WEST NOWRA RECYCLING AND WASTE FACILITY

Proposed Stage 4 Landfill Extension
Concept Design Report

Prepared for:

Shoalhaven City Council
36 Bridge Street
Nowra NSW 2541

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Shoalhaven City Council (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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DOCUMENT CONTROL

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1 Introduction

1.1 Scope and Project Requirements

Shoalhaven City Council (SCC) is proposing to develop an extension to the existing landfill operation (the Proposal) at the West Nowra Recycling and Waste Facility (the Facility) at Flatrock Road, Mundamia.

The key components required for the Proposal are as follows:

- Prepare a Landfill Master Plan for the operation of the landfill extension;
- Revise the existing Landfill Environmental Management Plan (LEMP) to include the proposed Landfill Extension development at the Facility.
- Undertake the Conceptual Design for the proposed Landfill Extension, sufficient in detail to be incorporated within the Environmental Impact Statement (EIS) application to gain approval for a concept design.

This document presents the basis of the conceptual landfill design, including input data and assumptions, regulatory requirements, conceptual drawings and technical specifications. The Master Plan and Landfill Environmental Management Plan (LEMP) are presented under separate cover.

The concept design represents Stage 4 at the Facility, and is aligned to the east of the current landfill operation, and takes into account required buffer zones from residential dwellings and properties, and from an environmental exclusion and conservation areas (i.e. Nowra Heath Myrtle).

It should be noted that the concept design for the landfill extension is required to meet the needs of the EIS submission and inform the technical studies of its siting and environmental impacts. The concept design is not intended to be at a level of detail to allow for final construction or to be issued for tendering to a construction contractor. The concept design will provide sufficient detail to allow accurate predictions of waste void capacity, and estimate construction cut and fill volumes as well as to derive lining, drainage and leachate requirements.

The scope of work to be covered as part of the conceptual design includes consideration of:

- Void space maximisation within the nominated extension footprint, for maximum landfill life expectancy;
- Side slope geometry and stability;
- Materials suitability;
- Base liner requirements;
- Leachate collection and extraction infrastructure;
- Leachate treatment requirements (dams, localised storage, irrigation and evaporation infrastructure etc);
- Surface water management;
- Groundwater management;
- Consideration of gas control requirements;
- Local dimensional and construction methods requirements; and
- Final capping and rehabilitation profile.

1.2 Regulatory Overview

The concept design is required to conform to the Environmental Guidelines: Solid Waste Landfills (Environmental Guidelines) (NSW EPA, 2016). Appendix A provides a full summary of the minimum requirements for the design components, and these are summarised in **Table 1**.

Table 1 Minimum Design Requirements

Design Component	Minimum Requirements
Landfill Siting	To identify and rank those sites that require the fewest engineering and management controls to meet the objectives of all State environmental protection policies.
Leachate Barrier System	The landfill must have a leachate barrier system to contain leachate and prevent the contamination of surface and groundwater over the life of the landfill. The leachate barrier system ensures that pollutants are not permitted to migrate beyond the boundaries of the premises.
Leachate storage and disposal	Sufficient leachate storage and disposal must be provided in order to not cause harm to the environment.
Surface water Management	Controls should be implemented to reduce erosion and minimise sediment load in surface water that is discharged from site.
Landfill gas management and monitoring	A landfill gas management program must be established to ensure that the appropriate engineering controls are in place to ensure that methane and other gases produced by the landfill are properly managed.
Final capping and revegetation	A completed landfill cell must be final capped and revegetated to ensure that waste is properly covered and remediated.

To establish best practice for the landfill design where not covered specifically by the NSW EPA Environmental Guidelines, reference has been made to the EPA Victoria Best Practice Environmental Management (**BPEM**) – Siting, design, operation and rehabilitation of landfills (Victorian Guidelines) (EPA Victoria, 2014).

2 Site Description

2.1 Site Location

The primary solid waste landfill that services the Shoalhaven Local Government Area is the West Nowra Recycling and Waste Facility (Facility), and it is located at 120 Flatrock Road, Mundamia, approximately 4.5km west of Nowra. The Facility is operated by Shoalhaven City Council (Council). The Facility currently receives waste from nine waste transfer stations and a domestic waste collections service, as well as public and commercial drop-off direct to the Facility. The location of the Facility can be found in **Figure 1**.

The Facility is bordered to the south by rural residential properties, with the closest being approximately 65m from the site boundary. Other surrounding land is predominantly undeveloped bushland, including the Bamarang Nature Reserve.

The Facility is located on parcels of land owned by Council and includes 14.52ha of undeveloped land, part of which is proposed for the Stage 4 extension of the existing landfill, as well as for environmental offsets.

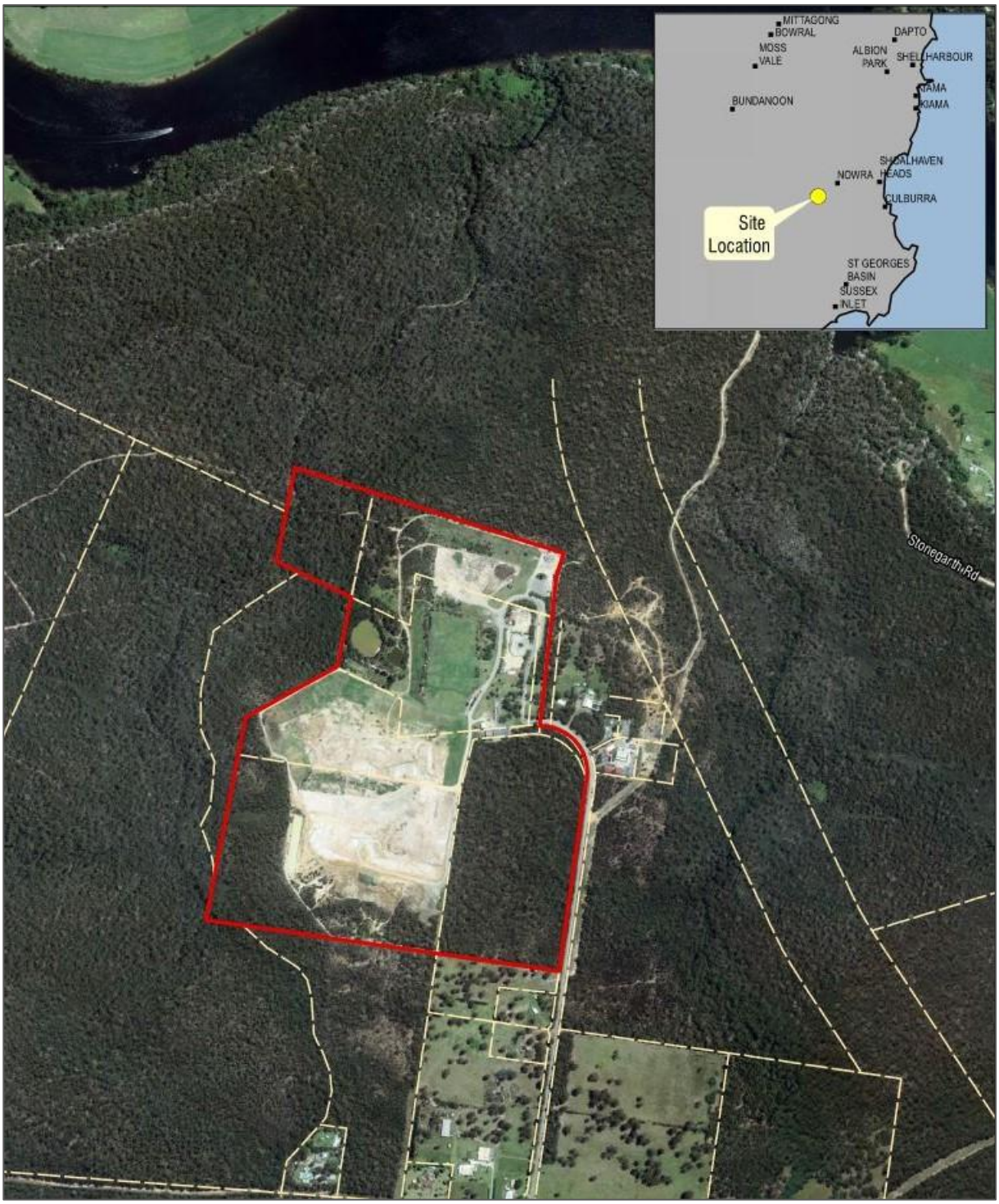


Figure 1 Site Location

The proposed Stage 4 landfill extension area is on Lot 1 DP 1104402, which is to the east of the stages 2 (Lot 1 DP 847203) and 3 (Lot 1 DP 870268) as can be seen in **Figure 2**.

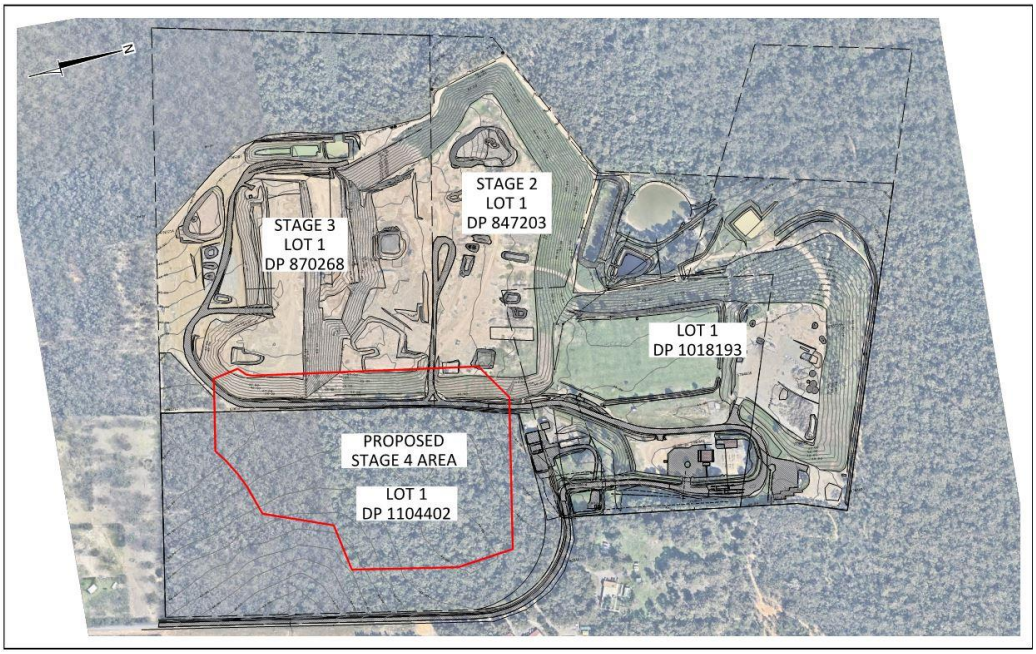


Figure 2 Current Landfill Layout

The footprint of the proposed Stage 4 landfill extension (the Proposal) is limited by a number of existing features, including existing Facility infrastructure, environmental conservation areas and a residential buffer zone. The development of the Proposal footprint is discussed in greater detail in Section 3.3.1, and is shown here in Figure 3.

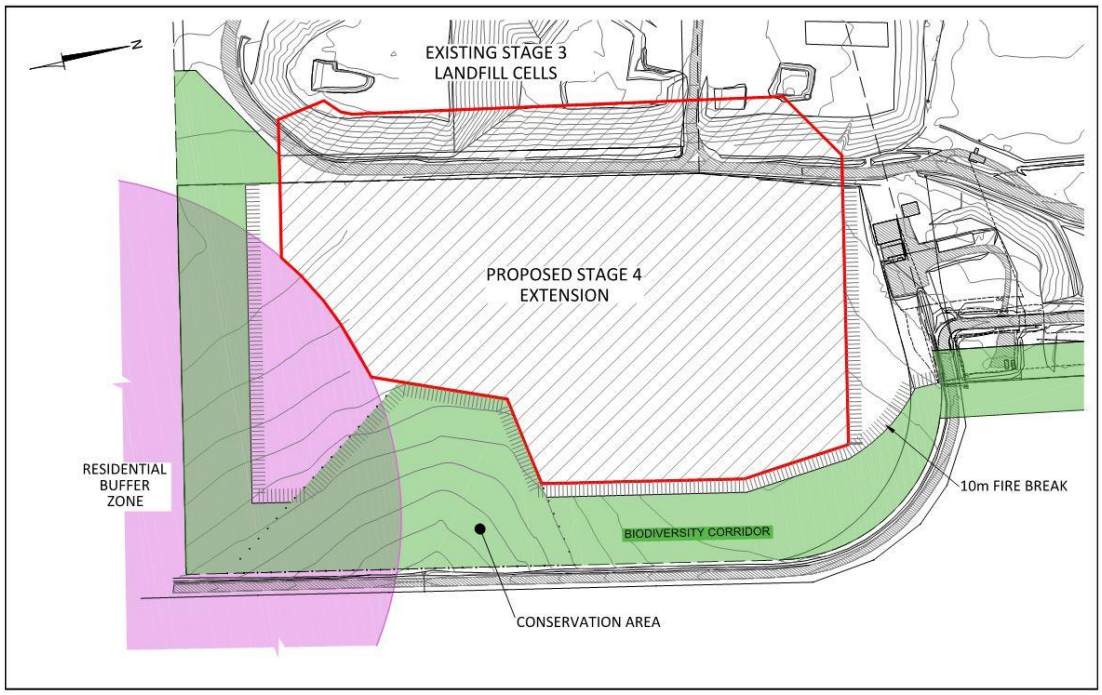


Figure 3 Proposed Stage 4 Extension Footprint

2.2 Site History

The Facility commenced operation in 1979. The current landfill operations were approved in 1988, under Environment Protection Licence (EPL) number 5877. The landfill originally received domestic, industrial and commercial liquid and solid wastes. Additionally, it has also received hazardous wastes such as asbestos and oil; however, with the exception of asbestos waste, the disposal of these wastes has been prohibited since 1996.

Historically, the landfill practices have consisted of the excavation and filling of a series of trenches. Operations have evolved over time to comply with the NSW EPA Guidelines. The development of the landfill has been divided into stages, which are:

- Stage 1 – "old" landfill area, stockpile and irrigation areas, and landfill gas extraction;
- Stage 2 – recently completed landfill area, currently utilised for stockpiling and landfill gas extraction;
- Stage 3 – the active landfill disposal area(s) and wet weather tipping area; and
- Stage 4 – proposed landfill extension area.

2.3 Topography and Hydrology

The Stage 4 landfill extension site is located approximately 1.5 km south and 2.5 km east of the Shoalhaven River. It is located on the eastern side of a ridge line, and is predominantly flat. There are several drainage features that border the extension site, with the area being predominantly drained by Cabbage Tree Creek, which flows northward to the Shoalhaven River.

The site area that is being investigated for the landfill extension proposal is approximately an area of 14.52 ha . The lowest point of the site is approximately RL 41 m, and the highest point of the site approximately RL 50m. The topography of the site is relatively flat with some undulatory variation. The surface drainage is predominantly to the north-west; however, the south-east portion of the site drains to the south east due to a localised bowl like feature. Within this bowl feature is a small drainage channel, and due to the presence of *Triplarina nowraensis* (Nowra Heath-Myrtle) it is to be protected. The site topography can be found in **Figure 4.**

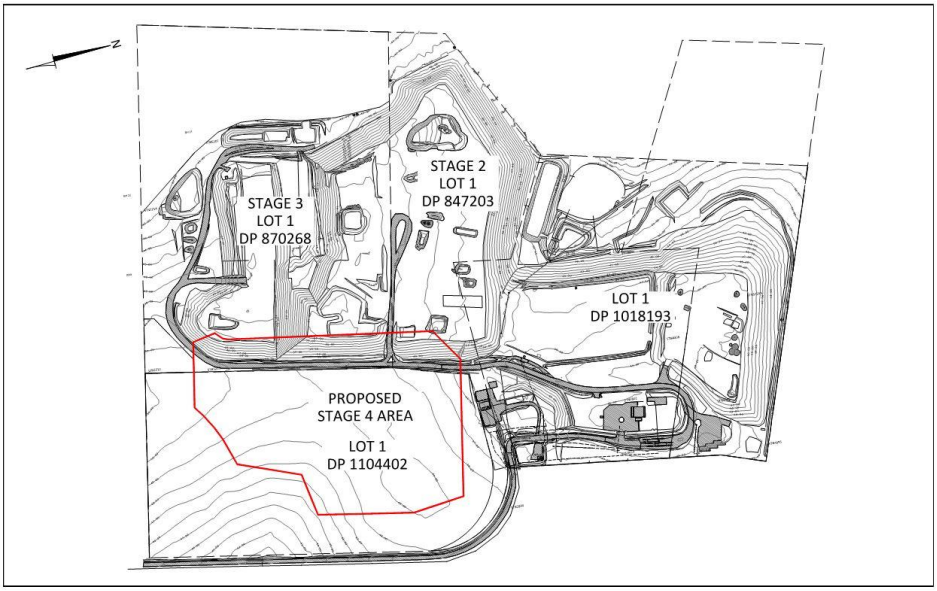


Figure 4 Site Topography

2.4 Geology

The site of the existing landfill and the proposed extension is underlain by Nowra Sandstone and Wandrawandian Siltstone of the Permian age Shoalhaven Group. The Shoalhaven Groups form the basal part of the Sydney Basin succession in the southern onshore extremity. The Shoalhaven group is predominantly comprised of marine shelf to coastal plain sediments. The Sydney Basin is part of the larger Sydney-Gunnedah-Bowen Basin (Tye, 1995)[1].

A study by Maunsell, 1991 states that the site of the existing and proposed landfill is typically underlain by (from top to bottom):

- 50 mm to 100mm of grey loam;
- 200 mm layer of yellow/white silt clay
- 300 mm layer of yellow clay; and
- >1600 mm red/yellow/white clay

A historical drilling report by Forbes Rigby, 1996 states that the depth to bedrock is highly variable and the condition of the bedrock ranges from moderately to heavily weathered.

SCC recently commissioned a geotechnical investigation of the proposed extension site (refer Section 3) and the findings are consistent with this existing information.

2.5 Hydrogeology

A previous site investigation by Forbes Rigby, 1996 for the existing landfill site area have shown that there are aquifers underlying the area. Two aquifers were noted in the site area – a semi-confined aquifer that follows the bedrock/overburden contact, and one within the sandstone unit. The depth to the groundwater table within both aquifers was typically found to be 2 m to 3 m below ground surface.

The Stage 1 area was noted to have a deep weathered sandstone profile that provides a highly permeable aquifer that bears water seasonally. The groundwater is believed to flow from northeast to southwest towards Sandy Creek.

Groundwater was noted during the recent site investigation as discussed in Section 3.

[1] http://passthrough.fw-notify.net/download/239097/http://ro.uow.edu.au/cgi/viewcontent.cgi?article=2983&context=theses

3 Site Investigation

3.1 Field Work

A site investigation was conducted by Coffey from 23 May 2016 to 1 July 2016. The field investigation comprised:

- Drilling of six (6) geotechnical boreholes (BH1-BH6), to a maximum depth of 10m;
- Excavation of 10 test pits (TP1-TP10) to a maximum depth of 6m;
- The drilling and installation of seven (7) standpipe piezometers to varying depths; and
- Laboratory testing on selected samples.

A copy of the Coffey report can be found in **Appendix B.**

The boreholes, piezometers and test pits were logged and sampled by Coffey's geotechnical engineer on site. The locations of the test locations can be found in **Figure 5.**

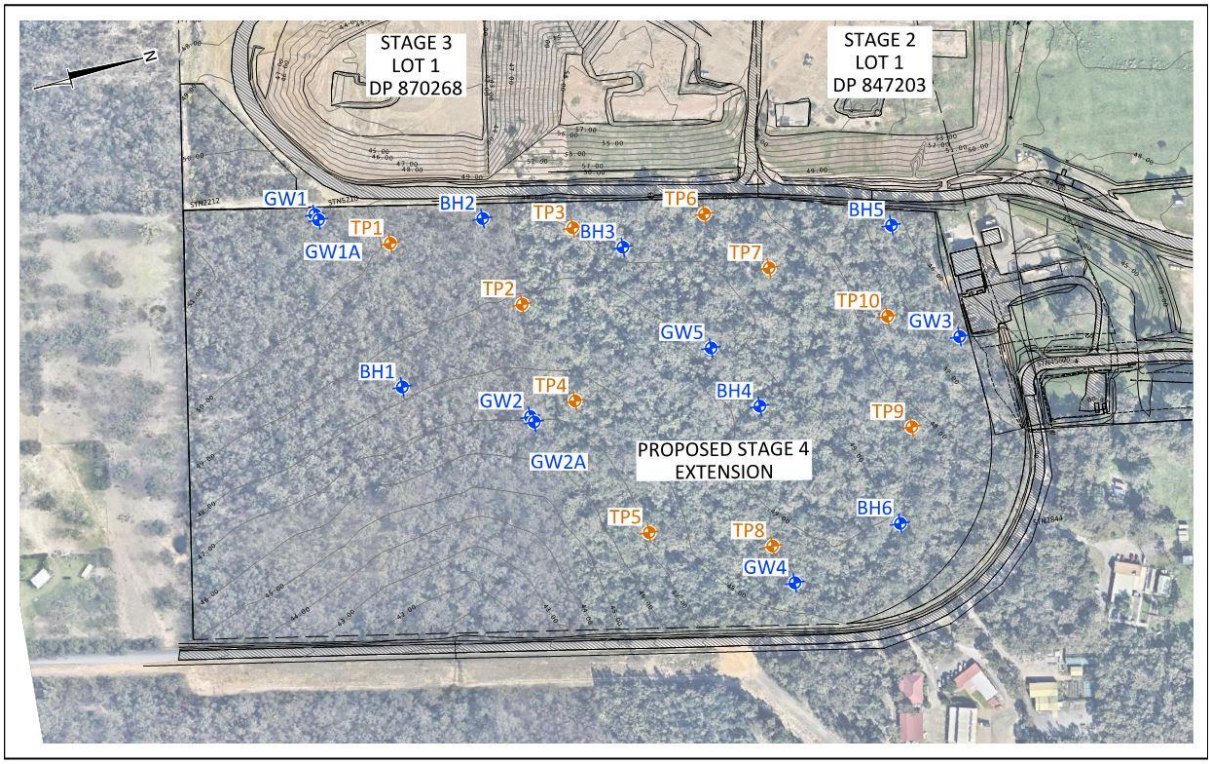


Figure 5 Site Investigation Test Location Plan

Boreholes GW1/GW1A and GW2/GW2A are very proximal as GW1A and GW2A contain shallow piezometers and GW1 and GW2 contain deep piezometers. The piezometers have been nested to ensure that groundwater variability, if present, is captured along the soil / bedrock interface.

3.2 Results

3.2.1 Ground Conditions

The top of bedrock was found to be between 6 and 7 m below ground surface and was found to be highly to moderately weathered sandstone. The groundwater table ranged from 5.5 m to 12 m below natural ground level. The overburden material is typically sandy or silty clay of low to high plasticity, overlying clayey sand, which is underlain by bedrock, comprising variably weathered sandstone. Excavator refusal occurred on bedrock in six of the test pits, ranging in depths from 2.5m to 4.5m.

3.2.2 Laboratory Testing

Laboratory testing has been conducted on selected recovered soil materials and indicates:

- Low dispersivity;
- Plasticity ranges from low to high plasticity, however the majority are of medium plasticity (i.e. liquid limit ranging from 35 to 50);
- High fines content; and
- Permeability results ranging from $5x10^{-9}$ m/s to $2x10^{-10}$ m/s.

3.2.3 Groundwater Conditions

The details of the piezometer installations can be found in **Table 2**.

Table 2 West Nowra Stage 4 Piezometer Details

Piezometer ID	Total Depth (mbgs)	Screen Depth (mbgs)	Top of Casing (RL m)	Depth to Water 15/8/2016 (mbgs)
GW1A	9.95	5.95 – 8.95	51.26	Dry
GW1	18.96	14.95 – 17.95	51.09	9.263
GW2A	9.93	5.93 – 8.93	47.71	Dry
GW2	17.94	13.94 – 16.94	47.84	8.04
GW3	18.91	14.91 – 17.91	47.06	6.503
GW4	13.78	9.78 – 12.78	49.26	9.984
GW5	18.88	14.88 – 17.88	49.77	9.455

The piezometers have been consistently monitored from 7 June, 2016 to 15 August, 2016. The average water levels of each piezometer over this time period can be found in **Table 3.**

Table 3 Average Water Level in Monitoring Wells from 7 June, 2016 to 15 August, 2016

Piezometer ID	Average Water Table Elevation (RL m)
GW1A	Dry
GW1	41.5
GW2A	Dry
GW2	39.9
GW3	40.6
GW4	38.5
GW5	40.4

The water monitoring data has also been plotted with the local rainfall data to show any fluctuations due to surface water infiltration; this can be found in **Figure 6**.

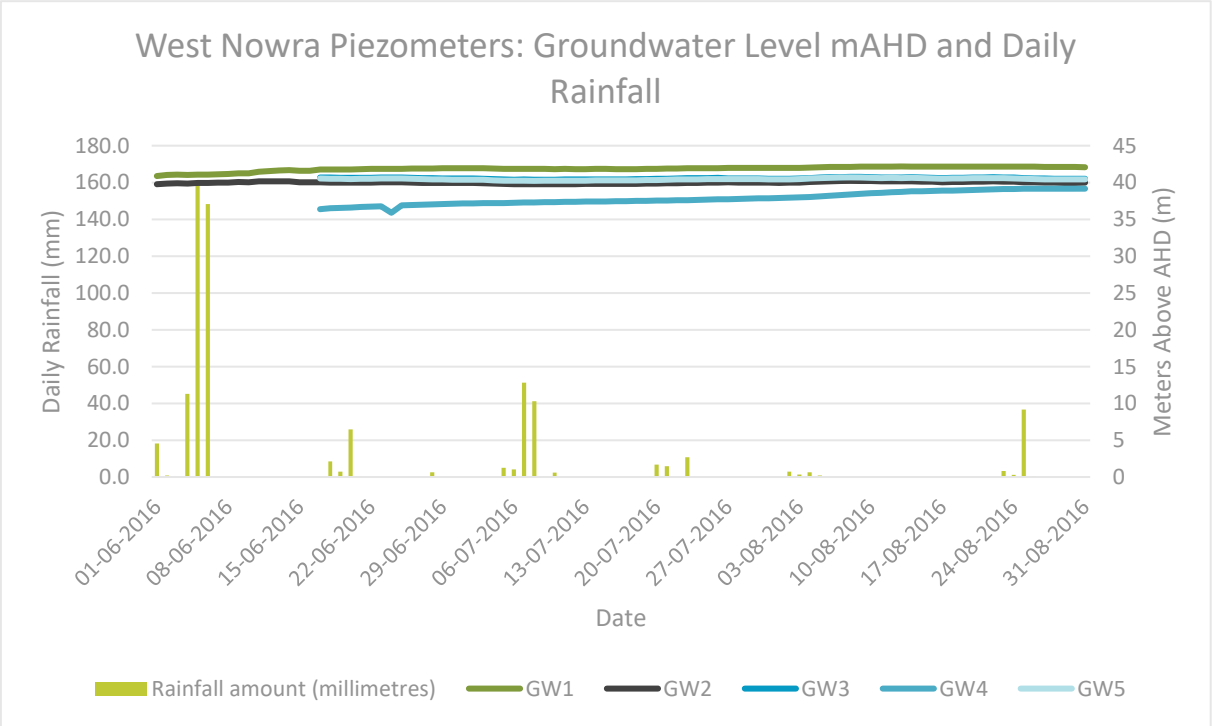


Figure 6 West Nowra Groundwater Monitoring and Daily Rainfall

3 Concept Landfill Design

3.1 Landfill Design Elements

Concept design considerations include:

- Develop the geometry of the extension footprint to maximise void space and landfill life expectancy while considering safe construction and operational areas;
- Side slope geometry and stability;
- Materials suitability;
- Base liner requirements;
- Leachate collection and extraction infrastructure;
- Leachate treatment requirements (dams, localised storage, irrigation and evaporation infrastructure etc);
- Surface water control;
- Groundwater management;
- Consideration of landfill gas control requirements;
- Local dimensional and construction methods requirements; and
- Final capping and rehabilitation profile.

The following sections discuss the individual design components.

3.2 Design Parameters and Assumptions

The concept design has been based on the following supplied design parameters and assumptions:

- To maximise capacity, the landfill cells are to be formed by excavating below the natural ground level. The level of excavation will be subject to the level of the groundwater table (see below).
- The groundwater table varies across the site, with an apparent divide approximately one third of the way between the north and south of the available extension footprint area. Based on the piezometer data available to date it is apparent that the average water table level can be defined as follows:
    - South – average of RL 41.5mAHD (approximately 9.5m below natural ground level)
    - North – average of RL 40.5mAHD (approximately 6.5 to 10.5m below natural ground level)
- In accordance with Victorian Guidelines (BEPM), the top of the basal liner must be greater than 2m above the average groundwater level, therefore the top of the basal liner will be at the following approximate levels:
    - South – RL 43.5mAHD
    - North – RL 42.5mAHD
- Excavation below the above RLs will be required to install the basal liner, the depth of which will be subject to the type of lining system.

- Excavation of batter side slopes is assumed to be as per current site conditions, i.e. 1 Vertical to 2 Horizontal (1V:2H).
- The maximum height of the final landform (at top of batter slope) is to be RL 59m. As agreed with SCC, the maximum height has been established based on a slope of 1% falling from the highest point on Stages 2 and 3 (RL 61m) to Stage 4.
- The access road between Stages 2 and 3 and the Stage 4 extension is to remain in place until final filling and closure.
- Leachate management is to be incorporated into existing site infrastructure and includes the development of a proposed new irrigation disposal area located over the existing closed Stage 2 landfill area. There is no sewer connection nearby therefore the leachate must be managed on site. It is understood this may change in the future, with the introduction of a nearby sewer system connection. Typical geology in the area comprises sandstone overlain by up to 7.0m of sandy clay. The bedrock profile has been described as being variable, ranging from moderately to heavily weathered.

3.3 Conceptual Landfill Geometry and Cell Layout

3.3.1 Site Layout

To maximise void space for the proposed Stage 4 landfill extension, the largest footprint available within the area constraints has been considered. The footprint boundary constraints are:

- Western boundary – existing Stages 2 and 3. There is an access road running between the existing stages and Stage 4 and it is proposed to fill over this in the final stages of filling, hence it will form part of the Stage 4 footprint.
- Northern boundary –Staff amenities building, including carpark.
- Eastern boundary – a biodiversity corridor, plus an environmental conservation area set aside for *Triplarina Nowraensis* vegetation. A 10m fire break has also been included which allows for the construction of an access / service road for fire management purposes as recommended in the SCC provided Bushfire Protection Plan.
- Southern boundary – there is a residential dwelling located at an approximate distance of 65m from the southern site boundary. In accordance with NSW EPA Environmental NSW Guidelines, the distance from the edge of the waste deposition area to the nearest environmentally sensitive location, which includes residences and dwellings is 250m. A buffer zone has therefore been set up from the nearest residential dwelling, making the closest point of the deposition area approximately 185m inside the site boundary.

The proposed landfill extension layout is therefore as shown in **Figure 7**.

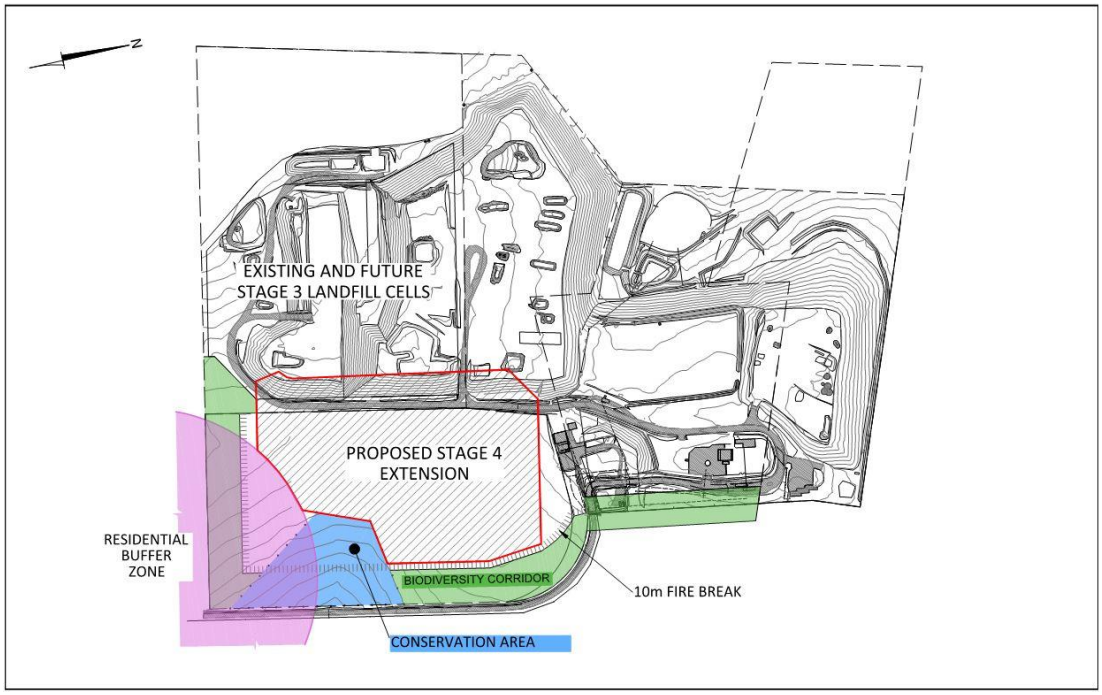


Figure 7 Landfill Extension Footprint

It is proposed to develop the landfill in 6 cell sub-stages, sequentially filled and moving from south (Landfill Cell 1) to north (Landfill Cell 6) with progressive side slope excavation and liner construction as required. Landfill Cell 1 lies to the south of the groundwater divide and therefore will have a top of basal liner at a level of 43.5m AHD, while the remaining landfill cells lie to the north of the divide and will have the top of the basal liner at level of 42.5m AHD. The development will allow for a gradient drop between each cell to allow for leachate and surface water to be directed to (separate) low points progressively until Landfill Cell 6. Longitudinal and transverse basal slopes of 1% and 3% as required in the EPA Guidelines shall be incorporated.

The layout of the landfill cells sub-stages is shown in **Figure 8** and in 3D in **Figure 9**.

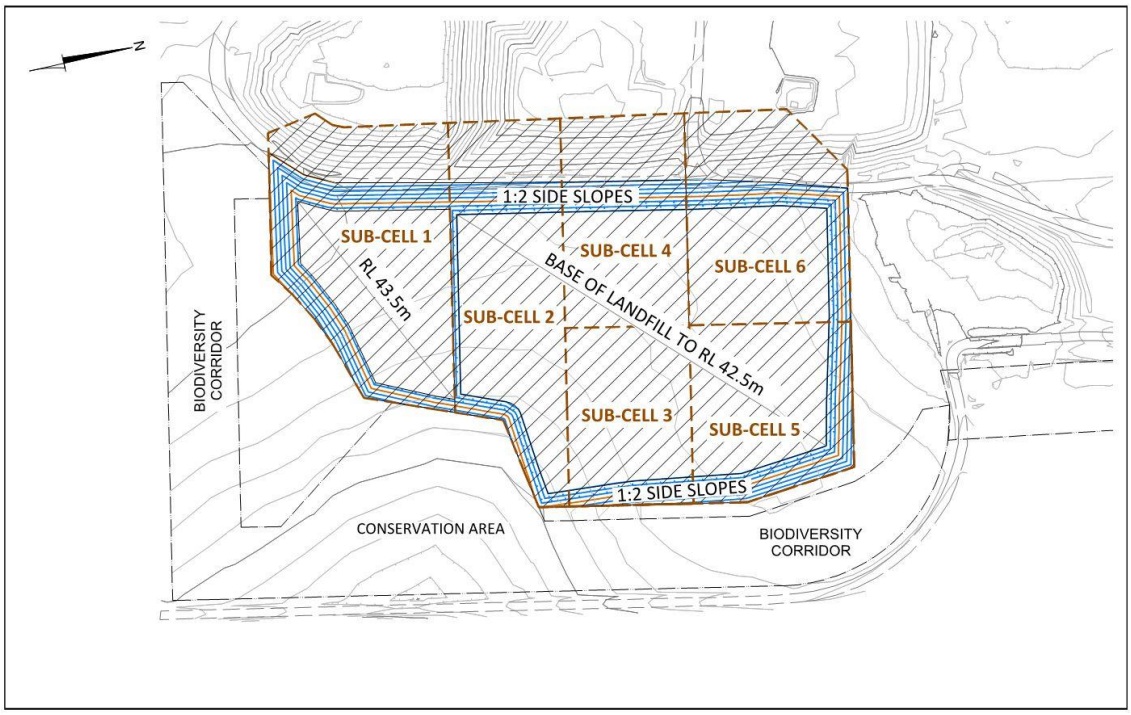


Figure 8 Proposed Landfill Cell sub-Stages Layout

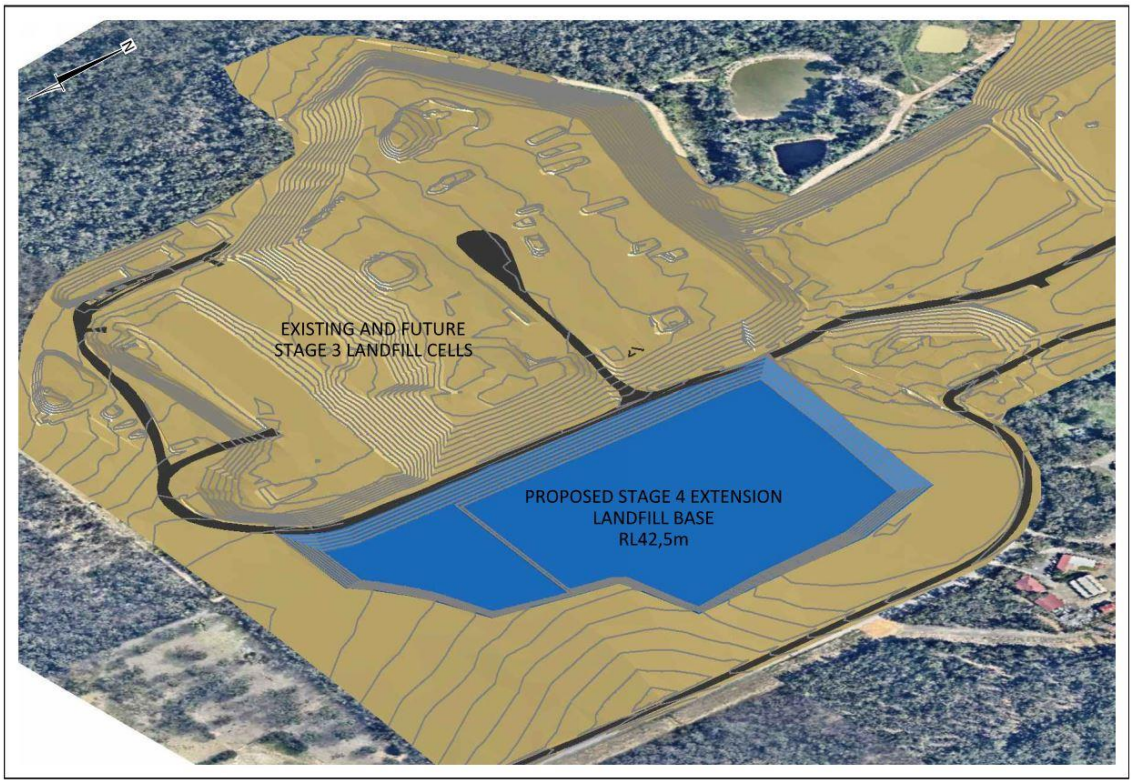


Figure 9 Conceptual Base Layout

3.3 Excavation Stability

The base excavations will be performed in a staged manner with Cells 1 and 2 being excavated during the initial development phase, and Cells 3 to 6 progressively excavated during the life of Stage 4. The side walls will have an angle of 1V:2H. The open excavation areas will be covered with an engineered lining system comprising a 200mm thick compacted subgrade, 1,000 mm of compacted clay liner (or an alternative geosynthetic clay liner), a 2.0 mm thick HDPE flexible geomembrane and a minimum 300 mm of leachate drainage material, which will provide added slope stability and protection from erosion.

The side wall batter slope angle has been determined utilising the ground conditions provided in Coffey's May 2016 geotechnical investigation. If ground conditions vary significantly from the conditions described in the Coffey investigation, re-evaluation of side slope angle may be required, (for example, if a layer of loose sand is found upon excavation).

The maximum depth of excavation will be approximately 7.1 m for the southern landfill cell stage, and 7.0 m for the northern landfill cell stages below the natural ground level. Groundwater infiltration is not anticipated, as the excavation levels will be above the assumed groundwater levels.

3.4 Landfill Final Landform and Capacity

The stage 4 landfill final landform can be found in **Figure 10**. The completed batter slopes shall have a gradient no greater than (1V:3H) and an approximate height of RL59m, which is equivalent to the maximum height on the Stage 3 development at the top of the batter slope.

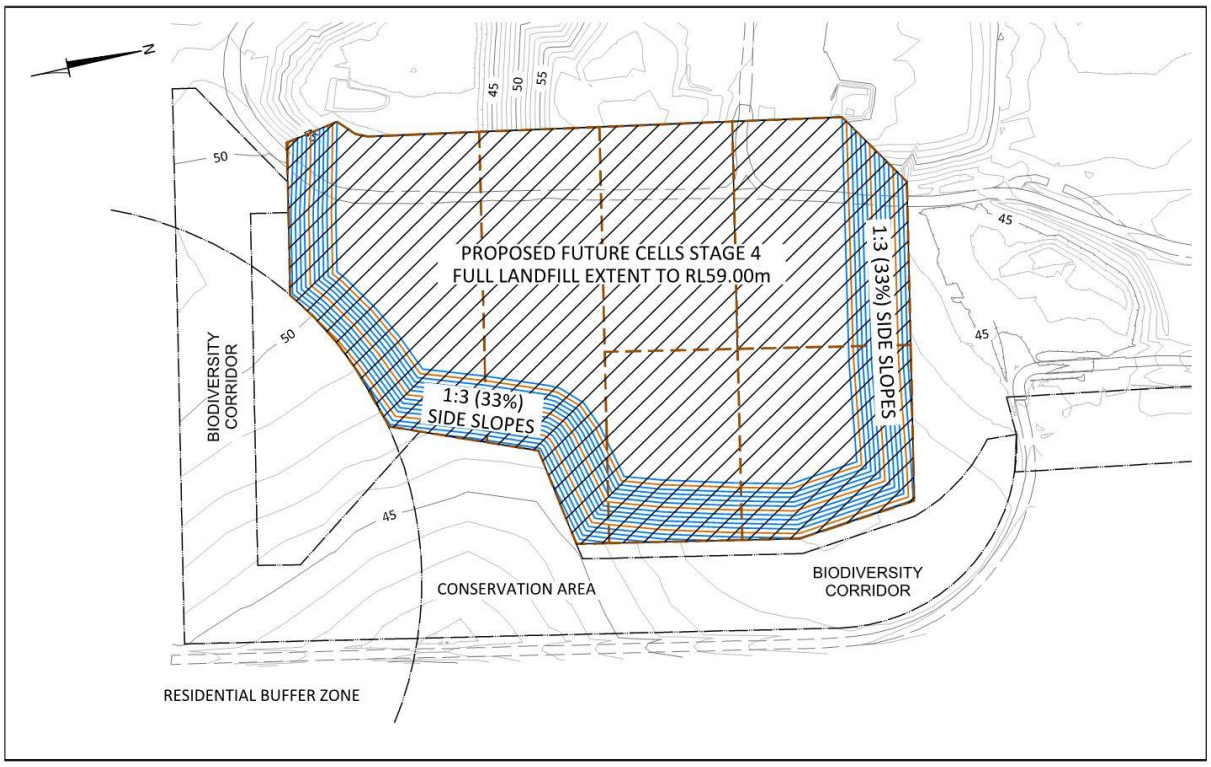


Figure 10 Final Landform

The final landfill capacity will be approximately 1,385,600m^3 upon completion, at an approximate maximum elevation of RL 59m at the top of the batter slope.

3.5 Landfill Filling Sequence

The waste landfilling sequence is to be developed from south to north. As each landfill cell stage is developed to nearing final waste filling design capacity, construction of an adjacent landfill cell stage shall commence. Access to each landfill cell stage is proposed via access ramps from road infrastructure between Stages 2 and 3, and Stage 4. These access ramps will be maintained until construction of each landfill cell stage is completed.

Earthen bunds shall be constructed between each landfill cell stage to provide stability while waste is placed in the active landfill cell, and to provide surface water management during construction. These bunds will incorporate a geomembrane liner overlap design with anchor trenches to ensure continuity in the geomembrane is present and that there is minimal slippage of the liner when loaded.

The location of the filling profile sections is shown in **Figure 11**. The profiles associated with the final landform are shown in **Figure 12.** The proposed landfilling plans can be found in **Figure 13** to **Figure 18**.

