL Metals in Waters - Acid extractable	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	122756-1	02/02/2015
Date analysed	-	[NT]	[NT]	122756-1	02/02/2015
Phosphorus - Total	mg/L	[NT]	[NT]	122756-1	110%

Report Comments:

The mass inbalance in sample #2 may be caused by other ions that have not been measured.

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NA: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

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.

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: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics and 10-140% for SVOC 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.

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CERTIFICATE OF ANALYSIS 127358

Client:

Martens & Associates Pty Ltd
Suite 201, 20 George St
Hornsby
NSW 2077

Attention: Ben Rose

Sample log in details:

Your Reference:	**P1303897JC06V01, Bob's Farm**
No. of samples:	5 waters
Date samples received / completed instructions received	04/05/2015 / 04/05/2015

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: / Issue Date:	11/05/15 / 11/05/15
Date of Preliminary Report:	Not issued

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Results Approved By:

Jacinta Hurst
Laboratory Manager

Ion Balance						
Our Reference:	UNITS	127358-1	127358-2	127358-3	127358-4	127358-5
Your Reference	----------	3897/BH1	3897/BH2	3897/BH3	3897/BH4	3897/BH5
Date Sampled	----------	1/05/2015	1/05/2015	1/05/2015	1/05/2015	1/05/2015
Type of sample		water	water	water	water	water
Date prepared	-	04/05/2015	04/05/2015	04/05/2015	04/05/2015	04/05/2015
Date analysed	-	04/05/2015	04/05/2015	04/05/2015	04/05/2015	04/05/2015
Calcium - Dissolved	mg/L	31	13	2.6	6.4	20
Potassium - Dissolved	mg/L	50	31	4.1	2.4	15
Sodium - Dissolved	mg/L	41	20	49	32	36
Magnesium - Dissolved	mg/L	13	12	5.6	5.2	13
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	7	11	<5	15	16
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	7	11	<5	15	16
Sulphate, SO4	mg/L	46	30	20	6	97
Chloride, Cl	mg/L	51	29	67	56	47
Ionic Balance	%	38	34	10	4.9	5.1

Miscellaneous Inorganics						
Our Reference:	UNITS	127358-1	127358-2	127358-3	127358-4	127358-5
Your Reference	----------	3897/BH1	3897/BH2	3897/BH3	3897/BH4	3897/BH5
Date Sampled	----------	1/05/2015	1/05/2015	1/05/2015	1/05/2015	1/05/2015
Type of sample		water	water	water	water	water
Date prepared	-	04/05/2015	04/05/2015	04/05/2015	04/05/2015	04/05/2015
Date analysed	-	04/05/2015	04/05/2015	04/05/2015	04/05/2015	04/05/2015
pH	pH Units	5.0	5.4	4.9	5.4	5.6
Electrical Conductivity	µS/cm	580	360	280	220	400
Total Dissolved Solids (grav)	mg/L	370	290	150	140	220
Total Suspended Solids	mg/L	24	<5	200	11	200
NOx as N in water	mg/L	31	19	0.08	<0.005	0.2
TKN in water	mg/L	15	14	11	40	9.4
Ammonia as N in water	mg/L	0.012	0.005	0.12	0.27	0.091
Nitrate as N in water	mg/L	31	18	0.077	<0.005	0.17

Metals in Water - Dissolved						
Our Reference:	UNITS	127358-1	127358-2	127358-3	127358-4	127358-5
Your Reference	----------	3897/BH1	3897/BH2	3897/BH3	3897/BH4	3897/BH5
Date Sampled	----------	1/05/2015	1/05/2015	1/05/2015	1/05/2015	1/05/2015
Type of sample		water	water	water	water	water
Date digested	-	05/05/2015	05/05/2015	05/05/2015	05/05/2015	05/05/2015
Date analysed	-	05/05/2015	05/05/2015	05/05/2015	05/05/2015	05/05/2015
Phosphorus - Dissolved	mg/L	0.8	<0.05	<0.05	<0.05	<0.05

Metals in Waters - Acid extractable						
Our Reference:	UNITS	127358-1	127358-2	127358-3	127358-4	127358-5
Your Reference	----------	3897/BH1	3897/BH2	3897/BH3	3897/BH4	3897/BH5
Date Sampled	----------	1/05/2015	1/05/2015	1/05/2015	1/05/2015	1/05/2015
Type of sample		water	water	water	water	water
Date prepared	-	05/05/2015	05/05/2015	05/05/2015	05/05/2015	05/05/2015
Date analysed	-	05/05/2015	05/05/2015	05/05/2015	05/05/2015	05/05/2015
Phosphorus - Total	mg/L	1.1	<0.05	0.2	<0.05	0.3

