Merimbula Sewage Treatment Plant Upgrade and Ocean Outfall

Appendix C

Geotechnical Interpretative Report

Appendix C

Geotechnical Interpretative Report

Client: Bega Valley Shire Council

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May 2021

Job No.: 60541653

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Acronyms

Acronym	Definition
AHD	Australian Height Datum
BH	Borehole (geotechnical)
BVSC	Bega Valley Shire Council
OOF	Ocean Outfall
DP&E	NSW Department of Planning and Environment
DLWC	NSW Department of Land and Water Conservation
HDD	Horizontal Directional Drilling
HDPE	High Density Polyethylene
kL	Kilolitre
LiDAR	Light Detection and Ranging
MHWM	Mean High Water Mark
mm	Millimetre
mbgl	Metres below ground level
NSW	New South Wales
PMGC	Pambula Merimbula Golf Course
RL	Relative level (with respect to Australian Height Datum)
SPT	Standard penetration test
SSI	State Significant Infrastructure
SSS	Side-scan sonar
STP	Sewage Treatment Plant

1.0 Introduction

AECOM has been engaged by the Bega Valley Shire Council to undertake the concept design and environmental assessment of the upgrade of the Merimbula Sewage Treatment Plant (STP) and the construction of an Ocean Outfall (OOF) (the Project).

This report presents a preliminary interpretation of the geotechnical conditions along the land portion of the proposed alignment of the ocean outfall pipeline. Geotechnical Investigations along the offshore portion of the route are provided in a separate report.

The scope of this report includes:

- a review of available information;
- the results of the 2018 geophysical investigation;
- borehole logs from the 2018 geotechnical investigation; and
- preliminary soil design parameters to inform concept design.

The factual information collected as part of the geotechnical investigation will be provided in a separate digital package in AGS 3.1 RTA 1.1 Data Format.

1.1 Structure of this report

The report includes the following Appendices (provided as separate pdfs):

- Appendix A: Proposed Alignment Options;
- Appendix B: Historical Borehole Location Plans;
- Appendix C: 2018 Investigation Plans;
- Appendix D: Borehole Logs;
- Appendix E: Laboratory Testing results;
- Appendix F: Geological Long Section; and
- Appendix G: Geophysical Report.

1.2 Proposed outfall pipeline

The proposed pipeline forming the OOF is expected to be fabricated using 300 mm to 450 mm diameter high density polyethylene (HDPE) pipes, welded to form a continuously welded sealed pipeline.

The outfall pipeline is anticipated to comprise two sections:

- Section 1: from the proposed effluent pump station within the STP to a point below the Mean High Water Mark (MHWM) of Merimbula Bay, offshore of the wave zone. This section would be installed using Horizontal Directional Drilling (or other directional drilling technique), with a rig within the STP and potentially another rig west of the disused exfiltration ponds.
- Section 2: a length of pipeline located on top of the seabed below MHWM, connecting Section One to the outfall diffuser.

A full description of the Project is provided in **Chapter 2 Project description** of the EIS.

1.3 Geological and geotechnical data sources

AECOM has referred to the sources of information shown in **Table 1**.

Table 1 Sources of Information

Source Name	Year	Originator	Provided by
Lewis P.C. and Glen R.A., 1995, Bega - Mallacoota 1:250 000 Geological Sheet SJ/55-04 & part SJ/55-08, 2nd edition, Geological Survey of New South Wales, Sydney	1995	Geological Survey of NSW	Publicly available
Assessment of Groundwater Conditions and Dune Disposal Options for Merimbula STP. PPK Environment & Infrastructure. April 2002	2002	PPK	Bega Valley Shire Council (BVSC)
PB, 2004a. Investigation of the Deep Disposal Option for Reclaimed Water from Merimbula STP, Stages 1 and 2 (draft report). Parsons Brinckerhoff. July 2004	2004	WSP (PB)	BVSC
PB, 2004b. Investigation of the Shallow Disposal Option for Reclaimed Water from Merimbula STP (draft report). Parsons Brinckerhoff. July 2004	2004	WSP (PB)	BVSC
Proposed Test Bore Sites Related to a Proposed Dunal Exfiltration Scheme at Merimbula, NSW - Aboriginal Archaeological Assessment	2009	New South Wales Archaeology	BVSC
WorleyParsons, 2011 Desktop Evaluation of Potential Sea Level Rise Impacts and Coastline Hazards at Merimbula Airport. WorleyParsons Services Pty Ltd. Letter Report Ref: Ir145-6rh110411- Merimbula Airport.doc. 11th April 2011.	2011	WSP (PB)	BVSC
Troedson A.L. & Hashimoto T.R. 2013. Bega Valley 1:100 000 and 1:25 000, Coastal Quaternary Geology Map Series. Geological Survey of New South Wales, Maitland.	2013	Geological Survey of NSW	Publicly available
http://www.geomaps.com.au/scripts/benboydnationalpark.php			Publicly available

2.0 Locational context

The State Significant Infrastructure (SSI) boundary[1] comprises:

- a 1 km long by 400 m wide land area, from the current STP to Merimbula Beach; and
- a 6 km long by 3 km wide marine area in Merimbula Bay.

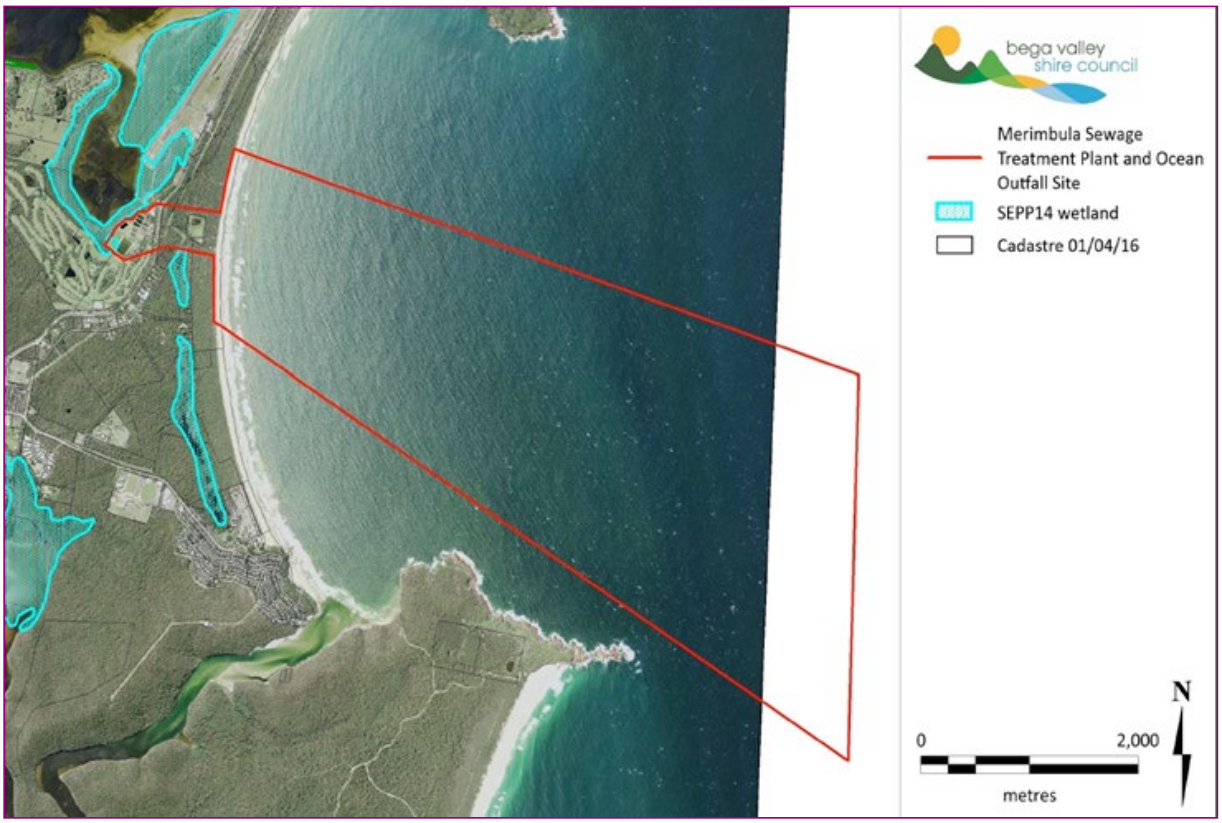

Figure 1 SSI declaration area (red polygon)

The alignment options for the Ocean Outfall are summarised in the Preliminary Outfall Pipeline Alignment Options dated 19 March 2018 and shown in full in Appendix A. The land section is identical across the proposed options and is shown on **Figure 2** (refer to **Chapter 2 project description** in the EIS for further description of the Project).

[1] Note that this is the former SSI boundary and has been amended subsequent to the preparation of this report.

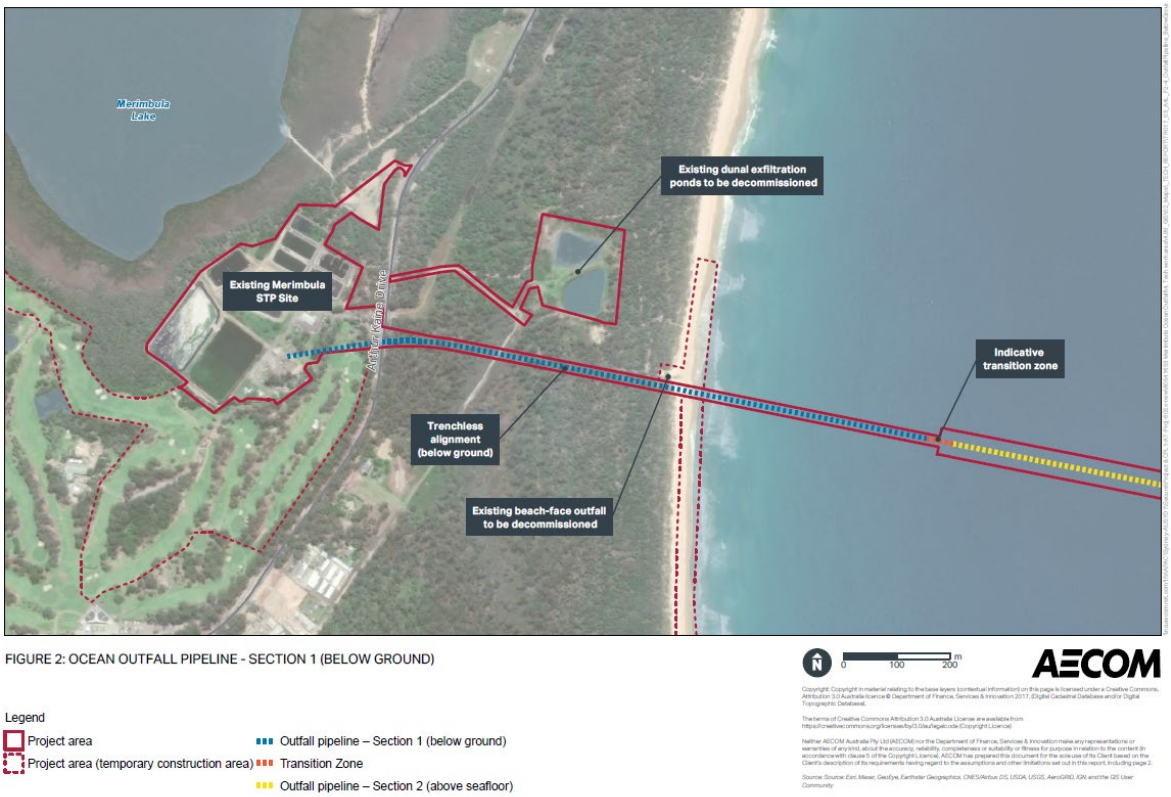

FIGURE 2: OCEAN OUTFALL PIPELINE - SECTION 1 (BELOW GROUND)

Figure 2 Ocean outfall pipeline – Section 1 (Below ground)

2.1 Topography

The Merimbula STP is located on Arthur Kaine Drive between the regional coastal townships of Merimbula to the north and Pambula to the south. The proposed alignment of the pipeline extends from the STP to the seaward side of the south end of the peninsula separating Merimbula Lake and Merimbula Bay. The peninsula is 3.5 km long, generally flat and low-lying.

Based on drone LiDAR data provided by BVSC, typical ground elevations at the site are about 7 mAHD in the central area of the alignment, with an increase to 10 to 15 mAHD between the exfiltration ponds and the beach where a coastal frontal dune system is present (**Figure 3**).

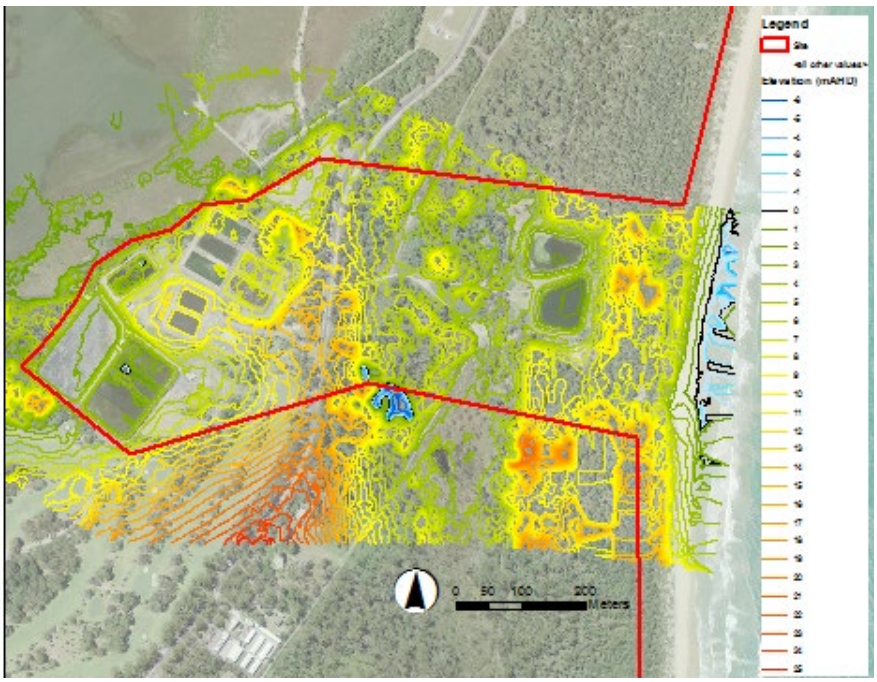

Figure 3 Elevation contours (data provided by BVSC)

2.2 Land use

The site is environmentally and archaeologically sensitive.

Key features of the STP and surrounds are presented in **Figure 4**. The site is currently vegetated, except for unsurfaced access tracks that cross the site and two exfiltration ponds. These ponds are in an old sand quarry and disposal of effluent to the ponds is managed to control waterlogging (PPK 2002) (refer **Figure 5**). Currently a shore-based outfall discharges on the beach.

Figure 4 Existing Merimbula STP and surrounding area*

**PS – Pump station; PMGC – Pambula Merimbula Golf Course; IDEA – Intermittently decanted extended aeration.*

Figure 5 Exfiltration ponds, looking East (image courtesy of BVSC)

2.3 Regional geology

Reference to the Bega – Mallacoota 1:250,000 Geological Map (1995) shows the geological units on a regional scale. These comprise in (as per the stratigraphic order in **Table 2** below):

- Quaternary (Holocene) alluvial and aeolian deposits;
- Tertiary fluvial sands and lacustrine clays; and
- Bedrock comprising metamorphosed sandstone and conglomerate or volcanics.

A substantial paleo-valley was eroded in bedrock by the Pambula River during a period of low sea level that extended until about 120,000 years ago (see **Figure 6**). In the Tertiary sea levels rose and Tertiary deposits occur at slightly higher elevations, slightly inland (south-west) of the current beach. Sea levels then fell and the Tertiary sediments were exposed, weathered, and partially eroded.

About 6,000 years ago, the sea levels rose again, and Holocene beach deposits started accumulating. The east-facing Merimbula beach barrier complex began accumulating 7,000 to 8,000 years ago following swell from the Tasman Sea and stabilised in its present form 5,000 years ago. It is 300 m wide, has a wide back-barrier flat and is relatively high. The beach barrier is crossed by a series of crests and swales parallel to the beach.

The pre-Tertiary palleovalley eroded in bedrock may be over 90 m in depth and is infilled with a complex sequence of both partially consolidated/weathered Tertiary material, and unconsolidated Holocene soils.

Table 2 Geological Unit Summary

Unit	Age	Description
Quaternary (Qa)	Quaternary (2.6 Ma - present	“Alluvial and colluvial deposits”
Ts	Tertiary (Oligocene to Eocene, 23-5.3 Ma)	“Fluvial sands, grits, lacustrine clays”
Merimbula Group (Dm, Dmb, Dmw, Dmc, Dmt)	Late Devonian (360 Ma)	Sandstone and conglomerate with mudrock

Unit	Age	Description
Boyd Volcanic Complex (Db)	Middle Devonian	“Acid volcanic, basalt, quartz porphyries and minor sediment”

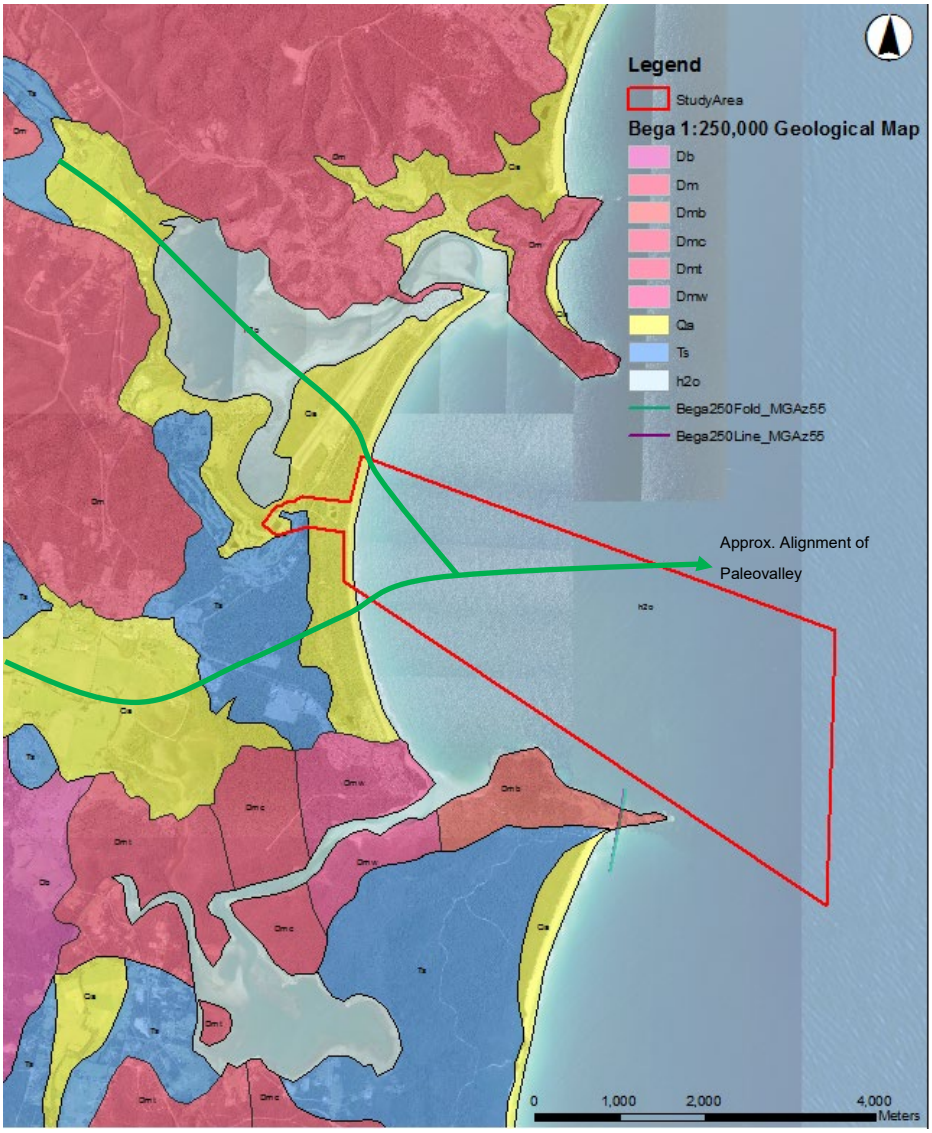

Figure 6 Extract from Bega-Mallacoota 1:250,000 Geological Sheet – Geological Survey of NSW

2.4 Local geology

The Bega Valley Area Coastal Quaternary Geology 1:100,000 and 1:25,000 Geological Map (2013) presents high-resolution geological surface coverage of unconsolidated sedimentary deposits, formed predominantly during the Quaternary (last 2.6 Ma). This map also includes simplified bedrock units (where these outcrop).

These show that the area is underlain by the following deposits, from west to east:

- Qheb: Holocene estuarine in-channel bar and beach: marine sand, silt, clay, shell, gravel. West of the site;
- Ts: Tertiary Sediments. Forms a low ridge trending north-south and underlies the alignment west of the exfiltration ponds;

- Qhbf: Holocene back-barrier flat: marine sand, silt, clay, gravel, shell: 10-20 m wide section, west of the exfiltration ponds;
- Qhbd: Holocene dunes: marine sand (exfiltration ponds to Pambula beach); and
- Qhbb: Holocene sandy beach: marine sand, shell, gravel (Pambula beach).

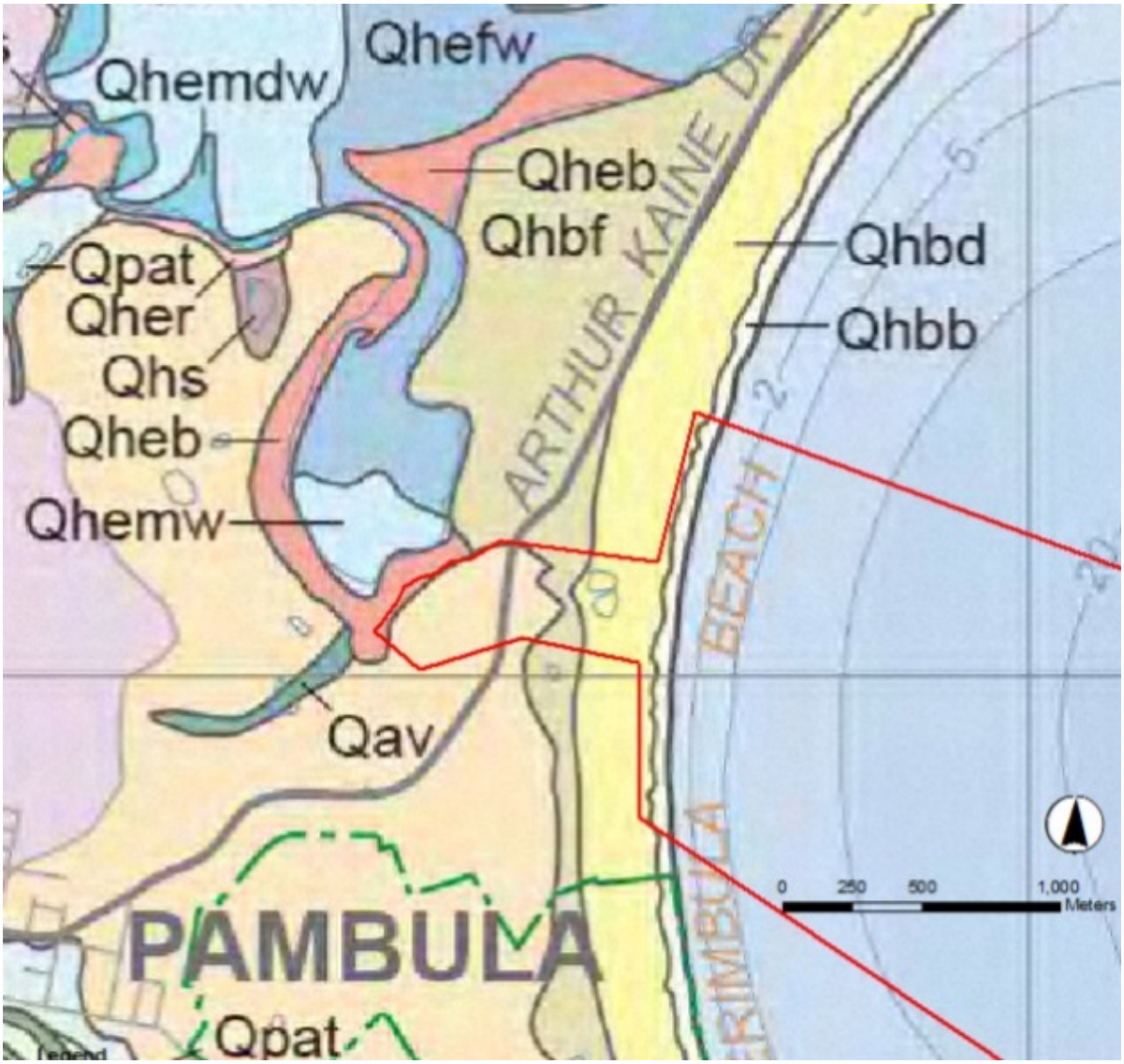

Figure 7 Extracts of Bega Valley Coastal Quaternary Geology Maps 1:100,000 and 1:25,000 – Geological Survey of NSW

2.5 Acid sulfate soil mapping

Based on the online SEED (Sharing and Enabling Environmental Data) mapping[2], the beach and dune sands have a low probability of occurrence for acid sulfate soils. The estuarine sediments on the lake side of the STP is mapped as having a high probability of acid sulfate soils.

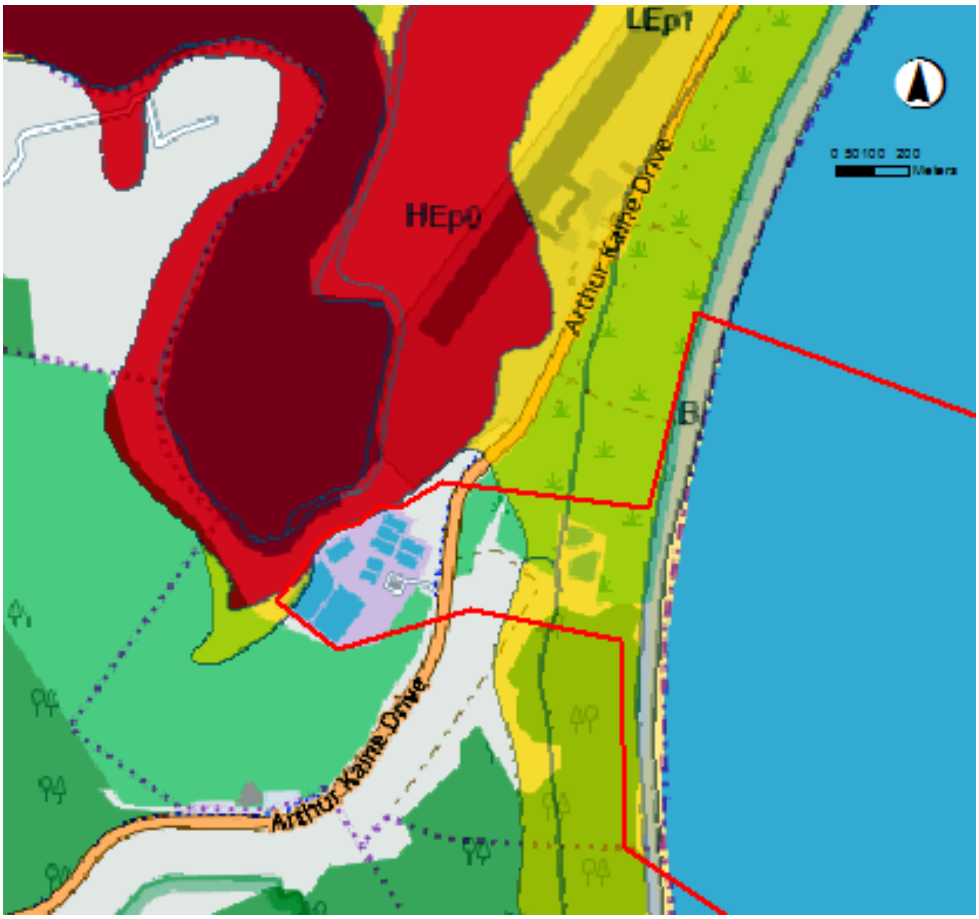

Figure 8 SEED extract – probability of acid sulfate soils (red: high, yellow: low)

[2]Available at https://www.seed.nsw.gov.au/

2.6 Previous site investigations

Previous intrusive investigations within 200 m from the STP site are summarised in **Table 3** and discussed below.

Table 3 Summary of previous intrusive investigations

Year	Project	Originator	Scope	Limitations
1983	Merimbula Wastewater Augmentation – Stage 1 (Report No. SC.103)	Coffey	Unknown	Report unavailable
1987	Appraisal of Sand Seepage Capacity and Conceptual Design of Infiltration Systems – Merimbula STW	Mackie Martin	22 geotechnical boreholes Groundwater sampling	Shallow Report unavailable – described in PPK2002
1988	Merimbula Wastewater Augmentation – Stage 2 Investigation	Public Works Department - Geotechnical Centre	12 boreholes to 4.7 m or 10.0 m Laboratory testing	Shallow Located in STP only
1991-1992	Various council groundwater monitoring	BVSC	7 monitoring wells (“A series”) - A1, A4, A5, A6	Logs unavailable. Conflicting location of A5 in PPK report
2002	Assessment of Groundwater conditions and dune disposal options for Merimbula STP	PPK	4 monitoring wells (PPK1, PPK2, PPK3, PPK4) Hydrochemistry Groundwater levels	Shallow Environmental logging
2004	Investigation of the Deep Disposal Option for Reclaimed Water from Merimbula STP, Stages 1 and 2	PB	Pilot hole, 62 m depth (1 monitoring well) Resistivity survey	Environmental logging
n/a	Monitoring Well GW047147	WaterNSW	1 well	Log unavailable – described in PPK2002

Historical boreholes were georeferenced by AECOM and are shown in Appendix B. Approximate coordinates of boreholes are provided in **Table 4**.

Table 4 Coordinates of georeferenced historical data

Borehole	Easting*	Northing*	Elevation from LiDAR (mAHD)	Termination Depth (m)
1988_BH1	758021	5910286	7.16	10
1988_BH2	758005	5910314	7.47	5
1988_BH3	757989	5910335	7.39	10
1988_BH4	757981	5910365	8.19	10
1988_BH5	757958	5910377	8.24	5
1988_BH6	757936	5910396	8.16	5
1988_BH7	757828	5910289	6.58	10
1988_BH8	757795	5910296	5.55	9.8
1988_BH9	757763	5910289	5.56	5
1988_BH10	757954	5910242	11.23	4.65
1988_BH11	757934	5910082	9.88	4.85
1988_BH12	757716	5910069	3.14	7.6
2004_PB1	758298	5910489	1.62	61.55
2002_PPK1	758642	5910209	6.81	9.5
2002_PPK2	758605	5910122	7.53	8

* Zone 55 MGA/GDA94

2.6.1 1987 Mackie Martin investigation

PPK 2002 states that all the Mackie Martin bores have either been lost or destroyed. PPK also note that Quaternary Sands were proven to 26 m, with an average depth of 7 to 10 m near exfiltration ponds. Most boreholes were terminated within the Quaternary deposits, usually within the first substantial clay layer.

1987_BH18, 1987_BH20 and 1987_BH21 were reported to terminate in weathered bedrock, however this is considered by PPK 2002 to be more likely Tertiary deposits.

2.6.2 WaterNSW well records

The WaterNSW records show a groundwater bore (GW047147) located along Arthur Kaine Drive, 400 m south from the STP site. The stratigraphy in this borehole is described in PPK 2002 as comprising sands, gravels and clays to 14 m (proven) and surface sand for the top 10 m, with a peaty layer from 1.2 to 5.5 m.

2.6.3 1988 Public Works STP investigation

Twelve boreholes were drilled to depths from 4.65 m to 10.00 m for the “Stage 2” STP at the time. The geology was described as medium dense to very dense clayey silty sands (SC or SM) interbedded with stiff to hard sandy silty clays (MH, CL or CH). The soils were non-dispersive. Occasionally, a variable 1 m thick fill layer is described over the natural ground.

1988_BH11 and 1988_BH10 are closest to the proposed alignment. 1988_BH10 shows Standard Penetration Tests (SPT) refusal from 1 m depth and refusal from 4.8 m depth in 1988_BH11 SPT.

Laboratory testing comprised Particle Size Distribution, hydrometer testing, Atterberg Limits and linear shrinkage, Emerson Class, standard compaction and unconfined undrained triaxial compression. This data has been included with the results of the 2018 laboratory testing below.

