Annex E – Preliminary Groundwater Assessment

AMMOS RESOURCE MANAGEMENT PTY LTD
C/- TATTERSALL LANDER PTY LTD

Preliminary Groundwater Assessment

Proposed Sand Quarry:
51 Nelson Bay Rd, Bobs Farm, NSW.

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

P1303897JR01V01
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All enquiries regarding this project are to be directed to the Project Manager.

Contents

1 Scope of Work

1.1 Overview

This report documents the findings of a preliminary groundwater assessment for a proposed sand quarry at 51 Nelson Bay Rd, Bobs Farm, NSW. The report has been prepared prior to the development of a Site Mining Plan (SMP) and therefore details regarding the proposed mining operations are preliminary only and based on information provided within the site's Stage 2 Sand Deposit Investigation (Quarry Mining Systems, 2013) and Stage Two Geological Assessment (VGT & Quarry Mining Systems, 2013).

Assumptions, findings and recommendations in this report should be reviewed by Martens and Associates (MA) following development of the SMP. If required, findings and recommendations should be revised to reflect the SMP.

1.2 Proposed Development

Based on review of Quarry Mining Systems (2013) and VGT & Quarry Mining Systems (2013), proposed development includes:

- Extraction and stockpiling of topsoil (sand) for future rehabilitation works.
- Extraction of sand above the water table using conventional excavation/extraction techniques.
- Extraction of sand from the water table to a level 16 m below the water table using a dredge.
- Rehabilitation.

For the purpose of this assessment, site extraction works are assumed to occur over the entire site excluding a 15 m buffer applied to the site boundary.

1.3 Objectives

Study objectives included:

1. Document existing groundwater conditions (levels, quality and flow directions).
2. Outline indicative hydrogeological hydraulic parameters.
3. Develop a conceptual groundwater model.

4. Undertake preliminary impact assessment of the proposed quarry with respect to the local groundwater system.

5. Undertake a preliminary acid sulphate soils assessment.

1.4 Abbreviations

AASS – actual acid sulfate soil

ASS – acid sulfate soil

BH - borehole

K – hydraulic conductivity

K_h, K_{xy} – horizontal hydraulic conductivity

K_v, K_z – vertical hydraulic conductivity

mBGL – m below ground level

PASS – potential acid sulfate soil

SMP – site mining plan

SWL – standing water level

TN – total nitrogen

TP - test pit

TP – total phosphorus

WBZ – water bearing zone

2 Site Description

2.1 Location and Setting

The site is located at 51 Nelson Bay Rd, Bobs Farm, NSW, Lot 254 DP753204, within Port Stephens Local Government Area (LGA) and has an area of approximately 40 ha. Refer to Attachment A, Figure 1, Figure 2 and Figure 3 for site location.

The site is situated in between the Tasman Sea (approximately 1.9 km south of site) and Telligerry Creek (approximately 1.4 km north of site).

Approximately 25% of the site's area is currently utilised for agriculture (typically olive and fig plantations) with a small proportion of this area occupied by farm sheds, a farm hand residence and a master residence. The remaining 75% of the site's area is forested and undeveloped apart from vehicle tracks.

2.2 Topography and Drainage

The majority of the site slopes towards the east, however, some portions of the site slope to the north, west and south west. Slopes are low (typically 0-5%) in the eastern portion of the site and higher (typically 10-50%) over the remainder of the site. The high slopes occur on dune knolls.

Site elevation ranges from approximately 35 mAHD at a knoll in the north west to approximately 2 mAHD at a depression in the site's north.

2.3 Site Flooding

The site is potentially partially affected by flood waters from Tilligerry Creek. Further consideration of this issue is beyond the scope of this report.

3 Hydrological Environment

3.1 Available Hydrogeological Data

The following information has been utilised for this investigation:

1. Stage 2 Sand Deposit Investigation (Quarry Mining Systems, 2013) and Stage Two Geological Assessment (VGT & Quarry Mining Systems, 2013) – these reports document:
    - Five TPs (TP1, TP2, TP3, TP4 and TP6) to depths ranging from 4 m to 6.5 mBGL.
    - Five boreholes to depths ranging between 19 and 26.5 mBGL using a hydraulic auger with all boreholes completed as groundwater monitoring bores. In terms of mAHD datum, the boreholes were taken to levels ranging between -8.25 and -14.78 mAHD.
    - Laboratory testing including particle shape analysis and particle size distribution.
2. MA field investigations undertaken on 07.08.2013, 22.08.2013, 01.10.2013 and 09.01.2014 which included:
    - Walkover inspection of the site to assess existing site conditions and local topography, geology, soil conditions and vegetation.
    - Measurement of groundwater levels via dip meter at all site bores.
    - Groundwater quality sampling at all site bores.
    - Slug testing at all site bores to determine hydraulic conductivity.
    - Commissioning of automated data loggers at all site bores to monitor groundwater levels between 22.08.2013 and 09.01.2014 at 15 minute intervals. At the time of preparing this report, data loggers remain within BH1, BH2 and BH3 and are intended to continue monitoring until 22.08.2014 resulting in one year of data.

3. Public domain bore data (NSW Natural Resource Atlas).

4. Survey data provided by Tattersal Lander.

Locations of boreholes/groundwater monitoring bores and test pits are shown on the site survey (Figure 1).

3.2 Geological Conditions

3.2.1 Geological Mapping

The Newcastle and Port Stephens 1:100,000 geological sheets indicate that the site underlain by Holocene sand (VGT & Quarry Mining Systems, 2013).

3.2.2 Borehole Investigations

With the exception of a clay/high organics layer located in the vicinity of the water table, borehole and test pit excavations revealed fine to medium grained sand to investigation levels (Table 1). The top of the clay/high organics layer (Table 2) varied from 0.78 to 4.61 m below the water table at BH1, BH2, BH3 and BH5 with thickness varying from 0.2 to 2.4 m. At BH4 the top of the clay/high organics layer was 1.46 m above the water table with a thickness of 0.4 m.

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

Detailed borehole logs are provided in Attachment B.

Table 1: Summary of borehole investigations levels.

BH	Ground Level (mAHD)	BH Depth (m)	BH Base (mAHD)
1	5.82	19.0	-13.18
2	11.72	26.5	-14.78
3	15.48	26.5	-11.02
4	9.45	24.0	-14.55
5	18.25	26.5	-8.25

Table 2: Summary of clay/high organics layer and groundwater levels.

BH	Top of Clay/Organic Layer (mAHD)	Bottom of Clay/Organic Layer (mAHD)	Groundwater Level (mAHD) [1]
1	1.52	1.32	2.31
2	1.22	-0.28	2.03
3	0.88	-0.12	2.33
4	3.65	3.25	2.19
5	-1.75	-4.15	2.86

Notes:
[1] Based on groundwater level observed on 22.08.2013.

3.3 Groundwater Levels

3.3.1 NSW Natural Resource Atlas

Review of the NSW Government Natural Resource Atlas (Figure 4) indicates 13 bores exist within approximately 2 km of the site. Based on available data (Table 3), bores are characterised as having shallow depths, viable yields and shallow SWLs. It is noted that no salinity data was available.

Table 3: NSW Natural Resource bore data summary.

Bore I.D [1]	Bore No# [2]	Purpose	Depth (m)	SWL (mBGL)	Salinity (µS/cm or TDS – unknown)	Yield (L/s)	Drilling Date
1	GW078478	Domestic	11			5	
2	GW062123	Irrigation	4				1938
3	GW062125	Irrigation	4				1938
4	GW062124	Irrigation	4				1938
5	GW080277	Irrigation	8			6	
6	GW080296	Domestic, farming, irrigation					2002
7	GW080269	Stock					2002
8	GW067296	Domestic	8	0.5		2.5	1991
9	GW056098	Domestic, Stock	13.3	3		6.31	1982
10	GW079677						
11	GW079354						
12	GW079401						
13	GW078618	Domestic	10				

Notes:
1. Identification adopted for this report.
2. NSW Natural Resource Atlas bore number.
3. Void table cells = no data available.

3.3.2 *Site Levels*

Groundwater was observed in all of the site's monitoring bores.

Dipped groundwater levels for the site's monitoring bores are provided in Table 4 (datum = mBGL) and Table 5 (datum = mAHD).

All site monitoring bores were equipped with data loggers to measure groundwater levels at 15 minute frequencies for a period of approximately 3 months. This data is summarised in Table 6 (datum =

mBGL) and Table 7 (datum = mAHD) and plotted with rainfall on the secondary axis in Figure 5, Figure 6, Figure 7, Figure 8 and Figure 9.

Table 4: Dipped groundwater levels (mBGL) at site bores.

	Groundwater Level (mBGL)		
Bore	**22.08.2013**	**01.10.2013**	**09.01.2014**
BH1	3.52	3.35	3.14
BH2	9.69	9.76	9.44
BH3	13.15	13.11	13.18
BH4	7.26	7.31	7.44
BH5	15.39	15.43	15.47

Table 5: Dipped groundwater levels (mAHD) at site bores.

	Groundwater Level (mAHD)		
Bore	**22.08.2013**	**01.10.2013**	**09.01.2014**
BH1	2.31	2.48	2.69
BH2	2.03	1.96	2.28
BH3	2.33	2.37	2.30
BH4	2.19	2.14	2.01
BH5	2.86	2.82	2.78

Table 6: Statistical summary of groundwater levels (mBGL) monitored by data logger at site bores between 22.08.2013 and 09.01.2014.

	Groundwater Depth (mBGL)				
Bore	**BH1**	**BH2**	**BH3**	**BH4**	**BH5**
Minimum	2.72	9.20	13.08	7.25	15.30
Mean	3.17	9.56	13.16	7.36	15.42
Maximum	3.53	9.78	13.22	7.50	15.57
Range	0.81	0.58	0.14	0.26	0.27

Table 7: Statistical summary of groundwater levels (mAHD) monitored by data logger at site bores between 22.08.2013 and 09.01.2014.

	Groundwater Depth (mAHD)				
Bore	**BH1**	**BH2**	**BH3**	**BH4**	**BH5**
Minimum	2.29	1.94	2.26	1.95	2.68
Mean	2.65	2.16	2.32	2.09	2.83
Maximum	3.10	2.52	2.40	2.21	2.95
Range	0.81	0.58	0.14	0.26	0.27

3.3.3 Site Levels and Relationship to Rainfall

Groundwater level/rainfall plots (Figure 5, Figure 6, Figure 7, Figure 8 and Figure 9) indicate groundwater levels respond to rainfall recharge. With respect to hydrograph trends, BH1 and BH2 are similar to one another, and BH3, BH4 and BH5 are similar.

BH1 and BH2 displayed the most prominent response to a recharge event which occurred between 17.11.2013 and 19.11.2013 that incorporated 137 mm of rainfall. Increases in groundwater level associated with this recharge event were approximately 0.42 m and 0.32 m for BH1 and BH2 respectively.

At both a macro and micro scale, BH1 and BH2 levels may be responding to irrigation recharge as these bores are within (BH1) and on the fringe (BH2) of fig plantations which are watered daily for a period of 2 hours with a sprinkler head at every fig plant. At a micro scale, BH1 levels may also be influenced by pumping of the site's water supply bore which is located to the south of the main dwelling. Analysis outside the scope of this report would be required to assess the impact irrigation and pumping have on BH1 and BH2 groundwater levels.

BH3, BH4 and BH5 each responded to the 17.11.2013 to 19.11.2013 recharge event albeit to a lesser degree and more slowly than BH1 and BH2. Increases in groundwater level associated with this recharge event were approximately 0.04 m, 0.18 m and 0.22 m for BH3, BH4 and BH5 respectively.

3.4 Background Groundwater Quality

Groundwater quality samples were taken from site bores on 22.08.2013 and submitted to a laboratory for analysis. Key analytes are summarised in Table 8 with laboratory reports for the complete suite of analytes in Attachment C and summary comments below.

- Groundwater is slightly acidic.
- Groundwater had an estimated maximum salinity concentration of 275 mg/L and is therefore fresh in the context of salinity classes summarised in Table 9.
- Nutrients are low aside from oxidised nitrogen which is elevated at BH1 and BH2. This may be due to application of fertilisers or some other agricultural source (Geese are kept near BH1), or a combination of both.

Table 8: Site groundwater quality summary.

Bore	Sample date	pH	EC [1] µS/cm	TDS [2] mg/L	TKN [3] mg/L	NOx [4] mg/L	TN [5] mg/L	TP [6] mg/L
BH1	22.08.2013	5.3	500	275	1.9	16	17.9	0.1
BH2	22.08.2013	5.4	490	270	2.3	21	23.3	<0.05
BH3	22.08.2013	5.6	250	138	0.5	0.01	0.51	<0.05
BH4	22.08.2013	5.2	190	105	0.3	<0.005	0.3	<0.05
BH5	22.08.2013	6.0	270	149	1.7	0.86	1.7	0.07

Notes:
[1] EC = electrical conductivity.
[2] TDS = total dissolved solids, estimated from EC * 0.55.
[3] TKN = total kjeldahl nitrogen.
[4] NOx = nitrogen oxide.
[5] TN = total nitrogen.
[6] TP = total phosphorous.