Method ID	Methodology Summary
Metals-020 ICP-AES	Determination of various metals by ICP-AES.
Inorg-006	Alkalinity - determined titrimetrically in accordance with APHA latest edition, 2320-B.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B.
Inorg-041	Gravimetric determination of the total solids content of water based on APHA latest edition 2540B.
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-018	Total Dissolved Solids - determined gravimetrically. The solids are dried at 180+/-5oC.
Inorg-019	Suspended Solids - determined gravimetrcially by filtration of the sample. The samples are dried at 104+/-5oC.
Inorg-055	Nitrate - determined colourimetrically. Soils are analysed following a water extraction.
Inorg-062	TKN - determined colourimetrically based on APHA latest edition 4500 Norg.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Soils are analysed following a KCl extraction.

QUALITY CONTROL Ion Balance	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			04/05/2015	127358-1	04/05/2015 || 04/05/2015	LCS-W1	04/05/2015
Date analysed	-			04/05/2015	127358-1	04/05/2015 || 04/05/2015	LCS-W1	04/05/2015
Calcium - Dissolved	mg/L	0.5	Metals-020 ICP-AES	<0.5	127358-1	31 || [N/T]	LCS-W1	106%
Potassium - Dissolved	mg/L	0.5	Metals-020 ICP-AES	<0.5	127358-1	50 || [N/T]	LCS-W1	116%
Sodium - Dissolved	mg/L	0.5	Metals-020 ICP-AES	<0.5	127358-1	41 || [N/T]	LCS-W1	105%
Magnesium - Dissolved	mg/L	0.5	Metals-020 ICP-AES	<0.5	127358-1	13 || [N/T]	LCS-W1	110%
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006	<5	127358-1	<5 || <5	[NR]	[NR]
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	127358-1	7 || 8 || RPD: 13	[NR]	[NR]
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	127358-1	<5 || <5	[NR]	[NR]
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	127358-1	7 || 8 || RPD: 13	LCS-W1	102%
Sulphate, SO4	mg/L	1	Inorg-081	<1	127358-1	46 || 46 || RPD: 0	LCS-W1	101%
Chloride, Cl	mg/L	1	Inorg-081	<1	127358-1	51 || 52 || RPD: 2	LCS-W1	100%
Ionic Balance	%		Inorg-041	[NT]	127358-1	38 || [N/T]	[NR]	[NR]

QUALITY CONTROL Miscellaneous Inorganics	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			04/05/2015	127358-1	04/05/2015 || 04/05/2015	LCS-W1	04/05/2015
Date analysed	-			04/05/2015	127358-1	04/05/2015 || 04/05/2015	LCS-W1	04/05/2015
pH	pH Units		Inorg-001	[NT]	127358-1	5.0 || 5.0 || RPD: 0	LCS-W1	100%
Electrical Conductivity	µS/cm	1	Inorg-002	<1	127358-1	580 || 580 || RPD: 0	LCS-W1	97%
Total Dissolved Solids (grav)	mg/L	5	Inorg-018	<5	127358-1	370 || 380 || RPD: 3	LCS-W1	86%
Total Suspended Solids	mg/L	5	Inorg-019	<5	127358-1	24 || 25 || RPD: 4	LCS-W1	110%
NOx as N in water	mg/L	0.005	Inorg-055	<0.005	127358-1	31 || 32 || RPD: 3	LCS-W1	108%
TKN in water	mg/L	0.1	Inorg-062	<0.1	127358-1	15 || 15 || RPD: 0	LCS-W1	115%
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	127358-1	0.012 || 0.008 || RPD: 40	LCS-W1	101%
Nitrate as N in water	mg/L	0.005	Inorg-055	<0.005	127358-1	31 || 31 || RPD: 0	LCS-W1	108%

QUALITY CONTROL Metals in Water - Dissolved	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date digested	-			05/05/2015	[NT]	[NT]	LCS-W1	05/05/2015
Date analysed	-			05/05/2015	[NT]	[NT]	LCS-W1	05/05/2015
Phosphorus - Dissolved	mg/L	0.05	Metals-020 ICP-AES	<0.05	[NT]	[NT]	LCS-W1	111%
QUALITY CONTROL Metals in Waters - Acid extractable	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			05/05/2015	127358-1	05/05/2015 || 05/05/2015	LCS-W1	05/05/2015
Date analysed	-			05/05/2015	127358-1	05/05/2015 || 05/05/2015	LCS-W1	05/05/2015
Phosphorus - Total	mg/L	0.05	Metals-020 ICP-AES	<0.05	127358-1	1.1 || 1.1 || RPD: 0	LCS-W1	119%

QUALITY CONTROL Metals in Waters - Acid extractable	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	127358-2	05/05/2015
Date analysed	-	[NT]	[NT]	127358-2	05/05/2015
Phosphorus - Total	mg/L	[NT]	[NT]	127358-2	112%

Report Comments:

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NA: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

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.