2.6.4 2002 PPK investigation

PPK installed 4 wells (PPK1, 2, 3, 4) to about 10 m, with 3 m long screens at their base. The geology was described as medium quartz sand, becoming coarse at depth, with organic material and shell fragments present in places", and interpreted to be dune and beach sands of "Recent/Pleistocene" origin.

PPK1 and PPK2 are close to the proposed alignment and encountered:

- 3.5 to 6 m of medium to coarse white, beige and orange quartz sand with "small amounts" of black organic fibres (<2 mm long);
- 1 m thick layer similar to above, but with shell fragments (1-2 mm); and
- 2.5 m thick layer similar to above, but with shells (5 mm) and organic fibres (4 mm).

The sampled groundwater pH was about 7, the EC about 900 µS/cm, the sulfate content varied from 15 to 30 mg/L and the chloride about 150 mg/L.

2.6.5 Pilot hole drilling 2004

In 2004, PB drilled out a pilot hole (PB1) to a depth of 61.55 m with rotary mud drilling. A standpipe piezometer was installed in this hole.

The PB 2004 report describes interlayered coarse sand and clay to a depth of at least 48 m. This sequence potentially extends to 61.6 m, however the blade bit could have penetrated the top of bedrock. A potential silcrete layer was encountered at 61.6 m. The sequence was described as:

- Upper Sand (7.8 m thick): medium to coarse, pale orange-brown to brown sand. Similar to the dune sand, but with increasing fine content towards its base.
- Middle Sequence (41.1 thick): clay interbedded with coarse sand. Clays are generally "puggy" [high plasticity], layers contain little or no sand and range in colour from pink to white to yellow. Four 2 m thick layers of coarse quartz sand occur in this sequence, with a total thickness of 8.3 m. The top of the middle sequence comprised 5.2 m of clay.
- Lower Sequence (12.7 m thick): coarse sand (with occasional 2 m thick beds containing traces of clay and silt). Contrary to the Middle Sequence, 5% of the gains comprise black, dark brown and pale orange-brown lithic fragments. Potential occurrence of siltcrete layers.

The Middle and Lower Sequence are interpreted to comprise the majority of the material deposited in the Pambula River paleochannel.

The Upper Sand constitutes a shallow unconfined aquifer, which was intersected at 0.7 m depth. The Middle and Lower Sequences were classified as a deep (generally confined) artesian aquifer (0.05 m above surface).

The standpipe piezometer screen was split in a 3 m long section in the Middle sequence, and a 12 m long section in the Lower Sequence. Groundwater quality testing from the deep aquifer returned an EC of 4045 microS/cm and a pH of 4.1, sulfate of 35 mg/L and chloride of 1240 mg/L.

2.6.6 Resistivity survey 2004

In 2004, PB investigated the option of deep disposal of effluent by carrying out a resistivity survey to provide an estimate of top of bedrock, an estimate of the thickness of the confining clay at the top of the Middle Sequence, and an indication of the nature of the deep sediments.

Resistivity data was collected along five resistivity transects (4 km in total) and in three vertical resistivity soundings targeted in key areas of interest.

The resistivity survey identified three layers: unsaturated sands (generally high resistivity), mixture of sands and clays (moderate resistivity with lateral variation), bedrock (higher resistivity than the soil above).

The contours of interpreted depth to bedrock were georeferenced by AECOM in ArcGIS and are shown on **Figure 9**. They suggest that the top of bedrock varies from 25 m to 30 m depth in the southern central area of the land side (of the ocean outfall alignment) but deepens to 35 m to the north of the exfiltration ponds and to the west towards the STP. These changes are greater than the changes in surface elevations, suggesting a deepening. However, the geophysical report mentions that the contrast in resistivity between the top of bedrock and the sand/clay mixture is low and that there is a high degree of uncertainty with the depths to top of bedrock. The deeper contours mostly indicate the most likely location of the expected paleochannel.

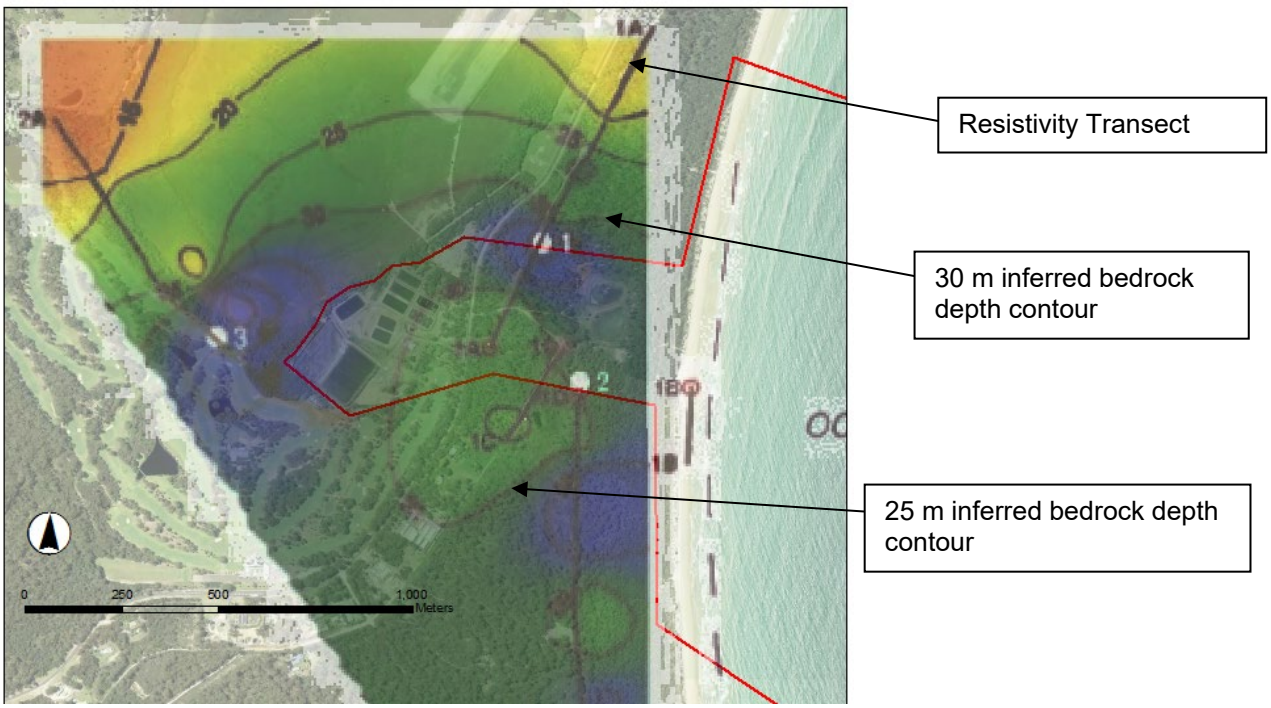

Figure 9 PB 2004 Resistivity survey

Note – (Lines: resistivity transects; Points: vertical resistivity sounding) – georeferenced by AECOM. Colours indicate inferred bedrock depth (blue deeper than 30 m, orange shallower than 15 m)

3.0 Site investigations

3.1 Gravity survey

GBG Australia carried out a gravity survey in October 2017 to try and find the top of bedrock. The survey comprised collection of gravity, passive seismic and GPS data at 41 predefined stations shown in Appendix C. Active seismic investigations using explosives were not used due to the environmental and archaeological sensitivity of the area.

The gravity results suggest:

- the gravity decreases towards the north, suggesting deeper bedrock to the north;
- higher gravity in the south-west corner of the site, suggesting shallower bedrock; and
- lower gravities south-west of the exfiltration ponds, however the readings at Station 37, 38 and 39 could have been impacted by the existing outfall.

In the absence of intrusive data, Tromino was used to collect a limited set of passive seismic data at four of the stations and generate a preliminary geological model for gravity data interpretation.

Three layers were interpreted.

This report is attached in Appendix G. Line 4 was regenerated, which are likely to have been affected but the existing outfall. This updated figure is presented in Appendix G after the report.

3.2 Intrusive geotechnical investigation

3.2.1 Borehole locations and buried services

As part of a project-specific site investigation, six vertical boreholes were drilled in October to November 2018, with an additional bore drilled in November 2019 as summarised in **Table 5**, **Figure 10** and Appendix C.

The location of the boreholes were determined with a hand-held GPS and the elevation of the ground surface were based on satellite LiDAR data.

Table 5 Summary of AECOM intrusive investigations

Borehole	Easting*	Northing*	Elevation from LiDAR (mAHD)	Termination Depth (m)
2018_BH002A	758385	5910184	4.3	20
2018_BH002B	758390	5910104	3.9	30
2018_BH003	758148	5910218	11.1	30
2018_BH004	758053	5910228	15.2	15
2018_BH006	758343	5910241	3.5	20
2018_BH007	758295	5910109	2.5	40
2019_BH08A	758601	5910122	6.8	19.95

* Zone 55 MGA/GDA94

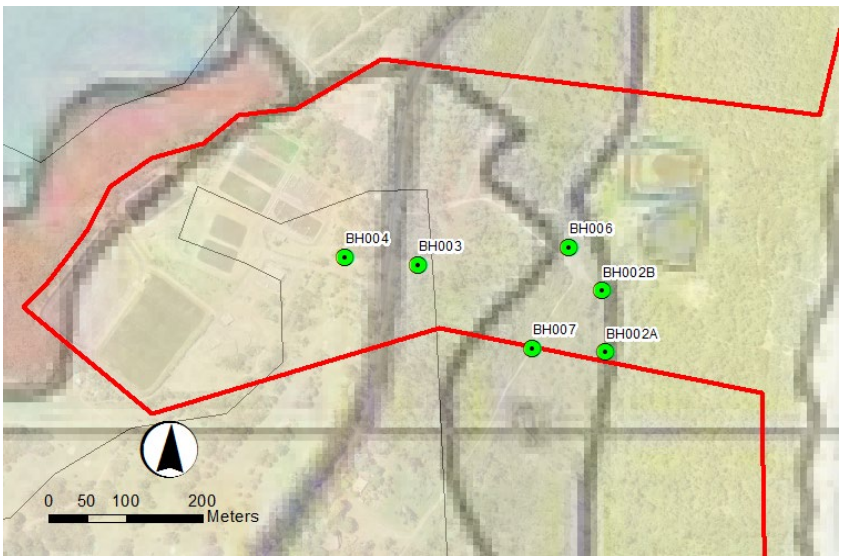

Figure 10 Locations of the 2018 Site Investigations (1:100,000 geological map overlay)

3.2.2 Drilling

A pre-drilling buried service check was undertaken at all locations by Vacgroup. The aim of this check was to confirm the utilities data from the Dial-Before-You-Dig drawings and walk-over survey.

A heritage survey was carried out on site by two AECOM archaeologists in early October 2018. This included manually excavating a heritage test pit (50 cm by 50 cm) at each borehole location (except 2018_BH004 due to the presence of asphaltic concrete). All test pits were excavated to depths of 50 cm to 80 cm. Aboriginal archaeological materials, comprising flaked stone artefacts, were identified in three test pits (2018_BH002A, 2B), all of which were located on low but locally prominent ‘spur dunes’ oriented at right angles to the frontal dune. Excavation in these pits was continued to culturally sterile depths, as determined by the vertical distribution of artefacts therein.

The boreholes were drilled with a tracked rig from Terratest. Generally, a solid flight auger was used to groundwater level, then rotary drilling with casing advancer in the water saturated soils.

3.2.3 Standard Penetration tests

SPTs were completed in vertical boreholes to provide information on the density of non-cohesive soils, and with lesser reliability, the stiffness of cohesive soils.

SPTs were carried out to Australian Standard AS1289.6.3.1-2004 at about 1.5 m intervals in soil strength materials. SPT tests were discontinued where 30 blows caused less than 100 mm penetration at any stage and/or where the hammer was observed to be bouncing for 10 consecutive blows. On completion of the SPT, the sample was placed in a labelled, plastic, zip lock bag.

3.2.4 Samples

U63 tube samples were taken in cohesive material. Sealed tube samples and bagged SPT samples were left on the STP site. A selection of samples was brought back to Macquarie Geotechnical laboratory in Sydney for subsequent testing.

4.0 Results

4.1 Geotechnical units

Two geotechnical units have been identified as documented in **Table 6** below.

Table 6 Geotechnical units

Geological Unit	Typical Description	Typical Density/ Consistency	Typical Thickness (m)
Dune Sand (DS)	Quartz SAND, fine to medium grained, brown to dark brown, occasional organic odour, trace silt	Variable - Loose to Dense	8m to >10 m
Interbedded Sand and Clay (S&C)	Quartz SAND medium to coarse grained, occasionally with silt. Occasional clay beds (approx. 15%), up to 2 m thick, medium plasticity, pale brown, with fine to medium grained sand. Red-grey mottling at depth.	Dense to Very Dense (Sands) Very stiff to Hard (Clays)	Base not encountered

The boundary between the two layers slopes gently to the east and was below the depth of investigation in bores 2002_PPK1, and 2002_PPK2.

Figure 11 to **Figure 14** illustrate each unit.

Figure 11 Example of Dune Sand unit (2018_BH007 at 2.5-3.0 m)

Figure 12 Example of Interbedded Sand & Clay (2018_BH007 at 16.0-16.5 m)

Figure 13 Example of Interbedded Sand & Clay (2018_BH007 at 25-30 m)

Figure 14 Example of Interbedded Sand & Clay (2018_BH004 at 8.5-9.0 m)

None of the boreholes encountered bedrock, indicating a deeper rock profile than suggested by the past geophysical surveys. In particular, 2018_BH007 was drilled to 40 m depth without encountering bedrock expected at 25 m based on the resistivity survey.

A long section of the geological conditions expected along the proposed alignment is presented in Appendix E. SPT results are presented on the cross sections.

4.2 Geotechnical parameters

Preliminary geotechnical design parameters for each unit are given below:

Table 7 Geotechnical Parameters

Geotechnical Unit	Unit Weight	Undrained Strength	Drained Cohesion c'	Drained Friction angle ϕ'	Youngs Modulus E
	kN/m^3	kPa	kPa	Degrees	MPa
DS	18	n/a	0	30 - 35	10
S&C - Sands	19	n/a	0	30 - 35	40
S&C - Clays	20	100	5	28	20

4.3 Groundwater

The level of groundwater inflows into both previous and current bores are recorded in **Table 8** below.

Table 8 Groundwater Levels

Bore	Water Level (mbgl)	Water Level (RL AHD)
1988_BH1	4.5	2.7
2018_BH03	5.0	6.1
2018_BH07	1.2	5.4
2018_BH06	1.2	2.3
2018_BH02A	1.3	3.0
2018_BH02B	1.3	2.6
2002_PPK2	4.0	2.8
2002_PPK1	5.5	-3.9

It is anticipated that groundwater levels are affected by both rainfall events and tidal variations.

4.4 Standard Penetration Testing (SPT)

SPT was carried out at 1.5 m spacing in each borehole. Results are shown against elevation and against depth on **Figure 15**. They suggest that:

- the SPT blow counts are highly variable in the Dune Sand unit, with a slight average increase with depth; and
- the SPT blow counts typically range between 30 to refusal in the interbedded sand and clay, with refusal below depths of 16 m.

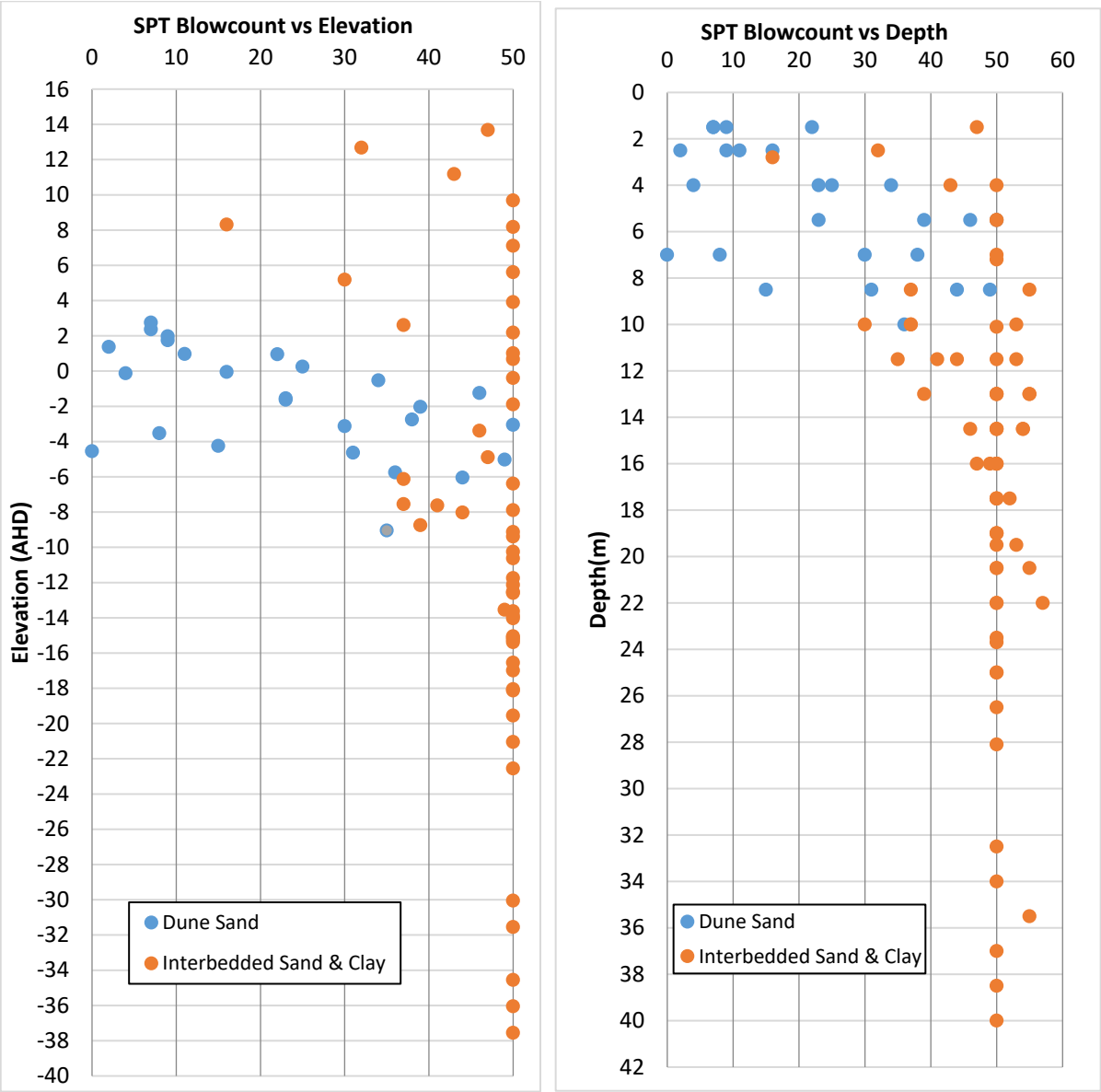

Figure 15 Standard Penetration Testing results.

4.5 Laboratory testing

Table 9 and **Table 10** summarise the laboratory test results completed on the samples collected during the 2018 investigation. Copies of the laboratory test sheets are provided in Appendix E.

Table 9 Soil Description, Atterberg Limits, Linear Shrinkage and Particle Size Distribution

Borehole	Sample Depth (m)	Unit	Soil Description	Atterberg Limits			Linear Shrinkage (%)	Percentage Mass			
				LL (%)	PL (%)	PI (%)		Clay (%)	Silt (%)	Sand (%)	Gravel (%)
2018_BH02B	7.00-7.45	DS	SAND	-	-	-	-	-	3	97	0
2018_BH02B	8.00-8.45	DS	SAND	-	-	-	-	-	4	96	0
2018_BH02B	10.00-10.45	S&C	SAND, medium to coarse, sand is poorly graded	-	-	-	-	-	4	96	0
2018_BH02B	22.0-22.8	S&C	Silty CLAY with Sand, medium plasticity	50	18	32	10	-	-	-	-
2018_BH03	11.50-11.95	S&C	(SM) SAND with silt, trace gravel, sand is fine to coarse	-	-	-	-	-	16	70	14
2018_BH03	16.00-16.45	S&C	(SC) SAND with Clay and Silt, sand is predominantly medium grained	-	-	-	-	9	8	83	0
2018_BH03	20.50-20.95	S&C	Silty CLAY, Medium Plasticity	39	17	22	8	-	-	-	-
2018_BH04	5.50-5.95	S&C	Silty CLAY, Medium Plasticity	46	17	29	10	-	-	-	-
2018_BH06	8.65-8.95	DS	(SP) SAND trace Silt trace Gravel,	-	-	-	-	-	3	92	5
2019_BH08A	11.5-11.8	DS	SAND, trace Gravel and Clay	-	-	-	-	-	5	91	4
2019_BH08A	13.0-13.25	DS	SAND, trace of clay	-	-	-	-	-	3	97	0
2019_BH08A	17.5-17.85	DS	SAND with silt and clay	Non plastic			-	7	8	85	0

Table 10 pH, Sulfate, Chloride and Electrical Conductivity

Borehole	Sample Depth (m)	Unit	Soil Description	pH (1:5 soil:water)	Sulphate (mg/kg)	Chloride (mg/kg)	Electrical Conductivity (µS/cm)
2018_BH02B	7.00 – 7.45	DS	SAND	4.2	440	<10	220
2018_BH02B	10.00 – 10.45	S&C	medium to coarse SAND	4.0	220	<10	2400
2018_BH07	13.3-13.45	S&C	medium to coarse SAND	7.4	10	41	54
2018_BH04	14.5-14.95	S&C	fine to medium sand with fines	6.6	20	28	44
2019_BH08A	13.0-13.25	DS	SAND, trace of clay	7.2	4.5	14.2	64.9

5.0 Discussion

5.1 Anticipated ground conditions

An inferred longitudinal section along the proposed onshore alignment is provided in Appendix F. West of chainage 300 the HDD/directional drilling is anticipated to be in interbedded sands and clays. East of chainage 300 the alignment is anticipated to be in dune sand.

The interbedded sands and clays comprise dense to very dense clayey sands with beds of very stiff to hard clay. During the investigation the loss of drilling fluid from the interbedded sands and clays was not recorded. Large obstacles such as cobbles and boulders were also not encountered in the bores. Fine gravel was encountered in 2018_BH03 with 100% passing the 9.5 mm sieve.

The dune sands vary considerably in strength and stiffness due to the variable density of the sands.

The depth to bedrock appears to be well below the proposed vertical alignment and the risk of encountering bedrock is considered to be very low.

5.2 Groundwater

Groundwater in the interbedded sands and clays are not well understood and are probably complex with the clay beds acting as aquicludes and the sandy beds and aquifers. The level of groundwater strike measured in 2018_BH03 may be a perched water table on a clay aquiclude.

The dune sand is anticipated to comprise a high permeability unconfined aquifer with a direct hydraulic connectivity to Merimbula Bay. Rough estimates of permeability based on the Hazen Formula indicate a range of 2×10^{-4} m/s to greater than 6×10^{-4} m/s. Groundwater levels are anticipated to slope towards the bay and vary in response to rainfall events and tidal range.

Groundwater salinity is anticipated to vary from an intermediate salinity of 2 mS/cm measured in BH02B at 10.0m, to equivalent to sea water under the bay.

5.3 Feasibility of horizontal directional drilling

The ground conditions expected along the proposed horizontal directional drill hole alignment shown in Appendix F are not anticipated to prevent construction of the pipeline by horizontal directional drilling. Potential geotechnical issues identified during the investigation include:

- areas of substantially reduced overburden stress due to low cover and high groundwater levels;
- the dune sands are anticipated to have a high potential for caving and fluid loss during drilling operations, due to their low fines content; and
- the variable salinity of the groundwater and potential impacts on mud chemistry.

Portions of the alignment that have areas where there is limited cover of saturated dune sand are Chainage 300 to 500, and from Chainage 750 to the offshore riser. In these areas where overburden stress is reduced, there is an increased risk of frac-out, where drilling fluid may fail the ground over the bore and discharge into the environment.

The geotechnical issues listed above are mainly construction risks and will need to be managed by the builder. To some extent the overburden stress issue may be reduced by modifying the vertical alignment to provide additional cover. It is recommended that these geotechnical issues be captured by the project risk register and be addressed during detailed design and construction.

While HDD/directional drilling conditions in the dune sands are anticipated to be challenging due to the above issues, a number of HDD projects with similar constraints have been successfully completed both in Australia and overseas.

5.4 Aggressivity

Assessment of the exposure Classification for concrete and steel as per AS2159-2009 based on soil testing is documented in **Table 11**. A severe exposure classification is indicated for both concrete and steel members in contact with the ground.

It should be noted that groundwater was not tested and given it could be similar to the chemistry of sea water, it may be more aggressive than the soils

Table 11 Soil Aggresivity Testing Results

Bore Details			Chemical Analysis							Exposure Classification Concrete (AS2159 2009)			Exposure Classification Steel (AS2159 2009)		
Bore	From (m)	To (m)	SO_4 (ppm)	SO_4 (%)	Cl (ppm)	Cl (%)	pH	EC (uS/cm)	Resistivity (Ω. cm)	Condition	SO_4 in soil	pH	Cl in soil	Resistivity	pH
2018_BH02B	7.00	7.45	440	0.04	<10	<0.001	4.2	220	455	A	Mild	**Severe**	Mild	**Severe**	Mild
2018_BH02B	10.00	10.45	220	0.02	<10	<0.001	4.0	2400	41.7	A	Mild	**Severe**	Mild	**Severe**	Mild
2018_BH07	13.3	13.45	10	0.001	41	0.004	7.4	54	1852	A	Mild	Mild	Mild	Moderate	Non
2018_BH04	14.5	14.95	20	0.002	28	0.003	6.6	44	2273	A	Mild	Mild	Mild	Mild	Non
2019_BH08A	13.0	13.25	4.5		14.2		7.2	64.9		A	Mild	Mild	Mild	Mild	Non

6.0 Important Information about this report

Client details, scope and reliance

AECOM has prepared this report for the sole use of the Client and for a specific purpose, each as expressly stated in the report. No other party should rely on this report without the prior written consent of AECOM. AECOM undertakes no duty, nor accepts any responsibility, to any third party who may rely upon or use this report. This report has been prepared based on the Client's description of its requirements and AECOM's experience, having regard to assumptions that AECOM can reasonably be expected to make in accordance with sound professional principles. AECOM's findings represent its reasonable judgment within the time and budget context of its commission and utilising the information available to it at the time.

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Variability in conditions and limitations of data

Subsurface conditions are formed through a variety of natural processes and can be altered by human activities. The behaviour of the ground, groundwater and contaminants are complex and conditions can vary across a particular site. As a result, subsurface conditions cannot be exhaustively defined by investigations at discrete locations. Therefore, it is unlikely that the results and assessments expressed in this report will represent conditions at any location removed from the specific points of sampling. The precision with which conditions can be inferred depends largely on the uniformity of subsurface conditions and on the frequency and method of sampling as constrained by factors such as project budget and time limitations and physical constraints.

Furthermore, subsurface conditions can change over time, which should be considered when interpreting or using the data within this report.

Verification of opinions and recommendations

The opinions and recommendations in this report apply to the proposed development and the site existing at the time of our investigation and cannot necessarily apply to changes in the proposed development or site changes of which AECOM is not aware and has not had the opportunity to evaluate. Our recommendations should be considered to be preliminary and subject to verification during project implementation. If conditions encountered at the site are subsequently found to differ significantly from those anticipated, AECOM must be notified and be provided with an opportunity to review the recommendations.

Appendix A

Alignment Options

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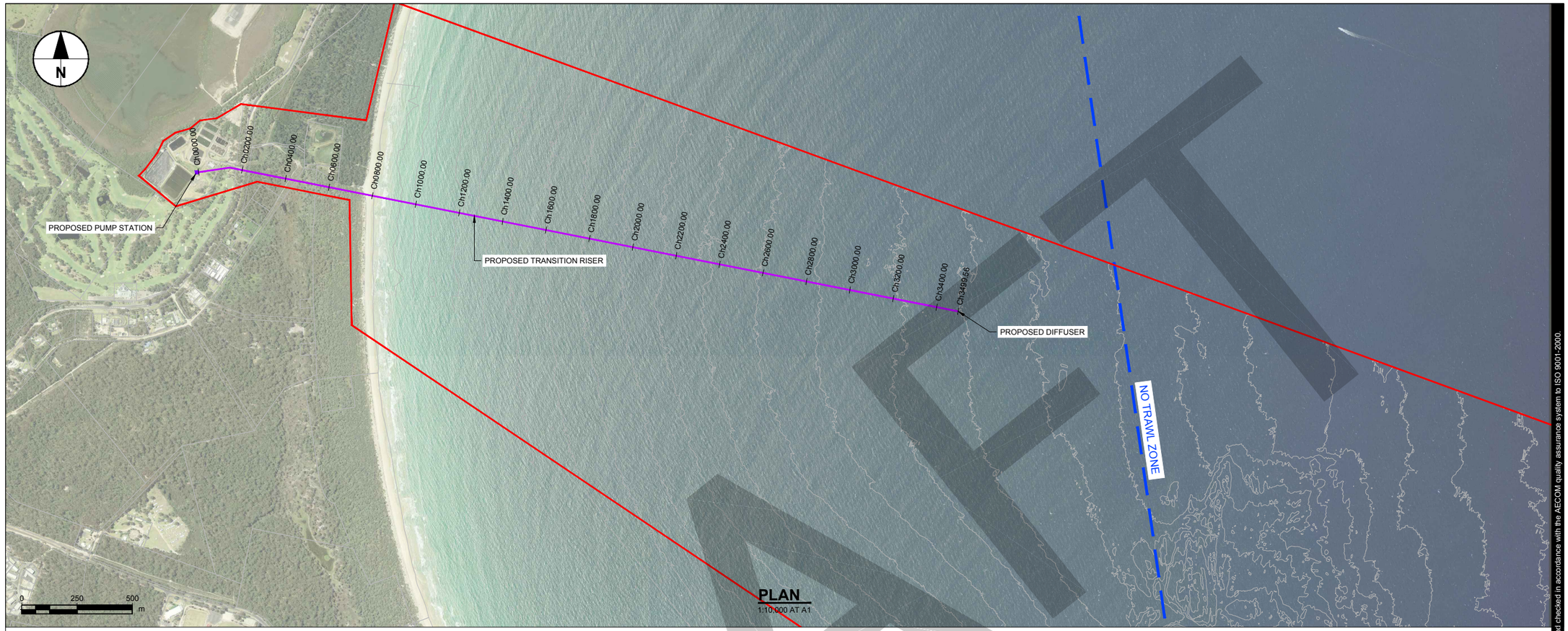

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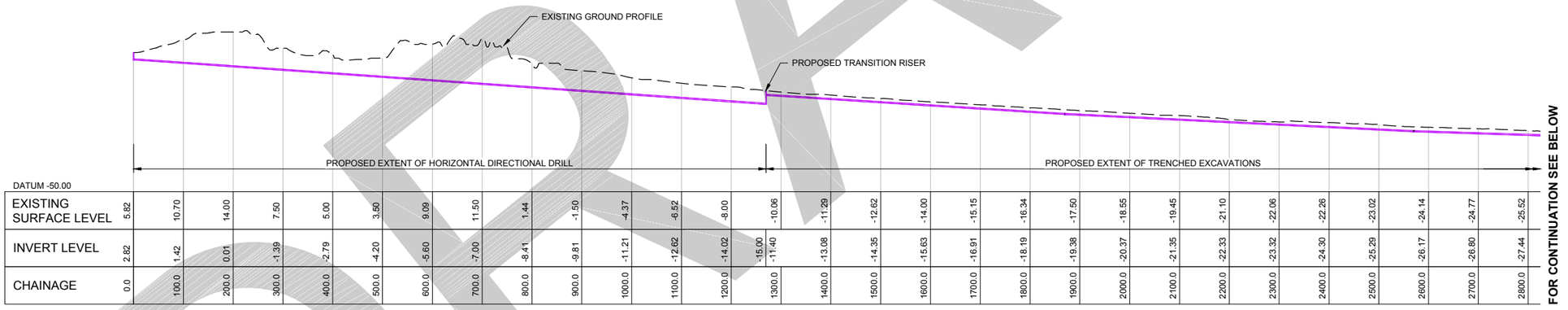