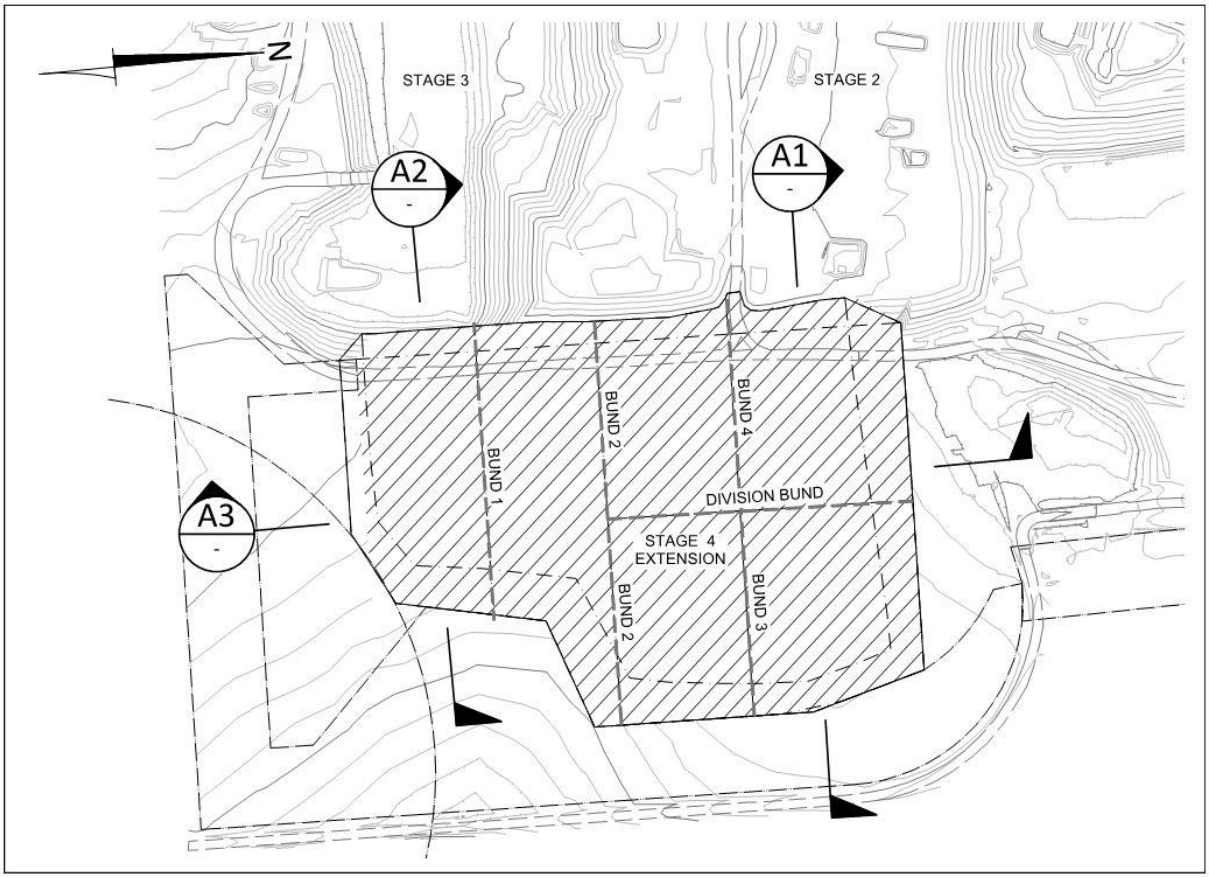


Figure 11 Section Locations for Filling Profiles

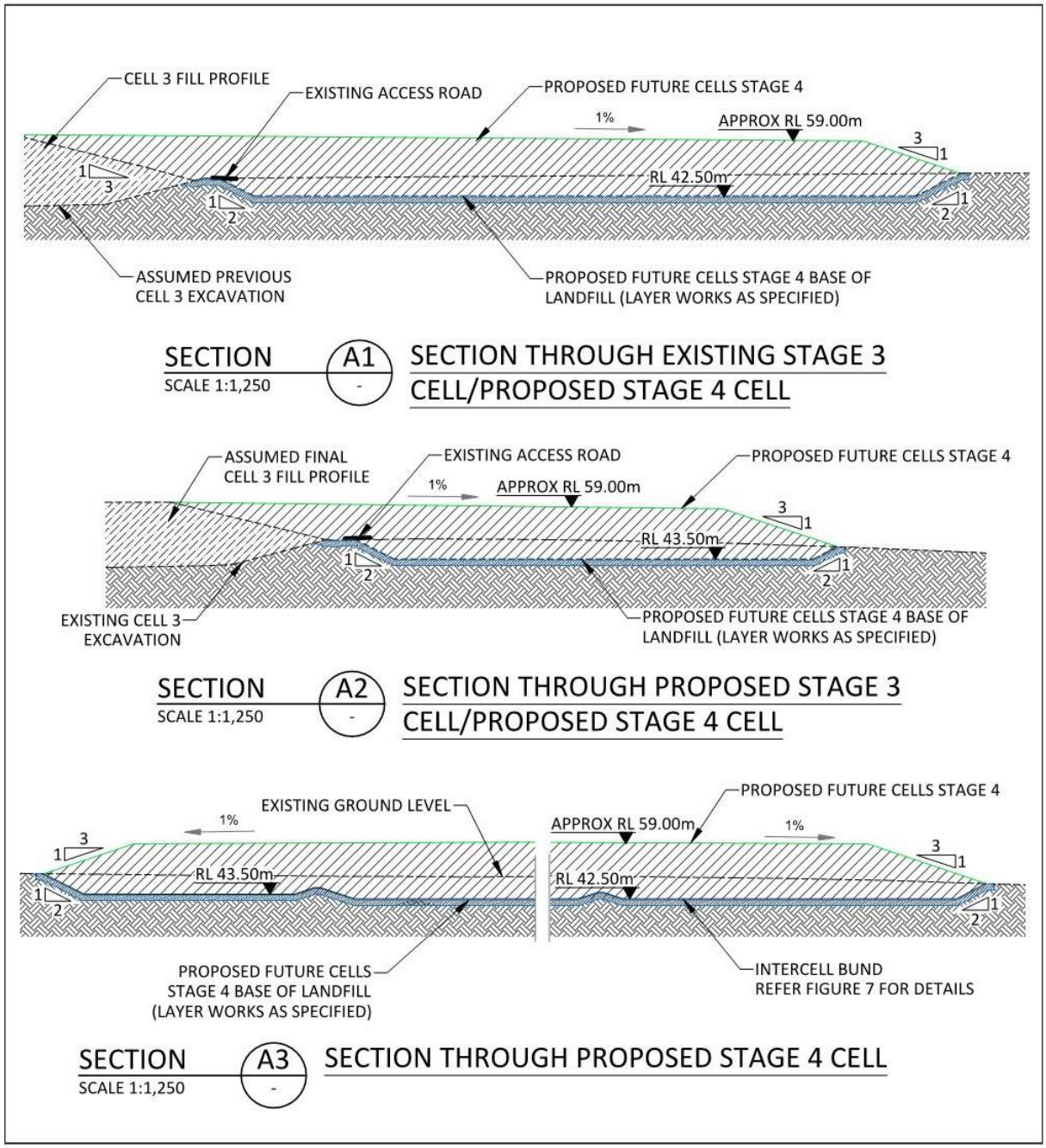


Figure 12 Conceptual Final Landform and Filling Profiles (Design Development Plan)

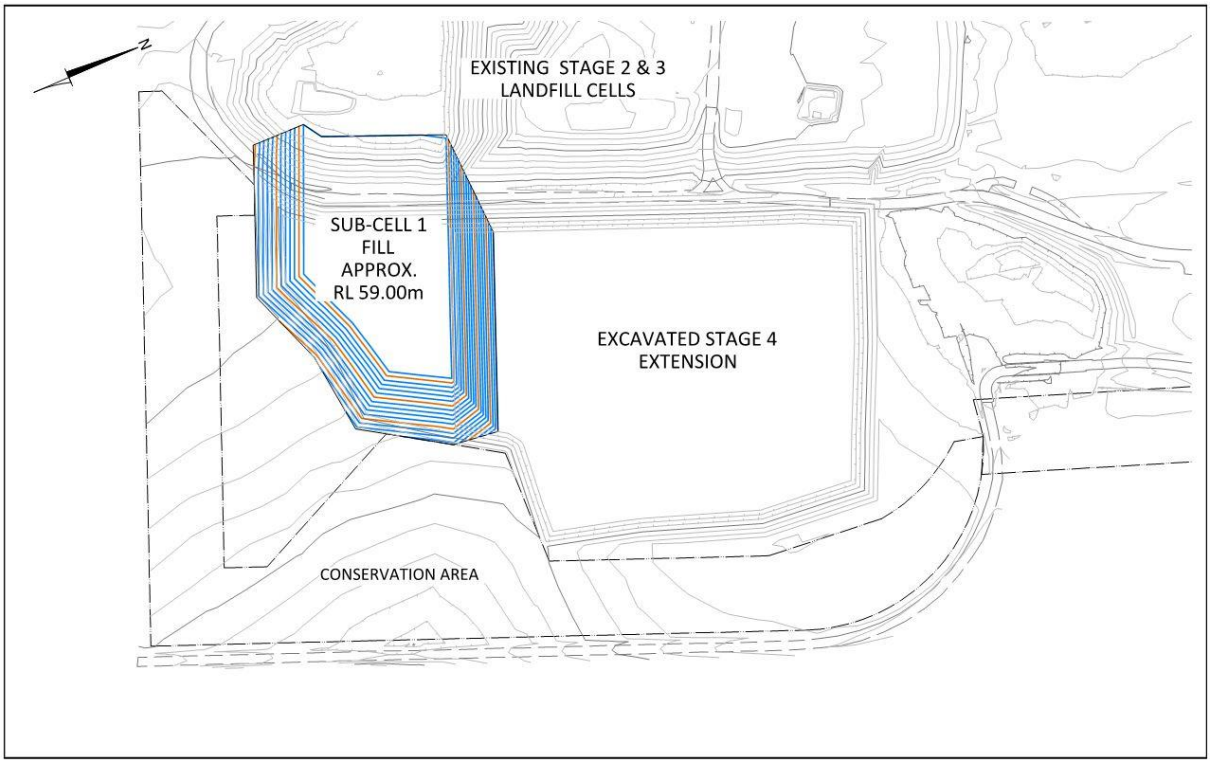


Figure 13 Filling Plan – Sub-Cell 1

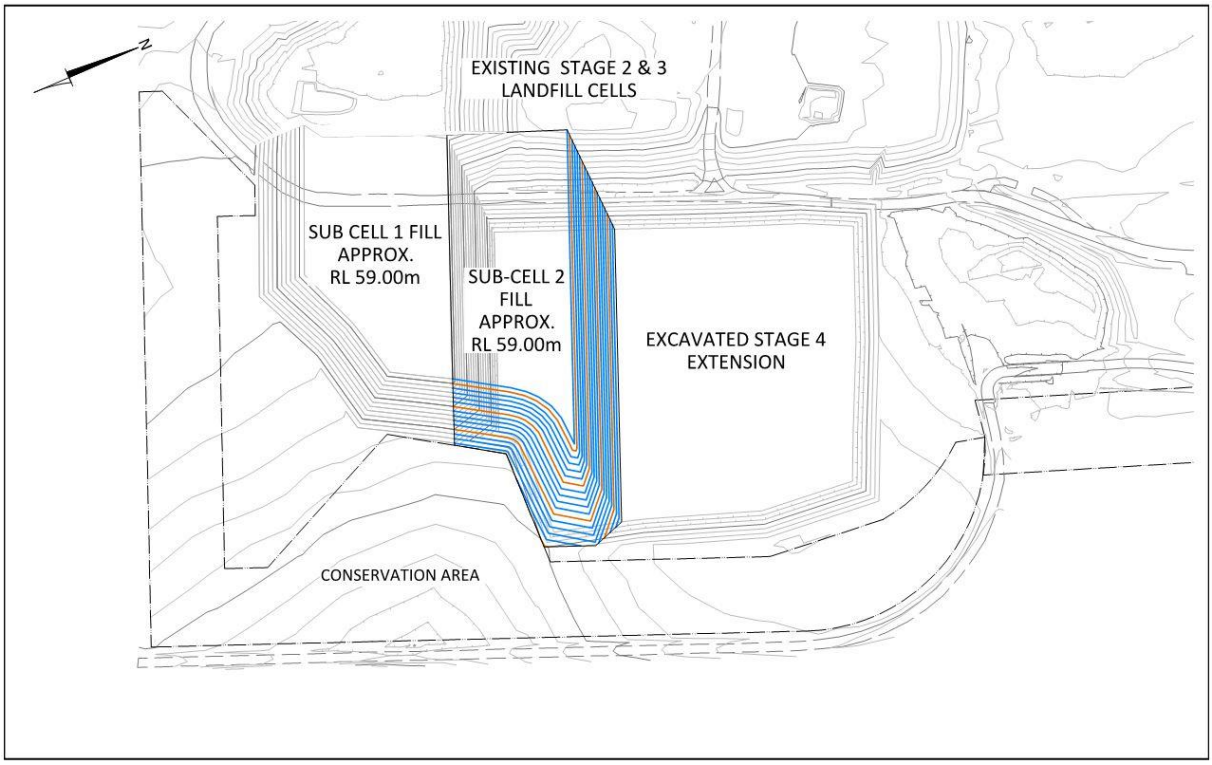


Figure 14 Filling Plan – Sub-Cell 2

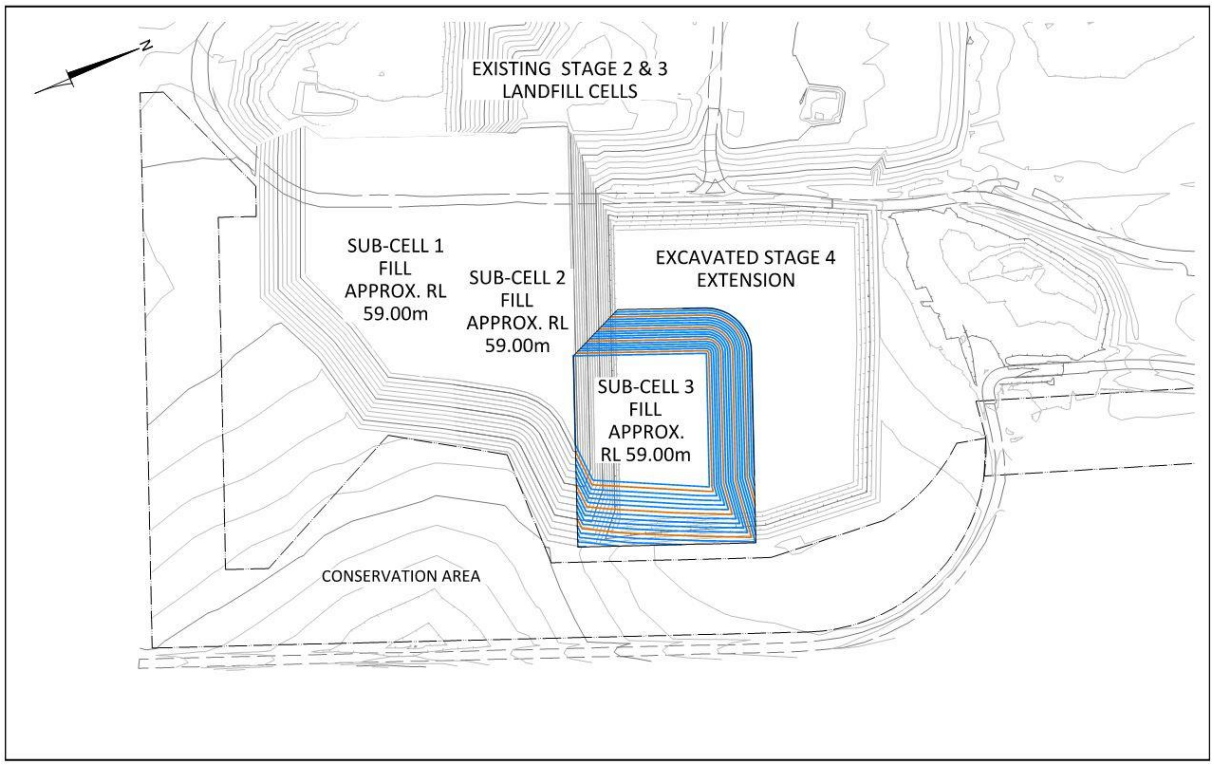


Figure 15 Filling Plan – Sub-Cell 3

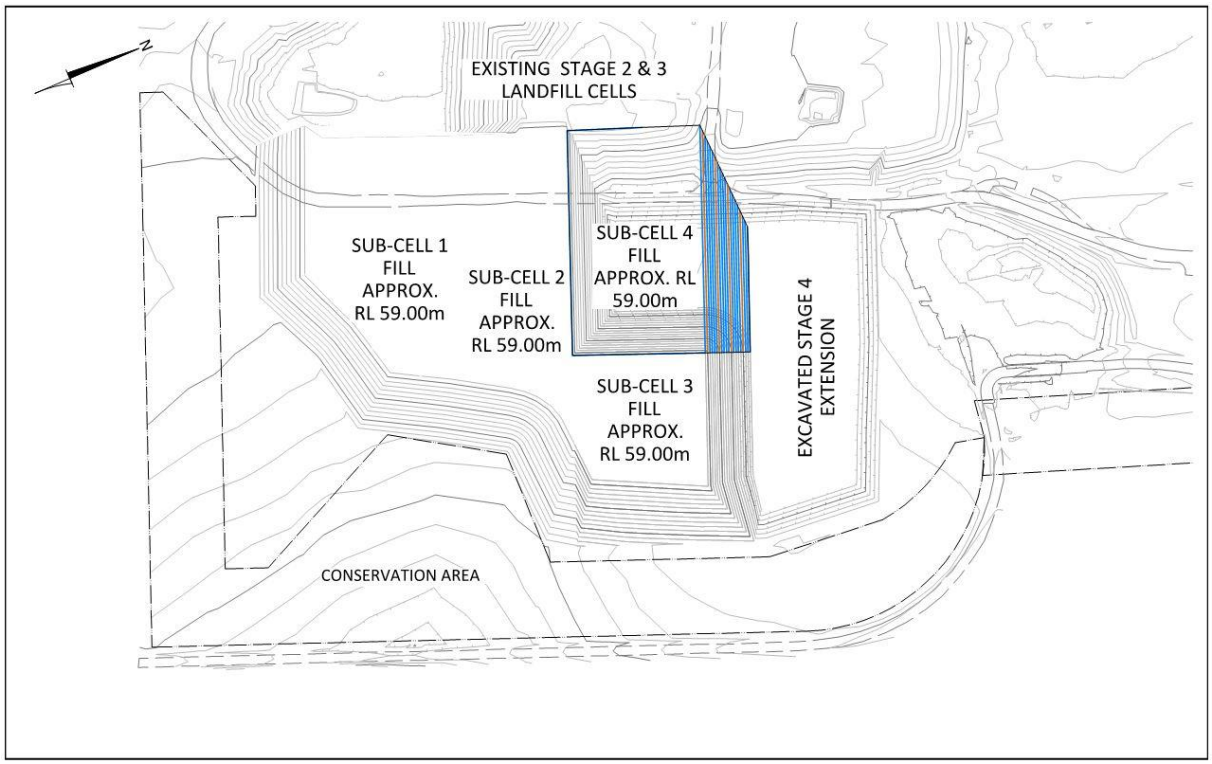


Figure 16 Filling Plan – Sub-Cell 4

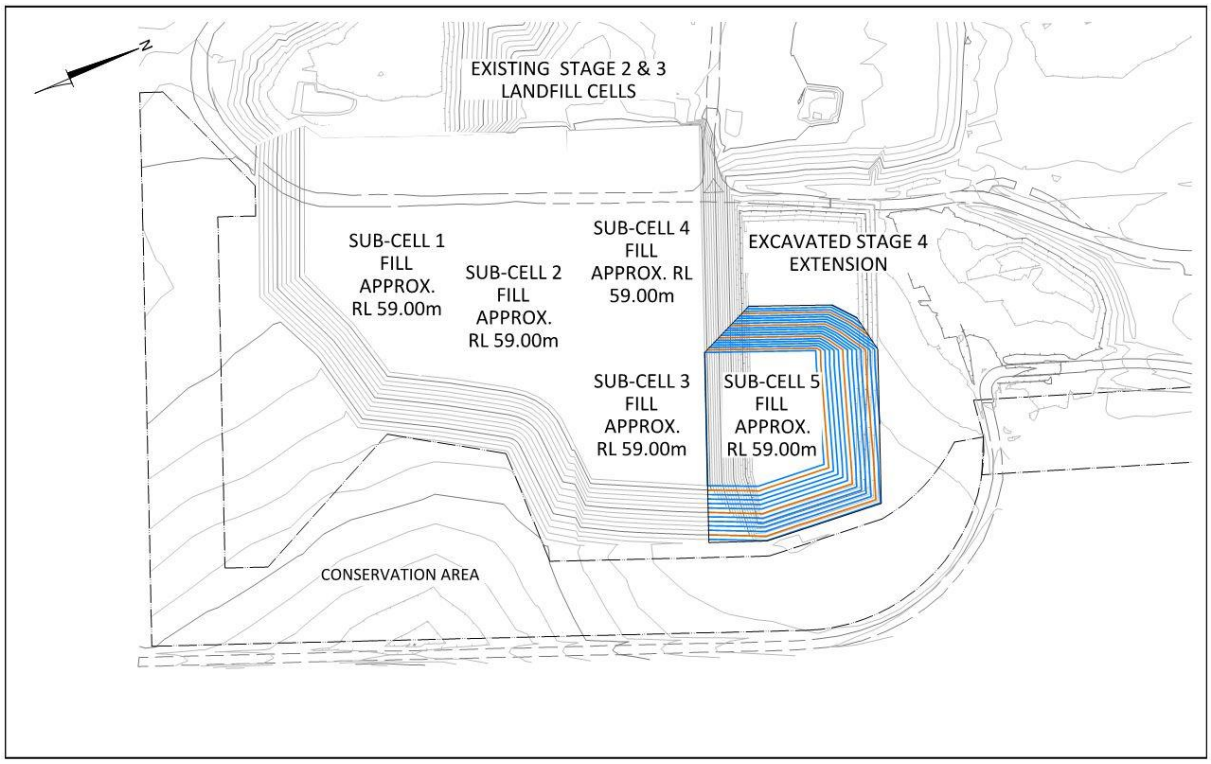


Figure 17 Filling Plan – Sub-Cell 5

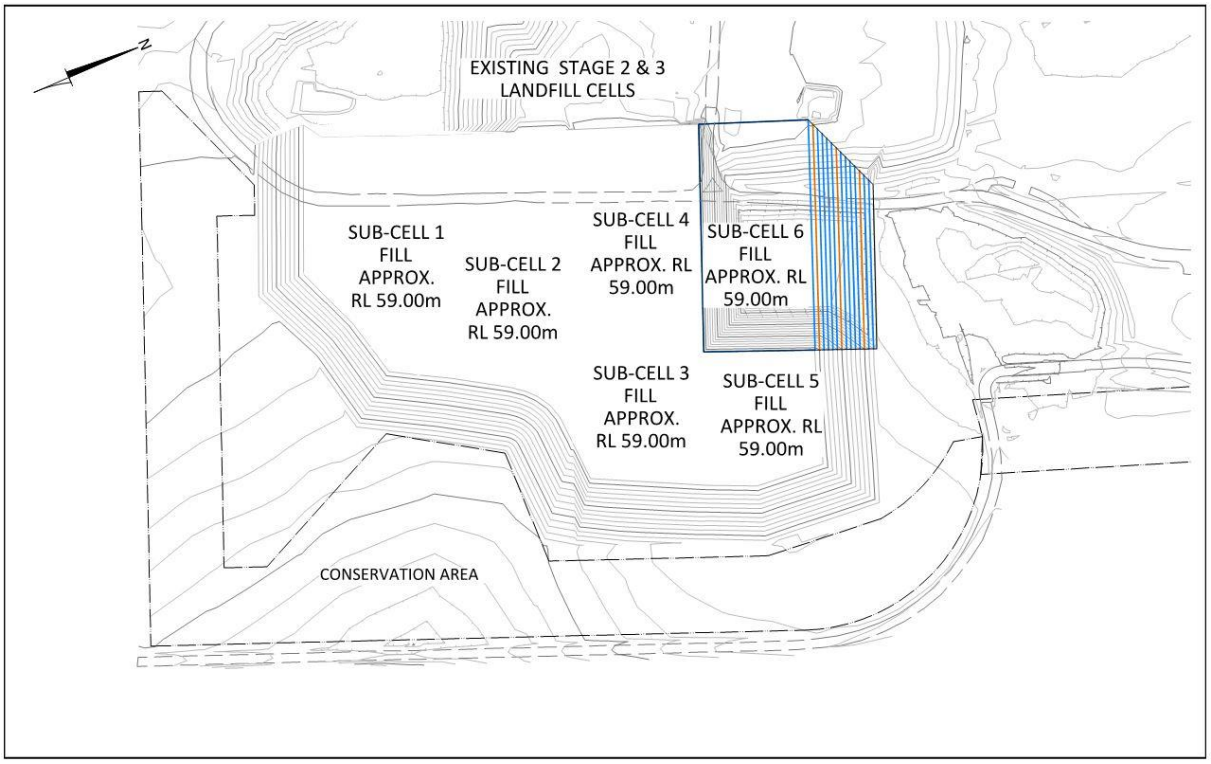


Figure 18 Filling Plan – Sub-Cell 6

3.6 Groundwater Management

The proposed subgrade level of the landfill extension area has taken into consideration the local groundwater table. The excavation will not exceed 100 mm within the average depth to groundwater in the area and the base of the landfill cell floor (i.e. top of leachate drainage layer) will be greater than 2m above the average groundwater table.

Seven (7) piezometers have been placed in and around the perimeter of the proposed landfill footprint. It is recommended that the piezometers be monitored regularly throughout the year to assess seasonal variation in the groundwater table as well as its response to wet weather events. This monitoring should be performed near the detailed design phase to ensure that the data is accurate.

For the purposes of this concept design it has been assumed that the groundwater table in the area of landfill cell 1 is at an average of RL41.5 m AHD, and an average of RL40.5 m AHD in the area of landfill cells 2 to 6. These average groundwater elevations are based on the current piezometer readings. A hydrogeological risk assessment (HRA) may be required if the groundwater is found to be inconsistent in depth and vary widely between readings; however, contingency has been provided for in the design elevations. If a HRA is required, it should address the following:

- Quality and behaviour of regional groundwater table;
- Likely inflow rate of groundwater to the landfill;
- Impact on the liner design;
- Impact on leachate development; and
- Treatment, disposal and / or reuse options for groundwater and surface water.

3.7 Lining System Requirements

Development of the lining system shall be in accordance with NSW regulatory requirements and be supported by best practice considerations.

3.7.1 Regulatory Requirements for Lining Systems

The Environmental Guidelines recommends the lining system comprise the following as a minimum:

- A compacted sub-base 200 mm thick to provide a firm, stable, smooth surface of high bearing strength on which to install the liner.
- A composite liner, comprising:
    - A compacted clay liner (CCL) at least 1,000 mm thick, with an in situ hydraulic conductivity of less than 1 x 10^{-9} m/s. The clay should contain no rock or soil clumps greater than 50 mm in any dimension;
    - A flexible membrane liner of high density polyethylene (HDPE) at least 2 mm thick;
    - The base liner should have gradients of greater than 1% longitudinally and 3% in transverse directions; and
    - An approved geosynthetic clay liner (GCL) may be used as an alternative to a CCL.

- Geosynthetic clay liners (GCLs) used as alternatives to a CCL shall:
    - Consist of a thin layer of bentonite 'sandwiched' between layers of geotextiles with a hydraulic conductivity less than 5 x 10^{-11} m/s;
    - Be reinforced (i.e. the geotextile layers are bonded by needle punching or stitching to enhance the internal shear strength of the geosynthetic clay liner compared with that of unreinforced products);
    - Have adequate strength, flexibility and durability to maintain performance over the entire life of the landfill (including the operating and post-closure periods); and
    - Meet or exceed the requirements for manufacture and performance contained in the relevant specifications published by the Geosynthetic Research Institute (GRI) (Folsom, PA, USA) from time to time, or in equivalent recognised industry standard specifications. Refer to GRI-GCL3 (Geosynthetic Research Institute, 2010).
- A protection or cushion geotextile to protect the flexible membrane liner from damage by construction equipment and overlying materials.
- A leachate collection layer comprising a minimum 300 mm thick gravel drainage layer including collection pipework, which slopes to a sump or other extraction point from which leachate can be conveyed from the landfill cell. The central (spine) leachate pipe should be a minimum diameter of 200mm while the spur pipes should be at least 150 mm in internal diameter. The spur drains are to be placed on the floor at intervals of not more than 25 m (running the length of the landfill cell), and be laid at gradients of at least 1% longitudinally into the sump and 3% in transverse directions.
- A separation geotextile comprising a non-woven geotextile fabric filter to reduce the ingress of fines from the overlying waste.
- A groundwater relief layer may be required below the leachate barrier in the event where high groundwater levels could affect the stability and performance of the barrier. Where required, the materials used in this system shall be of the same quality as the materials used in the barrier's drainage layer.

3.7.2 Recommended Basal Liner

The recommended base liner should include:

- Compacted subgrade formation level.
- The average groundwater level shall be greater than 2 m below the base of the waste (i.e. top of leachate drainage level), thus a groundwater extraction layer is not anticipated to be required.
- Composite liner for the base and side batter slopes. The composite liner shall comprise (from subgrade up):
    - A 1,000 mm thick CCL or alternatively an approved GCL. The excavated clay material from site has been found in the past to be generally suitable for use in the CCL, and this has been confirmed by the field investigation results (refer Section 3.2.2), which indicates the in-situ clay to be of low to moderate plasticity with a permeability of less than 1x10^{-9} m/s for the majority of the samples.
    - HDPE Liner – A 2 mm thick double-rough HDPE liner overlain by a protection geotextile shall be placed over the CCL or GCL, to provide a relatively impermeable barrier to leachate migration. At this concept design stage and based on information available, a double rough HDPE is recommended. Further investigation could be undertaken in the detailed design phase to establish if an alternative liner, such as smooth both sides, would be appropriate.

- Leachate collection layer and Separation Geotextile – A minimum 300 mm thick layer of drainage aggregate with perforated HDPE drainage pipes shall be placed over the protection geotextile layer, which shall promote the flow of leachate under the landfill and into the leachate collection system. The central drain and spur drains pipes shall have a minimum internal diameter of 200 mm and 150 mm respectively, and the spur drains placed at a maximum of 25 m intervals. The leachate collection system should be graded at a minimum of 1% longitudinally into the sump and 3% in the transverse direction. A separation geotextile shall be placed over the leachate collection layer to minimise fines migration.
- Leachate pipework is discussed in Section 3.10.

3.7.3 Overlapping Liner between Stage 4 and Existing Stages 2 and 3

Stage 4 will overlap the eastern edges of existing Stages 2 and 3. The Stage 4 lining system shall tie into the existing liner to ensure integrity of the system. The tie in detail is shown in **Figure 19**.

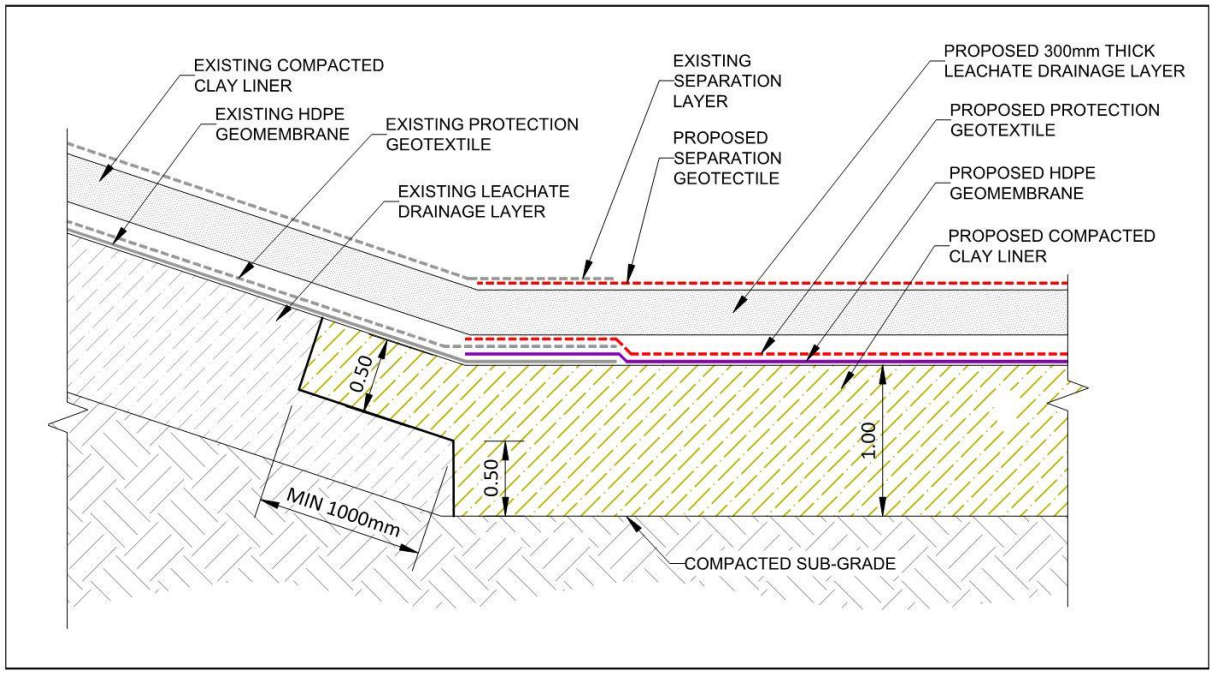


Figure 19 Overlapping Liner Tie-in Detail Between Stage 4 and Stages 2 and 3 for CCL

The CCL for Stage 4 may be replaced with a GCL if required.

There are existing leachate pipework inspection openings located between the eastern edges and the access road of Stages 2 and 3. These will need to be cut back to subgrade and capped off prior to construction of the liner in this location.

3.8 Surface Water Management System

Appropriate surface water management controls shall be applied to ensure clean surface water runoff is intercepted and diverted from the landfill footprint prior to entering the waste mass and thus becoming leachate. Stormwater (rain) that falls directly onto the landfill footprint is considered to be leachate.

Surface water management controls to be put in place will include:

- Sediment dams to manage potential sediment-laden runoff from the open and closed landfill cells
- Sediment erosion control measures (e.g. sediment fences etc.); and
- Surface diversion bunds and swale drains around open excavations (unfilled) and active landfill cells.

A conceptual erosion and sediment control plan has been developed and is shown in **Figure 20**.

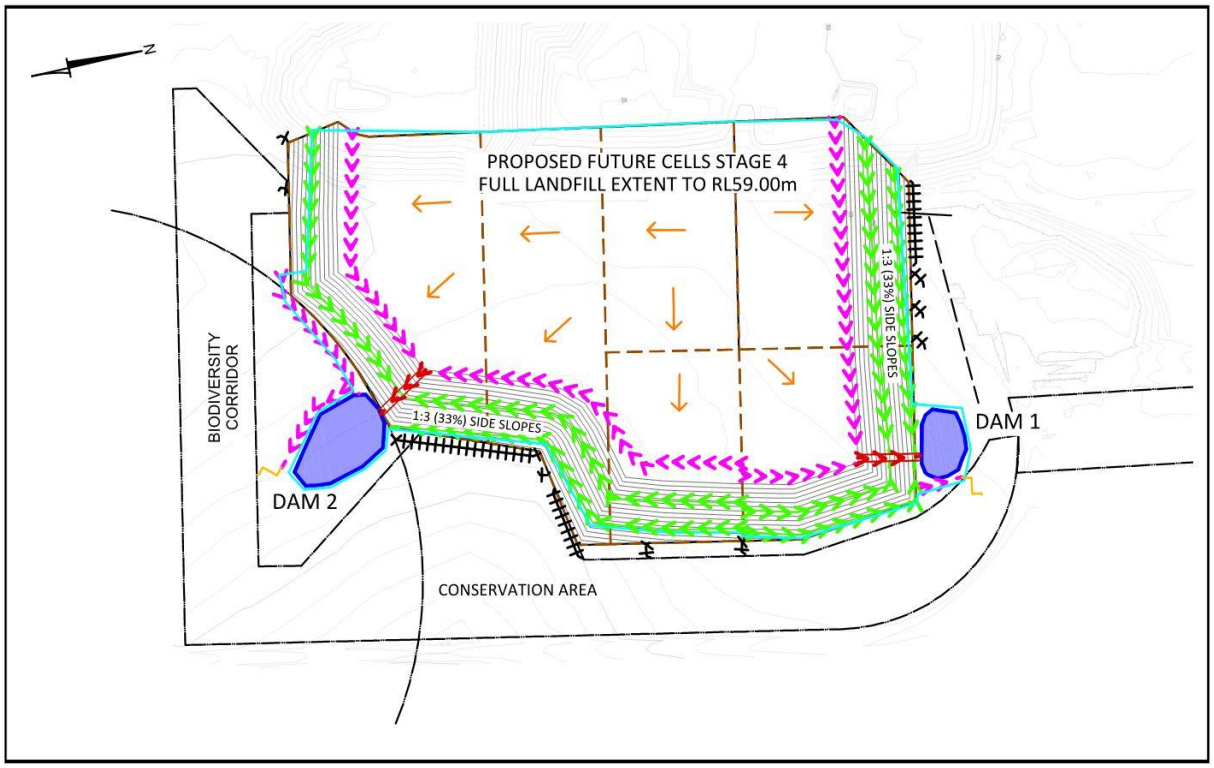


Figure 20 Conceptual Erosion and Sediment Control Plan

The required storage capacity of the dams has been determined in accordance with the requirements of the Blue Book (Managing Urban Stormwater: Soils and Construction, Volume 1 and Volume 2B Waste Landfills (Landcom, 2004 and DECC, 2008)) with the following design criteria and assumptions:

- Upslope catchment areas as shown in Figure 20 and Table 4;
- Capacity calculations based on a 5 day, 90th percentile rainfall depth of 67.0mm as listed in Table 6.3a of the Blue Book for Kangaroo Valley (closest listed location);
- The dams were designed as type F/D dams due to the nature of the soil in the area which contains some clay materials (in accordance with the Blue Book);
- Disturbed runoff coefficient of 0.79 in accordance with Table F2 of the Blue Book for a type D hydrological group with rainfall between 61 – 80mm;
- The sediment storage zone was based on a management period of 12 months (i.e. the sediment dam would be desilted once a year) and equates to 50% of the settling zone storage capacity of the dams.

The dams are to be regularly drawn down following rainfall (within 5 days). This is to ensure that the dams are operated in accordance with the requirements of the Blue Book to minimise the chances of an uncontrolled release. Suitably sized dam spillways shall be designed in accordance with the Blue Book requirements prior to construction.

The results of the dam capacity calculations are provided in **Table 4**.

Table 4 Shoalhaven Sediment Dam Capacity Details

Dam	Catchment Area (ha)	Settling Zone Volume (ML)	Sediment storage zone (ML)	Total Dam Storage Volume (ML)
Dam 1	3.0ha	1.58	0.79	2.37
Dam 2	6.5ha	3.46	1.73	5.19

3.9 Leachate Management System

Leachate can be defined as a liquid that passes through a landfill waste mass and has extracted dissolved and suspended matter from the waste.

The primary sources of leachate generation are:

- Stormwater infiltration into the waste mass during periods of prolonged rainfall;
- Surface water run-off that has come into contact with the landfill waste; and
- Leachate generated by the moisture content, and degradation of the received and emplaced waste.

The existing leachate collection system for Stages 2 and 3 involves diverting leachate to a leachate collection dam. The stored leachate is then disposed - on-site via spray irrigation over the designated irrigation area over the closed Stage 1 landfill area. It is proposed to collect and convey Stage 4 leachate to the existing leachate management infrastructure.

3.9.1 Leachate Collection and Disposal

The proposed leachate collection system will allow leachate to be collected and temporarily stored within the basal granular leachate drainage blanket. The design components shall include:

- The base of the leachate collection layer graded to direct leachate to specific leachate collection sumps;
- Perforated leachate collection pipe network within the collection layer, to promote the flow of leachate to the sumps;
- From the sumps, a series of inclined leachate extraction pipes shall be designed to draw leachate from the base of the landfill cell to the surface by a series of submersible pumps; and
- The pumped leachate shall be directed to the existing leachate dam for storage prior to being pumped to a newly established irrigation area for controlled disposal via spray irrigation.

The new irrigation area is proposed to be located within the area of the existing lined Stage 2 cell. Indicative area shown on **Figure 22 Proposed Stage 4 Irrigation Area**

3.3.2 Existing Site Leachate Management Infrastructure

Existing leachate management infrastructure at the site is detailed within **Table 5**.

Table 5 Existing Leachate Infrastructure

Parameter	Comment
Existing Irrigation System	On average since December 2015, Council has pumped 1257.84 m^3 of leachate to the irrigation area per year. (Shoalhaven City Council, 15/10/18)
Existing Leachate Dam Storage Capacity	Maximum storage capacity of Pond of 8.9 ML (Memorandum to David Hojem from Giordano Bianco 14/9/17)

3.3.3 Leachate Quantity

3.3.3.1 Existing Site Data

Council provided leachate generation data from Landfill Stages 1 - 3 (2013 - 2014) for potential use within the Site leachate generation water balance. Council also noted that no data was available for landfill Stages 1 and 2 (old unlicensed areas, and prior to any record keeping). Several months within the historical data set were noted to be missing with other years not available.

Due to the historical and incomplete nature of the site leachate generation data, estimates of leachate produced by Stages 1 – 3 were determined by the use of the Hydrologic Evaluation of Landfill Performance (HELP) computer program.

3.3.3.2 HELP Input Parameters

HELP input parameters developed for the Site leachate generation assessment is included within **Appendix D**.

3.3.3.3 Stages 1 - 3 Leachate Generation Summary

For the purposes of leachate generation modelling the HELP model conservatively incorporates 90th percentile annual rainfall volumes from historically wetter years. The monthly infiltration percentage rates are in accordance with associated capping arrangements (detailed within **Table 10**) and the monthly rainfall.

Where areas have been temporarily capped, an infiltration rate of 25 – 30% is typically attained and infiltration rates in restored (final capping areas) are typically in the range of 2 – 10% (Environmental Protection Agency, 2000).

Estimated leachate generation produced by Stages 1 – 3 is detailed in **Table 6**.

3.3.3.4 Stage 4 Leachate Generation Summary

The monthly infiltration percentage rates vary in accordance with associated capping arrangements and the associated monthly rainfall. Estimated leachate generation produced by Stage 4 is detailed in **Table 7**.

Table 6 Leachate Generation Summary – Stages 1-3

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total (m^3)
	Monthly Precipitation (mm)	63.5	81.5	93.4	96.0	87.3	70.5	98.5	121.5	138.3	108.0	106.8	115.6	1170.9
Stage 1 Closure Area	Monthly Infiltration (mm)	3.2	3.2	3.1	3.2	3.12	3.2	3.2	2.9	3.3	3.2	3.3	3.2	
	Monthly Infiltration Percentage (%)	4.8%	3.0%	3.2%	2.8%	2.6%	3.6%	2.3%	1.6%	1.7%	2.0%	2.4%	1.8%	
	Leachate Production (m^3)	92.3	91.2	88.3	92.3	88.9	90.9	91.5	82.6	92.9	89.8	93.5	90.9	1,085.3
Stage 2 Closure Area	Monthly Infiltration (mm)	1.3	0.9	1.7	1.4	0.9	0.5	0.7	0.7	1.1	1.2	1.8	1.4	
	Monthly Infiltration Percentage (%)	2.0%	1.1%	2.0%	1.4%	1.0%	0.7%	0.7%	0.6%	0.8%	1.1%	1.7%	1.2%	
	Leachate Production (m^3)	106.6	76.26	136.12	111.52	73.8	37.72	59.86	59.86	88.56	95.94	145.9	111.5	1103.7
Stage 3 Closure Area	Monthly Infiltration (mm)	1.0	1.0	1.5	1.4	1.0	0.6	0.8	0.7	0.8	1.0	1.4	1.2	
	Monthly Infiltration Percentage (%)	1.6%	1.3%	1.8%	1.5%	1.2%	0.9%	0.8%	0.6%	0.6%	0.9%	1.3%	1.1%	
	Leachate Production (m^3)	105.0	106.0	155.0	145.8	104.0	67.3	81.6	70.3	87.7	103.0	139.7	125.4	1291.3
	Monthly Infiltration (mm)	26.5	23.1	20.2	23.1	25.7	27.9	27.2	25.6	28.5	26	26.6	27.1	

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total (m^3)
	Monthly Precipitation (mm)	63.5	81.5	93.4	96.0	87.3	70.5	98.5	121.5	138.3	108.0	106.8	115.6	1170.9
Stage 3 Operational Area	Monthly Infiltration Percentage (%)	41.7%	28.3%	24.2%	24.0%	29.4%	39.5%	27.6%	21.0%	20.6%	24.0%	24.9%	23.4%	
	Leachate Production (m^3)	212	184.8	161.6	184.8	205.6	223.2	217.6	204.8	228	208	212.8	216.8	2460
Estimated Monthly Stage 1 -3 leachate production (m^3)		516.0	458.3	541.1	534.5	472.4	419.2	450.5	417.7	497.2	496.7	592.0	544.7	5940.3

Table 7 Leachate Generation Summary – Stage 4

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total (m^3)
	Precipitation (mm)	63.5	81.5	83.4	96.0	87.3	70.5	98.5	121.5	138.3	108.0	106.8	115.6	1170.9
Closure 8.9 Ha	Monthly Infiltration (mm)	4.7	4.7	4.5	4.7	4.5	4.6	4.6	4.2	4.6	4.5	4.7	4.6	
	Monthly Infiltration Percentage (%)	7.5%	5.8%	5.5%	4.9%	5.2%	6.6%	4.7%	3.5%	3.4%	4.2%	4.4%	4.0%	
	Leachate Production (m^3)	422.7	420.9	406.7	420.0	404.0	413.8	412.0	376.4	416.5	404.9	422.7	409.4	4930.6
Operational 0.8 Ha	Monthly Infiltration (mm)	26.5	23.1	20.2	23.1	25.7	27.9	27.2	25.6	28.5	26	26.6	27.1	
	Monthly Infiltration Percentage (%)	41.7%	28.3%	24.2%	24.0%	29.4%	39.5%	27.6%	21.0%	20.6%	24.0%	24.9%	23.4%	
	Leachate Production (m^3)	212	184.8	161.6	184.8	205.6	223.2	217.6	204.8	228	208	212.8	216.8	2460
Stage 4 monthly leachate production (m^3)		634.7	605.7	568.3	604.8	609.6	637.0	629.6	581.2	644.5	612.9	635.5	626.2	7390.6

3.9.2 Water Balance for Leachate Assessment

A water balance is developed for the analysis of alternate leachate management scenarios at the Site. In accordance with NSW EPA Environmental Guidelines: Solid Waste Landfills, the water balance was conducted over a period of two consecutive wet years (90th percentile) to ensure that the proposed system has sufficient capacity to deal with all leachate generated during both the operational and closure periods of the landfill. The model accounts for all predicted leachate inputs and outputs from the leachate management system.