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: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
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.

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CERTIFICATE OF ANALYSIS 237389

Client Details

Client	Martens & Associates Pty Ltd
Attention	William Xu
Address	Suite 201, 20 George St, Hornsby, NSW, 2077

Sample Details

Your Reference	**P1303897, Bobs Farm Port Stephens**
Number of Samples	9 WATER
Date samples received	24/02/2020
Date completed instructions received	24/02/2020

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	03/03/2020
Date of Issue	03/03/2020

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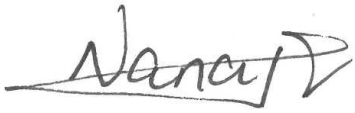
Results Approved By
Jaimie Loa-Kum-Cheung, Metals Supervisor
Priya Samarawickrama, Senior Chemist

Authorised By



Nancy Zhang, Laboratory Manager

Ion Balance						
Our Reference		237389-1	237389-2	237389-3	237389-4	237389-5
Your Reference	UNITS	MW1 / 200221	MW2 / 200221	MW3 / 200221	MW4 / 200221	MW5 / 200221
Date Sampled		21/02/2020	21/02/2020	21/02/2020	21/02/2020	21/02/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	25/02/2020	25/02/2020	25/02/2020	25/02/2020	25/02/2020
Date analysed	-	25/02/2020	25/02/2020	25/02/2020	25/02/2020	25/02/2020
Calcium - Dissolved	mg/L	32	16	2.6	1.9	10
Potassium - Dissolved	mg/L	34	40	8.1	1.3	20
Sodium - Dissolved	mg/L	25	23	29	22	29
Magnesium - Dissolved	mg/L	18	10	4.8	1.7	10
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	23	43	22	16	38
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	23	43	22	16	38
Sulphate, SO4	mg/L	41	50	15	1	60
Chloride, Cl	mg/L	41	28	46	23	49

Ion Balance					
Our Reference		237389-6	237389-7	237389-8	237389-9
Your Reference	UNITS	MW101 / 200221	MW102 / 200221	MW103 / 200221	MW104 / 200221
Date Sampled		21/02/2020	21/02/2020	21/02/2020	21/02/2020
Type of sample		WATER	WATER	WATER	WATER
Date prepared	-	25/02/2020	25/02/2020	25/02/2020	25/02/2020
Date analysed	-	25/02/2020	25/02/2020	25/02/2020	25/02/2020
Calcium - Dissolved	mg/L	7.0	25	33	13
Potassium - Dissolved	mg/L	260	12	37	1.9
Sodium - Dissolved	mg/L	49	32	40	27
Magnesium - Dissolved	mg/L	7.8	12	16	4.1
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	280	150	85	60
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	280	150	85	60
Sulphate, SO4	mg/L	130	5	150	<1
Chloride, Cl	mg/L	77	49	54	45

Miscellaneous Inorganics						
Our Reference		237389-1	237389-2	237389-3	237389-4	237389-5
Your Reference	UNITS	MW1 / 200221	MW2 / 200221	MW3 / 200221	MW4 / 200221	MW5 / 200221
Date Sampled		21/02/2020	21/02/2020	21/02/2020	21/02/2020	21/02/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	25/02/2020	25/02/2020	25/02/2020	25/02/2020	25/02/2020
Date analysed	-	25/02/2020	25/02/2020	25/02/2020	25/02/2020	25/02/2020
pH	pH Units	5.8	6.1	5.8	5.7	6.0
Electrical Conductivity	µS/cm	760	400	240	150	380
Total Suspended Solids	mg/L	71	<5	6	300	34
Total Dissolved Solids (grav)	mg/L	550	300	140	120	280
Total Nitrogen in water	mg/L	39	12	0.8	0.2	1.9
NOx as N in water	mg/L	29	11	0.04	<0.005	0.05
Ammonia as N in water	mg/L	0.11	0.037	0.63	0.14	0.87
Phosphate as P in water	mg/L	2.9	0.014	0.032	<0.005	0.064