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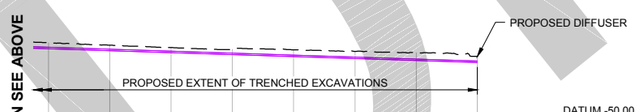
INVERT LEVEL	2.82	1.42	0.01	-1.39	-2.79	-4.20	-5.60	-7.00	-8.41	-9.81	-11.21	-12.62	-14.02	-15.00	-11.40	-13.08	-14.35	-15.63	-16.91	-18.19	-19.38	-20.37	-21.35	-22.33	-23.32	-24.30	-25.29	-26.17	-26.80	-27.44	
CHAINAGE	0.0	100.0	200.0	300.0	400.0	500.0	600.0	700.0	800.0	900.0	1000.0	1100.0	1200.0	1300.0	1400.0	1500.0	1600.0	1700.0	1800.0	1900.0	2000.0	2100.0	2200.0	2300.0	2400.0	2500.0	2600.0	2700.0	2800.0	



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A | OPTION 1 - LONGITUDINAL SECTION
1:5000H, 1:1000V AT A1

AECOM

PROJECT
MERIMBULA STP UPGRADE AND DEEP OCEAN OUTFALL

CLIENT
BEGA VALLEY SHIRE COUNCIL

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- PROPOSED PIPE ALIGNMENT

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DJK		

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KEY PLAN

PROJECT NUMBER
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SHEET TITLE
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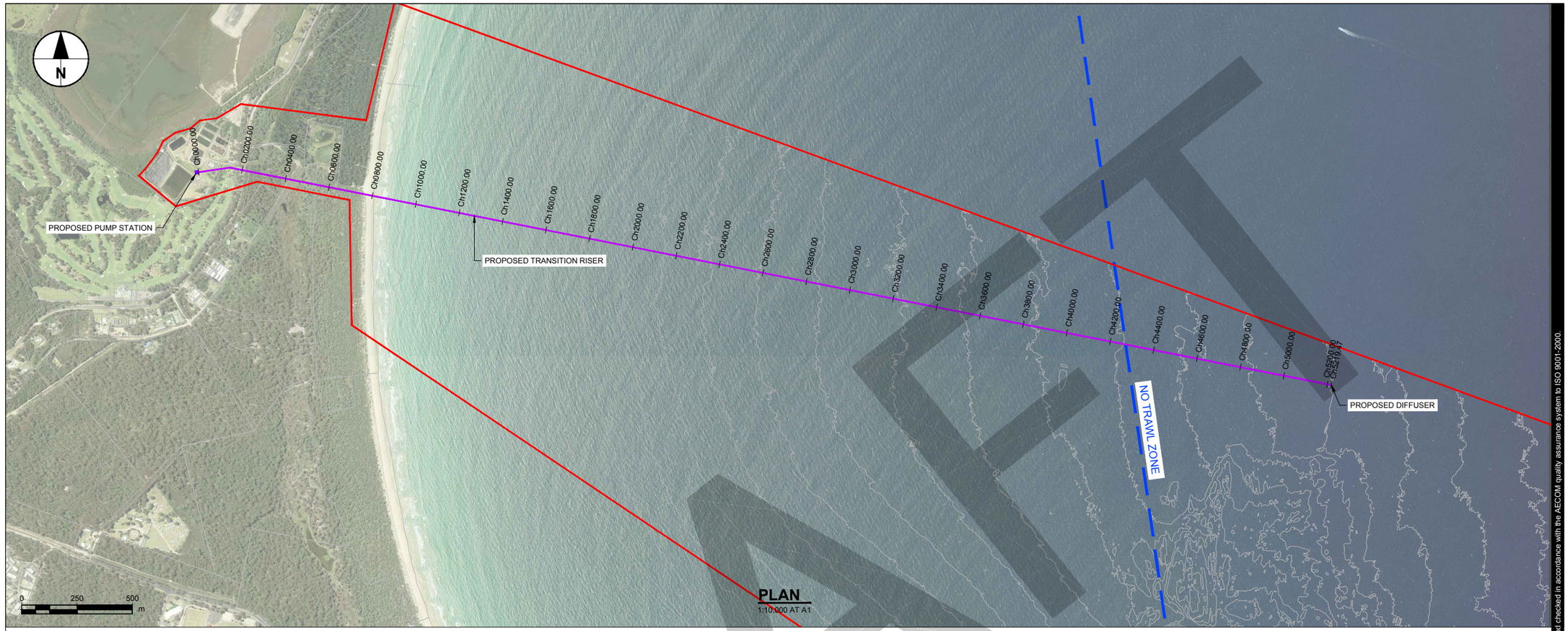

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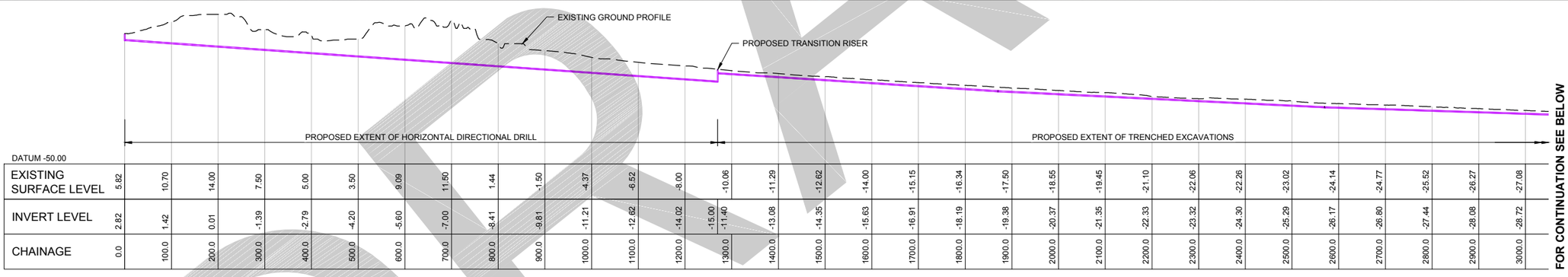

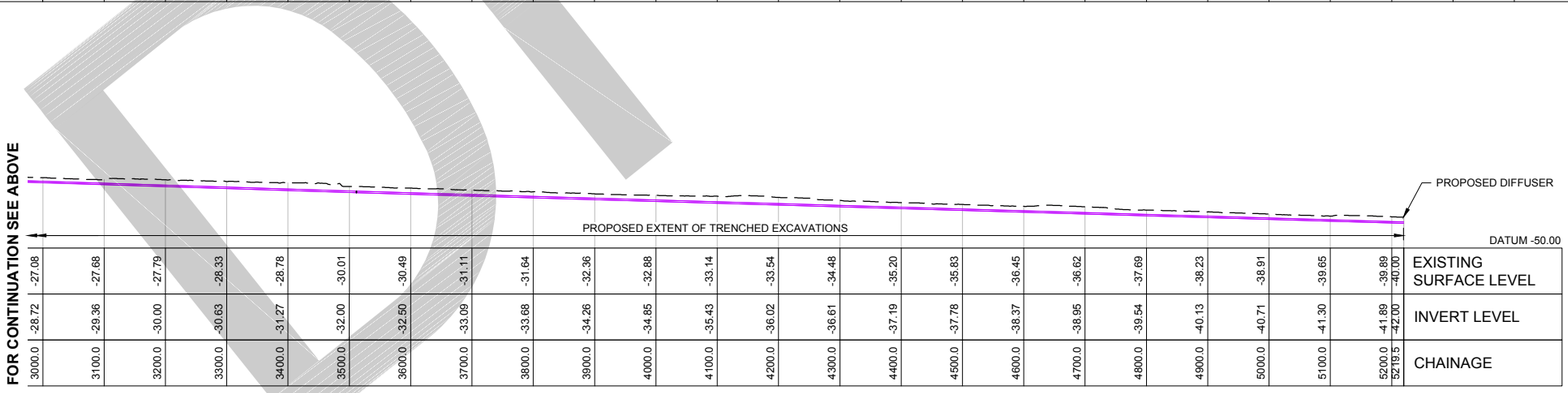

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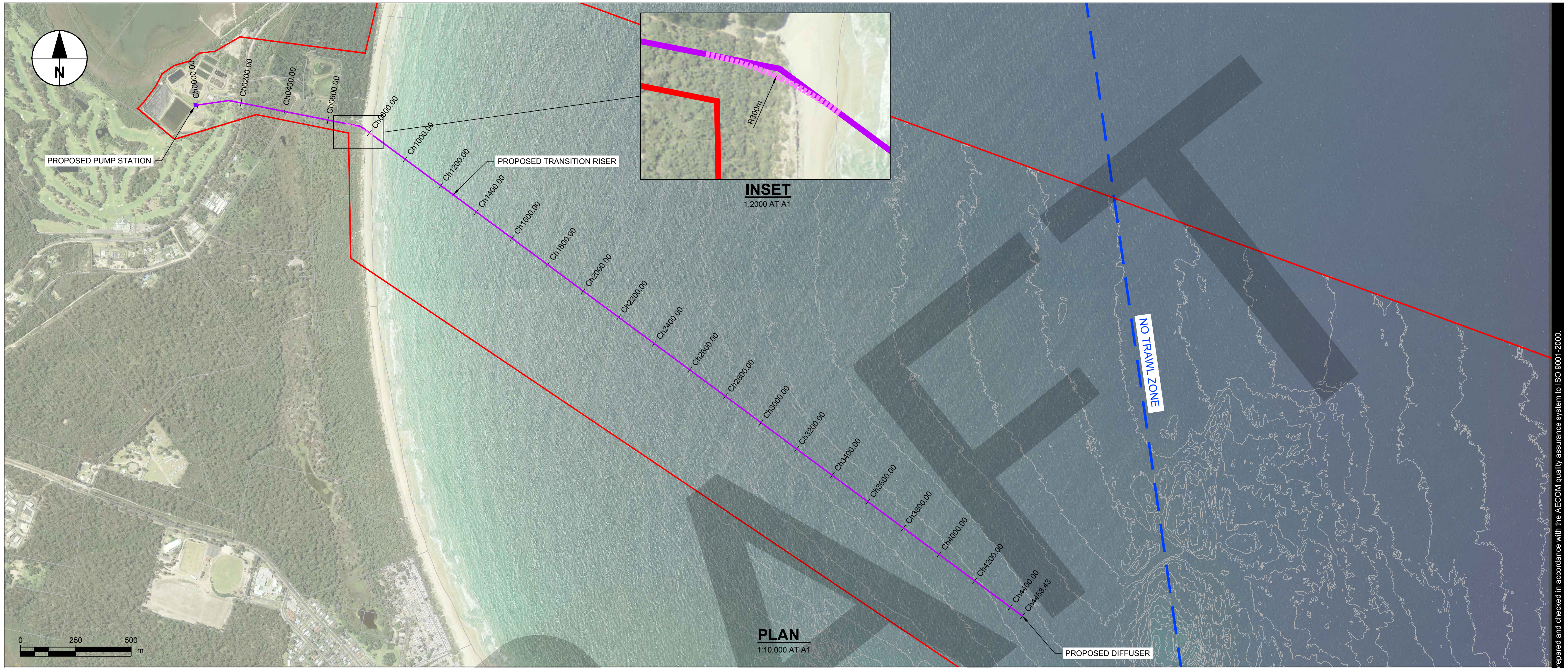

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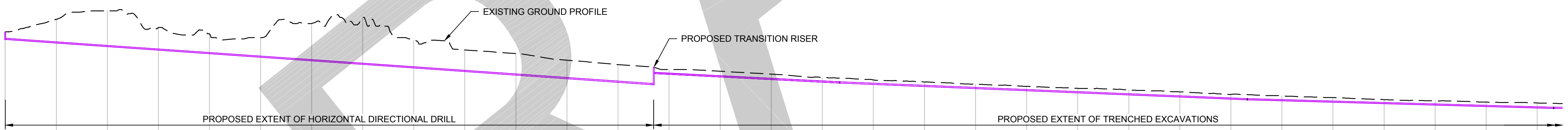

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INVERT LEVEL	2.82	1.42	0.01	-1.39	-2.79	-4.20	-5.60	-7.00	-8.41	-9.81	-11.21	-12.62	-14.02	-15.00 -10.59	-11.92	-12.94	-13.96	-14.85	-15.68	-16.50	-17.32	-18.14	-18.96	-19.78	-20.60	-21.25	-21.82	-22.38	-22.95	-23.52	-24.08
CHAINAGE	0.0	100.0	200.0	300.0	400.0	500.0	600.0	700.0	800.0	900.0	1000.0	1100.0	1200.0	1300.0	1400.0	1500.0	1600.0	1700.0	1800.0	1900.0	2000.0	2100.0	2200.0	2300.0	2400.0	2500.0	2600.0	2700.0	2800.0	2900.0	3000.0

FOR CONTINUATION SEE BELOW

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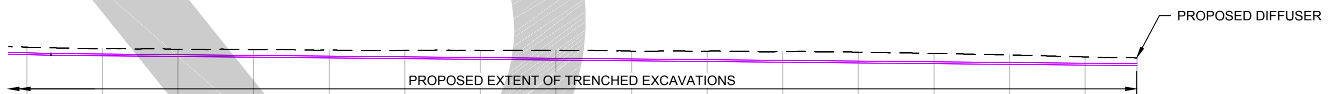

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-24.08	-24.39	-24.58	-24.78	-24.97	-25.16	-25.35	-25.54	-25.73	-25.92	-26.11	-26.30	-26.49	-26.68	-26.87	-27.00	INVERT LEVEL
3000.0	3100.0	3200.0	3300.0	3400.0	3500.0	3600.0	3700.0	3800.0	3900.0	4000.0	4100.0	4200.0	4300.0	4400.0	4468.4	CHAINAGE

C | OPTION 3 - LONGITUDINAL SECTION

1:5000H, 1:1000V AT A1

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PROJECT

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SHEET TITLE

OCEAN OUTFALL PIPELINE AND LONGITUDINAL SECTION OPTION 3

SHEET NUMBER

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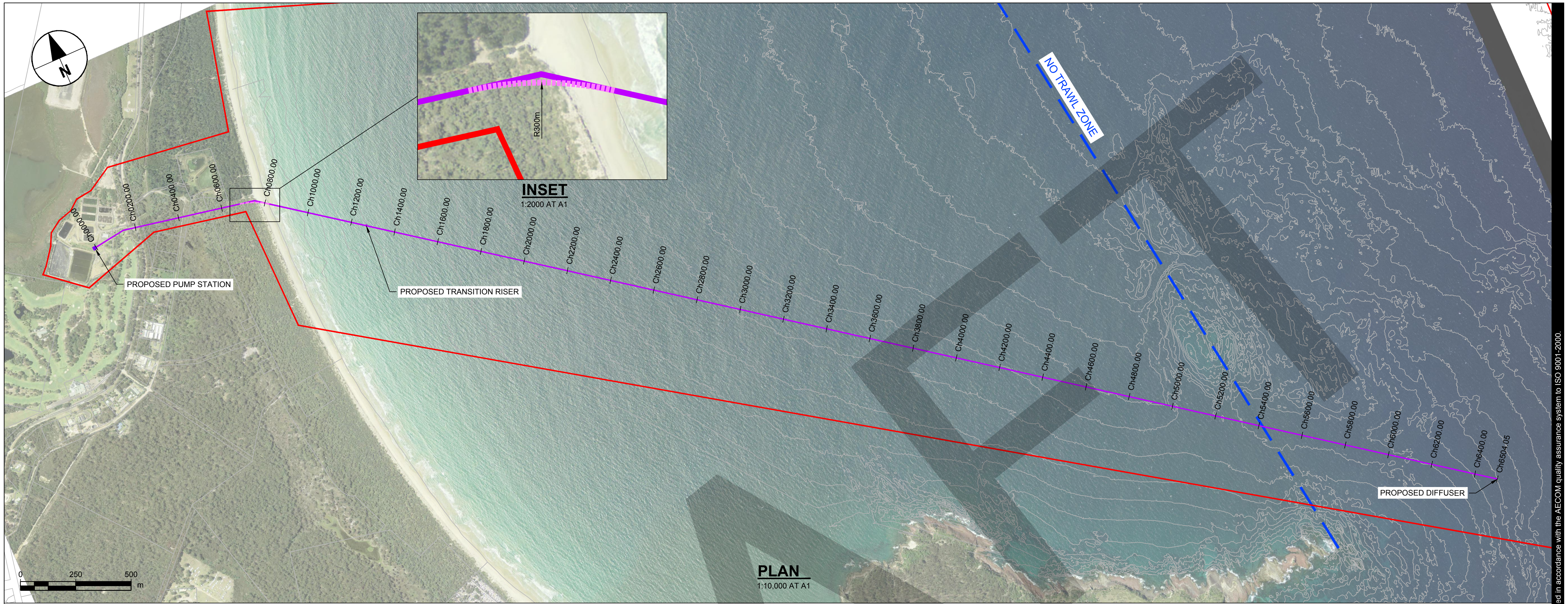

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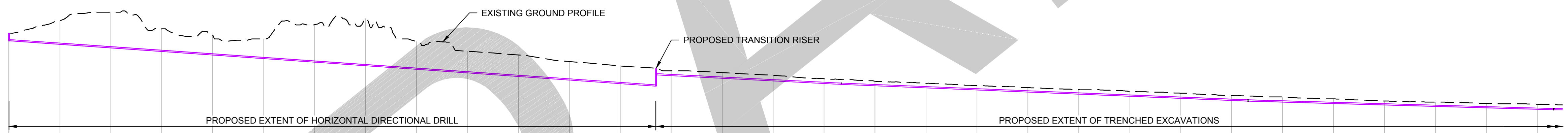

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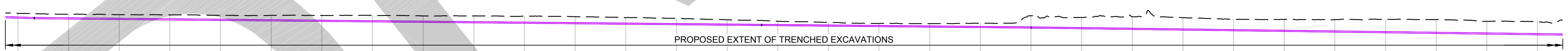
EXISTING SURFACE LEVEL	5.82	10.70	14.00	7.50	5.00	3.50	9.09	11.50	2.50	-1.32	-2.77	-5.37	-7.08	-9.00	-9.70	-10.79	-12.12	-13.10	-13.88	-14.75	-15.59	-16.40	-17.03	-17.79	-18.77	-19.32	-20.01	-20.84	-21.27	-21.79	-22.15
INVERT LEVEL	2.82	1.42	0.01	-1.39	-2.79	-4.20	-5.60	-7.00	-8.41	-9.81	-11.21	-12.62	-14.02	-15.00 -10.59	-11.92	-12.94	-13.96	-14.85	-15.68	-16.50	-17.32	-18.14	-18.96	-19.78	-20.60	-21.25	-21.82	-22.38	-22.95	-23.52	-24.08
CHAINAGE	0.0	100.0	200.0	300.0	400.0	500.0	600.0	700.0	800.0	900.0	1000.0	1100.0	1200.0	1300.0	1400.0	1500.0	1600.0	1700.0	1800.0	1900.0	2000.0	2100.0	2200.0	2300.0	2400.0	2500.0	2600.0	2700.0	2800.0	2900.0	3000.0

FOR CONTINUATION SEE BELOW

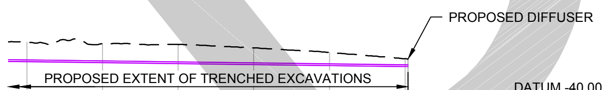
FOR CONTINUATION SEE ABOVE



-22.15	-22.51	-22.69	-22.80	-22.90	-22.97	-23.01	-22.96	-23.19	-23.20	-23.29	-23.49	-23.85	-24.18	-24.71	-25.30	-25.78	-26.15	-26.25	-26.02	-23.10	-23.81	-23.53	-23.87	-24.53	-24.58	-24.66	-24.49	-24.60	-25.34	-25.46
-24.08	-24.39	-24.58	-24.78	-24.97	-25.16	-25.35	-25.54	-25.73	-25.92	-26.11	-26.30	-26.49	-26.68	-26.87	-27.00 -27.06	-27.25	-27.44	-27.64	-27.83	-28.02	-28.29	-28.55	-28.81	-29.08	-29.34	-29.61	-29.87	-30.14	-30.40	-30.67
3000.0	3100.0	3200.0	3300.0	3400.0	3500.0	3600.0	3700.0	3800.0	3900.0	4000.0	4100.0	4200.0	4300.0	4400.0	4500.0	4600.0	4700.0	4800.0	4900.0	5000.0	5100.0	5200.0	5300.0	5400.0	5500.0	5600.0	5700.0	5800.0	5900.0	6000.0

FOR CONTINUATION SEE BELOW

FOR CONTINUATION SEE ABOVE



DATUM -40.00

-25.46	-25.91	-26.12	-27.01	-28.21	-29.87	-30.00	EXISTING SURFACE LEVEL
-30.67	-30.93	-31.20	-31.46	-31.73	-31.99	-32.00	INVERT LEVEL
6000.0	6100.0	6200.0	6300.0	6400.0	6500.0	6504.0	CHAINAGE

D | OPTION 4 - LONGITUDINAL SECTION

1:5000H, 1:1000V AT A1

Last saved by: DOBSONA(2018-02-23)   Last Plotted: 2018-03-02
Filename: P:\605X\60541653\5. CAD\20-SHEETS\60541653-SHT-WT-0004.DWG

AECOM

PROJECT

MERIMBULA STP UPGRADE AND DEEP OCEAN OUTFALL

CLIENT

BEGA VALLEY SHIRE COUNCIL

CONSULTANT

AECOM Australia Pty Ltd
LEVEL 21, 420 GEORGE STREET
SYDNEY
NSW
+61 2 8934 0000 tel   +61 2 8934 0001 fax
www.aecom.com

LEGEND:

- SITE WORK EXTENTS
- EXISTING CONTOURS
- NO TRAWL ZONE
- PROPOSED PIPE ALIGNMENT
- ALTERNATIVE CURVED ALIGNMENT

PROJECT MANAGEMENT INITIALS

DESIGNER	CHECKED	APPROVED
DJK		

ISSUE/REVISION

I/R	DATE	DESCRIPTION
		DRAFT

KEY PLAN

PROJECT NUMBER

60541653

SHEET TITLE

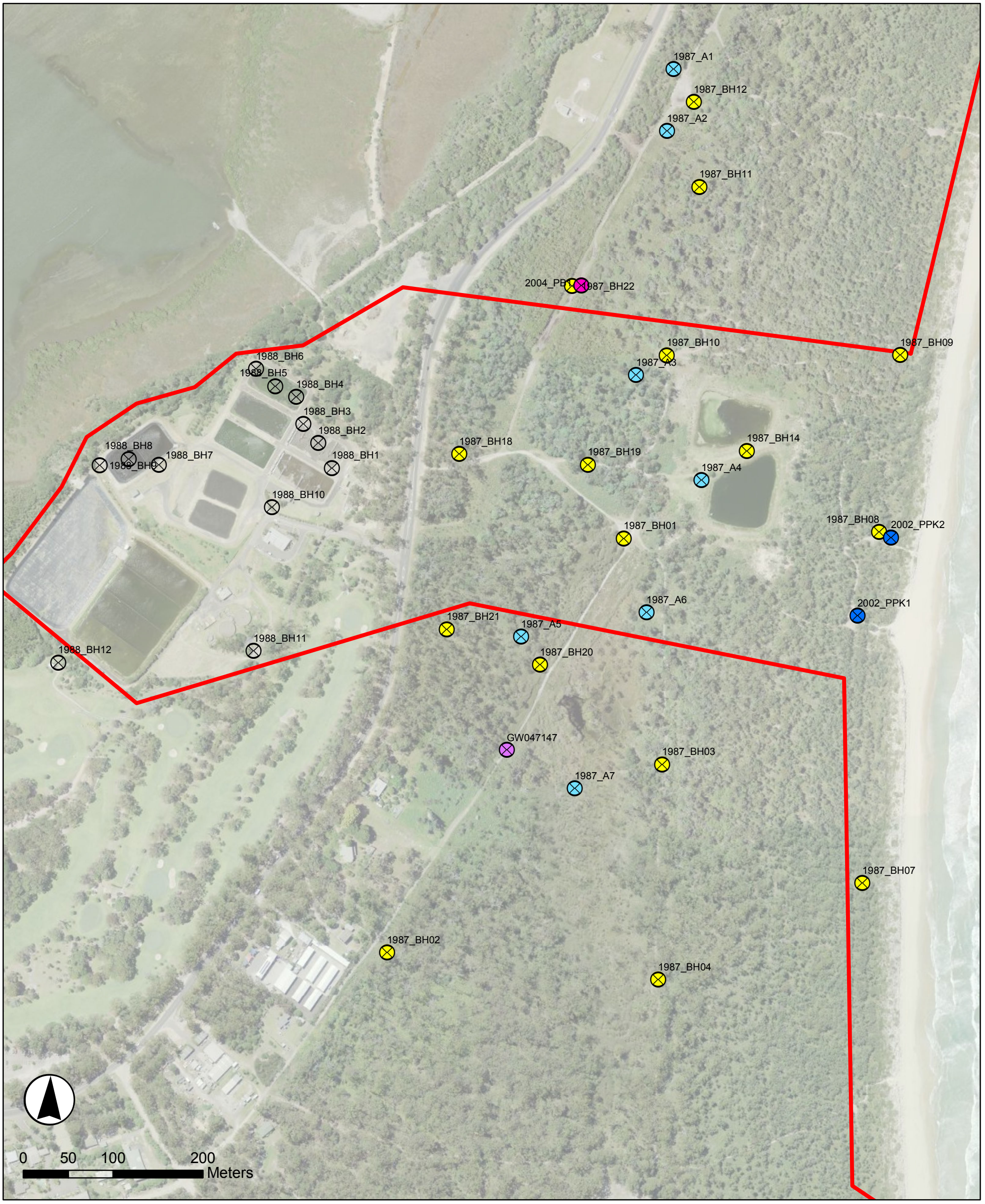
OCEAN OUTFALL PIPELINE AND LONGITUDINAL SECTION OPTION 4

SHEET NUMBER

60541653-SHT-WT-0004

Appendix B

Historical Data



P:\605X\605599014. Tech Work Area\4.2 Geotechnics\GIS\20181030_GIS_Geotech.mxd

Legend

- Site
- 1987_Council_Monitoring_Wells
- 1988_SI_BHs
- 1991_SI_MMA
- 2002_PPK_Wells
- 2004_PB1
- WaterNSW

MERIMBULA HISTORICAL BOREHOLES

14/12/2018

Appendix C

2018 Investigation

P:\605X\605599014. Tech Work Area\4.2 Geotechnics\GIS\20181030_GIS_Geotech.mxd

Legend

Site

2018_Borehole_Locations

0 50 100 200
Meters

MERIMBULA
2018 INVESTIGATIONS & SELECTED HISTORICAL DATA

13/02/2019

Appendix D

Borehole Logs

AECOM Engineering Log

BOREHOLE No. 2018_BH02A

Sheet: 1 of 2

Client:	Bega Valley Shire Council	**Project No:**	60541653	**Start Date:**	06/11/2018
Project:	Merimbula Ocean Outfall Site Investigation	**Logged by:**	LH	**End Date:**	06/11/2018
Location:	South of exfiltration pond	**Checked by:**	ST	**Location Meth.:**	MAP0.5
Driller:	Terratest	**Hole Diameter:**	96-118 mm	**Easting:**	758385.0 m
Drill Rig:	Commachio 405	**Inclination:**	-90°	**Northing:**	5910184.0 m
		Bearing:	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-55U
				RL:	4.3 m
				Ver. Datum:	AHD
				Surface:	Topsoil

Field Data								Material Description		Soil Condition		Comments
Method	Support	Ground Water	Field Tests	Samples	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	MATERIAL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Unit)
HA	U	6/11/18 ▽			4.0	0.5		SP	TOPSOIL: SAND: medium grained; pale grey		L	DUNE SAND
								SP	SAND: medium grained; brown; trace plastic fines and silt			
						1.0						
					3.0	1.5						
ADT			SPT:2,3,4 N=7	N*		2.0						
					2.0	2.5						
			SPT:2,3,6 N=9	N*								
						3.0						
					1.0	3.5						
						4.0						
			SPT:11,13,12 N=25	N*	0.0			SP	SAND: medium grained; pale grey			
						4.5					MD-D	
						5.0						
					-1.0	5.5						
CA+RB	HWT		SPT:6,22,24 N=46	N*				SP	SAND: fine grained; brown; with silt, strong organic odour			
						6.0						
					-2.0	6.5						
						7.0						
			SPT:11,19,19 N=38	N*	-3.0							
						7.5						
						8.0						
					-4.0	8.5						
			SPT:3,5,10 N=15	N*								
						9.0						
					-5.0	9.5						
						10.0						

2017_ANZ_BOREHOLE_MERIMBULA_STP.GPJ AECOM_5-00AA.GLB 3.5.2019

Engineering log should be read in conjunction with AECOM soil and rock description sheets.

AECOM Engineering Log

BOREHOLE No. 2018_BH02A

Sheet: 2 of 2

Client:	Bega Valley Shire Council	**Project No:**	60541653	**Start Date:**	06/11/2018
Project:	Merimbula Ocean Outfall Site Investigation	**Logged by:**	LH	**End Date:**	06/11/2018
Location:	South of exfiltration pond	**Checked by:**	ST	**Location Meth.:**	MAP0.5
Driller:	Terratest	**Hole Diameter:**	96-118 mm	**Easting:**	758385.0 m
Drill Rig:	Commachio 405	**Inclination:**	-90°	**Northing:**	5910184.0 m
		Bearing:	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-55U
				RL:	4.3 m
				Ver. Datum:	AHD
				Surface:	Topsoil

Field Data							Material Description			Soil Condition		Comments
Method	Support	Ground Water	Field Tests	Samples	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	MATERIAL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Unit)
CA+RB	HWT		SPT:8,20,16 N=36	N*	-6.0	10.5		SP	SAND: fine grained; brown; with silt, strong organic odour *(continued)*		MD-D	DUNE SAND *(continued)*
						11.0						
					-7.0	11.5						
			SPT:20,24,29 N=53	N*				SP	SAND: medium to coarse grained; pale grey; trace plastic fines			INTERBEDDED SAND AND CLAY
						12.0						
					-8.0	12.5						
						13.0						
			SPT:14,17,22 N=39	N*	-9.0							
						13.5						
						14.0						
					-10.0	14.5						
			SPT:20,25/100mm N=R	N*							VD	
						15.0						
					-11.0	15.5						
						16.0						
			SPT:22,26,R N=R	N*				SC	clayey SAND: fine to medium grained; pale grey; clay is medium plasticity			
					-12.0	16.5						
						17.0						
					-13.0	17.5						
			SPT:19,23,29 N=52	N*								
						18.0						
					-14.0	18.5						
						19.0						
					-15.0	19.5						
			SPT:15,22,28 N=50	N*					*2018_BH02A terminated at 20.00 m. Target depth*			
						20.0						

2017_ANZ_BOREHOLE_MERIMBULA_STP.GPJ AECOM_5-00AA.GLB 3.5.2019

Engineering log should be read in conjunction with AECOM soil and rock description sheets.

AECOM Engineering Log

BOREHOLE No. 2018_BH02B

Sheet: 1 of 3

Client:	Bega Valley Shire Council	**Project No:**	60541653	**Start Date:**	07/11/2018
Project:	Merimbula Ocean Outfall Site Investigation	**Logged by:**	LH	**End Date:**	08/11/2018
Location:	South of exfiltration pond	**Checked by:**	ST	**Location Meth.:**	MAP0.5
Driller:	Terratest	**Hole Diameter:**	96-118 mm	**Easting:**	758390.0 m
Drill Rig:	Commachio 405	**Inclination:**	-90°	**Northing:**	5910104.0 m
		Bearing:	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-55U
				RL:	3.9 m
				Ver. Datum:	AHD
				Surface:	Topsoil

Field Data							Material Description			Soil Condition		Comments
Method	Support	Ground Water	Field Tests	Samples	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	MATERIAL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Unit)
HA	U	7/11/18 ▽			3.0	0.5		SP	TOPSOIL: SAND: fine grained; pale grey	M	VL	DUNE SAND
						1.0		SP	SAND: fine grained; brown; with silt			
						1.5				W		
ADT			SPT:4,3,4 N=7	N*	2.0	2.0		SP	SAND: fine to medium grained; dark brown; with silt and trace clay			
						2.5						
			SPT:1,1,1 N=2	N*	1.0	3.0						
						3.5						
			SPT:3,1,3 N=4	N*	0.0	4.0						
						4.5						
					-1.0	5.0						
			SPT:6,10,13 N=23	N*		5.5					MD-D	
CA+RB	HWT				-2.0	6.0						
						6.5						
					-3.0	7.0		SP	SAND: fine grained; dark brown; trace silt, distinct organic odour			
			SPT:5,12,18 N=30	N*		7.5						
					-4.0	8.0						
						8.5			from 8.50 m to 10.00 m: no silt, decrease in organic odour			
			SPT:2,10,21 N=31	N*	-5.0	9.0						
						9.5						
					-6.0	10.0						

2017_ANZ_BOREHOLE MERIMBULA_STP.GPJ AECOM_5-00AA.GLB 3.5.2019

Engineering log should be read in conjunction with AECOM soil and rock description sheets.