Table 9: Summary of water uses on the basis of salinity.

Class	Salinity (mg/L)	Irrigation Suitability [1]	Suitable for Potable [2]
Fresh	< 1,000	500 – 1,000 can have detrimental effects on sensitive crops	0 - 600 good 600 – 900 fair 900 – 1000 poor
Brackish	1,000 – 5,000	1,000-2,000 adverse effects on many crops, requiring careful management practices	1000-1200 poor > 1,200 unacceptable / unpalatable
Highly Brackish	5,000 – 15,000	2,000 – 5,000 can be used for salt tolerant plants on permeable soils with careful management practices	No
Saline	15,000 – 30,000	Not suitable	No
Sea Water	30,000 – 40,000	Not suitable	No

Notes:
[1] From NSW Department of Conservation and Land Management (1992).
[2] From Australian Drinking Water Guidelines (2011).

3.5 Hydraulic Conductivity (K) Data

3.5.1 Regional Data

Aquifer(s) in the region of the site are characterised by medium to high K values which are typical of fine to medium grained quartz sand. Published K values for the Stockton Aquifer, the aquifer which the site occupies, are limited. However, Umwelt (2009) utilised a pre-calibration K range of 10 – 30 m/d and final calibrated K value of 10 m/d in a groundwater model which was developed to accompany an EA for a proposed sand quarry located approximately 10km south west of the site within the Stockton dune complex.

A groundwater model developed by SKM (2009) for the Tomago Aquifer, an aquifer located to the north of the Stockton Aquifer which the site occupies, utilised a K value of 3 m/d which was based on field testing. Geary (2003) reported that the typical K range for the Tomago Aquifer is 10 – 20 m/d.

The typical range of K values for fine to medium grained sand is of the order of 0.6 to 15 m/d (Bair and Lahm, 2006).

3.5.2 Site Data

Slug testing was undertaken at all site bores. The response was recorded by a data logger measuring at 1 second intervals and data analysed using the Hvorslev solution. Results are summarised in Table 10. It is noted that whilst results align with literature values, further pump testing should be completed to confirm these data at a later stage of the development process.

Table 10: Summarised slug test data.

Bore	Hydraulic Conductivity (m/d)
BH1	1.20
BH2	3.05
BH3	2.23
BH4	0.42
BH5	0.98

3.6 Groundwater Hydraulic Gradients

Groundwater hydraulic gradients (Table 11) were analysed between site bores using the mean groundwater level observed by data logger over the monitoring period and the distance between bores measured in a CAD survey plan. Hydraulic gradients are low and operating in a different direction than expected in the vicinity of BH1. Groundwater is elevated at BH1 above levels at BH2 and BH3 despite being at a significantly lower surface elevation. BH3 groundwater levels are above BH2 levels as expected. Based on above, for the bulk of the site, it is likely that groundwater flows towards the south east (Tasman Sea) with a locally elevated water table mound at BH1 due to fig plantation irrigation. In the far west and north west of the site, where the land surface slopes to the north, north west and west, groundwater is likely to flow towards Tilligerry Creek in a north north westerly direction.

Table 11: Summarised hydraulic gradients.

Bores	Inter Bore Hydraulic Gradient (m/m)
BH3 to BH1	-0.00156
BH3 to BH2	0.00107
BH2 to BH1	-0.00605

Notes:
[1] Negative value denotes hydraulic gradient operating inverse land surface gradient.

3.7 Groundwater Dependent Ecosystems (GDEs)

Based on information provided by the project's ecological consultant, Wildthing, two GDEs exist on/near the site, Swamp Mahogany Paperbark Forest and Tall Alluvial Moist Forest. The location of these GDEs is shown in Figure 12.

3.8 Conceptual Groundwater Model

Based on data presented in preceding sections of this report, a conceptual groundwater model (CGM) was prepared (Figure 10). The CGM indicates:

- A groundwater flow divide exists in the north, west and north west of the site and forms a groundwater ridge between Tilligerry Creek and the Tasman Sea. Groundwater flow is to the south east towards the Tasman Sea for the majority of the site. Small portions of the site have groundwater flowing to north north west towards Tilligerry Creek. A local groundwater mound exists in the region of BH1 and is associated with recharge from irrigation.

- Hydraulic gradients are low – there is only 0.74 mAHD variation in mean groundwater level between all site bores.
- Groundwater depth is highly variable due to varying land surface levels. Maximum groundwater depth is of the order of 32 m whilst minimum groundwater depth may be of the order of 0.5 to 1 m in the far north of the site where land surface levels are 2 mAHD.
- With the exception of a clay/high organics layer located just below the water table, the investigation and soil profile generally comprises fine to medium grained sand that is subrounded to rounded with moderately high sphericity.
- Hydraulic conductivity is likely to frequently fall between say 0.5 and 10 m/d but may vary outside of this range.
- Specific yield of sands is likely to be of the order of 0.25 based on typical values in Bair and Lahm (2006).
- Groundwater is fresh.
- Groundwater is recharged via rainfall and exits the study area via throughflow with ultimate discharge at either the Tasman Sea or Tilligerry Creek.

4 Groundwater Impact Assessment

4.1 Impact on Groundwater Dependent Ecosystems (GDEs)

Identified GDEs (Figure 12) are located outside of the proposed mining footprint based on advice provided by Tattersal Lander. Drawdown at the GDEs is expected to be negligible given sand removal below the water table is proposed via dredge and therefore the only dewatering that will occur will be through evaporation of the dredge lake.

4.2 Impact on Existing Bores and Farm Dams

The two nearest bores are located approximately 300 m from the site. Groundwater level changes at these bores due to proposed sand quarrying are expected to be negligible as sand removal below the water table is proposed via dredge and therefore the only dewatering that will occur will be through evaporation of the dredge lake.

4.3 Groundwater Licensing

Groundwater take in the form of evaporation will likely need to be licensed. The volume of take will depend on the area of the 'window lake' exposing groundwater to the atmosphere and therefore the SMP.

If the entire site is quarried to form a 'window lake', based on mean annual evaporation of 1,712 mm at Williamtown BOM station, 0.82 pan factor for Williamtown (McMahon *et al*, date omitted) and the site area excluding the 15 m buffer from fence line of 360,661 m^2 (VGT & Quarry Mining Systems, 2013), the annual take volume is 506 ML.

If the SMP results in a smaller 'window lake' area with progressive backfilling to above the water table, the take volume for licensing will be lower.

5 Preliminary Acid Sulfate Soils Assessment

5.1 Desktop Review

5.1.1 Acid Sulfate Soils Risk Map Classification

Council mapping (Figure 11) assigned a Class 4 category to the bulk of the site with a Class 3 category assigned to a small portion in the site's north:

- Class 3 – works beyond 1 m below the natural ground surface and works where the water table is likely to be lowered beyond 1 m are likely to present an environmental risk if undertaken in Class 3 land.

- Class 4 - works beyond 2 m below the natural ground surface and works where the water table is likely to be lowered beyond 2 m are likely to present an environmental risk if undertaken in Class 4 land.

5.1.2 Geomorphic Setting

The likelihood of acid sulfate soils occurrence at a site is a function of various geomorphic parameters, in particular those listed in Table 12 (ASSMAC, 1998). Each is an indicator that acid sulfate soils are likely to be present on-site. Some of the geomorphic features listed are present or possibly present on the site. Therefore, the geomorphic setting of the site indicates that actual or potential ASS could be present and further site testing is recommended.

Table 12: Geomorphic features indicative of acid sulfate soils.

Geomorphic Feature	Present on site?
Holocene sediments	Yes
Soil horizons less than 5 m AHD	Yes
Marine / estuarine sediments or tidal lakes	Yes
Coastal wetland; backwater swamps; waterlogged or scaled areas; interdune swales or coastal sand dunes.	Yes
Dominant vegetation is mangroves, reeds, rushes and other swamp or marine tolerant species.	No
Geologies containing sulphide bearing material / coal deposits or former marine shales/sediments	Possible
Deep older (Pleistocene) estuarine sediments	Possible

5.2 Soil Sampling and Laboratory Analysis

5.2.1 Soil Sampling Regime

Based on the total site area of approximately 40 ha, ASSMAC (1998) guidelines recommend 80 boreholes as appropriate number of sampling boreholes for the site. A total of 27 soil samples from three boreholes were selected to cover a range of locations and depths (Table 13) and submitted to laboratory for Peroxide Oxidation Combined Acidity and Sulfate (sPOCUS) analysis. We note that this degree of sampling density is below that recommended by ASSMAC (1998) but is considered appropriate for preliminary screening purposes given the site's soils were found to be similar between the five site boreholes.

Table 13: Summary of samples analysed by laboratory for sPOCUS.

BH	Samples Analysed	Surface Elevation (mAHD)	Upper Sample Elevation (mAHD)	Lower Sample Elevation (mAHD)
BH03	8	15.48	12.5	-13
BH04	8	9.45	5.5	-13.5
BH05	11	18.25	8.5	-7.5

5.2.2 Groundwater Sampling Regime

pH was tested at all site bores.

5.2.3 Results

Laboratory results are summarised in Table 14 with the complete laboratory report provided in Attachment C. Results exceeded the action criteria for 14 of the 30 samples and therefore a detailed management plan should be prepared. The shallowest sample depth which exceeded action criteria was 0.8 mAHD.

With respect to groundwater, pH was 5.3, 5.4, 5.6, 5.2 and 6.0 at bores BH1, BH2, BH3, BH4 and BH5 respectively. pH less than 5.5 occurred at three bores and is an indicator that actual acid sulphate soil (AASS) are present.

Table 14: ASS (SPOCAS) testing results. Samples exceeding the ASSMAC action criteria are highlighted.

BH	Sample Depth (mAHD)	pH_{KCL} [1]	pH_{OX} [2]	TPA [3]	TSA [4]	S_{POS} [5]
BH03	+12.5 to +11.5	4.8	3.9	30	20	<0.005
BH03	+12.5 to +11.5	4.8	4.0	12	5	<0.005
BH03	+6.5 to +5.5	5.4	4.5	<5	<5	<0.005
BH03	**+1.5 to +0.5** [7]	5.6	4.5	<5	<5	<0.005
BH03	-0.5 to -1.1	5.6	4.4	10	7	<0.005
BH03	-1.3 to -1.5	5.4	3.2	250	240	0.08
BH03	-1.3	5.2	2.7	460	450	0.13
BH03	-3.1	4.5	2.3	360	340	0.51
BH03	-13	5.3	3.3	27	25	0.03
BH04	+5.5 to +3.0	5.2	4.3	17	12	<0.005
BH04	+3.3 to +2.5	5.3	4.5	17	15	<0.005
BH04	+0.8 to +0.5	4.9	3.8	37	27	<0.005
BH04	+0.8 to +0.5	4.9	3.8	37	30	<0.005
BH04	-0.5 to -1.5	5.3	4.4	12	7	<0.005
BH04	-2.5 to -3.0	5.5	4.4	17	16	<0.005
BH04	-6.0 to -7.5	5.3	3.4	27	26	0.02
BH04	-11.0 to -13.5	5.4	3.8	20	19	0.02
BH04	-13.5 to -12.1	5.4	3.7	20	17	0.02
BH05	+8.5 to +8.0	5.5	4.6	7	5	<0.005
BH05	+2.0 to +1.0	5.5	4.5	12	10	<0.005
BH05	+0.0 to -0.5	4.4	3.4	47	40	<0.005
BH05	+0.0 to -1.0	5.3	4.5	7	<5	<0.005
BH05	-1.1 to -1.5	5.7	4.5	5	<5	<0.005
BH05	-1.1 to -1.5	5.6	4.5	<5	<5	<0.005
BH05	**-1.5 to -2.0** [7]	5.6	4.6	<5	<5	<0.005
BH05	**-2.5 to -3.0** [7]	5.6	4.4	<5	<5	<0.005
BH05	-5	5.9	2.2	1500	1500	2.6
BH05	-5.5	7.9	4.1	120	120	1.4
BH05	-6.5	7.0	2.2	820	820	1.5
BH05	-7.5	8.1	2.9	67	67	0.21
Guideline Limit (action criteria) [6]	sands and clays			18	18	0.03

Notes: [1] pH (actual acidity). [2] pH after oxidation with peroxide (potential acidity). [3] Titratable Peroxide Acidity (Moles H^+/tonne). [4] Titratable Sulfidic Acidity (Moles H^+/tonne). [5] Oxidisable sulphur (%). [6] ASSMAC (1998) p.27, for >1,000 tonnes disturbed soil. [7] Soil samples are clay – all other samples are sand.