Miscellaneous Inorganics					
Our Reference		237389-6	237389-7	237389-8	237389-9
Your Reference	UNITS	MW101 / 200221	MW102 / 200221	MW103 / 200221	MW104 / 200221
Date Sampled		21/02/2020	21/02/2020	21/02/2020	21/02/2020
Type of sample		WATER	WATER	WATER	WATER
Date prepared	-	25/02/2020	25/02/2020	25/02/2020	25/02/2020
Date analysed	-	25/02/2020	25/02/2020	25/02/2020	25/02/2020
pH	pH Units	6.7	6.5	6.3	6.2
Electrical Conductivity	µS/cm	1,500	440	650	260
Total Suspended Solids	mg/L	91	260	270	50
Total Dissolved Solids (grav)	mg/L	1,200	300	420	160
Total Nitrogen in water	mg/L	74	4.1	2.1	0.6
NOx as N in water	mg/L	33	<0.005	0.007	<0.005
Ammonia as N in water	mg/L	37	3.3	2.0	0.58
Phosphate as P in water	mg/L	0.76	0.35	0.080	0.056

Metals in Waters - Acid extractable						
Our Reference		237389-1	237389-2	237389-3	237389-4	237389-5
Your Reference	UNITS	MW1 / 200221	MW2 / 200221	MW3 / 200221	MW4 / 200221	MW5 / 200221
Date Sampled		21/02/2020	21/02/2020	21/02/2020	21/02/2020	21/02/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	27/02/2020	27/02/2020	27/02/2020	27/02/2020	27/02/2020
Date analysed	-	27/02/2020	27/02/2020	27/02/2020	27/02/2020	27/02/2020
Phosphorus - Total	mg/L	5.3	<0.05	0.06	0.2	0.1

Metals in Waters - Acid extractable					
Our Reference		237389-6	237389-7	237389-8	237389-9
Your Reference	UNITS	MW101 / 200221	MW102 / 200221	MW103 / 200221	MW104 / 200221
Date Sampled		21/02/2020	21/02/2020	21/02/2020	21/02/2020
Type of sample		WATER	WATER	WATER	WATER
Date prepared	-	27/02/2020	27/02/2020	27/02/2020	27/02/2020
Date analysed	-	27/02/2020	27/02/2020	27/02/2020	27/02/2020
Phosphorus - Total	mg/L	1.1	0.6	0.1	0.08

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-006	Alkalinity - determined titrimetrically in accordance with APHA latest edition, 2320-B.
Inorg-018	Total Dissolved Solids - determined gravimetrically. The solids are dried at 180+/-10°C.
Inorg-019	Suspended Solids - determined gravimetricially by filtration of the sample. The samples are dried at 104+/-5°C.
Inorg-055	Nitrate - determined colourimetrically. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a water extraction.
Inorg-055/062/127	Total Nitrogen - Calculation sum of TKN and oxidised Nitrogen. Alternatively analysed by combustion and chemiluminescence.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a KCl extraction.
Inorg-060	Phosphate determined colourimetrically based on EPA365.1 and APHA latest edition 4500 P E. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a water extraction.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.
Metals-020	Determination of various metals by ICP-AES.

QUALITY CONTROL: Ion Balance						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	237389-2
Date prepared	-			25/02/2020	1	25/02/2020	25/02/2020		25/02/2020	25/02/2020
Date analysed	-			25/02/2020	1	25/02/2020	25/02/2020		25/02/2020	25/02/2020
Calcium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	32	31	3	97	92
Potassium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	34	33	3	91	75
Sodium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	25	25	0	96	74
Magnesium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	18	18	0	100	94
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006	<5	1	<5	<5	0	<5	[NT]
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	23	22	4	<5	[NT]
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	<5	<5	0	<5	[NT]
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	23	22	4	110	[NT]
Sulphate, SO4	mg/L	1	Inorg-081	<1	1	41	41	0	104	[NT]
Chloride, Cl	mg/L	1	Inorg-081	<1	1	41	39	5	98	[NT]

