APPENDIX J

ACID SULFATE SOILS ASSESSMENT

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

REPORT NO. **717041_ASS**

ACID SULFATE SOIL IMPACT ASSESSMENT, STOCKTON SAND QUARRY, COXS LANE, FULLERTON COVE, NSW

ENVIRONMENTAL EARTH SCIENCES NSW
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EXECUTIVE SUMMARY

Boral Resources (NSW) Pty Ltd owns and operates the Stockton Sand Quarry (the site), a long-standing operation that extracts and transports up to 500,000 tonnes of sand product per year for use in the building, landscaping and construction markets.

Due to current and future demand for sand in the local Hunter and Sydney regions, Boral is seeking approval for continued operations at the site through a State Significant Development (SSD) application. Boral propose to extract sand from a former sandpit by excavator and dredging (the project). It is understood that approval will be sought for the extraction of a combined maximum of 750,000 tonnes per annum from the two operations for commercial sale until 2028, when the volume will be reduced to 500,000 tonnes per annum.

This project requires an Acid Sulfate Soil (ASS) Impact Assessment to support the Environmental Impact Statement (EIS).

The objective is to identify if actual or potential Acid Sulfate Soils (AASS / PASS) are present within the proposed dredging area and assess the potential impacts of ASS or PASS on sensitive receptors. This includes an assessment of the potential impacts on:

- acid generation from lowering the water table;
- groundwater-dependant ecosystems; and
- extracted sand for commercial sale.

The following scope of works was undertaken to meet the objectives:

- desktop study, including the area's hydrology, geology and ASS risk;
- installation of four representative bores to 16 m below the water table at each location;
- field study including detailed borelogs and field pH and peroxide testing;
- laboratory analysis of selected samples for ASS; and,
- provision of an acid sulfate soil assessment across the area of disturbance.

The likelihood of ASS within the site is considered low due to:

- desktop study of the site reports a low probability for ASS;
- twenty three of the 25 samples analysed reported a risk level of "no risk – no sulfur" and as such are considered Not Acid Sulfate Soils (NASS) and one sample is considered "no risk – non reactive";
- high alkalinity and a high buffering capacity was reported throughout the borehole investigations within the site;
- excavation activities within the site are considered unlikely to change the groundwater level due to high recharge rates and draining water back into the dredge pond; and,
- proposed dredging activities include the sieving of material, so that fines (materials finer than sand) and/or oversize material (outside the appropriate grading envelope) are separated on site and immediately returned below the water table. This reduces potential for acid generation and safeguards the final sand product for commercial sale.

One location reported a moderate risk for potential ASS. This was a localised occurrence.

Regular monitoring as part of an ASS Management Plan is recommended for a proactive monitoring regime so that early indications of localised acid generation could trigger appropriate management. Further testing at the time of extraction is recommended to confirm the assessment.

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1 INTRODUCTION

Boral Resources (NSW) Pty Ltd owns and operates the Stockton Sand Quarry (the site), a long-standing operation that extracts and transports up to 500,000 tonnes of sand product per year for use in the building, landscaping and construction markets.

Due to current and future demand for sand in the Hunter and Sydney, Boral is seeking approval for continued operations at the site through a State Significant Development (SSD) application. Boral propose to extract sand from a former sandpit by excavator and dredging (the project). It is understood that approval will be sought for the extraction of a combined maximum of 750,000 tonnes per annum from the two operations for commercial sale until 2028, when the volume will be reduced to 500,000 tonnes per annum.

This proposal requires an Acid Sulfate Soil (ASS) Impact Assessment to support the Environmental Impact Statement (EIS).

2 OBJECTIVES

To identify if actual or potential ASS (AASS/ PASS) are present within the proposed dredging area, hereto called the 'Inland extraction area (IEA)', an assessment of the potential impacts of AASS or PASS on sensitive receptors is required. This includes an assessment of the potential impacts on:

- acid generation from lowering the water table;
- groundwater-dependant ecosystems;
- extracted sand for commercial sale; and,
- provision of management options for addressing any AASS / PASS.

3 SCOPE OF WORKS

The following scope of works was undertaken to meet the objectives:

- desktop study, including the area's hydrology, geology and ASS risk;
- installation of four representative bores to 16 m below the water table at each location;
- field study including detailed borelogs and field pH and peroxide testing;
- laboratory analysis of selected samples for ASS; and
- provision of an acid sulfate soil assessment across the area of disturbance.

4 SITE IDENTIFICATION AND SETTING

4.1 Location and details

The site is located approximately 10 km north of Newcastle and is currently approved for windblown sand extraction from the Stockton dune fields along their south and eastern site boundary. Table 1 below presents key identification features of the site.

TABLE 1 SITE IDENTIFICATION

Item	Details
Site Owner	Boral
Address	Coxs Lane, Fullerton Cove, NSW 2318
Lot & Plan number	Part Lot 1 DP1006399 Lot 2 DP1006399 Part Lot 3 DP664552 Lot 7300 DP1130730 (Crown Land) NOTE: This application proposes no works on Crown Land
Area	Approx. 246 hectares
Size of IEA	Approx. 37 hectares
Zoning	RU2 – Rural Landscape
Proposed land use	Extractive Industry (sand)
Local Government Authority	Port Stephens Council
Site Location and Layout	Figure 1 and Figure 2

The site location and context is illustrated on Figure 1, while the approximate area proposed for sand extraction (the IEA) is shown in Figure 2.

4.2 Regional Meteorology

Regional meteorological data has been sourced from the Bureau of Meteorology (2018) (*www.bom.gov.au*, verified 28 March 2018) Williamtown RAAF weather station, approximately 5 km from site, and is summarised in Table 2.

Stockton's climate can be described as warm temperate with mild winters and warm summers. The temperature ranges from a mean daily maximum temperature of 17.1 ^{o}C in the coldest month of July, to warm summers with mean daily maximum temperatures of 28.2 ^{o}C in January. Minimum winter daily temperatures range from 6.4 – 8 ^{o}C and the area is rarely subjected to frosts and temperatures below 0 ^{o}C.

Mean annual rainfall recorded at Stockton is 1,124.9 mm and the rainfall pattern has a late summer to autumn dominant trend. Monthly total evaporation rates are less than the average monthly rainfall (Table 2), suggesting strong groundwater recharge rates.

TABLE 2 MONTHLY CLIMATE STATISTICS

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Mean maximum Temperature (ºC)	28.2	27.7	26.3	23.7	20.4	17.7	17.1	18.7	21.5	23.8	25.6	27.3
Mean minimum Temperature (ºC)	18.1	18.1	16.4	13.2	10.1	8.0	6.4	6.9	9.1	12.0	14.4	16.6
Mean rainfall (mm)	99.9	118	120	112	111	123	71.9	73.6	59.7	73.0	82.4	79.0
Mean evaporation (mm)	6.9	6.2	5.0	3.8	2.7	2.5	2.6	3.6	4.7	5.6	6.3	7.2

4.3 Landform and topography

The site is part of the Stockton Sand Dunes; aeolian sand deposits, that span 32 km from Stockton to Anna Bay. The dunes are mobile and as such, topography can alter depending on winds and weather.

The site has historically been used for sand extraction purposes, particularly of the foredunes (Figure 1). The IEA has been subjected to a revegetation initiative, providing a degree of stability to the underlying sands. Elevation within the IEA is generally between 3 – 11 m AHD.

4.4 Soil and geology

The local geology has been described in the Newcastle 1:250 000 Geological series sheet S1 56-2 (1966) as Quaternary gravel, sand, silt, “Waterloo Rock,” with marine and freshwater deposits.

Soil landscape information was sourced from eSPADE v2.0 published by the NSW Office of Environment & Heritage (2018) (espade.environment.nsw.gov.au/, verified 28 March 2018). Two soil landscape groups were identified within the IEA; predominantly Boyces Track with Hawks Nest along the southern Project Area boundary.

Boyces Track are Holocene transgressive aeolian dunes with deep (>300 cm), well-draining and weakly developed podzol soils. Typically, these soils are acid to neutral. Hawks Nest soil landscape are stable low Holocene sand sheets on low transgressive dunes with deep well-draining soils. Typically, they exhibit high water tables and a potential for ASS in low lying swampy swales. These soils may be strongly acid. Refer to Appendix A for Soil Landscape Reports.

4.5 Acid Sulfate Soils

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

Review of the Port Stephens Local Environmental Plan (LEP) 2013 identifies Class 3 and Class 4 ASS in the IEA. While this would usually trigger the requirement for a Development

Consent[1], it is noted that that the area of proposed extraction is already below the natural ground surface (given it is a former sandpit), therefore these clauses may not apply. Furthermore, it is noted as per Clause 7.1 subclause 4(a) and 4(b) of the LEP, the requisite Development Consent can be avoided if:

- a preliminary assessment for the proposed works is prepared in accordance with the ASS Manual indicating no ASS management plan is required; and,
- the preliminary assessment is provided to and approved by the consent authority.

A summary of information regarding the low probability for ASS in the IEA is provided in Table 3 below.

TABLE 3 SUMMARY OF ASS IN IEA

Low Probability for ASS[1]		
ASS MAP Class Description[1]	The environment of deposition has generally not been suitable for the formation of ASS. ASS, if present, is sporadic and may be buried by windblown sediments.	
Environmental Risk[1]	Majority of these landforms are not expected to contain ASS. Land management is generally not affected by ASS. Highly localised occurrences may be found, especially near boundaries with environments with a high probability for ASS. Environmental risk will vary with elevation and depth of disturbance.	
Typical Landform Types[1]	Wa2 - Aeolian sandplain approx 2-4m AHD	Wd4 - Aeolian dunes approx >4m AHD
Depth to sulfidic soil[1]	Between 1 – 3 m BGS	>3 m BGS
Port Stephens LEP (2013) class of land[2]	**Class 3** Development consent required for: Works >1 m BGS. Works by which the water table is likely to be lowered >1 m BGS.	**Class 4** Development consent required for: Works >2 m BGS. Works by which the water table is likely to be lowered >2 m BGS.
Soil Landscape[3]	Hawks Nest	Boyces Track

Notes:

1. Sourced from the Port Stephens 1:50 000 Acid Sulfate Soils Map (1996) produced by NSW Department of Land and Water Conservation.
2. Sourced from Port Stephens Local Environmental Plan 2013; Part 7 Clause 7.1 – Acid Sulfate Soils.
3. Sourced from eSPADE v2.0 published by the NSW Office of Environment & Heritage (2018) (espade.environment.nsw.gov.au/, verified 28 March 2018).

4.6 Hydrogeology and Groundwater Usage

The site is underlain by the Tomago Sandbeds, a shallow, unconfined, rainfed aquifer that runs parallel to the coast. The Tomago Sandbeds contribute to the lower Hunter drinking water supply.

[1] Required for works in Class 3/Class 4 areas proposed at depths of greater than 1 m BGS and 2 m BGS beyond natural ground surface, respectively.

The Report Card for the Stockton Groundwater Source, prepared by the NSW Government's Department of Primary Industries (2016), was reviewed with the following key findings:

- the Stockton Groundwater Source extends from the Hunter River in the south to Murrumburrimbah Swamp in the north. This includes the drainage complexes of Bobs Farm Creek and Fennigans Island Creek;
- the Stockton Groundwater Source spans 32 km in length, 2 – 3 km width, 78m^2 area and has a thickness of 10 – 40 m;
- the rainfall recharge rate is estimated at 20,000 megalitres per year. Rainfall recharges the aquifer via percolation.

The IEA lies within 1.5 km of the Pacific Ocean to the east, and 2.5 km of Fullerton Cove and the Hunter Wetlands National Park to the north and west respectively. The site is surrounded by the Worimi Conservation Area that encompasses a large section of the Stockton dune fields. A groundwater bore network has been established across the perimeter of the site. Several monitoring wells (GW1, MW_x3, MW_x4) are within the IEA or in close proximity (refer to Figure 2 for groundwater bore network).

4.7 Primary industry resources

The IEA is approximately ≥900 m away from any agricultural production, which ensures a buffer distance. The current dominant land uses adjacent to the IEA are sand mining activities and the Worimi State Conservation Area that encompasses the Stockton Sand Dunes adjacent to the site.

As such, there is no current evidence of crop production (irrigated or unirrigated) or intensive horticulture within the immediate surrounds (900 m radius) of the IEA.

5 ACID SULFATE SOIL ASSESSMENT METHODOLOGY

Section 5 outlines the activities undertaken to classify and analyse the main soil types located within the IEA.