3.9.2.1 Modelling Parameters

The design parameters appropriate for this water balance assessment as defined within Section 2.3 of the NSW EPA Environmental Guidelines: Solid Waste Landfills, are summarised in **Table 8**.

Table 8 Water Balance Design Parameters

Item	Requirement
General	Collected leachate must be stored in appropriately sized dams or tanks and disposed of so as not to cause environmental harm. There must be sufficient leachate disposal capacity to prevent the build-up of leachate and an increase in the risks of water pollution and offensive odours.
Water balance requirement	The model should account for all predicted leachate inputs and outputs from the leachate management system. The model should be run by using monthly time intervals, and it should estimate the changes in the cumulative volume with each month. The maximum cumulative volume may not be reached until many months into the landfill's operation.
Water balance duration	In deciding on any of the above management options, a water balance should be modelled over at least two consecutive wet years (90^{th} percentile) to ensure that the proposed system has sufficient capacity to deal with all leachate generated over the operational life of the landfill.
Pan Coefficient	The evaporation from the leachate dam should be estimated by using a pan coefficient of 70%.
Storage	The dam must have a freeboard that can accept rainfall directly on the dam from a 24hour rainfall event with a 1-in-25-year average recurrence interval without overflowing.

The water balance parameters and input parameters are provided in **Table 9** and **Table 10** respectively.

Table 9 Water Balance Parameters

Scenario	Purpose	Assumptions
1	Determine the sufficiency of the existing leachate management system to accommodate two consecutive wet years (90th percentile rainfall) and predicted leachate production from Stages 1 – 4.	1. Leachate management by the use of the existing leachate storage dam and a revised irrigation system constructed on Stage 2. 2. Irrigation system is able to dispose of 730mm/m^2 over the irrigation area per year at a rate of (851 m^3/month). 3. The clay cap in Stage 2 where the irrigation system is proposed requires removal and is to be re-instated with 1400mm depth of silty sand and 200mm of topsoil to allow for infiltration.

Table 10 Water Balance Inputs

Inputs	January	February	March	April	May	June	July	August	September	October	November	December
Average Monthly Rainfall (mm)	396	719	339	343	178	427	322	265	249	376	316	403
90th Percentile Rainfall	427	547	560	645	586	474	662	816	929	726	717	777
Total Leachate Production (m^3)	1151	1064	1109	1139	1082	1056	1080	999	1142	1110	1228	1171
Outputs												
Dam Evap (m^3)	908	724	642	483	376	316	358	488	604	749	800	953
Irrigation Use (m^3/month)	852	852	852	852	852	852	852	852	852	852	852	852

3.9.2.2 Preliminary Irrigation Area Sizing

The irrigation area was iteratively sized in accordance with the findings of the SEEP/W model. The irrigation modelling determined 730mm of leachate per m^2 can be applied over the irrigation area. The irrigation system to be constructed on Stage 2 is required to be at least 14,000 m^2 in size. The findings of the preliminary irrigation modelling and conceptual sizing of the disposal area are included in **Appendix D**. The water balance (average and 90th percentile rainfall events) is depicted within **Figure 21 Cumulative Leachate Pond Results**

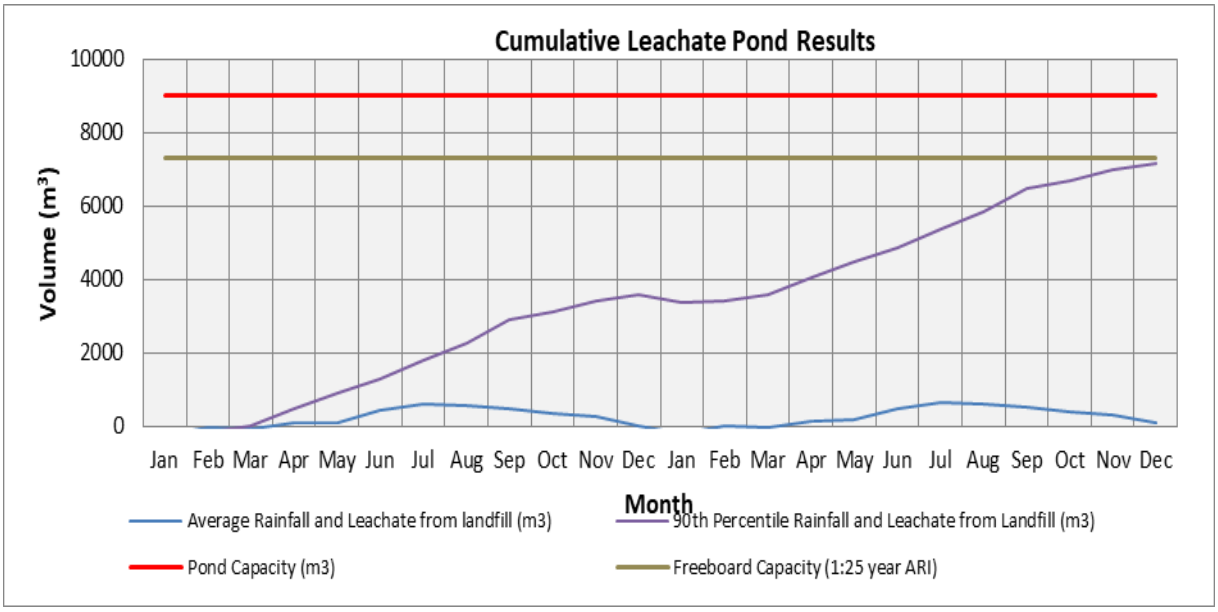


Figure 21 Cumulative Leachate Pond Results

As shown in **Figure 21** the water balance confirms sufficient capacity of the current leachate storage pond to accommodate two consecutive 90th percentile rainfall years and leachate generated by Stages 1-4 if a new irrigation area of 14,000m^2 is constructed.

The proposed location for the Stage 4Landfill Irrigation Area is presented in **Figure 22 and Appendix C.**

Figure 22 Proposed Stage 4 Irrigation Area

3.10 Leachate Collection Pipework

The landfill generated leachate shall be pumped from the sump of each landfill cell to the existing leachate dam. Leachate extraction pipework shall be progressively installed on the eastern and western perimeters of the Stage 4 landfill cells upon a compacted fill apron placed above the engineered lining system. The fill apron shall support the leachate extraction pipework over the series of rock benches. The leachate extraction risers per cell shall be placed within a recessed trench within the crown of the compacted fill apron.

The NSW EPA Environmental Guidelines: Solid Waste Landfills, 2016, section 1.5 require that leachate collector pipes should:

- Be flexible pipes (typically high density polyethylene) at least 150 millimetres in internal diameter (water balance and pipe flow calculations should confirm the pipe size needed to convey peak leachate flow rates)
- Be perforated such that the size, frequency and layout of the perforations are sufficient to facilitate leachate inflow and extraction without clogging, prevent entry of drainage gravel, and maintain adequate pipe strength

- Be strong enough to maintain performance under the maximum loads likely to be imposed in service, complying with the requirements of Australian standard as 2566.11998 buried flexible pipelines – structural design (standards Australia, various dates)
- Be joined by using techniques and materials recommended by the pipe manufacturer
- Loading calculations are required to determine the pipe strength to provide a pipe that is sufficient to resist buckling and deformation caused by the excessive loading from the anticipated depth of waste complying with the requirements of Australian standard as 2566.11998 buried flexible pipelines – structural design (standards Australia, various dates).

3.11 Landfill Gas

There is an existing landfill gas (LFG) extraction, cogeneration (generator) and treatment (flare) system operating at the Facility, which manages LFG generated from Stages 1 to 3. LFG generated from Stage 4 is expected to be managed by the existing system.

As part of the detailed design for Stage 4, the following shall be addressed:

- Establish the likely LFG generation from Stage 4 and assess if the existing LFG extraction system has the ability and capacity to manage the additional LFG expected to be generated from Stage 4;
- If an upgraded LFG management system is required then:
    - Design the LFG management system to ensure compliance with LFG hierarchy;
    - The LFG design shall include allowance for progressive installation; and
    - Provide details of ongoing monitoring required.

A typical landfill gas management system suitable for the landfill extension is shown in **Figure 23** and would include:

- Gas extraction wells laid out evenly across the extension area, at typical spacings of between 50m and 100m. The spacing will vary depending on the morphology of the landfill and efficiency of the gas extraction, cogeneration and treatment systems;
- Well head stations connected to the extraction wells to collect the gas; and
- A ring main system connecting the well heads back to the cogeneration and treatment systems.

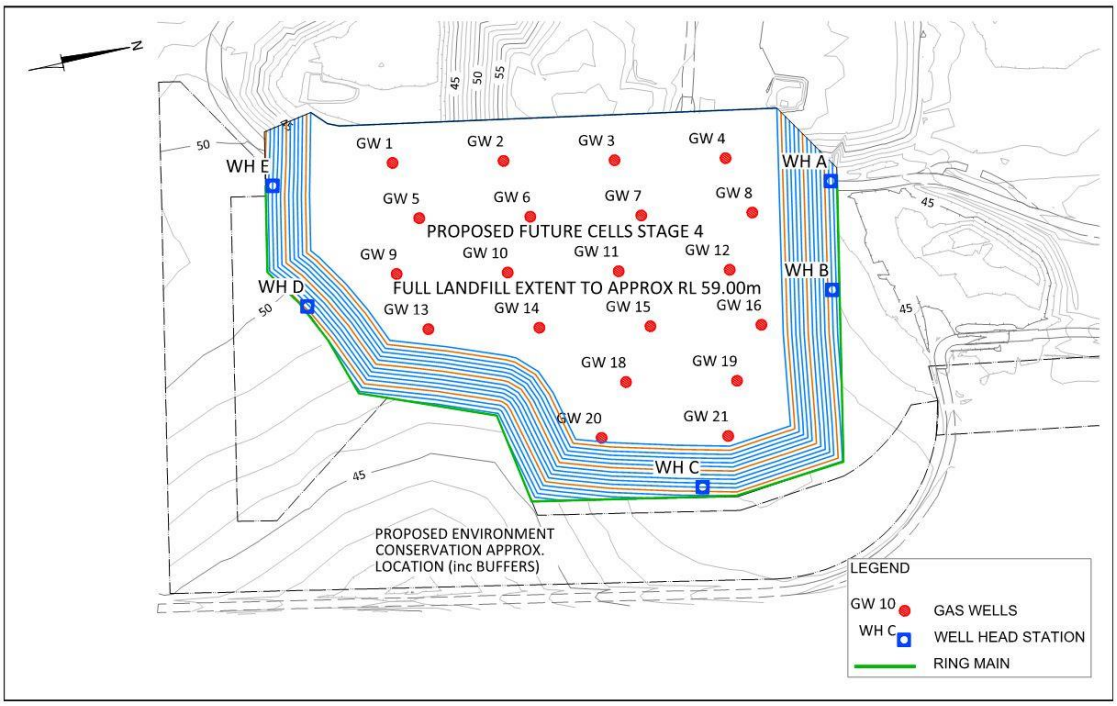


Figure 23 Typical Landfill Gas Management System

It is essential to ensure that the extraction wells are fully sealed when installed to maintain the integrity of the capping system. A typical section through the sealing detail is shown in **Figure 24**.

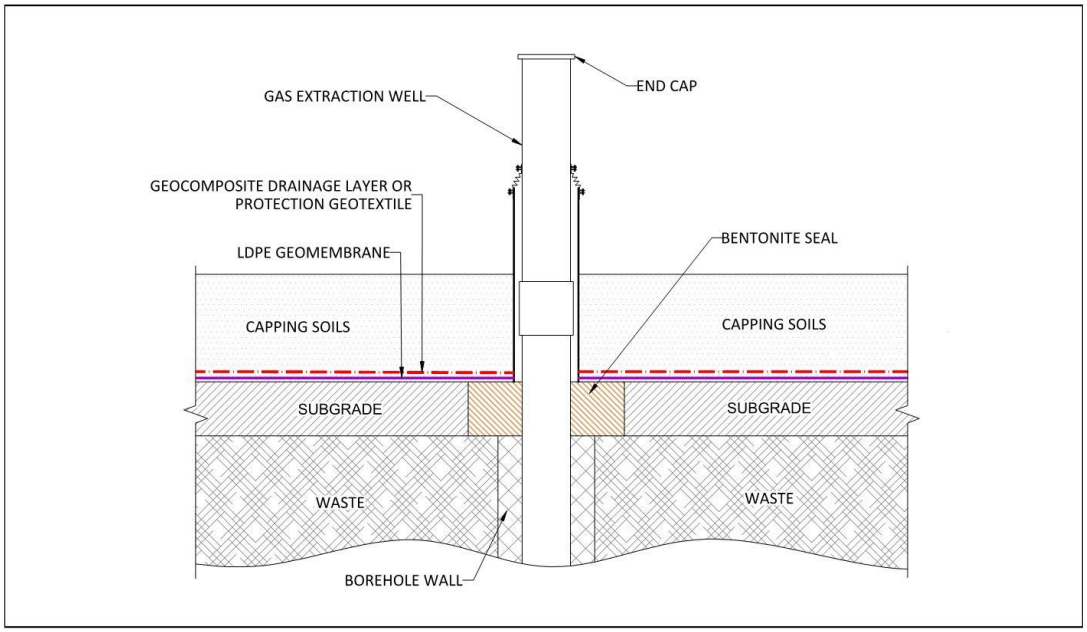


Figure 24 Typical Section through Extraction Well Sealing System

4 Closure Capping Requirements

The design of the final cap should prevent groundwater pollution and degradation of air quality, and should be capable of protecting the environment in the event of several components of the system failing.

The design objectives for the final cap, or surface, of the landfill are to:

- Isolate the deposited waste from the immediate environment;
- Reduce leachate generation by limiting water infiltration;
- Reduce surface emissions of landfill gas and assist in odour management; and
- Provide a stable and sustainable landform fit for its intended future purpose.

Development of the capping system is in accordance with NSW EPA Guidelines and is supported by best practice considerations.

The recommended system shall comprise the following as a minimum (from bottom to top):

- A seal bearing surface 300mm thick to provide a firm, stable, smooth surface of high bearing strength on which to install the cap. Engineered fill shall be used.
- A sealing layer comprising:
- A 2mm thick low density polyethylene flexible membrane (i.e. LDPE) or approved alternative and a GCL;A 1,000 mm revegetation layer, comprising a top 200mm of which should be topsoil (and may include compost to support vegetation growth), underlain by an 800mm thick infiltration layer.

A typical section through the capping layer is shown in **Figure 25**.

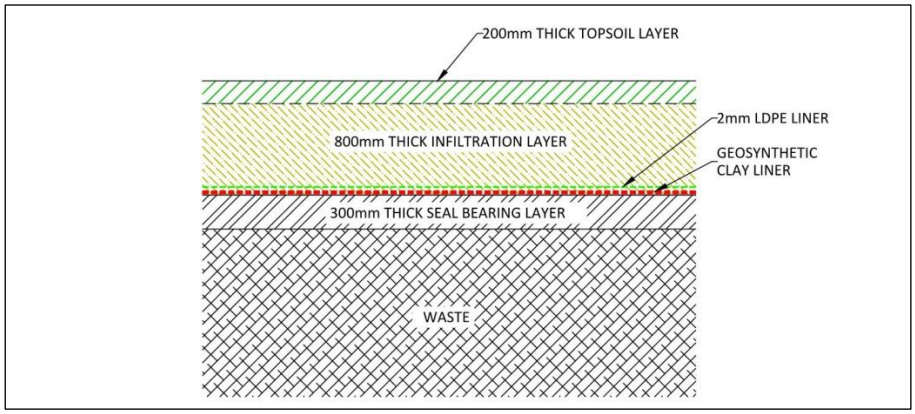


Figure 25 Typical Capping and Rehabilitation Detail

Alternative landfill caps are also options that will be considered, such as evapotranspiration caps (also referred to as 'ET caps') or phytocaps shall be assessed, as well as the conventional geomembrane capping system. The final design of the capping system shall be based on the outcomes from the hydrogeological, stability and landfill gas risk assessments for the site, and addressed as part of the Landfill Closure Plan for the Facility.

5 Preliminary Design Drawings

The concept design drawings are contained in **Appendix C**, and are summarised in Table 10.

Table 10 List of Design Drawings

Drawing No.	Description
610.15781 – Figure 00	General Arrangement and Drawing List
610.15781 – Figure 01	Site Master Plan
610.15781 – Figure 02	Existing Site Survey Layout
610.15781 – Figure 03	Landfill Location and Buffer Layout
610.15781 – Figure 04	Proposed Base of Landfill Layout
610.15781 – Figure 05	Proposed Final Landform Layout
610.15781 – Figure 06	Typical Sections Through Stage 4
610.15781 – Figure 07	Typical Lining System Sections
610.15781 – Figure 08	Proposed Leachate Drainage Layout
610.15781 – Figure 09	Leachate Drainage Typical Sections
610.15781 – Figure 10	Filling Plan Stage 4 Cell 1
610.15781 – Figure 11	Filling Plan Stage 4 Cell 2
610.15781 – Figure 12	Filling Plan Stage 4 Cell 3
610.15781 – Figure 13	Filling Plan Stage 4 Cell 4
610.15781 – Figure 14	Filling Plan Stage 4 Cell 5
610.15781 – Figure 15	Filling Plan Stage 4 Cell 6
610.15781 – Figure 16	Proposed Landfill Base 3D Layout
610.15781 – Figure 17	Proposed Final Landform 3D Layout
610.15781 – Figure 18	Monitoring Locations Layout
610.15781 – Figure 19	Typical Gas Management – Layout and Details
610.15781 – Figure 20	Disturbance Footprint For Landfill and Firebreak Layout
610.15781 – Figure 21	Proposed Filling Plan Layouts
610.15781 – Figure 22	Total Disturbance Area – Stage 4 Extension Layout
610.15781 – Figure 23	Conceptual Erosion Sediment Control Plan
610.15781 – Figure 24	Proposed Leachate Irrigation Area

6 Volumes and Areas

The estimated quantities of the primary material(s) that will be required for the development of Stage 4 are shown in **Table 11.** Material quantities to be confirmed at detail Design stage following project approval

Table 11 Estimated Material Quantities

Item	Volume (m^3) and Areas (m^2)
Total excavated material to below clay liner	509,780 m^3
300 mm leachate drainage blanket	17,807 m^3
1,000 mm CCL	81,910 m^3
GCL	81,910 m^2
HDPE membrane	81,910 m^2
Geotextiles	141,270 m^2
Leachate collection pipework	1, 250 lin. m
Waste fill void up to RL 59m	1,385,600 m^3

7 Technical Specifications

The design and material specifications are as set out in the following sections.

7.1 Earthworks

7.1.1 Subgrade Preparation

All excavation work shall be undertaken using conventional earthmoving equipment and methods e.g. dozers, excavators, rock breakers, and other equipment typical to this type of project.

Clearing and grubbing (removal of tree roots) shall only be undertaken in the approved disturbance area for construction (Works area) or to allow access to the Works area. Appropriate disposal and / or re-use of all materials that have been cleared and grubbed must also be undertaken as part of these Works. All natural landscape features, including natural rock outcrops, natural vegetation, soil and watercourses are to remain undisturbed except where affected by the Works. Cleared vegetation material shall be retained on site (chipped/re-used). If required, vegetation to be disposed of offsite shall be transported to an appropriately licenced facility.

Stripping of organic material may be required from the Works area. Material that is stripped shall be stockpiled for future use.

The finished design subgrade surface shall be trimmed, where applicable, to provide a smooth surface, free from debris, roots, angular or sharp rocks. The subgrade surface shall ensure a sufficiently compacted surface to allow for the movement of vehicles without causing rutting or other deleterious effects. It shall have no sharp or abrupt changes in grade, and 'soft spots' shall be removed and replaced with complying materials. All excavated or fill surfaces shall be graded to provide good drainage and prevent ponding of water. Surface water shall be managed to avoid damage to adjoining properties or to the finished work on the site.

Any soft or heave areas shall be excavated down to at least 0.5m and backfilled with appropriate approved excavated materials compacted in loose 150mm thick layers to the equivalent density of 98% of Standard Maximum Dry Density at a moisture content within the range of ±2% of Standard Optimum Moisture Content. General Construction Fill shall be compacted to a dry density of not less than 98% of standard maximum dry density (AS 1289.5.4.1). The final filled general subgrade shall be compacted and trimmed to provide a smooth final design surface. Any soft or heaving areas shall be removed and replaced as per above.

7.1.2 Earth Separation Bunds

The earth separation bunds shall comprise of clean soil free from roots, woody materials, vegetation, and other unsuitable material. Contaminated materials may be used for internal bunds that will not form part of the final landform profile.

Soil material shall be placed in lifts of not greater than 300 mm and compacted to the equivalent density of 95% to 98% of Standard Maximum Dry Density at a moisture content within the range of ±2% of Standard Optimum Moisture Content.

Where fill material is placed against in situ deposits, the surface of the existing material shall be cleared of any soft material. Each lift of fill placed shall be benched into the in situ deposits to ensure that a good key is achieved.

The final filled general subgrade shall be compacted to provide a smooth final design surface. Any soft or heaving areas shall be removed and replaced as per above.

Fill materials shall be placed with due regard to moisture conditioning and compaction, as necessary, to produce a fill material possessing the fill quality and performance, as specified.

Fill batter slopes shall be neatly trimmed and left without excessive loose surface materials. Fill batter slopes steeper than 20% gradient shall be overfilled as necessary and trimmed back with smooth blade to ensure that all fill in the slope is adequately compacted.

Compaction shall be undertaken in accordance with *AS 3798-2007 Guidelines on Earthworks for Commercial and Residential Developments.*

7.1.3 Survey

Prior to commencing the construction works and throughout the construction progress detailed field surveys shall be undertaken to confirm the construction works is being carried out in accordance with the design specifications.

Upon completion of the construction final 'works as constructed' drawings shall be prepared utilising construction records and detailed field surveys.

7.2 Construction Material Specifications

7.2.1 Compacted Clay Liner (CCL)

The low permeability layer shall be at least 1,000 mm thick, with the following properties:

- Hydraulic conductivity no less than $1x10^{-9}$ m/sec;
- Be of high plasticity; and
- Have a suitable particle size distribution, with no particles greater than 50mm in any dimension.

The clay material shall be placed in uniform 150 mm thick layers, compacted to the equivalent density of 98% of Standard Maximum Dry Density at a moisture content within the range of 0% to +2% of Standard Optimum Moisture Content.

A low permeability alternative GCL layer may be used in lieu of a CCL.

7.2.2 Geosynthetic Clay Liner (GCL)

A GCL may be used as an alternative to a compacted clay liner. The GCL shall exhibit the following properties:

- Consist of a thin layer of bentonite 'sandwiched' between layers of geotextiles with a hydraulic conductivity less than 5×10^{-11} m/s;
- Be reinforced (i.e. the geotextile layers are bonded by needle punching or stitching to enhance the internal shear strength of the geosynthetic clay liner compared with that of unreinforced products);
- Have adequate strength, flexibility and durability to maintain performance over the entire life of the landfill (including the operating and post-closure periods); and

- Meet or exceed the requirements for manufacture and performance contained in the relevant recognised industry standard specifications such as GRI-GCL3.
- Be made from bentonite that has been formulated for landfill applications; the bentonite should meet the specifications contained in Table 1 of the *Landfill Guidelines* (NSW EPA, 2016) as detailed in **Table 12** below.

Table 12 Minimum Bentonite Specification

Property	Range or value
Montmorillonite content	70 wt%
Carbonate content*	1 to 2 wt%
Bentonite form	Natural Na-bentonite, or 80 wt % sodium as activated bentonite
Particle size	Powdered (e.g. 80% passing 75-micron sieve), or Granulated (e.g. 1% passing 75-micron sieve)
Cation exchange capacity	70 meq/100 g (or cmol/kg)
Free swell index	24 cm^3/2 g

7.2.3 Drainage Layers

Drainage layers should be 300 mm thick and constructed from clean, durable, and sound gravel, rock or aggregate. It should have the following properties:

- Hydraulic conductivity greater than 1 x 10^{-3} m/sec;
- Material particle size should be less than 50mm and greater than 20 mm;
- Fines content less than 1%;
- Be relatively non-reactive, and uniform in grain size.

The aggregate may be sourced from numerous locations as long as each source meets these requirements.

7.2.4 Geomembranes

A geomembrane layer is required in the basal liner, and may be required the final capping. Alternative (EPA approved) options could be considered during the subsequent Detail Design phase of the project.

The basal liner geomembrane shall consist of 2.0mm thick, high density polyethylene (HDPE) unlaminated material, textured or untextured on both sides and shall comply with GRI GM13. The material should be produced from pure (non-recycled) resins and contain no fillers, plasticisers or additives of any kind with the exception of carbon black.

The geomembrane used in the final capping shall consist of a 2.0mm thick smooth, low density polyethylene (LDPE) unlaminated material that shall comply with GRI GM17.

7.2.5 Geotextiles

Geotextiles are required above and below the drainage layer in the basal liner. The separation geotextile is designed to prevent fines from clogging the drainage aggregate and the protection geotextile is designed to prevent damage to the geomembrane.

Geotextiles shall be comprised of polyester or polypropylene (with the exception of inhibitors and/or carbon black added for UV resistance), non-woven and needle-punched materials. Polypropylene materials shall be UV stabilised.

The geotextile shall be non-woven, needle punched, resin or heat bonded and manufactured from polyester, polyethylene or polypropylene. The geotextile shall comprise polymeric yarns or fibres, seamed or drawn strands orientated into a stable network which retains its structure during handling, placement and long term service. The geotextile filaments shall be rot-proof, chemically stable, with no water absorbency and the filaments being able to resist delamination.

8 Ongoing Design Considerations

The preliminary design philosophy utilises the available techniques to meet the NSW EPA Environmental Guidelines, 2016. Alternative techniques shall also be considered. However, information regarding the subsurface site conditions is limited thus several conservative preliminary design assumptions have been made based on literature and data provided from reports made on this and other parts of the site.

APPENDIX A

Regulatory Guidelines

The concept design is required to consider the requirements of the Environmental Guidelines: Solid Waste Landfills (NSW EPA, 2016) which are outlined in the table below. .

Design Component	Minimum Requirements
Landfill Siting	
To identify and rank those sites that require the fewest engineering and management controls to meet the objects of all State environmental protection policies.	• Within 250 m of an area of significant environmental or conservation value (including residential dwellings, schools, hospitals etc.) • Within specially reserved drinking water catchments • In or within 40 m of a permanent or intermittent water body or in an areas overlying an aquifer that contains drinking water quality groundwater that is vulnerable to pollution • Within a karst region or with substrata that are prone to land slip or subsidence • Within a floodway that may be subject to washout during a major flood event (a 1-in-100-year event) • In the case of large putrescible waste landfills (more than 50 000 tonnes of putrescible waste per year), buffers of at least 1000 m should be provided where practicable to residential zones, schools and hospitals to protect the amenity of these land uses from odour, noise, and other impacts
Leachate Barrier System	

The landfill must have a leachate barrier system to contain leachate and precent the contamination of surface and ground water over the life of the landfill. The leachate barrier system ensures that pollutants are not permitted to migrate beyond the boundaries of the premises.	• The primary barrier system should include the following components, from bottom to top:
	  ◦ A compacted sub-base 200mm thick;
	  ◦ A composite liner, comprising a lower compacted clay liner and an upper flexible membrane liner. A geosynthetic clay liner may be used as an alternative to the compacted clay liner.
	  ◦ Protection and separation geotextile layers above and below the 300 mm thick gravel drainage layer including leachate collection pipework.

Leachate storage and disposal	

Sufficient leachate storage and disposal must be performed in order to not cause harm to the environment	• The design, construction and operation of a new leachate storage dam must meet the following requirements:
	  ◦ The dam must have sufficient leachate storage volume and freeboard that can accept rainfall directly on the dam from a 24--h rainfall event with a 1-in-25 year average recurrence interval without overflowing.
	  ◦ Leachate storage areas should not be constructed over previously landfilled areas, except in exceptional circumstances;

Design Component	Minimum Requirements

	• If above-ground tanks are used, the tanks and associated connection points must be surrounded by a bund with a capacity of at least 110% of the tanks.
	• The disposal and treatment of the leachate must meet the following:
	  • Untreated leachate must not be disposed of to an off-site location and utilised to supply water needs for any process;
	  • Stored leachate must be: discharged to a sewer, tankered off site to a licensed treatment facility, evaporated, irrigated, or reinjected back into the waste, or spray irrigated over an existing licenced utilisation area
	• Leachate management shall be supported by water balance calculations that provide robust estimates of the required leachate storage capacity. A water balance should be conducted when a new landfill or cell is proposed
	• Leachate quality should be monitored to establish the composition, and volume of leachate produced by each landfill cell, as well as record any irregular discharges or overflows of the leachate

Surface Water Management	

Controls should be implemented to reduce erosion and minimise sediment load in surface water that is discharged from site.	• The following erosion control measures shall be taken into consideration:
	  • Minimise the area of exposed soils
	  • Stabilise exposed soil
	  • Reduce erosive effects of surface water
	  • Protect soil stockpiles
	  • Manage unsealed roads
	  • Site exit controls
	  • Maintain erosion control structures
	• Sediment control measures shall be taken, to ensure that sediment-laden surface water runoff passes through an appropriate sediment control structure. Sediment control structures include vegetative buffers, silt fences, fibre rolls, turbidity or silt curtains, and sedimentation dams
	• Surface water monitoring shall also be undertaken to detect excess sediment loads and detect if cross contamination of surface water with leachate is occurring.

Landfill gas management and monitoring	
A landfill gas management program must be established to ensure that	• Landfill gas practices must be adopted to: • Minimise emissions of untreated landfill gas to air and through sub-surface strata and services

Design Component	Minimum Requirements
the appropriate engineering controls are in place to ensure that methane and other gases produced by the landfill are properly managed.	• Minimise greenhouse gas emissions • Minimise emissions of offensive odour • Minimise the explosive risk to humans from gas build-up in confined spaces • Ensure that, wherever feasible, landfill gas is sustainably utilised for energy recovery • Minimise emissions of air pollutants from the combustion of landfill gas in flaring or electricity-generating equipment • A landfill gas monitoring program must be established to detect surface emissions of gas, sub-surface migration of gas, or accumulation of gas in buildings and other structures at potentially dangerous levels. Monitoring must also be able to demonstrate that the gas treatment technologies are effective in destroying methane and other potential air pollutants in landfill gas. Appropriate response action must be taken if the trigger or limit values specified in these guidelines are exceeded.
Final capping and revegetation	
A completed landfill cell must be capped and revegetated to ensure that waste is properly covered and remediated	• All landfill cells must be capped and revegetated within 6 months of the final delivery of waste to the cell. The final capping must: • Reduce surface water infiltration into the waste and thus minimise the generation of leachate (Ideally rainfall infiltration should be less than 5% of the annual rainfall) • Stabilise the surface of the completed part of the landfill • Reduce suspended sediment and contaminated runoff • Minimise the escape of untreated landfill gas • Minimise odour emissions, dust, litter, the presence of scavengers and vermin, and the risk of fire • Prepare the site for its future use; this includes protection of people, fauna and flora or near the site from exposure to pollutants still contained in, or escaping from, the landfill • The final capping of general solid waste landfills should comprise as a minimum, from bottom to top: • A seal-bearing surface consisting of properly designed and engineered layer of material at least 300 mm thick to support the sealing layer. The material should meet recognised specifications for engineered materials. • A composite sealing layer, comprising a lower compacted clay layer and an upper flexible membrane liner. The flexible membrane liner should be a high density polyethylene or linear low density polyethylene liner at least 2 mm thick. A geosynthetic clay liner may be used as an alternative to the compacted clay component.

Design Component	Minimum Requirements
	• A revegetation layer at least 1000 mm thick and comprising clean soils and vegetation with root systems that will not penetrate into lower layers. The upper 200 mm shall be a topsoil layer, which can include compost to help with vegetative establishment and growth. The revegetation layer shall promote water removal by evapotranspiration and runoff; protect the sealing layer from desiccation and / or damage; and sustain microbial populations that oxidise a proportion of any methane passing up through the cap • For final capping installed on steep slopes, the capping elements shall be demonstrated to have adequate slope stability. A slope stability analysis shall demonstrate that there are adequate factors of safety for all relevant potential failure mechanisms (e.g. veneer and global stability), both at the proposed final landform and at interim stages during construction. • A construction quality assurance program shall be implemented during construction of the final capping. • To assess the continued integrity and performance of the final capping, post-closure monitoring should be undertaken.

APPENDIX B

Coffey Geotechnical and Hydrogeological Investigation Report

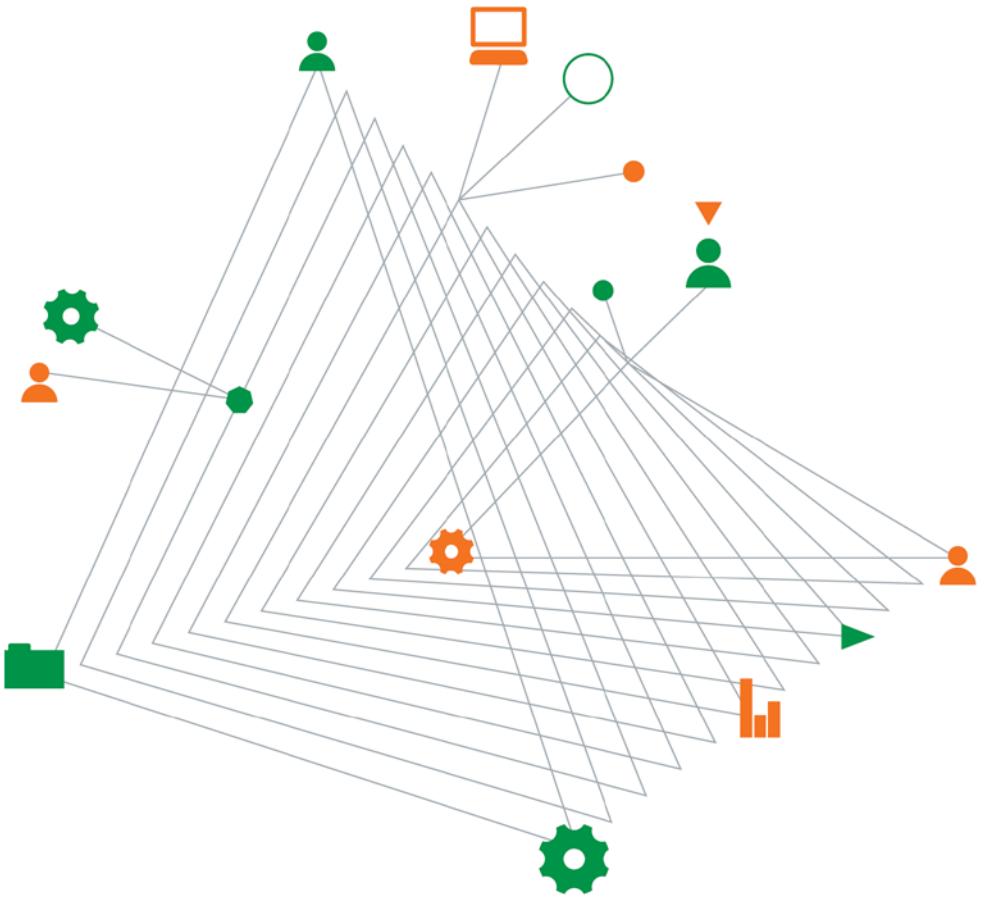
coffey
A TETRA TECH COMPANY

Shoalhaven City Council

Geotechnical and Hydrogeological Investigation

West Nowra Recycling and Waste Facility

27 July 2016



Experience comes to life when it is powered by expertise

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Geotechnical and Hydrogeological Investigation

Prepared for
Shoalhaven City Council
PO Box 42
Nowra NSW 2541

Prepared by
Coffey Geotechnics Pty Ltd
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27 July 2016

Document authorisation

Our ref: GEOTWOLL03957AA-AB

Attention: Giordano Bianco

Dear Giordano,

RE: Geotechnical and Hydrogeological Investigation - West Nowra Recycling and Waste Facility Stage 4 Landfill Extension Project

Coffey Geotechnics Pty Ltd (Coffey) is pleased to present the final geotechnical and hydrogeological report for the West Nowra Recycling and Waste Facility Stage 4 landfill extension project. The work was commissioned by Shoalhaven City Council (SCC) in response to our proposal GEOTWOLL03957AA-PAB, dated 6 May 2016.

Further advice on the uses and limitations of this report is presented in the attached document, *'Important information about your Coffey Report'.*

Should you require further information regarding this report please contact the undersigned or Jon Thompson on 02 4201 1400.

For and on behalf of Coffey

Corinna De Castro
Senior Hydrogeologist

Quality information

Revision history

Revision	Description	Date	Author	Reviewer	Signatory
AA	Original	22/07/2016	Corinna De Castro	Jon Thompson	Corinna De Castro
AB	Final	27/07/2016	Corinna De Castro	Jon Thompson	Corinna De Castro

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Appendices

Appendix A – Engineering Logs and Explanatory Notes

Appendix B – ENRS Hydrographs

Appendix C – Geotechnical Laboratory Test Reports

1. Introduction

Coffey Geotechnics Pty Ltd (Coffey) was commissioned by Shoalhaven City Council (SCC) to provide geotechnical and hydrogeological services in relation to the proposed Stage 4 landfill extension to the current West Nowra Recycling and Waste Facility (WNRWF), located at Lot 1 DP 1104402, Flatrock Road, Mundamia, NSW. The general site locality is shown in Drawing 1.

The proposed Stage 4 landfill extension (the Project) will create new landfill cells to accommodate waste management for a growing population. The proposed Stage 4 land area is approximately 14.5 ha and is classified under Zone SP2 Infrastructure – Waste/Resource Management Facilities.

WNRWF is licensed as a general solid waste (putrescible and non-putrescible) facility. Operations commenced in 1975. The disposal of hazardous and toxic waste, with the exception of asbestos, has been prohibited since 1986. Landfill waste staging is detailed below:

- Stage 1 - closed and rehabilitated after commencing in 1975;
- Stage 2 - operational with partial rehabilitation;
- Stage 3 - operational and landfilling, HDPE lined; and
- Stage 4 - preparation of an Environmental Impact Statement (EIS) for future landfill extension.

1.1. Objectives

The objectives of the geotechnical and hydrogeological investigation were to:

- Assess geotechnical conditions and provide descriptions of the sub-surface soil and rock conditions within the proposed Stage 4 landfill area;
- Provide recommendations in relation to excavation conditions;
- Assess permeability of the onsite materials to be used as clay liner fill at the base and final cap of the landfill;
- Install a groundwater monitoring network to assess soil and rock groundwater levels within and surrounding the proposed landfill cells;
- Provide recommendations in relation to groundwater monitoring frequency; and
- Provide a factual geotechnical and hydrogeological report discussing the findings of the investigation and our recommendations in relation to the above objectives.

2. Scope of work

To address the above objectives, the following scope of work was conducted:

- Field investigations from 23 May to 1 July 2016 including (locations as presented in Drawing 2):
  - Drilling of six geotechnical boreholes (BH1-BH6) within the footprint of the proposed landfill cells to a maximum depth of 10 m;
  - Excavation of 10 test pits (TP1-TP10) within the proposed landfill cells to a maximum depth of 6 m; and
  - Drilling and installation of seven piezometers (monitoring wells) at five locations within and surrounding the proposed landfill cells. Five piezometers (GW1-GW5) were drilled in sandstone to a maximum depth of 18 m and two piezometers (GW1A and GW2A) were drilled in residual soil and sandstone to a maximum depth of 9 m.

- Collection of soil samples from boreholes and test pits for subsequent laboratory testing comprising:
  - 15 Emerson dispersion tests (AS1289.3.8.1);
  - 11 particle size distribution (PSD) tests including hydrometer for fine particle analyses;
  - 21 moisture content tests (AS1289.2.1.1);
  - 15 Atterberg limits (liquid limit, plastic limit, plastic index) and linear shrinkage tests;
  - 8 standard compaction tests; and
  - 9 constant head permeability tests.
- Preparation of a geotechnical and hydrogeological factual report addressing the following objectives:
  - Assessment of geotechnical conditions including descriptions of the sub-surface soil and rock within the proposed Stage 4 landfill area;
  - Assessment of permeability of the onsite materials to be used as clay liner fill at the base of the proposed landfill;
  - Assessment of groundwater levels within and surrounding the proposed landfill cells;
  - Provision of recommendations in relation to excavation conditions; and
  - Provision of recommendations in relation to groundwater monitoring frequency.

3. Site setting

3.1. Topography and surface water

Topography in the Stage 4 Project area generally slopes east from a north-south ridgeline of around 50 m AHD towards Cabbage Tree Creek at an elevation of around 30 m AHD, approximately 500 m east of the Project area. Surface water in Cabbage Tree Creek flows north-east discharging into the Shoalhaven River approximately 1.5 km from the Project area. West of the ridgeline topography generally slopes west discharging towards Sandy Creek at an elevation of around 30 m AHD.

3.2. Geology and soil landscape

Reference to the 1:250,000 Wollongong Geological Series Sheet (SI 56-9), second edition prepared by the NSW Department of Mines (1966) indicates that the Project area is underlain by the Megalong Conglomerate of the Shoalhaven Group described as quartz sandstone with particular reference to Nowra Sandstone.

Reference to the 1:100,000 Kiama Soil Landscape Series Sheet (9028) prepared by the Department of Conservation and Land Management of NSW (1993) indicates that the Project area is located within the Nowra Depositional Landscape grouping with Disturbed Terrain. The Nowra Depositional Landscape is described as moderately to gently undulating rising to low hills on Nowra Sandstone with broad ridges and crests, benched sandstone outcrops and extensive to moderately cleared tall open-forest. Disturbed Terrain is generally described as varying topography ranging from level plains to undulating terrain which has been disturbed by human activity.

3.3. Hydrogeology

Groundwater in the Project area is within the Nowra Sandstone at depths ranging from around 5 m to 12 m below ground level. Current groundwater elevations range from approximately 42 m AHD along the ridgeline to 37 m AHD towards the eastern boundary of the proposed landfill cells.

East of the ridgeline groundwater currently flows east, discharging at Cabbage Tree Creek. West of the ridgeline groundwater flows west. Evaporation consumes groundwater within the Stage 3 landfill excavation, the remainder of groundwater flow discharges at Sandy Creek.

At lower elevations groundwater will occur within the alluvial sediments of Cabbage Tree Creek and Sandy Creek.

Recharge to the groundwater system is reliant on rainfall recharge. Rainfall infiltration is typically about 6% of rainfall. In virgin sandstone catchments, about half of this recharge (about 3% of rainfall) would report to drainage channels. The remainder (about 3%) would be consumed by evapotranspiration, hill slope discharge (mostly evapotranspiration), and down gradient groundwater flow.

4. Fieldwork

The field program conducted did not encroach into the designated environmental zone on the Stage 4 eastern boundary and the proposed wildlife corridor on the south western boundary.

Drilling and excavation works were organised by SCC and carried out by Highland Drilling and Normans Plant Hire.

Borehole, test pit and piezometer locations are provided in Drawing 2.

The following sections provide a general methodology of the adopted fieldwork investigation.

4.1. Borehole drilling

Six boreholes (BH1-BH6) were drilled from 23 to 30 May 2016 using a track mounted Hanjin DB8 drilling rig. All boreholes were advanced using solid flight augers and a Tungsten Carbide drill bit to refusal, then continued below refusal depth using diamond coring techniques to a maximum depth of 10 m. Standard penetration tests (SPTs) were undertaken at regular intervals down to auger refusal, to assess soil consistency or relative density.

SCC located the boreholes, a Coffey geotechnical engineer recorded test results, logged samples from the boreholes and noted soil moisture changes. No groundwater was observed within the augered soils. Water was used for rock coring therefore no observations were recorded for groundwater inflows within the sandstone.

SCC organised survey of each borehole location. Coordinates and ground levels are noted on the engineering logs of the boreholes in Appendix A.

4.2. Test pit excavations

Ten test pits (TP1-TP10) were excavated from 28 June to 1 July 2016 using a 35 tonne excavator PC350, to a maximum depth of 6 m.

SCC located the test pits, a Coffey geotechnical engineer logged samples from the test pits and noted soil moisture changes. No groundwater was observed within the soils and highly to moderately weathered sandstone encountered.

SCC organised survey of each test pit location. Coordinates and ground levels are noted on the engineering logs of the test pits in Appendix A.

4.3. Piezometer installation

Seven piezometers at five locations were drilled and installed from 26 May to 1 June 2016 using a track mounted Hanjin DB8 drilling rig and down hole air hammer drilling techniques. Five piezometers (GW1-GW5) were drilled in sandstone to a maximum depth of 18 m and two shallow nested piezometers (GW1A and GW2A) were drilled in residual soil and sandstone to a maximum depth of 9 m.