QUALITY CONTROL: Miscellaneous Inorganics						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	237389-2
Date prepared	-			25/02/2020	1	25/02/2020	25/02/2020		25/02/2020	25/02/2020
Date analysed	-			25/02/2020	1	25/02/2020	25/02/2020		25/02/2020	25/02/2020
pH	pH Units		Inorg-001	[NT]	1	5.8	5.7	2	102	[NT]
Electrical Conductivity	µS/cm	1	Inorg-002	<1	1	760	570	29	103	[NT]
Total Suspended Solids	mg/L	5	Inorg-019	<5	1	71	77	8	104	[NT]
Total Dissolved Solids (grav)	mg/L	5	Inorg-018	<5	1	550	550	0	107	[NT]
Total Nitrogen in water	mg/L	0.1	Inorg-055/062/127	<0.1	1	39	37	5	91	70
NOx as N in water	mg/L	0.005	Inorg-055	<0.005	1	29	29	0	96	[NT]
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	1	0.11	0.10	10	102	[NT]
Phosphate as P in water	mg/L	0.005	Inorg-060	<0.005	1	2.9	2.9	0	109	[NT]

QUALITY CONTROL: Metals in Waters - Acid extractable						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	237389-2
Date prepared	-			27/02/2020	1	27/02/2020	27/02/2020		27/02/2020	27/02/2020
Date analysed	-			27/02/2020	1	27/02/2020	27/02/2020		27/02/2020	27/02/2020
Phosphorus - Total	mg/L	0.05	Metals-020	<0.05	1	5.3	6.0	12	106	95

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.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

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 (not SPOCAS); 60-140% for organics/SPOCAS (+/-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.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

pH/nutrients - out of recommended holding time

Dissolved Metals: no filtered, preserved sample was received, therefore the unpreserved sample was filtered through 0.45µm filter at the lab. Note: there is a possibility some elements may be underestimated.

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CERTIFICATE OF ANALYSIS 242947

Client Details

Client	Martens & Associates Pty Ltd
Attention	William Xu
Address	Suite 201, 20 George St, Hornsby, NSW, 2077

Sample Details

Your Reference	**P1303897, Bobs Farm Port Stephens**
Number of Samples	8 WATER
Date samples received	14/05/2020
Date completed instructions received	14/05/2020

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	21/05/2020
Date of Issue	21/05/2020

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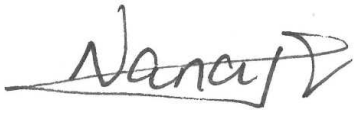
Results Approved By
Hannah Nguyen, Senior Chemist
Priya Samarawickrama, Senior Chemist

Authorised By



Nancy Zhang, Laboratory Manager

Ion Balance						
Our Reference		242947-1	242947-2	242947-3	242947-4	242947-5
Your Reference	UNITS	MW1 / 200221	MW2 / 200221	MW4 / 200221	MW5 / 200221	MW101 / 200221
Date Sampled		14/05/2020	14/05/2020	14/05/2020	14/05/2020	14/05/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	15/05/2020	15/05/2020	15/05/2020	15/05/2020	15/05/2020
Date analysed	-	15/05/2020	15/05/2020	15/05/2020	15/05/2020	15/05/2020
Calcium - Dissolved	mg/L	21	8.9	1.0	11	4.3
Potassium - Dissolved	mg/L	30	17	1.7	23	150
Sodium - Dissolved	mg/L	27	13	28	32	30
Magnesium - Dissolved	mg/L	11	5.1	3.3	11	7.2
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	25	19	6	30	73
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	25	19	6	30	73
Sulphate, SO4	mg/L	40	20	10	81	70
Chloride, Cl	mg/L	44	21	47	57	46

Ion Balance				
Our Reference		242947-6	242947-7	242947-8
Your Reference	UNITS	MW102 / 200221	MW103 / 200221	MW104 / 200221
Date Sampled		14/05/2020	14/05/2020	14/05/2020
Type of sample		WATER	WATER	WATER
Date prepared	-	15/05/2020	15/05/2020	15/05/2020
Date analysed	-	15/05/2020	15/05/2020	15/05/2020
Calcium - Dissolved	mg/L	24	31	13
Potassium - Dissolved	mg/L	13	32	1.9
Sodium - Dissolved	mg/L	33	38	27
Magnesium - Dissolved	mg/L	11	15	4.1
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	140	67	56
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	140	67	56
Sulphate, SO4	mg/L	9	150	<1
Chloride, Cl	mg/L	46	48	43