AECOM Engineering Log

BOREHOLE No. 2018_BH02B

Sheet: 2 of 3

Client:	Bega Valley Shire Council	**Project No:**	60541653	**Start Date:**	07/11/2018
Project:	Merimbula Ocean Outfall Site Investigation	**Logged by:**	LH	**End Date:**	08/11/2018
Location:	South of exfiltration pond	**Checked by:**	ST	**Location Meth.:**	MAP0.5
Driller:	Terratest	**Hole Diameter:**	96-118 mm	**Easting:**	758390.0 m
Drill Rig:	Commachio 405	**Inclination:**	-90°	**Northing:**	5910104.0 m
		Bearing:	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-55U
				RL:	3.9 m
				Ver. Datum:	AHD
				Surface:	Topsoil

Field Data								Material Description	Soil Condition		Comments
Method	Support	Ground Water	Field Tests	Samples	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	MATERIAL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Unit)
CA+RB	HWT		SPT:7,18,19 N=37	N*	-7.0	10.5		SP	SAND: medium grained; pale grey; clean sand	W	MD-D	INTERBEDDED SAND AND CLAY
						11.0						
			SPT:10,20,21 N=41	N*	-8.0	11.5						
						12.0						
						12.5						
			SPT:17,27,R N=R	N*	-9.0	13.0		SP	SAND: medium grained; mottled pale grey and pale brown; trace plastic fines		VD	
						13.5						
					-10.0	14.0						
			SPT:22,R N=R	N*		14.5			from 14.50 m: with low plastic fines			
					-11.0	15.0						
						15.5						
			SPT:18,R N=R	N*	-12.0	16.0		SP	SAND: medium to coarse grained; mottled pale grey and pale brown; trace plastic fines			
						16.5						
					-13.0	17.0						
			SPT:10,R N=R	N*		17.5		SP-SC	clayey SAND: fine to medium grained; mottled pale brown and pale grey; medium plasticity clays			
					-14.0	18.0						
						18.5						
			SPT:12,R N=R	N*	-15.0	19.0						
						19.5						
					-16.0	20.0						

2017_ANZ_BOREHOLE_MERIMBULA_STP.GPJ AECOM_5-00AA.GLB 3.5.2019

Engineering log should be read in conjunction with AECOM soil and rock description sheets.

AECOM Engineering Log

BOREHOLE No. 2018_BH02B

Sheet: 3 of 3

Client:	Bega Valley Shire Council	**Project No:**	60541653	**Start Date:**	07/11/2018
Project:	Merimbula Ocean Outfall Site Investigation	**Logged by:**	LH	**End Date:**	08/11/2018
Location:	South of exfiltration pond	**Checked by:**	ST	**Location Meth.:**	MAP0.5
Driller:	Terratest	**Hole Diameter:**	96-118 mm	**Easting:**	758390.0 m
Drill Rig:	Commachio 405	**Inclination:**	-90°	**Northing:**	5910104.0 m
		Bearing:	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-55U
				RL:	3.9 m
				Ver. Datum:	AHD
				Surface:	Topsoil

Field Data							Material Description		Soil Condition		Comments
Method	Support	Ground Water	Field Tests	Samples	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	MATERIAL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Unit)
CA+RB	HWT				20.5			SP-SC	clayey SAND: fine to medium grained; mottled pale brown and pale grey; medium plasticity clays *(continued)*	W	VD	INTERBEDDED SAND AND CLAY *(continued)*
			SPT:18,25,30 N=55	N*	-17.0	21.0						
					21.5							
			SPT:9,17,R N=R	N*	-18.0	22.0		CH-CI	CLAY: medium to high plasticity; cream			22.00-30.00m: Casing advancing was very slow in HARD clays and VERY DENSE sands. Commenced coring. 100% recovery was achieved in sands with an average of 50-60% recovery within sand materials. Infered conistencies of HARD Clays and VERY DENSE Sands
					22.5						H	
					-19.0	23.0						
					23.5							
					-20.0	24.0		SP	SAND: fine to medium grained; mottled pale grey and pale brown; trace plastic fines		VD	
					24.5							
					-21.0	25.0						
					25.5							
					-22.0	26.0						
					26.5							
					-23.0	27.0		CH-CI	CLAY: medium to high plasticity; cream		H	
					27.5							
					-24.0	28.0		SP	SAND: fine to medium grained; mottled pale grey and pale brown; trace plastic fines		VD	
					28.5							
					-25.0	29.0						
					29.5				*2018_BH02B terminated at 30.00 m. Target depth*			
					-26.0	30.0						

2017_ANZ_BOREHOLE_MERIMBULA_STP.GPJ AECOM_5-00AA.GLB 3.5.2019

AECOM Engineering Log

BOREHOLE No. 2018_BH03

Sheet: 1 of 3

Client:	Bega Valley Shire Council	**Project No:**	60541653	**Start Date:**	31/10/2018
Project:	Merimbula Ocean Outfall Site Investigation	**Logged by:**	LH	**End Date:**	02/11/2018
Location:	East of Arthur Kaine Drive	**Checked by:**	ST	**Location Meth.:**	MAP0.5
Driller:	Terratest	**Hole Diameter:**	96-118 mm	**Easting:**	758148.0 m
Drill Rig:	Commachio 305	**Inclination:**	-90°	**Northing:**	5910218.0 m
		Bearing:	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-55U
				RL:	11.1 m
				Ver. Datum:	AHD
				Surface:	Topsoil

Field Data								Material Description		Soil Condition		Comments
Method	Support	Ground Water	Field Tests	Samples	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	MATERIAL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Unit)
HA	U				11.0	0.5		SP	SAND: fine to medium grained; grey; rootlets	M	L	INTERBEDDED SAND AND CLAY
								CH	CLAY: high plasticity; mottled red grey; with roots		St	
ADV					10.0	1.0		CI	sandy CLAY: medium plasticity; brown			
						1.5		SM	silty SAND: fine grained; pale brown; with medium plasticity fines		VD	
					9.0	2.0						
			SPT:8,9,7 N=16	N*		2.5		SP	SAND: fine grained; pale grey			
					8.0	3.0						
						3.5						
			SPT:35/150mm N=R	N*		4.0		SP	SAND: fine grained; pale brown; trace low plasticity fines			
		8/11/18			7.0	4.5						
						5.0						
					6.0	5.5						
			SPT:35/150mm N=R	N*				CH-CI	CLAY: medium to high plasticity; cream; with silt		H	
CA+RB	HWT				5.0	6.0				W		
						6.5						
						7.0						
			SPT:7,25/50mm N=R	N*	4.0			SP	SAND: fine grained; pale brown; trace low plasticity fines		VD	
						7.5						
						8.0						
					3.0							
						8.5						
			SPT:8,15,22 N=37	N*				CH-CI	CLAY: medium to high plasticity; cream; with silt		H	
					2.0	9.0						
						9.5						
						10.0						

2017_ANZ_BOREHOLE_MERIMBULA_STP.GPJ AECOM_5-00AA.GLB 3.5.2019

Engineering log should be read in conjunction with AECOM soil and rock description sheets.

AECOM Engineering Log

BOREHOLE No. 2018_BH03

Sheet: 2 of 3

Client:	Bega Valley Shire Council	**Project No:**	60541653	**Start Date:**	31/10/2018
Project:	Merimbula Ocean Outfall Site Investigation	**Logged by:**	LH	**End Date:**	02/11/2018
Location:	East of Arthur Kaine Drive	**Checked by:**	ST	**Location Meth.:**	MAP0.5
Driller:	Terratest	**Hole Diameter:**	96-118 mm	**Easting:**	758148.0 m
Drill Rig:	Commachio 305	**Inclination:**	-90°	**Northing:**	5910218.0 m
		Bearing:	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-55U
				RL:	11.1 m
				Ver. Datum:	AHD
				Surface:	Topsoil

Field Data							Material Description			Soil Condition		Comments
Method	Support	Ground Water	Field Tests	Samples	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	MATERIAL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Unit)
CA+RB	HWT		SPT:21,27,25/50mm N=R	N*	10.5	1.0		SP	SAND: fine grained; pale brown; trace low plasticity fines	W	VD	INTERBEDDED SAND AND CLAY *(continued)*
			SPT:23,R N=R	N*	11.0	0.0		SP	SAND: medium to coarse grained; pale grey to cream; with low plasticity fines			
			SPT:28,R N=R	N*	12.0	-1.0						
			SPT:20,20,26 N=46	N*	12.5	-2.0		SP	SAND: fine grained; mottled pale brown and cream; trace low plasticity fines			
			SPT:16,20,27 N=47	N*	13.0	-3.0						
			SPT:19,R N=R	N*	13.5	-4.0						
			SPT:23,26,25/100mm N=R	N*	14.0	-5.0		SP	SAND: medium to coarse grained; mottled pale brown and cream			
					14.5	-6.0						
					15.0	-7.0						
					15.5	-8.0						
					16.0							
					16.5							
					17.0							
					17.5							
					18.0							
					18.5							
					19.0							
					19.5							
					20.0							

2017_ANZ_BOREHOLE_MERIMBULA_STP.GPJ AECOM_5-00AA.GLB 3.5.2019

Engineering log should be read in conjunction with AECOM soil and rock description sheets.

AECOM Engineering Log

BOREHOLE No. 2018_BH03

Sheet: 3 of 3

Client:	Bega Valley Shire Council	**Project No:**	60541653	**Start Date:**	31/10/2018
Project:	Merimbula Ocean Outfall Site Investigation	**Logged by:**	LH	**End Date:**	02/11/2018
Location:	East of Arthur Kaine Drive	**Checked by:**	ST	**Location Meth.:**	MAP0.5
Driller:	Terratest	**Hole Diameter:**	96-118 mm	**Easting:**	758148.0 m
Drill Rig:	Commachio 305	**Inclination:**	-90°	**Northing:**	5910218.0 m
		Bearing:	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-55U
				RL:	11.1 m
				Ver. Datum:	AHD
				Surface:	Topsoil

Field Data								Material Description			Soil Condition		Comments
Method	Support	Ground Water	Field Tests	Samples	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	MATERIAL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure		Moisture Condition	Density / Consistency	Additional Observations (Geological Unit)
CA+RB	HWT				-9.0	20.5		SP	SAND: medium to coarse grained; mottled pale brown and cream *(continued)*		W	VD	INTERBEDDED SAND AND CLAY *(continued)*
			SPT:11,23,25/100mm N=R	N*				CH	high plasticity; mottled red grey			H	20.50-30.00m: Very slow advancing.
					-10.0	21.0							
						21.5							
					-11.0	22.0							
			SPT:11,27,30 N=57	N*									
					-12.0	22.5							
						23.0							
						23.5							
			SPT:7,25/50mm N=R	N*				SP	SAND: medium to coarse grained; mottled pale brown and cream			VD	
					-13.0	24.0							
						24.5							
			SPT:29,25/140mm N=R	N*	-14.0	25.0							
						25.5							
					-15.0	26.0							
						26.5							
			SPT:23,28,25/50mm N=R	N*				SP	SAND: fine to medium grained; mottled pale brown and cream; trace plasticity fines				
					-16.0	27.0							
						27.5							
						28.0							
			SPT:13,25,25/50mm N=R	N*	-17.0			CH	CLAY: high plasticity; mottled red grey			H	
				U63		28.5							
						29.0							
					-18.0								
						29.5			*2018_BH03 terminated at 30.00 m. Target depth*				
						30.0							

2017_ANZ_BOREHOLE_MERIMBULA_STP.GPJ AECOM_5-00AA.GLB 3.5.2019

Engineering log should be read in conjunction with AECOM soil and rock description sheets.

AECOM Engineering Log

BOREHOLE No. 2018_BH04

Sheet: 1 of 2

Client:	Bega Valley Shire Council	**Project No:**	60541653	**Start Date:**	09/11/2018
Project:	Merimbula Ocean Outfall Site Investigation	**Logged by:**	LH	**End Date:**	09/11/2018
Location:	Car Park, STP	**Checked by:**	ST	**Location Meth.:**	MAP0.5
Driller:	Terratest	**Hole Diameter:**	96-118 mm	**Easting:**	758053.0 m
Drill Rig:	Commachio 405	**Inclination:**	-90°	**Northing:**	5910228.0 m
		Bearing:	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-55U
				RL:	15.2 m
				Ver. Datum:	AHD
				Surface:	Topsoil

Field Data								Material Description			Soil Condition		Comments
Method	Support	Ground Water	Field Tests	Samples	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	MATERIAL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure		Moisture Condition	Density / Consistency	Additional Observations (Geological Unit)
HA	U	NOT OBSERVED			15.0	0.0		GP	FILL: GRAVEL: medium grained; dark grey; road base material		M	H	INTERBEDDED SAND AND CLAY
						0.5		CL	sandy CLAY: low plasticity; brown; sand is fine grained				
					14.0	1.0							
						1.5							
ADT			SPT:19,24,23 N=47	N*				CI	CLAY: medium plasticity; cream mottled red				
					13.0	2.0							
						2.5					W		
			SPT:3,12,20 N=32	N*									
					12.0	3.0							
						3.5							
						4.0							
			SPT:10,19,24 N=43	N*	11.0			SC	clayey SAND: fine grained; pale grey; low to medium plasticity clays				
						4.5							
						5.0							
					10.0								
						5.5							
			SPT:12,22,R N=R	N*				CI	CLAY: medium plasticity; cream mottled red				
						6.0		SP	SAND: medium grained; mottled red grey; trace low plasticity fines				
CA+RB	HWT				9.0	6.5							
						7.0						D-VD	
			SPT:30,R N=R	N*									
					8.0	7.5							
						8.0							
					7.0								
						8.5							
			SPT:15,25,30 N=55	N*				SP	SAND: fine to medium grained; pale brown; with plasticity fines				
						9.0							
					6.0								
						9.5							
						10.0							

2017_ANZ_BOREHOLE MERIMBULA_STP.GPJ AECOM_5-00AA.GLB 3.5.2019

Engineering log should be read in conjunction with AECOM soil and rock description sheets.

AECOM Engineering Log

BOREHOLE No. 2018_BH04

Sheet: 2 of 2

Client:	Bega Valley Shire Council	**Project No:**	60541653	**Start Date:**	09/11/2018
Project:	Merimbula Ocean Outfall Site Investigation	**Logged by:**	LH	**End Date:**	09/11/2018
Location:	Car Park, STP	**Checked by:**	ST	**Location Meth.:**	MAP0.5
Driller:	Terratest	**Hole Diameter:**	96-118 mm	**Easting:**	758053.0 m
Drill Rig:	Commachio 405	**Inclination:**	-90°	**Northing:**	5910228.0 m
		Bearing:	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-55U
				RL:	15.2 m
				Ver. Datum:	AHD
				Surface:	Topsoil

Field Data							Material Description			Soil Condition		Comments
Method	Support	Ground Water	Field Tests	Samples	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	MATERIAL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Unit)
CA+RB	HWT	NOT OBSERVED	SPT:13,14,16 N=30	N*	5.0	10.5		SP	SAND: fine to medium grained; pale brown; with plasticity fines *(continued)*	W	D-VD	INTERBEDDED SAND AND CLAY *(continued)*
					4.0	11.0						
						11.5						
					3.0	12.0						
						12.5						
			SPT:9,R N=R	N*		13.0						
					2.0	13.5						
						14.0						
					1.0	14.5						
			SPT:20,R N=R	N*		15.0			*2018_BH04 terminated at 15.00 m. Target depth*			
					0.0	15.5						
						16.0						
					-1.0	16.5						
						17.0						
					-2.0	17.5						
						18.0						
					-3.0	18.5						
						19.0						
					-4.0	19.5						
						20.0						

2017_ANZ_BOREHOLE MERIMBULA_STP.GPJ AECOM_5-00AA.GLB 3.5.2019

Engineering log should be read in conjunction with AECOM soil and rock description sheets.

AECOM Engineering Log

BOREHOLE No. 2018_BH06

Sheet: 1 of 2

Client:	Bega Valley Shire Council	**Project No:**	60541653	**Start Date:**	05/11/2018
Project:	Merimbula Ocean Outfall Site Investigation	**Logged by:**	LH	**End Date:**	06/11/2018
Location:	Southwest of exfiltration pond	**Checked by:**	ST	**Location Meth.:**	MAP0.5
Driller:	Terratest	**Hole Diameter:**	96-118 mm	**Easting:**	758343.0 m
Drill Rig:	Commachio 405	**Inclination:**	-90°	**Northing:**	5910241.0 m
		Bearing:	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-55U
				RL:	3.5 m
				Ver. Datum:	AHD
				Surface:	Topsoil

Field Data								Material Description			Soil Condition		Comments
Method	Support	Ground Water	Field Tests	Samples	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	MATERIAL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure		Moisture Condition	Density / Consistency	Additional Observations (Geological Unit)
HA	U	5/11/18 ▽			3.0	0.5		SP	SAND: medium grained; pale grey		M	L	DUNE SAND
						1.0		SP-SC	SAND: fine grained; brown; with silt, rootlets to 1.70m				
ADT			SPT:3,4,5 N=9	N*	2.0	1.5					W		
						2.0							
			SPT:3,4,7 N=11	N*	1.0	2.5			at 2.50 m: strong odour, sewage potentially				
					0.0	3.0							
			SPT:7,14,20 N=34	N*		3.5			from 4.00 m: dark brown, increased silt content			D	
					-1.0	4.0							
			SPT:7,19,20 N=39	N*		4.5							
CA+RB	HWT				-2.0	5.0							
						5.5							
			SPT:1,3,5 N=8	N*	-3.0	6.0							
						6.5							
					-4.0	7.0		SP	SAND: medium grained; brown; occasional coarse grained lense			VL	
			SPT:5,19,30 N=49	N*		7.5							
					-5.0	8.0							
						8.5						D-VD	
						9.0		SP	SAND: medium to coarse grained; pale grey; trace gravel, rounded quartz clasts				INTERBEDDED SAND AND CLAY
					-6.0	9.5							
						10.0							

2017_ANZ_BOREHOLE_MERIMBULA_STP.GPJ AECOM_5-00AA.GLB 3.5.2019

Engineering log should be read in conjunction with AECOM soil and rock description sheets.

AECOM Engineering Log

BOREHOLE No. 2018_BH06

Sheet: 2 of 2

Client:	Bega Valley Shire Council	**Project No:**	60541653	**Start Date:**	05/11/2018
Project:	Merimbula Ocean Outfall Site Investigation	**Logged by:**	LH	**End Date:**	06/11/2018
Location:	Southwest of exfiltration pond	**Checked by:**	ST	**Location Meth.:**	MAP0.5
Driller:	Terratest	**Hole Diameter:**	96-118 mm	**Easting:**	758343.0 m
Drill Rig:	Commachio 405	**Inclination:**	-90°	**Northing:**	5910241.0 m
		Bearing:	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-55U
				RL:	3.5 m
				Ver. Datum:	AHD
				Surface:	Topsoil

Field Data							Material Description			Soil Condition		Comments
Method	Support	Ground Water	Field Tests	Samples	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	MATERIAL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Unit)
CA+RB	HWT		SPT:9,23,30 N=53	N*	-7.0	10.5		SP	SAND: medium grained; pale grey at 10.40 m: inferred large quartz cobbles blocking advancer	W	D-VD	INTERBEDDED SAND AND CLAY *(continued)*
						11.0						
			SPT:13,20,24 N=44	N*	-8.0	11.5		SP	SAND: medium to coarse grained; pale grey; with low plasticity fines			
						12.0						
					-9.0	12.5						
			SPT:18,27,28 N=55	N*		13.0						
					-10.0	13.5						
						14.0						
			SPT:14,25,29 N=54	N*	-11.0	14.5		SP	SAND: medium grained; pale brown; with low plasticity fines			
						15.0						
					-12.0	15.5						
			SPT:30/140mm N=R	N*		16.0		SP	SAND: medium to coarse grained; pale grey; with low plasticity fines			
					-13.0	16.5						
						17.0						
			SPT:19,30/140mm N=R	N*	-14.0	17.5		SP	SAND: medium grained; pale brown; with low plasticity fines			
						18.0						
					-15.0	18.5						
						19.0						
			SPT:6,23,30 N=53	N*	-16.0	19.5		SP-SC	CLAY: medium plasticity; pale brown *2018_BH06 terminated at 20.00 m.* *Target depth*		H	
						20.0						

2017_ANZ_BOREHOLE_MERIMBULA_STP.GPJ AECOM_5-00AA.GLB 3.5.2019

Engineering log should be read in conjunction with AECOM soil and rock description sheets.

AECOM Engineering Log

BOREHOLE No. 2018_BH07

Sheet: 1 of 5

Client:	Bega Valley Shire Council	**Project No:**	60541653	**Start Date:**	30/10/2018
Project:	Merimbula Ocean Outfall Site Investigation	**Logged by:**	LH	**End Date:**	31/10/2018
Location:	Access track	**Checked by:**	ST	**Location Meth.:**	MAP0.5
Driller:	Terratest	**Hole Diameter:**	96-118 mm	**Easting:**	758295.0 m
Drill Rig:	Commachio 305	**Inclination:**	-90°	**Northing:**	5910109.0 m
		Bearing:	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-55U
				RL:	2.5 m
				Ver. Datum:	AHD
				Surface:	Topsoil

Field Data							Material Description		Soil Condition		Comments
Method	Support	Ground Water	Field Tests	Samples	Reduced Level (m)	Depth (m)	Graphic Log / Classification Symbol	MATERIAL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Unit)
HA		31/10/18 ▽			2.0	0.5	SP	TOPSOIL: SAND: fine to medium grained; pale grey; with rootlets	D	D	DUNE SAND
							SP	SAND: fine to medium grained; dark brown	W		
					1.0	1.5					
AD	U		SPT:8,12,10 N=22	N*						VD	
					0.0	2.0					
			SPT:1,5,11 N=16	N*		2.5					
						3.0					
					-1.0	3.5					
			SPT:3,10,13 N=23	N*		4.0		from 4.00 m: darker brown, trace non plastic fines			
					-2.0	4.5					
						5.0					
			SPT:10,22,R N=R	N*	-3.0	5.5					
CA	HW					6.0					
					-4.0	6.5					
			SPT:2,0,0 N=0	N*		7.0				VL	
					-5.0	7.5				VD	
						8.0					
			SPT:20,23,21 N=44	N*	-6.0	8.5					
						9.0	SP	SAND: medium grained; pale grey; with low plasticity fines			INTERBEDDED SAND AND CLAY
					-7.0	9.5					
						10.0					

2017_ANZ_BOREHOLE_MERIMBULA_STP.GPJ AECOM_5-00AA.GLB 3.5.2019

Engineering log should be read in conjunction with AECOM soil and rock description sheets.

AECOM Engineering Log

BOREHOLE No. 2018_BH07

Sheet: 2 of 5

Client:	Bega Valley Shire Council	**Project No:**	60541653	**Start Date:**	30/10/2018
Project:	Merimbula Ocean Outfall Site Investigation	**Logged by:**	LH	**End Date:**	31/10/2018
Location:	Access track	**Checked by:**	ST	**Location Meth.:**	MAP0.5
Driller:	Terratest	**Hole Diameter:**	96-118 mm	**Easting:**	758295.0 m
Drill Rig:	Commachio 305	**Inclination:**	-90°	**Northing:**	5910109.0 m
		Bearing:	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-55U
				RL:	2.5 m
				Ver. Datum:	AHD
				Surface:	Topsoil

Field Data							Material Description			Soil Condition		Comments
Method	Support	Ground Water	Field Tests	Samples	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	MATERIAL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Unit)
CA	HW		SPT:10,17,20 N=37	N*	-8.0	10.5		SP	SAND: medium grained; pale grey; with low plasticity fines *(continued)*	W	VD	INTERBEDDED SAND AND CLAY *(continued)*
						11.0						
			SPT:8,13,22 N=35	N*	-9.0	11.5			from 11.70 m: mottled grey light brown, fine to medium grained			
						12.0						
					-10.0	12.5		SP	SAND: medium grained; brown			
			SPT:5,25,30 N=55	N*		13.0						
					-11.0	13.5		SP	SAND: medium to coarse grained; pale grey; trace gravel and medium plasticity fines			
						14.0						
			SPT:14,25,29 N=54	N*	-12.0	14.5		SP	SAND: fine to medium grained; mottled brown pale grey			
						15.0						
					-13.0	15.5						
			SPT:3,19,30 N=49	N*		16.0						
					-14.0	16.5		SP	SAND: medium grained; pale brown			
						17.0						
			SPT:3,18,R N=R	N*	-15.0	17.5						
						18.0						
					-16.0	18.5						
			SPT:21,R N=R	N*		19.0						
					-17.0	19.5						
						20.0						

2017_ANZ_BOREHOLE_MERIMBULA_STP.GPJ AECOM_5-00AA.GLB 3.5.2019

Engineering log should be read in conjunction with AECOM soil and rock description sheets.

Client:	Bega Valley Shire Council	**Project No:**	60541653	**Start Date:**	30/10/2018
Project:	Merimbula Ocean Outfall Site Investigation	**Logged by:**	LH	**End Date:**	31/10/2018
Location:	Access track	**Checked by:**	ST	**Location Meth.:**	MAP0.5
Driller:	Terratest	**Hole Diameter:**	96-118 mm	**Easting:**	758295.0 m
Drill Rig:	Commachio 305	**Inclination:**	-90°	**Northing:**	5910109.0 m
		Bearing:	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-55U
				RL:	2.5 m
				Ver. Datum:	AHD
				Surface:	Topsoil

Field Data								Material Description			Soil Condition		Comments
Method	Support	Ground Water	Field Tests	Samples	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	MATERIAL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure		Moisture Condition	Density / Consistency	Additional Observations (Geological Unit)
CA	HW				20.5	18.0		SP	SAND: medium grained; pale brown *(continued)*		W	VD	INTERBEDDED SAND AND CLAY *(continued)*
			SPT:30/150mm N=R	N*	18.0	20.5		SP	SAND: fine to medium grained; mottled brown pale grey				
					19.0	21.0							
						21.5							
			SPT:7,25,R N=R	N*	21.0	22.0		SP-SC	clayey SAND: fine grained; cream; medium plasticity clays				
					20.0	22.5							
						23.0							
			SPT:21,R N=R	N*	21.0	23.5							
						24.0		SP	SAND: medium grained; pale brown				
					22.0	24.5							
			SPT:13,28,R N=R	N*		25.0		Cl	CLAY: medium plasticity; bottled pale grey and brown; with fine grained sands			H	
						25.5							
				CS		26.0							
						26.5		SP	SAND: medium grained; pale brown				
						27.0							
						27.5							
						28.0							
						28.5		SP	SAND: fine grained; pale grey				
						29.0							
						29.5							
						30.0							

2017_ANZ_BOREHOLE_MERIMBULA_STP.GPJ AECOM_5-00AA.GLB 3.5.2019

AECOM Engineering Log

BOREHOLE No. 2018_BH07

Sheet: 4 of 5

Client:	Bega Valley Shire Council	**Project No:**	60541653	**Start Date:**	30/10/2018
Project:	Merimbula Ocean Outfall Site Investigation	**Logged by:**	LH	**End Date:**	31/10/2018
Location:	Access track	**Checked by:**	ST	**Location Meth.:**	MAP0.5
Driller:	Terratest	**Hole Diameter:**	96-118 mm	**Easting:**	758295.0 m
Drill Rig:	Commachio 305	**Inclination:**	-90°	**Northing:**	5910109.0 m
		Bearing:	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-55U
				RL:	2.5 m
				Ver. Datum:	AHD
				Surface:	Topsoil

Field Data							Material Description			Soil Condition		Comments
Method	Support	Ground Water	Field Tests	Samples	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	MATERIAL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Unit)
CA	HW					30.5		SP	SAND: fine grained; pale grey *(continued)*	W		INTERBEDDED SAND AND CLAY *(continued)*
						31.0		SP	SAND: medium grained; bottled pale brown and pale grey			
						31.5						
						32.0						
						32.5						
			SPT:11,28,R N=R	N*		33.0		SP	SAND: medium grained; pale brown		VD	
						33.5						
						34.0						
			SPT:26,29,30/140mm N=R	N*		34.5		Cl	CLAY: medium plasticity; cream to pale grey		H	
						35.0						
						35.5						
			SPT:17,26,29 N=55	N*		36.0		CL	sandy CLAY: low plasticity; bottled pale grey brown; sand is fine to medium grained			
						36.5						
						37.0						
			SPT:15,R N=R	N*		37.5		SP	SAND: medium grained; pale brown; with trace fines		VD	
						38.0						
						38.5						
			SPT:17,R N=R	N*		39.0						
						39.5						
						40.0						

2017_ANZ_BOREHOLE_MERIMBULA_STP.GPJ AECOM_5-00AA.GLB 3.5.2019

Engineering log should be read in conjunction with AECOM soil and rock description sheets.

AECOM Engineering Log

BOREHOLE No. 2018_BH07

Sheet: 5 of 5

Client:	Bega Valley Shire Council	**Project No:**	60541653	**Start Date:**	30/10/2018
Project:	Merimbula Ocean Outfall Site Investigation	**Logged by:**	LH	**End Date:**	31/10/2018
Location:	Access track	**Checked by:**	ST	**Location Meth.:**	MAP0.5
Driller:	Terratest	**Hole Diameter:**	96-118 mm	**Easting:**	758295.0 m
Drill Rig:	Commachio 305	**Inclination:**	-90°	**Northing:**	5910109.0 m
		Bearing:	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-55U
				RL:	2.5 m
				Ver. Datum:	AHD
				Surface:	Topsoil

Field Data							Material Description			Soil Condition		Comments
Method	Support	Ground Water	Field Tests	Samples	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	MATERIAL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Unit)
CA			SPT:27,25/50mm N=R	N*				SP	SAND: fine to medium grained, pale brown; with trace fines *(continued)*	W	VD	INTERBEDDED SAND AND CLAY *(continued)*
									2018_BH07 terminated at 40.20 m *Target depth*			

40.5
41.0
41.5
42.0
42.5
43.0
43.5
44.0
44.5
45.0
45.5
46.0
46.5
47.0
47.5
48.0
48.5
49.0
49.5
50.0

2017_ANZ_BOREHOLE_MERIMBULA_STP.GPJ AECOM_5-00AA.GLB 3.5.2019

Engineering log should be read in conjunction with AECOM soil and rock description sheets.

Appendix E

Laboratory Results

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

CERTIFICATE OF ANALYSIS 211730

Client Details

Client	Macquarie Geotech
Attention	Chris Lloyd
Address	3 Watt Dr, Bathurst, NSW, 2795

Sample Details

Your Reference	**S18539-2, Merimbula STP (60503757_2.4)**
Number of Samples	1 Soil
Date samples received	18/02/2019
Date completed instructions received	18/02/2019

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	20/02/2019
Date of Issue	20/02/2019

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Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By

Jacinta Hurst, Laboratory Manager

Misc Inorg - Soil		
Our Reference		211730-1
Sample ID	UNITS	S45899
Your Reference		BH2B 7.0-7.45m
Type of sample		Soil
Date prepared	-	20/02/2019
Date analysed	-	20/02/2019
pH 1:5 soil:water	pH Units	4.2
Electrical Conductivity 1:5 soil:water	µS/cm	220
Chloride, Cl 1:5 soil:water	mg/kg	<10
Sulphate, SO4 1:5 soil:water	mg/kg	440

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyer.