5.2.4 *Conclusion*

Potential acid sulphate soils (PASS) are present on the site at levels below approximately 0.8 mAHD and therefore a detailed management plan is required. We note that this detailed management plan may require additional sampling/laboratory testing if areas and depths of PASS are to be better delineated to enable application of variable liming rates for treatment. If no additional sampling/laboratory testing is undertaken then prescribed liming rates may be based on the sample requiring the highest liming rate.

Based on the current sampling, liming rates for treatment of impacted soils ranged from 0.75 kg/T (minimum) to 120 kg/T (maximum) with a mean of 20 kg/T.

6 Summary

With the exception of potential impacts associated with PASS, the proposed development is unlikely to significantly impact groundwater. Groundwater levels on the site and at surrounding bores will not be significantly altered as the proposed method of sand extraction below the water table is via dredge and therefore unlikely to result in significant groundwater drawdown. Some local groundwater level reduction may occur on the site due to evaporation of the 'window lake' and a changed recharge regime, however, this is expected to be minor given the high conductivity of the aquifer material surrounding the 'window lake'.

The site contains PASS at levels below approximately 0.8 mAHD which may generate sulfuric acid when oxidised. This impact can be mitigated with soil treatment, bunding, and possibly impermeably liners beneath mixing stockpiles, however, this should be reviewed in the site's detailed acid sulphate management plan which is required based on findings of this investigation.

Findings of this assessment should be reviewed by MA after the SMP has been formulated.

7 Limitations

Occasionally sub-surface soil conditions in areas of the site not investigated may be found to be different from those expected. This can also occur with groundwater conditions, especially after climatic changes. Should, during site works, soil or water conditions be found to be significantly different to those detailed in this report, works shall cease immediately and the new conditions should be addressed by Martens & Associates to determine hydrogeological implications before recommencement.

8 References

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

Bair and Lahm (2006), Practical Problems in Groundwater Hydrology, Pearson Education.

Geary, P. M (2003) On-site *Treatment System Failure and Shellfish Contamination in Port Stephens, NSW* – SepticSafe enhancement Grant Project E08

McMahon, Peel, Lowe, Srikanthan and McVicar (date omitted), Supplementary Material to paper 'Estimating actual, potential, reference crop and pan evaporation using standard meteorological data: A pragmatic synthesis'.

McMahon, Peel, Lowe, Srikanthan and McVicar (date omitted), Supplementary Material to paper 'Estimating actual, potential, reference crop and pan evaporation using standard meteorological data: A pragmatic synthesis'.

NSW Department of Conservation and Land Management (1992), What do all the numbers mean, a guide for the interpretation of soil test results.

Quarry Mining Systems (2013), *Bobs Farm Sand Deposit Stage 2 Investigation*, report REF: 2013-11-02-D.

SKM (2009), *Modelling Deatering Effects on Groundwater Dependent Ecosystems at Raymond Terrace, Newcastle*, slide show presented at the International Association of Hydrogeologists Groundwater in the Sydney Basin Symposium.

Umwelt (2009), *EA for Sand Extraction from Lots 218 and 220, Salt Ash, REF: 1646/R06/FINAL.*

VGT & Quarry Mining Systems (2013), *Bobs Farm Stage Two Geological Assessment*, report REF: BF13A.

9 Attachment A - Figures

FIGURE 1

FEATURE		EASTING (MGA)	NORTHING (MGA)	GROUND RL (m)	TOP OF PIPE RL (MARKED WITH TEXTA)	RL OF TOP OF COVER BOX (MARKED WITH)
MONITORING WELLS	PH1	406685.6	6373153.8	5.824	6.386	6.469
	PH2	406592.8	6373286.7	11.719	12.284	12.369
	PH3	406297.2	6373318.9	15.478	15.995	16.108
	PH4	406260.7	6373082.8	9.452	10.008	10.117
	PH5	406803.7	6373515.8	18.249	18.819	18.899
TEST PITS	TP1	406568.0	6373292.5	12.65	-	-
	TP2	406462.5	6373280.0	12.30	-	-
	TP3	406276.0	6373056.0	11.90	-	-
	TP4	406532.0	6373398.0	31.05	-	-
	TP6	406863.0	6373463.0	7.00	-	-

HORIZONTAL COORDINATE SYSTEM: APPROXIMATE MGA GROUND

VERTICAL DATUM: AHD71 (BASED ON PM 142840)

ORIGIN OF COORDINATES AND LEVELS:

	EASTING (MGA)	NORTHING (MGA)	RL (m)
PM 142840	406758.029	6372984.656	6.275

REV	DETAILS OF AMENDMENT	DESIGNED	DRAWN	CHECKED	APPROVED	DATE
A	Original Issue					

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

TATTERSALL LANDER PTY LTD
DEVELOPMENT CONSULTANTS
ENGINEERING, SURVEYING & PLANNING
2 Bourke St. P.O.Box 580
RAYMOND TERRACE 2324
Fax (02) 49871733 Phone (02) 49871500

PLAN SHOWING LOCATIONS OF TEST PITS AND MONITORING WELLS 51 NELSON BAY ROAD, BOBS FARM

COUNCIL: PORT STEPHENS	REFERENCE: ####
PARISH	SHEET SIZE: A1
SCALE: 1:2000	SHEET No.: ####
DATE : Plotted 09:41 21/08/13	
CLIENT: PATRA HOLDINGS PTY LTD	JOB No.: 212434
COMPUTER FILE : S:\Clients\2012\212434\Dwg\TOP0.dwg	

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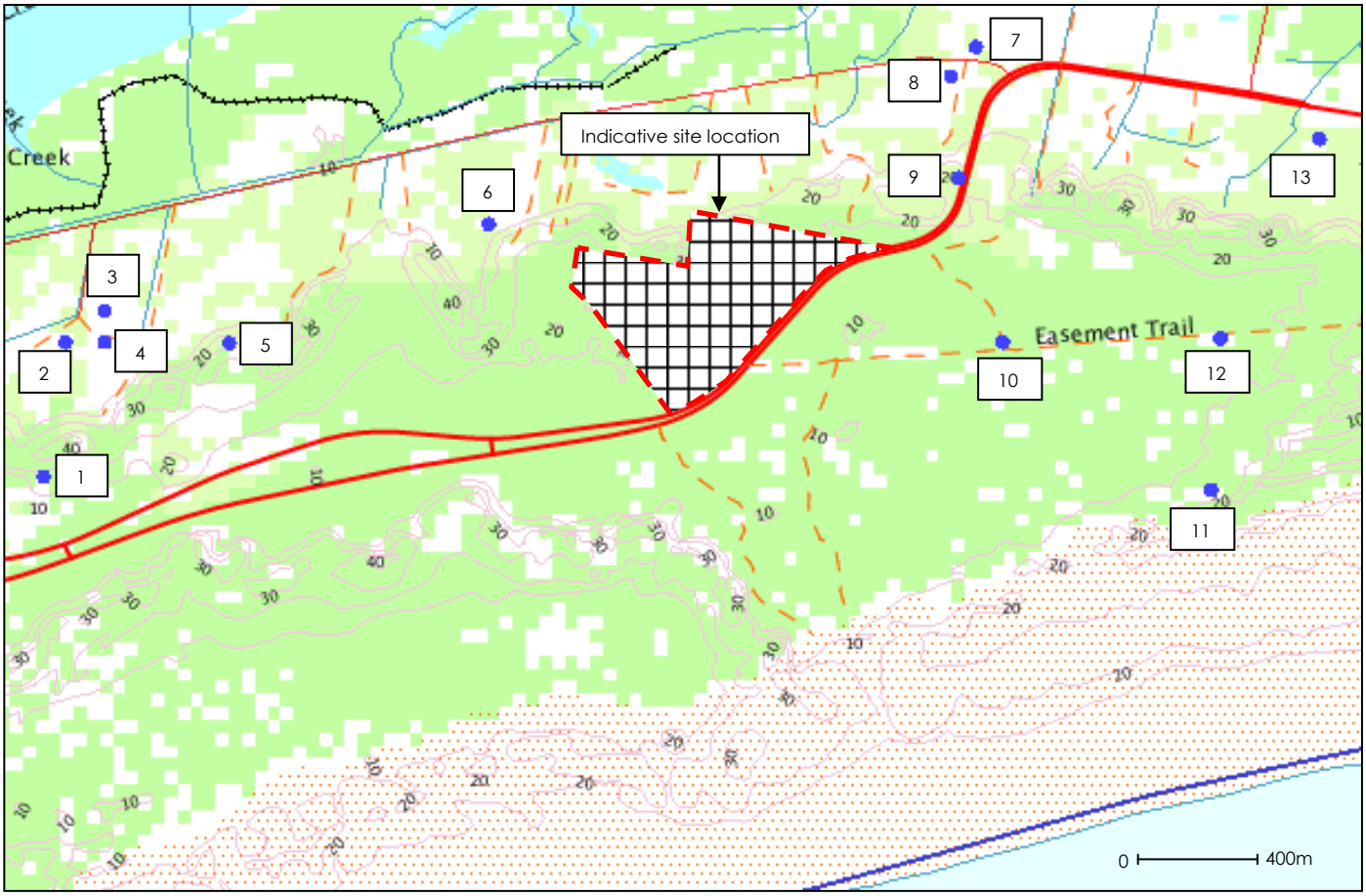
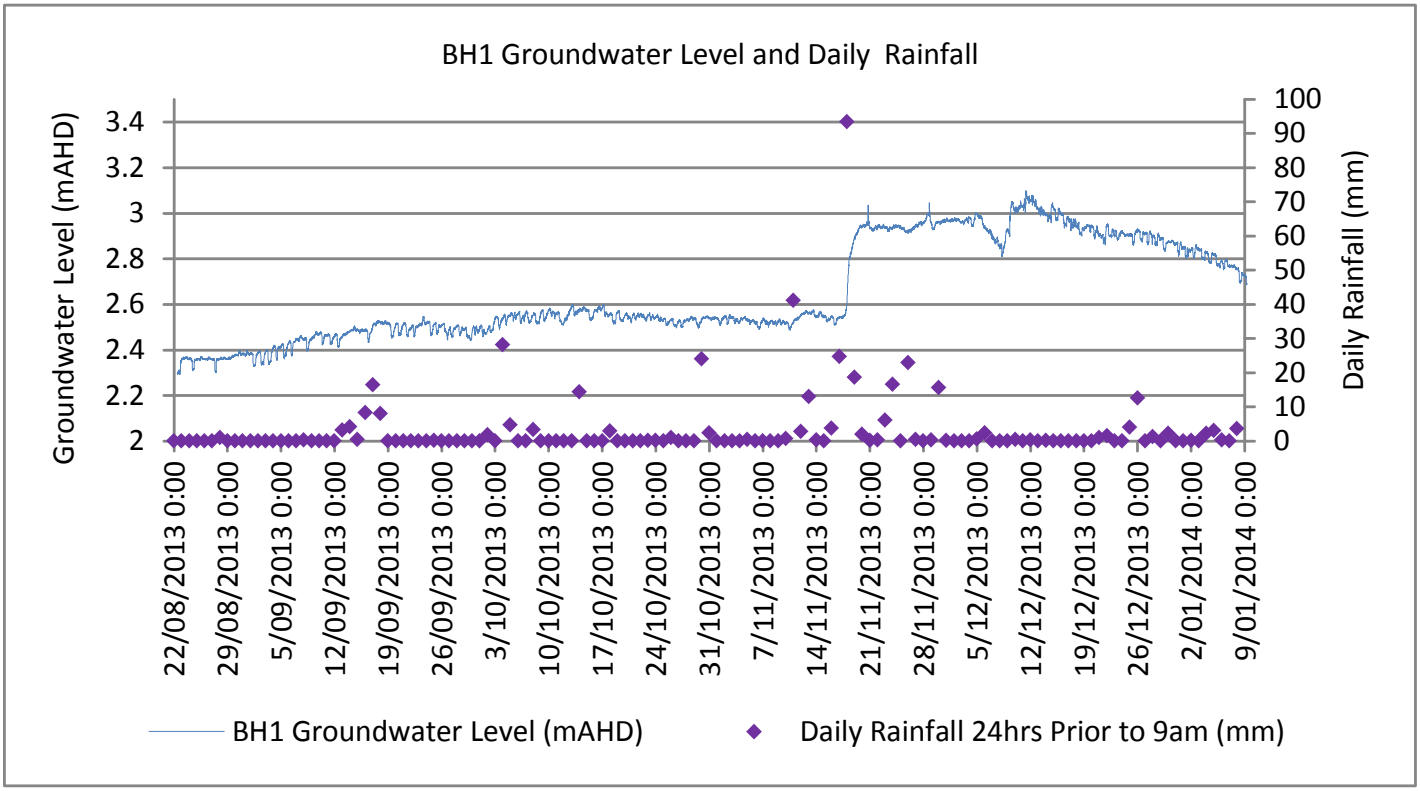
Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**SITE AERIAL AND LOCAL SETTING** SOURCE: SIX MAPS	Drawing No: FIGURE 2
Approved:	GT		
Date:	07.01.2014		
Scale:	NA		Job No: P1303897