Piezometer construction included a 1 m sump at the base of each piezometer using solid 50 mm PVC, a 3 m length of 50 mm PVC screen followed by solid casing to above the ground surface. A 2 mm sand filter pack was added from the base of the borehole annulus to at least 1 m above the screen interval, followed by a bentonite plug of at least 1 m and a grout mix to the surface. Each piezometer was completed using a steel lockable monument concreted at the ground surface.

SCC located the piezometers, a Coffey geotechnical engineer logged cuttings during drilling and noted soil and rock moisture changes. Groundwater was observed within highly to moderately weathered sandstone.

SCC organised survey of each piezometer. Coordinates and ground levels are noted on the engineering logs of the piezometers attached in Appendix A.

4.4. Laboratory testing

To aid in the assessment of material re-use, the following laboratory analysis was conducted on collected soil samples:

- 15 Emerson dispersion tests (AS1289.3.8.1);
- 11 particle size distribution (PSD) tests including hydrometer for fine particle analyses;
- 21 moisture content tests (AS1289.2.1.1);
- 15 Atterberg limits (liquid limit, plastic limit, plastic index) and linear shrinkage tests;
- 8 standard compaction tests; and
- 9 constant head permeability tests.

Internal geotechnical testing was provided by our NATA registered laboratories in Nowra, Sydney and Melbourne.

5. Results of investigation

5.1. Subsurface conditions

Detailed subsurface conditions are provided in the engineering logs attached in Appendix A. The depth of topsoil is relatively shallow (up to 0.4 m), however we note that there are many trees over the Project area and the root zone will extend into the residual soils. The Project area is underlain by residual sandy or silty clays ranging from low to high plasticity, with clayey sand layers generally towards the base of the extremely weathered material in some areas. Highly to moderately weathered sandstone was encountered at all locations except for test pit TP8. Excavator refusal occurred in six of the test pits at depths ranging from 2.5 m to 4.5 m.

A summary of the lithology from the field investigation is presented in **Table 1**.

Table 1 - Lithological summary

Location	Ground surface level (m AHD)	Base of topsoil (depth m)	Base of residual (depth m)	Base of extremely weathered material / top of rock (depth m)	Top of rock level (m AHD)	Total depth (m)	Comment
TP1	49.834	0.2	0.8	2.0	47.8	3.3	Excavator refusal on rock
TP2	48.978	0.3	0.7	5.0	44.0	6.0	Excavator extent - target depth on rock
TP3	48.973	0.2	0.8	5.0	44.0	5.5	Target depth on rock
TP4	47.552	0.25	0.8	5.0	42.6	5.6	Target depth on rock
TP5	47.008	0.25	0.7	3.0	44.0	4.5	Excavator refusal on rock
TP6	48.531	0.3	0.6	3.5	45.0	4.4	Excavator refusal on rock
TP7	48.691	0.3	0.7	3.5	45.2	4.0	Excavator refusal on rock
TP8	48.609	0.25	0.55	-	-	5.75	Excavator extent – no rock
TP9	48.259	0.25	0.8	3.0	45.3	3.8	Excavator refusal on rock
TP10	47.444	0.25	0.55	1.75	45.7	2.5	Excavator refusal on rock
BH1	48.25	0.35	1.0	7.6	40.6	10.0	Target depth on rock
BH2	49.31	0.3	2.0	6.7	42.6	9.5	Target depth on rock
BH3	48.913	0.3	1.5	7.0	41.9	9.3	Target depth on rock
BH4	49.11	0.3	2.0	7.0	42.1	10.0	Target depth on rock
BH5	46.35	0.3	2.0	8.3	38.1	9.39	Target depth on rock
BH6	48.92	0.35	1.75	6.275	42.6	9.57	Target depth on rock
GW1A	51.264	0.4	2.0	6.0	45.3	9.0	Target depth
GW1	51.109	0.3	2.0	6.5	44.6	18.0	Target depth
GW2A	47.709	0.3	3.0	7.0	40.7	9.0	Target depth
GW2	47.841	0.3	2.0	6.0	41.8	17.15	Target depth
GW3	47.057	0.4	2.0	7.0	40.1	18.0	Target depth
GW4	49.259	0.35	3.0	7.2	42.1	13.0	Target depth
GW5	49.771	0.3	3.0	7.0	42.8	18.0	Target depth

5.2. Groundwater

A groundwater monitoring network has been installed to assess soil and rock groundwater levels within and surrounding the proposed landfill cells. Assessment of groundwater quality will be conducted by others. Piezometer completion details are provided in **Table 2**.

Table 2 - Piezometer completion details

Piezometer ID	Easting (m MGA)	Northing (m MGA)	Ground level (m AHD)	Top of casing PVC (m AHD)	PVC stickup (m)	Drilled depth (m bgl)	Screen interval (m bgl)	Sand filter pack (m bgl)	Bentonite (m bgl)	Grout (m bgl)	Screen lithology
GW1A	276110.8	6136841.1	50.434	51.264	0.83	9	5-8	3.85-9	2.7-3.85	0-2.7	Sandy clay/clayey sand, HW to MW sandstone
GW1	276107.4	6136839.0	50.439	51.109	0.67	18	14-17	12.4-18	10.3-12.4	0-10.3	HW to MW sandstone
GW2A	276266.5	6136960.1	46.899	47.709	0.81	9	5-8	4.02-9	2.75-4.02	0-2.75	Clayey sand, HW to MW sandstone
GW2	276262.7	6136958.1	47.031	47.841	0.81	17.15	13.15-16.15	12-17.15	10.8-12	0-10.8	HW to MW sandstone
GW3	276257.5	6137248.1	46.312	47.057	0.745	18	14-17	13.1-18	12-13.1	0-12	HW to MW sandstone
GW4	276400.7	6137112.8	48.509	49.259	0.75	13	9-12	8.0-13	7.4-8	0-7.4	HW to MW sandstone
GW5	276238.2	6137084.4	49.171	49.771	0.6	18	14-17	7.5-18	6-7.5	0-6	HW to MW sandstone

m AHD - metres Australian Height Datum

m bgl - metres below ground level

HW - highly weathered

MW - moderately weathered

Selected groundwater depths below ground level measured by ENRS in the piezometers are provided in **Table 3**. Groundwater elevations shown are based on survey data provided by SCC.

Table 3 - Groundwater levels

Piezometer ID	Groundwater depth (m bgl) Dates measured			Groundwater level (m AHD) Dates measured			Water level logger installation date
	7-Jun-16	30-Jun-16	5-Jul-16	7-Jun-16	30-Jun-16	5-Jul-16	
GW1A	Dry	Dry	Dry	Dry	Dry	Dry	28 June 2016
GW1	8.66	8.44	9.72	41.78	42.00	40.72	3 June 2016
GW2A	Dry	Dry	Dry	Dry	Dry	Dry	28 June 2016
GW2	6.95	7.08	7.03	40.08	39.96	40.00	3 June 2016
GW3	5.61	5.68	5.60	40.70	40.63	40.71	7 June 2016
GW4	12.23	9.24	11.15	36.28	39.27	37.36	7 June 2016
GW5	8.63	8.72	8.65	40.54	40.45	40.52	7 June 2016

Hydraulic head surfaces for 7 June 2016 and 30 June 2016 are illustrated in Drawing 3 and Drawing 4 respectively.

Water level loggers were installed in the piezometers by ENRS between 3 June and 28 June 2016. Groundwater hydrographs prepared by ENRS are provided in Appendix B.

The pressure head profile based on hydraulic heads measured on 30 June 2016 is illustrated in Figure 1. The interpolated water table depth (where pressure head equals zero) is approximately 9 m below ground level.

Further discussion regarding the water table and drawdown impacts from the adjacent Stage 3 excavation is provided in Section 6.2.

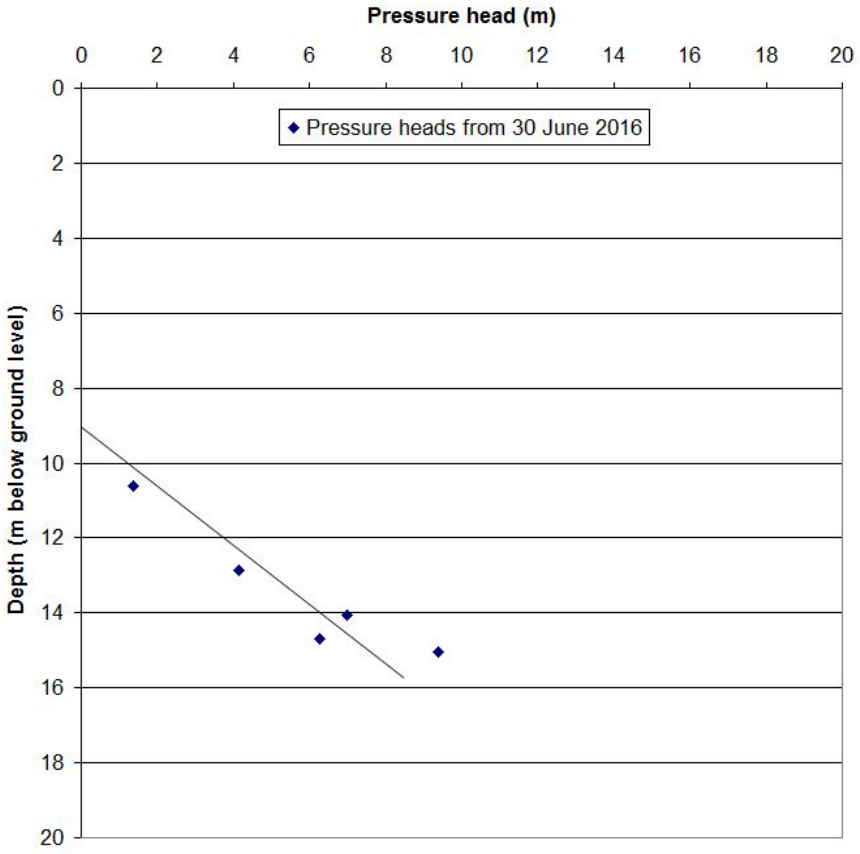


Figure 1 - Pressure head profile on 30 June 2016

5.3. Laboratory testing

Geotechnical laboratory test reports are attached in Appendix C.

Summary results are provided in **Table 4** to **Table 7**.

Table 4 - Emerson and moisture content results

Location and depth (m)	Moisture content (%)	Dispersion test - Emerson Class Number
BH1, Depth: 4.00-4.45m	9.1	-
BH2, Depth: 4.00-4.45m	7.9	-
BH3, Depth: 5.50-5.92m	7.4	-
BH4, Depth: 4.00-4.35m	4.7	-
BH5, Depth: 5.50-5.85m	9.9	-
BH6, Depth: 4.00-4.35m	6.9	-
TP1, Depth: 1-2m	15.7	5
TP2, Depth: 1-2m	15.7	-
TP2, Depth: 2-3m	10.7	-
TP2, Depth: 3-4m	9.0	-
TP2, Depth: 4-5m	13.6	5
TP3, Depth: 1-2m	-	5
TP3, Depth: 4-5m	-	5
TP4, Depth: 2-3m	11.1	5
TP4, Depth: 4-5m	-	5
TP5, Depth: 1-2m	-	6
TP5, Depth: 2-3m	6.4	5
TP6, Depth: 1-2m	11.2	5
TP6, Depth: 2-3m	10.3	-
TP6, Depth: 3-4m	10.8	-
TP6, Depth: 4-5m	6.7	-
TP7, Depth: 1-2m	-	6
TP7, Depth: 2-3m	6.9	-
TP7, Depth: 3-4m	-	6
TP8, Depth: 2-3m	-	6
TP8, Depth: 3-4m	10.5	-
TP8, Depth: 4-5m	-	5
TP9, Depth: 2-3m	9.8	6
TP10, Depth: 1-1.5m	10.9	6

Table 5 - Atterberg results

Location	Depth (m)	Plasticity Index	Liquid Limit	Plastic Limit	Linear Shrinkage	Classification*
BH1	4.00-4.45	15	34	19	8	L-MP
BH2	4.00-4.45	17	33	16	7	L-MP
BH3	5.50-5.92	16	31	15	7	L-MP
BH4	4.00-4.35	10	25	15	4	LP
BH5	5.50-5.85	6	21	15	3	LP
BH6	4.00-4.35	12	26	14	5	LP
TP1	1.0-2.0	28	48	20	8	M-HP
TP2	4.0-5.0	16	35	19	8	MP
TP4	2.0-3.0	23	42	19	10	M-HP
TP5	2.0-3.0	11	26	15	5	LP
TP7	2.0-3.0	13	27	14	5	L-MP
TP7	3.9-4.0	8	22	14	3	LP
TP8	3.0-4.0	23	36	13	9	MP
TP9	2.0-3.0	21	39	18	7	MP
TP10	1.0-1.5	13	28	15	5.5	L-MP

*Classification
LP - low plasticity clay: plasticity index <13, liquid limit <35
MP - medium plasticity clay: plasticity index 13-22, liquid limit 35-50
HP - high plasticity clay: plasticity index >22, liquid limit >50

Table 6 - Particle size distribution results

Location	Depth (m)	Natural Moisture Content (MC)	<37.5 mm	<26.5 mm	<19 mm	<13.2 mm	<9.5 mm	<6.7 mm	<4.75 mm	<2.36 mm	<1.18 mm	<600 µm	<425 µm	<300 µm	<150 µm	<75 µm	<2 µm
		(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
TP1	1.0-2.0m	13.9	100	100	98	96	93	90	87	84	80	77	74	71	64	59	29
TP2	4.0-5.0m	13.6	100	99	98	96	94	94	93	91	87	83	82	80	77	73	19
TP3	2.0-3.0m	11.5	100	100	100	99	97	94	92	89	84	80	78	76	73	69	22
TP3	3.0-4.0m	12.8	100	100	98	96	94	92	90	88	85	82	80	79	74	70	31
TP4	2.0-3.0m	15.1	100	100	99	99	96	94	93	91	89	87	86	84	82	78	36
TP5	1.0-2.0m	12.7	100	100	99	98	94	92	89	87	83	80	77	74	65	56	24
TP5	2.0-3.0m	6.9	100	100	99	97	95	91	89	84	79	74	71	67	59	51	16
TP7	2.0-3.0m	7.0	100	97	97	96	95	94	94	93	91	88	85	80	66	48	16
TP8	3.0-4.0m	11.9	100	100	100	100	99	99	98	97	95	93	91	89	84	80	32
TP9	2.0-3.0m	10.1	100	98	95	93	88	85	83	80	77	75	72	69	62	55	23
TP10	1.0-1.5m	14.7	100	100	100	99	98	96	95	94	91	87	86	83	77	64	25

Table 7 - Permeability and compaction testing results

Sample Location	Sample Depth (m)	Natural Moisture Content (MC)	Compaction testing		Permeability (constant head laboratory testing)	Permeability NSW EPA landfill guidelines
		(%)	SMDD (t/m^3)	OMC (%)	m/s	m/s
BH4	5.5-7.0m	-	-	-	2×10^{-9}	1×10^{-9}
BH6	5.5-7.0m	-	2.01	11.0	5.2×10^{-9}	1×10^{-9}
TP1	1.0-2.0m	13.9	1.80	16.0	3×10^{-10}	1×10^{-9}
TP2	4.0-5.0m	13.6	1.76	15.5	5×10^{-10}	1×10^{-9}
TP3	3.0-4.0m	12.8	1.75	17.0	2×10^{-10}	1×10^{-9}
TP4	2.0-3.0m	15.1	1.72	18.0	2×10^{-10}	1×10^{-9}
TP5	2.0-3.0m	6.9	1.91	11.5	1×10^{-9}	1×10^{-9}
TP9	2.0-3.0m	10.1	1.84	13.5	4×10^{-10}	1×10^{-9}
TP10	1.0-1.5m	14.7	1.82	15.0	7×10^{-10}	1×10^{-9}

SMDD - Standard Maximum Dry Density

OMC - Optimum Moisture Content

6. Discussion

6.1. Geotechnical

The results of the geotechnical investigation indicate the following:

- The depth to rock is variable across the site and is relatively shallow in some areas compared to the typical landfill cell depth of 7 m adopted for previous stages of the West Nowra Recycling and Waste Facility. Excavator refusal depths on rock occurred in six of the test pits at depths ranging from 2.5 m to 4.5 m below ground surface;
- The laboratory testing indicates that the residual soils and extremely weathered materials at the depths sampled have a clay component and range from low to high plasticity. The samples selected for permeability testing were remoulded at densities similar to that required for a clay liner. The results of the permeability tests indicate that of the nine samples tested, seven were at or lower than the required 10^{-9} m/s for material re-used as clay liner, with two results being higher ie. seven out of nine results were complying. As the samples tested had natural moisture contents drier than optimum moisture content, where these materials are re-used for lining of landfill cells, they will need moisture conditioning and suitable re-working with a padfoot roller to break down weathered rock materials;
- The near surface silty topsoil materials, root affected materials and highly to moderately weathered rock or less weathered rock encountered will not be suitable for re-use in low permeability liners or as capping material. The removal of trees and root affected materials will disturb the soils to possibly more than 1 m deep; and
- All soils and the weathered rock will soften or weaken when exposed to moisture ingress, particularly if in a disturbed condition.

6.2. Hydrogeological

Screen depths or hydraulic intervals are important when assessing groundwater levels measured in piezometers.

GW4 is the shallowest of the saturated piezometers. The hydraulic head surface from 30 June 2016 shows a significantly changed hydraulic gradient compared to the hydraulic head surface from 7 June 2016. The response to rainfall is greater at GW4 as it is shallower.

The hydrographs show the greatest response to rainfall was a 2.9 m rise in groundwater level recorded at piezometer GW4 approximately three weeks following the rain event. The deeper piezometers registered minimal increases in groundwater level, whereas below the shallow dry piezometers the water table probably increased.

Response to the significant rainfall event in early June 2016 was not captured in the shallow piezometers GW1A and GW2A, therefore no data characterising the water table rise is available to date.

Based on the pressure head profile on 30 June 2016, the interpolated water table depth (where pressure head equals zero) is approximately 9 m below ground level. However it is important to note that current groundwater levels are drawn down due to the Stage 3 landfill cell void to the west of the ridgeline. The maximum depth of the void is around 40 m AHD, below the maximum groundwater level of 42 m AHD, therefore evaporation is consuming groundwater. Once the Stage 3 excavation is filled and capped, groundwater levels will rise. Therefore the long-term average groundwater levels will be higher than what is currently being measured.

7. Conclusions

Based on the outcomes of the investigation conducted, the following conclusions are made:

- The depth to rock is variable across the site and is relatively shallow in some areas;
- The results of the permeability tests indicate that of the nine samples tested, seven were at or lower than the required 10^{-9} m/s for material re-used as clay liner, with two results being higher ie. seven out of nine results were complying;
- The near surface silty topsoil materials, root affected materials and highly to moderately weathered rock or less weathered rock encountered will not be suitable for re-use in low permeability liners or as capping material;
- All soils and the weathered rock will soften or weaken when exposed to moisture ingress, particularly if in a disturbed condition;
- Groundwater in the Project area is within the Nowra Sandstone at depths ranging from around 5 m to 12 m below ground level;
- Current groundwater elevations range from approximately 42 m AHD along the ridgeline to 37 m AHD towards the eastern boundary of the proposed landfill cells;
- East of the ridgeline groundwater flows east, discharging at Cabbage Tree Creek;
- West of the ridgeline groundwater flows west. Evaporation consumes groundwater within the Stage 3 landfill excavation, the remainder of groundwater flow discharges at Sandy Creek;
- Hydrographs show the greatest response to rainfall was a 2.9 m rise in groundwater level recorded at piezometer GW4 approximately three weeks following the early June 2016 rain event;
- The deeper piezometers registered minimal increases in groundwater level, whereas below the shallow dry piezometers the water table probably increased following the early June 2016 rain event;
- The water table may fluctuate up to 5 m with rainfall and seasons; and
- The interpolated water table depth is approximately 9 m below ground level however it is important to note that current groundwater levels are drawn down due to the Stage 3 landfill cell void to the west of the ridgeline. Once the Stage 3 excavation is filled and capped, groundwater levels will rise. Therefore the long-term average groundwater levels will be higher than what is currently being measured.

8. Recommendations

Based on the outcomes of the investigation conducted, the following recommendations are made:

- Further testing of selected materials will be required prior to final design and construction where excavated materials are proposed for re-use during construction of the cells;
- Baseline groundwater monitoring should be conducted to capture seasonal changes in groundwater levels and quality. A minimum monitoring period of six months is recommended; and
- Water level loggers should remain in the shallow piezometers GW1A and GW2A until a significant rain event is recorded showing the water table rise.

9. Limitations

The comments and recommendations provided within this report have been made on the basis of limited details of the proposed development. If details of the proposed development differ from those assumed in the preparation of this report, Coffey should be contacted for further geotechnical advice.

The findings in this report are the result of observations made at discrete test pit and borehole locations and observations of the surface conditions of the site. Due to the large site area, subsurface conditions could vary significantly across the site. Should different subsurface conditions to those expected be encountered during construction, Coffey should be contacted immediately.

We draw your attention to the attached sheets titled “Important information about your Coffey Report" which must be read in conjunction with this report.

Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Important information about your **Coffey** Report

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

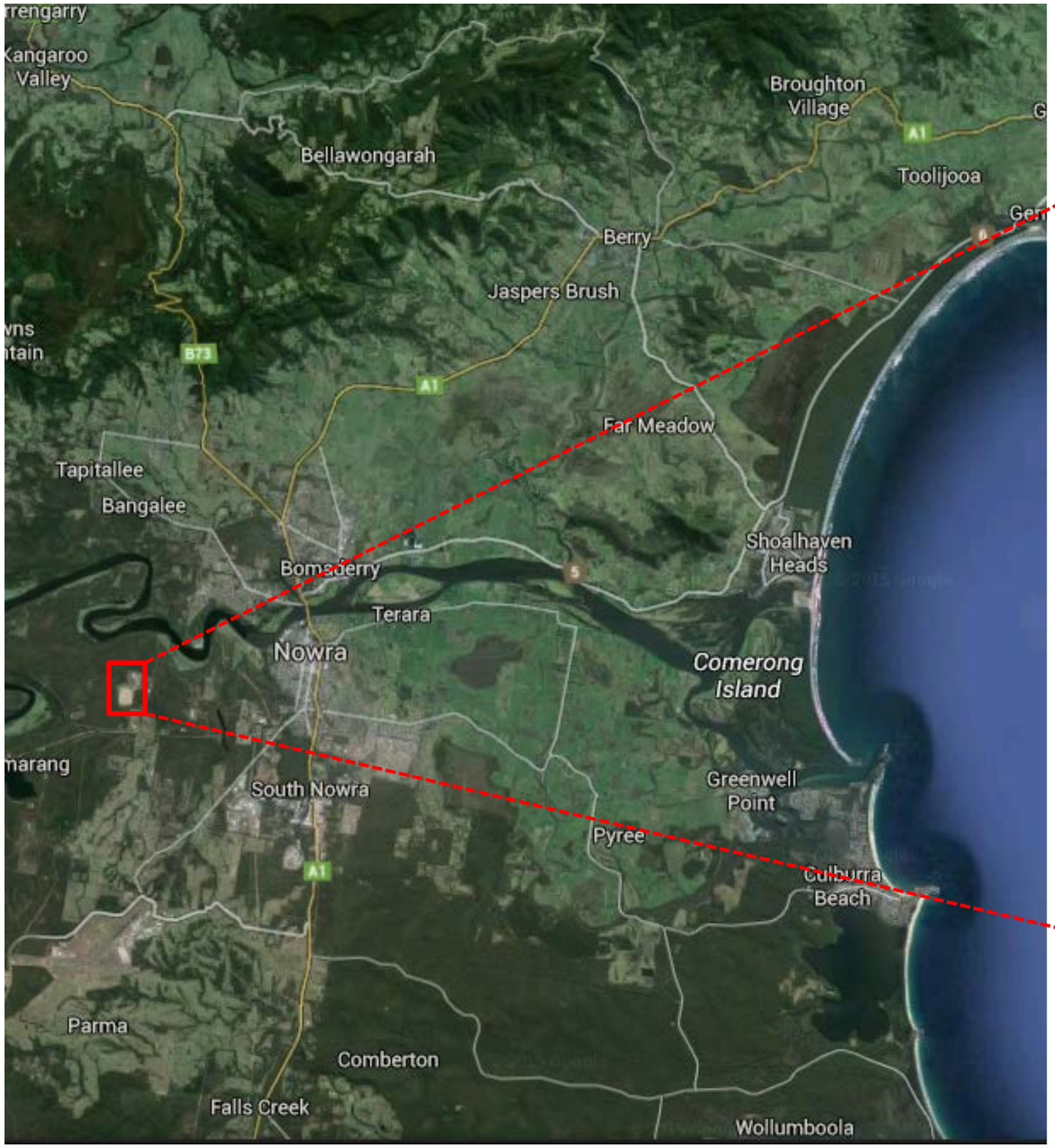
Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction,
speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Drawings



REFERENCE:

Google Earth image captured on 6/11/2015

revision	description	drawn	approved	date
	Locality Plan	DT/CDC	JPT	20/07/2016

N

drawn	DT/CDC
approved	JPT
date	20/07/2016
scale	N.T.S.
original size	A3

coffey
A TETRA TECH COMPANY

client:	Shoalhaven City Council
project:	West Nowra Recycling and Waste Facility Geotechnical and Hydrogeological Investigation
title:	Locality Plan
project no: GEOTWOLL03957AA	Drawing no: 1

TERMS & CONDITIONS FOR SUPPLY OF ELECTRONIC DATA

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N

ACCESS ROAD

BLDG

BLDG

CAR PARK

GW3

BH5

TP10

TP9

BH6

STAGE 2
LOT 1
DP 847203

ACCESS ROAD TO STAGES 2 & 3

TP7

LOT 1
DP 1104402

BH4

GW4

TP8

CRT AREA

TP 6

GW5

WET WEATHER TIPPING AREA

PROPOSED LANDFILL EXTENSION AREA

BH3

TP5

ACCESS ROAD TO STAGE 3

TP3

TP4

CURRENT DISPOSAL SITE

STAGE 3
LOT 1
DP 870268

TP2

GW2A
GW2

BH2

ENVIRONMENTAL ZONE

FLATROCK ROAD

TP 1

BH1

GW1A
GW1

PROPOSED WILDLIFE CORRIDOR

Code	Easting	Northing	Elevation
GW1 TOP OF COVER	276107.374	6136839.030	51.109
GW1 GROUND SURF	276107.374	6136839.030	50.439
GW1A TOP OF COVER	276110.540	6136841.108	51.264
GW1A GROUND SURF	276110.540	6136841.108	50.434
GW2 TOP OF COVER	276262.562	6136958.080	47.841
GW2 GROUND SURF	276262.562	6136958.080	47.031
GW2A TOP OF COVER	276265.537	6136960.076	47.709
GW2A GROUND SURF	276265.537	6136960.076	46.899
GW3 TOP OF COVER	276257.533	6137248.077	47.057
GW3 GROUND SURF	276257.533	6137248.077	46.312
GW4 TOP OF COVER	276400.884	6137112.751	49.259
GW4 GROUND SURF	276400.884	6137112.751	48.509
GW5 TOP OF COVER	276236.189	6137084.391	48.771
GW5 GROUND SURF	276236.189	6137084.391	48.171
TP1 GROUND SURF	276134.712	6136886.794	49.834
TP2 GROUND SURF	276189.083	6136966.198	48.978
TP3 GROUND SURF	276145.041	6137007.424	48.973
TP4 GROUND SURF	276257.553	6136889.717	47.552
TP5 GROUND SURF	276351.271	6137023.158	47.008
TP6 GROUND SURF	276160.232	6137094.303	48.531
TP7 GROUND SURF	276192.148	6137130.365	48.691
TP8 GROUND SURF	276373.876	6137102.583	48.609
TP9 GROUND SURF	276311.454	6137206.309	48.259
TP10 GROUND SURF	276236.740	6137202.454	47.444
BH1 GROUND SURF	276229.734	6136876.557	48.250
BH2 GROUND SURF	276128.943	6136949.571	49.310
BH3 GROUND SURF	276162.930	6137037.180	48.913
BH4 GROUND SURF	276281.165	6137109.243	49.110
BH5 GROUND SURF	276178.244	6137214.947	48.350
BH6 GROUND SURF	276372.990	6137188.075	48.920

DESIGNED: G. BIANCO 21/7/16	SURVEYED: E. VENHUIZEN	AMENDMENTS	
DRAWN: G. BIANCO 21/7/16	FIELD BOOK:		
CHECKED:	ORIGIN OF LEVELS:		
APPROVED:	DATUM: AHD		
DRAWING FILE:	CIVILCAD FILE:		

Shoalhaven City Council
Environment - Growth - Community

CITY OF SHOALHAVEN

West Nowra Recycling and Waste Facility
Geotechnical and Hydrogeological Investigation
Drawing 2 - Site Plan

SCALE:
1:1,000 for A1 size plot, 1:2,000 for A3 size plot
Do not scale off drawings.
Confirm all dimensions on site prior to start of construction.
NOTE:

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STAGE 2
LOT 1
DP 847203

ACCESS ROAD TO STAGES 2 & 3

CRT AREA

WET WEATHER TIPPING AREA

CURRENT DISPOSAL SITE

STAGE 3
LOT 1
DP 870268

ACCESS ROAD TO STAGE 3

PROPOSED WILDLIFE CORRIDOR

BLDG

BLDG

CAR PARK

ACCESS ROAD

LOT 1
DP 1104402

PROPOSED LANDFILL EXTENSION AREA

ENVIRONMENTAL ZONE

FLATROCK ROAD

GW3 40.7

BH5

TP10

TP9

BH6

TP7

BH4

TP8

GW4*

TP6

GW5 40.5

BH3

TP5

TP3

TP4

TP2

GW2A DRY
GW2 40.1

BH2

TP1

BH1

GW1A DRY
GW1 41.8

N

LEGEND

Piezometer screened in sandstone ■ GW1

Water table elevation (m AHD) 40.5

Interpreted water table contours (m AHD)

Interpreted groundwater flow direction

Interpreted groundwater divide

*GW4 -
Intermittent saturation around base of screen 36.5 m AHD

Code	Easting	Northing	Elevation
GW1 TOP OF COVER	276107.374	6136839.030	51.109
GW1 GROUND SURF	276107.374	6136839.030	50.439
GW1A TOP OF COVER	276110.540	6136841.108	51.254
GW1A GROUND SURF	276110.540	6136841.108	50.434
GW2 TOP OF COVER	276262.562	6136958.080	47.841
GW2 GROUND SURF	276262.562	6136958.080	47.031
GW2A TOP OF COVER	276265.537	6136960.076	47.709
GW2A GROUND SURF	276265.537	6136960.076	46.899
GW3 TOP OF COVER	276257.533	6137248.077	47.057
GW3 GROUND SURF	276257.533	6137248.077	46.312
GW4 TOP OF COVER	276400.884	6137112.751	49.259
GW4 GROUND SURF	276400.884	6137112.751	48.509
GW5 TOP OF COVER	276238.189	6137084.391	48.771
GW5 GROUND SURF	276238.189	6137084.391	48.171
TP1 GROUND SURF	276134.712	6136886.794	49.834
TP2 GROUND SURF	276189.083	6136966.198	48.978
TP3 GROUND SURF	276145.041	6137007.424	48.973
TP4 GROUND SURF	276257.553	6136889.717	47.552
TP5 GROUND SURF	276351.271	6137023.158	47.008
TP6 GROUND SURF	276150.232	6137094.303	48.531
TP7 GROUND SURF	276192.148	6137130.365	48.691
TP8 GROUND SURF	276373.875	6137102.583	48.609
TP9 GROUND SURF	276311.454	6137206.309	48.259
TP10 GROUND SURF	276238.740	6137202.454	47.444
BH1 GROUND SURF	276229.734	6136876.557	48.250
BH2 GROUND SURF	276128.943	6136949.571	49.310
BH3 GROUND SURF	276162.930	6137037.180	48.913
BH4 GROUND SURF	276281.165	6137109.243	49.110
BH5 GROUND SURF	276178.244	6137214.947	48.350
BH6 GROUND SURF	276372.990	6137188.075	48.920

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APPROVED:	DATUM: AHD		
DRAWING FILE:	CIVILCAD FILE:		

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Environment - Growth - Community

CITY OF SHOALHAVEN

West Nowra Recycling and Waste Facility
Geotechnical and Hydrogeological Investigation
Drawing 3 - Hydraulic Head Surface (m AHD) 7 June 2016

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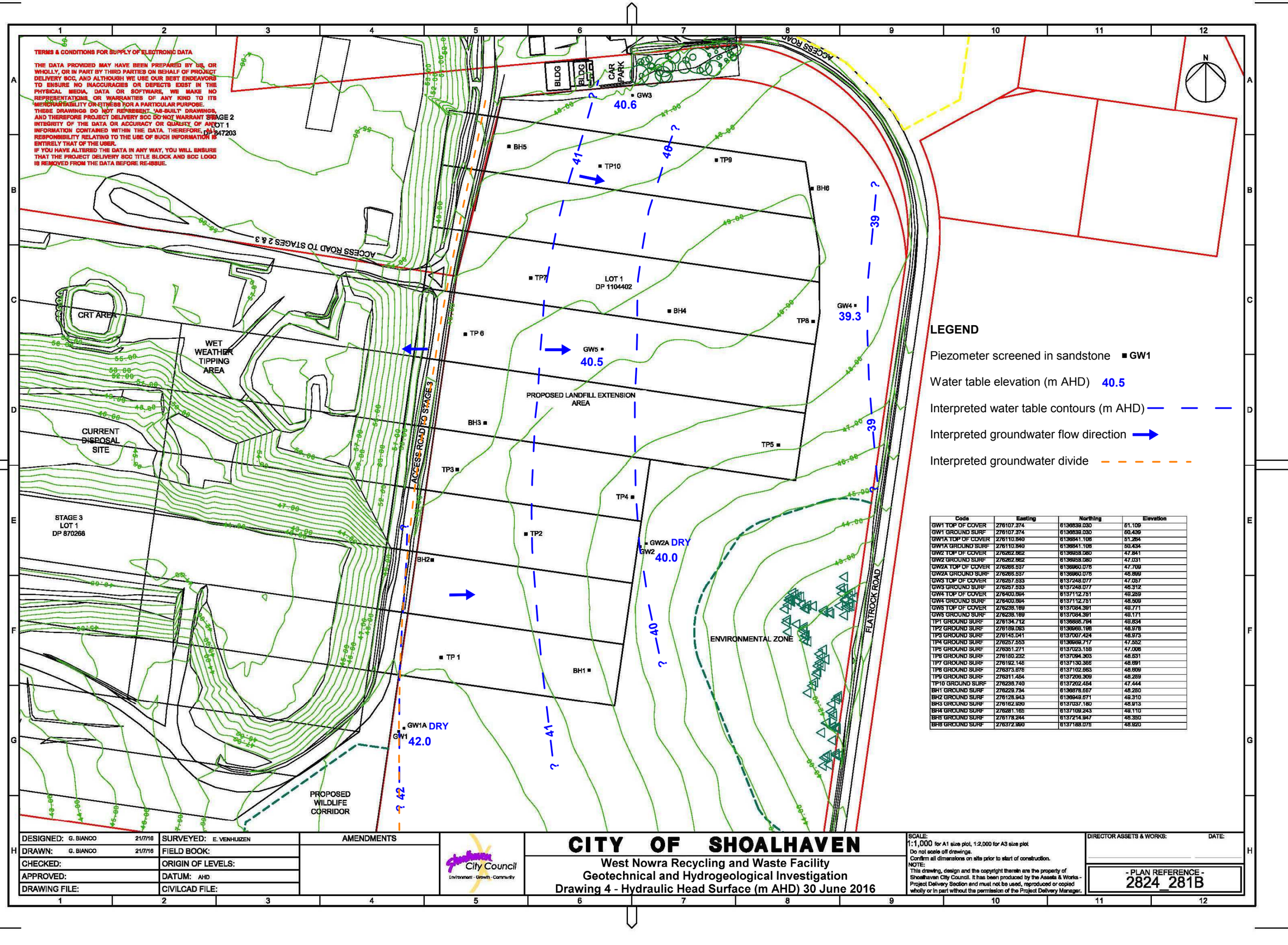

Code	Easting	Northing	Elevation
GW1 TOP OF COVER	276107.374	6136839.030	51.109
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GW2 TOP OF COVER	276262.562	6136958.080	47.841
GW2 GROUND SURF	276262.562	6136958.080	47.031
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GW2A GROUND SURF	276265.537	6136960.076	46.899
GW3 TOP OF COVER	276257.533	6137248.077	47.057
GW3 GROUND SURF	276257.533	6137248.077	46.312
GW4 TOP OF COVER	276400.884	6137112.751	49.259
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DRAWN: G. BIANCO 21/7/16	FIELD BOOK:		
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DRAWING FILE:	CIVILCAD FILE:		

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CITY OF SHOALHAVEN

West Nowra Recycling and Waste Facility
Geotechnical and Hydrogeological Investigation
Drawing 4 - Hydraulic Head Surface (m AHD) 30 June 2016

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Appendix A – Engineering Logs and Explanatory Notes

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Soil Description Explanation Sheet (1 of 2)

DEFINITION:

In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

CLASSIFICATION SYMBOL & SOIL NAME

Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on Sheet 2.

PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 μm to 2.36 mm
	medium	200 μm to 600 μm
	fine	75 μm to 200 μm

MOISTURE CONDITION

Dry Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.

Moist Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.

Wet As for moist but with free water forming on hands when handled.

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH s_u (kPa)	FIELD GUIDE
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12 - 25	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	–	Crumbles or powders when scraped by thumbnail.

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 - 35
Medium Dense	35 - 65
Dense	65 - 85
Very Dense	Greater than 85

MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

SOIL STRUCTURE

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous layers of lenticular shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

GEOLOGICAL ORIGIN

WEATHERED IN PLACE SOILS

Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TRANSPORTED SOILS

Aeolian soil	Deposited by wind.
Alluvial soil	Deposited by streams and rivers.
Colluvial soil	Deposited on slopes (transported downslope by gravity).
Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
Lacustrine soil	Deposited by lakes.
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.

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Soil Description Explanation Sheet (2 of 2)

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)							USC	PRIMARY NAME
COARSE GRAINED SOILS More than 50% of materials less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.36 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.			GW	GRAVEL
				Predominantly one size or a range of sizes with more intermediate sizes missing.			GP	GRAVEL
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)			GM	SILTY GRAVEL
				Plastic fines (for identification procedures see CL below)			GC	CLAYEY GRAVEL
		SANDS More than half of coarse fraction is smaller than 2.36 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes			SW	SAND
				Predominantly one size or a range of sizes with some intermediate sizes missing.			SP	SAND
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).			SM	SILTY SAND
				Plastic fines (for identification procedures see CL below).			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm			IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm.					
		SILTS & CLAYS Liquid limit less than 50	**DRY STRENGTH**	**DILATANCY**	**TOUGHNESS**			
			None to Low	Quick to slow	None		ML	SILT
			Medium to High	None	Medium		CL	CLAY
			Low to medium	Slow to very slow	Low		OL	ORGANIC SILT
		SILTS & CLAYS Liquid limit greater than 50	Low to medium	Slow to very slow	Low to medium		MH	SILT
			High	None	High		CH	CLAY
			Medium to High	None	Low to medium		OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS			Readily identified by colour, odour, spongy feel and frequently by fibrous texture.				Pt	PEAT

• Low plasticity – Liquid Limit w_L less than 35%. • Medium plasticity – w_L between 35% and 50%. • High plasticity – w_L greater than 50%.

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
JOINT	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2 m in length.	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	DEFINITION	DIAGRAM
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

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Rock Description Explanation Sheet (1 of 2)

The descriptive terms used by Coffey are given below. They are broadly consistent with Australian Standard AS1726-1993.

DEFINITIONS: Rock substance, defect and mass are defined as follows:

Rock Substance	In engineering terms rock substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic.
Defect	Discontinuity or break in the continuity of a substance or substances.
Mass	Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

SUBSTANCE DESCRIPTIVE TERMS:

ROCK NAME	Simple rock names are used rather than precise geological classification.
PARTICLE SIZE	Grain size terms for sandstone are:
Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm (just visible) to 0.2mm
FABRIC	Terms for layering of penetrative fabric (eg. bedding, cleavage etc.) are:
Massive	No layering or penetrative fabric.
Indistinct	Layering or fabric just visible. Little effect on properties.
Distinct	Layering or fabric is easily visible. Rock breaks more easily parallel to layering of fabric.

CLASSIFICATION OF WEATHERING PRODUCTS

Term	Abbreviation	Definition
Residual Soil	**RS**	Soil derived from the weathering of rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Material	**XW**	Material is weathered to such an extent that it has soil properties, ie, it either disintegrates or can be remoulded in water. Original rock fabric still visible.
Highly Weathered Rock	**HW**	Rock strength is changed by weathering. The whole of the rock substance is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by leaching or may be decreased due to the deposition of minerals in pores.
Moderately Weathered Rock	**MW**	The whole of the rock substance is discoloured, usually by iron staining or bleaching , to the extent that the colour of the fresh rock is no longer recognisable.
Slightly Weathered Rock	**SW**	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance (usually by limonite) has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Fresh Rock	**FR**	Rock substance unaffected by weathering.

Notes on Weathering:

1. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is judged that there is no advantage in making such a distinction. DW may be used with the definition given in AS1726.
2. Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term "altered" may be substituted for "weathering" to give the abbreviations XA, HA, MA, SA and DA.

ROCK SUBSTANCE STRENGTH TERMS

Term	Abbrev-iation	Point Load Index, $I_{s(50)}$ (MPa)	Field Guide
Very Low	**VL**	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	**L**	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm bows of a pick point; has a dull sound under hammer. Pieces of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	**M**	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	**H**	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	**VH**	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	**EH**	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

Notes on Rock Substance Strength:

1. In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy.
2. The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range are soils in engineering terms.
3. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index $I_{s(50)}$. The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

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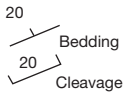
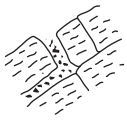
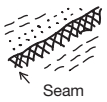
Rock Description Explanation Sheet (2 of 2)

COMMON DEFECTS IN ROCK MASSES Term	Definition	Diagram	Map Symbol	Graphic Log (Note 1)
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub parallel to layering (eg bedding) or a planar anisotropy in the rock substance (eg, cleavage). May be open or closed.			 (Note 2)
Joint	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.			 (Note 2)
Sheared Zone (Note 3)	Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.			
Sheared Surface (Note 3)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.			
Crushed Seam (Note 3)	Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties.			
Infilled Seam	Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.			
Extremely Weathered Seam	Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.			

DEFECT SHAPE TERMS	
Planar	The defect does not vary in orientation
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps
Irregular	The defect has many sharp changes of orientation

Note: The assessment of defect shape is partly influenced by the scale of the observation.

ROUGHNESS TERMS	
Slickensided	Grooved or striated surface, usually polished
Polished	Shiny smooth surface
Smooth	Smooth to touch. Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

COATING TERMS	
Clean	No visible coating
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

BLOCK SHAPE TERMS	
Blocky	Approximately equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greate than cross section

Notes on Defects:

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.
2. Partings and joints are not usually shown on the graphic log unless considered significant.
3. Sheared zones, sheared surfaces and crushed seams are faults in geological terms.