QUALITY CONTROL: Misc Inorg - Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			20/02/2019	[NT]	[NT]	[NT]	[NT]	20/02/2019	[NT]
Date analysed	-			20/02/2019	[NT]	[NT]	[NT]	[NT]	20/02/2019	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	[NT]	[NT]	101	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	[NT]	[NT]	[NT]	[NT]	105	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	94	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	96	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

SOIL CLASSIFICATION REPORT

Client	AECOM	**Source**	BH3 20.5-20.95m
Address	PO Box Q410, QVB PO Sydney NSW 1230	**Sample Description**	Silty CLAY
Project	Merimbula STP (60503757 2 4)	**Report No**	S45073-PI
Job No	S18539	**Lab No**	S45073

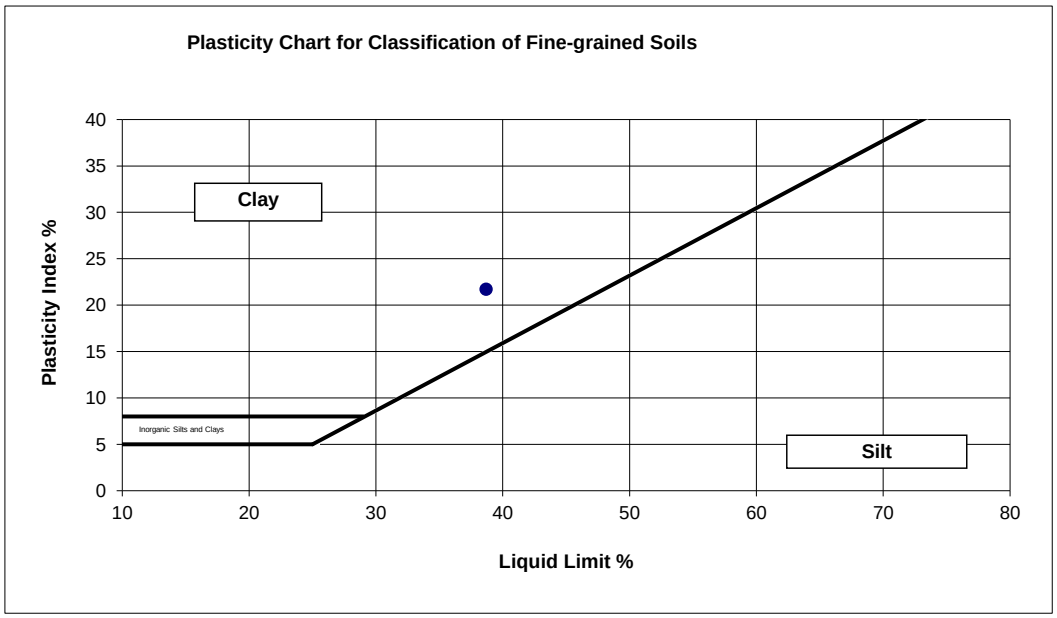
Test Procedure:

- ☑ AS1289 2.1.1 Soil moisture content tests (Oven drying method)
- ☑ AS1289 3.1.1 Soil classification tests - Determination of the liquid limit of a soil - Four point casagrande method
- ☐ AS1289 3.1.2 Soil classification tests - Determination of the liquid limit if a soil - One point Casagrande method (subsidiary method)
- ☑ AS1289 3.2.1 Soil classification tests - Determination of the plastic limit of a soil - Standard method
- ☑ AS1289 3.3.1 Soil classification tests - Calculation of the plasticity Index of a soil
- ☑ AS1289 3.4.1 Soil classification tests - Determination of the linear shrinkage of a soil - Standard method

Sampling: Sampled by Client **Date Sampled:** Unknown

Preparation: Prepared in accordance with the test method

Liquid Limit (%)	39	**Linear Shrinkage (%)**	8.0
Plastic Limit (%)	17	**Plasticity Index**	22



Soil Preparation Method: Dry Sieved
Soil History: Air Dried
Soil Condition: Linear

Notes

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

16/01/2019

Date:

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Alexandria NSW 2015

SOIL CLASSIFICATION REPORT

Client	AECOM	**Source**	BH4 5.5-5.95m
Address	PO Box Q410, QVB PO Sydney NSW 1230	**Sample Description**	Silty CLAY
Project	Merimbula STP (60503757 2 4)	**Report No**	S45076-PI
Job No	S18539	**Lab No**	S45076

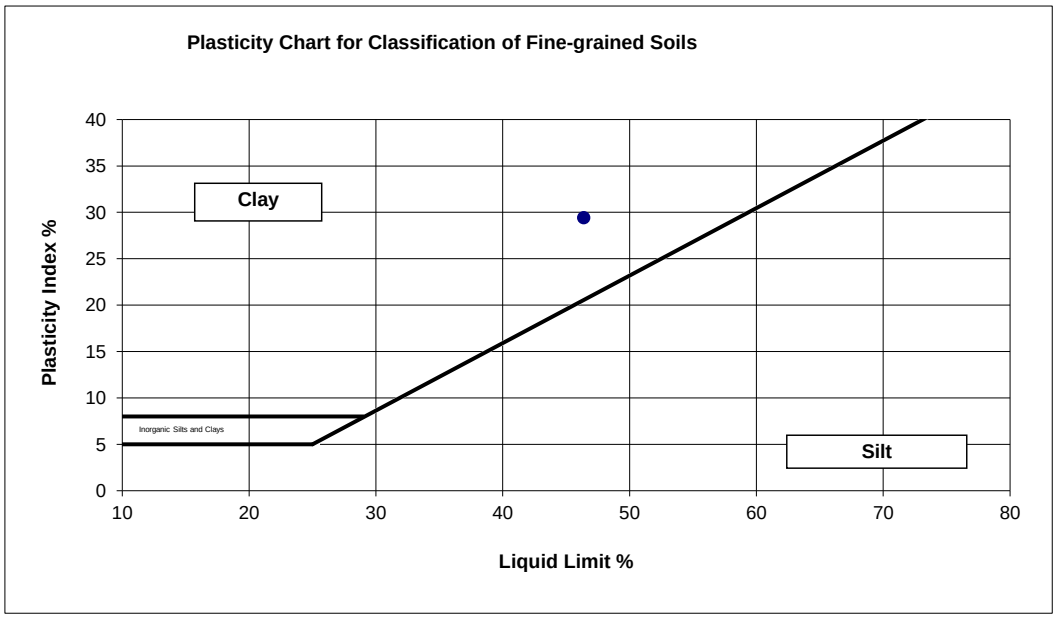
Test Procedure:

- ☑ AS1289 2.1.1 Soil moisture content tests (Oven drying method)
- ☑ AS1289 3.1.1 Soil classification tests - Determination of the liquid limit of a soil - Four point casagrande method
- ☐ AS1289 3.1.2 Soil classification tests - Determination of the liquid limit if a soil - One point Casagrande method (subsidiary method)
- ☑ AS1289 3.2.1 Soil classification tests - Determination of the plastic limit of a soil - Standard method
- ☑ AS1289 3.3.1 Soil classification tests - Calculation of the plasticity Index of a soil
- ☑ AS1289 3.4.1 Soil classification tests - Determination of the linear shrinkage of a soil - Standard method

Sampling: Sampled by Client **Date Sampled:** Unknown

Preparation: Prepared in accordance with the test method

Liquid Limit (%)	46	**Linear Shrinkage (%)**	10.0
Plastic Limit (%)	17	**Plasticity Index**	29



Soil Preparation Method: Dry Sieved
Soil History: Air Dried
Soil Condition: Linear

Notes

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Date:

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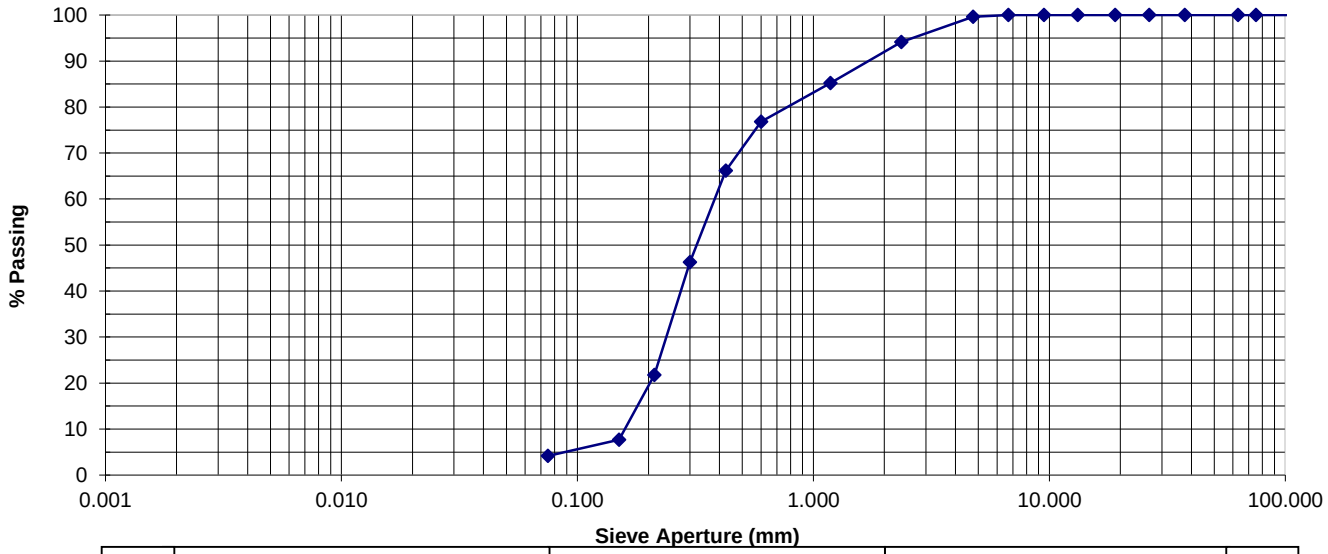
PARTICLE SIZE DISTRIBUTION REPORT

Client:	AECOM	**Source:**	BH2B 10-10.45m
Address:	PO Box Q410, QVB PO Sydney NSW 1230	**Sample Description:**	SAND trace of Gravel and Silt
Project:	Merimbula STP (60503757 2 4)	**Report No.:**	S45080-PSD
Job No.:	S18539	**Lab No.:**	S45080

Test Procedure: ☑ AS1289.3.6.1 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of analysis by sieving

Sampling: Sampled by Client | Date Sampled: Unknown

Preparation: Prepared in accordance with the test method



Sieve Apperture: (mm)	% Passing	Specification (..) Envelope	Sieve Aperture: (mm)	% Passing	Specification (..) Envelope
200	100		4.75	100	
75	100		2.36	94	
63	100		1.18	85	
37.5	100		0.600	77	
26.5	100		0.425	66	
19	100		0.300	46	
13.2	100		0.212	22	
9.5	100		0.150	8	
6.7	100		0.075	4	

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25/01/2019

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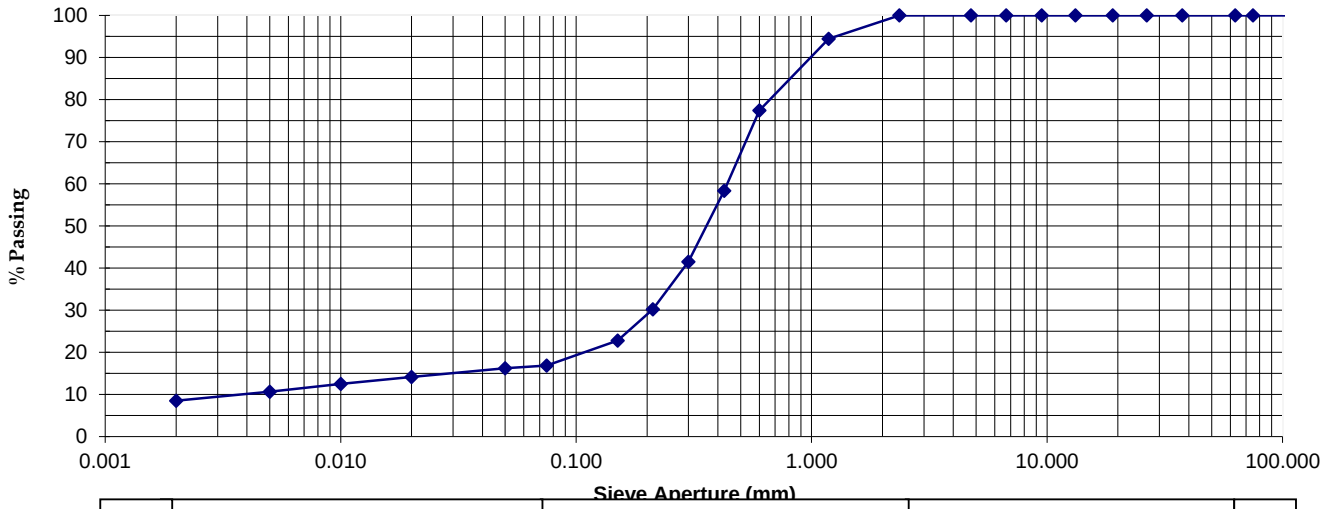
PARTICLE SIZE DISTRIBUTION (HYDROMETER) REPORT

Client:	AECOM	**Source:**	BH3 16-16.5m
Address:	PO Box Q410, QVB PO Sydney NSW 1230	**Sample Description:**	SAND with Silt and Clay
Project:	Merimbula STP (60503757 2 4)	**Report No.:**	S45074-HYD
Job No.:	S18539	**Lab No.:**	S45074

Test Procedure: ☑ AS1289.3.6.3 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of fine analysis using a hydrometer
☑ AS1289.3.6.1 Soil classification tests - Determination of particle size distribution of a soil standard method sieving

Sampling: Sampled by Client | Date Sampled: Unknown

Preparation: Prepared in accordance with the test method



Clay	Silt	Sand	Gravel	Cobbles

Sieve Apperture: (mm)	% Passing	Specification (..) Envelope	Sieve Aperture: (mm)	% Passing	Specification (..) Envelope
200	-		1.180	94	
75	-		0.600	77	
63	-		0.425	58	
37.5	-		0.300	41	
26.5	-		0.212	30	
19.0	-		0.150	23	
13.2	-		0.075	17	
9.5	-		0.050	16	
6.7	-		0.020	14	
4.75	-		0.010	13	
2.36	100		0.005	11	
			0.002	9	

Loss in Pre-treatment of Material (%)	0
Method of Dispersion:	Sodium Hexametaphosphate / Sodium Carbonate
Hydrometer Type:	ASTM

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

16/01/2019

Date:

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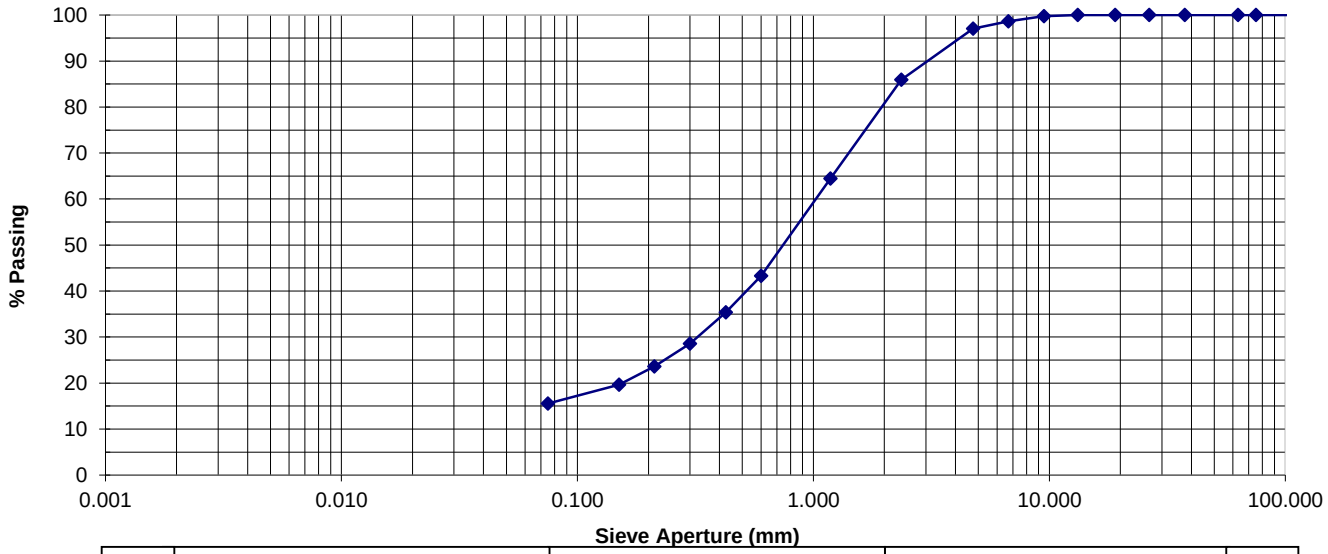
PARTICLE SIZE DISTRIBUTION REPORT

Client:	AECOM	**Source:**	BH3 11.5-11.95m
Address:	PO Box Q410, QVB PO Sydney NSW 1230	**Sample Description:**	SAND with Gravel and Clay
Project:	Merimbula STP (60503757 2 4)	**Report No.:**	S45075-PSD
Job No.:	S18539	**Lab No.:**	S45075

Test Procedure: ☑ AS1289.3.6.1 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of analysis by sieving

Sampling: Sampled by Client | Date Sampled: Unknown

Preparation: Prepared in accordance with the test method



Sieve Apperture: (mm)	% Passing	Specification (..) Envelope	Sieve Aperture: (mm)	% Passing	Specification (..) Envelope
200	100		4.75	97	
75	100		2.36	86	
63	100		1.18	64	
37.5	100		0.600	43	
26.5	100		0.425	35	
19	100		0.300	29	
13.2	100		0.212	24	
9.5	100		0.150	20	
6.7	99		0.075	16	

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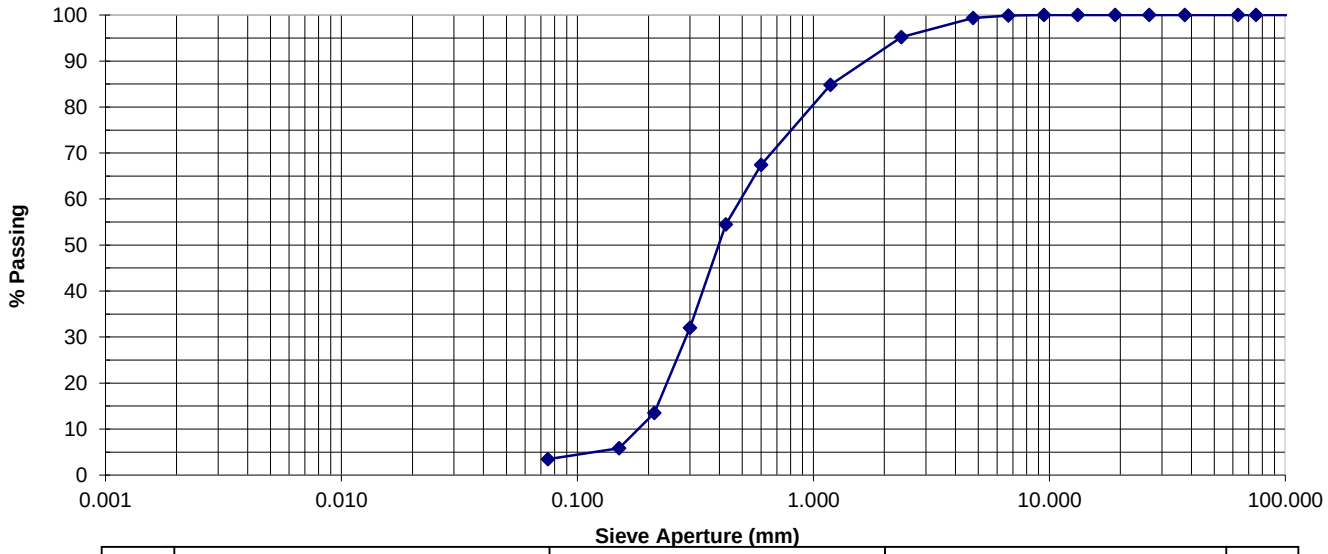
PARTICLE SIZE DISTRIBUTION REPORT

Client:	AECOM	**Source:**	BH6 8.65-8.95m
Address:	PO Box Q410, QVB PO Sydney NSW 1230	**Sample Description:**	SAND
Project:	Merimbula STP (60503757 2 4)	**Report No.:**	S45078-PSD
Job No.:	S18539	**Lab No.:**	S45078

Test Procedure: ☑ AS1289.3.6.1 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of analysis by sieving

Sampling: Sampled by Client | Date Sampled: Unknown

Preparation: Prepared in accordance with the test method



Sieve Apperture: (mm)	% Passing	Specification (..) Envelope	Sieve Aperture: (mm)	% Passing	Specification (..) Envelope
200	100		4.75	99	
75	100		2.36	95	
63	100		1.18	85	
37.5	100		0.600	67	
26.5	100		0.425	54	
19	100		0.300	32	
13.2	100		0.212	14	
9.5	100		0.150	6	
6.7	100		0.075	3	

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SOIL CLASSIFICATION REPORT

Client	AECOM	**Source**	BH08A 17.50-17.85m
Address	PO Box Q410, QVB PO Sydney NSW 1230	**Sample Description**	SAND, with Silt and Clay
Project	Merimbula STP (60541653-2)	**Report No**	S56644-PI
Job No	S19586	**Lab No**	S56644

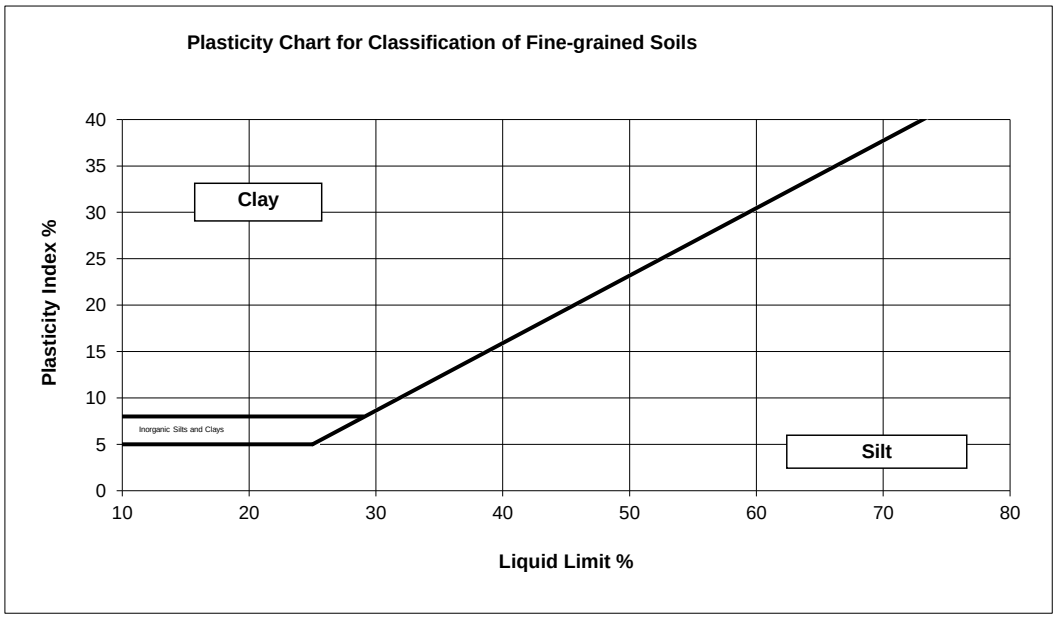
Test Procedure:

- ☑ AS1289 2.1.1 Soil moisture content tests (Oven drying method)
- ☑ AS1289 3.1.1 Soil classification tests - Determination of the liquid limit of a soil - Four point casagrande method
- ☐ AS1289 3.1.2 Soil classification tests - Determination of the liquid limit if a soil - One point Casagrande method (subsidiary method)
- ☑ AS1289 3.2.1 Soil classification tests - Determination of the plastic limit of a soil - Standard method
- ☑ AS1289 3.3.1 Soil classification tests - Calculation of the plasticity Index of a soil
- ☐ AS1289 3.4.1 Soil classification tests - Determination of the linear shrinkage of a soil - Standard method

Sampling: Sampled by Client **Date Sampled:** 28/11/2019

Preparation: Prepared in accordance with the test method

Liquid Limit (%)	Unobtainable	**Linear Shrinkage (%)**	-
Plastic Limit (%)	Unobtainable	**Plasticity Index**	Non Plastic



Soil Preparation Method: Dry Sieved
Soil History: Oven Dried
Soil Condition: N/A

Notes

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10/12/2019

Date:

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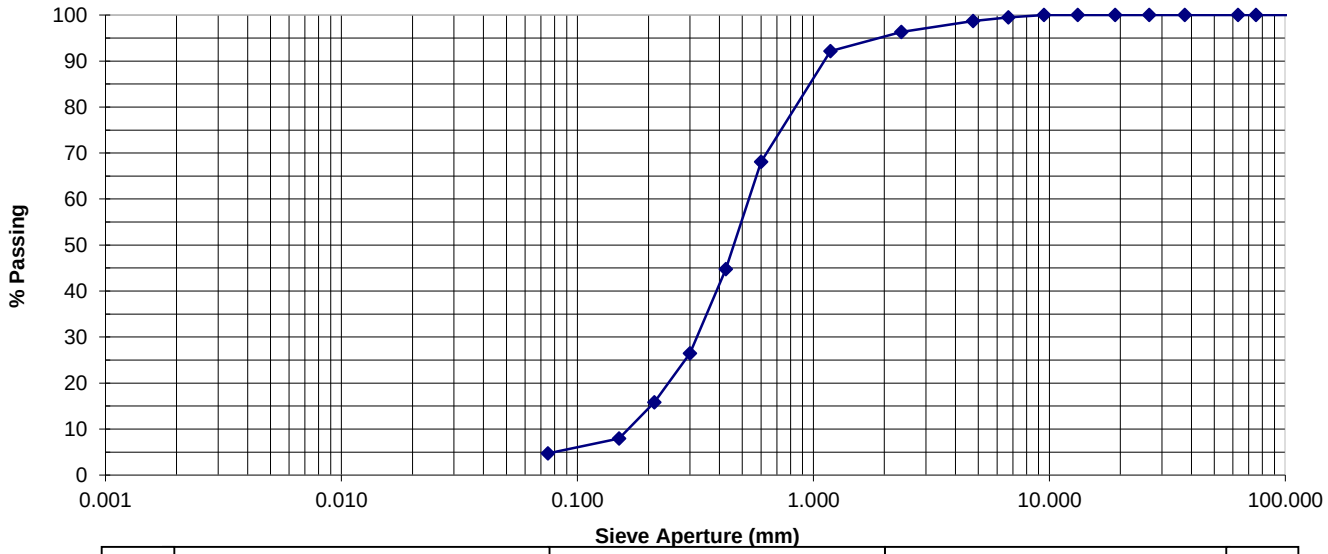
PARTICLE SIZE DISTRIBUTION REPORT

Client:	AECOM	**Source:**	BH08A 11.50-11.80m
Address:	PO Box Q410, QVB PO Sydney NSW 1230	**Sample Description:**	SAND, trace Gravel and Clay
Project:	Merimbula STP (60541653-2)	**Report No.:**	S56642-PSD
Job No.:	S19586	**Lab No.:**	S56642

Test Procedure: ☑ AS1289.3.6.1 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of analysis by sieving

Sampling: Sampled by Client | Date Sampled: 28/11/2019

Preparation: Prepared in accordance with the test method



Sieve Apperture: (mm)	% Passing	Specification (..) Envelope	Sieve Aperture: (mm)	% Passing	Specification (..) Envelope
200	100		4.75	99	
75	100		2.36	96	
63	100		1.18	92	
37.5	100		0.600	68	
26.5	100		0.425	45	
19	100		0.300	26	
13.2	100		0.212	16	
9.5	100		0.150	8	
6.7	99		0.075	5	

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10/12/2019

Date:

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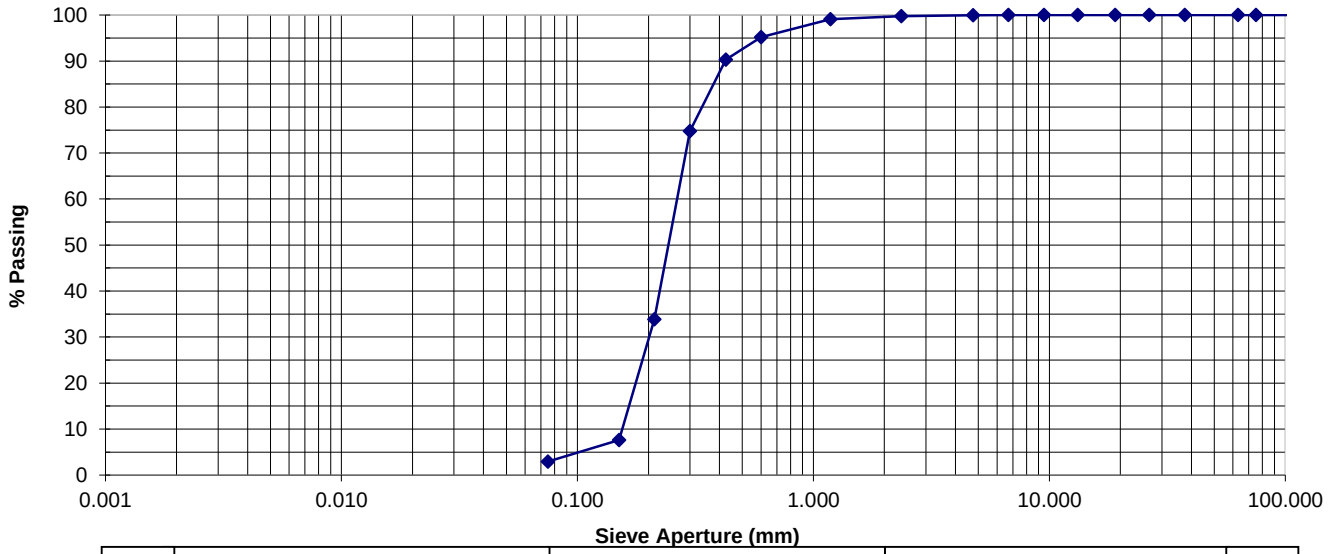
PARTICLE SIZE DISTRIBUTION REPORT

Client:	AECOM	**Source:**	BH08A 13.00-13.25m
Address:	PO Box Q410, QVB PO Sydney NSW 1230	**Sample Description:**	SAND, trace Clay
Project:	Merimbula STP (60541653-2)	**Report No.:**	S56643-PSD
Job No.:	S19586	**Lab No.:**	S56643

Test Procedure: ☑ AS1289.3.6.1 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of analysis by sieving

Sampling: Sampled by Client | Date Sampled: 28/11/2019

Preparation: Prepared in accordance with the test method



Sieve Apperture: (mm)	% Passing	Specification (..) Envelope	Sieve Aperture: (mm)	% Passing	Specification (..) Envelope
200	100		4.75	100	
75	100		2.36	100	
63	100		1.18	99	
37.5	100		0.600	95	
26.5	100		0.425	90	
19	100		0.300	75	
13.2	100		0.212	34	
9.5	100		0.150	8	
6.7	100		0.075	3	

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Chris Lloyd

9/12/2019

Date:

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Alexandria NSW 2015

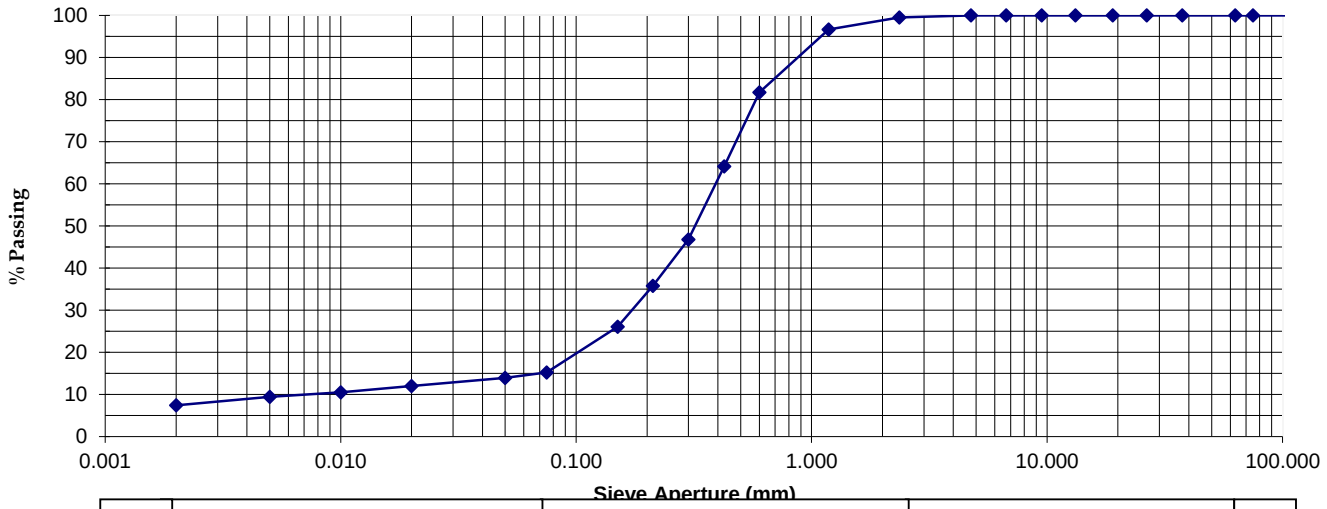
PARTICLE SIZE DISTRIBUTION (HYDROMETER) REPORT

Client:	AECOM	**Source:**	BH08A 17.50-17.85m
Address:	PO Box Q410, QVB PO Sydney NSW 1230	**Sample Description:**	SAND, with Silt and Clay
Project:	Merimbula STP (60541653-2)	**Report No.:**	S56644-HYD
Job No.:	S19586	**Lab No.:**	S56644

Test Procedure: ☑ AS1289.3.6.3 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of fine analysis using a hydrometer
☑ AS1289.3.6.1 Soil classification tests - Determination of particle size distribution of a soil standard method sieving

Sampling: Sampled by Client | Date Sampled: 28/11/2019

Preparation: Prepared in accordance with the test method



Clay	Silt	Sand	Gravel	Cobbles

Sieve Apperture: (mm)	% Passing	Specification (..) Envelope	Sieve Aperture: (mm)	% Passing	Specification (..) Envelope
200	-		1.180	97	
75	-		0.600	82	
63	-		0.425	64	
37.5	-		0.300	47	
26.5	-		0.212	36	
19.0	-		0.150	26	
13.2	-		0.075	15	
9.5	-		0.050	14	
6.7	-		0.020	12	
4.75	100		0.010	11	
2.36	100		0.005	9	
			0.002	7	

Loss in Pre-treatment of Material (%)	0
Method of Dispersion:	Sodium Hexametaphosphate / Sodium Carbonate
Hydrometer Type:	ASTM

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Chris Lloyd

10/12/2019

Date:

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Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

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customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 209517

Client Details

Client	Macquarie Geotech
Attention	Ian Goldschmidt
Address	3 Watt Dr, Bathurst, NSW, 2795

Sample Details

Your Reference	**S18539-1, Merimbula STP**
Number of Samples	2 Soil
Date samples received	15/01/2019
Date completed instructions received	15/01/2019

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	17/01/2019
Date of Issue	17/01/2019

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Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By

Jacinta Hurst, Laboratory Manager

Misc Inorg - Soil			
Our Reference		209517-1	209517-2
Your Reference	UNITS	S45077	S45079
Sample ID		BH7 13.30-13.45m	BH4 14.5-14.95m
Depth		13.30-13.45m	14.5-14.95m
Type of sample		Soil	Soil
Date prepared	-	16/01/2019	16/01/2019
Date analysed	-	16/01/2019	16/01/2019
pH 1:5 soil:water	pH Units	7.4	6.6
Electrical Conductivity 1:5 soil:water	µS/cm	54	44
Chloride, Cl 1:5 soil:water	mg/kg	41	28
Sulphate, SO4 1:5 soil:water	mg/kg	10	20

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyer.