N

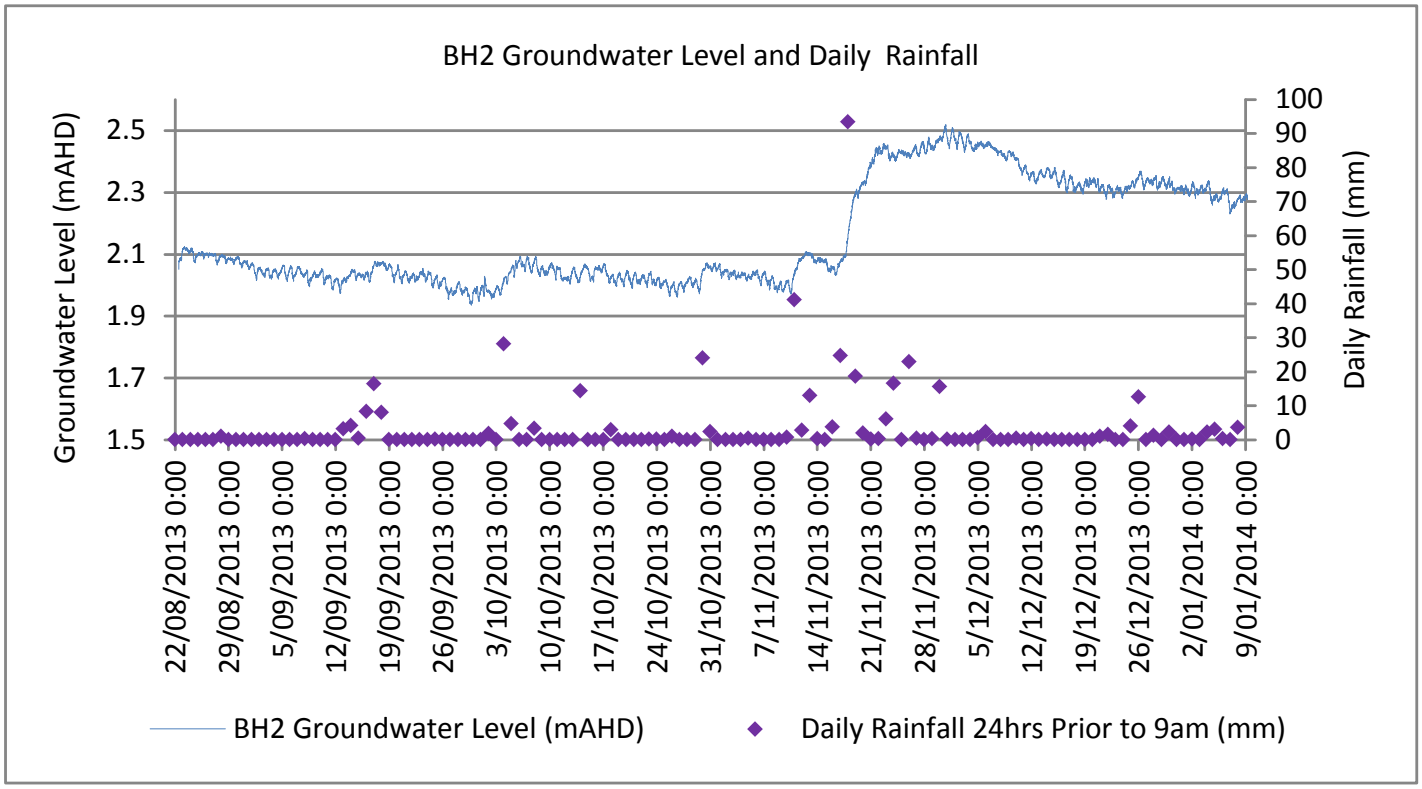
Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**SITE AERIAL** SOURCE: SIX MAPS	Drawing No: FIGURE 3
Approved:	GT		
Date:	07.01.2014		
Scale:	Aprrox. 1: 7,000		Job No: P1303897



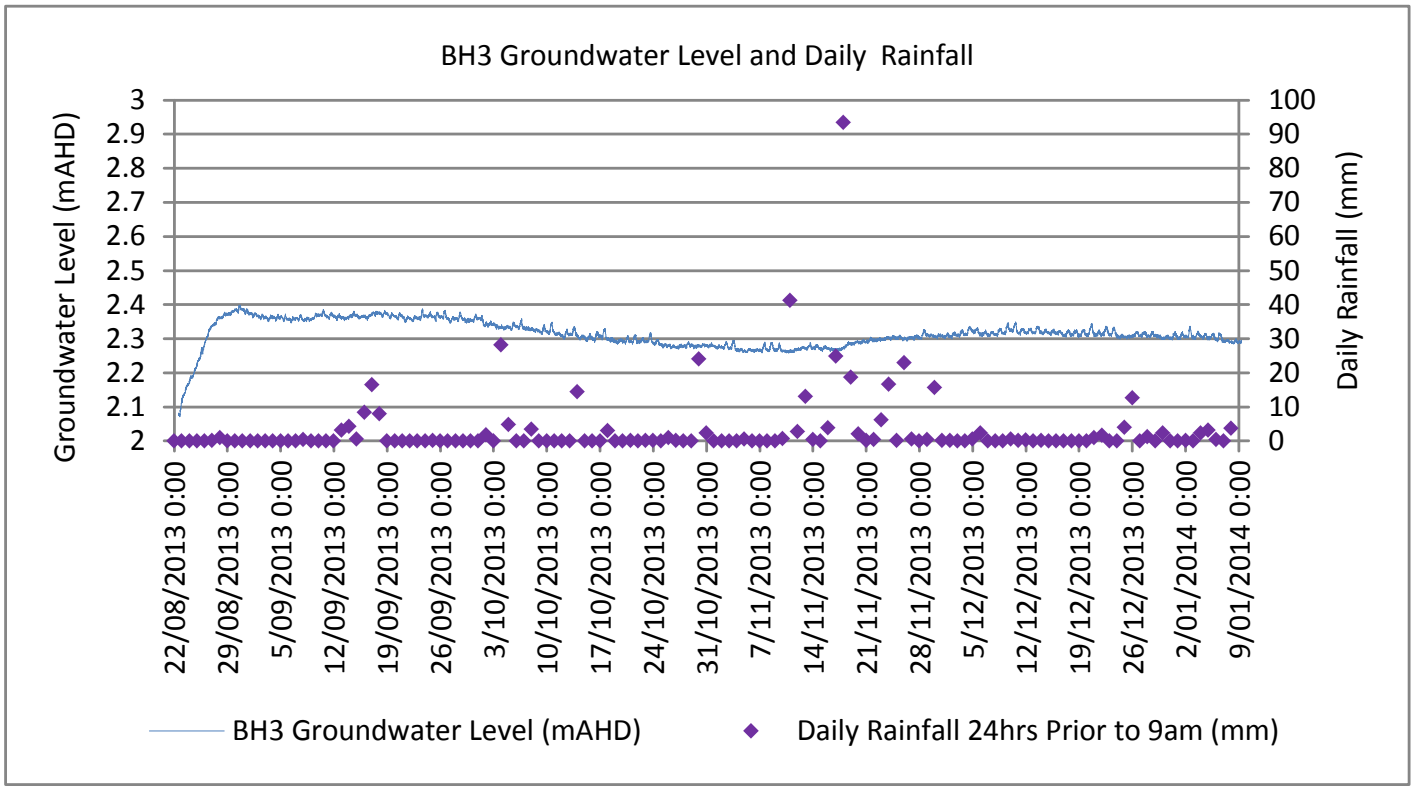
Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**SURROUNDING BORES** SOURCE: NSW NATURAL RESOURCE ATLAS	Drawing No: FIGURE 4
Approved:	GT		
Date:	07.01.2014		
Scale:	Aprrox. 1: 25,600		Job No: P1303897



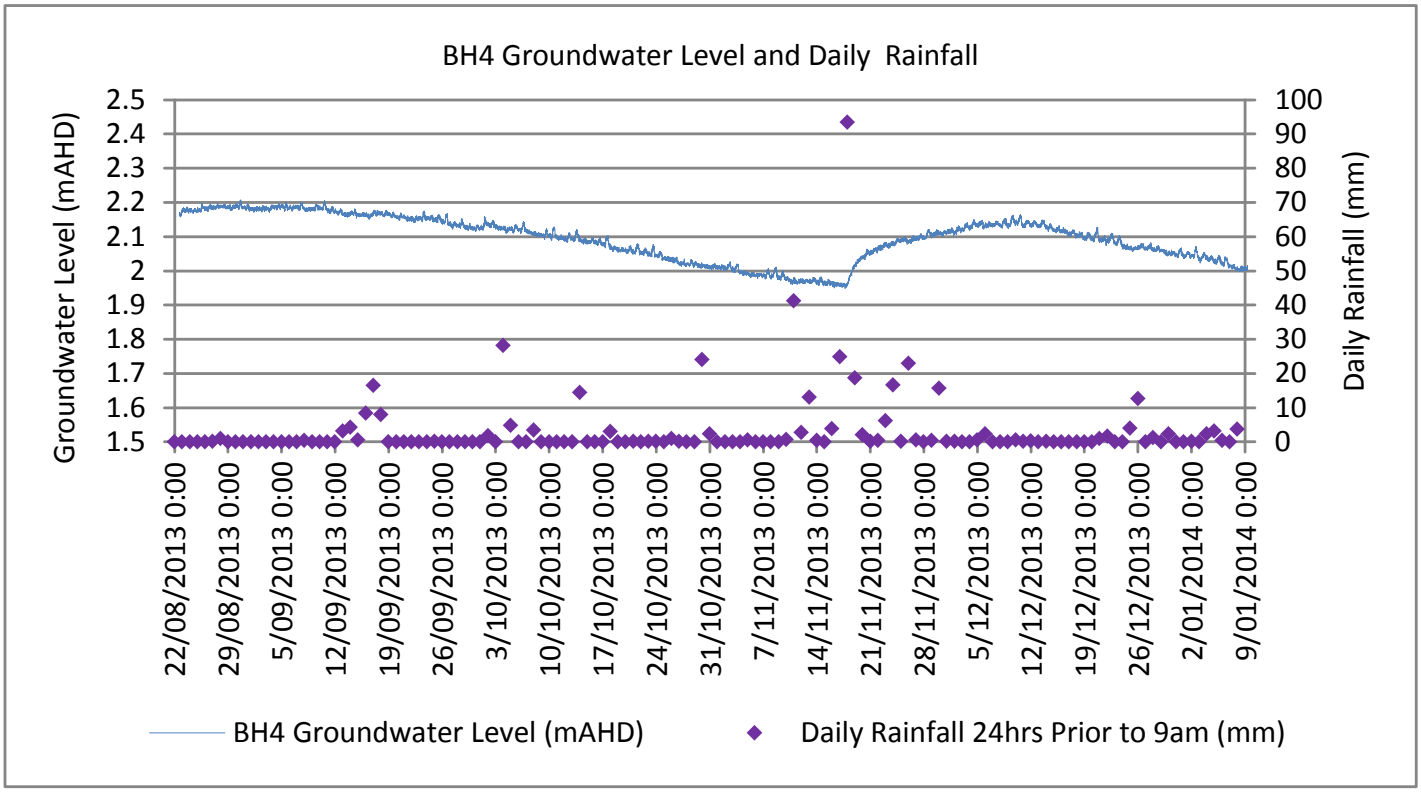
Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**BH1 GROUNDWATER LEVELS MONITORED BY DATA LOGGER**	Drawing No: FIGURE 5
Approved:	GT		
Date:	07.01.2014		
Scale:	NA		Job No: P1303897