5.1 Background information

Before conducting the field assessment, an initial understanding of the different types of soil and landscapes across the IEA was developed. These desktop investigations included:

- review of available topographic, geological, soil and acid sulfate soil maps;
- review of aerial photography for the purpose of delineating landscape features and geomorphic processes within the IEA; and,
- review of climatic data.

This information provided a preliminary understanding of the potential distribution of ASS across the IEA which informed the limited field activities and reporting components of the scope of works. Intrusive field work was then used to validate this information and assess ASS within the IEA and the potential impacts.

5.2 Rationale for sampling locations

The intrusive investigation was advanced within the limitation of heavy vegetation. It was a high priority to retain due to considerable dune revegetation efforts for the stability of the back dunes and the ecosystems they support. Soil sampling locations were selected with the following considerations to:

- obtain representative coverage of the IEA;
- target the lower-lying swales where possible;
- advance boreholes to 16 m below the water table at each location, to assess the full extent (if not more) of the proposed dredging profile.

A summary of soil borehole locations and rationale is provided in Table 4.

TABLE 4 SUMMARY OF LOCATIONS AND RATIONALE

Location	Sampled Media	Rationale
BH1	Soil	IEA coverage; east
BH2	Soil	IEA coverage; north
BH3	Soil	IEA coverage; west
BH4	Soil	IEA coverage; south

5.2.1 Field pH Screening

The following field assessment was undertaken to determine potential impacts of acid sulfate soil and determine sample selection for laboratory analysis:

- soil texture (proportion of sand, silt and clay);
- pH_F and temperature (1:5 soil/water);
- pH_{FOX} and temperature (30% H_2O_2); and
- level of effervescence following H_2O_2 addition.

Field pH screening equipment was calibrated before and after each borehole. For calibration records, refer to Appendix B – Calibration Certificates.

5.2.2 Soil sampling

Investigation works were carried out by Environmental Earth Sciences using a Sonic drill rig. The field team drilled four boreholes within proposed sand extraction area, to depths between 18 - 24 m BGS. A minimum of one soil sample and field pH and peroxide test was undertaken at every change in lithology. Soil samples were collected in a zip-lock bag and placed on ice immediately. Soil sampling locations are shown in Figure 3.

5.2.3 Stratigraphy

The profiles of all bores (BH1 – BH4) consisted entirely of sand. In general, sands encountered were light brown, faun, grey and cream in colour. Typically, they were medium grained and occasionally shell grit was noted.

An organic layer was observed at one location (BH2_2.0) that consisted of dark brown sand and organics from approximately 2.0 – 2.5 m BGS. Groundwater was typically encountered

between 1.5 – 3.5 m BGS except in BH3, where groundwater was encountered approximately between 5.5 – 6.0 m BGS. Refer to Appendix C for the complete borelogs.

5.3 Laboratory soil assessment

A total of 44 samples were collected, of which those whose water to peroxide difference in field pH tests were ≥2 were selected for laboratory analysis. Selected samples (n. 25) were then submitted to a NATA accredited laboratory for the following analytes:

- Chromium Reducible Sulfur (CRS) suite (EA033-A, -B, -C and -E), to determine the on-site potential for the presence of potential, actual or partially oxidised acid sulfate soils including:
    - total actual acidity (TAA) (including pH_{KCl});
    - potential acidity (S_{CR}) using the Chromium Reducible Sulfur (CRS) method;
    - retained acidity as Net Acid Soluble Sulfur (S_{NAS}) when pH_{KCl} ≤4.5;
    - Acid Neutralising Capacity (ANC) –when pH_{KCl} ≥6.5; and
    - Acid Base Accounting (ABA) based on the above results.
- three samples were selected for further testing for Acid Neutralising Capacity (ANC) (EA033-C).

Laboratory transcripts are presented in Appendix D.

Samples were analysed by ALS Environmental (ALS), accredited with the National Association of Testing Authorities (NATA) for the methods used. Intra laboratory duplicates were analysed as part of our standard QA/QC procedures.

5.4 Analytical schedule

The final analytical schedule was chosen in consideration of field observations and the results of the field test for soils. The final analytical schedule is summarised in Table 5. Laboratory transcripts are provided in Appendix D.

TABLE 5 ANALYTICAL SCHEDULE

Soil	No. of samples	No. of intra-lab duplicates	Total
CRS (EA033-A, EA033-B and EA033-E)	25	4	29
ANC (EA033-C)	3	0	3

6 ASSESSMENT CRITERIA

The term acid sulfate soils (ASS) includes both actual and potential acid sulfate soils (AASS and PASS). Actual ASS is defined as soil “containing highly acidic soil horizons” producing “hydrogen ions in excess of the sediments capacity to neutralise the acidity, resulting in soil pH of 4 or less when measured in dry season conditions”. PASS is defined as soil “that contains sulfidic material that has not been oxidised and poses a considerable environmental risk, as they will become extremely acid when exposed to air and oxidised.”

Hazard classes are a means to define material based on impact to the environment and are based on soil sulfide (S) and net acidity (NA) values. Net acidity refers to acid-base accounting (ABA), as it includes assessment of the natural buffering capacity of soil, usually present as carbonates measured as acid neutralising capacity (ANC) in the laboratory. Risk classes normally used to determine the degree of management and remediation required (if any) are no risk - no sulfur, no risk - non-reactive, moderate risk and high risk. An explanation of these classes is presented below and summarised in Table 6.

6.1 No risk-no sulfur and no risk – non-reactive

The no risk – no sulfur classification is based solely on the presence of sulfides measured by the CRS, S_{POS} or TOS methods (Ahern, *et al*. 2004). Soils classified as 'no sulfur' are not acid sulfate soils (NASS), while 'non-reactive' soils are completely self-buffering and do not require management through neutralization if oxidized (although they do require monitoring).

No risk - non-reactive is based on NA and is defined as having S values greater than the no risk – no sulfur threshold but NA values below 3 times that of the no risk – no sulfur values. Thus: for sand, NA <3 kg H_2SO_4/ tonne of soil; for sandy silts and silts, NA <6 kg H_2SO_4/ tonne of soil; and for sandy clays, silty clays and clays, NA <9 kg H_2SO_4/tonne of soil (Table 6).

Note that these levels are based on consideration of buffering agents in the soil, as per the equation:

- NA (kg H_2SO_4/tonne) = sulfur (S) + acidity (TAA) + retained acidity (S_{RAS} at pH_{KCl}<4.5) – buffering (ANC/Ca+Mg)

These levels are also based on Environmental Earth Sciences experience with ASS and require consideration and trialling on a site-specific basis to define the exact value, as soil texture variation can cause deviation by up to 30% from the anticipated value.

6.2 Moderate risk and high-risk ASS

Moderate risk and high-risk sediment and soil could potentially cause a significant adverse risk to the environment. Essentially, moderate risk will generate a small amount of acid slowly while high risk will either generate acid quickly, in large volumes or both. Values for moderate or high-risk sediments have to be derived by either field trials or accelerated weathering experiments, but broad class groups are presented in Table 6. These are the only two classes that are considered ASS from a management point of view.

Table 6 presents soil sulfide hazard classes which rank the net acidity of a soil against its texture. This reflects the buffering capacity of the soil, which is generally lower in coarser (sandier) soils (i.e. sands have limited ability to offset acid generation).

TABLE 6 SOIL SULFIDE HAZARD CLASSES

Risk Class	**No Risk**				**Risk**			
Hazard Class	'No-sulfur'		'Non-reactive'		'Moderate Risk'		'High Risk'	
Texture Group	Sulfur	NA	Sulfur	NA	Sulfur	NA	Sulfur	NA
1	1	N/A	>1 (<10)[4]	<3	>1	>3	>10	>5
2	2	N/A	>2 (<20)[4]	<6	>2	>6	>20	>10

Risk Class	No Risk				Risk			
Hazard Class	'No-sulfur'		'Non-reactive'		'Moderate Risk'		'High Risk'	
Texture Group	Sulfur	NA	Sulfur	NA	Sulfur	NA	Sulfur	NA
3	3	N/A	>3 (<30)[4]	<9	>3	>9	>30	>15

Note(s): 1. all units in kg H_2SO_4 generated per tonne of soil
2. NA net acidity (sulfur + acid – buffering capacity)
3. Texture groups are: 1. Coarse: sand; 2. Medium: loams/silt-light clay; 3. Fine: medium to heavy clay, silty clay
4. [4] sulfur levels exceeding the values in brackets require confirmation through incubation tests or weathering trials
5. shaded values indicate relevant texture group and associated criteria for the IEA

6.3 Procedures for quality control and quality assurance

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

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

Field observations are compared with laboratory results when they are not as expected. Confirmation, re-sampling and re-analysis of a sample are undertaken if the results are not consistent with field observations and/or measurements. In addition, field duplicate sample results have to be within the acceptable range of reproducibility. A discussion of the quality of internal laboratory results and field duplicate relative percentage difference (RPD) calculations are presented in Appendix E.

7 ACID SULFATE SOILS ASSESSMENT RESULTS

7.1 Field pH_F and pH_{FOX} screening

Of the 44 samples field tested, all displayed mild effervescence to peroxide testing with the exception of BH2_2.0 (extreme) where organics were observed and BH3_2.75 (strong) where finer particles were observed in loamy sand.

The pH_F was neutral to mildly acidic across all lithologies, with the most acid reported at pH 5.0 (BH2_2.0) and the most alkaline at pH 8.8 (BH4_20.5). The pH_{FOX} was mildly acid to acid across all lithologies, with the most acid reported at pH 1.3 (BH2_2.0) and the most alkaline at pH 6.6 (BH2_0.5). Refer to Tables 7, 8, 9 and 10 below and overleaf for field screening results.

TABLE 7 FIELD pH SCREENING RESULTS FOR BH1

BH1 Sample (mBGS)	Soil characteristics	pH_F (pH in water)	Water temp (°C)	pH_{FOX} (pH in H_2O_2)	pH_{FOX} temp (°C)	Difference pH_F - pH_{FOX}	Effervescence (none/ mild/ strong/extreme)
0.3	grey / brown SAND w chitter	6.9	31.3	5.7	37.0	1.2	mild
1.0	faun SAND	7.2	28.9	6.1	30.2	1.1	none
1.5	dark brown SAND	6.8	29.1	3.7	31.2	3.1	mild
2.0	faun SAND	6.5	28.9	4.9	29.0	1.6	mild
3.0	brown SAND w chitter	6.5	28.5	3.6	30.2	2.9	mild
4.0	faun / brown SAND	6.2	28.9	3.7	29.6	2.5	mild
7.0	light brown SAND	5.4	35.8	3.2	36.6	2.2	mild
10.5	light grey SAND w shell grit	6.3	33.1	6.1	34.0	0.2	mild
12.0	light brown SAND w shell grit	7.8	30.9	6.1	34.9	1.7	mild
15.0	light grey SAND w shell grit	8.3	30.5	6.1	31.4	2.2	mild

TABLE 8 FIELD pH SCREENING RESULTS FOR BH2

BH2 Sample (mBGS)	Soil characteristics	pH_F (pH in water)	Water temp (°C)	pH_{FOX} (pH in H_2O_2)	pH_{FOX} temp (°C)	Difference pH_F - pH_{FOX}	Effervescence (none/mild/ strong/extreme)
0.25	light brown SAND	6.8	24.5	6.0	26.5	0.8	mild
0.5	cream / light brown SAND w chitter	8.7	24.2	6.6	28.4	2.1	mild
2.0	dark brown / black SAND w organics	5.0	24.0	1.3	93.1	3.7	extreme
2.5	light brown / grey SAND	6.5	24.0	2.8	28.5	3.7	mild
3.0	cream / light brown SAND	6.4	23.9	5.2	25.5	1.2	mild
6.0	cream / light brown SAND w minor organics	6.2	23.9	5.6	25.5	0.6	mild
9.0	light brown SAND	6.4	24.4	3.1	27.4	3.3	mild
12.0	cream SAND	6.9	26.4	5.8	29.1	1.1	none
16.0	light grey SAND	6.5	26.7	5.5	30.6	1.0	mild

BH2 Sample (mBGS)	Soil characteristics	pH_F (pH in water)	Water temp (°C)	pH_{FOX} (pH in H_2O_2)	pH_{FOX} temp (°C)	Difference pH_F - pH_{FOX}	Effervescence (none/mild/ strong/extreme)
19.5	light grey SAND w dark grey mottle	6.0	27.6	6.4	31.0	0.4	mild
24.0	light grey SAND w dark grey mottle	6.6	27.0	6.1	28.6	0.5	mild