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			16/01/2019	[NT]	[NT]	[NT]	[NT]	16/01/2019	[NT]
Date analysed	-			16/01/2019	[NT]	[NT]	[NT]	[NT]	16/01/2019	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	[NT]	[NT]	102	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	[NT]	[NT]	[NT]	[NT]	105	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	89	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	90	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Envirolab Services Pty Ltd
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www.envirolab.com.au

CERTIFICATE OF ANALYSIS 210116

Client Details

Client	Macquarie Geotech
Attention	Ian Goldschmidt
Address	3 Watt Dr, Bathurst, NSW, 2795

Sample Details

Your Reference	**S18539-1, Merimbula STP**
Number of Samples	1 Soil
Date samples received	23/01/2019
Date completed instructions received	23/01/2019

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	31/01/2019
Date of Issue	31/01/2019

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Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By

Jacinta Hurst, Laboratory Manager

Misc Inorg - Soil		
Our Reference		210116-1
Your Reference	UNITS	S45080
Sample ID		BH2B 10-10.45m
Depth		10-10.45m
Type of sample		Soil
Date prepared	-	25/01/2019
Date analysed	-	25/01/2019
pH 1:5 soil:water	pH Units	4.0
Electrical Conductivity 1:5 soil:water	µS/cm	150
Chloride, Cl 1:5 soil:water	mg/kg	<10
Sulphate, SO4 1:5 soil:water	mg/kg	220
Organic Matter, Walkely Black	mg/kg	2,400

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-036	Total Organic Matter - A titrimetric method that measures the oxidisable organic content of soils. Based upon Rayment and Lyons 2011 where TOM is estimated as = TOC * 1.724.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyer.

QUALITY CONTROL: Misc Inorg - Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			25/01/2019	[NT]	[NT]	[NT]	[NT]	25/01/2019	[NT]
Date analysed	-			25/01/2019	[NT]	[NT]	[NT]	[NT]	25/01/2019	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	[NT]	[NT]	102	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	[NT]	[NT]	[NT]	[NT]	108	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	95	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	97	[NT]
Organic Matter, Walkely Black	mg/kg	1000	Inorg-036	<1000	[NT]	[NT]	[NT]	[NT]	90	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
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LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
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.

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For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

SOIL CHEMICAL PROPERTIES REPORT

Client	AECOM	**Source**	BH08A 13.00-13.25
Address	PO Box Q410, QVB PO Sydney NSW 1230	**Sample Description**	Silty SAND
Project	Merimbula STP (60541653-2)	**Report No.**	B59807-SCP
Job No	S19586	**Lab No.**	B59807 (S56643)

Test Procedure:

☐	AS1289 4.2.1	Soil Chemical Tests - Determination of a sulfate content of a natural soil and the sulfate content of the groundwater - Normal Method
☐	AS1289 4.3.1	Soil Chemical Tests - Determination of the pH value of a soil - Electrometric method
☐	AS 1289 4.4.1	Soil Chemical Tests - Determination of the electrical resistivity of a soil - Method for sands and granular material
☐	AS 1012.20	Chloride and sulphate
☐	RMS T123	pH value of a soil (electrometric method)
☐	RMS T185	Resistivity of sands and granular road construction materials
☐	RMS T200	Chloride content of roadbase
☐	RMS T1010	Quantitative determination of chlorides in soil
☐	RMS T1011	Quantitative determination of sulphates in soil
☐	BS1377(1990 pt.3)	Water soluble sulphate content
☑	APHA 4500 H+B	pH
☑	APHA 4500 SO4 2-B	Sulphate
☑	APHA 4500 Cl-B	Chloride
☑	APHA 2510 & 2520-B	Electrical Conductivity
☐	TAI B117	Sulphides Present (This service Not Covered by NATA Accreditation)

Sampling:	Sampled by Client	**Date Sampled:**	28/11/2019
Preparation:	Prepared in accordance with the test method		

Sulphides Present	-
Sulphur Peroxide (% w/w)	-
Sulphate content (ppm)	4.5
Sulphate content (% w/w)	-
Chloride ion content (ppm)	14.2
Chloride ion content (% w/w)	-
pH	7.2
Electrical Conductivity (uS/cm)	64.9
Mean Resistivity Ω.m	-
(Resisitivity) Density ratio (R_D)	-
(Resisitivity) Density index (I_D)	-

NATA

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The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Brad Morris

9/12/2019

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
3 Watt Drive
Bathurst NSW 2795

Appendix F

Geotechnical Long Section

DISTANCE (m)

ELEVATION (AHD)

1988_BH11
Offset - 98.6m
CH 21m
RL 9.88 AHD
EOH 4.9 m

1988_BH10
Offset 57.1m
CH 63m
RL 11.23 AHD
EOH 4.7 m

1988_BH9
Offset 91.4m
CH 135m
RL 7.16 AHD
EOH 10.0 m

2018_BH04
Offset 32.5m
CH 148m
RL 15.18 AHD
EOH 15.0 m

2018_BH03
Offset 41.1m
CH 243m
RL 11.11 AHD
EOH 30.0 m

2004_PB1
Offset 336.0m
CH 338m
RL 7.53 AHD
EOH 61.6 m

2018_BH06
Offset - 37.4m
CH 409m
RL 2.45 AHD
EOH 40.2 m

2018_BH06
Offset 101.4m
CH 430m
RL 3.47 AHD
EOH 20.0 m

2018_BH02A
Offset 52.9m
CH 482m
RL 4.25 AHD
EOH 20.0 m

2018_BH02B
Offset - 23.9m
CH 503m
RL 3.87 AHD
EOH 30.0 m

2019_BH08A
Offset 34.7m
CH 706m
RL 6.81 AHD
EOH 20.0 m

Dune Sand

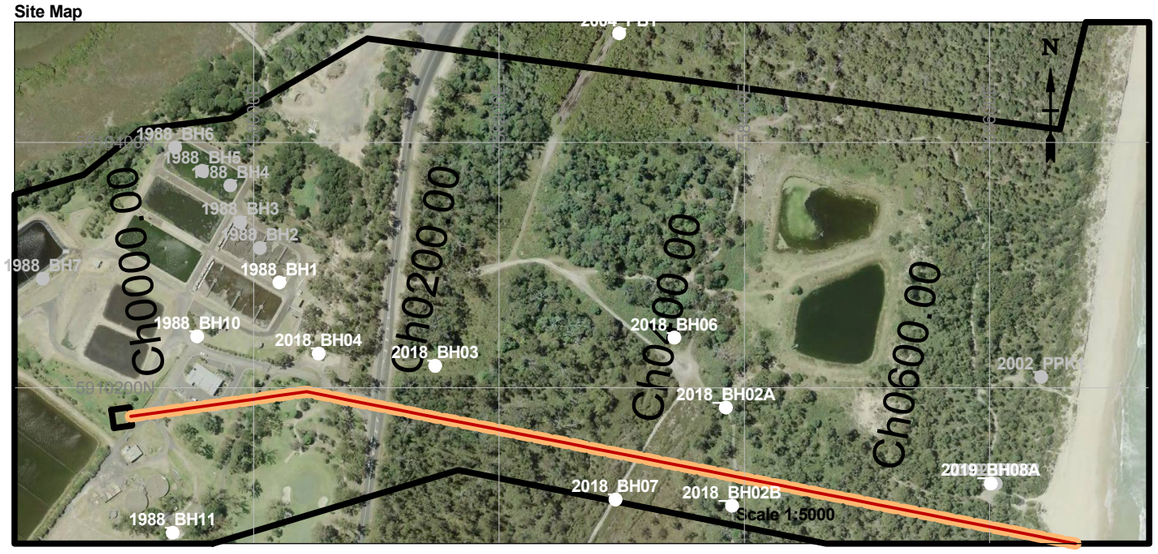
Loose Sand Layer

Interbedded
Sand & Clay

Final

Final

Site Map



LEGEND

- SILTY GRAVELLY SAND
- SILTY SAND
- CLAYEY SILT
- SANDY SILT
- SAND
- CLAY
- SANDY CLAY
- CLAYEY SAND
- GRAVEL
- FILL

UNIT CODES AND COLOURS

F	FILL
DS	Dune Sand
S&C	Interbedded Sand and Clay

Borehole Name
Fence Offset
Elevation
SPT N
Water after drilling / during drilling
Circulation loss: total loss / partial loss
End Of Hole depth

Notes:
1. For detailed descriptions of the geological material at specific investigation locations, refer to the respective logs and explanatory notes.
2. Any geological boundaries are inferred.

AECOM

Vert Scale: 1:500
Horiz Scale: 1:2500

GEOLOGICAL CROSS SECTION

CLIENT: Bega Valley Shire Council
PROJECT NAME: Merimbula Ocean Outfall Site Investigation
PROJECT No: 60541653

2017_AECOM_STRATIGRAPHY_MAP_REV4 60541653_MERIMBULA_2019.GPJ AECOM_5-00AA.GLB 2.12.2019

Appendix G

Geophysical Report

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North Parramatta, NSW. 2151.
Tel: 9890 2122. Fax: 9890 2922.
E-Mail: jamie@gbgoz.com.au.

A.B.N. 77 009 550 869.

24th January 2019

Final Report: GBGA2068 Rev E

FAO: Subha Balasubramanian
Senior Engineer - Water and Wastewater

AECOM
PO Box Q410,
QVB PO, Sydney, NSW, 1230
Phone: 02 8934 0323 Mobile 0407 522 300
Email: *Subha.Balasubramanian@aecom.com*

GEOPHYSICAL INVESTIGATION USING GRAVITY SURVEYING COMPLIMENTED WITH TROMINO READINGS TO DELINEATE THE DEPTH TO BEDROCK FOR AN ENGINEERING ASSESSMENT FOR PLACEMENT OF A PUMPING STATION AND OUTFALL PIPE AT MERIMBULA, NSW.

1. INTRODUCTION

A geophysical investigation was undertaken at the proposed site of construction of the new sewer outfall infrastructure near Merimbula, NSW, as part of a geotechnical project with gravity, passive seismics and GPS data being collected on 19th, 20th & 21st October 2017.

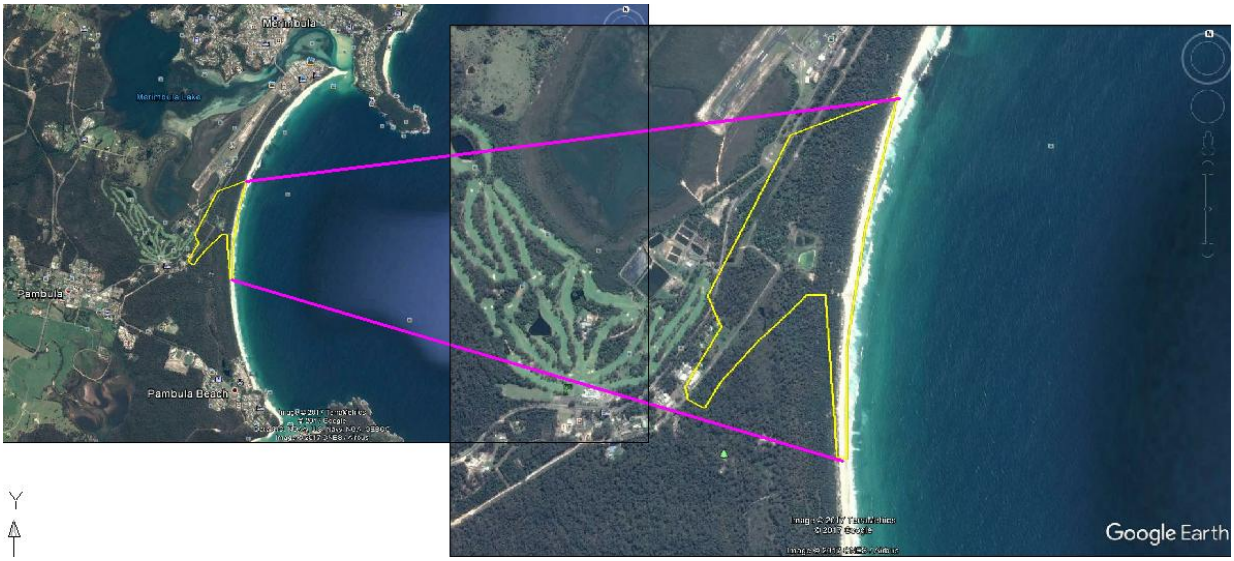

Figure 1: Site location, outlined in yellow, images from Google Earth.

The site is within the vacant land between Arthur Kaine Drive and the beach opposite the sewer treatment works.

GB Geotechnics Australia Pty Ltd (GBG) was commissioned by AECOM Australia Pty Ltd (AECOM) to undertake a gravity survey. The survey comprised collection of gravity, passive seismic and GPS data at predefined locations. These locations were supplied by the client.

Gravity data was acquired using a Sintrex CG-3 gravity meter. Supplemental passive seismic data was collected using a Tromino (MOHO Science & Technology). With site set out and GPS data being collected using a Trimble R10 with RTK corrections from the Bega CORS Network base station.

This report presents the findings from the survey.

2. SURVEY SITE

The investigation fieldwork was undertaken during day light hours on the 19th, 20th & 21st October 2017. The fieldwork was conducted by a two person crew, consisting of a senior geophysicist from GBG Australia and a materials engineer from AECOM, with four additional passive seismic readings acquired on the following morning.

The locations of data collection are shown in Figure 2 below and tabulated in Table 1 overleaf.

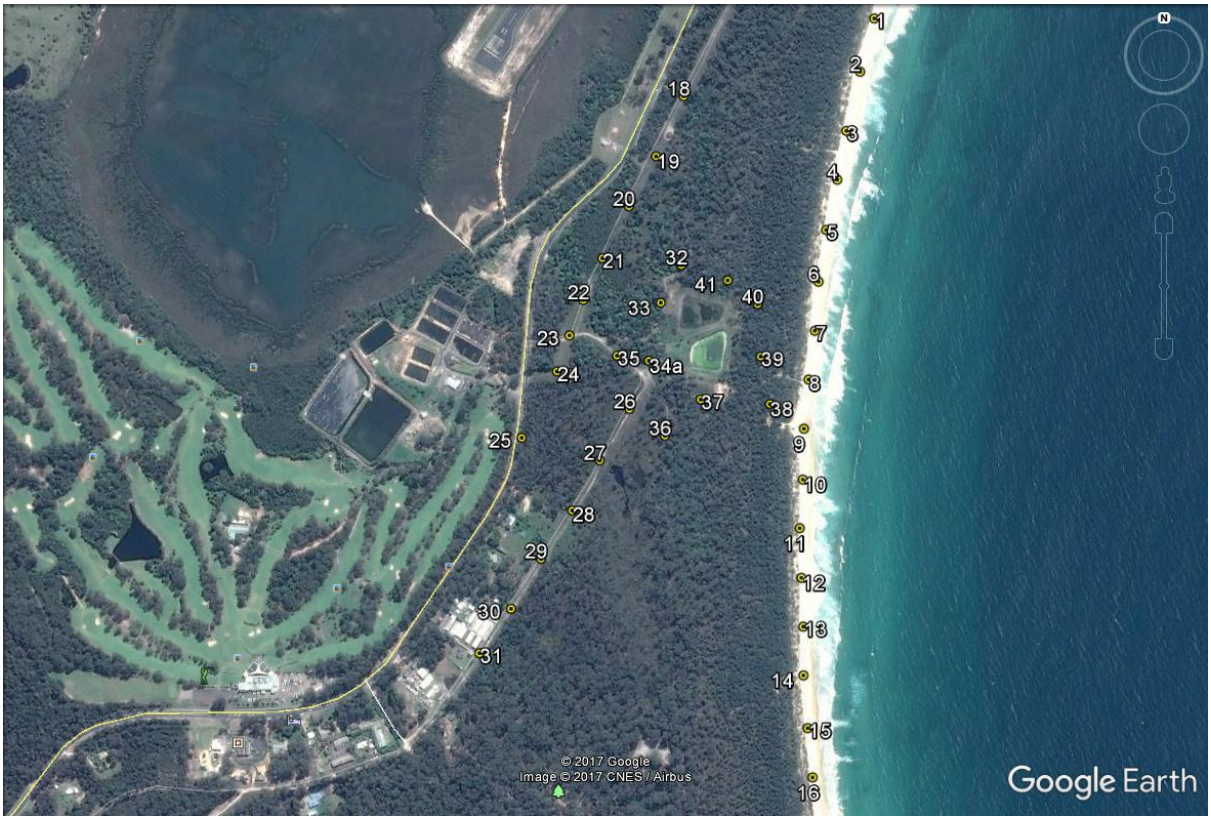

Figure 2: Surveyed location of collected gravity stations, image from Google Earth.

3. SURVEY PROGRAM

Global Positioning System survey

Survey set out was undertaken using a Trimble R10 Differential Global Positioning System (DGPS), with Real Time Kinematic (RTK) corrections using the Continuously Operating Reference Station (CORS) network with the station located in Eden, NSW. Using this equipment and setup, high accuracy data acquisition was achieved, with horizontal errors of less than 0.034m, and vertical errors being in the range 0.016m to 0.052m. Statistics from the RTK GPS acquisition are supplied in Table 1 below. GPS data is supplied in MGA Zone 55H, which uses GDA94 datum.

Table 1: Horizontal and Vertical Precision (HDOP & VDOP) statistics of RTK GPS data acquired

Horizontal	Precision (m)	Vertical	Precision (m)
Mean Precision	0.015	Mean Precision	0.026
Min Precision	0.009	Min Precision	0.016
Max Precision	0.034	Max Precision	0.052

Tromino Stations

At eight of the Gravity Stations passive seismic readings were collected. Each reading was acquired over 20 minutes. The instrument was aligned to magnetic north then levelled. Ground coupling was achieved using 50mm ground spikes. After placing the instrument the operator carefully walked away from the station and did not return until 25 minutes had elapsed. The instrument is shown in Image 1 overleaf.

The locations and elevations of the stations that were occupied with the Tromino are tabulated below in Table 2.

Table 2: Location and elevation of Tromino readings. MGA Zone 55H, which uses GDA94 datum.

Station	East (m)	North (m)	Elevation (m) AHD	Comment
9	758671.110	5910100.910	1.845	
19	758385.380	5910656.850	1.311	
22	758231.930	5910371.930	2.954	
25	758101.060	5910097.710	15.958	
27	758256.120	5910047.760	2.125	
31	758006.930	5909672.980	31.393	
32	758430.750	5910436.330	3.319	
34	758360.300	5910245.840	3.114	Station moved to gain good GPS

Gravity survey

The gravity survey was conducted using a Scintrex CG5 Autograv meter, shown below in Image 2. The instrument is a microprocessor-based automated gravity meter. It has a measurement range of over 7000 mgals without resetting and a reading resolution of 0.001 mGal (CG–3M).

The gravity meter was set up at multiple stations, levelled and allowed to take stable readings at each station. Readings were acquired over one minute, with the average of the readings being recorded.

At close to hourly times, Station 37 (Survey Base Station) was rerecorded. This data was used as base station readings to allow drift and tidal corrections to be carried out.

Image 1: Tromino reading taking place at Station 25.

Image 2: Gravity reading taking place at Station 1 on the beach.

The locations of acquired Stations are given in Table 3 over leaf. Table 4 shows the planned locations and the coordinates of the acquired data as well as the distance between the two sets of coordinates.

16 Stations are more than 0.5m from the requested location, these are highlighted in yellow in the table; this is due to local conditions, eg trees, unstable surface, rutted ground or poor GPS reception. One Station (Station 34) was moved 3.012m, this was due to the poor RTK GPS reception at the requested location. Locations are given in MGA Zone 55H, which uses GDA94 datum. WGS84 Zone 55H

A table listing GPS precisions, PDOP and HDOP is given in the results section of this report.

Table 3: Location and elevation of gravity stations: MGA Zone 55H, which uses GDA94 datum.

Station	Eastings (m)	Northings (m)	Elevation (m) AHD
1	758834.350	5910923.910	2.401
2	758803.350	5910817.930	2.323
3	758772.400	5910699.260	2.433
4	758751.140	5910600.950	2.190
5	758725.990	5910500.330	2.427
6	758708.350	5910396.640	2.470
7	758698.560	5910297.920	2.146
8	758683.200	5910199.800	2.325
9	758671.110	5910100.910	1.845
10	758666.290	5909998.630	2.261
11	758657.350	5909900.860	2.596
12	758658.350	5909800.700	2.398
13	758659.880	5909702.100	2.214
14	758657.720	5909603.850	2.480
15	758663.670	5909497.180	2.228
16	758670.800	5909398.190	2.091
18	758444.700	5910775.500	2.162
19	758385.380	5910656.850	1.311
20	758328.080	5910557.550	1.722
21	758271.590	5910454.350	1.306
22	758231.930	5910371.930	2.954
23	758201.410	5910300.190	5.470
24	758174.500	5910228.520	7.556
25	758101.060	5910097.710	15.958
26	758318.700	5910149.710	2.182
27	758256.120	5910047.760	2.125
28	758198.210	5909949.150	5.896
29	758133.490	5909854.830	14.758
30	758071.870	5909758.860	27.033
31	758006.930	5909672.980	31.393
32	758430.750	5910436.330	3.319
33	758387.460	5910361.940	3.077
34	758360.300	5910245.840	3.114
35	758296.120	5910257.420	3.941
36	758388.930	5910093.930	3.371
37	758463.530	5910165.430	7.214
38	758602.430	5910152.520	7.517
39	758586.240	5910248.470	8.738
40	758582.960	5910353.700	8.111
41	758523.550	5910403.180	7.936

Table 4: Location and elevation of gravity stations compared with requested Station locations.

Station Number	Collected Location (Zone 55H GDA94)		Requested Location (Zone 55H GDA94)		Offset Dist (m)
	Eastings (m)	Northings (m)	Eastings (m)	Northings (m)	
1	758834.350	5910923.910	758834.170	5910923.726	0.258
2	758803.350	5910817.930	758802.775	5910817.874	0.578
3	758772.400	5910699.260	758772.317	5910699.269	0.084
4	758751.140	5910600.950	758750.696	5910600.979	0.445
5	758725.990	5910500.330	758725.485	5910500.657	0.601
6	758708.350	5910396.640	758708.880	5910396.269	0.647
7	758698.560	5910297.920	758698.848	5910297.979	0.294
8	758683.200	5910199.800	758683.155	5910199.593	0.212
9	758671.110	5910100.910	758670.653	5910100.923	0.457
10	758666.290	5909998.630	758666.113	5909999.044	0.450
11	758657.350	5909900.860	758657.378	5909900.754	0.110
12	758658.350	5909800.700	758658.329	5909800.431	0.269
13	758659.880	5909702.100	758659.756	5909702.141	0.131
14	758657.720	5909603.850	758657.723	5909603.851	0.004
15	758663.670	5909497.180	758663.691	5909497.431	0.252
16	758670.800	5909398.190	758670.609	5909398.060	0.231
18	758444.700	5910775.500	758444.566	5910775.572	0.152
19	758385.380	5910656.850	758385.318	5910657.163	0.319
20	758328.080	5910557.550	758328.017	5910557.548	0.063
21	758271.590	5910454.350	758270.834	5910454.069	0.807
22	758231.930	5910371.930	758231.958	5910372.009	0.084
23	758201.410	5910300.190	758201.419	5910299.250	0.940
24	758174.500	5910228.520	758174.453	5910228.196	0.328
25	758101.060	5910097.710	758100.211	5910098.233	0.997
26	758318.700	5910149.710	758318.402	5910149.757	0.302
27	758256.120	5910047.760	758256.195	5910047.634	0.147
28	758198.210	5909949.150	758198.817	5909949.158	0.607
29	758133.490	5909854.830	758133.442	5909854.724	0.116
30	758071.870	5909758.860	758072.087	5909759.308	0.498
31	758006.930	5909672.980	758007.762	5909672.982	0.832
32	758430.750	5910436.330	758430.630	5910436.515	0.220
33	758387.460	5910361.940	758387.501	5910362.178	0.242
34	758360.300	5910245.840	758363.179	5910246.728	3.012
35	758296.120	5910257.420	758295.881	5910256.913	0.561
36	758388.930	5910093.930	758389.331	5910095.523	1.642
37	758463.530	5910165.430	758464.436	5910166.090	1.120
38	758602.430	5910152.520	758601.693	5910153.075	0.923
39	758586.240	5910248.470	758587.123	5910248.793	0.940
40	758582.960	5910353.700	758583.123	5910355.304	1.612
41	758523.550	5910403.180	758523.194	5910402.771	0.542

4. PROCESSING AND ANALYSIS

GPS

GPS data was transferred from the data logger as csv, dbf and jxl (Trimble job file) file formats. Data precision results, PDOP, HDOP, number of satellites, and time stamps were obtained from the jxl file. The precision information was used to generate the statistics presented below (see results section).

Tromino passive seismic data

Tromino data was analysed, processed and modelled using Grilla Software by MOHO Science & Technology (Ver 2015.01).

Gravity

Gravity processing was conducted by performing calculations in Microsoft Excel. The below corrections were made;
Instrument tilt was corrected in real time (for tilt variations within a $\pm 9.7 \times 10^{-4}$ radians (±200 arcsec) range, tilts outside this range or where movement occurred during reading were automatically rejected) within the instrument via the application of a correction algorithm.

- Drift and tidal corrections were calculated from repeated base station readings.
- Latitude correction
- Free Air correction (less gravity due to increased elevation); and
- Bouguer corrections (extra mass due to elevation correction)

The corrected gravity data was modelled in IX2D-GM Ver 1.05 software from Interpex Ltd USA. An initial three layer model as generated from the Tromino results was used as a starting point for the Gravity model inversion.

All data presented below is corrected relative gravity data.

5. RESULTS AND INTERPRETATION

The results of the geophysical investigation at Merimbula are given below.

GPS Quality.

GPS data quality information is presented in Table 5 below.

GPS data precision has been reported, this is a calculation performed within the GPS instrument to account for number of satellites, satellite position in the sky, distance from the base station (Base Line) and time acquiring (GPS Epoc). Lower precision is not the only source of error that the data will contain. Quantifying additional errors is not possible for this survey. These include, but are not limited to, errors that are the result of the following tilt of antenna, the tip penetrating into soft soil, minor movements during acquisition.

Table 5: GPS PDOP, Horizontal Precision, VDOP, Vertical Precision and Number of Satellites

Station	PDOP @ Store	Horizontal Precision (m)	VDOP @ Store	Vertical Precision (m)	No of Satellites @ Store
1	1.514272332	0.014	1.220947027	0.020	12
2	1.482045531	0.013	1.180856586	0.019	12
3	1.602069259	0.012	1.32653296	0.017	12
4	1.566344142	0.012	1.287469149	0.018	12
5	1.326056242	0.012	1.051207066	0.017	14
6	1.496196628	0.013	1.19986999	0.018	13
7	1.497417331	0.012	1.206584454	0.017	13
8	1.485930085	0.012	1.199698687	0.017	13
9	1.467129707	0.012	1.184358478	0.017	13
10	1.608326197	0.012	1.268607736	0.020	12
11	2.138893604	0.013	1.703083515	0.022	11
12	1.512005568	0.013	1.186085939	0.023	12
13	1.46536243	0.013	1.143766642	0.026	12
14	2.08420682	0.012	1.685290456	0.024	11
15	2.572153091	0.013	2.234544277	0.028	11
16	1.981526732	0.012	1.678532124	0.024	11
18	1.824390531	0.014	1.58276999	0.032	12
19	1.498634696	0.011	1.320841551	0.025	14
20	1.438278675	0.015	1.249748468	0.033	14
21	1.619743228	0.014	1.45062077	0.032	13
22	1.612698674	0.009	1.442596436	0.027	13
23	1.522594452	0.009	1.348651767	0.025	14
24	1.415700555	0.010	1.178509593	0.016	14
25	1.500231028	0.023	1.244452477	0.034	12
26	1.617264152	0.012	1.410586596	0.023	13
27	1.494945049	0.012	1.291243315	0.023	14
28	1.354569912	0.012	1.175037146	0.024	16
29	1.460589528	0.012	1.269942403	0.033	15
30	1.601626992	0.014	1.341213226	0.030	12
31	1.299517035	0.011	1.126016259	0.023	16
32	1.812120557	0.026	1.584558845	0.036	11
33	1.788213372	0.018	1.511151791	0.026	11
34	1.487097383	0.030	1.257708907	0.052	13
35	1.602925658	0.011	1.375362515	0.028	12
36	1.90703547	0.022	1.49963069	0.028	9
37	2.044910431	0.017	1.747421861	0.026	10
38	1.762428284	0.021	1.474031568	0.031	11
39	1.873008966	0.016	1.608876348	0.023	11
40	2.064803839	0.034	1.795827866	0.052	11
41	1.494194865	0.017	1.261428237	0.023	14
Mean	**1.647436476**	**0.015**	**1.382641593**	**0.026**	**12.5**
Min	**1.299517035**	**0.009**	**1.051207066**	**0.016**	**9**
Max	**2.572153091**	**0.034**	**2.234544277**	**0.052**	**16**

Tromino Results

Tromino results are summarised in; Tables 6 and 7 and displayed graphically in Figure 3 below.