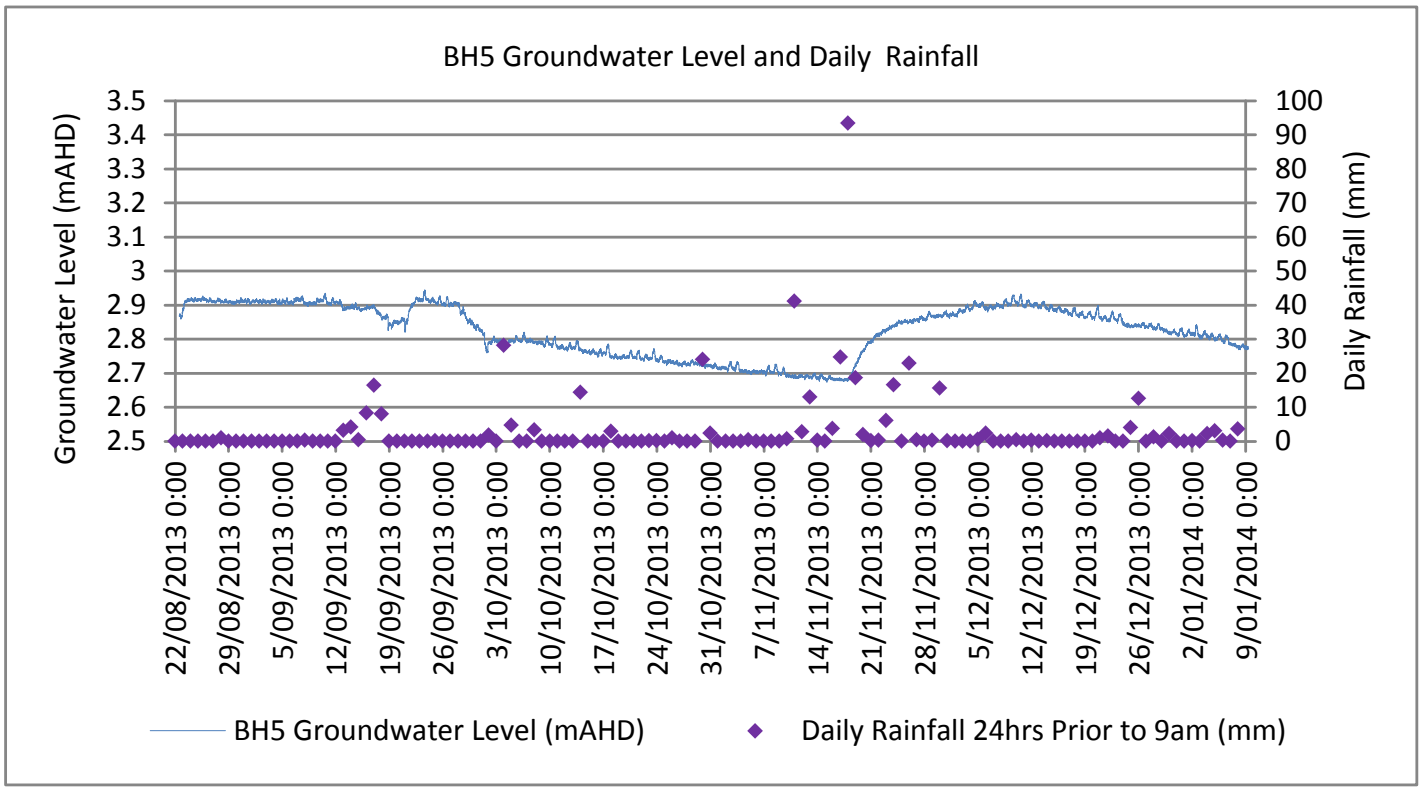
Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**BH2 GROUNDWATER LEVELS MONITORED BY DATA LOGGER**	Drawing No: FIGURE 6
Approved:	GT		
Date:	07.01.2014		
Scale:	NA		Job No: P1303897



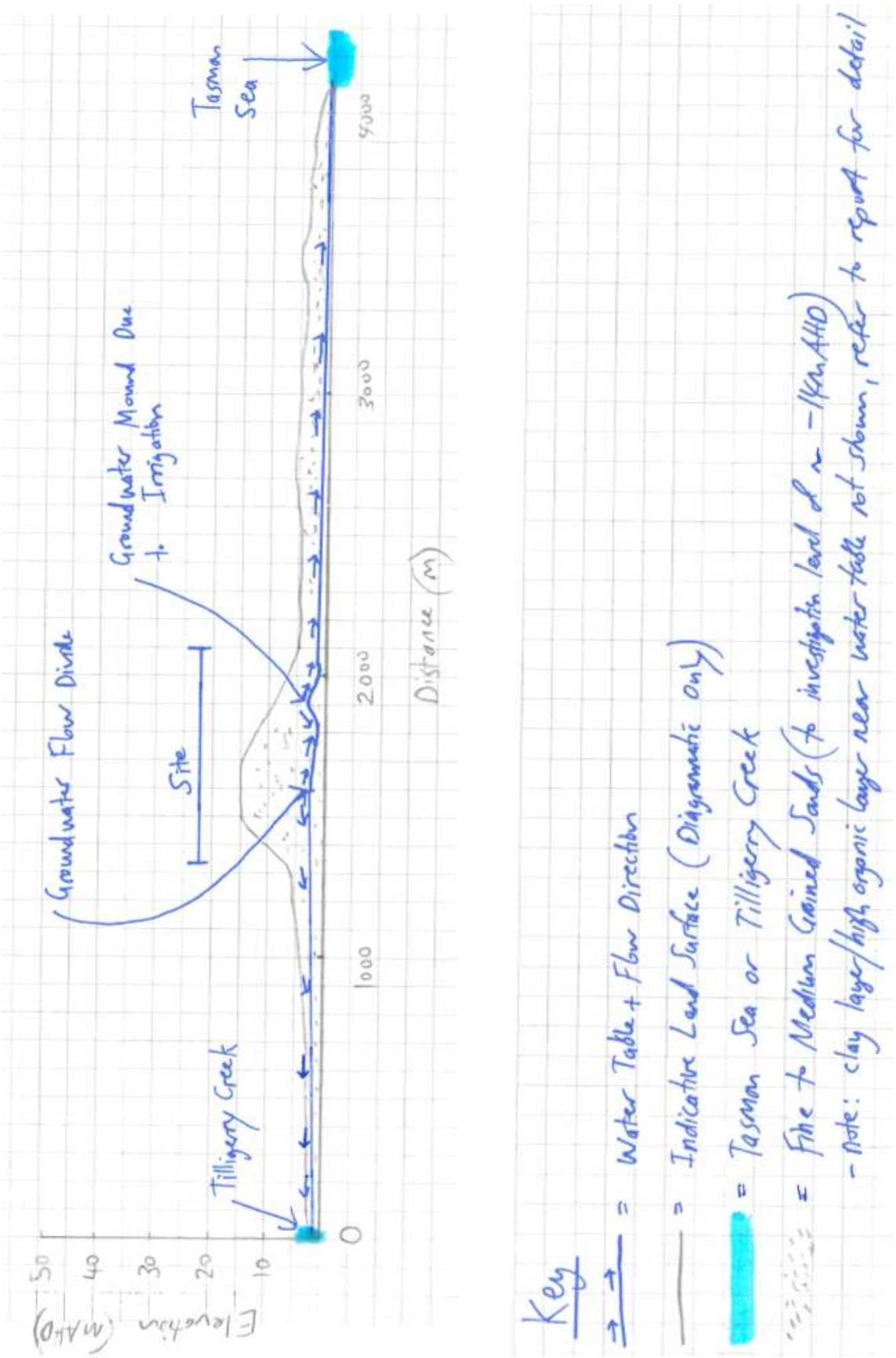
Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**BH3 GROUNDWATER LEVELS MONITORED BY DATA LOGGER**	Drawing No: FIGURE 7
Approved:	GT		
Date:	07.01.2014		
Scale:	NA		Job No: P1303897



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**BH4 GROUNDWATER LEVELS MONITORED BY DATA LOGGER**	Drawing No: FIGURE 8
Approved:	GT		
Date:	07.01.2014		
Scale:	NA		Job No: P1303897



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**BH5 GROUNDWATER LEVELS MONITORED BY DATA LOGGER**	Drawing No: FIGURE 9
Approved:	GT		
Date:	07.01.2014		
Scale:	NA		Job No: P1303897



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**CONCEPTUAL GROUNDWATER MODEL**	Drawing No: FIGURE 10
Approved:	GT		
Date:	14.01.2014		
Scale:	NA		Job No: P1303897

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LEGEND

Acid Sulfate Soil Planning Categories

- (1) Any Works
- (2) Works Below the Ground Surface
- (3) Works Beyond 1m Below the Natural Ground Surface
- (4) Works Beyond 2m Below the Natural Ground Surface
- (5) Works Within 500m of Adjacent Class
- Adjacent Local Government Area
- Ocean

Map prepared by Land Use Planning, Sustainable Planning Group. Printed February, 2007

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**ACID SULFATE SOIL MAPPING** MAPPING BY PORT STEPHENS COUNCIL	Drawing No: FIGURE 11
Approved:	GT		
Date:	14.01.2014		
Scale:	NA		Job No: P1303897

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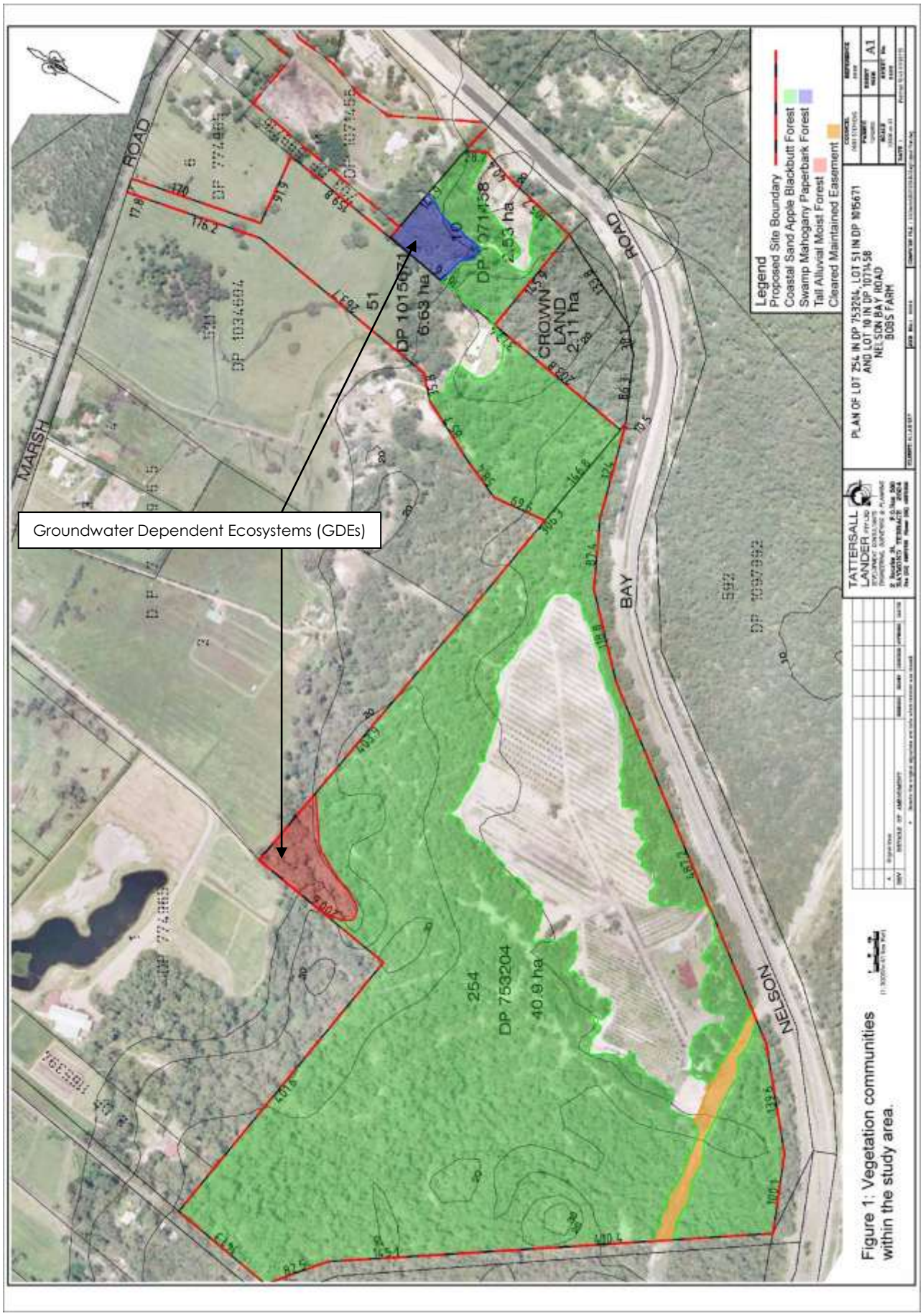

Figure 1: Vegetation communities within the study area.