TABLE 9 FIELD pH SCREENING RESULTS FOR BH3

BH3 Sample (mBGS)	Soil characteristics	pH_F (pH in water)	Water temp (°C)	pH_{FOX} (pH in H_2O_2)	pH_{FOX} temp (°C)	Difference pH_F - pH_{FOX}	Effervescence (none/mild/ strong/extreme)
0.5	grey SAND	7.2	27.1	6.9	28.8	0.3	mild
2.75	dark brown loamy SAND w chitter	7.4	27.5	6.5	91.1	0.9	strong
3.5	cream SAND w brown mottle	7.7	27.3	5.9	30.5	1.8	mild
4.0	cream SAND	7.4	27.3	5.7	28.2	1.7	mild
6.0	cream SAND	7.0	27.0	5.8	27.2	1.2	mild
8.0	cream SAND	7.1	27.7	5.7	31.0	1.4	mild
9.0	grey / brown SAND	6.9	27.4	2.6	30.5	4.3	mild
12.0	grey SAND w shell grit	7.4	27.5	6.3	31.0	1.1	mild
15.0	grey SAND w shell grit and grey mottle	8.2	27.7	6.2	31.2	2.0	mild
16.0	grey SAND w shell grit	8.6	28.2	6.1	29.7	2.5	mild
18.0	yellow / grey SAND	6.8	29.3	5.9	29.0	0.9	mild

TABLE 10 FIELD pH SCREENING RESULTS FOR BH4

BH4 Sample (mBGS)	Soil characteristics	pH_F (pH in water)	Water temp (°C)	pH_{FOX} (pH in H_2O_2)	pH_{FOX} temp (°C)	Difference pH_F - pH_{FOX}	Effervescence (none/mild/ strong/extreme)
0.5	grey SAND w gravel and organics	7.2	27.9	5.5	28.6	1.7	mild
2.0	grey SAND w gravels and chitter	7.3	27.6	5.1	34.9	2.2	mild
3.5	coffee SAND	7.5	27.6	4.8	28.9	2.7	none
5.0	latte SAND	7.4	27.5	5.0	29.0	2.4	mild

BH4 Sample (mBGS)	Soil characteristics	pH_F (pH in water)	Water temp (°C)	pH_{FOX} (pH in H_2O_2)	pH_{FOX} temp (°C)	Difference pH_F - pH_{FOX}	Effervescence (none/mild/ strong/extreme)
6.0	light brown SAND	7.3	27.5	3.0	29.1	4.3	mild
9.0	light brown SAND	7.0	27.4	2.6	29.4	4.4	mild
12.0	light grey SAND	7.4	27.7	4.6	29.9	2.8	mild
15.0	brown SAND	7.2	29.6	3.9	31.8	3.3	mild
16.0	light grey SAND	7.2	28.8	2.6	31.0	4.6	mild
16.5	dark grey SAND	7.5	28.4	6.1	34.6	1.4	mild
17.0	light brown /grey SAND	8.7	28.0	5.6	31.7	3.1	mild
20.5	white / light grey SAND	8.8	27.7	6.1	29.2	2.7	mild

7.2 Laboratory Results

The pH_{KCl} ranged from 5.1 (BH2_2.0) to 10.2 and overall reported a high amount of alkalinity within the soil profiles of BH1, BH2, BH3 and BH4. Eleven samples were analysed for their buffering capacity (ANC) which ranged from 0.196 kg H_2SO_4 (BH4_9.0) to 80.948 kg H_2SO_4 (BH4_2.0).

All 25 samples except BH2_2.0 and BH4_9.0 reported Potential Acidity (CRS) of <1 kg H_2SO_4 per tonne of soil and NA <1 kg H_2SO_4 per tonne of soil. Sample BH4_9.0 reported NA of 1.016 kg H_2SO_4 per tonne of soil however, due to a CRS of <1 kg H_2SO_4 per tonne of soil there is not enough sulfur present to be considered PASS or AASS. Therefore, all samples except BH2_2.0 have a risk level of "no risk – no sulfur" and as such are considered Not Acid Sulfate Soils (NASS).

Sample BH2_2.0 reported CRS of 3.02 kg H_2SO_4 per tonne of soil and NA of 4.008 kg H_2SO_4 per tonne of soil which is considered as a moderate risk for PASS.

Refer to Table 11 below for a summary of the results and Appendix D for laboratory transcripts.

TABLE 11 SUMMARY OF ACIDITY RESULTS

Sample (depth m BGS)	Texture	pH_{KCl} (1:5)	pH_F (1:5)	pH_{FOX} (H_2O_2)	Potential Acidity (CRS)	Actual Acidity (TAA)	Buffering Capacity (ANC)	Net acidity (NA)	Risk Level
Criteria	-	>5	>5	>2.5	1	1	-	3	-
BH1_1.5	Sand	5.6	6.8	3.7	0.79	0.098	-	0.893	NASS
BH1_3.0	Sand	6	6.5	3.6	0.48	<0.049	-	0.538	NASS
BH1_4.0	Sand	5.5	6.2	3.7	0.73	0.098	-	0.832	NASS
BH1_7.0	Sand	6.1	5.4	3.2	0.55	<0.049	-	0.600	NASS
BH1_15.5	Sand	9.5	8.3	6.1	0.48	<0.049	11.858	-11.320	NASS

Sample (depth m BGS)	Texture	pH_{KCl} (1:5)	pH_F (1:5)	pH_{FOX} (H_2O_2)	Potential Acidity (CRS)	Actual Acidity (TAA)	Buffering Capacity (ANC)	Net acidity (NA)	Risk Level
BH2_0.5	Sand	10	8.7	6.6	0.30	<0.049	32.144	-31.790	NASS
BH2_2.0	Sand	5.1	5.0	1.3	3.02	2.058	1.078	4.008	Moderate Risk
BH2_2.5	Sand	6	6.5	2.8	0.79	<0.049	-	0.844	NASS
BH2_3.0	Sand	6.2	6.4	5.2	0.27	<0.049	-	0.324	NASS
BH2_9.0	Sand	5.8	8.7	6.6	0.61	<0.049	-	0.661	NASS
BH3_3.5	Sand	6.1	7.7	5.9	0.21	<0.049	-	0.263	NASS
BH3_4.0	Sand	6	7.4	5.7	0.24	<0.049	-	0.293	NASS
BH3_9.0	Sand	5.7	6.9	2.6	0.55	<0.049	-	0.600	NASS
BH3_15.0	Sand	9.6	8.2	6.2	0.52	<0.049	47.432	-46.863	NASS
BH3_16.0	Sand	9.5	8.6	6.1	0.36	<0.049	6.37	-5.954	NASS
BH4_2.0	Sand	10.2	7.3	5.1	1.53	<0.049	80.948	-79.370	NRNR
BH4_3.5	Sand	6.6	7.5	4.8	0.21	<0.049	2.646	-2.383	NASS
BH4_5.0	Sand	6.2	7.4	5.0	0.21	<0.049	-	0.263	NASS
BH4_6.0	Sand	5.3	7.3	3.0	0.83	0.196	1.47	-0.448	NASS
BH4_9.0	Sand	5.4	7.0	2.6	0.92	0.294	0.196	1.016	NASS
BH4_12.0	Sand	6	7.4	4.6	0.88	<0.049	-	0.936	NASS
BH4_15.0	Sand	8	7.2	3.9	0.55	<0.049	1.96	-1.360	NASS
BH4_16.0	Sand	5.5	7.2	2.6	0.52	<0.049	-	0.569	NASS
BH4_17.0	Sand	5.9	8.8	6.1	0.55	<0.049	-	0.600	NASS
BH4_20.5	Sand	9.2	7.2	5.5	0.36	<0.049	6.076	-5.660	NASS

Notes:
1. NASS indicates Not Acid Sulfate Soils; NRNR indicates No Risk-Non Reactive
2. Shaded cells indicate exceeds criteria; **shaded and bold cells** indicate High Risk (requires management if disturbed)
3. – indicates no data available

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 General

The objective of this report was to identify if PASS were present within the proposed IEA and if so, assess the potential impacts of PASS on sensitive receptors/uses, as such Environmental Earth Sciences undertook in-situ and laboratory characterisation assessment of soils within the proposed area of sand extraction.

Field tests were generally undertaken at 0.25 m intervals along the soil profile in each of the four boreholes, with laboratory analysis scheduled, based on the field testing results.

Ground conditions assessed in the proposed IEA typically comprised medium-grained sand that extend past the base of the dredging area, to the final depth of investigation (18 to 24 m BGS). No fine sediments such as estuarine muds, clays or silts were observed.

Groundwater was encountered between 1.5 and 3.5 m BGS in the boreholes drilled across the site to depths of between 18 and 24 m BGS, with the exception of BH03 where groundwater was encountered between 5.5 – 6.0 m BGS.

No fine sediments (e.g. clays, silts or estuarine muds) were encountered in shallow profiles at any location during the intrusive assessment. As sulphides typically reside in the finer grained sediments, this observation further reduces the risk for the potential for PASS to be present and, associated oxidisation potential.

Based on the results of the investigation, localised soils in the vicinity of BH2 between 2 and 3 m bgl were identified as a moderate risk acid sulfate soil. However, it is noted that the soil profile in BH02 immediately above and below this medium risk ASS layer can be classified as NASS and, naturally contains a significant buffering capacity (32 kg H_2SO_4 per tonne of soil) lowering the potential for acid generation in this area.

All remaining soils analysed were classified as NASS or NRNR. Given the above, it is reasonable to extrapolate that a natural buffering capacity exists across the IEA due to the presence of shell grit ($CaCO_3$) within sand deposits.

8.2 Mitigation Measures

It is understood that extracted sands will be washed and screened whereby fine-grained material (if present), sands and oversize material not meeting the grading envelope for concrete will be returned to the dredging pond, reducing the risk of any localised finer grained sediments oxidising into PASS.

We recommend all sand be sluiced (or similarly screened) to remove the fines. This would also remove the PASS risk to the final commercial sand product intended for sale. However, it should be noted that the presence of NASS and/or NRNR could still cause iron speckling in any cement render; testing will be required to confirm this. Environmental Earth Sciences assumes removal of finer particles from the sands will reduce any sulphides that may be occurring at low levels.

As the sand extraction activities will see the majority of the water drain back into the dredging pond, there is deemed to be a low risk posed from the oxidation of potentially localised instances of PASS. Furthermore, returning water to the dredging pond also prevents a lowering of the groundwater table, which will ensure in-situ PASS will remain saturated and will not oxidise.

This assessment did not encounter any other specific management considerations in the IEA. However, continual monitoring of pH is required during further works to confirm the classification and ensure that procedures for any treatment and remediation of PASS (as required) is undertaken appropriately.

8.3 Acid Sulfate Soil Management Plan (ASSMP)

Given that a moderate PASS risk was identified within the IEA in the vicinity of BH02, it is recommended, as a precautionary measure, that an Acid Sulfate Soil Management Plan (ASSMP) be prepared in support of the proposed development to properly mitigate any

health and environmental harm during the proposed material extraction/dredging within the EIA.

This plan will cover the entire IEA but will have a particular focus on the area of moderate PASS risk identified (in the vicinity of BH02). This plan will allow a proactive monitoring regime to be established so that early indications of acid generation can trigger appropriate management and/or mitigation strategies before any impact to the environment is realised. Monitoring should commence immediately prior to, during and at the conclusion of the proposed dredging and filling activities.

The ASSMP is recommended to be prepared in accordance with Ahern, C R, Stone, Y, and Blunden, B (1998) – Acid Sulfate Soils Management Guidelines, Acid Sulfate Soil Management Advisory Committee NSW (August 1998).

9 LIMITATIONS

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

1. The specific instructions received from client Element Environment;
2. The specific scope of works set out in PO717059 issued by Environmental Earth Sciences for and on behalf of Element Environment;
3. May not be relied upon by any third party not named in this report for any purpose except with the prior written consent of Environmental Earth Sciences NSW (which consent may or may not be given at the discretion of Environmental Earth Sciences NSW);
4. This report comprises the formal report, documentation sections, tables, figures and appendices as referred to in the index to this report and must not be released to any third party or copied in part without all the material included in this report for any reason;
5. The report only relates to the site referred to in the scope of works being located at Stockton Boral Quarry, Fullerton Cove, NSW (“the site”);
6. The report relates to the site as at the date of the report as conditions may change thereafter due to natural processes and/or site activities;
7. No warranty or guarantee is made in regard to any other use than as specified in the scope of works and only applies to the depth tested and reported in this report;
8. Fill, soil, groundwater and rock to the depth tested on the site may be fit for the use specified in this report. Unless it is expressly stated in this report, the fill, soil and/or rock may not be suitable for classification as clean fill if deposited off site; and
9. Our General Limitations set out at the back of the body of this report.