72710 / 07-06

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Engineering Log - Borehole

Borehole ID.	**BH1**
sheet:	1 of 2
project no.	**GEOTWOLL03957AA**
client:	***Shoalhaven City Council***
date started:	***23 May 2016***
principal:	**-**
date completed:	***23 May 2016***
project:	***Geotechnical and Hydrogeological Investigation***
logged by:	***MB***
location:	***West Nowra Recycling and Waste Facility, Mundamia NSW***
checked by:	***CDC***

position: E: 276230; N: 6136879 (MGA94 Zone 56) | surface elevation: 48.25 m (AHD) | angle from horizontal: 90°

drill model: Hanjin DB8, Track mounted | drilling fluid: water | hole diameter : 114 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
AD/T		Not Observed		48				**Sandy CLAY**: medium plasticity, brown, fine grained sand, trace of sub-angular gravel, trace of organics (rootlets).	D	F		**TOPSOIL**
			SPT 4, 9, 15 N*=24					**CLAY**: high plasticity, red, orange, brown, grey mottled, trace of fine grained sand, trace of organics (rootlets), trace of sub-angular to angular gravel.		St - VSt		**RESIDUAL**
			SPT 6, 15, 22 N*=37	47	1.0			**Sandy CLAY**: medium plasticity, red, brown, grey mottled, fine grained sand, trace of sub-angular to angular gravel. colour change to grey, red, orange mottled		VSt / H		**EXTREMELY WEATHERED MATERIAL**
				46	2.0							
			SPT 9, 28, 32/105mm N*=R	45	3.0			**CLAY**: medium plasticity, grey, brown, orange mottled, trace of fine grained sand, trace of sub-rounded gravel.				
			SPT 14, 40, 22/50mm N*=R	44	4.0			**Sandy CLAY**: low to medium plasticity, brown, grey, orange mottled, fine to medium grained sand.				
				43	5.0							
			SPT 42, 20/30mm N*=R	42	6.0			**CLAYEY SAND**: fine to medium grained, brown grey, medium plasticity clay, trace of sub-angular gravel.		H		
			SPT 20/50mm N*=R	41	7.0							
								Borehole BH1 continued as cored hole				**HIGHLY TO MODERATELY WEATHERED SANDSTONE**

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- DHH downhole hammer

* bit shown by suffix
e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Cored Borehole

Borehole ID.	**BH1**
sheet:	2 of 2
project no.	**GEOTWOLL03957AA**
client:	**Shoalhaven City Council**
date started:	**23 May 2016**
principal:	**-**
date completed:	**23 May 2016**
project:	**Geotechnical and Hydrogeological Investigation**
logged by:	**MB**
location:	**West Nowra Recycling and Waste Facility, Mundamia NSW**
checked by:	**CDC**

position: E: 276230; N: 6136879 (MGA94 Zone 56) surface elevation: 48.25 m (AHD) angle from horizontal: 90°

drill model: Hanjin DB8, Track mounted drilling fluid: water hole diameter : 114 mm vane id.:

drilling information				material substance					rock mass defects			
method & support	water	RL (m)	depth (m)	graphic log	material description **ROCK TYPE**: grain characterisics, colour, structure, minor components	weathering & alteration	estimated strength & Is50 (X = axial; O = diametral) VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run details	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
					start coring at 7.62m						
NMLC	Not Observed	40	8.0		**SANDSTONE**: fine to medium grained, brown.	HW					JT, 15°, PL, RO, VN
					colour change to grey	MW / SW					JT, 25°, CU, RO, VN
											JT, 10°, PL, RO, VN
					colour change to brown						JT, 10°, CU, RO, VN
		39	9.0		colour change to grey	HW / MW					JT, 10°, CU, RO, Sand CO
					colour change to brown						JT, 10°, PL, RO, VN
					colour change to grey	MW / SW					
			10.0		Borehole BH1 terminated at 10.00 m Target depth						
		38	11.0								
		37	12.0								
		36	13.0								
		35	14.0								
		34	15.0								
		33									

method & support
AS auger screwing
AD auger drilling
CB claw or blade bit
W washbore
NMLC NMLC core (51.9 mm)
NQ wireline core (47.6mm)
HQ wireline core (63.5mm)
PQ wireline core (85.0mm)
SPT standard penetration test
DHH downhole hammer

water
10/10/12, water level on date shown
water inflow
complete drilling fluid loss
partial drilling fluid loss
25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
core recovered (graphic symbols indicate material)
no core recovered

core run details
barrel withdrawn

TCR = Total Core Recovery (%)
SCR = Solid Core Recovery (%)
RQD = Rock Quality Designation (%)

weathering & alteration*
RS residual soil
XW extremely weathered
HW highly weathered
DW distinctly weathered
MW moderately weathered
SW slightly weathered
FR fresh
*W replaced with A for alteration

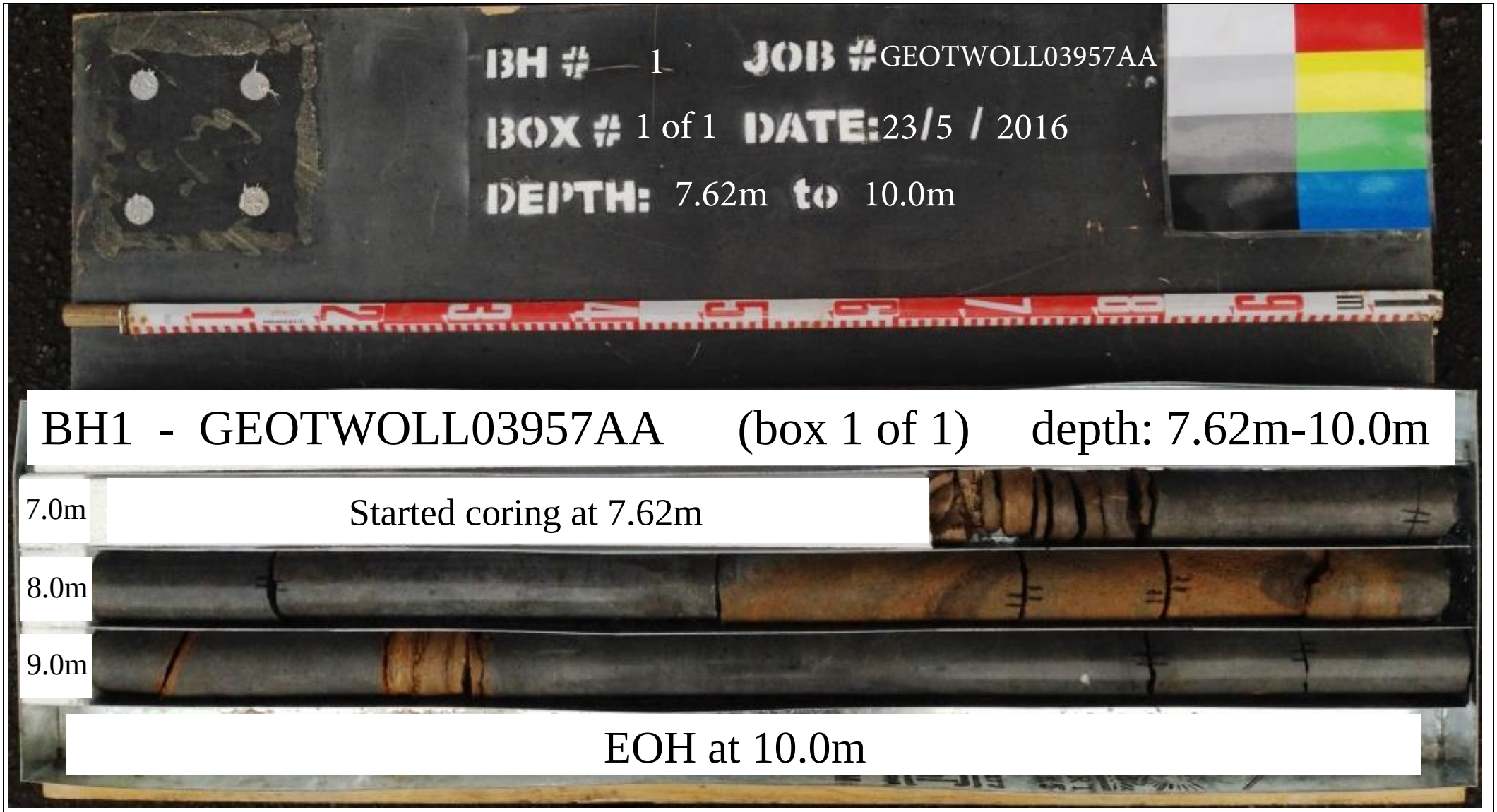
strength
VL very low
L low
M medium
H high
VH very high
EH extremely high

defect type
PT parting
JT joint
SZ shear zone
SS shear surface
CO contact
CS crushed seam
SM seam

planarity
PL planar
CU curved
UN undulating
ST stepped
IR Irregular

roughness
SL slickensided
POL polished
SO smooth
RO rough
VR very rough

coating
CN clean
SN stain
VN veneer
CO coating



drawn	**MB**	coffey A TETRA TECH COMPANY	client:	**Shoalhaven City Council**
approved	**JPT**		project:	**Geotechnical and Hydrogeological Investigation**
date	**3/6/2016**		title:	**Core photograph BH1**
scale	**N.T.S.**		project no: GEOTWOLL03957AA	figure no: 1
original size	**A4**			

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Engineering Log - Borehole

Borehole ID.	**BH2**
sheet:	1 of 2
project no.	**GEOTWOLL03957AA**
client:	**Shoalhaven City Council**
date started:	**24 May 2016**
principal:	**-**
date completed:	**24 May 2016**
project:	**Geotechnical and Hydrogeological Investigation**
logged by:	**MB**
location:	**West Nowra Recycling and Waste Facility, Mundamia NSW**
checked by:	**CDC**

position: E: 276129; N: 6136950 (MGA94 Zone 56) | surface elevation: 49.31 m (AHD) | angle from horizontal: 90°

drill model: Hanjin DB8, Track mounted | drilling fluid: water | hole diameter : 114 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
AD/T		Not Observed	SPT 4, 10, 14 N*=24	49				**Gravelly Sandy CLAY**: medium plasticity, pale brown, fine grained sand, sub-angular to angular gravel, trace of organics (rootlets).	D	F - St		**TOPSOIL**
								Sandy CLAY: medium plasticity, brown, red to grey mottled, fine grained sand, trace of organics, trace of sub-angular gravel.		St - VSt		**RESIDUAL**
			SPT 4, 3, 9 N*=12	48	1.0							
				47	2.0			**Sandy CLAY**: low to medium plasticity, pale brown, grey mottled, red mottled, fine grained sand, trace of sub-angular to angular gravel.		VSt / H		**EXTREMELY WEATHERED MATERIAL**
			SPT 7, 20, 21 N*=41	46	3.0			colour change to pale brown, grey, red to orange mottled				
			SPT 8, 22, 35 N*=57	45	4.0			colour change to grey, pale brown				
				44	5.0			**Sandy CLAY**: medium plasticity, pale brown, grey, red mottled, fine grained sand, trace of sub-angular to angular gravel.	M			
			SPT 18/90mm N*=R	43	6.0			**CLAYEY SAND**: fine grained, brown, grey.		VD		
				42	7.0			Borehole BH2 continued as cored hole				**HIGHLY TO MODERATELY WEATHERED SANDSTONE**

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method
AD auger drilling*
AS auger screwing*
HA hand auger
W washbore
DHH downhole hammer

* bit shown by suffix
e.g. AD/T
B blank bit
T TC bit
V V bit

support
M mud
C casing
N nil

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
B bulk disturbed sample
D disturbed sample
E environmental sample
SS split spoon sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
VS vane shear; peak/remouded (kPa)
R refusal
HB hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Cored Borehole

Borehole ID.	**BH2**
sheet:	2 of 2
project no.	**GEOTWOLL03957AA**
client:	**Shoalhaven City Council**
date started:	**24 May 2016**
principal:	**-**
date completed:	**24 May 2016**
project:	**Geotechnical and Hydrogeological Investigation**
logged by:	**MB**
location:	**West Nowra Recycling and Waste Facility, Mundamia NSW**
checked by:	**CDC**

position: E: 276129; N: 6136950 (MGA94 Zone 56) surface elevation: 49.31 m (AHD) angle from horizontal: 90°

drill model: Hanjin DB8, Track mounted drilling fluid: water hole diameter : 114 mm vane id.:

drilling information				material substance						rock mass defects		
method & support	water	RL (m)	depth (m)	graphic log	material description **ROCK TYPE**: grain characterisics, colour, structure, minor components	weathering & alteration	estimated strength & Is50 (X = axial; O = diametral) VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run details	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
					start coring at 6.70m						
NMLC	Not Observed	42	7.0		**SANDSTONE**: fine to coarse grained, brown, orange, grey, iron stained, trace of sub-angular gravel.	HW MW					PT, 10°, PL, RO, Clayey sand CO JT, 30°, PL, RO, SN PT, 10°, PL, RO, Clayey sand CO PT, 10°, PL, RO, Clayey sand CO
		41	8.0			HW MW					JT, 10°, PL, RO, Clayey sand CO SM, 10°, PL, RO, Gravelly Clay CO - Clayey sand JT, 10°, PL, RO, Clayey sand CO JT, 10°, PL, RO, Clayey sand CO JT, 10°, PL, RO, Clayey sand CO
		40	9.0			XW MW					JT, 10°, PL, RO, Clayey sand CO SM, 10°, PL, RO, Clayey sand CO SM, 10°, PL, RO, Clayey sand CO JT, 25°, PL, RO, Clayey sand CO JT, 10°, PL, RO, Clayey sand CO
		39	10.0		Borehole BH2 terminated at 9.50 m Target depth						
		38	11.0								
		37	12.0								
		36	13.0								
		35	14.0								

method & support
AS auger screwing
AD auger drilling
CB claw or blade bit
W washbore
NMLC NMLC core (51.9 mm)
NQ wireline core (47.6mm)
HQ wireline core (63.5mm)
PQ wireline core (85.0mm)
SPT standard penetration test
DHH downhole hammer

water
10/10/12, water level on date shown
water inflow
complete drilling fluid loss
partial drilling fluid loss
25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
core recovered (graphic symbols indicate material)
no core recovered

core run details
barrel withdrawn
TCR = Total Core Recovery (%)
SCR = Solid Core Recovery (%)
RQD = Rock Quality Designation (%)

weathering & alteration*
RS residual soil
XW extremely weathered
HW highly weathered
DW distinctly weathered
MW moderately weathered
SW slightly weathered
FR fresh
*W replaced with A for alteration

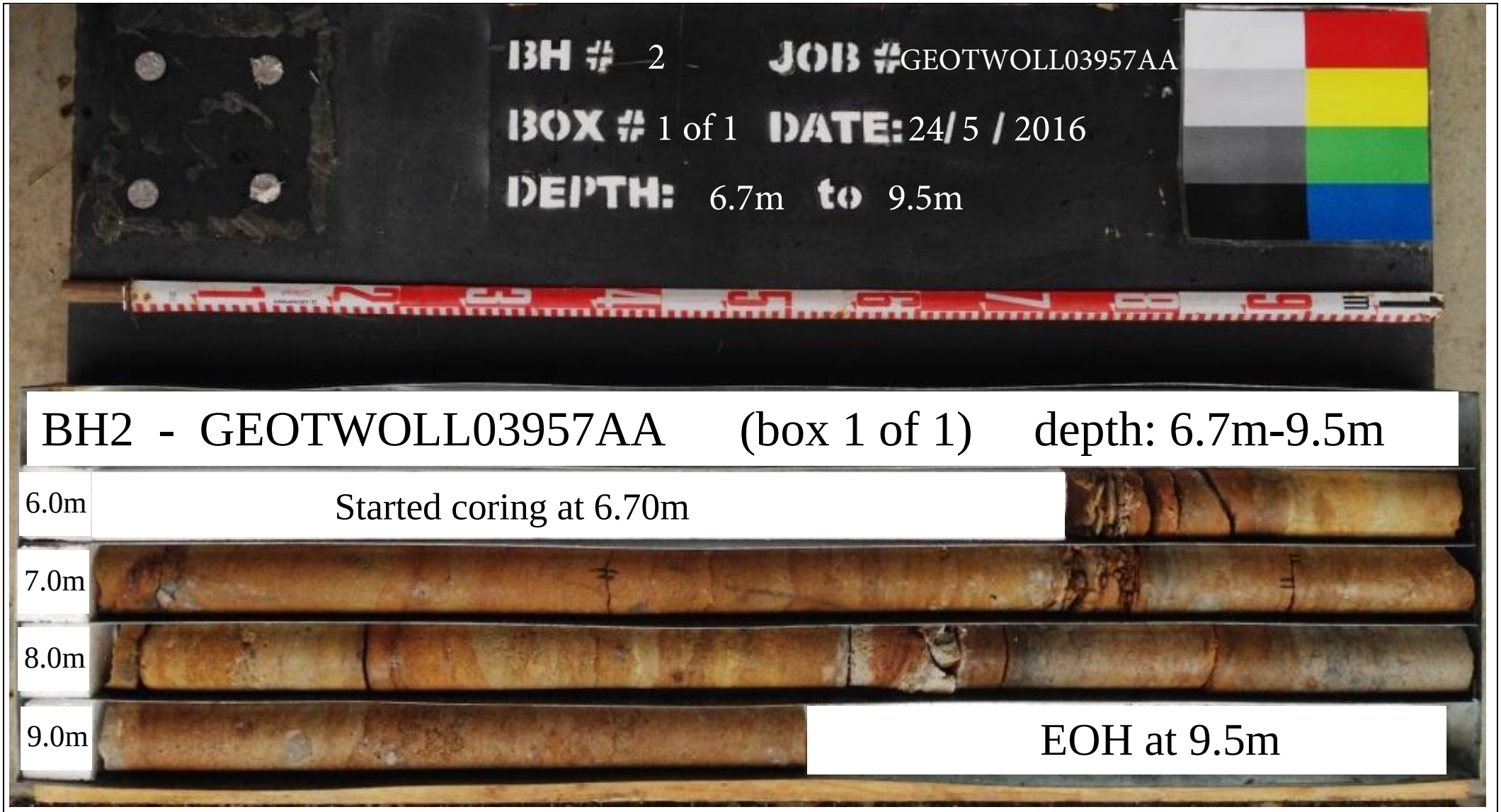
strength
VL very low
L low
M medium
H high
VH very high
EH extremely high

defect type
PT parting
JT joint
SZ shear zone
SS shear surface
CO contact
CS crushed seam
SM seam

planarity
PL planar
CU curved
UN undulating
ST stepped
IR Irregular

roughness
SL slickensided
POL polished
SO smooth
RO rough
VR very rough

coating
CN clean
SN stain
VN veneer
CO coating



drawn	**MB**
approved	**JPT**
date	**3/6/2016**
scale	**N.T.S.**
original size	**A4**

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client:	**Shoalhaven City Council**
project:	**Geotechnical and Hydrogeological Investigation**
title:	**Core photograph BH2**
project no: GEOTWOLL03957AA	figure no: 2

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Engineering Log - Borehole

Borehole ID.	**BH3**
sheet:	1 of 2
project no.	**GEOTWOLL03957AA**
client:	***Shoalhaven City Council***
date started:	***24 May 2016***
principal:	**-**
date completed:	***24 May 2016***
project:	***Geotechnical and Hydrogeological Investigation***
logged by:	***MB***
location:	***West Nowra Recycling and Waste Facility, Mundamia NSW***
checked by:	***CDC***

position: E: 276163; N: 6137037 (MGA94 Zone 56) | surface elevation: 48.91 m (AHD) | angle from horizontal: 90°

drill model: Hanjin DB8, Track mounted | drilling fluid: water | hole diameter : 114 mm

drilling information | **material substance**

method & support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa)	structure and additional observations
AD/T		Not Observed	SPT 5, 11, 11 N*=22	48	0.0			**Gravelly Sandy CLAY**: medium plasticity, pale brown, fine grained sand, sub-angular gravel, trace of organics.	D	MD		**TOPSOIL**
								Sandy CLAY: medium plasticity, brown, orange mottled, fine grained sand, trace of sub-angular gravel, trace of organics.		F - St		**RESIDUAL**
			SPT 2, 12, 22 N*=34		1.0			colour change to brown, orange to red mottled		VSt / H		
				47	2.0			**Sandy CLAY**: medium plasticity, brown, red to grey to orange mottled, fine grained sand, trace of sub-angular gravel.				**EXTREMELY WEATHERED MATERIAL**
			SPT 8, 22, 31 N*=53	46	3.0			colour change to grey, brown, red to orange mottled				
			SPT 10, 19, 26 N*=45	45	4.0							
				44	5.0							
			SPT 15, 23, 30/120mm N*=R	43	6.0			**Sandy CLAY**: medium to high plasticity, brown, grey mottled, fine to medium grained sand, trace of sub-angular to sub-rounded gravel.				
								ironstone fragments		H		
				42	7.0			Borehole BH3 continued as cored hole				**HIGHLY WEATHERED SANDSTONE**
				41								

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- DHH downhole hammer

* bit shown by suffix
e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Cored Borehole

Borehole ID.	**BH3**
sheet:	2 of 2
project no.	**GEOTWOLL03957AA**
client:	**Shoalhaven City Council**
date started:	**24 May 2016**
principal:	**-**
date completed:	**24 May 2016**
project:	**Geotechnical and Hydrogeological Investigation**
logged by:	**MB**
location:	**West Nowra Recycling and Waste Facility, Mundamia NSW**
checked by:	**CDC**

position: E: 276163; N: 6137037 (MGA94 Zone 56) surface elevation: 48.91 m (AHD) angle from horizontal: 90°

drill model: Hanjin DB8, Track mounted drilling fluid: water hole diameter : 114 mm vane id.:

drilling information				material substance						rock mass defects		
method & support	water	RL (m)	depth (m)	graphic log	material description **ROCK TYPE**: grain characterisics, colour, structure, minor components	weathering & alteration	estimated strength & Is50 (X = axial; O = diametral) VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run details	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
					start coring at 7.00m						
NMLC	Not Observed	41	8.0		**NO CORE:** 1.00 m						
					SANDSTONE: fine to medium grained, grey, trace of sub-angular to angular gravel.	XW HW					SM, 10°, PL, RO, Sand CO JT, 10°, PL, RO, Sand CO
					colour change to brown	XW					JT, 10°, PL, RO, Sand CO SM, 10°, PL, RO, Gravel CO - Sand
		40	9.0		colour change to red [iron stained at 8.7 to 8.8m]	HW					JT, 10°, PL, RO, Sand CO SM, 10°, PL, RO, Sand CO
					colour change to orange, brown with grey bands						JT, 45°, PL, RO, Sand CO JT, 10°, PL, RO, Sand CO SM, 10°, PL, RO, Gravel CO - Sand JT, 10°, PL, RO, Sand CO JT, 10°, PL, RO, Gravel CO - Sand
		39	10.0		Borehole BH3 terminated at 9.30 m Target depth						
		38	11.0								
		37	12.0								
		36	13.0								
		35	14.0								
		34									

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method & support
- AS auger screwing
- AD auger drilling
- CB claw or blade bit
- W washbore
- NMLC NMLC core (51.9 mm)
- NQ wireline core (47.6mm)
- HQ wireline core (63.5mm)
- PQ wireline core (85.0mm)
- SPT standard penetration test
- DHH downhole hammer

water
- 10/10/12, water level on date shown
- water inflow
- complete drilling fluid loss
- partial drilling fluid loss
- 25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
- core recovered (graphic symbols indicate material)
- no core recovered

core run details
- barrel withdrawn

TCR = Total Core Recovery (%)
SCR = Solid Core Recovery (%)
RQD = Rock Quality Designation (%)

weathering & alteration*
- RS residual soil
- XW extremely weathered
- HW highly weathered
- DW distinctly weathered
- MW moderately weathered
- SW slightly weathered
- FR fresh

*W replaced with A for alteration

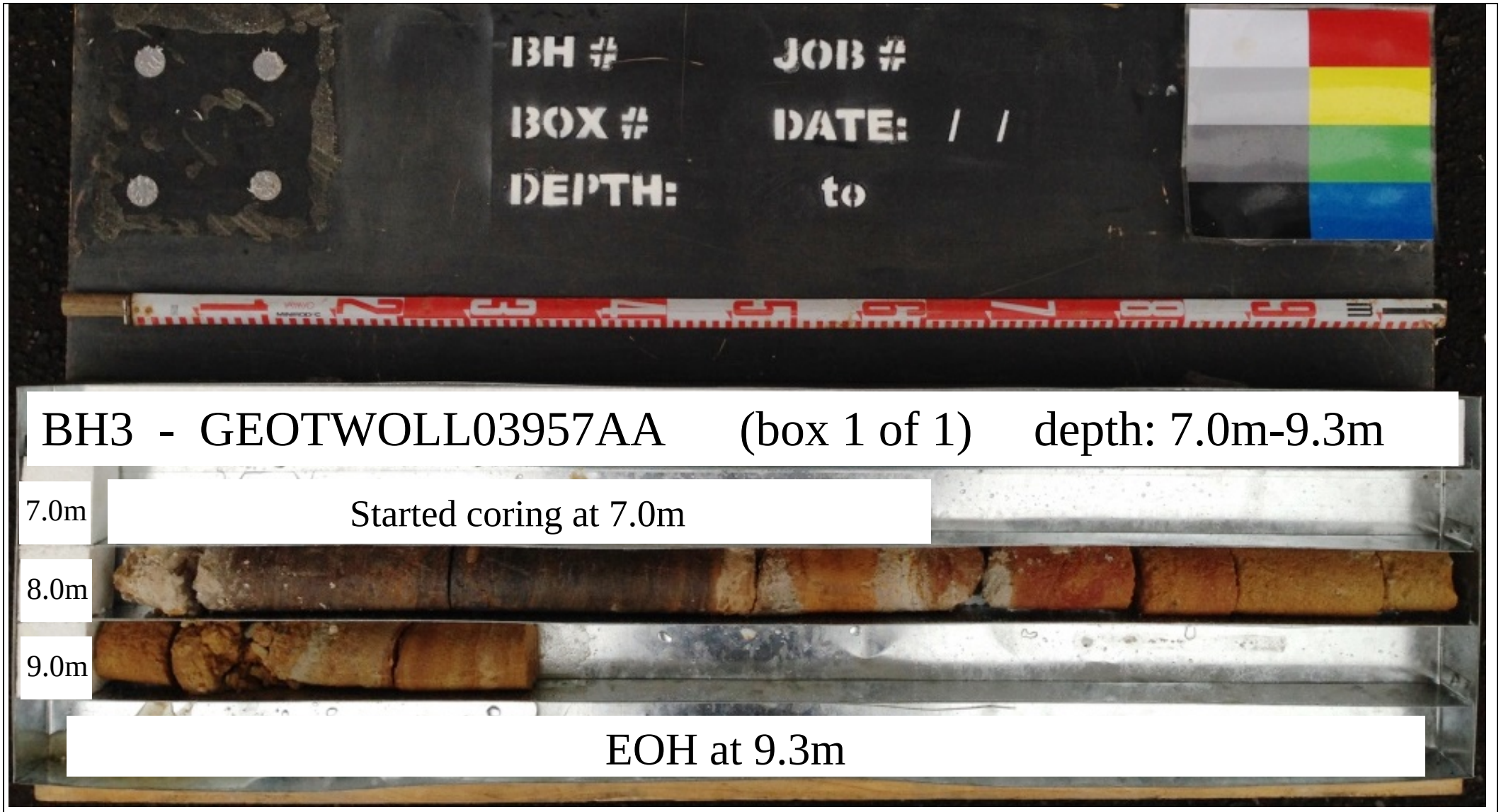
strength
- VL very low
- L low
- M medium
- H high
- VH very high
- EH extremely high

defect type
- PT parting
- JT joint
- SZ shear zone
- SS shear surface
- CO contact
- CS crushed seam
- SM seam

planarity
- PL planar
- CU curved
- UN undulating
- ST stepped
- IR Irregular

roughness
- SL slickensided
- POL polished
- SO smooth
- RO rough
- VR very rough

coating
- CN clean
- SN stain
- VN veneer
- CO coating



drawn	**MB**	coffey A TETRA TECH COMPANY	client:	**Shoalhaven City Council**
approved	**JPT**		project:	**Geotechnical and Hydrogeological Investigation**
date	**3/6/2016**		title:	**Core photograph BH3**
scale	**N.T.S.**		project no: GEOTWOLL03957AA	figure no: 3
original size	**A4**			

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Engineering Log - Borehole

Borehole ID.	**BH4**
sheet:	1 of 2
project no.	**GEOTWOLL03957AA**
client:	***Shoalhaven City Council***
date started:	***30 May 2016***
principal:	**-**
date completed:	***30 May 2016***
project:	***Geotechnical and Hydrogeological Investigation***
logged by:	***MB***
location:	***West Nowra Recycling and Waste Facility, Mundamia NSW***
checked by:	***CDC***

position: E: 276281; N: 6137109 (MGA94 Zone 56) | surface elevation: 49.11 m (AHD) | angle from horizontal: 90°

drill model: Hanjin DB8, Track mounted | drilling fluid: water | hole diameter : 114 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
AD/T		Not Observed		49				**Gravelly Sandy CLAY**: medium plasticity, pale brown, fine grained sand, sub-angular to angular gravel, trace of organics.	D	F		**TOPSOIL**
			SPT 9, 17, 25 N*=42					**Sandy CLAY**: medium to high plasticity, brown, red to orange mottled, fine grained sand, trace of sub-angular to sub-rounded gravel, trace of organics.		St - VSt		**RESIDUAL**
			SPT 4, 18, 21 N*=39	48	1.0			**Sandy CLAY**: medium to high plasticity, brown, red, grey to orange mottled, trace of sub-angular gravel.				
				47	2.0			colour change to grey brown, orange to red mottled		H		**EXTREMELY WEATHERED MATERIAL**
			SPT 25, 30/30mm N*=R	46	3.0							
			SPT 9, 20, 26/100mm N*=R	45	4.0			**Sandy CLAY**: low plasticity, brown grey, orange mottled, fine to coarse grained sand, trace of sub-angular to sub-rounded gravel.		VSt		
				44	5.0			**CLAYEY SAND**: fine to coarse grained, brown, grey, orange mottled, low plasticity clay, trace of sub-angular to sub-rounded gravel.		D		
			SPT 16, 28/40mm N*=R	43	6.0			**Sandy Silty CLAY**: low to medium plasticity, yellow brown, fine to coarse grained sand.		VSt		
				42	7.0			Borehole BH4 continued as cored hole				**HIGHLY TO MODERATELY WEATHERED SANDSTONE**

CDF_0_9_06_LIBRARY.GLB rev:AM Log COF BOREHOLE: NON CORED GW03957AA_DATABASE.GPJ <<DrawingFile>> 27/07/2016 10:46

method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- DHH downhole hammer

* bit shown by suffix
e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Cored Borehole

Borehole ID.	**BH4**
sheet:	2 of 2
project no.	**GEOTWOLL03957AA**
client:	***Shoalhaven City Council***
date started:	***30 May 2016***
principal:	**-**
date completed:	***30 May 2016***
project:	***Geotechnical and Hydrogeological Investigation***
logged by:	***MB***
location:	***West Nowra Recycling and Waste Facility, Mundamia NSW***
checked by:	***CDC***

position: E: 276281; N: 6137109 (MGA94 Zone 56) surface elevation: 49.11 m (AHD) angle from horizontal: 90°

drill model: Hanjin DB8, Track mounted drilling fluid: water hole diameter : 114 mm vane id.:

drilling information | **material substance** | **rock mass defects**

method & support	water	RL (m)	depth (m)	graphic log	material description (ROCK TYPE: grain characterisics, colour, structure, minor components)	weathering & alteration	estimated strength & Is50 (X = axial; O = diametral) VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run details	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
NMLC	Not Observed	42			start coring at 7.00m						
					SANDSTONE: fine to medium grained, brown, trace of sub-angular gravel.	HW - MW					
					ironstone band at 7.5 to 7.7m						JT, 10 - 15°, PL, RO, Clayey sand CO
		41	8.0		colour change to grey	SW - FR					
											JT, 45°, PL, SO, VN
		40	9.0								JT, 10°, PL, RO, Clayey sand CO
											SM, PL, RO, Clayey sand CO
						HW					JT, PL, RO, Clayey sand CO
			10.0			SW					
		39			Borehole BH4 terminated at 10.00 m Target depth						
		38	11.0								
		37	12.0								
		36	13.0								
		35	14.0								

method & support
AS auger screwing
AD auger drilling
CB claw or blade bit
W washbore
NMLC NMLC core (51.9 mm)
NQ wireline core (47.6mm)
HQ wireline core (63.5mm)
PQ wireline core (85.0mm)
SPT standard penetration test
DHH downhole hammer

water
10/10/12, water level on date shown
water inflow
complete drilling fluid loss
partial drilling fluid loss
25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
core recovered (graphic symbols indicate material)
no core recovered

core run details
barrel withdrawn
TCR = Total Core Recovery (%)
SCR = Solid Core Recovery (%)
RQD = Rock Quality Designation (%)

weathering & alteration*
RS residual soil
XW extremely weathered
HW highly weathered
DW distinctly weathered
MW moderately weathered
SW slightly weathered
FR fresh
*W replaced with A for alteration

strength
VL very low
L low
M medium
H high
VH very high
EH extremely high

defect type
PT parting
JT joint
SZ shear zone
SS shear surface
CO contact
CS crushed seam
SM seam

planarity
PL planar
CU curved
UN undulating
ST stepped
IR Irregular

roughness
SL slickensided
POL polished
SO smooth
RO rough
VR very rough

coating
CN clean
SN stain
VN veneer
CO coating

drawn	MB	coffey A TETRA TECH COMPANY	client:	Shoalhaven City Council
approved	JPT		project:	Geotechnical and Hydrogeological Investigation
date	3/6/2016		title:	Core photograph BH4
scale	N.T.S.		project no: GEOTWOLL03957AA	figure no: 4
original size	A4			

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Engineering Log - Borehole

Borehole ID.	**BH5**
sheet:	1 of 2
project no.	**GEOTWOLL03957AA**
client:	***Shoalhaven City Council***
date started:	***25 May 2016***
principal:	**-**
date completed:	***25 May 2016***
project:	***Geotechnical and Hydrogeological Investigation***
logged by:	***MB***
location:	***West Nowra Recycling and Waste Facility, Mundamia NSW***
checked by:	***CDC***

position: E: 276178; N: 6137215 (MGA94 Zone 56) | surface elevation: 46.35 m (AHD) | angle from horizontal: 90°

drill model: Hanjin DB8, Track mounted | drilling fluid: water | hole diameter : 114 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
AD/T		Not Observed	SPT 7, 14, 21 N*=35	46				**Gravelly Sandy CLAY**: medium plasticity, pale brown, orange mottled, fine to medium grained sand, sub-angular to angular gravel, trace of organics.	D	F		**TOPSOIL**
								Sandy CLAY: medium plasticity, pale brown, orange to red mottled, fine to coarse grained sand, trace of sub-angular to angular gravel.		F - St		**RESIDUAL**
			SPT 3, 24, 22 N*=46	45	1.0			colour change to pale brown, grey to red to orange mottled		VSt		
					2.0			**Sandy CLAY**: medium plasticity, pale brown, grey, red to orange mottled, trace of sub-angular to sub-rounded gravel.		VSt / H		**EXTREMELY WEATHERED MATERIAL**
			SPT 8, 21, 25 N*=46	44				colour change to grey, red, orange mottled				
				43	3.0				M			
			SPT 17, 16, 19 N*=35	42	4.0							
					5.0			**CLAYEY SAND**: fine to medium grained, grey, brown, red, orange mottled, low plasticity clay, trace of sub-angular gravel.		VD		
			SPT 28, 28, 36/100mm N*=R	41	6.0							
				40				**SAND**: fine to medium grained, brown, grey, orange, trace of sub-angular gravel.				
			SPT 35/100mm N*=R	39	7.0							
					8.0							
				38				Borehole BH5 continued as cored hole				**HIGHLY WEATHERED SANDSTONE**

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- DHH downhole hammer

* bit shown by suffix
e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Cored Borehole

Borehole ID.	**BH5**
sheet:	2 of 2
project no.	**GEOTWOLL03957AA**
client:	**Shoalhaven City Council**
date started:	**25 May 2016**
principal:	**-**
date completed:	**25 May 2016**
project:	**Geotechnical and Hydrogeological Investigation**
logged by:	**MB**
location:	**West Nowra Recycling and Waste Facility, Mundamia NSW**
checked by:	**CDC**

position: E: 276178; N: 6137215 (MGA94 Zone 56) surface elevation: 46.35 m (AHD) angle from horizontal: 90°

drill model: Hanjin DB8, Track mounted drilling fluid: water hole diameter : 114 mm vane id.:

drilling information				material substance					rock mass defects		
method & support	water	RL (m)	depth (m)	graphic log	material description **ROCK TYPE**: grain characterisics, colour, structure, minor components	weathering & alteration	estimated strength & Is50 (X = axial; O = diametral) VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run details	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
					start coring at 8.30m						
NMLC	Not Observed	38			**SANDSTONE**: fine to coarse grained, brown, grey, orange, trace of sub-angular gravel.	HW					JT, 10°, PL, RO, SN
						XW					JT, 10°, PL, RO, SN SM, 10°, PL, RO, Sand CO
			9.0		black rounded pebble at 8.9m	HW - MW					JT, 20°, PL, RO, SN JT, 10°, PL, RO, SN SS, 10°, PL, RO, SN JT, 10°, CU, RO, SN JT, 10°, CU, RO, SN
		37			Borehole BH5 terminated at 9.39 m Target depth						
			10.0								
		36									
			11.0								
		35									
			12.0								
		34									
			13.0								
		33									
			14.0								
		32									
			15.0								
		31									
			16.0								
		30									
			17.0								

method & support
AS auger screwing
AD auger drilling
CB claw or blade bit
W washbore
NMLC NMLC core (51.9 mm)
NQ wireline core (47.6mm)
HQ wireline core (63.5mm)
PQ wireline core (85.0mm)
SPT standard penetration test
DHH downhole hammer

water
10/10/12, water level on date shown
water inflow
complete drilling fluid loss
partial drilling fluid loss
25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
core recovered (graphic symbols indicate material)
no core recovered

core run details
barrel withdrawn

TCR = Total Core Recovery (%)
SCR = Solid Core Recovery (%)
RQD = Rock Quality Designation (%)

weathering & alteration*
RS residual soil
XW extremely weathered
HW highly weathered
DW distinctly weathered
MW moderately weathered
SW slightly weathered
FR fresh
*W replaced with A for alteration

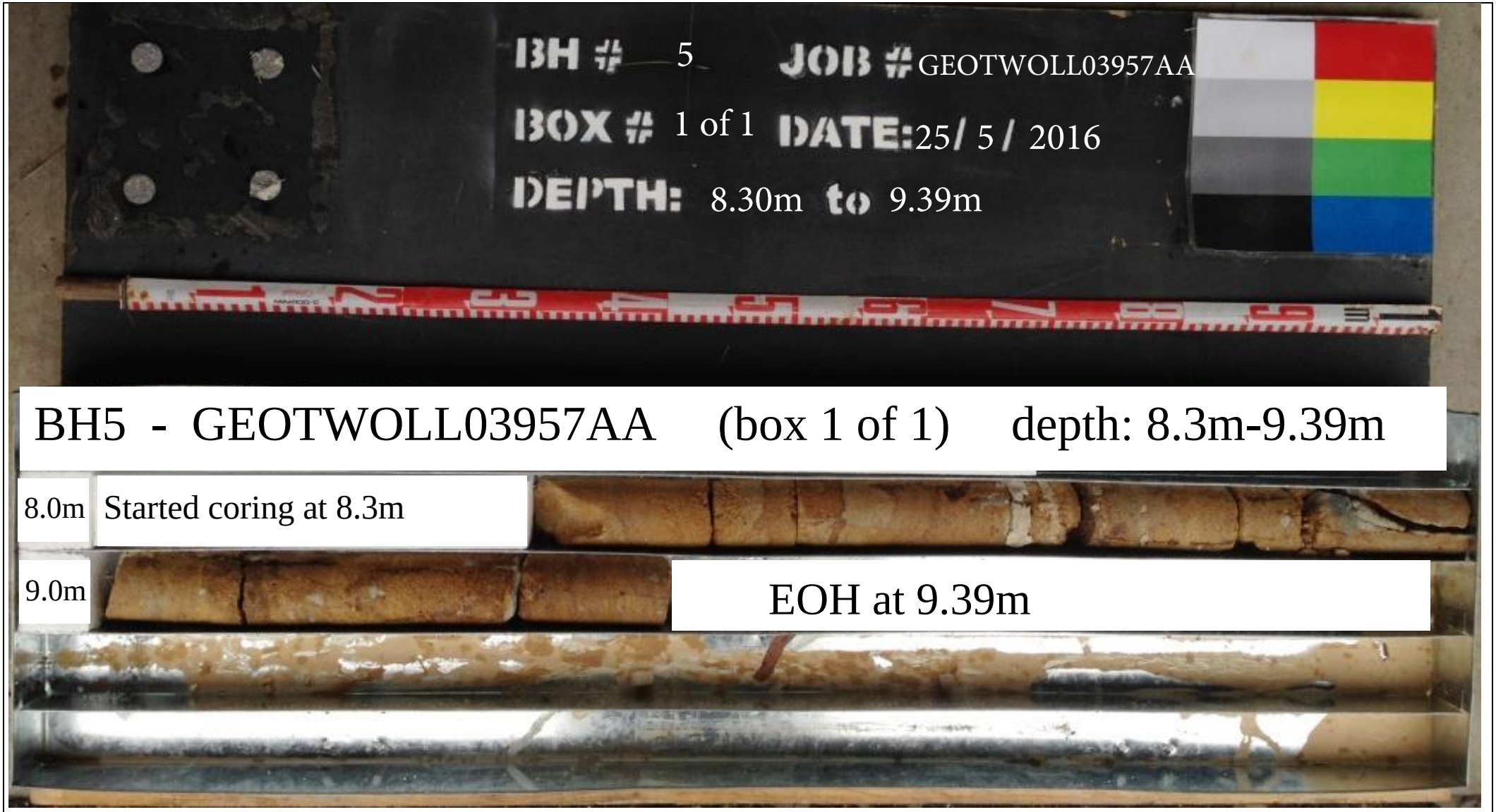
strength
VL very low
L low
M medium
H high
VH very high
EH extremely high

defect type
PT parting
JT joint
SZ shear zone
SS shear surface
CO contact
CS crushed seam
SM seam

planarity
PL planar
CU curved
UN undulating
ST stepped
IR Irregular

roughness
SL slickensided
POL polished
SO smooth
RO rough
VR very rough

coating
CN clean
SN stain
VN veneer
CO coating



drawn	**MB**	coffey A TETRA TECH COMPANY	client:	**Shoalhaven City Council**
approved	**JPT**		project:	**Geotechnical and Hydrogeological Investigation**
date	**3/6/2016**		title:	**Core photograph BH5**
scale	**N.T.S.**		project no: GEOTWOLL03957AA	figure no: 5
original size	**A4**			

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Engineering Log - Borehole

Borehole ID.	**BH6**
sheet:	1 of 2
project no.	**GEOTWOLL03957AA**
client:	***Shoalhaven City Council***
date started:	***27 May 2016***
principal:	**-**
date completed:	***27 May 2016***
project:	***Geotechnical and Hydrogeological Investigation***
logged by:	***MB***
location:	***West Nowra Recycling and Waste Facility, Mundamia NSW***
checked by:	***CDC***

position: E: 276373; N: 6137188 (MGA94 Zone 56) | surface elevation: 48.92 m (AHD) | angle from horizontal: 90°

drill model: Hanjin DB8, Track mounted | drilling fluid: water | hole diameter : 114 mm

drilling information | **material substance**

method & support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa)	structure and additional observations
AD/T		Not Observed	SPT 7, 16, 44 N*=60	48	0.0			**Gravelly Sandy CLAY**: medium plasticity, brown, orange mottled, fine to medium grained sand, sub-angular gravel, trace of organics.	D	F		**TOPSOIL**
								Sandy CLAY: medium to high plasticity, brown, red to orange mottled, fine grained sand, trace of sub-angular gravel, trace of organics.		St - VSt		**RESIDUAL**
			SPT 3, 9, 29 N*=38		1.0			**Sandy CLAY**: medium plasticity, brown, grey to red to orange mottled, fine grained sand, trace of sub-angular to sub-rounded gravel.		VSt / H		
				47	2.0			colour change to brown, red, orange to grey mottled				**EXTREMELY WEATHERED MATERIAL**
			SPT 7, 23, 36 N*=59	46	3.0							
			SPT 10, 41, 26/55mm N*=R	45	4.0			**CLAYEY SAND**: fine to medium grained, brown, grey, red to orange mottled, low plasticity clay, trace of sub-angular gravel.	M	VD		
				44	5.0			**SAND**: fine to coarse grained, brown, grey, orange, trace of sub-angular gravel.				
				43	6.0			**Sandy Silty CLAY**: low to medium plasticity, yellow brown, fine to coarse grained sand.		VSt		
				42	7.0			Borehole BH6 continued as cored hole				**MODERATELY WEATHERED SANDSTONE**
				41								

CDF_0_9_06_LIBRARY.GLB rev:AM Log COF BOREHOLE: NON CORED GW03957AA_DATABASE.GPJ <<DrawingFile>> 27/07/2016 10:46

method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- DHH downhole hammer

* bit shown by suffix
e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey
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Engineering Log - Cored Borehole

Borehole ID.	**BH6**
sheet:	2 of 2
project no.	**GEOTWOLL03957AA**
client:	**Shoalhaven City Council**
date started:	**27 May 2016**
principal:	**-**
date completed:	**27 May 2016**
project:	**Geotechnical and Hydrogeological Investigation**
logged by:	**MB**
location:	**West Nowra Recycling and Waste Facility, Mundamia NSW**
checked by:	**CDC**

position: E: 276373; N: 6137188 (MGA94 Zone 56) surface elevation: 48.92 m (AHD) angle from horizontal: 90°

drill model: Hanjin DB8, Track mounted drilling fluid: water hole diameter : 114 mm vane id.:

drilling information				material substance					rock mass defects			
method & support	water	RL (m)	depth (m)	graphic log	material description **ROCK TYPE**: grain characterisics, colour, structure, minor components	weathering & alteration	estimated strength & Is50 (X = axial; O = diametral) VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run details	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
					start coring at 6.28m						
NMLC	Not Observed	42	7.0		**SANDSTONE**: fine to coarse grained, brown, trace of sub-angular to angular gravel, distinctly bedded.	MW					PT, 10°, PL, RO, VN
											JT, 10°, PL, RO, VN
											SM, 10°, PL, RO, Clayey sand CO
					colour change to grey brown						
		41	8.0								JT, 10 - 15°, CU, RO, VN
											JT, 10°, PL, RO, VN
											PT, 10°, PL, RO, VN
		40	9.0			MW / SW					PT, 10°, PL, RO, VN
		39	10.0		Borehole BH6 terminated at 9.57 m Target depth						
		38	11.0								
		37	12.0								
		36	13.0								
		35	14.0								

method & support
AS auger screwing
AD auger drilling
CB claw or blade bit
W washbore
NMLC NMLC core (51.9 mm)
NQ wireline core (47.6mm)
HQ wireline core (63.5mm)
PQ wireline core (85.0mm)
SPT standard penetration test
DHH downhole hammer

water
10/10/12, water level on date shown
water inflow
complete drilling fluid loss
partial drilling fluid loss
25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
core recovered (graphic symbols indicate material)
no core recovered

core run details
barrel withdrawn
TCR = Total Core Recovery (%)
SCR = Solid Core Recovery (%)
RQD = Rock Quality Designation (%)

weathering & alteration*
RS residual soil
XW extremely weathered
HW highly weathered
DW distinctly weathered
MW moderately weathered
SW slightly weathered
FR fresh
*W replaced with A for alteration