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Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	Tattersal Lander	**GDE LOCATIONS** FIGURE PROVIDED BY TATTERSAL LANDER	Drawing No: FIGURE 12
Approved:	BR		
Date:	14.02.2014		
Scale:	NA		Job No: P1303897

10 Attachment B – Borehole Logs

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

vgt
Environmental Compliance Solutions

Drill Hole Number: BH 1

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

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

BH1-BL-AWT
0.6 to 3.5m

Above Water Table

Water Table 3.5m

Not Tested

Below Water Table

BH1-BL-G2
4.2 to 12m

BH1-BL-G1
12 to 19m

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

vgt
Environmental Compliance Solutions

Drill Hole Number: BH 2

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

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

Not Tested
Too Variable

BH2-BL-B
4.2 to 9.5m

Water Table 10.2m

10.5 to 12.0m

13.5 to 14.0m

17.5 to 18.5m

26.0 to 26.5m

Above Water Table

Below Water Table

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

vgt
Environmental Compliance Solutions

Drill Hole Number: BH 3

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

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

Not Tested
Too Variable

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

BH3-BL-B2
10.0 to 14.6m

Water Table 13.2m

Not Tested
Too Variable

17.0 to 17.5m

26.0 to 26.5m

Above Water Table

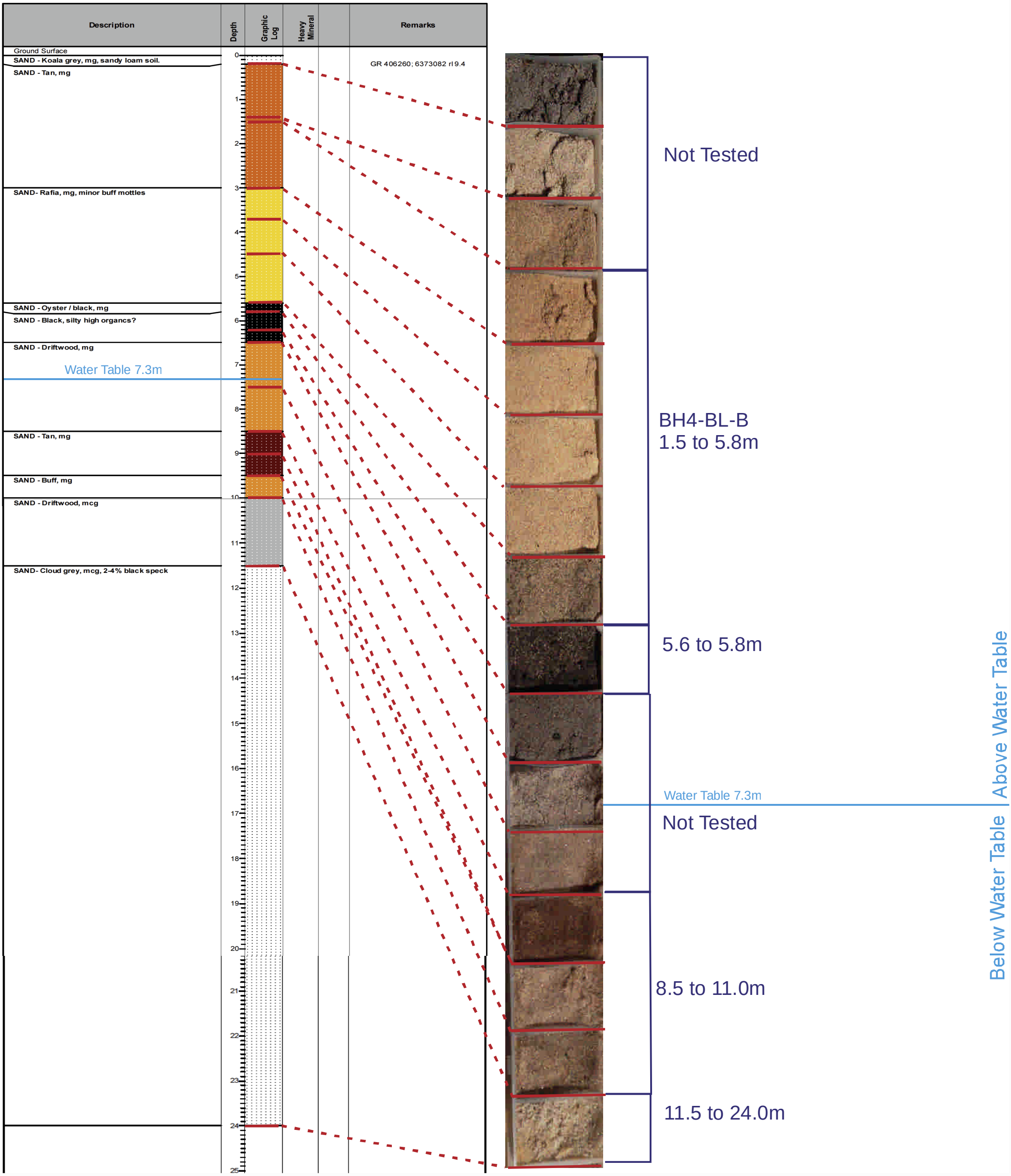
Below Water Table

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

vgt
Environmental Compliance Solutions

Drill Hole Number: BH 4

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



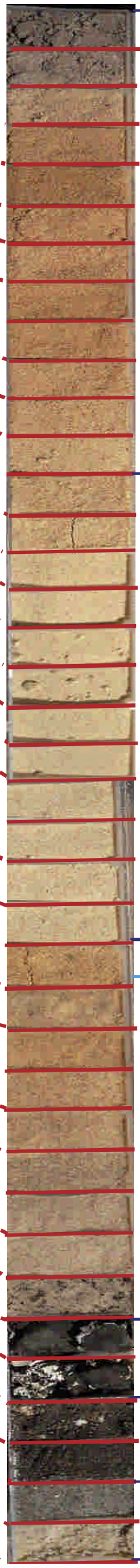
Plan of:	Bobs Farm Quarry BH-5	***Location:***	Bobs Farm	***Projection:***	N/A	***Date:***	26/11/2013	***Version:***	A
				Contour Interval:	N/A	***Sheet:***	2 of 2	***Survey:***	N/A
						Plan By:	TC	***Source:***	VGT Pty Ltd
Figure:	FIVE	***Council:***	Port Stephens Council			***Project Manager:***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

vgt
Environmental Compliance Solutions

Drill Hole Number: BH 5

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

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



Not Tested

BH5-BL-B
5.5 to 14.5m

Water Table 15.4m

Not Tested

BH5-BL-M
20.0 to 22.0m

BH5-BL-G
23.0 to 25.65m

Above Water Table | Below Water Table

11 Attachment C – Laboratory Reports

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

CERTIFICATE OF ANALYSIS 96132

Client:

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

Attention: Ben Rose, Gray Taylor

Sample log in details:

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

Analysis Details:

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	30/08/13	/	30/08/13
Date of Preliminary Report:	Not issued		

NATA accreditation number 2901. This document shall not be reproduced except in full.
Accredited for compliance with ISO/IEC 17025. **Tests not covered by NATA are denoted with *.**

Results Approved By:

Jacinta Hurst
Laboratory Manager

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

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

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

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

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

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

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

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

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

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

Report Comments:

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

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

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

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

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

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CERTIFICATE OF ANALYSIS 95948

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

Attention: Gray Taylor

Sample log in details:

Your Reference:	**P12303897, Bobs Farm**
No. of samples:	27 Soils
Date samples received / completed instructions received	21/08/2013 / 21/08/2013

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	29/08/13 / 28/08/13
Date of Preliminary Report:	Not Issued

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

Results Approved By:

Jacinta Hurst
Laboratory Manager

sPOCAS Our Reference: Your Reference Depth Type of sample	UNITS ---------- ----------	95948-1 3897/BH03 +12.5 to +11.5 Soil	95948-2 3897/BH03 +6.5 to +5.5 Soil	95948-3 3897/BH03 +1.5 to +0.5 Soil	95948-4 3897/BH03 -0.5 to -1.1 Soil	95948-5 3897/BH03 -1.3 to -1.5 Soil
Date prepared	-	22/08/2013	22/08/2013	22/08/2013	22/08/2013	22/08/2013
Date analysed	-	22/08/2013	22/08/2013	22/08/2013	22/08/2013	22/08/2013
pH $_{kcl}$	pH units	4.8	5.4	5.6	5.6	5.4
TAA pH 6.5	moles H^+/t	10	<5	<5	<5	10
s-TAA pH 6.5	%w/w S	0.02	<0.01	<0.01	<0.01	0.02
pH $_{Ox}$	pH units	3.9	4.5	4.5	4.4	3.2
TPA pH 6.5	moles H^+/t	30	<5	<5	10	250
s-TPA pH 6.5	%w/w S	0.05	<0.01	<0.01	0.02	0.40
TSA pH 6.5	moles H^+/t	20	<5	<5	7	240
s-TSA pH 6.5	%w/w S	0.03	<0.01	<0.01	0.01	0.38
ANC_E	% $CaCO_3$	<0.05	<0.05	<0.05	<0.05	<0.05
a-ANC_E	moles H^+/t	<5	<5	<5	<5	<5
s-ANC_E	%w/w S	<0.05	<0.05	<0.05	<0.05	<0.05
S_{KCl}	%w/w S	<0.005	<0.005	<0.005	<0.005	<0.005
S_P	%w/w	<0.005	<0.005	<0.005	<0.005	0.08
S_{POS}	%w/w	<0.005	<0.005	<0.005	<0.005	0.08
a-S_{POS}	moles H^+/t	<5	<5	<5	<5	51
Ca_{KCl}	%w/w	<0.005	<0.005	<0.005	<0.005	0.12
Ca_P	%w/w	<0.005	<0.005	<0.005	<0.005	0.13
Ca_A	%w/w	<0.005	<0.005	<0.005	<0.005	0.014
Mg_{KCl}	%w/w	<0.005	<0.005	<0.005	<0.005	0.15
Mg_P	%w/w	<0.005	<0.005	<0.005	<0.005	0.16
Mg_A	%w/w	<0.005	<0.005	<0.005	<0.005	0.009
Fineness Factor	-	1.5	1.5	1.5	1.5	1.5
a-Net Acidity	moles H^+/t	10	<10	<10	<10	61
Liming rate	kg $CaCO_3$/t	0.75	<0.75	<0.75	<0.75	4.6
a-Net Acidity without ANCE	moles H^+/t	NA	NA	NA	NA	NA
Liming rate without ANCE	kg $CaCO_3$/t	NA	NA	NA	NA	NA

sPOCAS Our Reference: Your Reference Depth Type of sample	UNITS ---------- ----------	95948-6 3897/BH03 -1.3 Soil	95948-7 3897/BH03 -3.1 Soil	95948-8 3897/BH03 -13 Soil	95948-9 3897/BH04 +5.5 to +3.0 Soil	95948-10 3897/BH04 +3.3 to +2.5 Soil
Date prepared	-	22/08/2013	22/08/2013	22/08/2013	22/08/2013	22/08/2013
Date analysed	-	22/08/2013	22/08/2013	22/08/2013	22/08/2013	22/08/2013
pH $_{kcl}$	pH units	5.2	4.5	5.3	5.2	5.3
TAA pH 6.5	moles H^+/t	10	17	<5	5	<5
s-TAA pH 6.5	%w/w S	0.02	0.03	<0.01	<0.01	<0.01
pH $_{Ox}$	pH units	2.7	2.3	3.3	4.3	4.5
TPA pH 6.5	moles H^+/t	460	360	27	17	17
s-TPA pH 6.5	%w/w S	0.74	0.58	0.04	0.03	0.03
TSA pH 6.5	moles H^+/t	450	340	25	12	15
s-TSA pH 6.5	%w/w S	0.73	0.55	0.04	0.02	0.02
ANC$_E$	%$CaCO_3$	<0.05	<0.05	<0.05	<0.05	<0.05
a-ANC$_E$	moles H^+/t	<5	<5	<5	<5	<5
s-ANC$_E$	%w/w S	<0.05	<0.05	<0.05	<0.05	<0.05
S$_{KCl}$	%w/w S	0.005	0.06	<0.005	<0.005	<0.005
S$_P$	%w/w	0.14	0.56	0.03	<0.005	<0.005
S$_{POS}$	%w/w	0.13	0.51	0.03	<0.005	<0.005
a-S$_{POS}$	moles H^+/t	84	320	18	<5	<5
Ca$_{KCl}$	%w/w	0.15	0.04	<0.005	<0.005	<0.005
Ca$_P$	%w/w	0.15	0.03	<0.005	<0.005	<0.005
Ca$_A$	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
Mg$_{KCl}$	%w/w	0.15	0.044	<0.005	<0.005	<0.005
Mg$_P$	%w/w	0.13	0.036	<0.005	<0.005	<0.005
Mg$_A$	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
Fineness Factor	-	1.5	1.5	1.5	1.5	1.5
a-Net Acidity	moles H^+/t	94	330	21	<10	<10
Liming rate	kg $CaCO_3$/t	7.0	25	1.5	<0.75	<0.75
a-Net Acidity without ANCE	moles H^+/t	NA	NA	NA	NA	NA
Liming rate without ANCE	kg $CaCO_3$/t	NA	NA	NA	NA	NA