10 REFERENCES

Australian Soil Resources Information System (ASRIS) (2013). *Online soils mapping, acid sulfate soils*.

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

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

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

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

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

NSW Office of Environment & Heritage (2018). eSPADE v2.0 espade.environment.nsw.gov.au/ (viewed 28 March 2018).

NSW Department of Land and Water Conservation (1996). *Port Stephens 1:50 000 Acid Sulfate Soils Map*.

NSW Department of Primary Industries Office of Water (2015). http://waterinfo.nsw.gov.au/gw/. (viewed 28 March 2018).

NSW Environment Protection Authority (EPA) (1995). *Contaminated Sites: Sampling design guidelines.*

NSW Department of Primary Industries (2016). Report Card for the Stockton Groundwater Source. https://www.water.nsw.gov.au/__data/assets/pdf_file/0011/587225/wsp_north_coast_report_card_stockton.pdf (viewed 28 March 2018).

Port Stephens Council (2013). Port Stephens Local Environmental Plan. https://www.legislation.nsw.gov.au/#/view/EPI/2013/755/part7/cl7.1 (viewed 28 March 2018).

11 GLOSSARY OF TERMS

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

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

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

Anaerobic. Reducing or without oxygen.

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

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

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

Background. The natural level of a property.

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

Borehole. An uncased well drill hole.

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

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

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

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

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

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

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

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

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

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

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

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

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

type, whilst clay minerals are representative of the latter and are normally associated with cation exchange.

Ions. An ion is a charged element or compound as a result of an excess or deficit of electrons. Positively charged ions are called cations, whilst negatively charged ions are called anions. Cations are written with superscript +, whilst anions use - as the superscript. The major aqueous ions are those that dominate total dissolved solids (TDS). These ions include Cl^-, SO_4^{2-}, HCO_3^-, Na^+, Ca^{2+}, Mg^{2+}, K^+, NH_4^+, NO_3^-, NO_2^-, F^-, PO_4^{3-} and the heavy metals.

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

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

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

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

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

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

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

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

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

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

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

Stratigraphy. A vertical sequence of geological units.

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

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

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

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

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

ENVIRONMENTAL EARTH SCIENCES GENERAL LIMITATIONS

Scope of services

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

Data should not be separated from the report

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

Subsurface conditions change

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

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

Problems with interpretation by others

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

Obtain regulatory approval

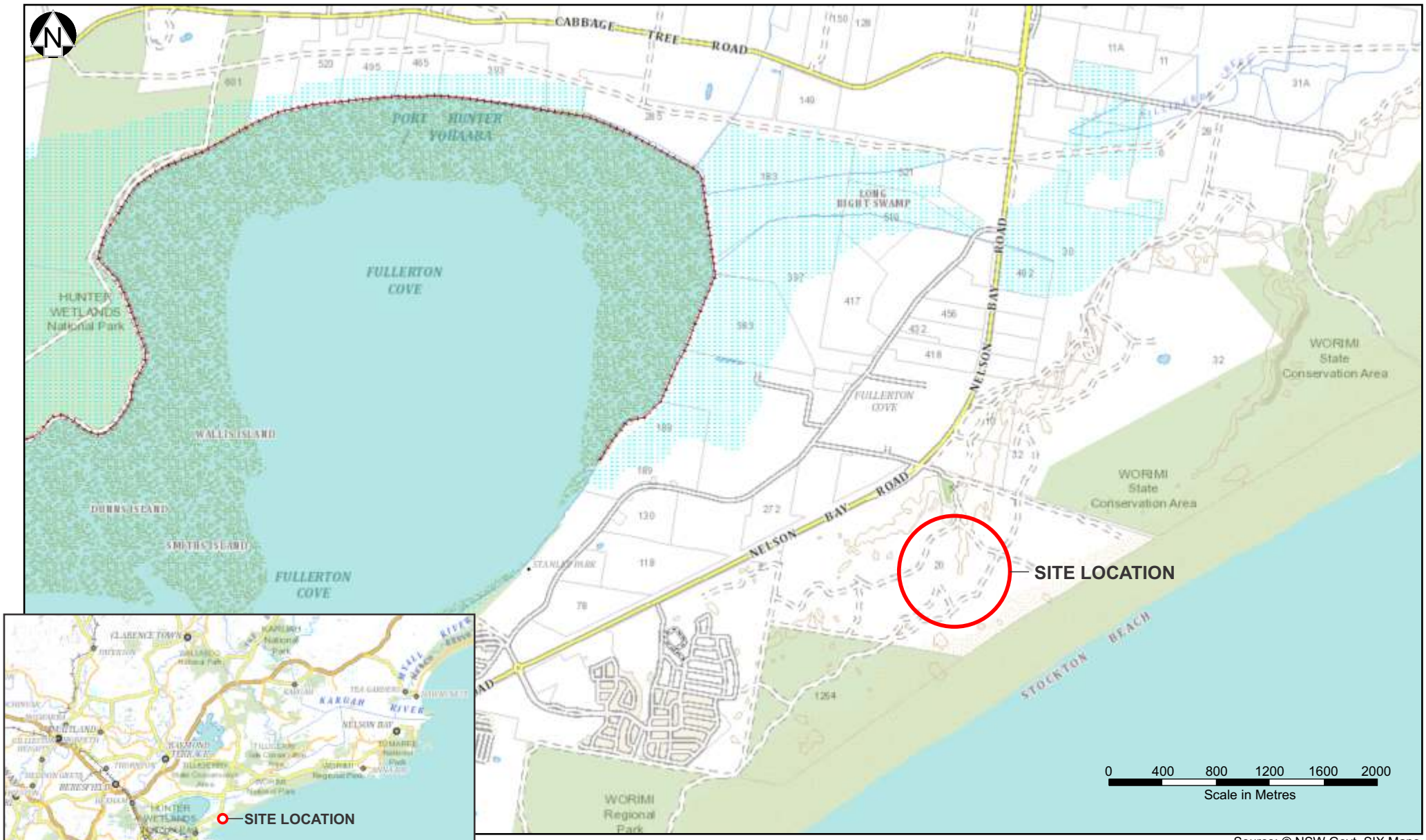
The investigation and remediation of contaminated sites is a field in which legislation and interpretation of legislation is changing rapidly. Our interpretation of the investigation findings should not be taken to be that of any other party. When approval from a statutory authority is required for a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

Limit of liability

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

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

FIGURES

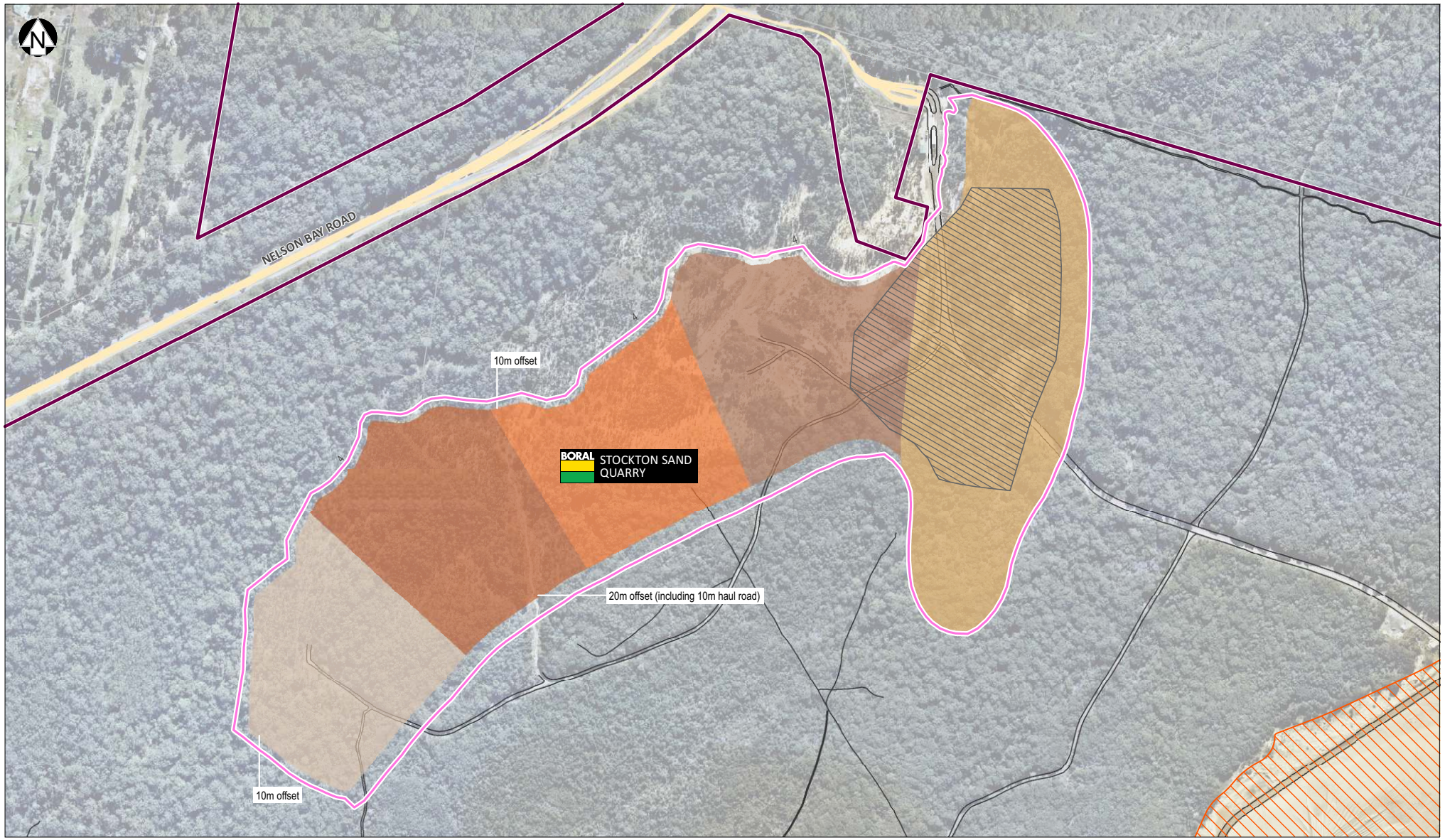


Source: © NSW Govt. SIX Maps

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Title:	**Site Location**
Location:	**Nelson Bay Road, Fullerton Cove, NSW**
Client: **Boral Quarries**	Job No: **717041**
Project Man: **EG**	Scale: **As shown**
Drawn By: **LB**	Date: **November 2018**

Figure 1



Source: Element Environment

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

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

0 50 100 150 200 250
Scale in Metres

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Title: **Extraction Staging Plan**

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

Client: **Boral Quarries**

Job No: **717041**

Project Man: **LL/AS**

Scale: **As shown**

Drawn By: **LB**

Date: **July 2019**

Figure 2

LEGEND:

- Lot area
- Dune extraction area
- Approximate inland extraction area
- Borehole location

0 100 200 300 400 500
Scale in Metres

DEPTH TO ACID SULFATE SOIL MATERIALS:

HIGH PROBABILITY :

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

LOW PROBABILITY :

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

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Title: **Acid Sulfate Soil Sampling Locations**