Miscellaneous Inorganics						
Our Reference		242947-1	242947-2	242947-3	242947-4	242947-5
Your Reference	UNITS	MW1 / 200221	MW2 / 200221	MW4 / 200221	MW5 / 200221	MW101 / 200221
Date Sampled		14/05/2020	14/05/2020	14/05/2020	14/05/2020	14/05/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	15/05/2020	15/05/2020	15/05/2020	15/05/2020	15/05/2020
Date analysed	-	15/05/2020	15/05/2020	15/05/2020	15/05/2020	15/05/2020
pH	pH Units	5.9	6.1	5.5	6.0	6.4
Electrical Conductivity	µS/cm	480	240	200	450	890
Total Suspended Solids	mg/L	44	6	<5	34	7
Total Dissolved Solids (grav)	mg/L	470	180	140	310	670
Total Nitrogen in water	mg/L	22	8.9	0.5	4.0	63
NOx as N in water	mg/L	18	7.7	0.02	<0.005	39
Ammonia as N in water	mg/L	0.026	<0.005	0.096	0.89	13
Phosphate as P in water	mg/L	3.9	0.010	<0.005	0.051	0.16

Miscellaneous Inorganics				
Our Reference		242947-6	242947-7	242947-8
Your Reference	UNITS	MW102 / 200221	MW103 / 200221	MW104 / 200221
Date Sampled		14/05/2020	14/05/2020	14/05/2020
Type of sample		WATER	WATER	WATER
Date prepared	-	15/05/2020	15/05/2020	15/05/2020
Date analysed	-	15/05/2020	15/05/2020	15/05/2020
pH	pH Units	6.6	6.3	6.4
Electrical Conductivity	µS/cm	460	650	260
Total Suspended Solids	mg/L	350	310	68
Total Dissolved Solids (grav)	mg/L	320	400	160
Total Nitrogen in water	mg/L	8.1	1.8	5.6
NOx as N in water	mg/L	0.006	<0.005	<0.005
Ammonia as N in water	mg/L	5.8	1.8	0.54
Phosphate as P in water	mg/L	0.37	0.059	0.042

Metals in Waters - Acid extractable						
Our Reference		242947-1	242947-2	242947-3	242947-4	242947-5
Your Reference	UNITS	MW1 / 200221	MW2 / 200221	MW4 / 200221	MW5 / 200221	MW101 / 200221
Date Sampled		14/05/2020	14/05/2020	14/05/2020	14/05/2020	14/05/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	19/05/2020	19/05/2020	19/05/2020	19/05/2020	19/05/2020
Date analysed	-	19/05/2020	19/05/2020	19/05/2020	19/05/2020	19/05/2020
Phosphorus - Total	mg/L	4.2	<0.05	<0.05	0.09	0.2

Metals in Waters - Acid extractable				
Our Reference		242947-6	242947-7	242947-8
Your Reference	UNITS	MW102 / 200221	MW103 / 200221	MW104 / 200221
Date Sampled		14/05/2020	14/05/2020	14/05/2020
Type of sample		WATER	WATER	WATER
Date prepared	-	19/05/2020	19/05/2020	19/05/2020
Date analysed	-	19/05/2020	19/05/2020	19/05/2020
Phosphorus - Total	mg/L	0.5	0.1	0.08

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-006	Alkalinity - determined titrimetrically in accordance with APHA latest edition, 2320-B.
Inorg-018	Total Dissolved Solids - determined gravimetrically. The solids are dried at 180+/-10°C.
Inorg-019	Suspended Solids - determined gravimetricially by filtration of the sample. The samples are dried at 104+/-5°C.
Inorg-055	Nitrate - determined colourimetrically. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a water extraction.
Inorg-055/062/127	Total Nitrogen - Calculation sum of TKN and oxidised Nitrogen. Alternatively analysed by combustion and chemiluminescence.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a KCl extraction.
Inorg-060	Phosphate determined colourimetrically based on EPA365.1 and APHA latest edition 4500 P E. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a water extraction.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.
Metals-020	Determination of various metals by ICP-AES.

QUALITY CONTROL: Ion Balance						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	242947-2
Date prepared	-			15/05/2020	1	15/05/2020	15/05/2020		15/05/2020	15/05/2020
Date analysed	-			15/05/2020	1	15/05/2020	15/05/2020		15/05/2020	15/05/2020
Calcium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	21	[NT]		91	[NT]
Potassium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	30	[NT]		83	[NT]
Sodium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	27	[NT]		92	[NT]
Magnesium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	11	[NT]		92	[NT]
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006	<5	1	<5	<5	0	[NT]	[NT]
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	25	24	4	[NT]	[NT]
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	<5	<5	0	[NT]	[NT]
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	25	24	4	103	[NT]
Sulphate, SO4	mg/L	1	Inorg-081	<1	1	40	39	3	108	84
Chloride, Cl	mg/L	1	Inorg-081	<1	1	44	43	2	88	82