sPOCAS Our Reference: Your Reference Depth Type of sample	UNITS ---------- ----------	95948-11 3897/BH04 +0.8 to +0.5 Soil	95948-12 3897/BH04 -0.5 to -1.5 Soil	95948-13 3897/BH04 -2.5 to -3.0 Soil	95948-14 3897/BH04 -6.0 to -7.5 Soil	95948-15 3897/BH04 -11.0 to -13.5 Soil
Date prepared	-	22/08/2013	22/08/2013	22/08/2013	22/08/2013	22/08/2013
Date analysed	-	22/08/2013	22/08/2013	22/08/2013	22/08/2013	22/08/2013
pH $_{kcl}$	pH units	4.9	5.3	5.5	5.3	5.4
TAA pH 6.5	moles H^+/t	10	5	<5	<5	<5
s-TAA pH 6.5	%w/w S	0.02	<0.01	<0.01	<0.01	<0.01
pH $_{Ox}$	pH units	3.8	4.4	4.4	3.4	3.8
TPA pH 6.5	moles H^+/t	37	12	17	27	20
s-TPA pH 6.5	%w/w S	0.06	0.02	0.03	0.04	0.03
TSA pH 6.5	moles H^+/t	27	7	16	26	19
s-TSA pH 6.5	%w/w S	0.04	0.01	0.03	0.04	0.03
ANC$_E$	%$CaCO_3$	<0.05	<0.05	<0.05	<0.05	<0.05
a-ANC$_E$	moles H^+/t	<5	<5	<5	<5	<5
s-ANC$_E$	%w/w S	<0.05	<0.05	<0.05	<0.05	<0.05
S$_{KCl}$	%w/w S	<0.005	<0.005	<0.005	<0.005	<0.005
S$_P$	%w/w	<0.005	<0.005	<0.005	0.03	0.02
S$_{POS}$	%w/w	<0.005	<0.005	<0.005	0.02	0.02
a-S$_{POS}$	moles H^+/t	<5	<5	<5	14	11
Ca$_{KCl}$	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
Ca$_P$	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
Ca$_A$	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
Mg$_{KCl}$	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
Mg$_P$	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
Mg$_A$	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
Fineness Factor	-	1.5	1.5	1.5	1.5	1.5
a-Net Acidity	moles H^+/t	10	<10	<10	16	12
Liming rate	kg $CaCO_3$/t	0.75	<0.75	<0.75	1.2	0.93
a-Net Acidity without ANCE	moles H^+/t	NA	NA	NA	NA	NA
Liming rate without ANCE	kg $CaCO_3$/t	NA	NA	NA	NA	NA

sPOCAS Our Reference: Your Reference Depth Type of sample	UNITS ---------- ----------	95948-16 3897/BH04 -13.5 to -12.1 Soil	95948-17 3897/BH05 +8.5 to +8.0 Soil	95948-18 3897/BH05 +2.0 to +1.0 Soil	95948-19 3897/BH05 +0.0 to -0.5 Soil	95948-20 3897/BH05 +0.0 to -1.0 Soil
Date prepared	-	22/08/2013	22/08/2013	22/08/2013	22/08/2013	22/08/2013
Date analysed	-	22/08/2013	22/08/2013	22/08/2013	22/08/2013	22/08/2013
pH $_{kcl}$	pH units	5.4	5.5	5.5	4.4	5.3
TAA pH 6.5	moles H^+/t	<5	<5	<5	7	5
s-TAA pH 6.5	%w/w S	<0.01	<0.01	<0.01	0.01	<0.01
pH $_{Ox}$	pH units	3.7	4.6	4.5	3.4	4.5
TPA pH 6.5	moles H^+/t	20	7	12	47	7
s-TPA pH 6.5	%w/w S	0.03	0.01	0.02	0.08	0.01
TSA pH 6.5	moles H^+/t	17	5	10	40	<5
s-TSA pH 6.5	%w/w S	0.03	<0.01	0.02	0.06	<0.01
ANC$_E$	%$CaCO_3$	<0.05	<0.05	<0.05	<0.05	<0.05
a-ANC$_E$	moles H^+/t	<5	<5	<5	<5	<5
s-ANC$_E$	%w/w S	<0.05	<0.05	<0.05	<0.05	<0.05
S$_{KCl}$	%w/w S	<0.005	<0.005	<0.005	<0.005	<0.005
S$_P$	%w/w	0.02	<0.005	<0.005	<0.005	<0.005
S$_{POS}$	%w/w	0.02	<0.005	<0.005	<0.005	<0.005
a-S$_{POS}$	moles H^+/t	10	<5	<5	<5	<5
Ca$_{KCl}$	%w/w	<0.005	<0.005	<0.005	0.005	<0.005
Ca$_P$	%w/w	<0.005	<0.005	<0.005	0.005	<0.005
Ca$_A$	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
Mg$_{KCl}$	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
Mg$_P$	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
Mg$_A$	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
S$_{HCl}$	%w/w S	[NT]	[NT]	[NT]	<0.005	[NT]
S$_{NAS}$	%w/w S	[NT]	[NT]	[NT]	<0.005	[NT]
a-S$_{NAS}$	moles H^+/t	[NT]	[NT]	[NT]	<5	[NT]
s-S$_{NAS}$	%w/w S	[NT]	[NT]	[NT]	<0.01	[NT]
Fineness Factor	-	1.5	1.5	1.5	1.5	1.5
a-Net Acidity	moles H^+/t	12	<10	<10	<10	<10
Liming rate	kg $CaCO_3$/t	0.92	<0.75	<0.75	<0.75	<0.75
a-Net Acidity without ANCE	moles H^+/t	NA	NA	NA	NA	NA
Liming rate without ANCE	kg $CaCO_3$/t	NA	NA	NA	NA	NA

sPOCAS Our Reference: Your Reference Depth Type of sample	UNITS ---------- ----------	95948-21 3897/BH05 -1.1 to -1.5 Soil	95948-22 3897/BH05 -1.5 to -2.0 Soil	95948-23 3897/BH05 -2.5 to -3.0 Soil	95948-24 3897/BH05 -5.0 Soil	95948-25 3897/BH05 -5.5 Soil
Date prepared	-	22/08/2013	22/08/2013	22/08/2013	22/08/2013	22/08/2013
Date analysed	-	22/08/2013	22/08/2013	22/08/2013	22/08/2013	22/08/2013
pH $_{kcl}$	pH units	5.7	5.6	5.6	5.9	7.9
TAA pH 6.5	moles H^+/t	<5	<5	<5	5	<5
s-TAA pH 6.5	%w/w S	<0.01	<0.01	<0.01	<0.01	<0.01
pH $_{Ox}$	pH units	4.5	4.6	4.4	2.2	4.1
TPA pH 6.5	moles H^+/t	5	<5	<5	1,500	120
s-TPA pH 6.5	%w/w S	<0.01	<0.01	<0.01	2.4	0.19
TSA pH 6.5	moles H^+/t	<5	<5	<5	1,500	120
s-TSA pH 6.5	%w/w S	<0.01	<0.01	<0.01	2.4	0.19
ANC_E	%$CaCO_3$	<0.05	<0.05	<0.05	<0.05	<0.05
a-ANC_E	moles H^+/t	<5	<5	<5	<5	<5
s-ANC_E	%w/w S	<0.05	<0.05	<0.05	<0.05	<0.05
S_{KCl}	%w/w S	<0.005	<0.005	<0.005	0.13	0.09
S_P	%w/w	<0.005	<0.005	<0.005	2.8	1.5
S_{POS}	%w/w	<0.005	<0.005	<0.005	2.6	1.4
a-S_{POS}	moles H^+/t	<5	<5	<5	1,600	870
Ca_{KCl}	%w/w	<0.005	<0.005	<0.005	0.32	0.39
Ca_P	%w/w	<0.005	<0.005	<0.005	0.39	1.5
Ca_A	%w/w	<0.005	<0.005	<0.005	0.075	1.2
Mg_{KCl}	%w/w	<0.005	<0.005	<0.005	0.23	0.14
Mg_P	%w/w	<0.005	<0.005	<0.005	0.28	0.16
Mg_A	%w/w	<0.005	<0.005	<0.005	0.048	0.014
Fineness Factor	-	1.5	1.5	1.5	1.5	1.5
a-Net Acidity	moles H^+/t	<10	<10	<10	1,600	370
Liming rate	kg $CaCO_3$/t	<0.75	<0.75	<0.75	120	28
a-Net Acidity without ANCE	moles H^+/t	NA	NA	NA	NA	NA
Liming rate without ANCE	kg $CaCO_3$/t	NA	NA	NA	NA	NA

sPOCAS Our Reference: Your Reference Depth Type of sample	UNITS ---------- ----------	95948-26 3897/BH05 -6.5 Soil	95948-27 3897/BH05 -7.5 Soil
Date prepared	-	22/08/2013	22/08/2013
Date analysed	-	22/08/2013	22/08/2013
pH $_{kcl}$	pH units	7.0	8.1
TAA pH 6.5	moles H^+/t	<5	<5
s-TAA pH 6.5	%w/w S	<0.01	<0.01
pH $_{Ox}$	pH units	2.2	2.9
TPA pH 6.5	moles H^+/t	820	67
s-TPA pH 6.5	%w/w S	1.3	0.11
TSA pH 6.5	moles H^+/t	820	67
s-TSA pH 6.5	%w/w S	1.3	0.11
ANC_E	% $CaCO_3$	<0.05	<0.05
a-ANC_E	moles H^+/t	<5	<5
s-ANC_E	%w/w S	<0.05	<0.05
S_{KCl}	%w/w S	0.08	0.01
S_P	%w/w	1.6	0.22
S_{POS}	%w/w	1.5	0.21
a-S_{POS}	moles H^+/t	960	130
Ca_{KCl}	%w/w	0.37	0.07
Ca_P	%w/w	0.54	0.10
Ca_A	%w/w	0.17	0.030
Mg_{KCl}	%w/w	0.19	0.016
Mg_P	%w/w	0.23	0.022
Mg_A	%w/w	0.039	0.006
Fineness Factor	-	1.5	1.5
a-Net Acidity	moles H^+/t	870	88
Liming rate	kg $CaCO_3$/t	65	6.6
a-Net Acidity without ANCE	moles H^+/t	NA	NA
Liming rate without ANCE	kg $CaCO_3$/t	NA	NA

Method ID	Methodology Summary
Inorg-064	sPOCAS determined using titrimetric and ICP-AES techniques. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004.

QUALITY CONTROL sPOCAS	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			22/08/2013	95948-1	22/08/2013 || 22/08/2013	LCS-1	22/08/2013
Date analysed	-			22/08/2013	95948-1	22/08/2013 || 22/08/2013	LCS-1	22/08/2013
pH kcl	pH units		Inorg-064	[NT]	95948-1	4.8 || 4.8 || RPD: 0	LCS-1	95%
TAA pH 6.5	moles H^+/t	5	Inorg-064	<5	95948-1	10 || 7 || RPD: 35	LCS-1	129%
s-TAA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	95948-1	0.02 || 0.01 || RPD: 67	[NR]	[NR]
pH Ox	pH units		Inorg-064	[NT]	95948-1	3.9 || 4.0 || RPD: 3	LCS-1	99%
TPA pH 6.5	moles H^+/t	5	Inorg-064	<5	95948-1	30 || 12 || RPD: 86	LCS-1	103%
s-TPA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	95948-1	0.05 || 0.02 || RPD: 86	[NR]	[NR]
TSA pH 6.5	moles H^+/t	5	Inorg-064	<5	95948-1	20 || 5 || RPD: 120	LCS-1	101%
s-TSA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	95948-1	0.03 || <0.01	[NR]	[NR]
ANC_E	% $CaCO_3$	0.05	Inorg-064	<0.05	95948-1	<0.05 || <0.05	[NR]	[NR]
a-ANC_E	moles H^+/t	5	Inorg-064	<5	95948-1	<5 || <5	[NR]	[NR]
s-ANC_E	%w/w S	0.05	Inorg-064	<0.05	95948-1	<0.05 || <0.05	[NR]	[NR]
S_{KCl}	%w/w S	0.005	Inorg-064	<0.005	95948-1	<0.005 || <0.005	LCS-1	83%
S_P	%w/w	0.005	Inorg-064	<0.005	95948-1	<0.005 || <0.005	LCS-1	79%
S_{POS}	%w/w	0.005	Inorg-064	<0.005	95948-1	<0.005 || <0.005	LCS-1	79%
a-S_{POS}	moles H^+/t	5	Inorg-064	<5	95948-1	<5 || <5	LCS-1	79%
Ca_{KCl}	%w/w	0.005	Inorg-064	<0.005	95948-1	<0.005 || <0.005	LCS-1	89%
Ca_P	%w/w	0.005	Inorg-064	<0.005	95948-1	<0.005 || <0.005	[NR]	[NR]
Ca_A	%w/w	0.005	Inorg-064	<0.005	95948-1	<0.005 || <0.005	[NR]	[NR]
Mg_{KCl}	%w/w	0.005	Inorg-064	<0.005	95948-1	<0.005 || <0.005	LCS-1	87%
Mg_P	%w/w	0.005	Inorg-064	<0.005	95948-1	<0.005 || <0.005	[NR]	[NR]
Mg_A	%w/w	0.005	Inorg-064	<0.005	95948-1	<0.005 || <0.005	[NR]	[NR]
S_{HCl}	%w/w S	0.005	Inorg-064	<0.005	[NT]	[NT]	[NR]	[NR]
S_{NAS}	%w/w S	0.005	Inorg-064	<0.005	[NT]	[NT]	[NR]	[NR]
a-S_{NAS}	moles H^+/t	5	Inorg-064	<5	[NT]	[NT]	[NR]	[NR]
s-S_{NAS}	%w/w S	0.01	Inorg-064	<0.01	[NT]	[NT]	[NR]	[NR]
Fineness Factor	-	1.5	Inorg-064	<1.5	95948-1	1.5 || 1.5 || RPD: 0	[NR]	[NR]
a-Net Acidity	moles H^+/t	10	Inorg-064	<10	95948-1	10 || <10	LCS-1	81%
Liming rate	kg $CaCO_3$/t	0.75	Inorg-064	<0.75	95948-1	0.75 || <0.75	LCS-1	80%