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

Client: **Boral Quarries**

Job No: **717041**

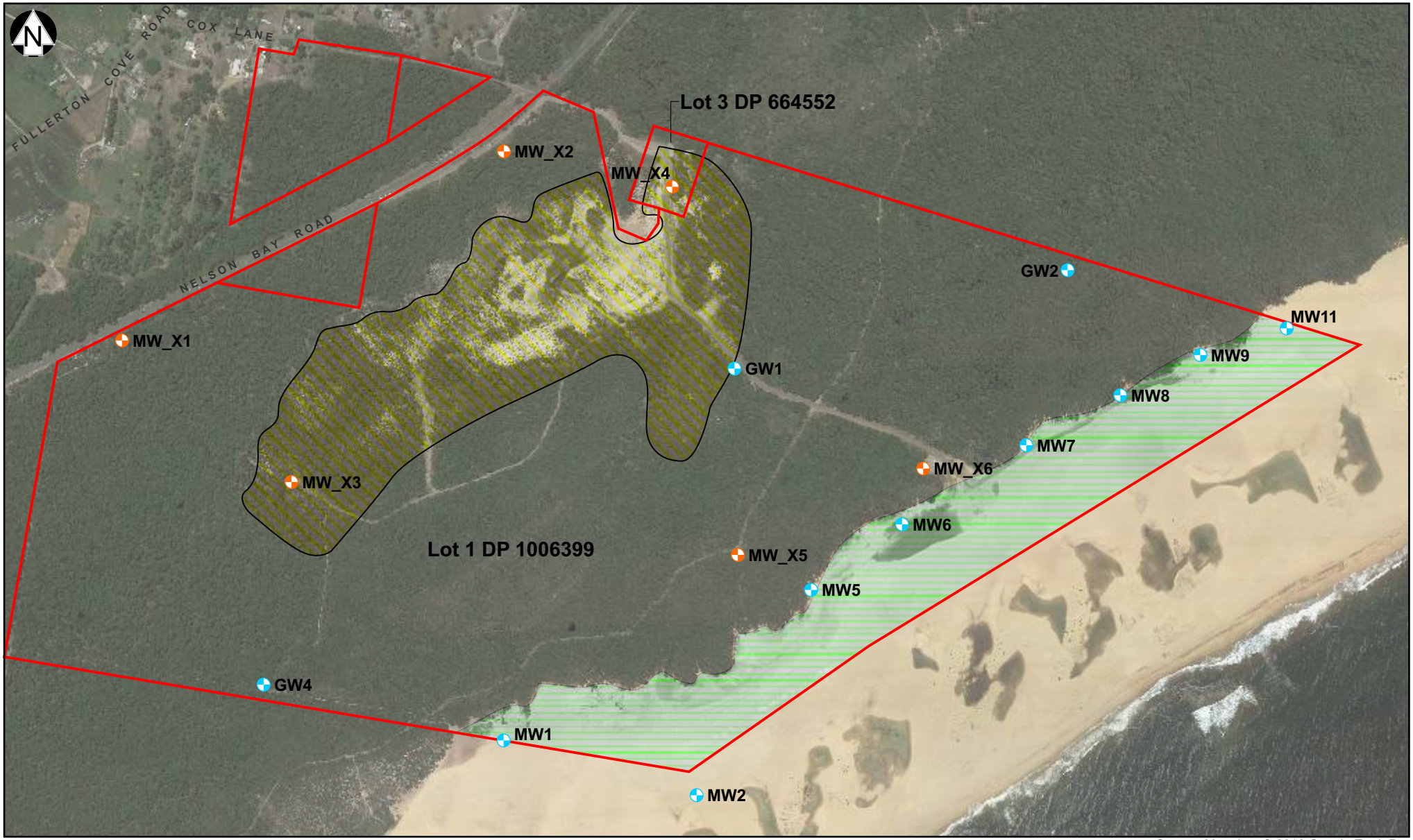
Project Man: **LV**

Scale: **As shown**

Drawn By: **LB**

Date: **April 2018**

Figure 4



Source: Map data © 2016 Google Earth Pro

LEGEND:

- Lot area
- Dune extraction area
- Inland extraction area
- Additional groundwater monitoring location - installed April 2017
- Current groundwater monitoring location

0 100 200 300 400 500

Scale in Metres

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Title:	**Bore location plan**
Location:	**Nelson Bay Road, Fullerton Cove, NSW**
Client: **Boral Quarries**	Job No: **717041**
Project Man: **LV**	Scale: **As shown**
Drawn By: **LB**	Date: **April 2018**

Figure 3

APPENDIX A SOIL LANDSCAPE REPORTS

bt BOYCES TRACK

Landscape—steep Quaternary Holocene sand dunes on the Tomago Coastal Plain. Local relief 10–30 m, slopes >25%, elevation 10–40 m. Uncleared tall open-forest.

Soils—deep (>300 cm), well-drained weakly developed Podzols (Uc2.2).

Qualities and Limitations—wind erosion hazard, steep slopes, mass movement hazard (if disturbed), ground water pollution hazard, non-cohesive acid soils of low fertility.

LOCATION

Steep stable Holocene dunes on the Tomago Coastal Plain between North Stockton and Bobs Farm. Type location is along Boyces Track (Area reference 4**01****E, 63 **70**5**N).

LANDSCAPE

Geology and Regolith

Holocene transgressive aeolian dunes.

Topography

Steep stable Holocene transgressive dunes. Two long walled ridges, parallel to the shoreline, form the major part of this landscape (Thom *et al*. 1992). These ridges are separated by a low relief sand plain (see Hawks Nest **(hn)** soil landscape). Local relief 10–20 m, slope gradients often >30 %, elevation 10–40 m. Windward slopes are generally longer and more gently inclined than leeward slopes which are shorter and steeper, often having formed at the angle of repose of the sand.

Vegetation

Predominantly uncleared tall open-forest containing *Eucalyptus pilularis* (blackbutt), *Angophora costata* (smooth-barked apple), *Banksia serrata* (old man banksia), *Acacia longifolia* (sydney golden wattle) with an understorey of *Persoonia* spp. (geebung), *Pteridium esculentum* (bracken) and *Imperata cylindrica* (blady grass).

Land Use

Predominantly bushland. Some areas are being sand mined.

Existing Land Degradation

This landscape is often being buried on the seaward side by large encroaching unstable transgressive dunes.

SOILS

Dominant Soil Materials

bt1—Speckled loose loamy sand (topsoil—A_1 horizon)

Colour	commonly brownish grey (10YR 4/1)
Texture	coarse loamy sand
Structure	loose
Fabric	sandy
Field pH	moderately to slightly acid (pH 5.0–6.0)
Coarse fragments	few charcoal fragments
Roots	common fine, few coarse
Exposed condition	loose
Permeability	high
Type location	Boyces Track on top of dune 500 m south of Nelson Bay Road (Grid Ref. 4 **01**10*E, 63 **70**40*N). *Soil Landscapes of the Port Stephens 1:100 000 Sheet* Soil Data System card 25, 0–40 cm

bt2—Bleached loose sand (topsoil—A_2 horizon)

Colour	greyish yellow brown (10YR 5/2) to light grey (10YR 7/1, 10YR 8/1). Dry colours usually bleached light grey (10YR 7/1, 10YR8/1)
Texture	sand
Structure	loose

Fabric	sandy
Field pH	slightly acid to neutral (pH 6.0–7.0)
Coarse fragments	few charcoal fragments
Roots	few fine, few coarse
Exposed condition	loose
Permeability	high
Type location	Boyces Track on top of dune 500 m south of Nelson Bay Road (Grid Ref. 4 **01**10*E, 63 **70**40*N). *Soil Landscapes of the Port Stephens 1:100 000 Sheet* Soil Data System card 25, 40–140 cm

bt3—Faintly mottled sand (topsoil—weak Bhs horizon)

Colour	mixture of dark brown (10YR 4/3) or brown (10YR 4/4) mottles in a background colour of dull yellow orange (10YR 6/4)
Texture	sand
Structure	loose
Fabric	sandy
Field pH	slightly acid to neutral (pH 6.0–7.0)
Coarse fragments	absent
Roots	few fine, few coarse
Exposed condition	loose
Permeability	high
Type location	Boyces Track on top of dune 500 m south of Nelson Bay Road (Grid Ref. 4 **01**10*E, 63 **70**40*N). *Soil Landscapes of the Port Stephens 1:100 000 Sheet* Soil Data System card 25, 140–180 cm

bt4—Loose dull yellow orange sand (parent material—C horizon)

Colour	dull yellow orange (10YR 6/4)
Texture	sand
Structure	loose
Fabric	sandy
Field pH	slightly acid to neutral (pH 6.0–7.0)
Coarse fragments	absent
Roots	absent
Exposed condition	loose
Permeability	high
Type location	Boyces Track on top of dune 500 m south of Nelson Bay Road (Grid Ref. 4 **01**10*E, 63 **70**40*N). *Soil Landscapes of the Port Stephens 1:100 000 Sheet* Soil Data System card 25, >180 cm

Occurrence and Relationships

Generally. Up to 40 cm of speckled loose loamy sand **(bt1)** overlies up to 100 cm of bleached loose light grey sand **(bt2)**, which overlies up to a 50 cm of faintly mottled sand **(bt3)** and >500 cm of loose dull yellow orange sand **(bt4)** [well-drained weakly developed Podzols (Uc2.2)]. Boundaries are clear except for **bt3/bt4** which is diffuse. Total soil depth >300 cm.

QUALITIES AND LIMITATIONS

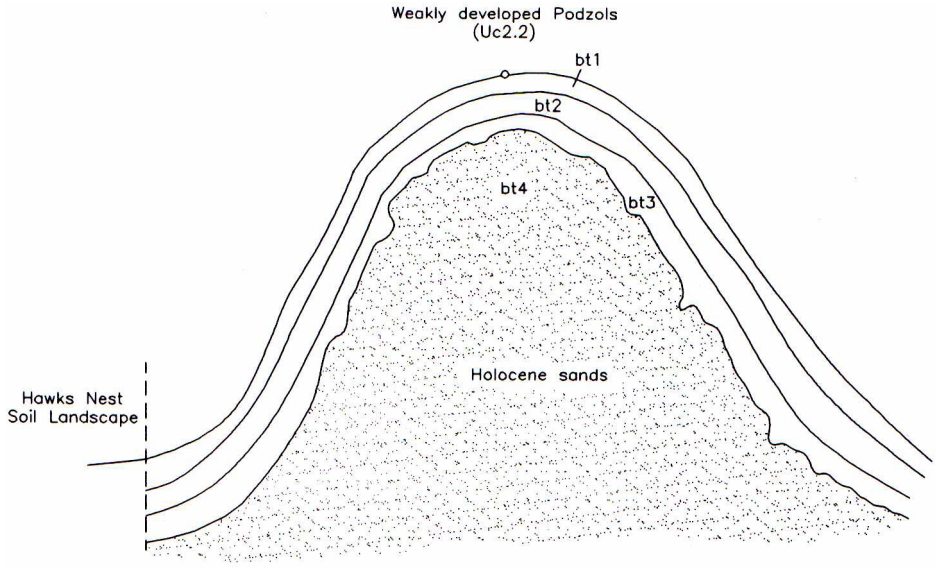
Landscape Limitations

High wind erosion hazard
Mass movement hazard (if disturbed)
Steep slopes (localised)
Non-cohesive soils
Foundation hazard
Ground water pollution hazard

Soil Limitations

bt1 High erodibility
High permeability
Very strong acidity
Low fertility
Low available water-holding capacity

bt2 High erodibility
High permeability
Strong acidity
Very low fertility
Very low available water-holding capacity



■ ***Schematic cross-section of Boyces Track soil landscape illustrating the occurrence and relationship of the dominant soil materials.***

bt3 High erodibility
High permeability
Strong acidity
Very low fertility
Very low available water-holding capacity

bt4 High erodibility
High permeability
Very low fertility
Very low available water-holding capacity

Fertility

Soil Materials as Plant Growth Media. Soil material suitability as growth media is generally low, due to strongly acid soils, high permeability, low fertility and very low available water-holding capacity.

Soil Profile Fertility. Soil profile suitability is generally low to moderate for deep, well-drained Podzols.

Erodibility

	K factor	Non-concentrated flows	Concentrated flows	Wind
bt1	0.000	very low	high	moderate
bt2	0.000	very low	very high	high
bt3	0.000	very low	high	high
bt4	0.000	very low	high	high

Erosion Hazard

	Non-concentrated flows	Concentrated flows	Wind
grazing	slight	high	V high
cultivation	slight	high	extreme
urban	slight	very high	V high

Foundation Hazard

High foundation hazard due to steep slopes and localised mass movement hazard.

Urban Capability

Generally high to severe limitations for urban development.

Rural Capability

Generally severe limitations for cultivation and high limitations for grazing. This landscape is best left undisturbed and retained under native vegetation.

Sustainable Land Management Recommendations

To prevent wind erosion it is important to maintain sufficient ground cover. Fertilisers may be necessary to establish good cover. Protective fences around critical vegetated areas and weed control may also be necessary.

Soil Conservation Earthworks

Not suitable, due to highly pervious soil materials.

hn HAWKS NEST

Landscape—low Holocene sandsheets and low transgressive dunes on the Tomago Coastal Plain. Local relief <3 m, slope gradients <10%, elevation 3–12 m. Dry scrubland, woodland and tall open-forest.