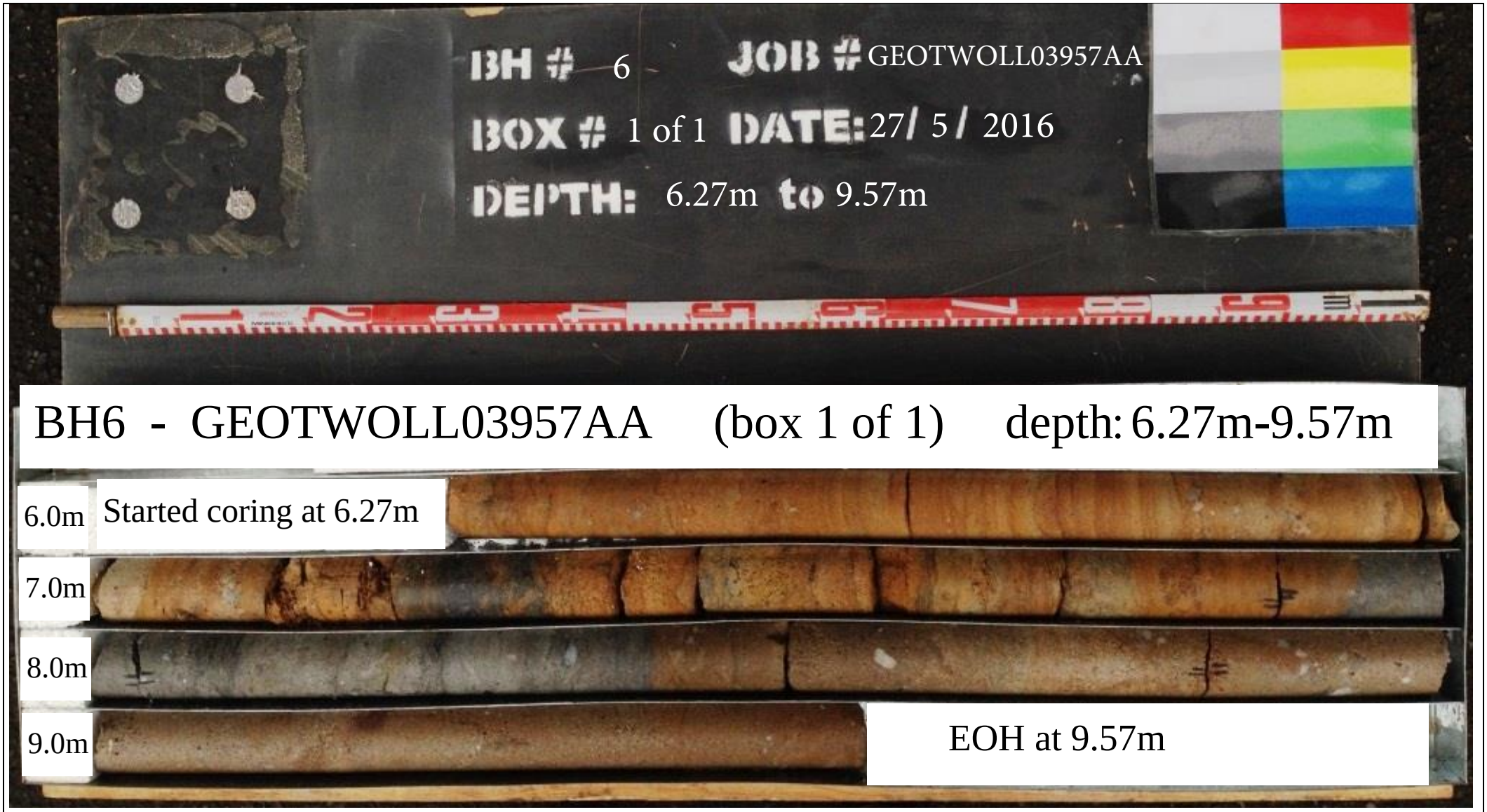
strength
VL very low
L low
M medium
H high
VH very high
EH extremely high

defect type
PT parting
JT joint
SZ shear zone
SS shear surface
CO contact
CS crushed seam
SM seam

planarity
PL planar
CU curved
UN undulating
ST stepped
IR Irregular

roughness
SL slickensided
POL polished
SO smooth
RO rough
VR very rough

coating
CN clean
SN stain
VN veneer
CO coating



drawn	MB	coffey A TETRA TECH COMPANY	client:	Shoalhaven City Council
approved	JPT		project:	Geotechnical and Hydrogeological Investigation
date	3/6/2016		title:	Core photograph BH6
scale	N.T.S.		project no: GEOTWOLL03957AA	figure no: 6
original size	A4			

coffey
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Engineering Log - Excavation

Excavation ID.	***TP1***
sheet:	1 of 1
project no.	***GEOTWOLL03957AA***
client:	***Shoalhaven City Council***
date excavated:	***28 Jun 2016***
principal:	***-***
date completed:	***28 Jun 2016***
project:	***Geotechnical and Hydrogeological Investigation***
logged by:	***MB***
location:	***West Nowra Recycling and Waste Facility, Mundamia NSW***
checked by:	***CDC***

position: E: 276135; N: 6136887 (MGA94 Zone 56) | surface elevation: 49.83 m (AHD) | pit orientation:

equipment type: 35 Tonne Excavator PC350 | excavation method: | excavation dimensions: 7.0 m long 2.0 m wide

excavation information | **material substance**

method	support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
E			Not Observed		49.5				**Silty CLAY**: medium plasticity, brown, trace of fine grained sand, trace of sub-rounded gravel, trace of organics (rootlets).	M	F		**TOPSOIL**
									Sandy CLAY: medium to high plasticity, brown, fine grained sand, trace of sub-rounded gravel, trace of organics.		F - St		**RESIDUAL**
					49.0	1.0			**Sandy CLAY**: medium to high plasticity, red, grey, brown orange mottled, fine grained sand, trace of sub-rounded to sub-angular gravel, trace of organics.		St - VSt		**EXTREMELY WEATHERED MATERIAL**
					48.5				**CLAYEY SAND**: fine to coarse grained, grey, brown, orange, trace of sub-angular gravel, trace of organics.	D	VD		
					48.0	2.0			**SANDSTONE**: fine to coarse grained, grey, brown, orange, with some ironstone, trace of sub-angular gravel.				**HIGHLY WEATHERED SANDSTONE**
					47.5								**HIGHLY TO MODERATELY WEATHERED SANDSTONE**
					47.0	3.0							
					46.5				Test pit TP1 terminated at 3.3 m Refusal				
					46.0	4.0							
					45.5								
					45.0	5.0							
					44.5								
					44.0								

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- U## undisturbed sample ##mm diameter
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear peak/remouded (uncorrected kPa)
- R refusal

classification symbol & soil description
based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- W_P plastic limit
- W_L liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation ID.	***TP2***
sheet:	1 of 1
project no.	***GEOTWOLL03957AA***
client:	***Shoalhaven City Council***
date excavated:	***29 Jun 2016***
principal:	***-***
date completed:	***29 Jun 2016***
project:	***Geotechnical and Hydrogeological Investigation***
logged by:	***MB***
location:	***West Nowra Recycling and Waste Facility, Mundamia NSW***
checked by:	***CDC***

position: E: 276189; N: 6136966 (MGA94 Zone 56) | surface elevation: 48.98 m (AHD) | pit orientation:

equipment type: 35 Tonne Excavator PC350 | excavation method: | excavation dimensions: 7.0 m long 2.0 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
E			Not Observed		48.98	0.0			**Silty Sandy CLAY**: medium plasticity, brown, orange mottled, fine grained sand, trace of sub-angular gravel, trace of organics (rootlets).	M	F		**TOPSOIL**
					48.5				**Sandy CLAY**: medium to high plasticity, brown, orange mottled, fine to medium grained sand, trace of sub-angular gravel, trace of organics.		F - St		**RESIDUAL**
					48.0	1.0			**Sandy CLAY**: medium to high plasticity, red, grey, brown to orange mottled, fine grained sand, trace of sub-rounded gravel, trace of organics.	D	St - VSt		**EXTREMELY WEATHERED MATERIAL**
					47.5								
					47.0	2.0			**Sandy CLAY**: medium to high plasticity, grey, red, brown to orange mottled, fine to medium grained sand, trace of sub-rounded gravel.		VSt		
					46.5								
					46.0	3.0			**Sandy CLAY**: medium plasticity, grey, orange to brown mottled, fine to medium grained sand, trace of sub-rounded gravel.		VSt - H		
					45.5								
					45.0	4.0							
					44.5								
					44.0	5.0			**SANDSTONE**: fine to medium grained, grey, orange, brown, trace of sub-rounded gravel, trace of medium plasticity clay.				**HIGHLY WEATHERED SANDSTONE**
					43.5								
					43.0	6.0			Test pit TP2 terminated at 6.0 m Machine limit				**MODERATELY WEATHERED SANDSTONE**

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests

U##	undisturbed sample ##mm diameter
D	disturbed sample
B	bulk disturbed sample
E	environmental sample
HP	hand penetrometer (kPa)
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
VS	vane shear peak/remouded (uncorrected kPa)
R	refusal

classification symbol & soil description
based on Unified Classification System

moisture

D	dry
M	moist
W	wet
W_P	plastic limit
W_L	liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation ID.	***TP3***
sheet:	1 of 1
project no.	***GEOTWOLL03957AA***
client: ***Shoalhaven City Council***	date excavated: ***28 Jun 2016***
principal: ***-***	date completed: ***28 Jun 2016***
project: ***Geotechnical and Hydrogeological Investigation***	logged by: ***MB***
location: ***West Nowra Recycling and Waste Facility, Mundamia NSW***	checked by: ***CDC***

position: E: 276145; N: 6137007 (MGA94 Zone 56) surface elevation: 48.97 m (AHD) pit orientation:

equipment type: 35 Tonne Excavator PC350 excavation method: excavation dimensions: 7.0 m long 2.0 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
E			Not Observed		48.97	0.0			**Silty Sandy CLAY**: medium plasticity, dark brown, fine grained sand, trace of sub-rounded gravel, trace of organics.	M	F		**TOPSOIL**
					48.5				**Sandy CLAY**: medium to high plasticity, brown, fine grained sand, trace of organics (rootlets).		F - St		**RESIDUAL**
					48.0	1.0			**Sandy CLAY**: medium to high plasticity, red, grey, brown, orange mottled, fine grained sand, trace of organics.	D	St - VSt		**EXTREMELY WEATHERED MATERIAL**
					47.5								
					47.0	2.0			**Sandy CLAY**: medium to high plasticity, grey, red, orange mottled, fine grained sand, trace of ironstone fragments, trace of sub-angular gravel.		VSt - H		
					46.5								
					46.0	3.0			**Sandy CLAY**: medium plasticity, grey, brown to red to orange mottled, fine grained sand, trace of ironstone fragments, trace of sub-angular gravel.				
					45.5								
					45.0	4.0							
					44.5								
					44.0	5.0			**SANDSTONE**: fine to medium grained, grey, brown, orange, trace of sub-angular gravel.				**HIGHLY WEATHERED SANDSTONE**
					43.5				Test pit TP3 terminated at 5.5 m Target depth				

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- U## undisturbed sample ##mm diameter
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear peak/remouded (uncorrected kPa)
- R refusal

classification symbol & soil description
based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- W_P plastic limit
- W_L liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation ID.	***TP4***
sheet:	1 of 1
project no.	***GEOTWOLL03957AA***
client:	***Shoalhaven City Council***
date excavated:	***29 Jun 2016***
principal:	***-***
date completed:	***29 Jun 2016***
project:	***Geotechnical and Hydrogeological Investigation***
logged by:	***MB***
location:	***West Nowra Recycling and Waste Facility, Mundamia NSW***
checked by:	***CDC***

position: E: 276258; N: 6136990 (MGA94 Zone 56) | surface elevation: 47.55 m (AHD) | pit orientation:

equipment type: 35 Tonne Excavator PC350 | excavation method: | excavation dimensions: 5.0 m long 2.0 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa)	structure and additional observations
E			Not Observed		47.5				**Silty CLAY**: medium plasticity, dark brown, trace of fine grained sand, trace of sub-rounded gravel, trace of organics (rootlets).	M	F		**TOPSOIL**
					47.0				**Sandy CLAY**: medium to high plasticity, brown, orange mottled, fine to medium grained sand, trace of sub-rounded to sub-angular gravel, trace of organics (rootlets).		F - St		**RESIDUAL**
					46.5	1.0			**Sandy CLAY**: medium to high plasticity, red, grey, brown to orange mottled, fine to medium grained sand, trace of sub-rounded to sub-angular gravel, trace of organics.		St - VSt		**EXTREMELY WEATHERED MATERIAL**
					46.0				trace of ironstone fragments				
					45.5	2.0			colour change to grey, red, orange mottled	D	VSt		
					45.0								
					44.5	3.0			**Sandy CLAY**: medium plasticity, grey, red to orange to brown mottled, fine grained sand, trace of sub-rounded gravel, trace of ironstone fragments.				
					44.0								
					43.5	4.0			**CLAYEY SAND**: fine to medium grained, grey, orange, brown, medium plasticity clay, trace of sub-rounded gravel, trace of ironstone fragments.		VD		
					43.0								
					42.5	5.0			**SANDSTONE**: fine to coarse grained, brown, grey, orange, trace of sub-rounded gravel, trace of low to medium plasticity clay.				**HIGHLY WEATHERED SANDSTONE**
					42.0				Test pit TP4 terminated at 5.6 m Refusal				

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- U## undisturbed sample ##mm diameter
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear peak/remouded (uncorrected kPa)
- R refusal

classification symbol & soil description
based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- W_P plastic limit
- W_L liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation ID.	***TP5***
sheet:	1 of 1
project no.	***GEOTWOLL03957AA***
client:	***Shoalhaven City Council***
date excavated:	***01 Jul 2016***
principal:	***-***
date completed:	***01 Jul 2016***
project:	***Geotechnical and Hydrogeological Investigation***
logged by:	***MB***
location:	***West Nowra Recycling and Waste Facility, Mundamia NSW***
checked by:	***CDC***

position: E: 276351; N: 6137023 (MGA94 Zone 56) | surface elevation: 47.01 m (AHD) | pit orientation:

equipment type: 35 Tonne Excavator PC350 | excavation method: | excavation dimensions: 8.0 m long 2.0 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
					47.0				**Sandy CLAY**: medium plasticity, dark brown, fine grained sand, trace of sub-rounded gravel, trace of organics (rootlets).	M	F		**TOPSOIL**
									Sandy CLAY: medium to high plasticity, brown, orange mottled, fine grained sand, trace of sub-rounded gravel, trace of organics (rootlets).		F - St		**RESIDUAL**
					46.5				**Sandy CLAY**: medium to high plasticity, grey, red, brown, orange mottled, fine grained sand, trace of organics, trace of sub-rounded gravel.		St - VSt		**EXTREMELY WEATHERED MATERIAL**
					46.0	1.0							
					45.5								
			Not Observed		45.0	2.0			**Sandy CLAY**: low plasticity, grey, brown, red mottled, orange mottled, fine to medium grained sand, trace of sub-rounded gravel.	D	VSt - H		
					44.5				**CLAYEY SAND**: fine to medium grained, grey, brown, orange, low plasticity clay, trace of organics, trace of sub-rounded gravel.		VD		
					44.0	3.0			**SANDSTONE**: fine to medium grained, grey, brown, orange, trace of sub-rounded gravel.				**HIGHLY WEATHERED SANDSTONE**
					43.5								
					43.0	4.0							**HIGHLY TO MODERATELY WEATHERED SANDSTONE**
					42.5				Test pit TP5 terminated at 4.5 m Refusal				
					42.0	5.0							
					41.5								

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- U## undisturbed sample ##mm diameter
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear peak/remouded (uncorrected kPa)
- R refusal

classification symbol & soil description
based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- W_P plastic limit
- W_L liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation ID.	***TP6***
sheet:	1 of 1
project no.	***GEOTWOLL03957AA***
client: ***Shoalhaven City Council***	date excavated: ***30 Jun 2016***
principal: ***-***	date completed: ***30 Jun 2016***
project: ***Geotechnical and Hydrogeological Investigation***	logged by: ***MB***
location: ***West Nowra Recycling and Waste Facility, Mundamia NSW***	checked by: ***CDC***

position: E: 276150; N: 6137094 (MGA94 Zone 56) surface elevation: 48.53 m (AHD) pit orientation:

equipment type: 35 Tonne Excavator PC350 excavation method: excavation dimensions: 7.0 m long 2.0 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa)	structure and additional observations
					48.5				**Sandy CLAY**: medium plasticity, dark brown, fine grained sand, trace of sub-rounded gravel, trace of organics (rootlets).	M	F		**TOPSOIL**
									Sandy CLAY: medium to high plasticity, brown, orange mottled, fine grained sand, trace of sub-rounded gravel, trace of organics.		St		**RESIDUAL**
					48.0				**Sandy CLAY**: medium to high plasticity, red, grey, brown orange mottled, fine grained sand, trace of sub-angular gravel.		St - VSt		**EXTREMELY WEATHERED MATERIAL**
					47.5	1.0							
					47.0					D	VSt		
			Not Observed		46.5	2.0							
					46.0								
					45.5	3.0			**Sandy CLAY**: medium plasticity, grey, orange mottled, fine grained sand, trace of sub-rounded gravel including ironstone.		VSt - H		
					45.0				**SANDSTONE**: fine to medium grained, brown to grey, trace of clay, trace of sub-angular gravel.				**HIGHLY WEATHERED SANDSTONE**
					44.5	4.0							**HIGHLY TO MODERATELY WEATHERED SANDSTONE**
					44.0				Test pit TP6 terminated at 4.4 m Refusal				
					43.5	5.0							
					43.0								

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- U## undisturbed sample ##mm diameter
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear peak/remouded (uncorrected kPa)
- R refusal

classification symbol & soil description
based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- W_P plastic limit
- W_L liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation ID.	***TP7***
sheet:	1 of 1
project no.	***GEOTWOLL03957AA***
client:	***Shoalhaven City Council***
date excavated:	***29 Jun 2016***
principal:	***-***
date completed:	***29 Jun 2016***
project:	***Geotechnical and Hydrogeological Investigation***
logged by:	***MB***
location:	***West Nowra Recycling and Waste Facility, Mundamia NSW***
checked by:	***CDC***

position: E: 276192; N: 6137130 (MGA94 Zone 56) | surface elevation: 48.69 m (AHD) | pit orientation:

equipment type: 35 Tonne Excavator PC350 | excavation method: | excavation dimensions: 6.0 m long 2.0 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
					48.5				**Silty CLAY**: medium plasticity, dark brown, fine grained sand, trace of sub-rounded gravel, trace of organics (rootlets).	M	F		**TOPSOIL**
									Sandy CLAY: medium to high plasticity, brown mottled , orange mottled, fine grained sand, trace of sub-angular gravel, trace of organics.		St - VSt		**RESIDUAL**
					48.0				**Sandy CLAY**: medium to high plasticity, red, brown, grey mottled, orange mottled, trace of sub-rounded gravel.		VSt		**EXTREMELY WEATHERED MATERIAL**
						1.0							
					47.5					D	VSt - H		
					47.0				**CLAYEY SAND**: fine to medium grained, brown, grey, orange, red, low to medium plasticity clay, trace of sub-angular gravel including ironstone.		VD		
						2.0							
					46.5								
					46.0								
						3.0							
					45.5								
					45.0				**SANDSTONE**: fine to medium grained, brown, grey, some ironstone bands.				**HIGHLY TO MODERATELY WEATHERED SANDSTONE**
						4.0			Test pit TP7 terminated at 4.0 m Refusal				
					44.5								
					44.0								
						5.0							
					43.5								
					43.0								

Not Observed

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- U## undisturbed sample ##mm diameter
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear peak/remouded (uncorrected kPa)
- R refusal

classification symbol & soil description
based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- W_P plastic limit
- W_L liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation ID.	***TP8***
sheet:	1 of 1
project no.	***GEOTWOLL03957AA***
client: ***Shoalhaven City Council***	date excavated: ***01 Jul 2016***
principal: ***-***	date completed: ***01 Jul 2016***
project: ***Geotechnical and Hydrogeological Investigation***	logged by: ***MB***
location: ***West Nowra Recycling and Waste Facility, Mundamia NSW***	checked by: ***CDC***

position: E: 276374; N: 6137103 (MGA94 Zone 56) | surface elevation: 48.61 m (AHD) | pit orientation:

equipment type: 35 Tonne Excavator PC350 | excavation method: | excavation dimensions: 7.0 m long 2.0 m wide

excavation information | **material substance**

method	support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
E			Not Observed		48.5				**Sandy CLAY**: medium plasticity, brown, fine grained sand, trace of sub-angular gravel, trace of organics (rootlets).	M	F		**TOPSOIL**
									Sandy CLAY: medium to high plasticity, brown, fine grained sand, trace of sub-rounded gravel, trace of organics (rootlets).		F - St		**RESIDUAL**
					48.0				**Sandy CLAY**: medium to high plasticity, red, brown, grey to orange mottled, fine grained sand, trace of organics, trace of sub-rounded gravel.		St - VSt		**EXTREMELY WEATHERED MATERIAL**
					47.5	1.0							
					47.0				trace of ironstone fragments	D	VSt		
					46.5	2.0			**CLAYEY SAND**: fine to medium grained, grey, brown, orange, medium plasticity clay, trace of sub-angular gravel.		D		
					46.0				**CLAYEY SAND**: fine to medium grained, grey, brown, medium plasticity clay, with some sandstone fragments.		VD		
					45.5	3.0			**Sandy CLAY**: medium to high plasticity, grey, orange to red mottled, with some ironstone fragments.		VSt - H		
					45.0								
					44.5	4.0							
					44.0								
					43.5	5.0			**Sandy CLAY**: medium plasticity, grey, brown, fine to medium grained sand, trace of sub-angular gravel.				
					43.0				Test pit TP8 terminated at 5.75 m Machine limit				

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- U## undisturbed sample ##mm diameter
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear peak/remouded (uncorrected kPa)
- R refusal

classification symbol & soil description
based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- W_P plastic limit
- W_L liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation ID.	***TP9***
sheet:	1 of 1
project no.	***GEOTWOLL03957AA***
client:	***Shoalhaven City Council***
date excavated:	***30 Jun 2016***
principal:	***-***
date completed:	***30 Jun 2016***
project:	***Geotechnical and Hydrogeological Investigation***
logged by:	***MB***
location:	***West Nowra Recycling and Waste Facility, Mundamia NSW***
checked by:	***CDC***

position: E: 276312; N: 6137206 (MGA94 Zone 56) | surface elevation: 48.26 m (AHD) | pit orientation:

equipment type: 35 Tonne Excavator PC350 | excavation method: | excavation dimensions: 7.0 m long 2.0 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
E			Not Observed		48.0				**Sandy CLAY**: medium plasticity, dark brown, fine grained sand, trace of sub-rounded gravel, trace of organics (rootlets).	M	F		**TOPSOIL**
									Sandy CLAY: medium to high plasticity, brown, orange mottled, fine grained sand, trace of organics (rootlets).		F - St		**RESIDUAL**
					47.5				colour change to grey, red, orange mottled		St		
						1.0			**CLAYEY SAND**: fine to medium grained, brown, grey, red, orange, trace of sub-angular gravel.		D		**EXTREMELY WEATHERED MATERIAL**
					47.0								
					46.5				**Sandy CLAY**: medium plasticity, brown, grey, orange mottled, trace of sub-angular gravel including ironstone.		VSt - H		
						2.0							
					46.0								
					45.5				**CLAYEY SAND**: fine to medium grained, brown, grey, orange, low plasticity clay, trace of sub-angular gravel.		VD		
						3.0			**SANDSTONE**: fine to medium grained, brown, grey, orange, trace of low plasticity clay, trace of sub-angular gravel.				**HIGHLY TO MODERATELY WEATHERED SANDSTONE**
					45.0								
					44.5								
						4.0			Test pit TP9 terminated at 3.8 m Refusal				
					44.0								
					43.5								
						5.0							
					43.0								
					42.5								

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests

U##	undisturbed sample ##mm diameter
D	disturbed sample
B	bulk disturbed sample
E	environmental sample
HP	hand penetrometer (kPa)
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
VS	vane shear peak/remouded (uncorrected kPa)
R	refusal

classification symbol & soil description
based on Unified Classification System

moisture

D	dry
M	moist
W	wet
W_P	plastic limit
W_L	liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation ID.	***TP10***		
sheet:	1 of 1		
project no.	***GEOTWOLL03957AA***		
client:	***Shoalhaven City Council***	date excavated:	***30 Jun 2016***
principal:	***-***	date completed:	***30 Jun 2016***
project:	***Geotechnical and Hydrogeological Investigation***	logged by:	***MB***
location:	***West Nowra Recycling and Waste Facility, Mundamia NSW***	checked by:	***CDC***

position: E: 276237; N: 6137203 (MGA94 Zone 56) | surface elevation: 47.44 m (AHD) | pit orientation:

equipment type: 35 Tonne Excavator PC350 | excavation method: | excavation dimensions: 7.0 m long 2.0 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
E			Not Observed		47.0				**Sandy CLAY**: medium plasticity, dark brown, fine grained sand, trace of sub-angular gravel, trace of organics (rootlets).	M	F		**TOPSOIL**
									Sandy CLAY: medium to high plasticity, brown, orange mottled, trace of rootlets, trace of sub-rounded gravel.		St		**RESIDUAL**
					46.5	1.0			**Sandy CLAY**: medium plasticity, red, grey, orange to brown mottled, fine grained sand, trace of sub-rounded gravel.		St - VSt		**EXTREMELY WEATHERED MATERIAL**
					46.0				**CLAYEY SAND**: fine to medium grained, brown, grey, orange, red, trace of fine to medium gravel, trace of low plasticity clay.		VD		
					45.5	2.0			**SANDSTONE**: fine to medium grained, brown, grey, orange, red, trace of sub-angular gravel, trace of low plasticity clay.				**HIGHLY TO MODERATELY WEATHERED SANDSTONE**
					45.0				Test pit TP10 terminated at 2.5 m Refusal				
					44.5	3.0							
					44.0								
					43.5	4.0							
					43.0								
					42.5	5.0							
					42.0								
					41.5								

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- U## undisturbed sample ##mm diameter
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear peak/remouded (uncorrected kPa)
- R refusal

classification symbol & soil description
based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- W_P plastic limit
- W_L liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Monitoring Well

Hole ID.	**GW1**
sheet:	1 of 1
project no.	**GEOTWOLL03957AA**
client:	**Shoalhaven City Council**
date started:	**26 May 2016**
principal:	**-**
date completed:	**26 May 2016**
project:	**Geotechnical and Hydrogeological Investigation**
logged by:	**MB**
location:	**West Nowra Recycling and Waste Facility, Mundamia NSW**
checked by:	**CDC**

position: E: 276107; N: 6136839 (MGA94 Zone 56) | surface elevation: 50.44 m (AHD) | angle from horizontal: 90°

equipment type: Hanjin DB8, Track mounted | drilling fluid: none | hole diameter : 110 mm

drilling information | **well details** | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	well details GW1	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	structure and additional observations
AD/T		07/06/16 ▽			50				**Sandy CLAY**: medium plasticity, brown, fine grained sand, trace of sub-angular gravel, trace of organics.	D	F	**TOPSOIL**
					49						F - St	**RESIDUAL**
					48	2.0			**Sandy CLAY**: medium to high plasticity, brown, red mottled, orange mottled, trace of sub-angular gravel, trace of organics. some sub-angular to angular gravel, including ironstone at 1m		St - VSt	**EXTREMELY WEATHERED MATERIAL**
					47							
					46	4.0			**Sandy CLAY**: low to medium plasticity, brown, grey.		VSt	
					45							
					44	6.0			**CLAYEY SAND**: fine to medium grained, brown, grey, low plasticity clay, trace of sub-angular gravel.	M	VSt - H	
DHH					43				**SANDSTONE**: fine grained, brown, trace of sub-angular gravel, including ironstone.	D	H	Refusal, borehole continued as down hole hammer at 6.48m
					42	8.0						**HIGHLY TO MODERATELY WEATHERED SANDSTONE**
					41				colour change to grey			
					40	10.0			colour change to brown, grey			
					39				colour change to grey			
					38	12.0						
					37					M		moist at 13.3m
					36	14.0						
					35							
					34	16.0						
					33							
					32	18.0			Monitoring Well GW1 terminated at 18.00 m Target depth			**backfill details:** 0.0-10.3m: Grout 10.3-12.4m: Bentonite 12.4-18.0m: Sand **standpipe piezo. GW1 details:** stickup: -0.67m 14.0-17.0m: screen
					31							
					30	20.0						

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- DHH downhole hammer

* bit shown by suffix e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Monitoring Well

Hole ID.	**GW1A**
sheet:	1 of 1
project no.	**GEOTWOLL03957AA**
client:	**Shoalhaven City Council**
date started:	**26 May 2016**
principal:	**-**
date completed:	**26 May 2016**
project:	**Geotechnical and Hydrogeological Investigation**
logged by:	**MB**
location:	**West Nowra Recycling and Waste Facility, Mundamia NSW**
checked by:	**CDC**

position: E: 276111; N: 6136841 (MGA94 Zone 56) | surface elevation: 50.43 m (AHD) | angle from horizontal: 90°

equipment type: Hanjin DB8, Track mounted | drilling fluid: none | hole diameter : 110 mm

drilling information				well details	material substance							
method & support	penetration 1 2 3	water	samples & field tests	GW1A	RL (m)	depth (m)	graphic log	classification symbol	material description **SOIL TYPE**: plasticity or particle characteristic, colour, secondary and minor components	moisture condition	consistency / relative density	structure and additional observations
CB					50	0.0			**Gravelly CLAYEY SAND**: fine to medium grained, brown, sub-angular gravel, trace of organics.	D	F	**TOPSOIL**
									Sandy CLAY: medium to high plasticity, brown, red mottled, orange mottled, fine grained sand, trace of sub-angular gravel.		St	**RESIDUAL**
					49	1.0						
					48	2.0					VSt	**EXTREMELY WEATHERED MATERIAL**
					47	3.0						
					46	4.0						
					45	5.0			**CLAYEY SAND**: brown, grey, low plasticity clay, trace of sub-angular gravel.			
DHH					44	6.0			**SANDSTONE**: fine grained, brown, trace of sub-angular gravel.		H	**HIGHLY TO MODERATELY WEATHERED SANDSTONE**
					43	7.0						
					42	8.0						GW1A was dry on 7 June 2016
					41	9.0			Monitoring Well GW1A terminated at 9.00 m Target depth			**backfill details:** 0.0-2.7m: Grout 2.7-3.85m: Bentonite 3.85-9.0m: Sand **standpipe piezo. GW1A details:** stickup: -0.83m 5.0-8.0m: screen
					40	10.0						

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- DHH downhole hammer

* bit shown by suffix
e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Monitoring Well

Hole ID.	**GW2**
sheet:	1 of 1
project no.	**GEOTWOLL03957AA**
client:	***Shoalhaven City Council***
date started:	***31 May 2016***
principal:	**-**
date completed:	***31 May 2016***
project:	***Geotechnical and Hydrogeological Investigation***
logged by:	***MB***
location:	***West Nowra Recycling and Waste Facility, Mundamia NSW***
checked by:	***CDC***

position: E: 276263; N: 6136958 (MGA94 Zone 56) | surface elevation: 47.03 m (AHD) | angle from horizontal: 90°

equipment type: Hanjin DB8, Track mounted | drilling fluid: none | hole diameter : 110 mm

drilling information | **well details** | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	GW2	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	structure and additional observations
DHH		07/06/16			47					D	F	**TOPSOIL**
					46				**Sandy Gravelly CLAY**: medium plasticity, brown, sub-angular gravel, fine to medium grained sand, trace of organics.		St	**RESIDUAL**
					45	2.0			**Sandy CLAY**: medium to high plasticity, brown, red mottled, orange mottled, trace of sub-rounded gravel, trace of organics.			
					44				**Sandy CLAY**: medium to high plasticity, brown, grey, red mottled, orange mottled, sub-angular gravel.		VSt	**EXTREMELY WEATHERED MATERIAL**
					43	4.0						
					42				**Sandy CLAY**: low to medium plasticity, grey, orange mottled, fine to medium grained sand, trace of sub-angular gravel.			
					41	6.0			**SANDSTONE**: fine to medium grained, grey, brown, trace of sub-angular gravel, including ironstone.		H	**HIGHLY TO MODERATELY WEATHERED SANDSTONE**
					40				colour change to dark brown			
					39	8.0						
					38				colour change to dark grey			
					37	10.0						
					36							
					35	12.0			colour change to brown, grey	M		moist at 11.9m
					34				colour change to grey			
					33	14.0			colour change to grey, brown mottled			
					32				colour change to dark grey			
					31	16.0						
					30							
					29	18.0			Monitoring Well GW2 terminated at 17.15 m Target depth			**backfill details:** 0.0-10.8m: Grout 10.8-12.0m: Bentonite 12.0-17.15m: Sand **standpipe piezo. GW2 details:** stickup: -0.81m 13.15-16.15m: screen
					28							
					27	20.0						

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- DHH downhole hammer

* bit shown by suffix
e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Monitoring Well

Hole ID.	***GW2A***
sheet:	1 of 1
project no.	***GEOTWOLL03957AA***
client:	***Shoalhaven City Council***
date started:	***26 May 2016***
principal:	***-***
date completed:	***26 May 2016***
project:	***Geotechnical and Hydrogeological Investigation***
logged by:	***MB***
location:	***West Nowra Recycling and Waste Facility, Mundamia NSW***
checked by:	***CDC***

position: E: 276267; N: 6136960 (MGA94 Zone 56) | surface elevation: 46.90 m (AHD) | angle from horizontal: 90°

equipment type: Hanjin DB8, Track mounted | drilling fluid: none | hole diameter : 110 mm

drilling information | **well details** | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	GW2A	RL (m)	depth (m)	graphic log	classification symbol	material description **SOIL TYPE**: plasticity or particle characteristic, colour, secondary and minor components	moisture condition	consistency / relative density	structure and additional observations
CB					46	1.0			**Sandy CLAY**: medium plasticity, brown, fine grained sand, trace of sub-angular gravel.	D	F	**TOPSOIL**
									Sandy CLAY: medium to high plasticity, brown, orange mottled, red mottled, trace of sub-angular gravel.		F - St	**RESIDUAL**
					45	2.0						
					44	3.0			colour change to pale brown with white mottling		VSt	**EXTREMELY WEATHERED MATERIAL**
					43	4.0			**CLAYEY SAND**: fine grained, brown, grey, medium plasticity clay, trace of sub-angular gravel.			
					42	5.0						
					41	6.0						
					40	7.0						
DHH					39	8.0			**SANDSTONE**: fine to coarse grained, grey, trace of sub-angular gravel.		H	**HIGHLY TO MODERATELY WEATHERED SANDSTONE** GW2A was dry on 7 June 2016
					38	9.0			Monitoring Well GW2A terminated at 9.00 m Target depth			**backfill details:** 0.0-2.75m: Grout 2.75-4.02m: Bentonite 4.02-9.0m: Sand **standpipe piezo. GW2A details:** stickup: -0.81m 5.0-8.0m: screen
					37	10.0						
					36							

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- DHH downhole hammer

* bit shown by suffix e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remoulded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Monitoring Well

Hole ID.	**GW3**
sheet:	1 of 1
project no.	**GEOTWOLL03957AA**
client:	***Shoalhaven City Council***
date started:	***31 May 2016***
principal:	**-**
date completed:	***31 May 2016***
project:	***Geotechnical and Hydrogeological Investigation***
logged by:	***MB***
location:	***West Nowra Recycling and Waste Facility, Mundamia NSW***
checked by:	***CDC***

position: E: 276258; N: 6137248 (MGA94 Zone 56) | surface elevation: 46.31 m (AHD) | angle from horizontal: 90°

equipment type: Hanjin DB8, Track mounted | drilling fluid: none | hole diameter : 110 mm

drilling information | **well details** | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	GW3	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	structure and additional observations
DHH		07/06/16			46				**Gravelly Sandy CLAY**: medium plasticity, brown, fine grained sand, sub-angular gravel, trace of organics.	D	F	**TOPSOIL**
					45						St	**RESIDUAL**
					44	2.0			**Sandy CLAY**: medium to high plasticity, brown, red mottled, orange mottled, fine to medium grained sand, trace of sub-angular to sub-rounded gravel.		VSt	**EXTREMELY WEATHERED MATERIAL**
					43							
					42	4.0			colour change to grey			
					41							
					40	6.0			**CLAYEY SAND**: fine to medium grained, brown, grey, trace of sub-angular gravel.			
					39				**SANDSTONE**: fine to medium grained, brown, with some ironstone.		H	**HIGHLY TO MODERATELY WEATHERED SANDSTONE**
					38	8.0			colour change to brown, grey mottled			
					37				colour change to grey			
					36	10.0			colour change to grey, brown mottled			
					35							
					34	12.0			colour change to grey			
					33							
					32	14.0			colour change to dark grey	M		
					31					W		Water at 15.3m approximate air lift yield of 0.2 l/s
					30	16.0						
					29							
					28	18.0			Monitoring Well GW3 terminated at 18.00 m Target depth			**backfill details:** 0.0-12.0m: Grout 12.0-13.1m: Bentonite 13.1-18.0m: Sand **standpipe piezo. GW3 details:** stickup: -0.745m 14.0-17.0m: screen
					27							
					26	20.0						

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- DHH downhole hammer

* bit shown by suffix
e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Monitoring Well

Hole ID.	***GW4***
sheet:	1 of 1
project no.	***GEOTWOLL03957AA***
client:	***Shoalhaven City Council***
date started:	***01 Jun 2016***
principal:	***-***
date completed:	***01 Jun 2016***
project:	***Geotechnical and Hydrogeological Investigation***
logged by:	***MB***
location:	***West Nowra Recycling and Waste Facility, Mundamia NSW***
checked by:	***CDC***

position: E: 276401; N: 6137113 (MGA94 Zone 56) | surface elevation: 48.51 m (AHD) | angle from horizontal: 90°

equipment type: Hanjin DB8, Track mounted | drilling fluid: none | hole diameter : 110 mm

drilling information				well details	material substance							
method & support	penetration 1 2 3	water	samples & field tests	GW4	RL (m)	depth (m)	graphic log	classification symbol	material description **SOIL TYPE**: plasticity or particle characteristic, colour, secondary and minor components	moisture condition	consistency / relative density	structure and additional observations
DHH		07/06/16			48 47 46 45 44 43 42 41 40 39 38 37 36 35 34 33 32 31 30 29 28	2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0			**Sandy Gravelly CLAY**: medium plasticity, brown, fine to medium grained sand, sub-rounded gravel, trace of organics.	W D	F F - St	**TOPSOIL** **RESIDUAL**
									Sandy CLAY: medium to high plasticity, brown, orange mottled, red mottled, fine grained sand, trace of organics, trace of sub-angular gravel.			
									Sandy CLAY: medium to high plasticity, brown, red, orange mottled, grey mottled, trace of sub-angular gravel.		VSt	**EXTREMELY WEATHERED MATERIAL**
									colour change to brown, grey mottled			
									SANDSTONE: fine to coarse grained, brown.	M	H	**HIGHLY TO MODERATELY WEATHERED SANDSTONE**
									colour change to grey			
									Monitoring Well GW4 terminated at 13.00 m Target depth			**backfill details:** 0.0-7.4m: Grout 7.4-8.0m: Bentonite 8.0-13.0m: Sand **standpipe piezo. GW4 details:** stickup: -0.75m 9.0-12.0m: screen

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- DHH downhole hammer

* bit shown by suffix
e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Monitoring Well

Hole ID.	**GW5**
sheet:	1 of 1
project no.	**GEOTWOLL03957AA**
client:	***Shoalhaven City Council***
date started:	***30 May 2016***
principal:	**-**
date completed:	***31 May 2016***
project:	***Geotechnical and Hydrogeological Investigation***
logged by:	***MB***
location:	***West Nowra Recycling and Waste Facility, Mundamia NSW***
checked by:	***CDC***

position: E: 276238; N: 6137084 (MGA94 Zone 56) | surface elevation: 49.17 m (AHD) | angle from horizontal: 90°

equipment type: Hanjin DB8, Track mounted | drilling fluid: none | hole diameter : 110 mm

drilling information | **well details** | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	GW5	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	structure and additional observations
DHH		07/06/16			49				**Gravelly Sandy CLAY**: medium plasticity, brown, fine grained sand, sub-angular gravel, trace of organics.	D	F	**TOPSOIL**
					48						St	**RESIDUAL**
					47	2.0			**Sandy CLAY**: medium to high plasticity, brown, red mottled, fine grained sand, trace of sub-angular gravel, trace of organics.			
					46				**Sandy CLAY**: medium to high plasticity, brown, red, orange mottled, grey mottled, trace of sub-angular gravel. colour change to grey colour change to pale brown, grey		VSt	**EXTREMELY WEATHERED MATERIAL**
					45	4.0						
					44				colour change to brown, grey			
					43	6.0						
					42				**SANDSTONE**: fine grained, dark brown, trace of sub-angular gravel, including ironstone.		H	**HIGHLY TO MODERATELY WEATHERED SANDSTONE**
					41	8.0						
					40							
					39	10.0			colour change to grey			
					38				colour change to dark brown			
					37	12.0			colour change to dark grey			
					36							
					35	14.0				M		moist at 13.7m
					34							
					33	16.0						
					32							
					31	18.0			Monitoring Well GW5 terminated at 18.00 m Target depth			**backfill details:** 0.0-6.0m: Grout 6.0-7.5m: Bentonite 7.5-18.0m: Sand **standpipe piezo. GW5 details:** stickup: -0.6m 14.0-17.0m: screen
					30							
					29	20.0						

CDF_0_9_06_LIBRARY.GLB rev:AM Log COF PIEZOMETER GW03957AA_DATABASE.GPJ <<DrawingFile>> 15/06/2016 15:01

method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- DHH downhole hammer

* bit shown by suffix
e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description based on Unified Classification System

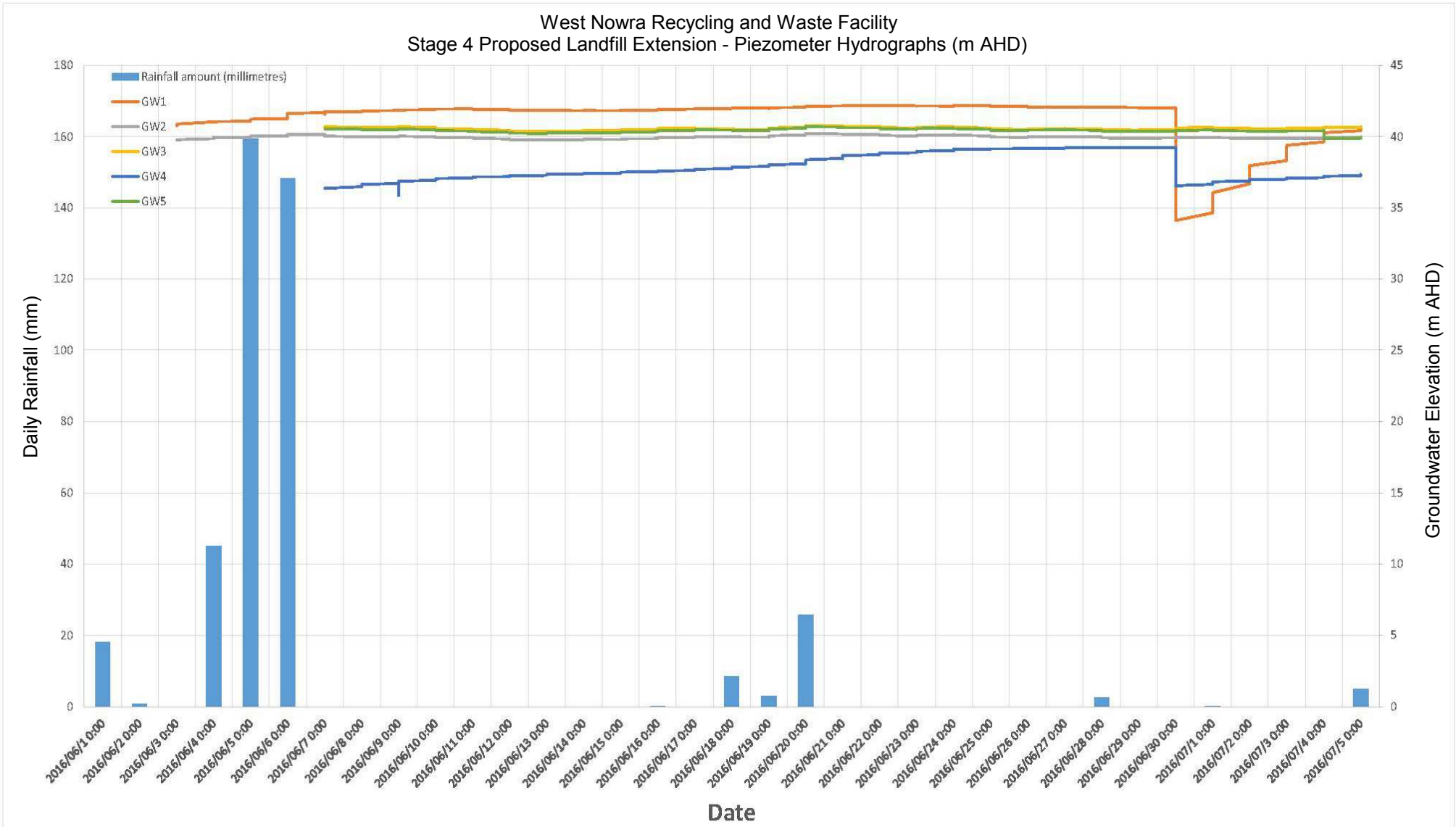
moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