QUALITY CONTROL sPOCAS	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
a-Net Acidity without ANCE	moles H^+/t	10	Inorg-064	<10	95948-1	NA || NA	[NR]	[NR]
Liming rate without ANCE	kg $CaCO_3$/t	0.75	Inorg-064	<0.75	95948-1	NA || NA	[NR]	[NR]

QUALITY CONTROL sPOCAS	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	95948-11	22/08/2013 || 22/08/2013	LCS-2	22/8/2013
Date analysed	-	95948-11	22/08/2013 || 22/08/2013	LCS-2	22/8/2013
pH $_{kcl}$	pH units	95948-11	4.9 || 4.9 || RPD: 0	LCS-2	94%
TAA pH 6.5	moles H^+/t	95948-11	10 || 7 || RPD: 35	LCS-2	113%
s-TAA pH 6.5	%w/w S	95948-11	0.02 || 0.01 || RPD: 67	[NR]	[NR]
pH $_{Ox}$	pH units	95948-11	3.8 || 3.8 || RPD: 0	LCS-2	93%
TPA pH 6.5	moles H^+/t	95948-11	37 || 37 || RPD: 0	LCS-2	102%
s-TPA pH 6.5	%w/w S	95948-11	0.06 || 0.06 || RPD: 0	[NR]	[NR]
TSA pH 6.5	moles H^+/t	95948-11	27 || 30 || RPD: 11	LCS-2	101%
s-TSA pH 6.5	%w/w S	95948-11	0.04 || 0.05 || RPD: 22	[NR]	[NR]
ANC_E	% $CaCO_3$	95948-11	<0.05 || <0.05	[NR]	[NR]
a-ANC_E	moles H^+/t	95948-11	<5 || <5	[NR]	[NR]
s-ANC_E	%w/w S	95948-11	<0.05 || <0.05	[NR]	[NR]
S_{KCl}	%w/w S	95948-11	<0.005 || <0.005	LCS-2	87%
S_P	%w/w	95948-11	<0.005 || <0.005	LCS-2	86%
S_{POS}	%w/w	95948-11	<0.005 || <0.005	LCS-2	86%
a-S_{POS}	moles H^+/t	95948-11	<5 || <5	LCS-2	86%
Ca_{KCl}	%w/w	95948-11	<0.005 || <0.005	LCS-2	91%
Ca_P	%w/w	95948-11	<0.005 || <0.005	[NR]	[NR]
Ca_A	%w/w	95948-11	<0.005 || <0.005	[NR]	[NR]
Mg_{KCl}	%w/w	95948-11	<0.005 || <0.005	LCS-2	88%
Mg_P	%w/w	95948-11	<0.005 || <0.005	[NR]	[NR]
Mg_A	%w/w	95948-11	<0.005 || <0.005	[NR]	[NR]
Fineness Factor	-	95948-11	1.5 || 1.5 || RPD: 0	[NR]	[NR]
a-Net Acidity	moles H^+/t	95948-11	10 || <10	LCS-2	87%
Liming rate	kg $CaCO_3$/t	95948-11	0.75 || <0.75	LCS-2	86%
a-Net Acidity without ANCE	moles H^+/t	95948-11	NA || NA	[NR]	[NR]
Liming rate without ANCE	kg $CaCO_3$/t	95948-11	NA || NA	[NR]	[NR]

QUALITY CONTROL sPOCAS	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD
Date prepared	-	95948-21	22/08/2013 || 22/08/2013
Date analysed	-	95948-21	22/08/2013 || 22/08/2013
pH $_{kcl}$	pH units	95948-21	5.7 || 5.6 || RPD: 2
TAA pH 6.5	moles H^+/t	95948-21	<5 || <5
s-TAA pH 6.5	%w/w S	95948-21	<0.01 || <0.01
pH $_{Ox}$	pH units	95948-21	4.5 || 4.5 || RPD: 0
TPA pH 6.5	moles H^+/t	95948-21	5 || <5
s-TPA pH 6.5	%w/w S	95948-21	<0.01 || <0.01
TSA pH 6.5	moles H^+/t	95948-21	<5 || <5
s-TSA pH 6.5	%w/w S	95948-21	<0.01 || <0.01
ANC$_E$	% $CaCO_3$	95948-21	<0.05 || <0.05
a-ANC$_E$	moles H^+/t	95948-21	<5 || <5
s-ANC$_E$	%w/w S	95948-21	<0.05 || <0.05
S$_{KCl}$	%w/w S	95948-21	<0.005 || <0.005
S$_P$	%w/w	95948-21	<0.005 || <0.005
S$_{POS}$	%w/w	95948-21	<0.005 || <0.005
a-S$_{POS}$	moles H^+/t	95948-21	<5 || <5
Ca$_{KCl}$	%w/w	95948-21	<0.005 || <0.005
Ca$_P$	%w/w	95948-21	<0.005 || <0.005
Ca$_A$	%w/w	95948-21	<0.005 || <0.005
Mg$_{KCl}$	%w/w	95948-21	<0.005 || <0.005
Mg$_P$	%w/w	95948-21	<0.005 || <0.005
Mg$_A$	%w/w	95948-21	<0.005 || <0.005
S$_{HCl}$	%w/w S	[NT]	[NT]
S$_{NAS}$	%w/w S	[NT]	[NT]
a-S$_{NAS}$	moles H^+/t	[NT]	[NT]
s-S$_{NAS}$	%w/w S	[NT]	[NT]
Fineness Factor	-	95948-21	1.5 || 1.5 || RPD: 0
a-Net Acidity	moles H^+/t	95948-21	<10 || <10
Liming rate	kg $CaCO_3$/t	95948-21	<0.75 || <0.75
a-Net Acidity without ANCE	moles H^+/t	95948-21	NA || NA
Liming rate without ANCE	kg $CaCO_3$/t	95948-21	NA || NA

Report Comments:

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

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

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

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

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Pages:		3
cc.		-

30 November, 2016

Ammos Resource Management P/L
C/- Tattersall Lander P/L
Att: Bob Lander
By Email

Dear Bob,

RE: RESPONSE TO KEY ADEQUACY ISSUES WITH EIS; BOBS FARM SAND PROJECT (SSD 6395).

This letter has been prepared in response to NSW Department of Planning and Environment (DoPE) correspondence dated April 14, 2016 outlining key inadequacies of the submitted draft Environmental Impact Statement (EIS) (February, 2016). Specifically this advice addresses issues DoPE have raised under '*Water Resources*'.

We provide this response to further clarify data within the EIS and satisfy concerns raised. Martens and Associates (MA) reports referenced within this advice include:

- *Preliminary Groundwater Assessment* (P1303897JR01V01, February, 2014).
- *Groundwater Management Plan* (P1303897JR03V02, June 2015).
- *Stormwater Management Plan* (P1303897JR05V02; June, 2015).

DoPE Point 1:

- The groundwater take of 506 ML/year has been sourced from MA *Preliminary Groundwater Assessment* (February, 2014). This report was preliminary and based on conceptual development form.
- The basis of the 506 ML/year calculation is explained in Section 4.3 of the *Preliminary Groundwater Assessment*, which states:

  "If the entire site is quarried to form a 'window lake', based on mean annual evaporation of 1,712 mm at Williamtown BOM station, 0.82 pan factor for Williamtown (McMahon et al, date omitted) and the site area excluding the 15 m buffer from fence line of 360,661 m² (VGT & Quarry Mining Systems, 2013), the annual take volume is 506 ML".

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- Reporting and modelling further into the project's life resulted in preparation of MA report *Groundwater Management Plan* (June 2015). Section 4.4 of this document reports the gross groundwater take as 137 ML/yr (136.81 ML/yr) and outlines the basis for this calculation as:

    - 89.16 ML/yr evaporation from dredge 'window' lake; plus
    - 45.14 ML/yr loss from plant operations; plus
    - 2.51 ML/yr loss from dust suppression.

- The groundwater take of 137 ML/yr therefore supersedes 506 ML/year.

- The discrepancy between the groundwater take values presented in the MA groundwater reports is attributed to the following differences in calculations for the dredge 'window' lake losses:

    1. During the course of the project Martens received advice from NSW Office of Water (NOW) in relation to another quarry site where licensable groundwater 'take' off a window lake was to be offset by direct rainfall into the lake (T Baker, NSW DPI, February 2015).

       The 137 ML/yr total 'take' is therefore based on 297 mm/year net evaporation (being 1,122 mm direct rainfall less 1,732 mm evaporation x pan factor of 0.82), unlike calculations for preliminary reporting which didn't account for any offset.

    2. The area of the window lake was refined between preliminary and final modelling from 36.07 ha to 30.02 ha.

- Section 6.5.2 of MA *Stormwater Management Plan* (June, 2015) reports a net groundwater take of 132.9 ML/yr. The basis of this calculation is provided in Table 12 of the document being:

    - 12 KL/day (2.51 ML/yr for operational days only) loss from dust suppression; plus
    - 216 KL/day (45.14 ML/yr for operational days only) loss from plant operations; plus
    - 244.3 KL/day (89.16 ML/yr year-round) evaporation from dredge 'window' lake; less
    - 10.84 KL/day (3.96 ML/year year-round) groundwater gain from bioretention basin overflow.

- The discrepancy between the gross groundwater take of 137 ML/yr (Groundwater Management Plan reporting) and the net groundwater take of 132.9 ML/yr (Stormwater Management Plan) can be attributed to the Groundwater Management Plan not accounting for the groundwater gain of 10.84 kl/d (3.96 ML/yr) from the bioretention basin, although it is noted as a potential opportunity in Section 4.4 of the Groundwater Management Plan.

- The 137 ML/yr (136.81 ML/yr without rounding) volume reported in the Groundwater Management Plan less the groundwater gain of 10.84 kl/d (3.96

ML/yr) is 132.85 ML - which aligns with 132.9 ML/yr reported in the Stormwater Management Plan. The MA reports are therefore consistent in their reporting of net groundwater take from the proposed development.

DoPE Point 3:

- Clarification of operational water balance input/output values from Section 6.2.7 of the EIS is provided below, along with MA Stormwater Management Plan report reference.

	Element	Calculation/Source	MA Stormwater Management Plan report reference [1]
Groundwater Extraction	Dust Suppression	As determined by Vipac Engineers and Scientists.	Section 6.2
	Plant Loss	2% of daily water demand in processing plant assumed to be lost. Processing plant demand based on client information.	Section 6.2, 6.3 and 6.4
	Window Lake Evaporation	297mm net evaporation over an extraction basin area of 30.02 ha divided by 365 to get daily rate.	Section 6.4 and 6.5
Groundwater Gain	Bioretention Basin overflow	Estimated based on water quality modelling as a combination of infiltration, weir overflow and high flow bypass from the bioretention basin.	Section 6.3 and 6.5
Net Groundwater Demand		Losses plus gains noting that dust suppression and plant losses only occur during operation (19 days/month, 11 months/year) while remaining elements occur year-round.	Section 6.5.2

Notes:

[1] P1303897JR05V02; June, 2015

We note that should the surface area of the dredged area be reduced then the groundwater loss via evaporation would also be reduced. Indicatively 1m^2 of surface area of the dredged lake is equivalent to 0.81L/day or 297L/year however this would need to be confirmed via detailed modelling of the entire dredge lake.

If you have any further queries please do not hesitate in contacting us.

For and on behalf of

MARTENS & ASSOCIATES PTY LTD

MEGAN KOVELIS
Environmental Scientist

BEN ROSE
Environmental Engineer

GRAY TAYLOR
Project Manager