Soils—deep (>300 cm), well-drained Podzols (Uc2.3) and Siliceous Sands/Podzols (Uc2.21) on dunes, deep (>200 cm), poorly drained Humus Podzols (Uc5.1) on sandsheets.

Qualities and Limitations—wind erosion hazard, high watertables (localised), seasonal waterlogging (localised), permanent waterlogging (localised), non-cohesive, potential acid sulphate soils, ground water pollution hazard.

LOCATION

Stable low Holocene sandsheets and low transgressive dunes on the Tomago Coastal Plain from North Stockton to Bobs Farm (Area reference Salt Ash 4 **00**5**E, 63 **70**6**N).

LANDSCAPE

Geology and Regolith

Holocene quartz sandsheets and beach ridges.

Topography

Stable, gently undulating, Holocene, sandsheets and low transgressive dunes. Local relief <3 m, slope gradients <10%, elevation 3–12 m ASL. Low sandy dunes and swales are the dominant landform elements. The area is generally well drained apart from isolated, small, shallow swamps which occur in low lying, poorly drained swales and depressions.

Vegetation

Predominantly uncleared woodland and tall open-forest. Common species include *Angophora costata* (smooth-barked apple), *Eucalyptus pilularis* (blackbutt), *Eucalyptus gummifera* (red bloodwood), *Banksia serrata* (old man banksia), with an understorey of *Pteridium esculentum* (bracken), *Imperata cylindrica* (blady grass), *Actinotus helianthi* (flannel flower), *Persoonia* spp. (geebung), *Acacia longifolia* (sydney golden wattle).

Land Use

The main land use is bushland.

Existing Land Degradation

None identified.

SOILS

Dominant Soil Materials

hn1—Loose speckled grey brown loamy sand (topsoil—A_1 horizon)

Colour	brownish grey (10YR 4/1), occasionally brownish black in moist areas
Texture	loamy sand
Structure	single-grained
Fabric	sandy
Field pH	moderately acid (pH 5.5)
Coarse fragments	few charcoal fragments
Roots	fine common, few to common coarse
Exposed condition	loose
Permeability	very high
Type location	Boyces Track 300 m south of Nelson Bay Road (Grid Ref. 4 **00**850*E, 63 **70**80*N). *Soil Landscapes of the Port Stephens 1: 100 000 Sheet* Soil Data System card 246, 0–45 cm

hn2—Loose bleached sand (subsoil—A_2 horizon)

Colour	dull yellow orange (10YR 7/2), bleached
Texture	sand **Structure** single-grained
Fabric	sandy
Field pH	moderately acid (pH 5.5)

Coarse fragments	absent
Roots	few
Exposed condition	loose
Permeability	very high
Type location	Boyces Track 300 m south of Nelson Bay Road (Grid Ref. 4 **00**850*E, 63 **70**80*N). *Soil Landscapes of the Port Stephens 1:100 000 Sheet* Soil Data System card 246, 45–150 cm

hn3—Coloured mottled sand (subsoil—Bhs horizon)

Colour	organic staining; dark brown (10YR 3/4), brown (10YR 4/4) , organic/iron staining dull yellow orange (10YR 6/4) to dull yellow brown (10YR 5/4) with pale brown mottles
Texture	sand
Structure	single-grained
Fabric	sandy
Field pH	moderately to slightly acid (pH 5.5–6.0)
Coarse fragments	absent
Roots	fine common, few to common coarse
Exposed condition	loose to slightly hardsetting
Permeability	high
Type location	Boyces Track 300 m south of Nelson Bay Road (Grid Ref. 4 **00**850*E, 63 **70**80*N). *Soil Landscapes of the Port Stephens 1:100 000 Sheet* Soil Data System card 246, 150–270 cm

hn4—Greyish yellow brown sand (C horizon)

Colour	commonly greyish yellow brown (10YR 6/2)
Texture	sand
Structure	single-grained
Fabric	sandy
Field pH	moderately acid to neutral (pH 5.5–7.0)
Coarse fragments	absent
Roots	absent
Exposed condition	loose
Permeability	very high
Type location	Boyces Track 300 m south of Nelson Bay Road (Grid Ref. 4 **00**850*E, 63 **70**80*N). *Soil Landscapes of the Port Stephens 1:100 000 Sheet* Soil Data System card 246, 270–>300 cm

Occurrence and Relationships

Soil type is dependent on the age of the sand body. Along the coastal fringe lie the youngest aged dunes, and soil development is very poor apart from some organic matter build-up on the surface and minor development of a Bhs horizon. Further inland the dunes become progressively older and consequently the soils become more strongly developed with increasing age. It must be noted that the poorly developed soils of the seaward dunes very slowly become more developed as one travels landward.

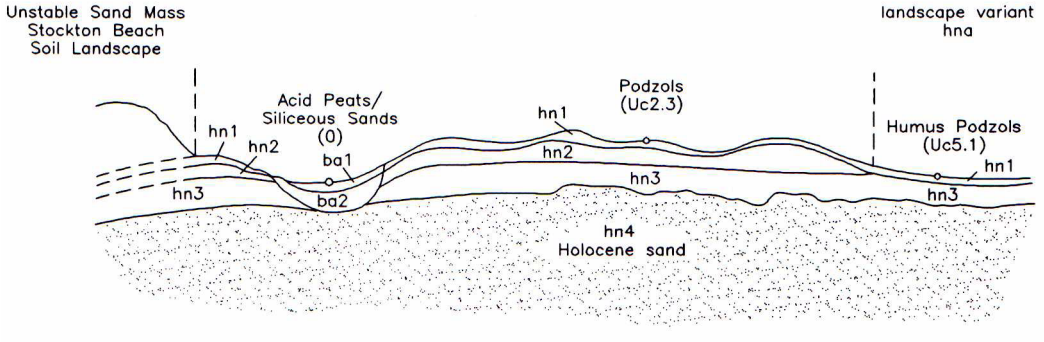
Dunes. Up to 40 cm of **hn1** overlies 10–150 cm of bleached loose sand **(hn2)**. **hn2** overlies 30–>100 cm of coloured mottled sand **(hn3)** and over 300 cm of greyish yellow brown sand **(hn4)** [well-drained Siliceous Sand/Podzol intergrades (Uc2.21) on the seaward fringe, Podzols (Uc2.3) occur landward]. Total soil depth is >300 cm and the boundaries between the soil materials are clear except for the boundary between **hn3** and **hn4** which is often diffuse.

Swampy swales. Small areas Acid Peats (O) occur in low lying, poorly drained swales with up to 10 cm **ba1** overlying >100 cm **ba2** [very poorly drained Acid Peat/Siliceous Sand intergrades]. (See Blind Harrys Swamp **(ba)** soil landscape.)

QUALITIES AND LIMITATIONS

Landscape Limitations

Wind erosion hazard
Non-cohesive soil
High watertables (localised, swales)
Seasonal waterlogging (localised, swales)
Permanent waterlogging (localised, swamps)
Ground water pollution hazard



■ ***Schematic cross-section of Hawks Nest soil landscape illustrating the occurrence and relationship of the dominant soil materials.***

Soil Limitations

hn1 High permeability
Strong acidity
Low fertility
Low available water-holding capacity
hn2 High erodibility
High permeability
Very low fertility
Very low available water-holding capacity
hn3 High erodibility
High permeability
Very low fertility
Very low available water-holding capacity
hn4 High erodibility
High permeability
Strong acidity
Very low fertility
Very low available water-holding capacity
Potential acid sulphate soil (localised)

Fertility

Soil Materials as Plant Growth Media. Soil material suitability is generally low due to very low nutrient and moisture retention capacities, low exchangeable cations and high permeability.

Soil Profile Fertility. Generally low suitability for deep, poorly drained Humus Podzols and deep, well-drained Podzols and Siliceous Sands/Podzols.

Erodibility

	K factor	Non-concentrated flows	Concentrated flows	Wind
hn1	0.000	very low	high	high
hn2	0.000	very low	high	high
hn3	0.000	very low	high	high
hn4	0.000	very low	high	high

Erosion Hazard

	Non-concentrated flows	Concentrated flows	Wind
grazing	slight	high	high
cultivation	slight	high	V high
urban	slight	very high	high

Foundation Hazard

Generally low, except for swampy swales which have a high foundation hazard due to high watertables.

Urban Capability

Exposed areas, swamps, and poorly drained sand flats have high limitations for urban development. Sheltered areas have moderate limitations for urban development.

Rural Capability

Due to the highly sensitive nature of the dunes which are easily predisposed to wind erosion, there is generally a high limitation for both cultivation and grazing. The area is best retained under native timber.

Sustainable Land Management Recommendations

To prevent wind erosion, it is important to maintain sufficient ground cover. Fertilisers may be necessary to establish good cover. Protective fences around critical vegetated areas and weed control may be necessary.

Soil Conservation Earthworks

Not suitable, due to highly pervious soil materials.

APPENDIX B CALIBRATION CERTIFICATES

ENVIRONMENTAL
EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: Eco - Tester pH2

Date Calibrated: 12/3/18 (17:00)

Calibrated By: LJ (name)

Job Number: 717041

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: 717041

Date Calibrated: 13/3/18 (13:00)

Calibrated By: LV (name)

Job Number: 717041

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: Eco Tester pH2

Date Calibrated: 14/3/18

Calibrated By: CV (name)

Job Number: 171241

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

APPENDIX C GEOLOGICAL BORELOGS

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

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

PAGE #: 1/1

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

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

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

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

PAGE #: 1/1

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

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

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

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

PAGE #: 1/1

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

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

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

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

PAGE #: 1/1

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

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

APPENDIX D LABORATORY TRANSCRIPTS AND CHAIN OF CUSTODY FORMS

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1807945**	Page	: 1 of 8
Client	: **ENVIRONMENTAL EARTH SCIENCES**	Laboratory	: Environmental Division Sydney
Contact	: LORETTA VISINTIN	Contact	: Peter Ravlic
Address	:	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: +61 02 99221777	Telephone	: +61-2-8784 8555
Project	: 717041	Date Samples Received	: 15-Mar-2018 17:30
Order number	:	Date Analysis Commenced	: 24-Mar-2018
C-O-C number	: ----	Issue Date	: 26-Mar-2018 12:44
Sampler	: LV		
Site	: Boral Stockton		
Quote number	: EN/010/17		
No. of samples received	: 48		
No. of samples analysed	: 29		