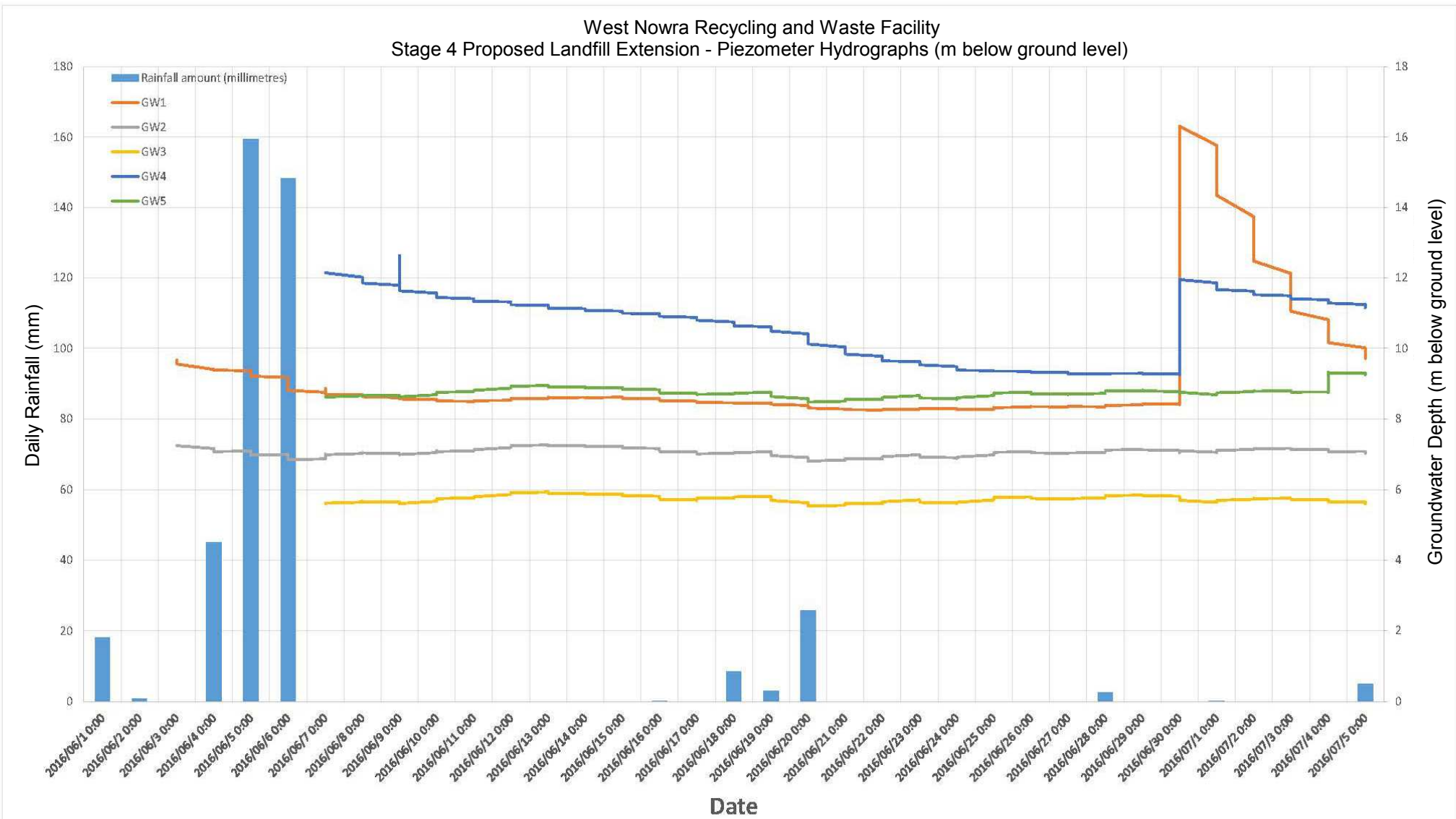
consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Appendix B – ENRS Hydrographs

Appendix B - ENRS Hydrographs





Appendix C – Geotechnical Laboratory Test Reports

South Nowra Laboratory

Coffey Testing Pty Ltd
ABN 92 114 364 046
43 Quinns Lane
South Nowra NSW 2541

Phone: +61 2 4429 5000
Fax: +61 2 4429 5099

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Material Test Report

Report No: SNOW16S-01862-1
Issue No: 1

Client:	Coffey Geotechnics Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	
Project No.:	INFOSNOW00518AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 16/06/2016

Sample Details

Sample ID:	SNOW16S-01862
Client Sample:	
Date Sampled:	
Source:	
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	BH01 Depth: 4.00-4.45m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	9.1	
Date Tested		10/06/2016	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	8.0	
Mould Length (mm)		250	
Liquid Limit (%)	AS 1289.3.1.1	34	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	19	
Plasticity Index (%)	AS 1289.3.3.1	15	
Date Tested		15/06/2016	

Comments

N/A

South Nowra Laboratory

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Material Test Report

Report No: SNOW16S-01863-1
Issue No: 1

Client:	Coffey Geotechnics Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	
Project No.:	INFOSNOW00518AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 16/06/2016

Sample Details

Sample ID:	SNOW16S-01863
Client Sample:	
Date Sampled:	
Source:	
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	BH02 Depth: 4.00-4.45m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	7.9	
Date Tested		10/06/2016	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	7.0	
Mould Length (mm)		250	
Liquid Limit (%)	AS 1289.3.1.1	33	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	16	
Plasticity Index (%)	AS 1289.3.3.1	17	
Date Tested		15/06/2016	

Comments

N/A

South Nowra Laboratory

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Fax: +61 2 4429 5099

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Report No: SNOW16S-01864-1
Issue No: 1

Material Test Report

Client:	Coffey Geotechnics Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	
Project No.:	INFOSNOW00518AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

NATA
WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 16/06/2016

Sample Details

Sample ID:	SNOW16S-01864
Client Sample:	
Date Sampled:	
Source:	
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	BH03 Depth: 5.50-5.92m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	7.4	
Date Tested		10/06/2016	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	7.0	
Mould Length (mm)		250	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	31	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	15	
Plasticity Index (%)	AS 1289.3.3.1	16	
Date Tested		15/06/2016	

Comments

N/A

South Nowra Laboratory

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Material Test Report

Report No: SNOW16S-01865-1
Issue No: 1

Client:	Coffey Geotechnics Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	
Project No.:	INFOSNOW00518AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 16/06/2016

Sample Details

Sample ID:	SNOW16S-01865
Client Sample:	
Date Sampled:	
Source:	
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	BH04 Depth: 4.00-4.35m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	4.7	
Date Tested		10/06/2016	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	4.0	
Mould Length (mm)		250	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	25	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	15	
Plasticity Index (%)	AS 1289.3.3.1	10	
Date Tested		15/06/2016	

Comments

N/A

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Report No: SNOW16S-01866-1
Issue No: 1

Material Test Report

Client:	Coffey Geotechnics Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	
Project No.:	INFOSNOW00518AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

NATA
WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 16/06/2016

Sample Details

Sample ID:	SNOW16S-01866
Client Sample:	
Date Sampled:	
Source:	
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	BH05 Depth: 5.50-5.85m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	9.9	
Date Tested		10/06/2016	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	3.0	
Mould Length (mm)		253	
Liquid Limit (%)	AS 1289.3.1.1	21	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	15	
Plasticity Index (%)	AS 1289.3.3.1	6	
Date Tested		15/06/2016	

Comments

N/A

South Nowra Laboratory

Coffey Testing Pty Ltd
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South Nowra NSW 2541

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Material Test Report

Report No: SNOW16S-01867-1
Issue No: 1

Client:	Coffey Geotechnics Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	
Project No.:	INFOSNOW00518AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 16/06/2016

Sample Details

Sample ID:	SNOW16S-01867
Client Sample:	
Date Sampled:	
Source:	
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	BH06 Depth: 4.00-4.35m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	6.9	
Date Tested		10/06/2016	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	5.0	
Mould Length (mm)		250	
Liquid Limit (%)	AS 1289.3.1.1	26	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	14	
Plasticity Index (%)	AS 1289.3.3.1	12	
Date Tested		15/06/2016	

Comments

N/A

South Nowra Laboratory

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Material Test Report

Report No: SNOW16S-02193-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 6/07/2016

Sample Details

Sample ID:	SNOW16S-02193
Client Sample:	
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP1 Depth: 1-2m

Other Test Results

Description	Method	Result	Limits
Emerson Class Number	AS 1289.3.8.1	5	
Soil Description		Refer to test pit logs.	
Type of Water		Distilled	
Temperature of Water (°C)		16.0	
Date Tested		5/07/2016	

Particle Size Distribution

Chart

Comments

N/A

South Nowra Laboratory

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Material Test Report

Report No: SNOW16S-02194-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 6/07/2016

Sample Details

Sample ID:	SNOW16S-02194
Client Sample:	
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP2 Depth: 4-5m

Test Results

Description	Method	Result	Limits
Emerson Class Number	AS 1289.3.8.1	5	
Soil Description		Refer to test pit logs.	
Type of Water		Distilled	
Temperature of Water (°C)		16.0	
Date Tested		5/07/2016	

Comments

N/A

South Nowra Laboratory

Coffey Corporate Services Pty Ltd
ABN 55 139 460 521
43 Quinns Lane
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Material Test Report

Report No: SNOW16S-02195-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 6/07/2016

Sample Details

Sample ID:	SNOW16S-02195
Client Sample:	
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP3 Depth: 1-2m

Test Results

Description	Method	Result	Limits
Emerson Class Number	AS 1289.3.8.1	5	
Soil Description		Refer to test pit log.	
Type of Water		Distilled	
Temperature of Water (°C)		16.0	
Date Tested		5/07/2016	

Comments

N/A

South Nowra Laboratory

Coffey Corporate Services Pty Ltd
ABN 55 139 460 521
43 Quinns Lane
South Nowra NSW 2541

Phone: +61 2 4429 5000
Fax: +61 2 4429 5099

A TETRA TECH COMPANY

Material Test Report

Report No: SNOW16S-02196-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 6/07/2016

Sample Details

Sample ID:	SNOW16S-02196
Client Sample:	
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP3 Depth: 4-5m

Test Results

Description	Method	Result	Limits
Emerson Class Number	AS 1289.3.8.1	5	
Soil Description		Refer to test pit logs.	
Type of Water		Distilled	
Temperature of Water (°C)		16.0	
Date Tested		5/07/2016	

Comments

N/A

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Material Test Report

Report No: SNOW16S-02197-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 6/07/2016

Sample Details

Sample ID:	SNOW16S-02197
Client Sample:	
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP4 Depth: 2-3m

Test Results

Description	Method	Result	Limits
Emerson Class Number	AS 1289.3.8.1	5	
Soil Description		Refer to test pit log	
Type of Water		Distilled	
Temperature of Water (°C)		16.0	
Date Tested		5/07/2016	

Comments

N/A

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Material Test Report

Report No: SNOW16S-02198-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 6/07/2016

Sample Details

Sample ID:	SNOW16S-02198
Client Sample:	
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP4 Depth: 4-5m

Test Results

Description	Method	Result	Limits
Emerson Class Number	AS 1289.3.8.1	5	
Soil Description		Refer to test pit log	
Type of Water		Distilled	
Temperature of Water (°C)		16.0	
Date Tested		5/07/2016	

Comments

N/A

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Material Test Report

Report No: SNOW16S-02199-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

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Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 6/07/2016

Sample Details

Sample ID:	SNOW16S-02199
Client Sample:	
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP5 Depth: 1-2m

Test Results

Description	Method	Result	Limits
Emerson Class Number	AS 1289.3.8.1	6	
Soil Description		Refer to test pit log	
Type of Water		Distilled	
Temperature of Water (°C)		16.0	
Date Tested		5/07/2016	

Comments

N/A

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Material Test Report

Report No: SNOW16S-02200-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 6/07/2016

Sample Details

Sample ID:	SNOW16S-02200
Client Sample:	
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP5 Depth: 2-3m

Test Results

Description	Method	Result	Limits
Emerson Class Number	AS 1289.3.8.1	5	
Soil Description		Refer to test pit log	
Type of Water		Distilled	
Temperature of Water (°C)		16.0	
Date Tested		5/07/2016	

Comments

N/A

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Material Test Report

Report No: SNOW16S-02201-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 6/07/2016

Sample Details

Sample ID:	SNOW16S-02201
Client Sample:	
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP8 Depth: 2-3m

Test Results

Description	Method	Result	Limits
Emerson Class Number	AS 1289.3.8.1	6	
Soil Description		Refer to test pit log	
Type of Water		Distilled	
Temperature of Water (°C)		16.0	
Date Tested		5/07/2016	

Comments

N/A

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Material Test Report

Report No: SNOW16S-02202-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

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Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 6/07/2016

Sample Details

Sample ID:	SNOW16S-02202
Client Sample:	
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP8 Depth: 4-5m

Test Results

Description	Method	Result	Limits
Emerson Class Number	AS 1289.3.8.1	5	
Soil Description		Refer to test pit log	
Type of Water		Distilled	
Temperature of Water (°C)		16.0	
Date Tested		5/07/2016	

Comments

N/A

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Material Test Report

Report No: SNOW16S-02203-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 6/07/2016

Sample Details

Sample ID:	SNOW16S-02203
Client Sample:	
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP6 Depth: 1-2m

Test Results

Description	Method	Result	Limits
Emerson Class Number	AS 1289.3.8.1	5	
Soil Description		Refer to test pit log	
Type of Water		Distilled	
Temperature of Water (°C)		16.0	
Date Tested		6/07/2016	

Comments

N/A

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Material Test Report

Report No: SNOW16S-02204-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 6/07/2016

Sample Details

Sample ID:	SNOW16S-02204
Client Sample:	
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP7 Depth: 1-2m

Test Results

Description	Method	Result	Limits
Emerson Class Number	AS 1289.3.8.1	6	
Soil Description		Refer to test pit log	
Type of Water		Distilled	
Temperature of Water (°C)		16.0	
Date Tested		6/07/2016	

Comments

N/A

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Material Test Report

Report No: SNOW16S-02205-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

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Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 6/07/2016

Sample Details

Sample ID:	SNOW16S-02205
Client Sample:	
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP7 Depth: 3-4m

Test Results

Description	Method	Result	Limits
Emerson Class Number	AS 1289.3.8.1	6	
Soil Description		Refer to test pit log	
Type of Water		Distilled	
Temperature of Water (°C)		16.0	
Date Tested		6/07/2016	

Comments

N/A

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A TETRA TECH COMPANY

Material Test Report

Report No: SNOW16S-02206-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 6/07/2016

Sample Details

Sample ID:	SNOW16S-02206
Client Sample:	
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP9 Depth: 2-3m

Test Results

Description	Method	Result	Limits
Emerson Class Number	AS 1289.3.8.1	6	
Soil Description		Refer to test pit log	
Type of Water		Distilled	
Temperature of Water (°C)		17.0	
Date Tested		6/07/2016	

Comments

N/A

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Material Test Report

Report No: SNOW16S-02207-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 6/07/2016

Sample Details

Sample ID:	SNOW16S-02207
Client Sample:	
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP10 Depth: 1-1.5m

Test Results

Description	Method	Result	Limits
Emerson Class Number	AS 1289.3.8.1	6	
Soil Description		Refer to test pit log	
Type of Water		Distilled	
Temperature of Water (°C)		16.0	
Date Tested		6/07/2016	

Comments

N/A

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Material Test Report

Report No: SNOW16S-02210-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 11/07/2016

Sample Details

Sample ID:	SNOW16S-02210
Client Sample:	-
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP1 Depth: 1-2m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	15.7	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	8.0	
Mould Length (mm)		250	
Liquid Limit (%)	AS 1289.3.1.1	48	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	20	
Plasticity Index (%)	AS 1289.3.3.1	28	
Date Tested		7/07/2016	

Comments

N/A.

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Material Test Report

Report No: SNOW16S-02211-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 11/07/2016

Sample Details

Sample ID:	SNOW16S-02211
Client Sample:	-
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP2 Depth: 1-2m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	15.7	
Date Tested		4/07/2016	

Comments

N/A.

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Material Test Report

Report No: SNOW16S-02212-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 11/07/2016

Sample Details

Sample ID:	SNOW16S-02212
Client Sample:	-
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP2 Depth: 2-3m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	10.7	
Date Tested		4/07/2016	

Comments

N/A.

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Material Test Report

Report No: SNOW16S-02213-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

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The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 11/07/2016

Sample Details

Sample ID:	SNOW16S-02213
Client Sample:	-
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP2 Depth: 3-4m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	9.0	
Date Tested		4/07/2016	

Comments

N/A

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Material Test Report

Report No: SNOW16S-02214-1
Issue No: 2
This report replaces all previous issues of report no 'SNOW16S-02214-1'.

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

NATA
WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 12/07/2016

Sample Details

Sample ID:	SNOW16S-02214
Client Sample:	-
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP2 Depth: 4-5m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	13.6	
Date Tested		4/07/2016	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	8.0	
Mould Length (mm)		250	
Liquid Limit (%)	AS 1289.3.1.1	35	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	19	
Plasticity Index (%)	AS 1289.3.3.1	16	
Date Tested		7/07/2016	

Comments

Report reissued due to data entry error.

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Material Test Report

Report No: SNOW16S-02215-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 11/07/2016

Sample Details

Sample ID:	SNOW16S-02215
Client Sample:	-
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP4 Depth: 2-3m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	11.1	
Date Tested		4/07/2016	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	10.0	
Mould Length (mm)		253	
Liquid Limit (%)	AS 1289.3.1.1	42	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	19	
Plasticity Index (%)	AS 1289.3.3.1	23	
Date Tested		7/07/2016	

Comments

N/A.

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Material Test Report

Report No: SNOW16S-02216-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 11/07/2016

Sample Details

Sample ID:	SNOW16S-02216
Client Sample:	-
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP5 Depth: 2-3m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	6.4	
Date Tested		4/07/2016	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	5.0	
Mould Length (mm)		250	
Liquid Limit (%)	AS 1289.3.1.1	26	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	15	
Plasticity Index (%)	AS 1289.3.3.1	11	
Date Tested		7/07/2016	

Comments

N/A

South Nowra Laboratory

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Material Test Report

Report No: SNOW16S-02217-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 11/07/2016

Sample Details

Sample ID:	SNOW16S-02217
Client Sample:	-
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP8 Depth: 3-4m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	10.5	
Date Tested		4/07/2016	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	9.0	
Mould Length (mm)		250	
Liquid Limit (%)	AS 1289.3.1.1	36	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	13	
Plasticity Index (%)	AS 1289.3.3.1	23	
Date Tested		7/07/2016	

Comments

N/A

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Material Test Report

Report No: SNOW16S-02218-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 11/07/2016

Sample Details

Sample ID:	SNOW16S-02218
Client Sample:	-
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP6 Depth: 1-2m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	11.2	
Date Tested		4/07/2016	

Comments

N/A.

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Material Test Report

Report No: SNOW16S-02219-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

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Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 11/07/2016

Sample Details

Sample ID:	SNOW16S-02219
Client Sample:	-
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP6 Depth: 2-3m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	10.3	
Date Tested		4/07/2016	

Comments

N/A

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Material Test Report

Report No: SNOW16S-02220-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

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Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 11/07/2016

Sample Details

Sample ID:	SNOW16S-02220
Client Sample:	-
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP6 Depth: 3-4m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	10.8	
Date Tested		4/07/2016	

Comments

N/A

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Material Test Report

Report No: SNOW16S-02221-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 11/07/2016

Sample Details

Sample ID:	SNOW16S-02221
Client Sample:	-
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP6 Depth: 4-5m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	6.7	
Date Tested		4/07/2016	

Comments

N/A

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Material Test Report

Report No: SNOW16S-02222-1
Issue No: 2
This report replaces all previous issues of report no 'SNOW16S-02222-1'.

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

NATA
WORLD RECOGNISED ACCREDITATION

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Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 12/07/2016

Sample Details

Sample ID:	SNOW16S-02222
Client Sample:	-
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP7 Depth: 2-3m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	6.9	
Date Tested		4/07/2016	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	5.0	
Mould Length (mm)		250	
Liquid Limit (%)	AS 1289.3.1.1	27	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	14	
Plasticity Index (%)	AS 1289.3.3.1	13	
Date Tested		7/07/2016	

Comments

Report reissued due to data entry error.

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Material Test Report

Report No: SNOW16S-02223-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

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Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 11/07/2016

Sample Details

Sample ID:	SNOW16S-02223
Client Sample:	-
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP7 Depth: 3.9-4.0m

Test Results

Description	Method	Result	Limits
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	3.0	
Mould Length (mm)		250	
Liquid Limit (%)	AS 1289.3.1.1	22	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	14	
Plasticity Index (%)	AS 1289.3.3.1	8	
Date Tested		7/07/2016	

Comments

N/A

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Material Test Report

Report No: SNOW16S-02224-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 11/07/2016

Sample Details

Sample ID:	SNOW16S-02224
Client Sample:	-
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP9 Depth: 2-3m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	9.8	
Date Tested		4/07/2016	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	7.0	
Mould Length (mm)		250	
Liquid Limit (%)	AS 1289.3.1.1	39	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	18	
Plasticity Index (%)	AS 1289.3.3.1	21	
Date Tested		7/07/2016	

Comments

N/A

South Nowra Laboratory

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Material Test Report

Report No: SNOW16S-02225-1
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	Shoalhaven City COuncil
Project No.:	INFOSNOW00523AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Wayne Beach
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 11/07/2016

Sample Details

Sample ID:	SNOW16S-02225
Client Sample:	-
Date Sampled:	01/07/2016
Source:	Not Specified
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	West Nowra. NSW
Sample Location:	TP10 Depth: 1-1.5m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	10.9	
Date Tested		4/07/2016	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	5.5	
Mould Length (mm)		250	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	28	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	15	
Plasticity Index (%)	AS 1289.3.3.1	13	
Date Tested		8/07/2016	

Comments

N/A

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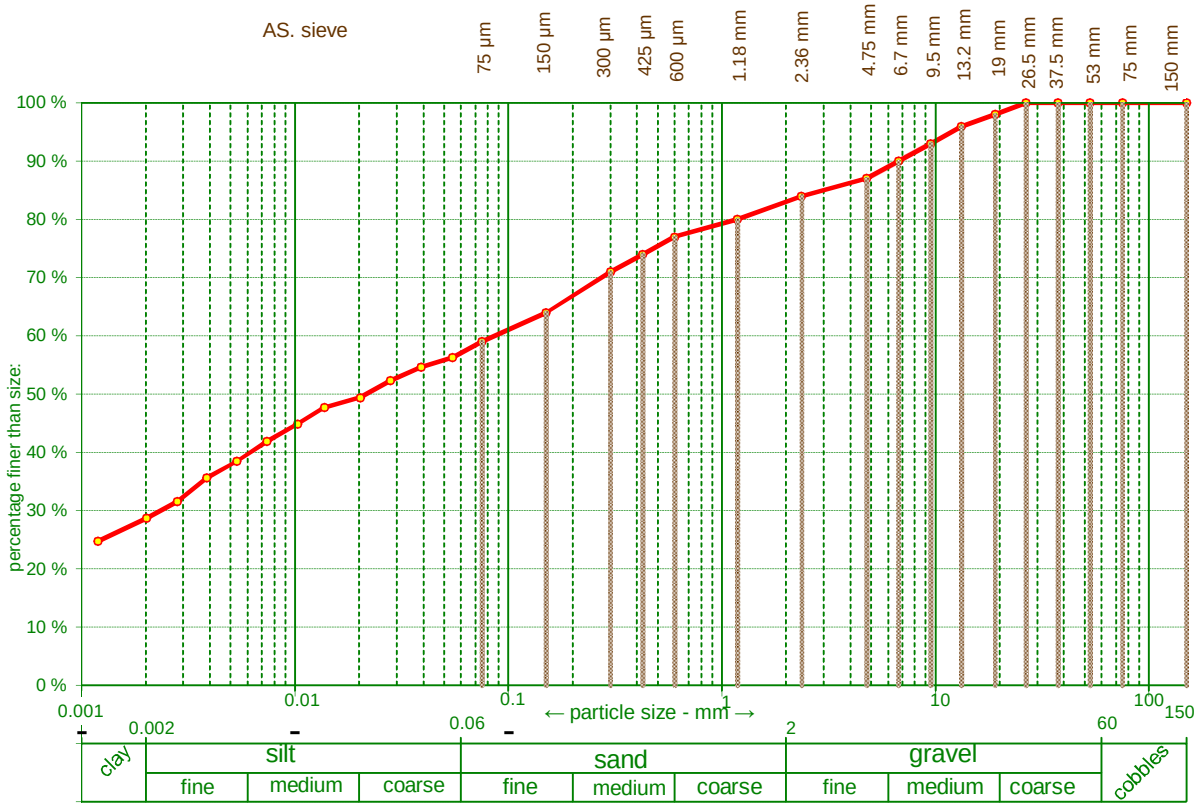
PARTICLE SIZE DISTRIBUTION & HYDROMETER

Client:	Coffey Corporate Services Pty Ltd (Wollongong)	Job No:	INFOABTM00688AA
Principal:		Laboratory:	Abbotsford
Project:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility	Report Date	20-Jul-16
Location:		Test report No:	PSDH:ABTM16S-03258
Test procedure:	AS1289.3.6.1, 3.6.3	Client ref:	
Sample No:	ABTM16S-03258		
Sample Identification	TP1 (1.0-2.0m)		



Sieve Analysis		Hydrometer Analysis	
Sieve Size	% Passing	Particle Size	% Passing
75 mm	100	54.5 µm	56
53 mm	100	39 µm	55
37.5 mm	100	28 µm	52
26.5 mm	100	20.2 µm	49
19 mm	98	13.8 µm	48
13.2 mm	96	10.3 µm	45
9.5 mm	93	7.4 µm	42
6.7 mm	90	5.4 µm	39
4.75 mm	87	3.9 µm	36
2.36 mm	84	2.8 µm	32
1.18 mm	80	2 µm	29
600 µm	77	1.2 µm	25
425 µm	74		
300 µm	71		
150 µm	64		
75 µm	59		

Comments

NOTES:

Loss of mass in pretreatment:	No pretreatment.
Dispersion method:	Sodium hexametaphosphate and Sodium carbonate
Type of hydrometer:	ASTM 152H
Soil Particle density(assumed):	2.65 g/cm3
Preparation method	Wet analysis

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NATA Accredited Laboratory No. 431 Date: 20/07/2016
Approved Signatory: Gayani Samaradiwakara

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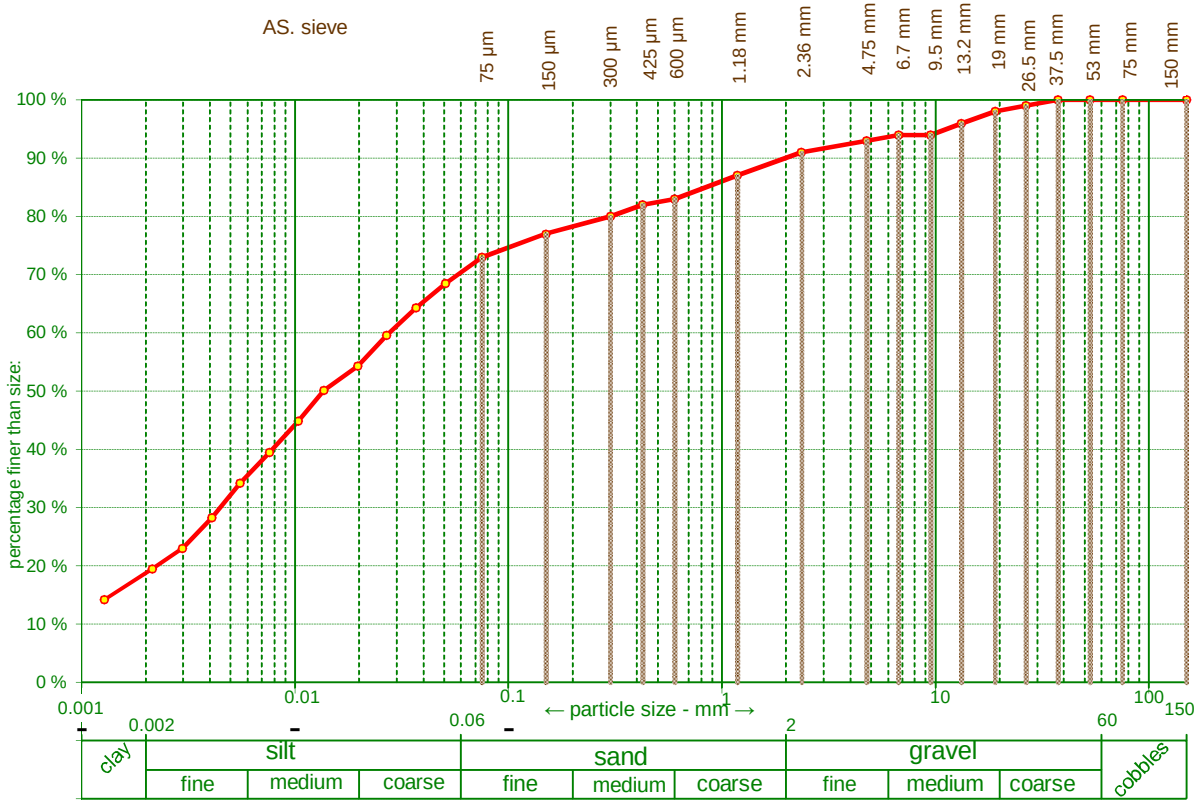
PARTICLE SIZE DISTRIBUTION & HYDROMETER

Client:	Coffey Corporate Services Pty Ltd (Wollongong)	Job No:	INFOABTM00688AA
Principal:		Laboratory:	Abbotsford
Project:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility	Report Date	21-Jul-16
Location:		Test report No:	PSDH:ABTM16S-03259
Test procedure:	AS1289.3.6.1, 3.6.3	Client ref:	
Sample No:	ABTM16S-03259		
Sample Identification	TP2 (4.0-5.0m)		



Sieve Analysis		Hydrometer Analysis	
Sieve Size	% Passing	Particle Size	% Passing
75 mm	100	50.6 µm	68
53 mm	100	36.9 µm	64
37.5 mm	100	26.9 µm	60
26.5 mm	99	19.7 µm	54
19 mm	98	13.6 µm	50
13.2 mm	96	10.3 µm	45
9.5 mm	94	7.6 µm	40
6.7 mm	94	5.5 µm	34
4.75 mm	93	4.1 µm	28
2.36 mm	91	3 µm	23
1.18 mm	87	2.1 µm	19
600 µm	83	1.3 µm	14
425 µm	82		
300 µm	80		
150 µm	77		
75 µm	73		

Comments

NOTES:

Loss of mass in pretreatment:	No pretreatment.
Dispersion method:	Sodium hexametaphosphate and Sodium carbonate
Type of hydrometer:	ASTM 152H
Soil Particle density(assumed):	2.65 g/cm3
Preparation method	Wet analysis

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NATA Accredited Laboratory No. 431 Date: 21/07/2016
Approved Signatory: Gayani Samaradiwakara

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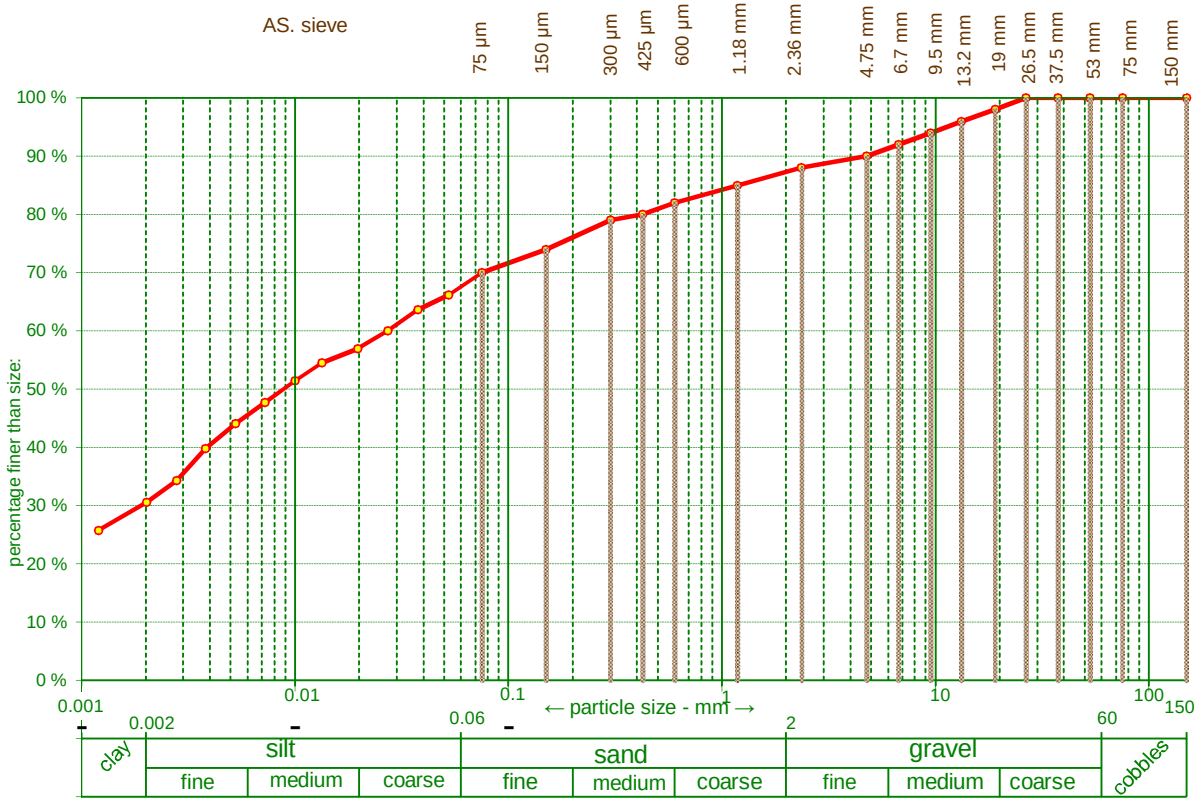
PARTICLE SIZE DISTRIBUTION & HYDROMETER

Client:	Coffey Corporate Services Pty Ltd (Wollongong)	Job No:	INFOABTM00688AA
Principal:		Laboratory:	Abbotsford
Project:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility	Report Date	20-Jul-16
Location:		Test report No:	PSDH:ABTM16S-03260
Test procedure:	AS1289.3.6.1, 3.6.3	Client ref:	
Sample No:	ABTM16S-03260		
Sample Identification	TP3 (3.0-4.0m)		



Sieve Analysis		Hydrometer Analysis	
Sieve Size	% Passing	Particle Size	% Passing
75 mm	100	52.3 µm	66
53 mm	100	37.6 µm	64
37.5 mm	100	27.3 µm	60
26.5 mm	100	19.7 µm	57
19 mm	98	13.4 µm	54
13.2 mm	96	10 µm	51
9.5 mm	94	7.3 µm	48
6.7 mm	92	5.3 µm	44
4.75 mm	90	3.8 µm	40
2.36 mm	88	2.8 µm	34
1.18 mm	85	2 µm	31
600 µm	82	1.2 µm	26
425 µm	80		
300 µm	79		
150 µm	74		
75 µm	70		

Comments

NOTES:

Loss of mass in pretreatment:	No pretreatment.
Dispersion method:	Sodium hexametaphosphate and Sodium carbonate
Type of hydrometer:	ASTM 152H
Soil Particle density(assumed):	2.65 g/cm3
Preparation method	Wet analysis

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NATA Accredited Laboratory No. 431 Date: 20/07/2016
Approved Signatory: Gayani Samaradiwakara

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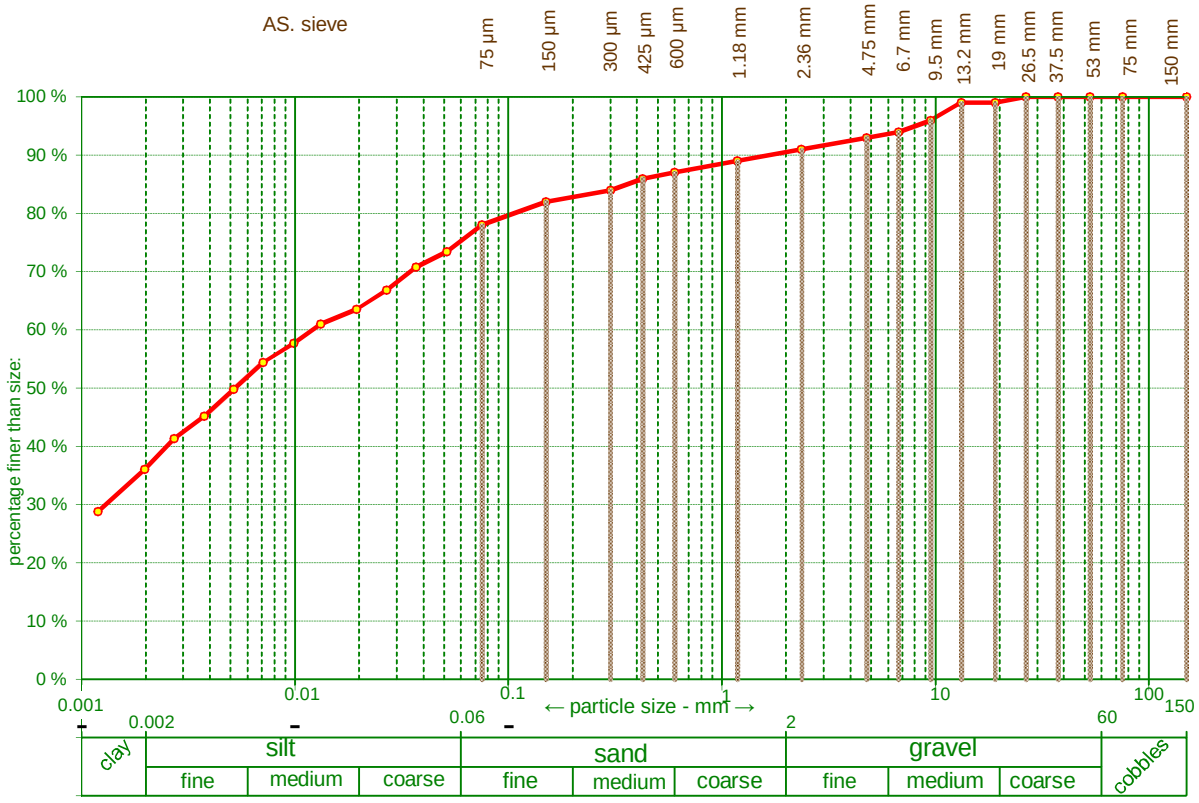
PARTICLE SIZE DISTRIBUTION & HYDROMETER

Client:	Coffey Corporate Services Pty Ltd (Wollongong)	Job No:	INFOABTM00688AA
Principal:		Laboratory:	Abbotsford
Project:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility	Report Date	20-Jul-16
Location:		Test report No:	PSDH:ABTM16S-03261
Test procedure:	AS1289.3.6.1, 3.6.3	Client ref:	
Sample No:	ABTM16S-03261		
Sample Identification	TP4 (2.0-3.0m)		



Sieve Analysis		Hydrometer Analysis	
Sieve Size	% Passing	Particle Size	% Passing
75 mm	100	51.5 µm	73
53 mm	100	37 µm	71
37.5 mm	100	26.8 µm	67
26.5 mm	100	19.4 µm	64
19 mm	99	13.2 µm	61
13.2 mm	99	9.8 µm	58
9.5 mm	96	7.1 µm	54
6.7 mm	94	5.2 µm	50
4.75 mm	93	3.8 µm	45
2.36 mm	91	2.7 µm	41
1.18 mm	89	2 µm	36
600 µm	87	1.2 µm	29
425 µm	86		
300 µm	84		
150 µm	82		
75 µm	78		

Comments

NOTES:

Loss of mass in pretreatment:	No pretreatment.
Dispersion method:	Sodium hexametaphosphate and Sodium carbonate
Type of hydrometer:	ASTM 152H
Soil Particle density(assumed):	2.65 g/cm3
Preparation method	Wet analysis

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NATA Accredited Laboratory No. 431 Date: 20/07/2016
Approved Signatory: Gayani Samaradiwakara

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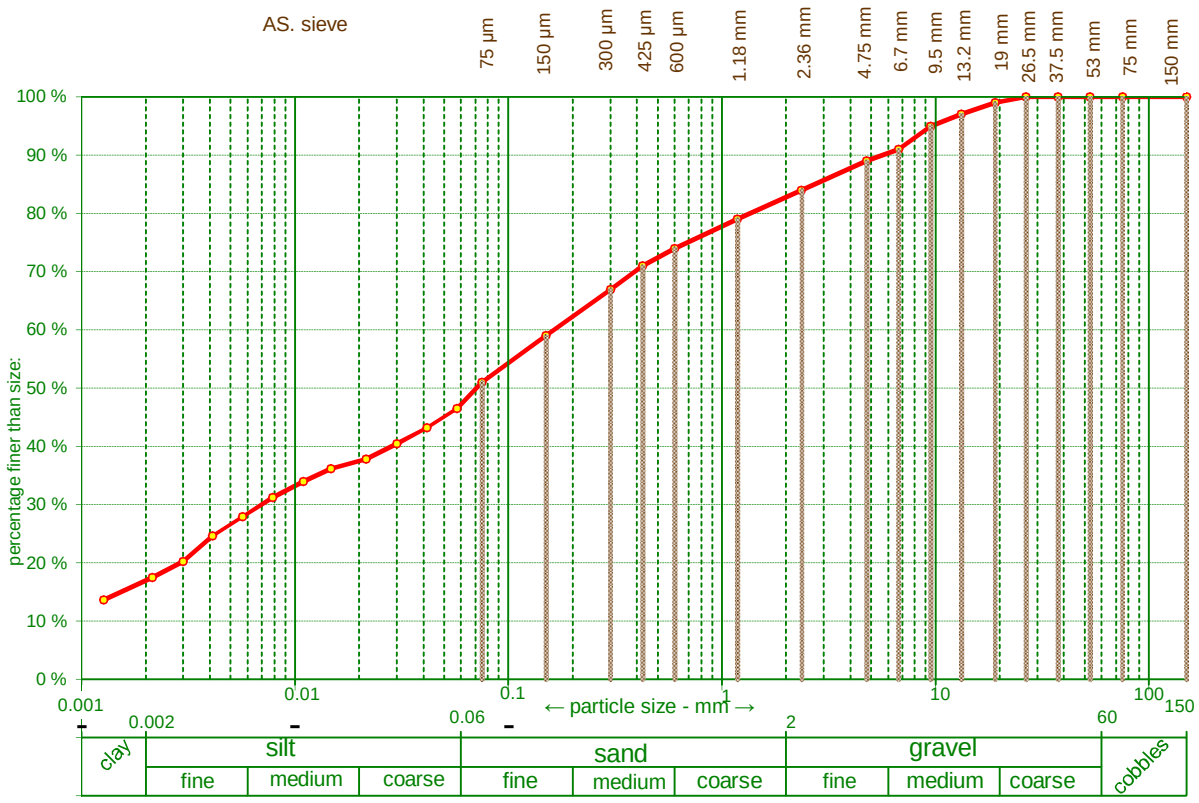
PARTICLE SIZE DISTRIBUTION & HYDROMETER

Client:	Coffey Corporate Services Pty Ltd (Wollongong)	Job No:	INFOABTM00688AA
Principal:		Laboratory:	Abbotsford
Project:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility	Report Date	21-Jul-16
Location:		Test report No:	PSDH:ABTM16S-03262
Test procedure:	AS1289.3.6.1, 3.6.3	Client ref:	
Sample No:	ABTM16S-03262		
Sample Identification	TP5 (2.0-3.0m)		



Sieve Analysis		Hydrometer Analysis	
Sieve Size	% Passing	Particle Size	% Passing
75 mm	100	57.4 µm	47
53 mm	100	41.5 µm	43
37.5 mm	100	29.9 µm	41
26.5 mm	100	21.5 µm	38
19 mm	99	14.7 µm	36
13.2 mm	97	10.9 µm	34
9.5 mm	95	7.9 µm	31
6.7 mm	91	5.7 µm	28
4.75 mm	89	4.1 µm	25
2.36 mm	84	3 µm	20
1.18 mm	79	2.2 µm	18
600 µm	74	1.3 µm	14
425 µm	71		
300 µm	67		
150 µm	59		
75 µm	51		

Comments

NOTES:

Loss of mass in pretreatment:	No pretreatment.
Dispersion method:	Sodium hexametaphosphate and Sodium carbonate
Type of hydrometer:	ASTM 152H
Soil Particle density(assumed):	2.65 g/cm3
Preparation method	Wet analysis

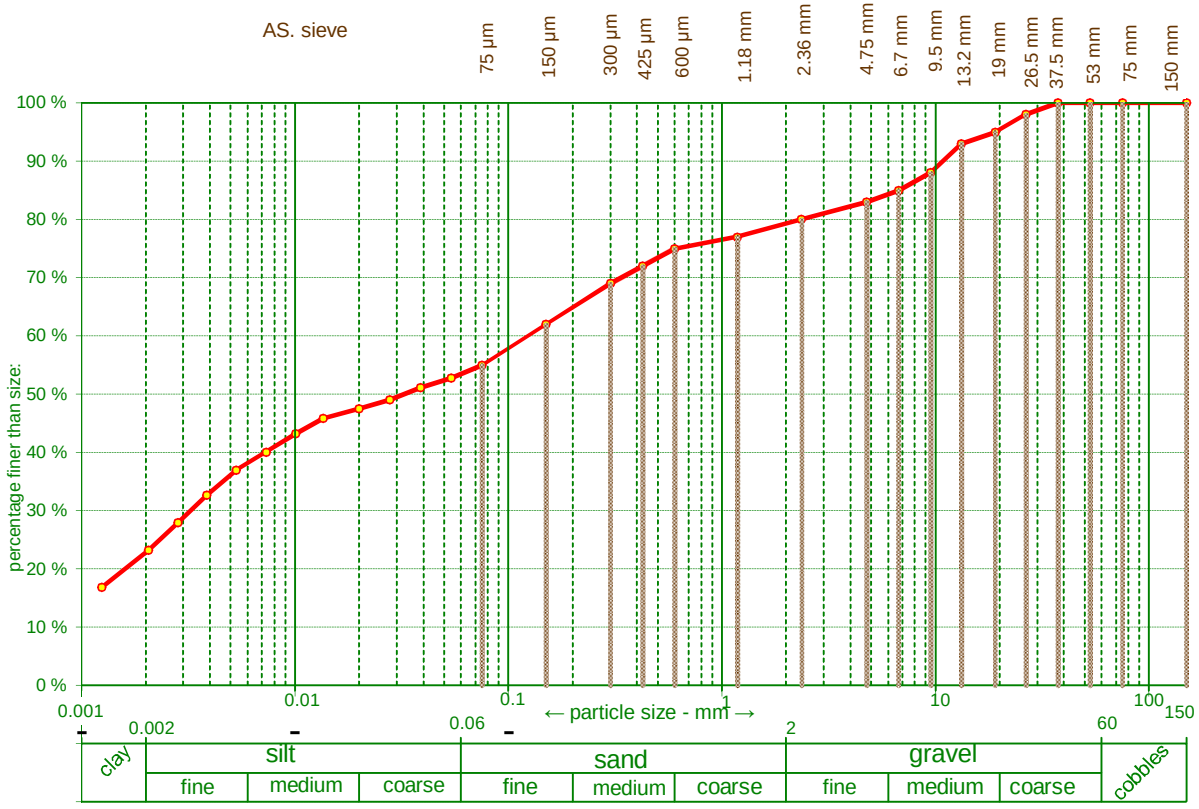
J:\+Testing\Test Reports-Specialized testing\Hydrometer Analysis\2016\INFOABTM00688AA\[PSD+Hydro_ABTM16S-03262.xls]Calculations