Table 6: Tromino results, layer interface elevation and thickness

Station	MGA 55H Projection (GDA94 datum)		Elevation AHD (m)	Elevation AHD (m)			Thickness (m)		
	Eastings (m)	Northings (m)	Elevation AHD (m)	Layer 1	Layer 2	Layer 3	Layer 1	Layer 2	Layer 3
9	758671.110	5910100.910	1.845	-3	-38	-228	5	35	190
19	758385.380	5910656.850	1.311	-4	-32	-302	5	28	270
22	758231.930	5910371.930	2.954	-3	-29	-219	6	26	190
25	758101.060	5910097.710	15.958	*	-14	-134	*	30	120
27	758256.120	5910047.760	2.125	-3	-25	-135	5	22	110
31	758006.930	5909672.980	31.393	29	7	-143	2	22	150
32	758430.750	5910436.330	3.319	-2	-42	-389	5	37	350
34	758360.300	5910245.840	3.114	-4	-64	-444	7	60	380
Average:							5	33	220

Table 7: Tromino results, P-wave and S-wave velocities

Tromino Station	P-wave velocity (m/s)			S-wave velocity (m/s)		
	Layer 1	Layer 2	Layer 3	Layer 1	Layer 2	Layer 3
9	934	1561	3000	347	580	905
19	1117	1939	4371	415	720	1318
22	845	1957	2749	314	727	1021
25	*	1267	1997	*	470	742
27	693	1292	1851	257	48	688
31	597	1213	2256	222	451	741
32	1348	2609	5534	501	969	1668
34	1247	2675	5349	463	993	1613
Average	969	1814	3388	360	620	1087

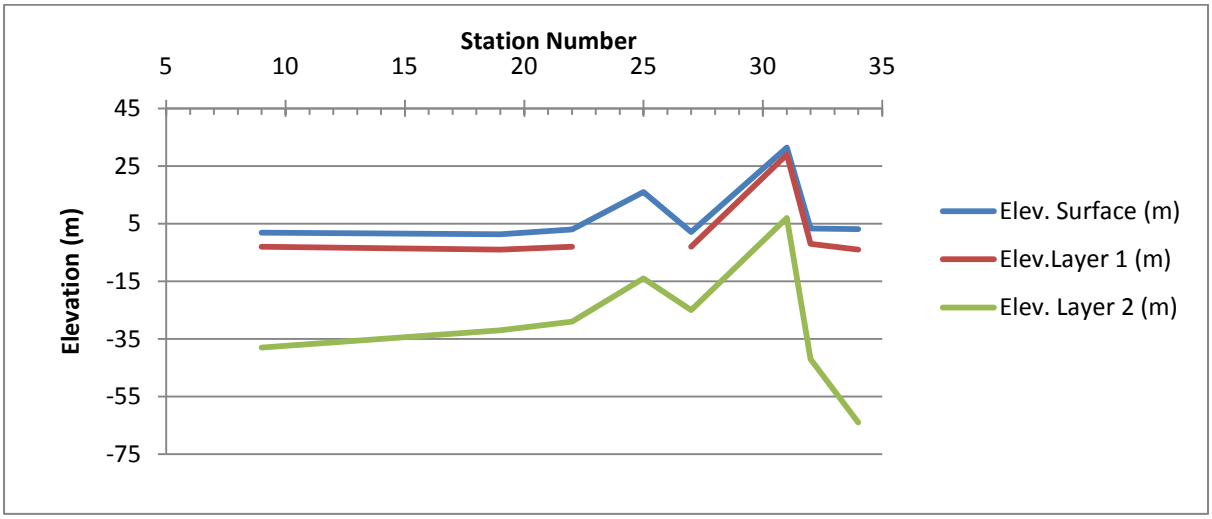

Figure 3: Modelled passive seismic (Tromino) layer depths plotted against Station number

Gravity Results and Modelling

Corrected gravity results are tabulated in Table 8 below.

Table 8: Gravity results

Station	MGA 55H Projection (GDA94 datum)		Elevation AHD (m)	Corrected Relative Bouger 2.67 (mgal)
	Easting (m)	Northing (m)		
1	758834.350	5910923.910	2.401	-0.181
2	758803.350	5910817.930	2.323	0.038
3	758772.400	5910699.260	2.433	0.269
4	758751.140	5910600.950	2.190	0.476
5	758725.990	5910500.330	2.427	0.652
6	758708.350	5910396.640	2.470	0.895
7	758698.560	5910297.920	2.146	1.004
8	758683.200	5910199.800	2.325	1.174
9	758671.110	5910100.910	1.845	1.356
10	758666.290	5909998.630	2.261	1.505
11	758657.350	5909900.860	2.596	1.611
12	758658.350	5909800.700	2.398	1.724
13	758659.880	5909702.100	2.214	1.863
14	758657.720	5909603.850	2.480	1.906
15	758663.670	5909497.180	2.228	2.089
16	758670.800	5909398.190	2.091	2.193
18	758444.700	5910775.500	2.162	0.741
19	758385.380	5910656.850	1.311	1.139
20	758328.080	5910557.550	1.722	1.407
21	758271.590	5910454.350	1.306	1.672
22	758231.930	5910371.930	2.954	1.761
23	758201.410	5910300.190	5.470	1.861
24	758174.500	5910228.520	7.556	1.997
25	758101.060	5910097.710	15.958	2.125
26	758318.700	5910149.710	2.182	1.905
27	758256.120	5910047.760	2.125	2.199
28	758198.210	5909949.150	5.896	2.181
29	758133.490	5909854.830	14.758	1.991
30	758071.870	5909758.860	27.033	1.797
31	758006.930	5909672.980	31.393	1.826
32	758430.750	5910436.330	3.319	1.175
33	758387.460	5910361.940	3.077	1.400
34	758360.300	5910245.840	3.114	1.604
35	758296.120	5910257.420	3.941	1.672
36	758388.930	5910093.930	3.371	1.991
37	758463.530	5910165.430	7.214	0.000
38	758602.430	5910152.520	7.517	0.287
39	758586.240	5910248.470	8.738	0.288
40	758582.960	5910353.700	8.111	0.344
41	758523.550	5910403.180	7.936	0.431

Figure 3 below shows a plot of the classed corrected relative gravity data with elevation contours. The magenta lines are the projections of the modelled profiles. The magenta lines show the modelled gravity profiles.

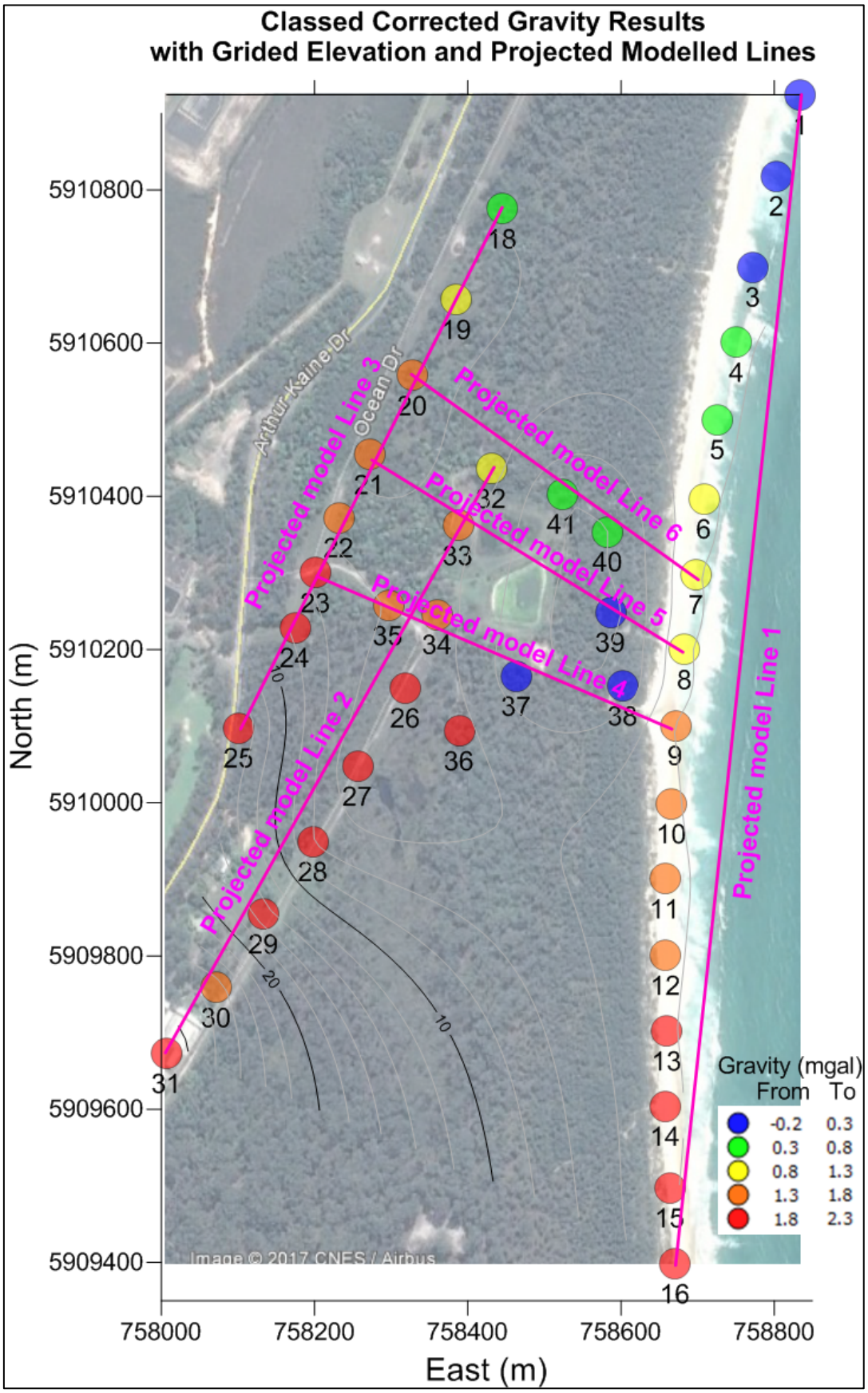

Figure 3: Classed gravity results with gridded elevation and projected modelled gravity lines

Figure 4 below shows a plot of the Tromino locations and modelled layers plotted over the classed corrected relative gravity data with gridded elevation contours.

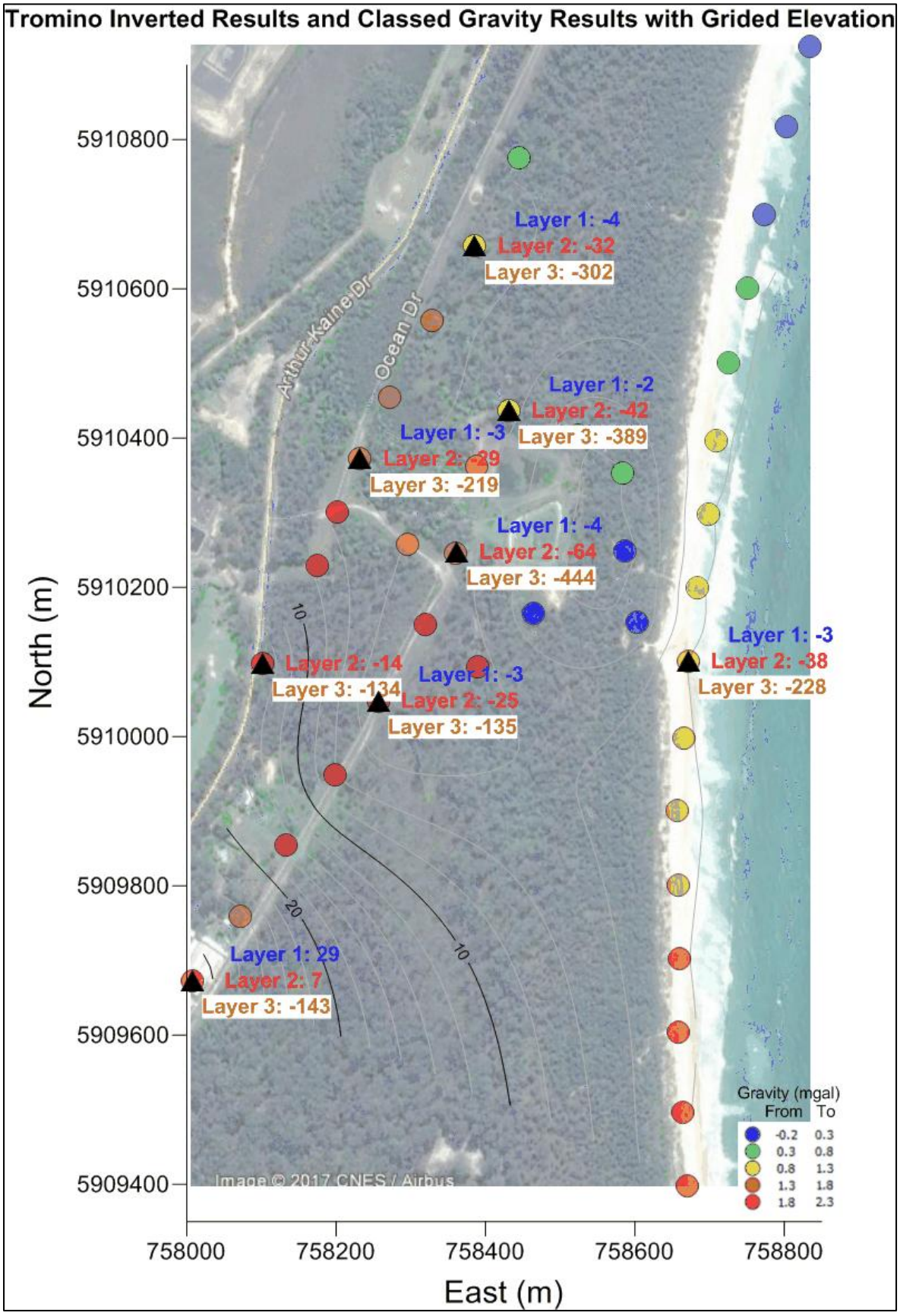

Figure 4:Tomino data acquisition location, Inverted Tromino results and classed corrected relative gravity results with gridded and contoured elevation

As there is no unique model for a particular data set, a requirement of gravity modelling, is to have a beginning model for inversions. There appears to have been no deep drilling undertaken on the site. With 12 shallow drill holes (4.65 to 10 m), undertaken in 1988, off the site on the western side of Arthur Kaine Drive, at the site of the current Merimbula Waste Water Treatment Plant. From the NSW Public Work Department report (*Merimbula Wastewater Augmentation, Wastewater Treatment Plant, Stage 2, Geotechnical Investigation. Report 88187. December 1988*.), the top 5 to 10 metres of that site is sand, silty sand, silty sand with trace of clay, and silty clayey sand. At no location tested was firmer material recovered. Due to the lack of deep drill hole information and limited geological information available on the site, we have used the results from the small number of passive seismic data points collected with the Tromino, for the generation of seed models for each inversion. These basic geological models generated, from the Tromino results, was used as starting points for modelling the gravity profiles. An example of an averaged site seed model is shown below. It is a four layer model with density increasing with depth. A four layer model with density contrasts of 0, 0.4, 0.7 and 1.2 g/cc over a background of 1.6 g/cc was used in the seed model. These values are based on dry sand, wet sand and gravel, sandstone and basalt average densities for the respective layers.

Depths at the stations occupied with the Tromino were fixed during the inversions. However if an unrealistic model was produced the station near the perceived error was allowed to move in the Z direction, all stations were locked in the X direction.

From Tromino inversions		Geological Model	Assumptions	
Average layer thickness (m)	Average Vp (m/s)		Density (g/cc)	Relative density (g/cc)
5	969	Dry sand /soil	1.6	0
37	1814	Wet Sand / unconsolidated material (Tertiary sediments? - velocities not high enough for well consolidated material)	2	0.4
257	3388	Bedrock - could be Devonian sedimentary rocks	2.3	0.7
not detected	not detected	Crystalline volcanic basement possibly Devonian rift material	2.8	1.2

Figure 5: Basic conceptual geological model generated from the averaged Tromino iversions. The actual model used to seed the gravity inversions differed only in the thickness of the layers.

Six profile lines were modelled from the corrected gravity data; Tabulated results are given below in Tables 9 to 13. Plots of each modelled profile at different elevation scales are given below in Figures 6 to 17 below. The surface elevation and three interfaces are plotted as colour filled contour plots, these are supplied in the attached drawing GBGA2068-01.

During the modelling process an extra two vertices were added at each end of the profiles (at 100 m spacing). This was to overcome abrupt changes in structure at the edge of the model.

Line 1

Line 1 consisted of Stations 16 to 1 running from south to north.

The seed model for the inversion used the depths generated from the inversion of Tromino data at Station 9. The layer depths at this station was fixed, all X locations were locked.
This profile was collected along the beach. It shows an increasing gravity response to the south. The model shows that this is due to the thinning of the top 2 layers and the underlying rock sequences (Layers 3 and 4) coming closer to the surface in the south of the profile.
The layer depths at Station 9 were locked during the modelling of the gravity data.

Table 9: Line 1 modelled layers

Station	Easting (m) MGA 55H, GDA 94	Northing (m) MGA 55H, GDA 94	Surface Elevation mAHD	Top of Layer Elevation mAHD		
				Layer one	Layer two	Layer three
16	758670.800	5909398.190	2.091	0.4	-10	-195
15	758663.670	5909497.180	2.228	1.5	-18	-193
14	758657.720	5909603.850	2.480	0.6	-29	-196
13	758659.880	5909702.100	2.214	0.2	-22	-200
12	758658.350	5909800.700	2.398	0.3	-30	-203
11	758657.350	5909900.860	2.596	0.5	-31	-207
10	758666.290	5909998.630	2.261	0.3	-31	-208
9	758671.110	5910100.910	1.845	-3.0	-38	-228
8	758683.200	5910199.800	2.325	-2.9	-36	-220
7	758698.560	5910297.920	2.146	-5.5	-42	-230
6	758708.350	5910396.640	2.470	-2.1	-39	-238
5	758725.990	5910500.330	2.427	-6.5	-46	-248
4	758751.140	5910600.950	2.190	-7.0	-49	-257
3	758772.400	5910699.260	2.433	-8.8	-54	-269
2	758803.350	5910817.930	2.323	-10.7	-63	-278
1	758834.350	5910923.910	2.401	-22.7	-76	-273

Modelled Profile for Line 1

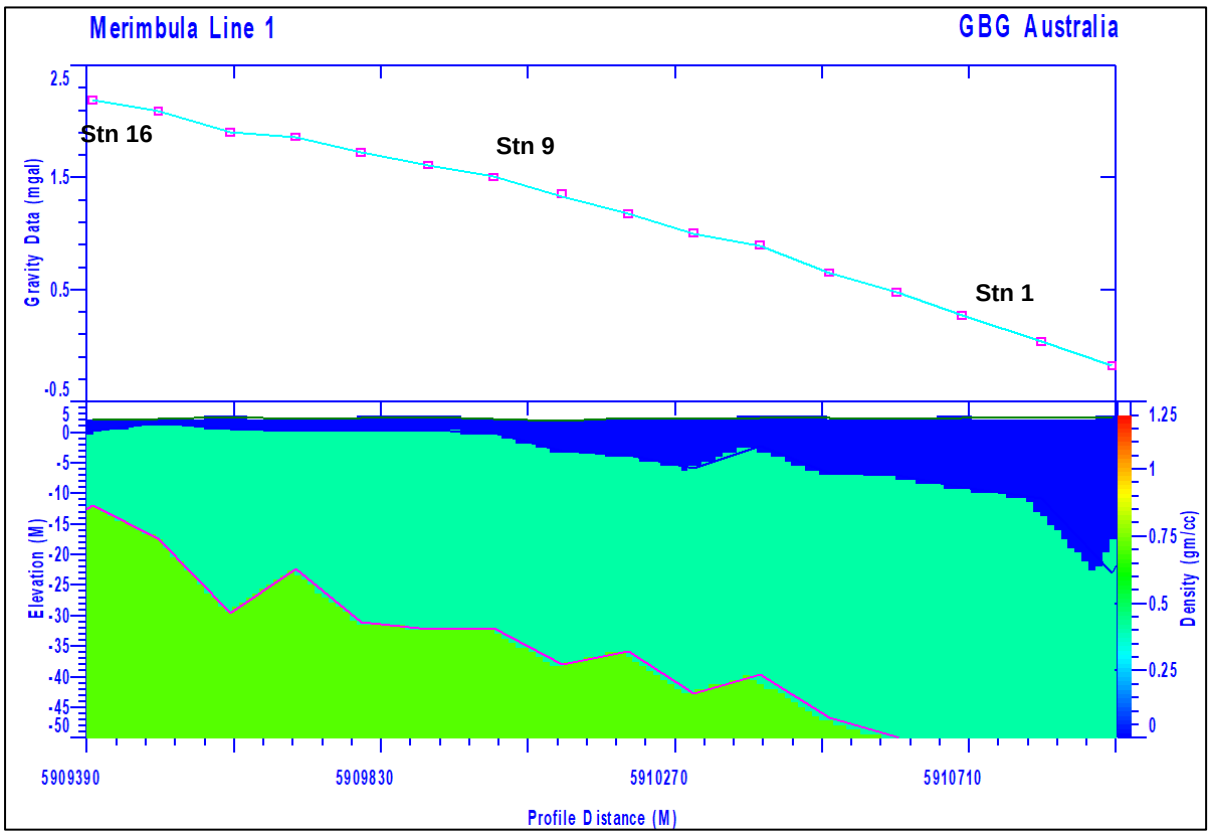

Figure 6: Modelled section projected along Line 1: Stations 16 to 1, 4 Layers modelled, displaying to -50 m AHD.

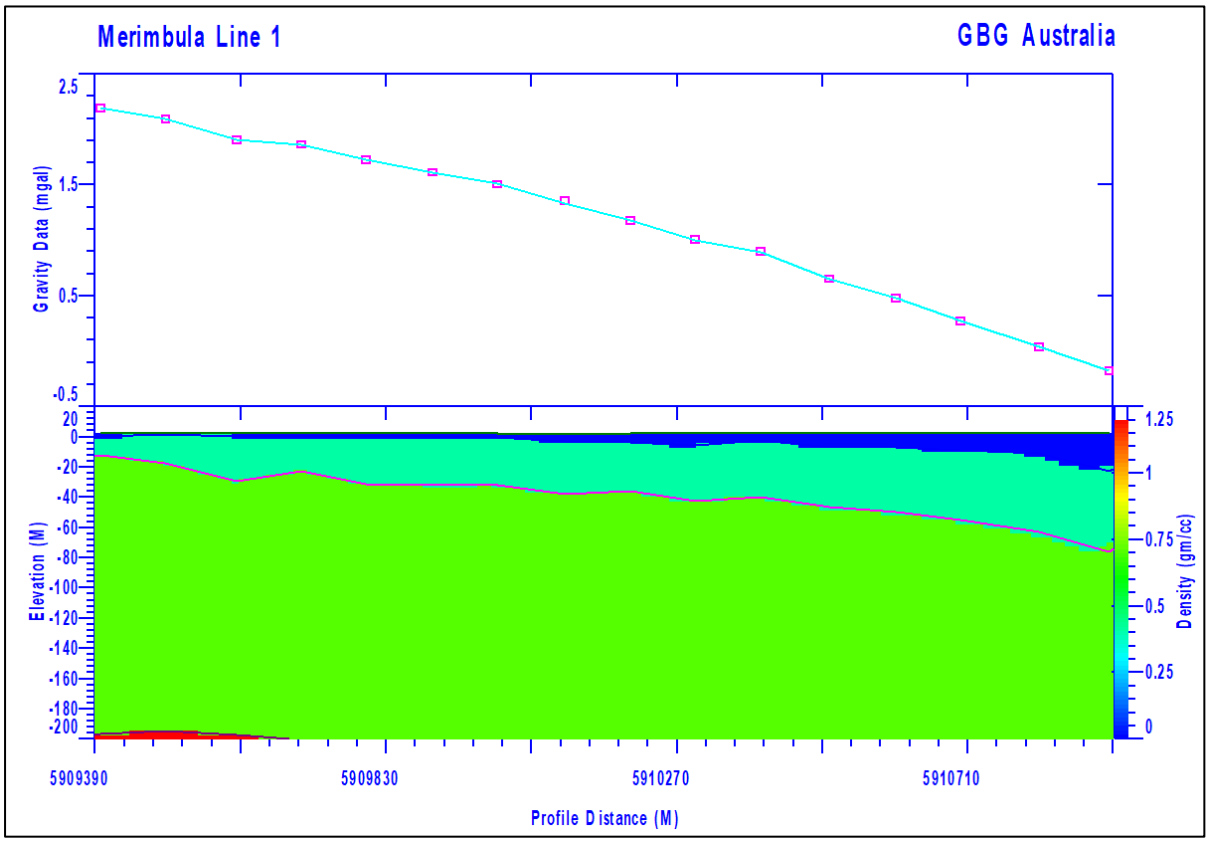

Figure 7: Modelled section projected along Line 1: Stations 16 to 1, 4 Layers modelled, displaying to -200m AHD.

Line 2

Line two consisted of Stations; 31, 30, 29, 28, 27,26, 34, 33 & 32 running from south to north.

The seed model for the inversion used the depths generated from the inversion of Tromino data at Stations; 27,31,32,34. Initially the layer depths at these stations were fixed. However, due to the seemingly unrealistic results that occurred if the depths were locked, the layer depths at all Stations were unlocked during the modelling, all X locations were locked.

Data displayed as Line 2 was collected along the service road running parallel with the electrical transmission line behind the dune line to the west of the beach. It shows a marked increasing response towards the centre of the profile and then towards the southern extent the response decreases, it is not coincident with the increasing elevation as would be expected. The model shows that this is due to the inferred underlying rock layer rising steeply towards the surface in the south of the profile; there are undulations of 10 to 30m in the Devonian sedimentary rocks.

Table 9: Line 2 modelled layers

Station	Easting (m) MGA 55H, GDA 94	Northing (m) MGA 55H, GDA 94	Surface Elevation mAHD	Top of Layer Elevation mAHD		
				Layer one	Layer two	Layer three
31	758007	5909673	31.393	29.0	-4	-130
30	758072	5909759	27.033	12.0	-15	-127
29	758133	5909855	14.758	5.0	-34	-168
28	758198	5909949	5.896	0.0	-34	-160
27	758256	5910048	2.125	-3.0	-24	-135
26	758319	5910150	2.182	-4.0	-19	-289
34	758360	5910246	3.114	-4.0	-17	-440
33	758387	5910362	3.077	-2.0	-15	-344
32	758431	5910436	3.319	-2.0	-42	-390

Modelled Profiles for Line 2

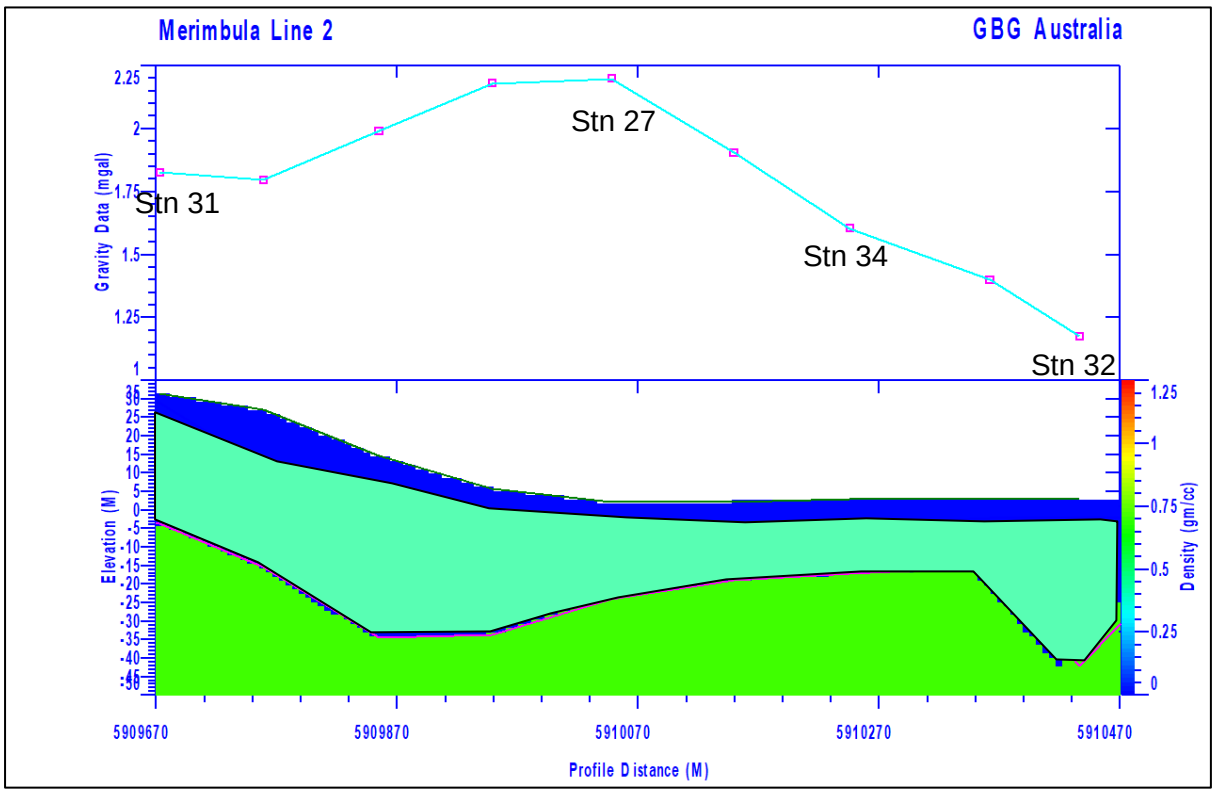

Figure 8: Modelled section projected along Line 2: Stations 31 to 32, 4 Layers modelled, 4 Layers modelled, displaying to -50m AHD.

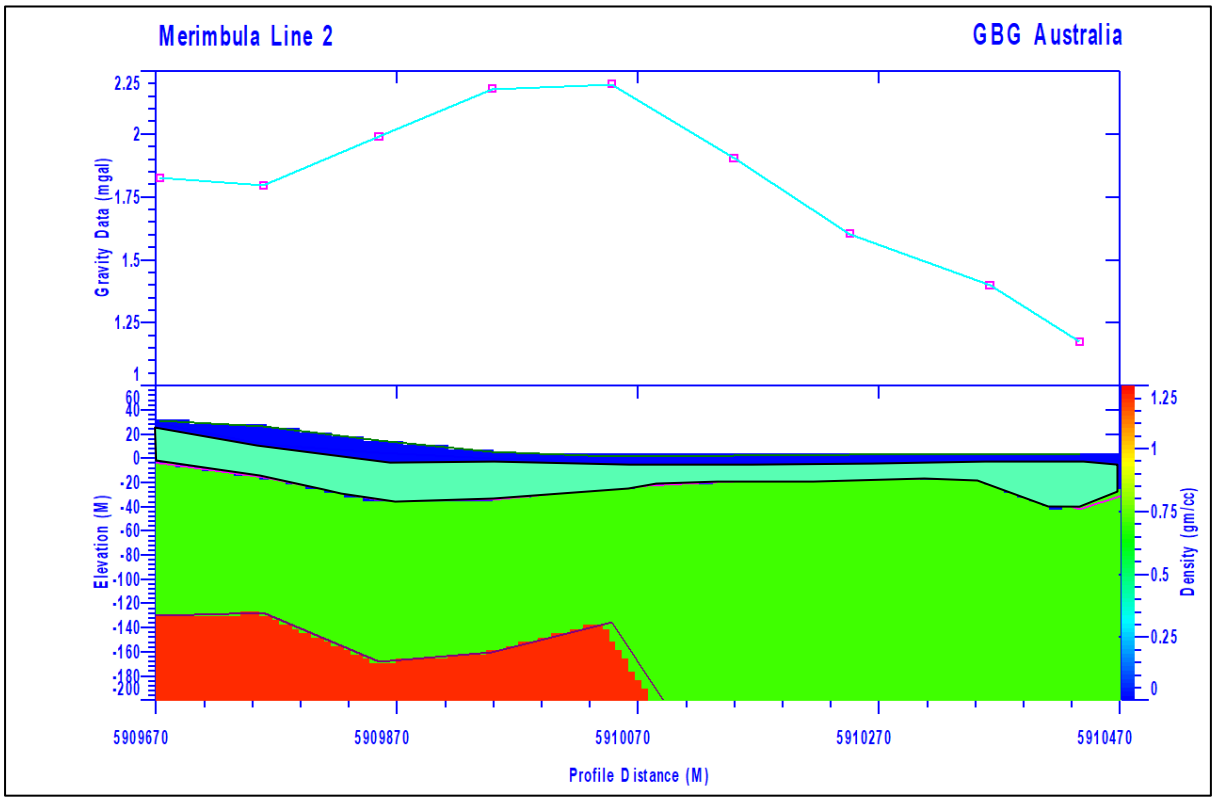

Figure 9: Modelled section projected along Line 2: Stations 31 to 32, 4 Layers modelled, 4 Layers modelled, displaying to -200m AHD.

Line 3

Line 3 was collected along the service road running parallel with the electrical transmission line to the close to Arthur Kaine Drive. It shows a marked increasing response to the south which coincides with the increasing elevation. The model shows that this is due to the inferred underlying deeper rock layer coming steeply towards the surface in the south of the profile.

The layer depths at Stations 19, 22 & 25 were locked during the modelling of the gravity data, all X locations were locked.

The model is a good fit as can be seen from the cyan line passing through the plotted corrected gravity values.