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ASS: EA033 (CRS Suite):Retained Acidity not required because pH KCl greater than or equal to 4.5
- ASS: EA033 (CRS Suite): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m3'.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1_1.5	BH1_3.0	BH1_4.0	BH1_7.0	BH1_15.5
			Client sampling date / time	12-Mar-2018 00:00	12-Mar-2018 00:00	12-Mar-2018 00:00	12-Mar-2018 00:00	12-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	ES1807945-003	ES1807945-005	ES1807945-006	ES1807945-007	ES1807945-010
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**5.6**	**6.0**	**5.5**	**6.1**	**9.5**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	**2**	<2	**2**	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.026**	**0.016**	**0.024**	**0.018**	**0.016**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	**16**	**10**	**15**	**11**	<10
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	**----**	**----**	**----**	**----**	**1.21**
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	**----**	**----**	**----**	**----**	**241**
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	**----**	**----**	**----**	**----**	**0.39**
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	**0.03**	<0.02	**0.03**	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	**18**	**10**	**17**	**11**	<10
Liming Rate	----	1	kg CaCO3/t	**1**	<1	**1**	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.03**	<0.02	**0.03**	<0.02	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**18**	**10**	**17**	**11**	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t	**1**	<1	**1**	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH2_0.5	BH2_2.0	BH2_2.5	BH2_3.0	BH2_9.0
			Client sampling date / time	13-Mar-2018 00:00	13-Mar-2018 00:00	13-Mar-2018 00:00	13-Mar-2018 00:00	13-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	ES1807945-012	ES1807945-013	ES1807945-014	ES1807945-015	ES1807945-017
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**10.0**	**5.1**	**6.0**	**6.2**	**5.8**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	**42**	<2	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	**0.07**	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.010**	**0.099**	**0.026**	**0.009**	**0.020**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	**62**	**16**	<10	**12**
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	**3.28**	**----**	**----**	**----**	**----**
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	**656**	**----**	**----**	**----**	**----**
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	**1.05**	**----**	**----**	**----**	**----**
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	<0.02	**0.17**	**0.03**	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	**104**	**17**	<10	**12**
Liming Rate	----	1	kg CaCO3/t	<1	**8**	**1**	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	**0.17**	**0.03**	<0.02	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	**104**	**17**	<10	**12**
Liming Rate excluding ANC	----	1	kg CaCO3/t	<1	**8**	**1**	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH3_3.5	BH3_4.0	BH3_9.0	BH3_15.0	BH3_16.0
			Client sampling date / time	13-Mar-2018 00:00	13-Mar-2018 00:00	13-Mar-2018 00:00	13-Mar-2018 00:00	13-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	ES1807945-024	ES1807945-025	ES1807945-028	ES1807945-030	ES1807945-031
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	6.1	6.0	5.7	9.6	9.5
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	0.007	0.008	0.018	0.017	0.012
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	<10	11	10	<10
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	----	----	----	4.84	0.65
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	----	----	----	967	130
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	----	----	----	1.55	0.21
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	12	<10	<10
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	<10	12	10	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t	<1	<1	<1	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH4_2.0	BH4_3.5	BH4_5.0	BH4_6.0	BH4_9.0
			Client sampling date / time	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	ES1807945-034	ES1807945-035	ES1807945-036	ES1807945-037	ES1807945-038
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**10.2**	**6.6**	**6.2**	**5.3**	**5.4**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	**4**	**6**
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.050**	**0.007**	**0.007**	**0.027**	**0.030**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	**31**	<10	<10	**17**	**18**
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	**8.26**	**0.27**	----	----	----
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	**1650**	**54**	----	----	----
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	**2.65**	**0.09**	----	----	----
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	**0.03**	**0.04**
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	**21**	**24**
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	**2**	**2**
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.05**	<0.02	<0.02	**0.03**	**0.04**
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**31**	<10	<10	**21**	**24**
Liming Rate excluding ANC	----	1	kg CaCO3/t	**2**	<1	<1	**2**	**2**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH4_12.0	BH4_15.0	BH4_16.0	BH4_17.0	BH4_20.5
			Client sampling date / time	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	ES1807945-039	ES1807945-040	ES1807945-041	ES1807945-043	ES1807945-044
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**6.0**	**8.0**	**5.5**	**5.9**	**9.2**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.029**	**0.018**	**0.017**	**0.018**	**0.012**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	**18**	**11**	**11**	**11**	<10
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	**----**	**0.20**	**----**	**----**	**0.62**
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	**----**	**39**	**----**	**----**	**125**
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	**----**	**0.06**	**----**	**----**	**0.20**
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	**0.03**	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	**18**	<10	**12**	**11**	<10
Liming Rate	----	1	kg CaCO3/t	**1**	<1	<1	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.03**	<0.02	<0.02	<0.02	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**18**	**11**	**12**	**11**	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t	**1**	<1	<1	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	FD1	FD2	FD3	FD4	----
			Client sampling date / time	13-Mar-2018 00:00	12-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	----
Compound	CAS Number	LOR	Unit	ES1807945-045	ES1807945-046	ES1807945-047	ES1807945-048	--------
				Result	Result	Result	Result	----
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**8.6**	**9.3**	**6.3**	**5.6**	**----**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	<2	**----**
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	**----**
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.014**	**0.016**	<0.005	**0.025**	**----**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	<10	<10	**16**	**----**
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	**0.21**	**1.18**	**----**	**----**	**----**
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	**41**	**235**	**----**	**----**	**----**
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	**0.07**	**0.38**	**----**	**----**	**----**
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**----**
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	**0.03**	**----**
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	**17**	**----**
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	**1**	**----**
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	**0.03**	**----**
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	<10	<10	**17**	**----**
Liming Rate excluding ANC	----	1	kg CaCO3/t	<1	<1	<1	**1**	**----**

CHAIN OF CUSTODY - ANALYSIS REQUEST FORM

Project Manager: Loretta Visintin | Sampler: LV | Job No: 717041 | Site Location: Boral Stockton | Laboratory: ALS | Sheet: 1 of 1

No. of samples	Sample ID/ Depth	Field pH water	Date sampled	Field Test: Difference pHFOX	Sample Matrix			Analysis Required													Sample-specific instructions/ notes
					Soil	Water	Sediment	EA033 (Cr suite complete)	HOLD												
1	BH1_0.3	6.9	12/03/2018	1.2	X				x												
2	BH1_1.0	7.2	12/03/2018	1.1	X				x												
3	BH1_1.5	6.8	12/03/2018	3.1	X			x													
4	BH1_2.0	6.2	12/03/2018	1.6	X				x												
5	BH1_3.0	6.5	12/03/2018	2.9	X			x													
6	BH1_4.0	6.2	12/03/2018	2.5	X			x													
7	BH1_7.0	5.4	12/03/2018	2.2	X			x													
8	BH1_10.5	6.3	12/03/2018	0.2	X				x												
9	BH1_12.0	7.8	12/03/2018	1.7	X				x												
10	BH1_15.5	8.3	12/03/2018	2.2	X			x													
11	BH2_0.25	6.8	13/03/2018	0.8	X				x												
12	BH2_0.5	8.7	13/03/2018	2.1	X			x													
13	BH2_2.0	5	13/03/2018	3.7	X			x													
14	BH2_2.5	6.5	13/03/2018	3.7	X			x													
15	BH2_3.0	6.4	13/03/2018	1.2	X			x													
16	BH2_6.0	6.2	13/03/2018	0.6	X				x												
17	BH2_9.0	6.4	13/03/2018	3.3	x			x													
	TOTAL																				

Turn Around *(circle)*: **NORMAL** / **3 DAYS** / **48 HRS** / **24 HRS** *(confirm with lab in advance if quick turn-around is required)*

Comments/ Instructions:

Lab Quotation No. *(if applicable)*:

Send report to *(email address)*: lvisintin@environmentalearthsciences.com

Cc: report to *(email address)*: mstuckey@eesigroup.com

Cc: invoice to *(email address)*: accounts@eesigroup.com

	Name	Signature	Date	Time
Sent off Site/Office by:	Loretta Visintin		15-Mar-18	
Receiving Lab:	Scanned	yes	15/3/18	1730 ork
Receiving Lab:				

Phone: (02) 9922 1777
Fax: (02) 9922 1010
PO Box 380 North Sydney NSW 2059
Email: eesnsw@environmentalearthsciences.com

ENVIRONMENTAL EARTH SCIENCES

Gibson Forward Lab / Split WO
Lab / Analysis: Brisbane / Cr suite EA033
Organised By / Date: _____
Relinquished By / Date: _____
Courier / Courier: _____
WO No: _____
Attach By PO / Internal Sheet: _____

Environmental Division
Sydney
Work Order Reference
ES1807945

Telephone : + 61-2-8784 8555

CHAIN OF CUSTODY - ANALYSIS REQUEST FORM

Project Manager: Loretta Visintin | Sampler: LV | Job No: 717041 | Site Location: Boral Stockton | Laboratory: ALS | Sheet: 1 of 1

No. of samples	Sample ID/ Depth	Field pH water	Date sampled	Field Test: Difference pHFOX	Sample Matrix			Analysis Required												Sample-specific instructions/ notes
					Soil	Water	Sediment	EA033 (Cr suite complete)	HOLD											
18	BH2_12.0	6.9	13/03/2018	1.1	X				x											
19	BH2_16.0	6.5	13/03/2018	1	X				x											
20	BH2_19.5	6	13/03/2018	0.4	X				x											
21	BH2_24.0	6.6	13/03/2018	0.5	X				x											
22	BH3_0.5	7.2	13/03/2018	0.3	X				x											
23	BH3_2.75	7.4	13/03/2018	0.9	X				x											
24	BH3_3.5	7.7	13/03/2018	1.8	X			x												
25	BH3_4.0	7.4	13/03/2018	1.7	X			x												
26	BH3_6.0	7	13/03/2018	1.2	X				x											
27	BH3_8.0	7.1	13/03/2018	1.4	X				x											
28	BH3_9.0	6.9	13/03/2018	4.3	X			x												
29	BH3_12.0	7.4	13/03/2018	1.1	X				x											
30	BH3_15.0	8.2	13/03/2018	2	X			x												
31	BH3_16.0	8.6	13/03/2018	2.5	X			x												
32	BH3_18.0	6.8	13/03/2018	0.9	X				x											
33	BH4_0.5	7.2	14/03/2018	1.7	X				x											
34	BH4_2.0	7.3	14/03/2018	2.2	X			x												
	TOTAL																			

Turn Around *(circle)*: **NORMAL** / **3 DAYS** / **48 HRS** / **24 HRS** *(confirm with lab in advance if quick turn-around is required)*

Comments/ Instructions:

Lab Quotation No. *(if applicable)*:

Send report to *(email address)*: lvisintin@environmentalearthsciences.com

Cc: report to *(email address)*: mstuckey@eesigroup.com

Cc: Invoice to *(email address)*: accounts@eesigroup.com

	Name	Signature	Date	Time
Sent off Site/Office by:	Loretta Visintin		15-Mar-18	
Receiving Lab:	[illegible]		15/3/18	1730 OK
Receiving Lab:				

Phone: (02) 9922 1777
Fax: (02) 9922 1010
PO Box 380 North Sydney NSW 2059
Email: eesnsw@environmentalearthsciences.com

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CHAIN OF CUSTODY - ANALYSIS REQUEST FORM

Project Manager: Loretta Visintin | Sampler: LV | Job No: 717041 | Site Location: Boral Stockton | Laboratory: ALS | **Sheet:** 1 **of** 1

No. of samples	Sample ID/ Depth	Field pH water	Date sampled	Field Test: Difference pHFOX	Sample Matrix: Soil	Water	Sediment	Analysis Required: EA033 (Cr suite complete)	HOLD											Sample-specific instructions/ notes
35	BH4_3.5	7.5	14/03/2018	2.7	X			x												
36	BH4_5.0	7.4	14/03/2018	2.4	X			x												
37	BH4_6.0	7.3	14/03/2018	4.3	X			x												
38	BH4_9.0	7	14/03/2018	4.4	X			x												
39	BH4_12.0	7.4	14/03/2018	2.8	X			x												
40	BH4_15.0	7.2	14/03/2018	3.3	X			x												
41	BH4_16.0	7.2	14/03/2018	4.6	X			x												
42	BH4_16.5	7.5	14/03/2018	1.4	X				x											
43	BH4_17.0	8.7	14/03/2018	3.1	X			x												
44	BH4_20.5	8.8	14/03/2018	2.7	X			x												
45	FD1		13/03/2018		X			x												
46	FD2		12/03/2018		X			x												
47	FD3		14/03/2018		X			x												
48	FD4		14/03/2018		x			x												
	TOTAL		48					29	19											

Turn Around *(circle)*: **NORMAL** / **3 DAYS** / **48 HRS** / **24 HRS** *(confirm with lab in advance if quick turn-around is required)*

Lab Quotation No. *(if applicable)*:

Comments/ Instructions:

Send report to *(email address)*: lvisintin@environmentalearthsciences.com

Cc: report to *(email address)*: mstuckey@eesigroup.com

Cc: invoice to *(email address)*: accounts@eesigroup.com

	Name	Signature	Date	Time
Sent off Site/Office by:	Loretta Visintin		15-Mar-18	
Receiving Lab:	Soils Lab	AJS.	15/3/18	1730 O/C
Receiving Lab:				

Phone: (02) 9922 1777
Fax: (02) 9922 1010
PO Box 380 North Sydney NSW 2059
Email: eesnsw@environmentalearthsciences.com

ENVIRONMENTAL EARTH SCIENCES

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1807813**	Page	: 1 of 2
Client	: **ENVIRONMENTAL EARTH SCIENCES**	Laboratory	: Environmental Division Brisbane
Contact	: LORETTA VISINTIN	Contact	: Peter Ravlic
Address	:	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 02 99221777	Telephone	: +61-7-3243 7222
Project	: 717041	Date Samples Received	: 27-Mar-2018 10:19
Order number	:	Date Analysis Commenced	: 29-Mar-2018
C-O-C number	: ----	Issue Date	: 29-Mar-2018 10:54
Sampler	: LORETTA VISINTIN		
Site	: Boral Stockton		
Quote number	: EN/010/17		
No. of samples received	: 3		
No. of samples analysed	: 3		

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- **The samples in this work order have been re-batched from ES1807945.**
- ASS: EA033 (CRS Suite): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m3'.