QUALITY CONTROL: Miscellaneous Inorganics						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	242947-2
Date prepared	-			15/05/2020	1	15/05/2020	15/05/2020		15/05/2020	15/05/2020
Date analysed	-			15/05/2020	1	15/05/2020	15/05/2020		15/05/2020	15/05/2020
pH	pH Units		Inorg-001	[NT]	1	5.9	5.9	0	101	[NT]
Electrical Conductivity	µS/cm	1	Inorg-002	<1	1	480	470	2	102	[NT]
Total Suspended Solids	mg/L	5	Inorg-019	<5	1	44	40	10	93	[NT]
Total Dissolved Solids (grav)	mg/L	5	Inorg-018	<5	1	470	[NT]		104	[NT]
Total Nitrogen in water	mg/L	0.1	Inorg-055/062/127	<0.1	1	22	23	4	99	82
NOx as N in water	mg/L	0.005	Inorg-055	<0.005	1	18	18	0	105	[NT]
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	1	0.026	0.028	7	99	[NT]
Phosphate as P in water	mg/L	0.005	Inorg-060	<0.005	1	3.9	3.9	0	107	[NT]

QUALITY CONTROL: Metals in Waters - Acid extractable						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	242947-2
Date prepared	-			19/05/2020	1	19/05/2020	19/05/2020		19/05/2020	19/05/2020
Date analysed	-			19/05/2020	1	19/05/2020	19/05/2020		19/05/2020	19/05/2020
Phosphorus - Total	mg/L	0.05	Metals-020	<0.05	1	4.2	4.2	0	88	89

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.
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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.
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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.

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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 (not SPOCAS); 60-140% for organics/SPOCAS (+/-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.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

Dissolved Metals: no filtered, preserved sample was received, therefore the unpreserved sample was filtered through 0.45µm filter at the lab. Note: there is a possibility some elements may be underestimated.