Table 10: Line 3 modelled layers

Station	Easting (m) MGA 55H, GDA 94	Northing (m) MGA 55H, GDA 94	Surface Elevation mAHD	Top of Layer Elevation mAHD		
				Layer one	Layer two	Layer three
25	758101	5910098	15.958	1.9	-14	-134
24	758175	5910229	7.556	-4.6	-27	-191
23	758201	5910300	5.470	0.0	-40	-224
22	758232	5910372	2.954	-3.0	-29	-219
21	758272	5910454	1.306	-0.7	-31	-245
20	758328	5910558	1.722	-6.5	-15	-260
19	758385	5910657	1.311	-4.0	-32	-302
18	758445	5910776	2.162	-17.7	-30	-288

Modelled Profile for Line 3

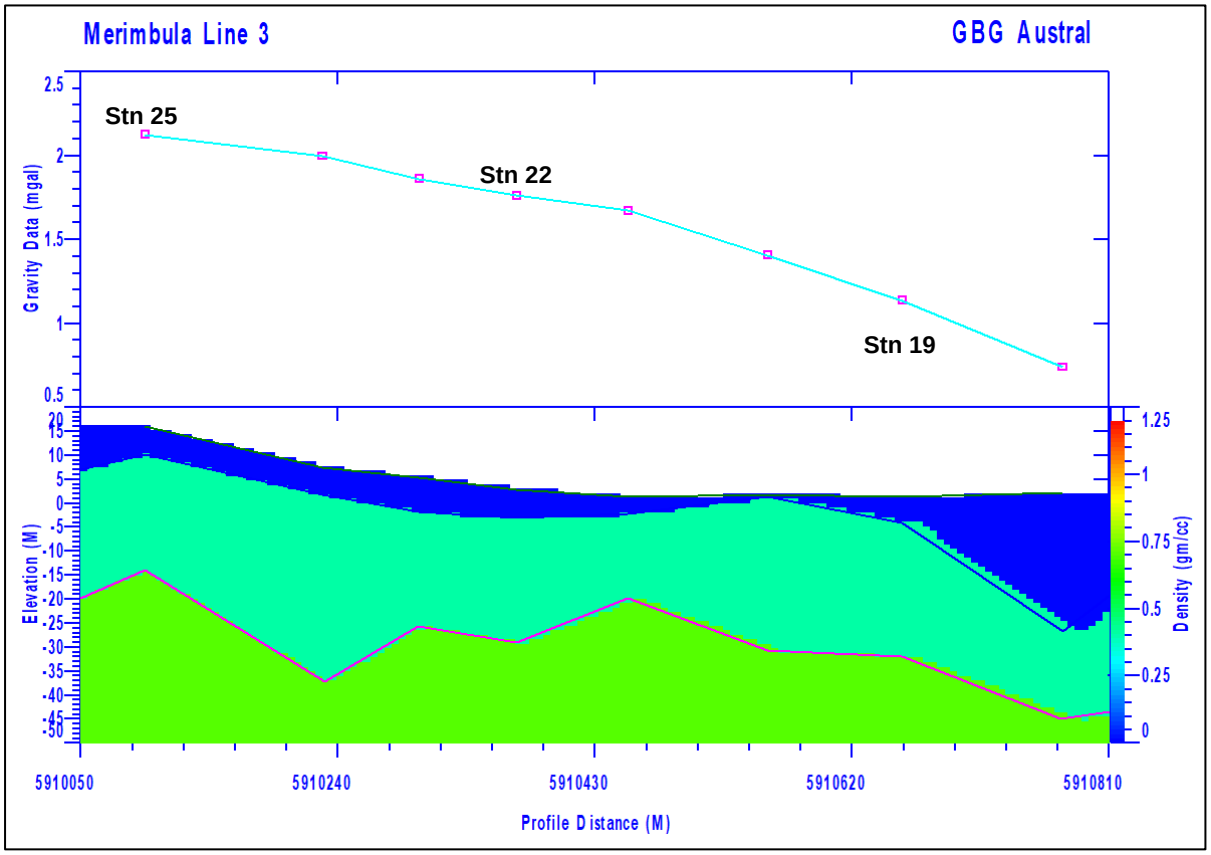

Figure 10: Modelled section projected along Line 3: Stations 25 to 18, 4 Layers modelled, displaying to -50m AHD.

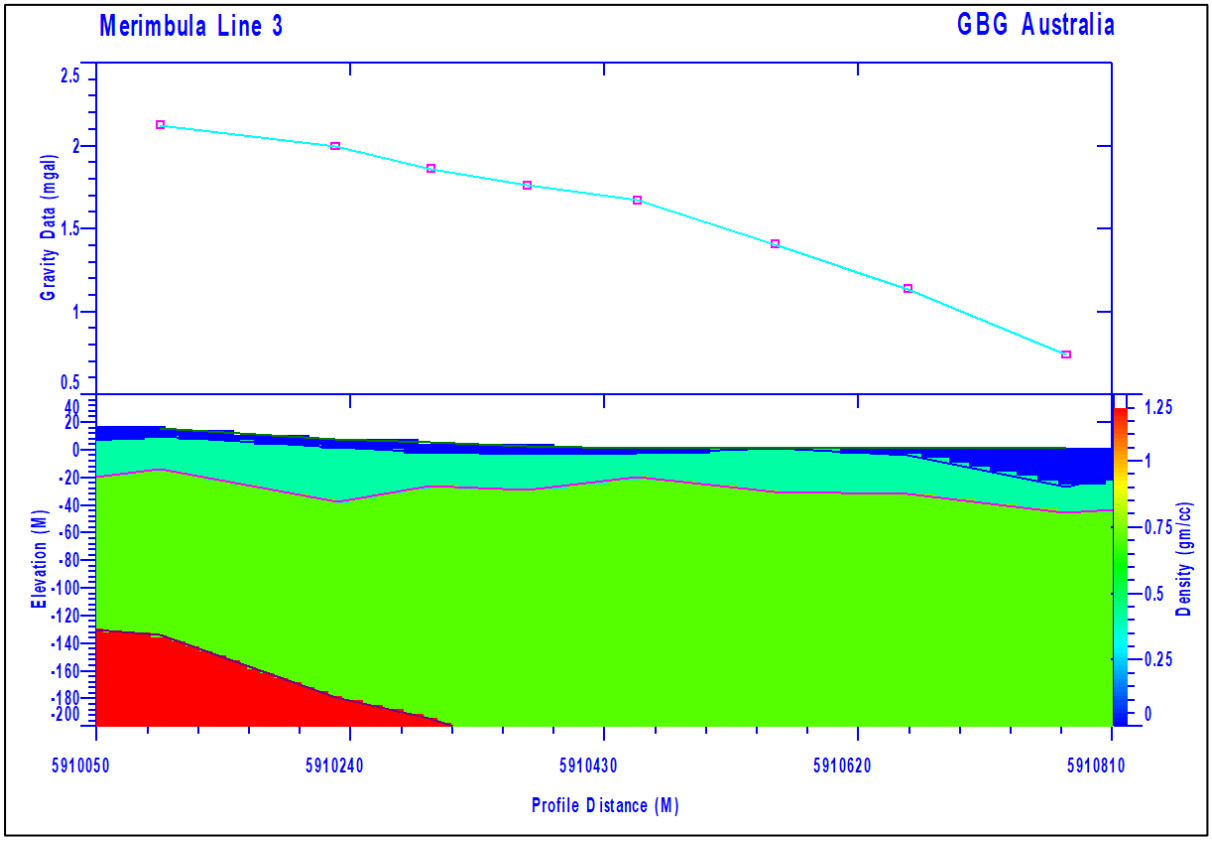

Figure 11: Modelled section projected along Line 3: Stations 25 to 18, 4 Layers modelled, displaying to -200m AHD.

Line 4

Line 4 consists of Stations; 23, 35, 34, & 9. Profile Line 4 is the southern, east west profile. As the profile consists of only 4 data points it is felt that the inversion may not be a realistic representation of the subsurface. The model was seeded using the average depths found from the Tromino inversions at Station 34, and Station 9 For the modelling of the gravity profile depths at these Stations were not fixed, with an additional node placed internally (the stating values for this node were the averages of the stating model values on either side of it). to allow a more even spread of modelling nodes.

The model is presented below in Figures 12 and 13.

The model is a very good fit as can be seen from the cyan line passing through all five of the data points of the plotted corrected gravity values.

Table 11: Line 4 modelled layers

Station	Easting (m) MGA 55H, GDA 94	Northing (m) MGA 55H, GDA 94	Surface Elevation mAHD	Top of Layer Elevation mAHD		
				Layer one	Layer two	Layer three
23	758201	5910300	5.47	6	-22	-172
35	758296	5910257	3.941	1	-14	-177
34	758360	5910246	3.114	-4	-64	-444
9	758671	5910101	1.845	-3	-38	-228

Modelled Profile for Line 4

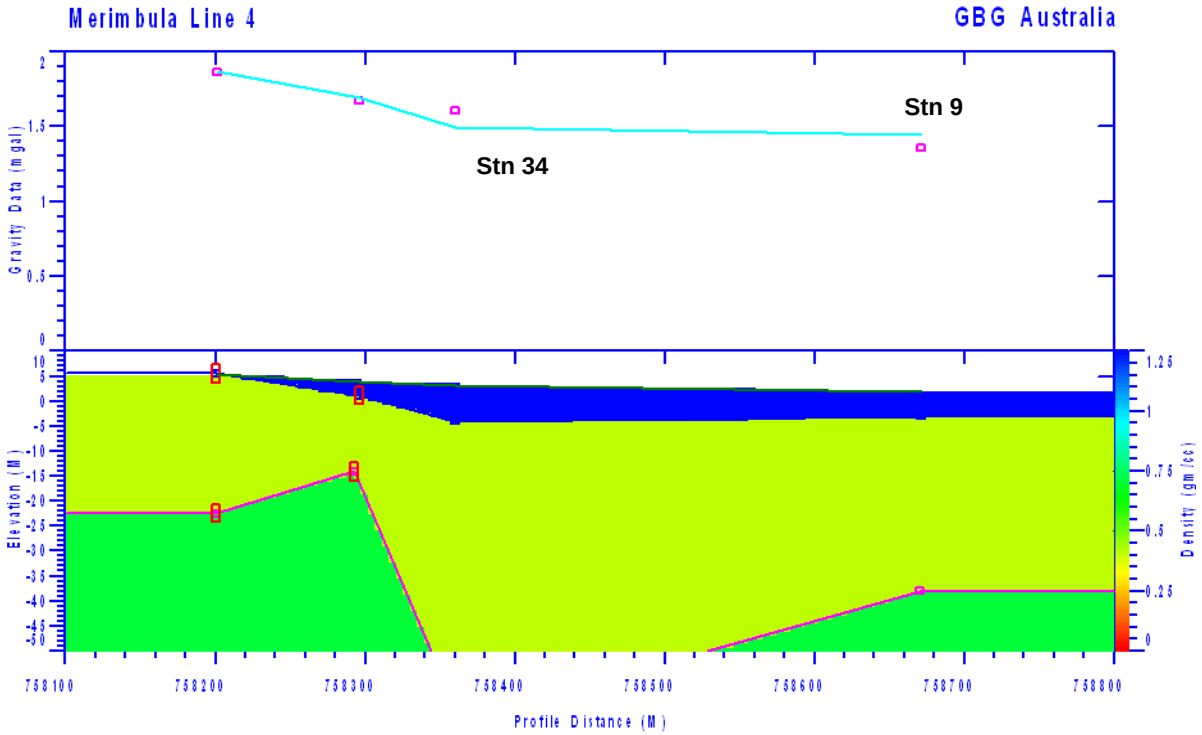

Figure 12: Modelled section projected along Line 4: Stations 23 to 9, 4 Layers modelled, displaying to -50m AHD.

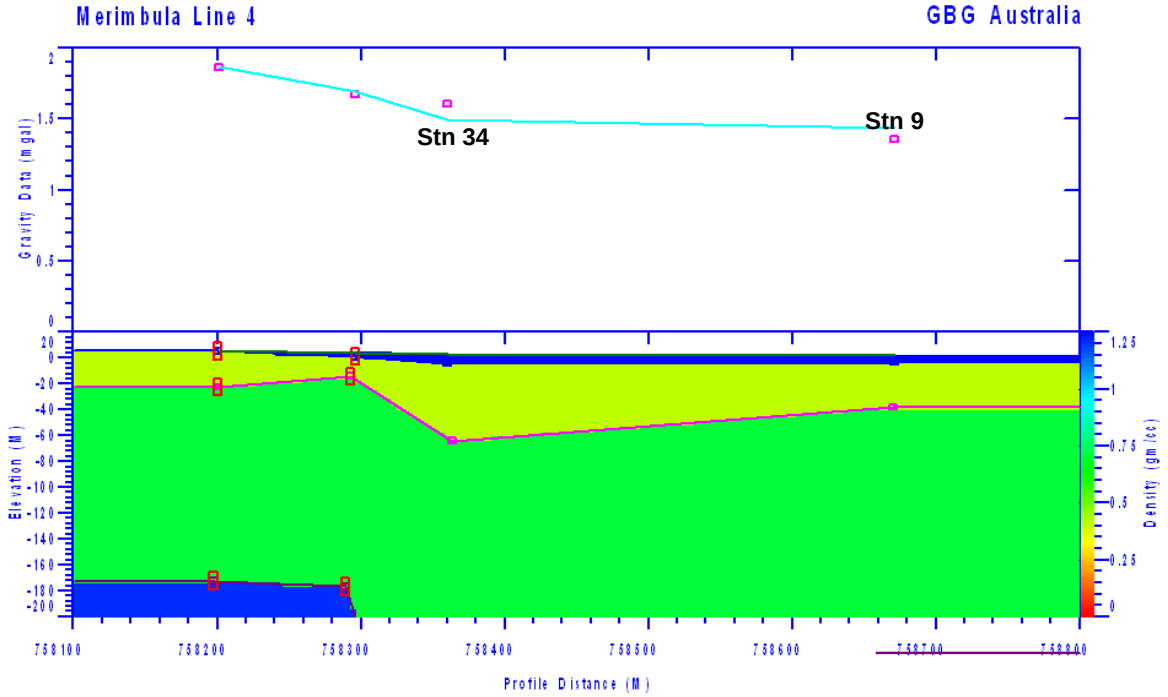

Figure 13: Modelled section projected along Line 4: Stations 23 to 9, 4 Layers modelled, displaying to -200m AHD

Line 5

Line 5 consists of Stations; 21, 33, 39, & 8.

Profile Line 5 is the central, east west profile. As the profile consists of only 4 data points it is felt that the inversion may not be a realistic representation of the subsurface. The model was seeded using the average depths found from the Tromino inversions at Station 32, and the depths from the inversion of Line 1 at Station 8. For the modelling of the gravity profile no depths were fixed and all x locations were fixed

The model is presented below in Figures 14 and 15.

The model is a good fit as can be seen from the cyan line passing through the plotted corrected gravity values.

Table 12: Line 5 modelled layers

Station	Easting (m) MGA 55H, GDA 94	Northing (m) MGA 55H, GDA 94	Surface Elevation mAHD	Top of Layer Elevation mAHD		
				Layer one	Layer two	Layer three
21	758272	5910454	1.306	-2.9	-26	-295
33	758387	5910362	3.077	-2.0	-36	-300
39	758586	5910248	8.738	-68.3	-80	-306
38	758683	5910200	2.325	2.2	-53	-304

Modelled Profile for Line 5

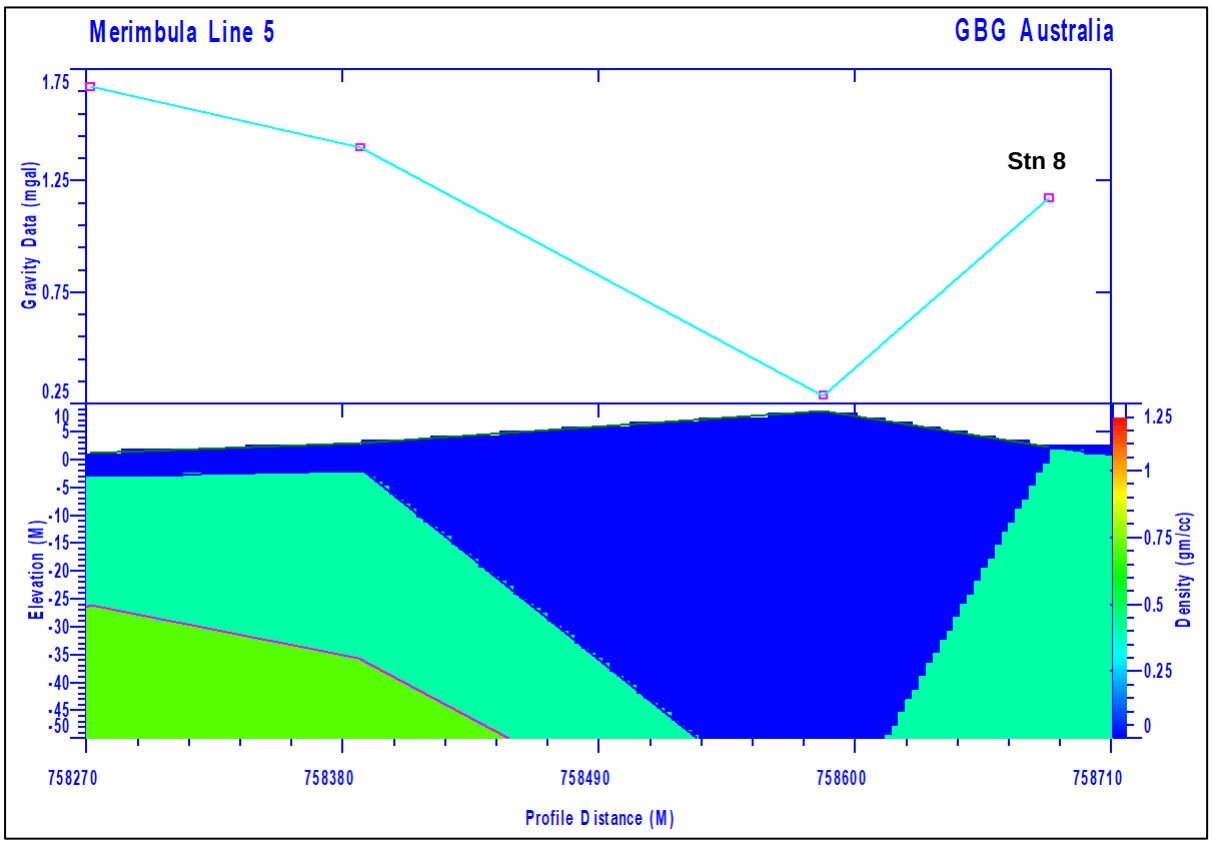

Figure 14: Modelled section projected along Line 5: Stations 21, 33, 39 & 8, 4 Layers modelled, displaying to -50m AHD

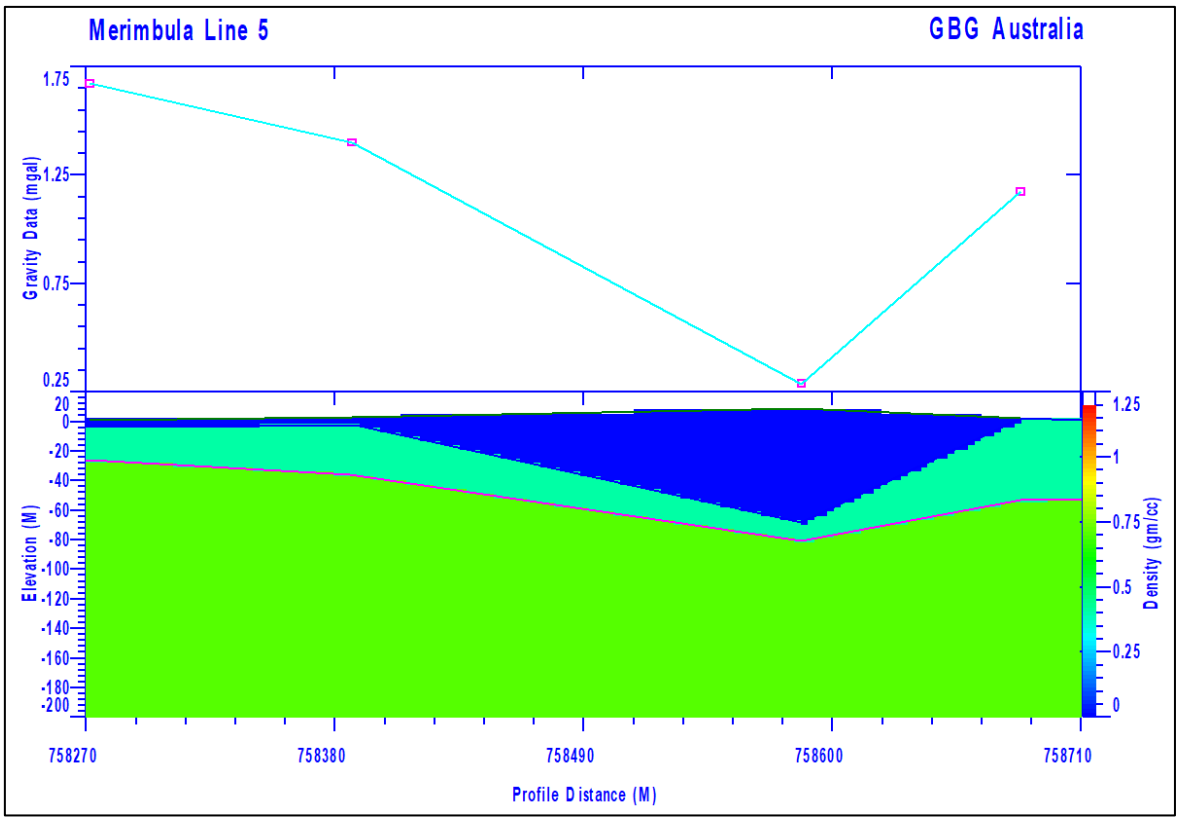

Figure 15: Modelled section projected along Line 5: Stations 21, 33, 39 & 8, 4 Layers modelled, displaying to -200m AHD

Line 6

Line 6 consists of Stations; 20, 32, 41, 40 & 7.

Profile Line 6 is the most northern of the east west profiles. As the profile consists of only 5 data points it is felt that the inversion may not be a realistic representation of the subsurface. The model was seeded using the depths found from the Tromino inversions at Station 32. For the modelling of the gravity profile the depths at Station 32 were fixed.

The model is presented below in Figures 16 and 17.

The model is a good fit as can be seen from the cyan line passing through the plotted corrected gravity values.

Table 13: Line 6 modelled layers

Station	Easting (m) MGA 55H, GDA 94	Northing (m) MGA 55H, GDA 94	Surface Elevation mAHD	Top of Layer Elevation mAHD		
				Layer one	Layer two	Layer three
20	758328	5910558	1.722	-3.6	-37	-397
32	758431	5910436	3.319	-2.0	-42	-389
41	758524	5910403	7.936	-51.6	-52	-399
40	758583	5910354	8.111	-51.4	-67	-401
7	758699	5910298	2.146	-8.0	-56	-402

Modelled Profile for Line 6

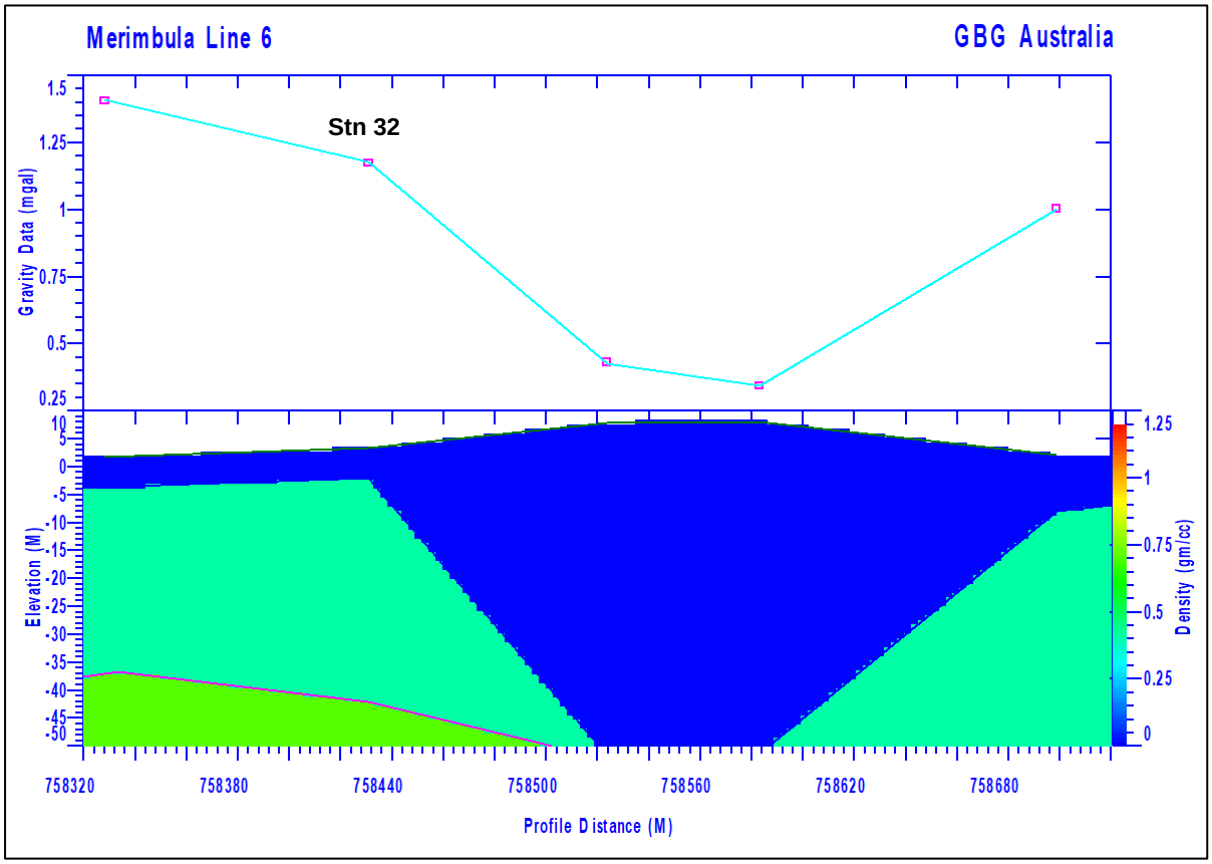

Figure 16: Modelled section projected along Line 6: Stations 20, 32, 41, 40 & 7, 4 Layers modelled, displaying to -50m AHD

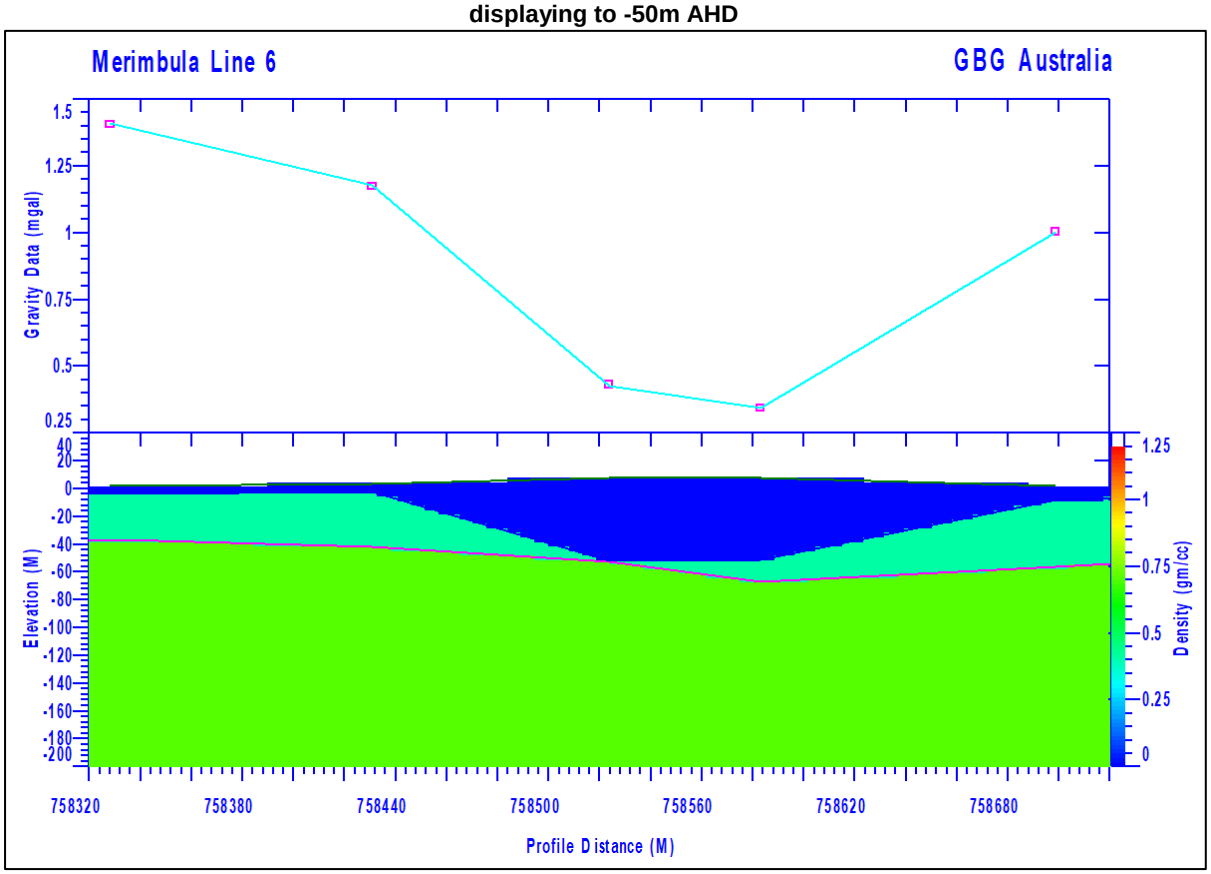

Figure 17: Modelled section projected along Line 6: Stations 20, 32, 41, 40 & 7, 4 Layers modelled, displaying to -200m AHD

6. DISCUSSION

Assumptions were made as to the type of rock underlying the site, these in conjunction with the passive seismic data led to the development of seed models for each of the profile models. These assumptions are given in the seed model shown above.

Depth of the Devonian sedimentary sequence is modelled as deepening to the north along each profile.

The deeper basement material is modelled to be deeper than 140m below sea level. This could be shallower but with limited information and the assumptions made in this report. And is also deepening to the north.

The area around the pond (central area of the site) appears to have some deeper levels for the rock sequence. However as this was only assessed from the Tromino reading at Station 34 there is insufficient data to gain a consistent model over this area. The gravity data would present profiles with only 4 to 6 data points. The passive seismic collected at Station 34 reveals an inversion with both the interpreted sedimentary layer and the volcanic being considerably deeper in this region. At this time it is not known if the data from this section of the site is realistic or not as there has been no drilling undertaken on the site.

To adequately constrain any modelling of data from this site (indeed any site) we recommend a number of holes be drilled and logged.

Further geophysical techniques that would be useful on this project are; Passive seismic using Tromino and or Refraction Microtremor (ReMi). Using the Tromino additional passive seismics data collection within the site to give a grid of data, enabling contour surfaces over the site to be constructed.

Additionally Refraction Microtremor (ReMi) method could be undertaken, using 5m spaced geophones, to gain profiles of shear wave velocities along the existing tracks and the beach at high data density (say 20m sample spacing). ReMi involves minimal disturbance as it is a passive seismic technique using ambient noise for energy. Access would be gained along tracks and the beach. The technique has minimal impact on the ground and environment.

7. CONCLUSIONS

A gravity survey was successfully undertaken at Merimbula, NSW.

As there is no unique model for a particular data set, there is a need to have a seed model to commence with. Due to the lack of geological information and drill hole data, we have used the Tromino to collect a limited set of point passive seismic data, for the generation of seed models. The basic geological model generated, from the Tromino results, was used as a starting point for modelling the gravity profiles.

The seed model used for the inversions was a four layer model with density increasing with depth. Density contrasts of 0, 0.4, 0.7 and 1.2 over a background of 1.6 g/cc were used in the seed model.

Three south to north profiles were modelled. All display decreasing depth of cover of the rock layers towards the south of the investigation area. Line 1 was along the beach with no topographical relief in evidence. Lines 2 and 3 are on Electrical Transmission Line alignments with elevation increasing to the south of the profiles. There is no corresponding

increase in response with elevation in the processed data from Line 2, Line 3 had an increase in elevation that is coincident with an increased gravity response. The models for Lines 2 and three display a marked rise in the lower layer towards the southern end of each profile.

The three cross profiles, Lines 4, 5 & 6, are from west to east and show a deepening section of the underlying material towards the centre of the site. This may be correct but it should also be noted that these profiles have a limited number of data points.

Care should be taken in accepting the inversion results as definitive. The site must be investigated further, including drilling.

For and on behalf of

Regards,

FOR AND BEHALF OF GBG AUSTRALIA PTY LTD

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B.Sc (Hons Geophys/Geochem)