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)				Client sample ID	**BH2_2.0 ES1807945-013**	**BH4_6.0 ES1807945-037**	**BH4_9.0 ES1807945-038**	**----**	**----**
				Client sampling date / time	13-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	----	----
Compound	*CAS Number*	*LOR*	*Unit*		**EB1807813-001**	**EB1807813-002**	**EB1807813-003**	**--------**	**--------**
					Result	Result	Result	----	----
EA033-C: Acid Neutralising Capacity									
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3		**0.11**	**0.15**	**0.02**	**----**	**----**
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t		**22**	**30**	<10	**----**	**----**
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S		**0.03**	**0.05**	<0.01	**----**	**----**

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EB1807813**

Client	: **ENVIRONMENTAL EARTH SCIENCES**	Laboratory	: Environmental Division Brisbane
Contact	: LORETTA VISINTIN	Contact	: Peter Ravlic
Address	:	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: lvisintin@environmentalearthsciences.com	E-mail	: peter.ravlic@alsglobal.com
Telephone	: +61 02 99221777	Telephone	: +61-7-3243 7222
Facsimile	: +61 02 99221010	Facsimile	: +61-7-3243 7218
Project	: 717041	Page	: 1 of 2
Order number	:	Quote number	: ES2015ENVEAR0001 (EN/010/17)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: Boral Stockton		
Sampler	: LORETTA VISINTIN		

Dates

Date Samples Received	: 27-Mar-2018 10:19	Issue Date	: 27-Mar-2018
Client Requested Due Date	: 04-Apr-2018	Scheduled Reporting Date	: **04-Apr-2018**

Delivery Details

Mode of Delivery	: Samples On Hand	Security Seal	: Not Available
No. of coolers/boxes	: ----	Temperature	: ----
Receipt Detail	: REBATCH	No. of samples received / analysed	: 3 / 3

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- **The samples in this work order have been re-batched from ES1807945.**
- Discounted Package Prices apply only when specific ALS Group Codes ('W', 'S', 'NT' suites) are referenced on COCs.
- Please direct any turn around / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (3 weeks), Solid (2 months) from receipt of samples.
- Analysis will be conducted by ALS Environmental, Brisbane, NATA accreditation no. 825, Site No. 818 (Micro site no. 18958).
- **Breaches in recommended extraction / analysis holding times (if any) are displayed overleaf in the Proactive Holding Time Report table.**

From: Loretta Visintin [mailto:lvisintin@eesigroup.com]
Sent: Tuesday, 27 March 2018 10:19 AM
To: ALSEnviro Sydney <ALSEnviro.Sydney@ALSGlobal.com>
Cc: Mark Stuckey <mstuckey@eesigroup.com>
Subject: RE: RESULTS & EDD for ALS Workorder : ES1807945 | Your Reference: 717041

Hello,

We have an additional analysis request; we would like to schedule ANC titration (EA033-C) analysis on the following samples:

1 • BH2_2.0
2 • BH4_6.0
3 • BH4_9.0

Standard turnaround will suffice, thanks.

Kind regards, Loretta

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

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EB1807813

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APPENDIX E QUALITY ASSURANCE AND QUALITY CONTROL PROCEDURES

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1 DATA QUALITY OBJECTIVES

Development of data quality objectives (DQOs) for each project is a requirement of the National Environment Protection (Assessment of Site Contamination) Amendment Measure (NEPC 2013). Specific discussion in the development of the DQO's has been included in the main report.

Based on the DQOs the following measurement data quality indicators (MDQIs) are provided in Table 1.

TABLE 1 MEASUREMENT DATA QUALITY INDICATORS (MDQIS)

Parameter	Procedure	Minimum Frequency	Criteria	
			(5 to 10x LOR[4])	>10x LOR
Precision	Field Duplicates	1 in 20 - metals	<80 RPD	<50 RPD
		1 in 20 - semi-volatiles	<100 RPD	<80 RPD
		1 in 20 - volatiles	<150 RPD	<130 RPD
	Lab Replicate*	1 in 20	<50 RPD	<30 RPD
Accuracy*	Reference Material	1 in 10	60% to 140%R	80% to 120%R
	Matrix spikes			
	Surrogate spikes			
Representativeness*	Reagent Blanks	1 per batch	No detection	
	Holding Times*	Every sample	-	
Blanks**	Trip Blank	1 per batch	No detection	
	Rinsate Blanks			
Sensitivity	Limit of Reporting	Every sample	LOR < ½ site criteria	

Notes:

1. RPD – relative percentage difference;
2. %R – percent recovery;
3. LOR – limit of reporting;
4. [4] no limit at <5x LOR;
5. * the MDQI is usually specified in the standard method. If not, use the default values set out in this table; and
6. ** only necessary when measuring dissolved metals and volatile organic compounds in water samples.

It should be noted that Standards Australia (i.e. AS4482.1) specify that typical MDQIs for precision should be ≤50% RPD, however it should be noted that low concentrations and organic compounds can be acceptable if reported outside of this range. As the standard suggests, an RPD of >50% has been used as a 'trigger' and values above this level of repeatability have also been noted and explained.

Our adopted MDQIs for precision acknowledge the intrinsic heterogeneity of metal and semi volatile chemical concentrations in disturbed soil that may potentially cause large variations in results between laboratory subsamples (although all efforts are made to homogenise non volatile duplicate samples). Similarly, large variations in volatile chemical concentrations between duplicates may be unavoidable even when using best practice sampling

methodology, especially as we seek to minimise the disturbance to the sample while splitting it which means a high degree of inherent heterogeneity is expected.

As such, our adopted RPD criteria are considered to be a suitable measure for the reproducibility of results within a naturally heterogeneous media such as soil. A ≤50% RPD trigger value will be used, with any exceedance discussed and assessed for acceptability.

2 FIELD QA/QC PROGRAM

2.1 Sample collection, preservation, transportation and storage

Soil samples were collected and placed in appropriate sample containers as supplied by the nominated National Association of Testing Authorities (NATA) laboratory. Samples were labelled with the corresponding field/sample identification number, site reference and date in accordance with Environmental Earth Science sample procedures. Samples were placed in an iced container prior to transport to the nominated laboratory.

Soil samples were supplied to NATA accredited laboratories (ALS Laboratory) under a completed chain of custody (CoC). Copies of the CoC documentation and laboratory transcripts are provided in Appendix D of the main report.

2.2 Calibration of field equipment

The calibration of field equipment (hand held pH reader) was undertaken before and after each bore hole during the soil sampling program. The calibration records can be found within Attachment B.

2.3 Intra (blind) duplicate sampling

2.3.1 Soil

Four intra (blind) samples were collected during collection of soil samples. The relative percentage differences (RPD) calculations of the collected intra duplicate samples are presented in Table 2 below.

Calculated RPDs between the primary sample and their corresponding duplicate samples were all within the acceptable limits (MQDIS), as such, we consider the data set to be reliable.

TABLE 2 SOIL FIELD INTRA DUPLICATE RESULTS

Sample			Primary Sample	Intra duplicate sample	RPD%	Primary Sample	Inter duplicate sample	RPD%	Primary Sample	Inter duplicate sample	RPD%
Analyte	**units**	**LOR**	**BH1_15.5**	**FD2**		**BH4_3.5**	**FD3**		**BH4_6.0**	**FD4**	
Depth (m)			15.5	15.5		3.5	3.5		6.0	6.0	
pH KCl	pH Unit	0.1	9.5	9.3	2.1	6.6	6.3	4.7	5.3	5.6	5.5
Titratable Actual Acidity	mole H+/t	2	nd	nd	nd	nd	nd	-	4	nd	-
sulfidic - Titratable Actual Acidity	% pyrite S	0.02	0.01	0.01	0.0	0.01	0.01	0.0	0.01	0.01	0.0
Chromium Reducible Sulfur	% S	0.005	0.016	0.016	0.0	0.007	nd	-	0.027	0.025	7.7
acidity - Chromium Reducible Sulfur	mole H+/t	10	nd	nd	-	nd	nd	-	17	16	6.1
Acid Neutralising Capacity	% CaCO3	0.01	1.21	1.18	2.5	0.27	-	-	-	-	-
acidity - Acid Neutralising Capacity	mole H+/t	0.5	241	235	2.5	54	-	-	-	-	-
sulfidic - Acid Neutralising Capacity	% pyrite S	0.01	0.39	0.38	2.6	0.09	-	-	-	-	-
ANC Fineness Factor		0.5	1.5	1.5	0.0	1.5	1.5	0.0	1.5	1.5	0.0
Net Acidity	% S	0.02	nd	nd	-	nd	nd	-	0.03	0.03	0.0
Net Acidity	mole H+/t	10	nd	nd	-	nd	nd	-	21	17	21.1
Liming Rate	kg CaCO3/t	1	nd	nd	-	nd	nd	-	2	1	66.7
Net Acidity excluding ANC	% S	0.02	nd	nd	-	nd	nd	-	0.03	0.03	0.0
Net Acidity excluding ANC	mole H+/t	10	nd	nd	-	nd	nd	-	21	17	21.1

Sample			Primary Sample	Intra duplicate sample	RPD%	Primary Sample	Inter duplicate sample	RPD%	Primary Sample	Inter duplicate sample	RPD%
Analyte	**units**	**LOR**	**BH1_15.5**	**FD2**		**BH4_3.5**	**FD3**		**BH4_6.0**	**FD4**	
Liming Rate excluding ANC	kg CaCO3/t	1	nd	nd	-	nd	nd	-	2	1	66.7

Notes:

1. LOR level of reporting
2. RPD relative percentage difference
3. - not analysed, or RPD not calculable
4. nd – not detected above the Laboratory LOR

3 LABORATORY QUALITY CONTROL

3.1 Holding time

Analysed samples were extracted and analysed within acceptable holding times as defined in AS4482.1-2005.

3.2 Laboratories and analytical procedures

Laboratory analysis of primary and intra (blind) duplicate samples for this project was completed by ALS. The laboratory is accredited by NATA for the methods used, details of this accreditation can be viewed at http://www.nata.asn.au/, while details of the samples sent to each laboratory and the analysis requested are contained in the chain of custody documentation held in Appendix D of the main report. The analytical methods are noted on the laboratory transcripts.

3.3 Required limits of reporting

Acceptable limits of reporting (LOR) were provided by the analytical laboratory to allow the results to be compared against the soil investigation levels.

3.4 Laboratory method blanks

Reported results for laboratory method blank samples were acceptable or lower than laboratory LORs.

3.5 Laboratory duplicates

Laboratory duplicate results can be found in the analytical laboratory reports. The RPD between analytical results for primary samples and their corresponding laboratory soil duplicates were within acceptable limits.

4 ASSESSMENT OF DATA QUALITY

Based on information presented above, it can be confidently stated that the MDQO's for this project have been met and the data set is considered to be reliable for interpretative use.

5 QA/QC APPENDIX REFERENCES

American Public Health Association (APHA) (2012). *Standard methods for the examination of water and waste-water.* 22nd edition, APHA, Washington DC.

Australian/New Zealand Standard (AS/NZS) (2008). *Quality management systems - Requirements* (AS/NZS ISO 9001:2008). Standards Australia/Standards New Zealand, Sydney/Wellington.

Environmental Earth Sciences Pty Ltd (2011). *Soil, gas and groundwater sampling manual.* 7th Edition (Unpublished).

International Organisation for Standardisation (2005). *Quality management systems – Fundamentals and vocabulary*. (ISO 9000:2005).

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

Queensland Department of Environment and Heritage Protection (EHP) (2015). *Queensland auditor handbook for contaminated land. Module 5: Contaminated land investigation documents, auditor certification and compliance assessment*, EM1344 Version 1, September 2015, Department of Environment and Heritage Protection, Brisbane, QLD.

Queensland Department of Environment and Resource Management (DERM) (2010). *Monitoring and Sampling Manual 2009 (Water) Version 2.* Brisbane, QLD.

Queensland Department of Natural Resources (DNR) (2000). *Hydrographic procedure water quality sampling.*

Queensland Environmental Protection Agency (EPA) (1999). *Water quality sampling manual*. Brisbane, QLD.

Rayment, G. E, and Lyon, D. J. (2011). *Soil chemical methods – Australasia*, CSIRO Publishing.

Rayment, G. E, and Higginson, F. R, (1992). *Australian laboratory handbook of soil and water chemical methods*, Inkarta Press, Melbourne.

Standards Australia (2005). *Guide to the investigation and sampling of sites with potentially contaminated soil, Part 1: Non-volatile and semi-volatile compounds* (AS 4482.1).

Standards Australia (1999). *Guide to the investigation and sampling of sites with potentially contaminated soil, Part 2: Volatile substances* (AS4482.2).