17 Attachment G – Conceptual Groundwater Model Section

NOT TO SCALE

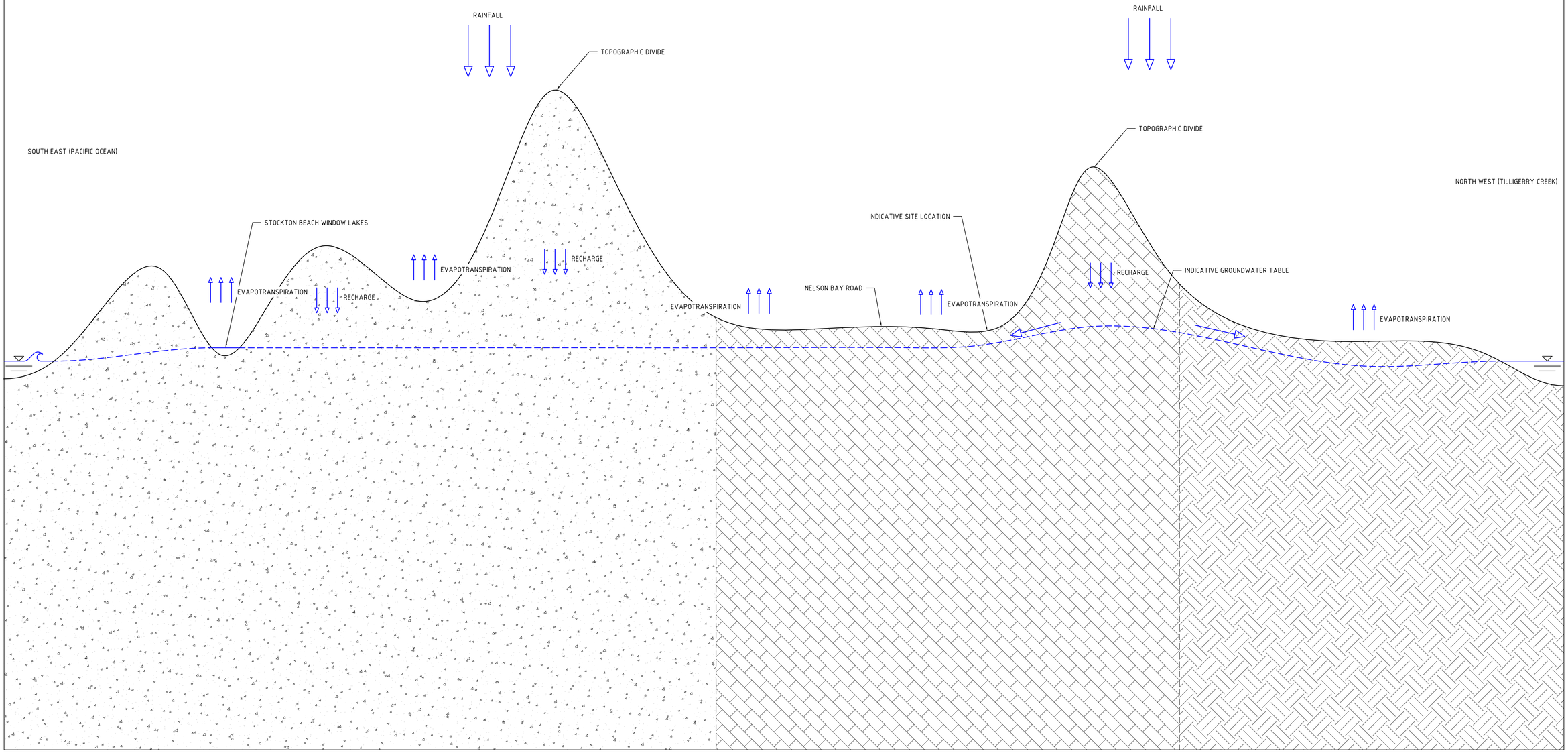
LEGEND

INDICATIVE WATER FLOW PATH

ACTIVE DUNES AND BEACH SANDS

STABLE DUNES (FINE TO MED. SANDS)

SILT CLAY AND ESTUARINE SEDIMENTS



RESPONSE TO AGENCY SUBMISSIONS

REV	DESCRIPTION	DATE	DRAWN	DESIGNED	CHECKED	APPRVD
B	SUBMISSION	05/11/2020	JCF	JCF	DM	DM
A	INITIAL RELEASE	15/10/2020	JCF	JCF	DM	DM

SCALE

GRID: N/A | DATUM: mAHD | PROJECT MANAGER: JF

CLIENT: AMMOS RESOURCE MANAGEMENT P/L

PROJECT NAME/PLANSET TITLE

PROPOSED SAND MINE

HYDROGEOLOGICAL ASSESSMENT

3631, 3679 & 3721 NELSON BAY RD,
BOBS FARM, NSW

martens & Associates Pty Ltd

Consulting Engineers
Environment
Water
Geotechnical
Civil

Suite 201, 20 George St, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767
Email: mail@martens.com.au Internet: www.martens.com.au

DRAWING TITLE: CONCEPT HYDROGEOLOGICAL MODEL

PROJECT NO.	PLANSET NO.	RELEASE NO.	DRAWING NO.	REVISION
P1303897	PS01	R02	PS01-JZ01	B

DRAWING ID: P1303897-PS01-R02-JZ01

PRINTED: 05/11/2020 - USER: JFECHER

A1 / A3 LANDSCAPE (A1LC_v02.0.01)

18 Attachment H – Aquifer Interference Policy Compliance Assessment – Highly Productive Coastal Sands Groundwater Sources

Minimal Impact Consideration	Assessment
Water Table	
1. Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40m from any: a) high priority groundwater dependent ecosystem; or b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan; or A maximum of a 2m decline cumulatively at any water supply work.	Complies: o The proposed development does not cause any impact 40 m from a high priority GDE mapped in the WSP (Section 6.1). o No high priority culturally significant sites are identified in the WSP (Section 3.10). o The proposed development does not cause a decline in the water table of greater than 2 m at any water supply work (Section 6.2).
2. If more than 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40m from any: a) high priority groundwater dependent ecosystem; or b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan then appropriate studies (including the hydrogeology, ecological condition and cultural function) will need to demonstrate to the Minister's satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site. If more than 2m decline cumulatively at any water supply work then make good provisions should apply.	Not Applicable
Water Pressure	
1. A cumulative pressure head decline of not more than a 2m decline, at any water supply work.	Complies: o The proposed development does not cause a decline in the water head of greater than 2 m at any water supply work (Section 6.2).
2. If the predicted pressure head decline is greater than requirement 1. above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.	Not Applicable
Water Quality	
1. Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40m from the activity.	Complies: o Risk to groundwater quality will be minimal with implementation of suitable engineering controls (Section 6.5 and Section 7).
2. If condition 1 is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works.	Not Applicable