NATA Accredited Laboratory No. 431 Date: 21/07/2016
Approved Signatory: Gayani Samaradiwakara

Abbotsford, Melbourne Laboratory, Coffey Testing Pty Ltd
ABN 92 114 364 046
3G Marine Parade Abbotsford VIC 3067
Telephone: +61 3 8413 6900 Facsimile: +61 3 8413 6999

PARTICLE SIZE DISTRIBUTION & HYDROMETER

Client:	Coffey Corporate Services Pty Ltd (Wollongong)	Job No:	INFOABTM00688AA
Principal:		Laboratory:	Abbotsford
Project:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility	Report Date	21-Jul-16
Location:		Test report No:	PSDH:ABTM16S-03263
Test procedure:	AS1289.3.6.1, 3.6.3	Client ref:	
Sample No:	ABTM16S-03263		
Sample Identification	TP9 (2.0-3.0m)		



Sieve Analysis		Hydrometer Analysis	
Sieve Size	% Passing	Particle Size	% Passing
75 mm	100	54.1 µm	53
53 mm	100	38.7 µm	51
37.5 mm	100	27.8 µm	49
26.5 mm	98	19.9 µm	47
19 mm	95	13.5 µm	46
13.2 mm	93	10.1 µm	43
9.5 mm	88	7.3 µm	40
6.7 mm	85	5.3 µm	37
4.75 mm	83	3.9 µm	33
2.36 mm	80	2.8 µm	28
1.18 mm	77	2.1 µm	23
600 µm	75	1.2 µm	17
425 µm	72		
300 µm	69		
150 µm	62		
75 µm	55		

Comments

NOTES:

Loss of mass in pretreatment:	No pretreatment.
Dispersion method:	Sodium hexametaphosphate and Sodium carbonate
Type of hydrometer:	ASTM 152H
Soil Particle density(assumed):	2.65 g/cm3
Preparation method	Wet analysis

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NATA Accredited Laboratory No. 431 Date: 21/07/2016
Approved Signatory: Gayani Samaradiwakara

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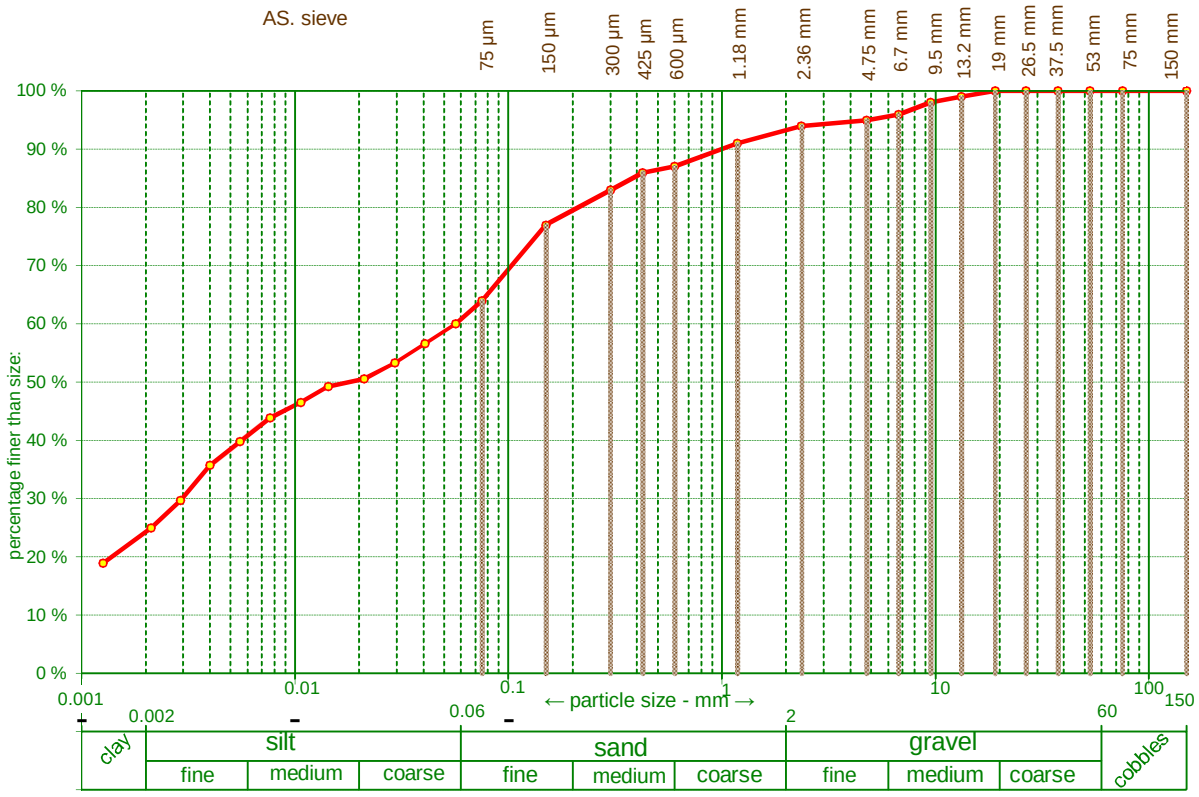
PARTICLE SIZE DISTRIBUTION & HYDROMETER

Client:	Coffey Corporate Services Pty Ltd (Wollongong)	Job No:	INFOABTM00688AA
Principal:		Laboratory:	Abbotsford
Project:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility	Report Date	21-Jul-16
Location:		Test report No:	PSDH:ABTM16S-03264
Test procedure:	AS1289.3.6.1, 3.6.3	Client ref:	
Sample No:	ABTM16S-03264		
Sample Identification	TP10 (1.0-1.5m)		



Sieve Analysis		Hydrometer Analysis	
Sieve Size	% Passing	Particle Size	% Passing
75 mm	100	56.5 µm	60
53 mm	100	40.7 µm	57
37.5 mm	100	29.4 µm	53
26.5 mm	100	21.1 µm	51
19 mm	100	14.3 µm	49
13.2 mm	99	10.6 µm	47
9.5 mm	98	7.6 µm	44
6.7 mm	96	5.5 µm	40
4.75 mm	95	4 µm	36
2.36 mm	94	2.9 µm	30
1.18 mm	91	2.1 µm	25
600 µm	87	1.3 µm	19
425 µm	86		
300 µm	83		
150 µm	77		
75 µm	64		

Comments

NOTES:

Loss of mass in pretreatment:	No pretreatment.
Dispersion method:	Sodium hexametaphosphate and Sodium carbonate
Type of hydrometer:	ASTM 152H
Soil Particle density(assumed):	2.65 g/cm3
Preparation method	Wet analysis

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NATA Accredited Laboratory No. 431 Date: 21/07/2016
Approved Signatory: Gayani Samaradiwakara

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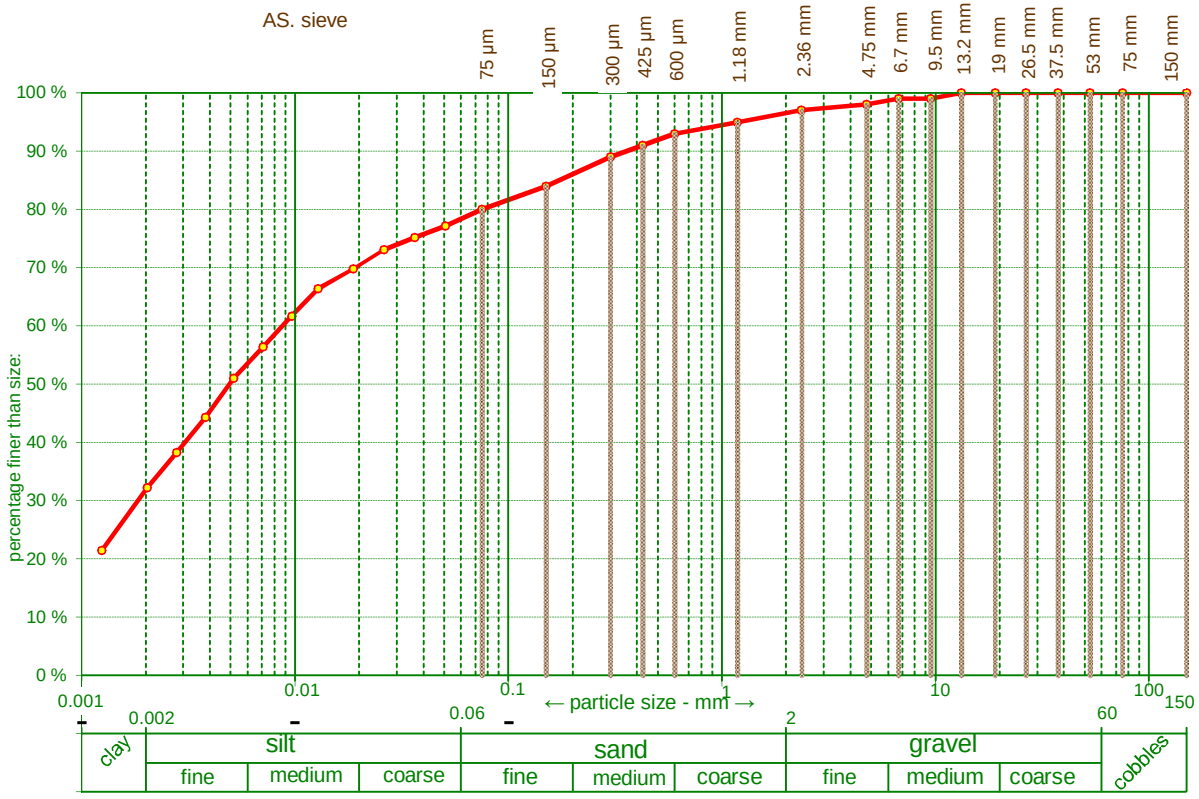
PARTICLE SIZE DISTRIBUTION & HYDROMETER

Client:	Coffey Corporate Services Pty Ltd (Wollongong)	Job No:	INFOABTM00688AA
Principal:		Laboratory:	Abbotsford
Project:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility	Report Date	21-Jul-16
Location:		Test report No:	PSDH:ABTM16S-03265
Test procedure:	AS1289.3.6.1, 3.6.3	Client ref:	
Sample No:	ABTM16S-03265		
Sample Identification	TP8 (3.0-4.0m)		



Sieve Analysis		Hydrometer Analysis	
Sieve Size	% Passing	Particle Size	% Passing
75 mm	100	50.8 µm	77
53 mm	100	36.4 µm	75
37.5 mm	100	26.1 µm	73
26.5 mm	100	18.8 µm	70
19 mm	100	12.8 µm	66
13.2 mm	100	9.7 µm	62
9.5 mm	99	7.1 µm	56
6.7 mm	99	5.2 µm	51
4.75 mm	98	3.8 µm	44
2.36 mm	97	2.8 µm	38
1.18 mm	95	2 µm	32
600 µm	93	1.2 µm	21
425 µm	91		
300 µm	89		
150 µm	84		
75 µm	80		

Comments

NOTES:

Loss of mass in pretreatment:	No pretreatment.
Dispersion method:	Sodium hexametaphosphate and Sodium carbonate
Type of hydrometer:	ASTM 152H
Soil Particle density(assumed):	2.65 g/cm3
Preparation method	Wet analysis

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NATA Accredited Laboratory No. 431 Date: 21/07/2016
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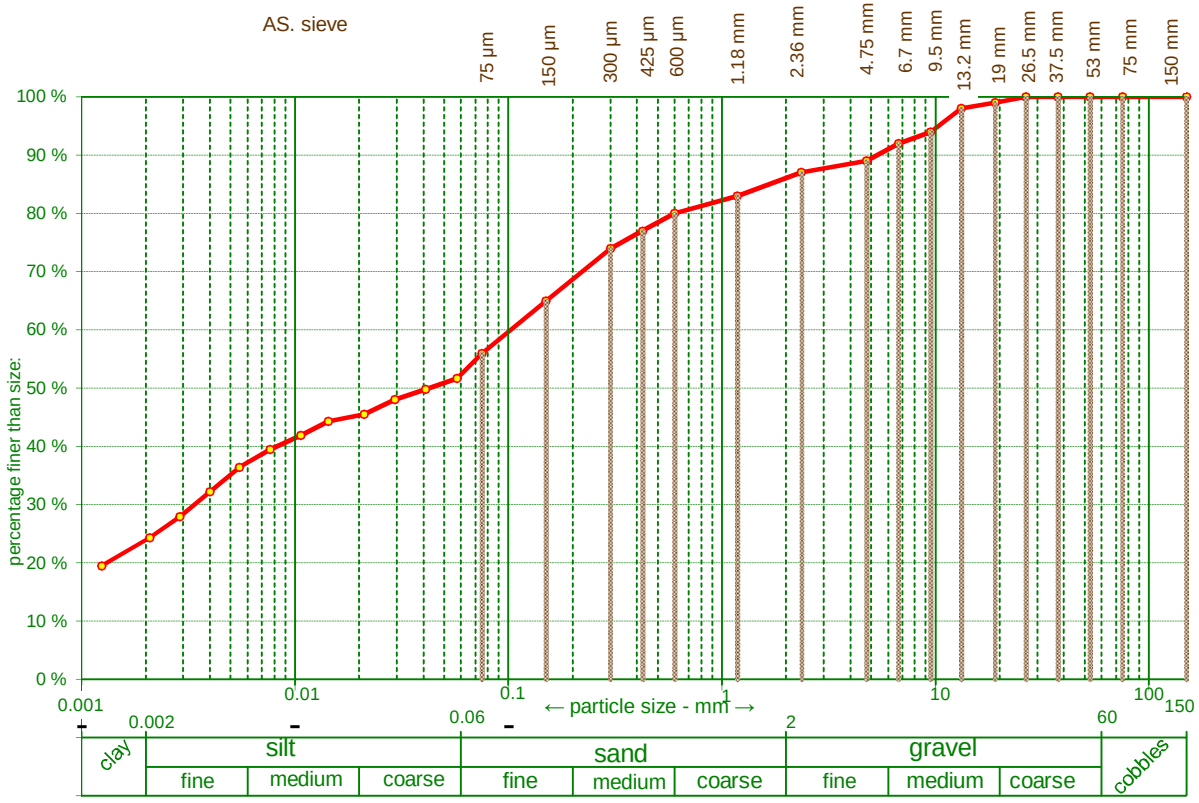
PARTICLE SIZE DISTRIBUTION & HYDROMETER

Client:	Coffey Corporate Services Pty Ltd (Wollongong)	Job No:	INFOABTM00688AA
Principal:		Laboratory:	Abbotsford
Project:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility	Report Date	21-Jul-16
Location:		Test report No:	PSDH:ABTM16S-03266
Test procedure:	AS1289.3.6.1, 3.6.3	Client ref:	
Sample No:	ABTM16S-03266		
Sample Identification	TP5 (1.0-2.0m)		



Sieve Analysis		Hydrometer Analysis	
Sieve Size	% Passing	Particle Size	% Passing
75 mm	100	57.4 µm	52
53 mm	100	41.1 µm	50
37.5 mm	100	29.4 µm	48
26.5 mm	100	21.1 µm	46
19 mm	99	14.3 µm	44
13.2 mm	98	10.6 µm	42
9.5 mm	94	7.6 µm	39
6.7 mm	92	5.5 µm	36
4.75 mm	89	4 µm	32
2.36 mm	87	2.9 µm	28
1.18 mm	83	2.1 µm	24
600 µm	80	1.2 µm	19
425 µm	77		
300 µm	74		
150 µm	65		
75 µm	56		

Comments

NOTES:

Loss of mass in pretreatment:	No pretreatment.
Dispersion method:	Sodium hexametaphosphate and Sodium carbonate
Type of hydrometer:	ASTM 152H
Soil Particle density(assumed):	2.65 g/cm3
Preparation method	Wet analysis

J:\+Testing\Test Reports-Specialized testing\Hydrometer Analysis\2016\INFOABTM00688AA\[PSD+Hydro_ABTM16S-03266.xls]Calculations

NATA Accredited Laboratory No. 431 Date: 21/07/2016
Approved Signatory: Gayani Samaradiwakara

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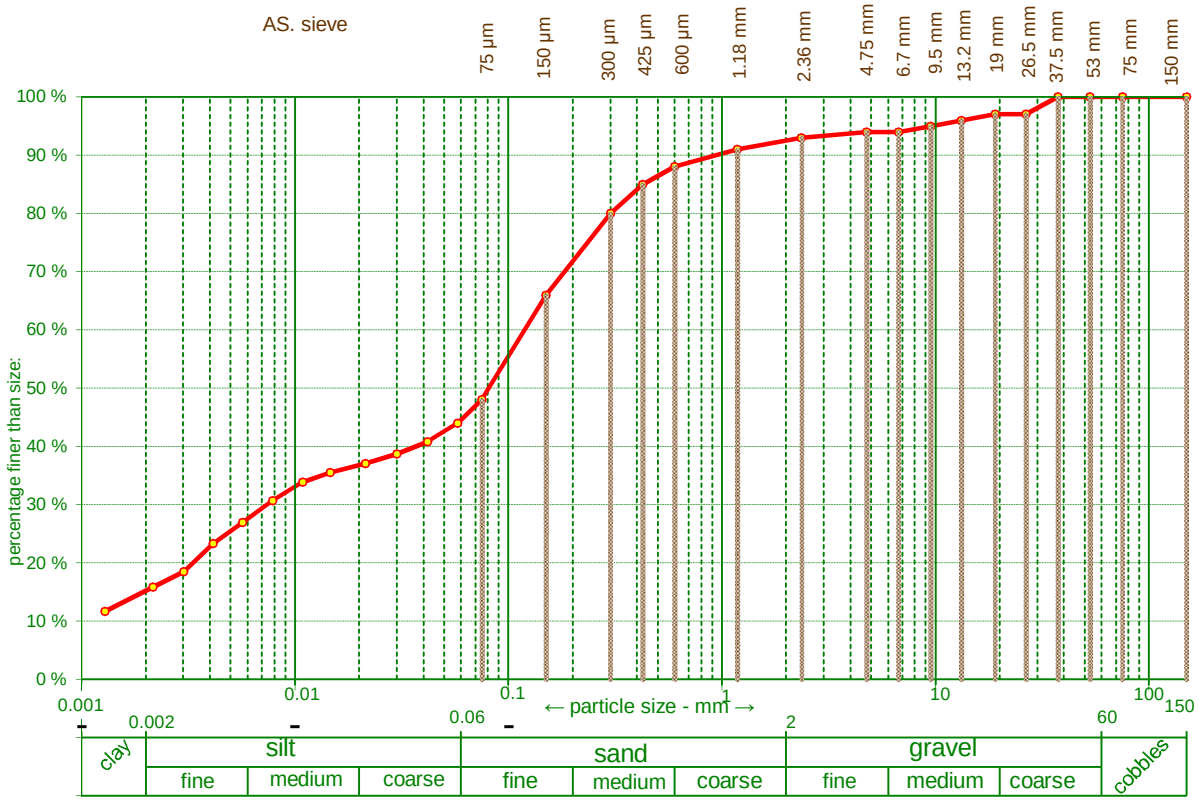
PARTICLE SIZE DISTRIBUTION & HYDROMETER

Client:	Coffey Corporate Services Pty Ltd (Wollongong)	Job No:	INFOABTM00688AA
Principal:		Laboratory:	Abbotsford
Project:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility	Report Date	21-Jul-16
Location:		Test report No:	PSDH:ABTM16S-03267
Test procedure:	AS1289.3.6.1, 3.6.3	Client ref:	
Sample No:	ABTM16S-03267		
Sample Identification	TP7 (2.0-3.0m)		



Sieve Analysis		Hydrometer Analysis	
Sieve Size	% Passing	Particle Size	% Passing
75 mm	100	57.8 µm	44
53 mm	100	41.8 µm	41
37.5 mm	100	30 µm	39
26.5 mm	97	21.5 µm	37
19 mm	97	14.7 µm	35
13.2 mm	96	10.8 µm	34
9.5 mm	95	7.8 µm	31
6.7 mm	94	5.7 µm	27
4.75 mm	94	4.1 µm	23
2.36 mm	93	3 µm	19
1.18 mm	91	2.2 µm	16
600 µm	88	1.3 µm	12
425 µm	85		
300 µm	80		
150 µm	66		
75 µm	48		

Comments

NOTES:

Loss of mass in pretreatment:	No pretreatment.
Dispersion method:	Sodium hexametaphosphate and Sodium carbonate
Type of hydrometer:	ASTM 152H
Soil Particle density(assumed):	2.65 g/cm3
Preparation method	Wet analysis

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NATA Accredited Laboratory No. 431 Date: 21/07/2016
Approved Signatory: Gayani Samaradiwakara

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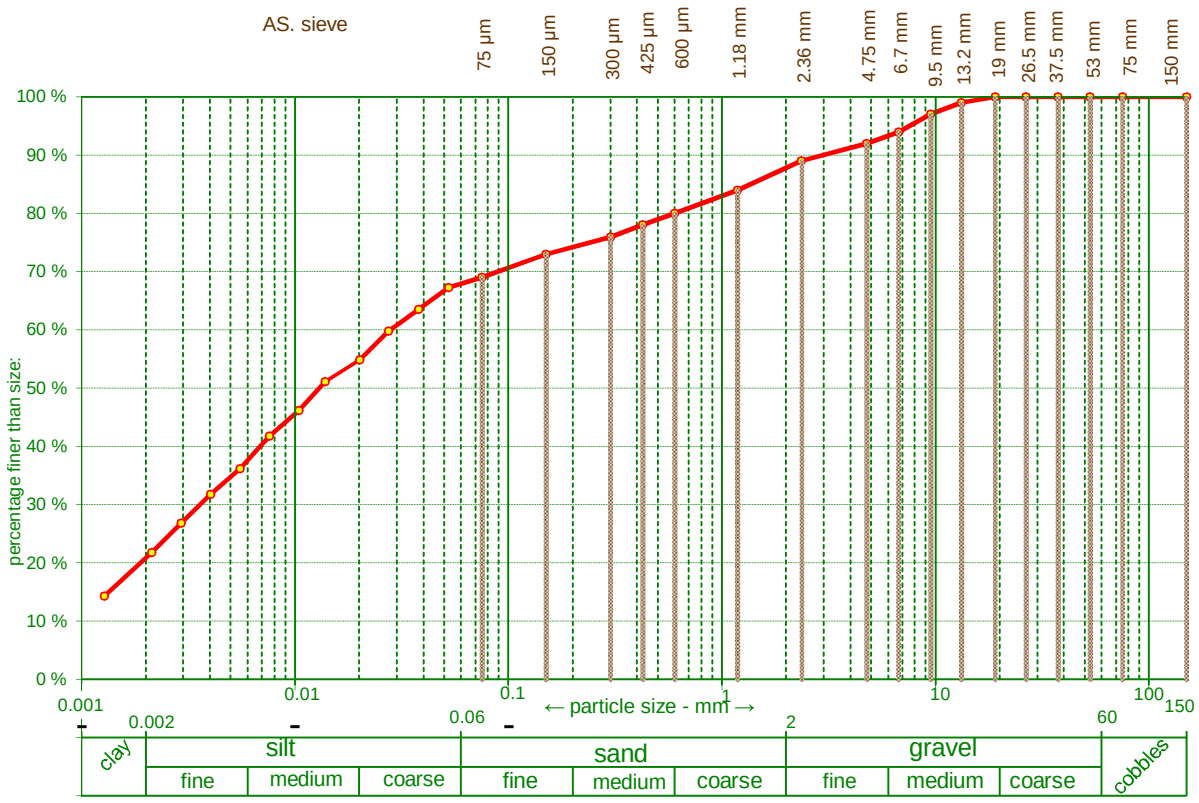
PARTICLE SIZE DISTRIBUTION & HYDROMETER

Client:	Coffey Corporate Services Pty Ltd (Wollongong)	Job No:	INFOABTM00688AA
Principal:		Laboratory:	Abbotsford
Project:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility	Report Date	19-Jul-16
Location:		Test report No:	PSDH:ABTM16S-03270
Test procedure:	AS1289.3.6.1, 3.6.3	Client ref:	
Sample No:	ABTM16S-03270		
Sample Identification	TP3 (2.0-3.0m)		



Sieve Analysis		Hydrometer Analysis	
Sieve Size	% Passing	Particle Size	% Passing
75 mm	100	52.3 µm	67
53 mm	100	37.9 µm	64
37.5 mm	100	27.5 µm	60
26.5 mm	100	20.1 µm	55
19 mm	100	13.8 µm	51
13.2 mm	99	10.4 µm	46
9.5 mm	97	7.6 µm	42
6.7 mm	94	5.5 µm	36
4.75 mm	92	4 µm	32
2.36 mm	89	2.9 µm	27
1.18 mm	84	2.1 µm	22
600 µm	80	1.3 µm	14
425 µm	78		
300 µm	76		
150 µm	73		
75 µm	69		

Comments

NOTES:

Loss of mass in pretreatment:	No pretreatment.
Dispersion method:	Sodium hexametaphosphate and Sodium carbonate
Type of hydrometer:	ASTM 152H
Soil Particle density(assumed):	2.65 g/cm3
Preparation method	Wet analysis

J:\+Testing\Test Reports-Specialized testing\Hydrometer Analysis\2016\INFOABTM00688AA\[PSD+Hydro_ABTM16S-03270.xls]Calculations

NATA Accredited Laboratory No. 431 Date: 19/07/2016
Approved Signatory: Gayani Samaradiwakara

Artarmon, Sydney Laboratory

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coffey
A TETRA TECH COMPANY

Maximum Dry Density Report

Report No: MDD:ARTA16S-00271
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	
Project No.:	INFOARTA01469AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

NATA
WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025.

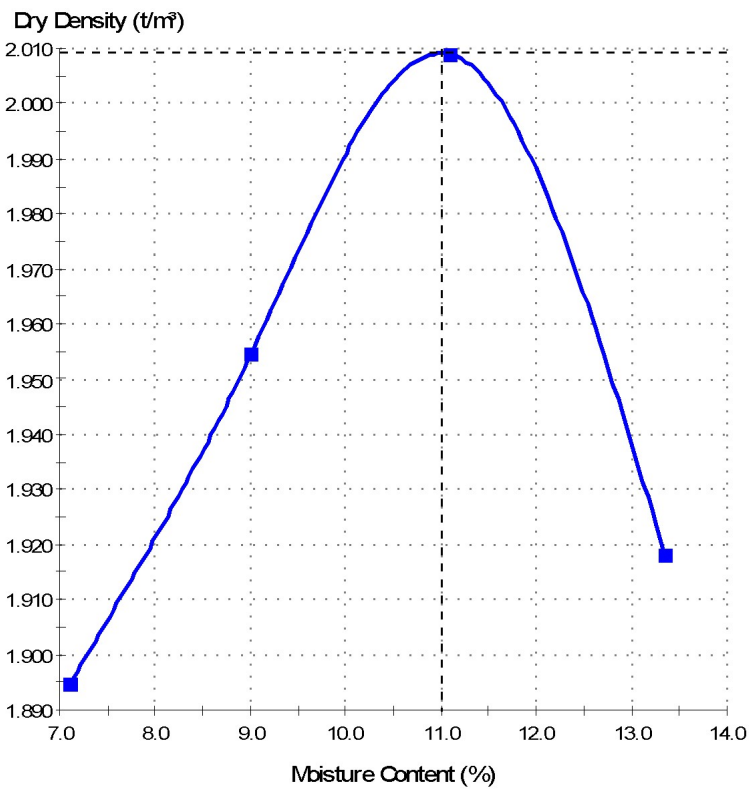
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Garry Collins
(Specialised Testing Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 14/07/2016

Sample Details

Sample ID:	ARTA16S-00271	**Sampling Method:**	Submitted by client
Date Sampled:		**Material:**	Subgrade
Date Submitted:		**Source:**	Ex Job Site
Date Tested:	24/06/2016	**Specification:**	No Specification
Project Location:	West Nowra		
Sample Location:	BH06 (5.50 to 7.00 m)		

Dry Density - Moisture Content Relationship



Test Results

AS 1289.5.1.1

Standard MDD (t/m³):	**2.01**
Standard OMC (%):	**11.0**
Retained Sieve 19.0mm (%):	0

Comments

Abbotsford, Melbourne Laboratory

Coffey Corporate Services Pty Ltd
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Abbotsford VIC 3067

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Report No: MDD:ABTM16S-03258
Issue No: 1

Maximum Dry Density Report

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	
Project No.:	INFOABTM00688AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

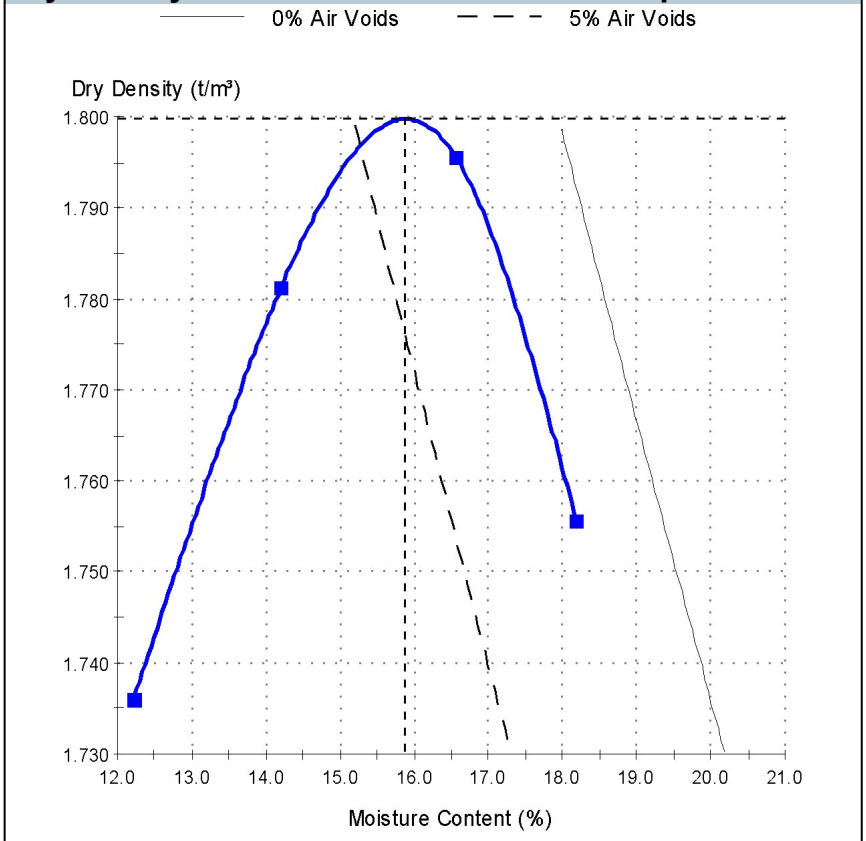
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Ketankumar Patel
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 12/07/2016

Sample Details

Sample ID:	ABTM16S-03258	**Sampling Method:**	Submitted by client
Date Sampled:	1/07/2016	**Material:**	
Date Submitted:	1/07/2016	**Source:**	
Date Tested:	11/07/2016	**Specification:**	No Specification
Project Location:			
Sample Location:	TP1_1.00-2.00m		

Dry Density - Moisture Content Relationship



Test Results

AS 1289.5.1.1

Standard MDD (t/m³): **1.80**
Standard OMC (%): **16.0**
Retained Sieve 19mm (%): 2

Comments

Abbotsford, Melbourne Laboratory

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Report No: MDD:ABTM16S-03259
Issue No: 1

Maximum Dry Density Report

Client: Coffey Corporate Services Pty Ltd (Wollongong)
118 Auburn Street
Wollongong NSW 2500

Principal:
Project No.: INFOABTM00688AA
Project Name: GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.: **TRN:**

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The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

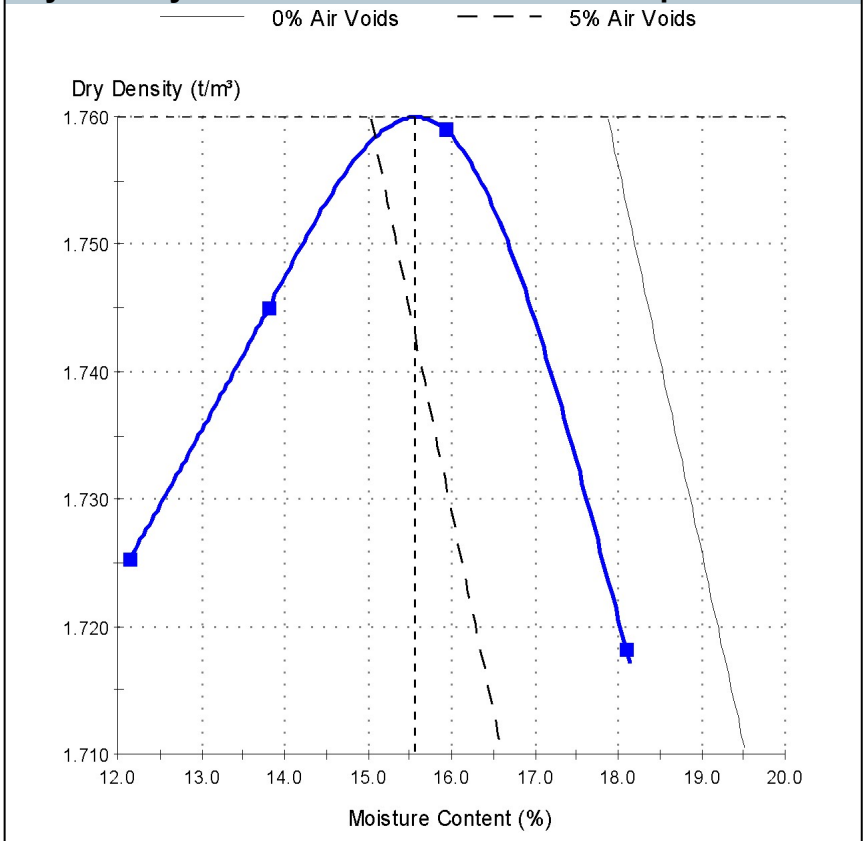
Approved Signatory: Ketankumar Patel
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 12/07/2016

Sample Details

Sample ID: ABTM16S-03259
Date Sampled: 1/07/2016
Date Submitted: 1/07/2016
Date Tested: 11/07/2016
Project Location:
Sample Location: TP2_4.00-5.00m

Sampling Method: Submitted by client
Material:
Source:
Specification: No Specification

Dry Density - Moisture Content Relationship



Test Results

AS 1289.5.1.1

Standard MDD (t/m³): **1.76**
Standard OMC (%): **15.5**
Retained Sieve 19mm (%): 2

Comments

Abbotsford, Melbourne Laboratory

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Maximum Dry Density Report

Report No: MDD:ABTM16S-03260
Issue No: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	
Project No.:	INFOABTM00688AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

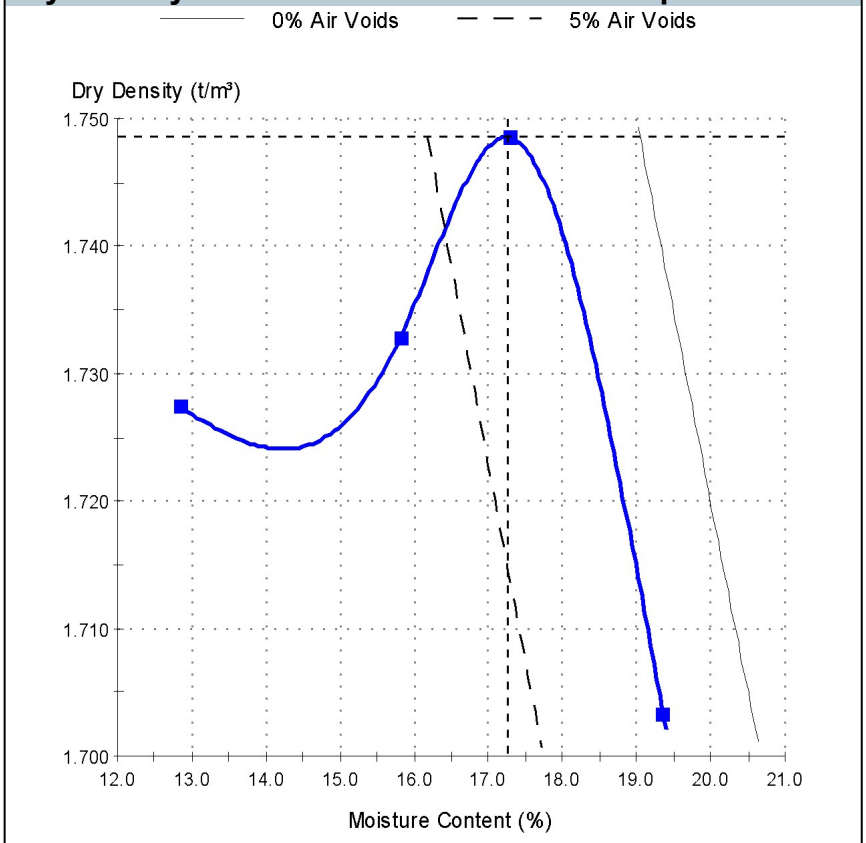
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Ketankumar Patel
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 12/07/2016

Sample Details

Sample ID:	ABTM16S-03260	**Sampling Method:**	Submitted by client
Date Sampled:	1/07/2016	**Material:**	
Date Submitted:	1/07/2016	**Source:**	
Date Tested:	11/07/2016	**Specification:**	No Specification
Project Location:			
Sample Location:	TP3_3.00-4.00m		

Dry Density - Moisture Content Relationship



Test Results

AS 1289.5.1.1

Standard MDD (t/m³):	**1.75**
Standard OMC (%):	**17.0**
Retained Sieve 19mm (%):	1

Comments

Abbotsford, Melbourne Laboratory

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Report No: MDD:ABTM16S-03261
Issue No: 1

Maximum Dry Density Report

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	
Project No.:	INFOABTM00688AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

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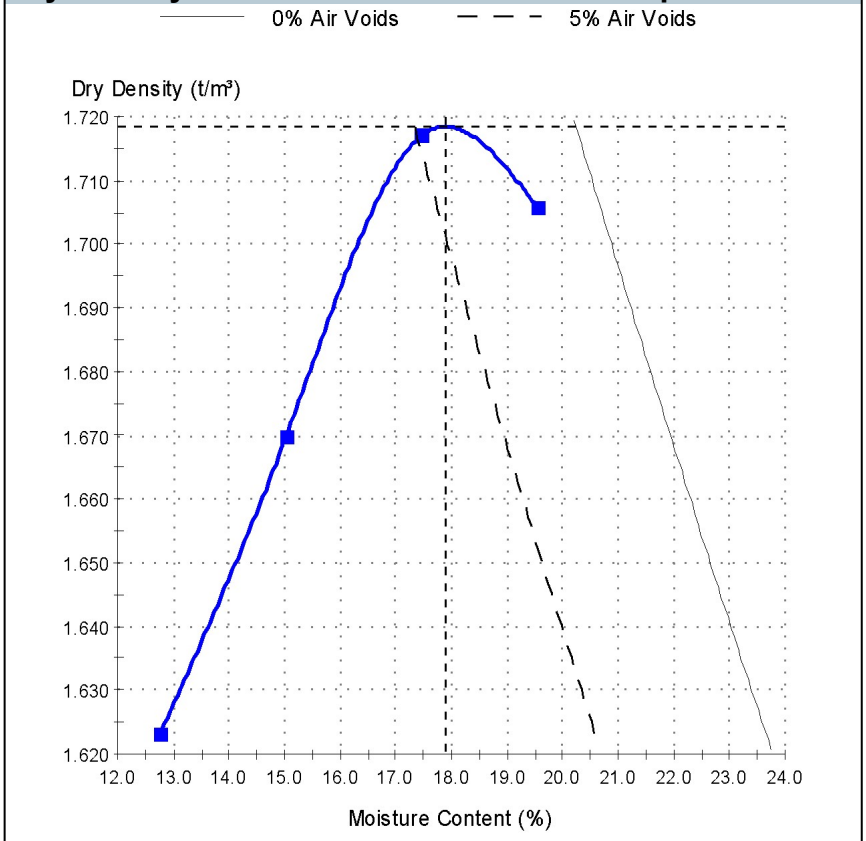
Approved Signatory: Ketankumar Patel
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 12/07/2016

Sample Details

Sample ID:	ABTM16S-03261	**Sampling Method:**	Submitted by client
Date Sampled:	1/07/2016	**Material:**	
Date Submitted:	1/07/2016	**Source:**	
Date Tested:	11/07/2016	**Specification:**	No Specification
Project Location:			
Sample Location:	TP4 (2.00-3.00m		

Dry Density - Moisture Content Relationship



Test Results

AS 1289.5.1.1

Standard MDD (t/m³):	**1.72**
Standard OMC (%):	**18.0**
Retained Sieve 19mm (%):	1

Comments

Abbotsford, Melbourne Laboratory

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Report No: MDD:ABTM16S-03262
Issue No: 1

Maximum Dry Density Report

Client: Coffey Corporate Services Pty Ltd (Wollongong)
118 Auburn Street
Wollongong NSW 2500

Principal:
Project No.: INFOABTM00688AA
Project Name: GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.: **TRN:**

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The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

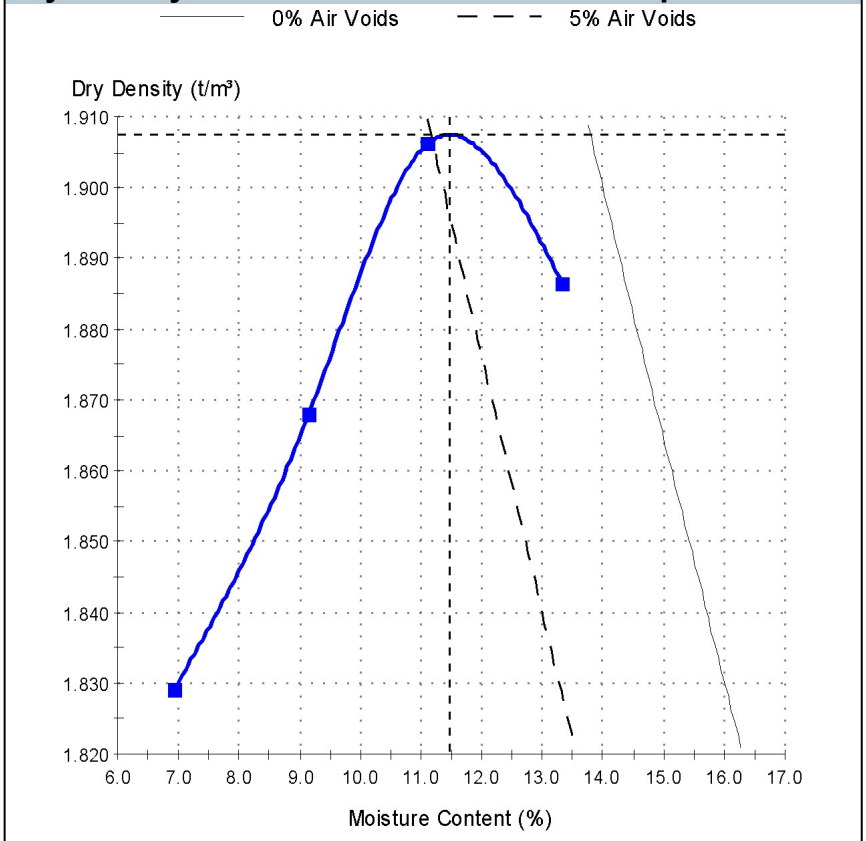
Approved Signatory: Ketankumar Patel
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 12/07/2016

Sample Details

Sample ID: ABTM16S-03262
Date Sampled: 1/07/2016
Date Submitted: 1/07/2016
Date Tested: 11/07/2016
Project Location:
Sample Location: TP5 (2.0-3.0m)

Sampling Method: Submitted by client
Material:
Source:
Specification: No Specification

Dry Density - Moisture Content Relationship



Test Results

AS 1289.5.1.1

Standard MDD (t/m³): **1.91**
Standard OMC (%): **11.5**
Retained Sieve 19mm (%): 1

Comments

Abbotsford, Melbourne Laboratory

Coffey Corporate Services Pty Ltd
ABN 55 139 460 521
3G Marine Parade
Abbotsford VIC 3067

Phone: +61 3 8413 6900
Fax: +61 3 8413 6999

Report No: MDD:ABTM16S-03263
Issue No: 1

Maximum Dry Density Report

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	
Project No.:	INFOABTM00688AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

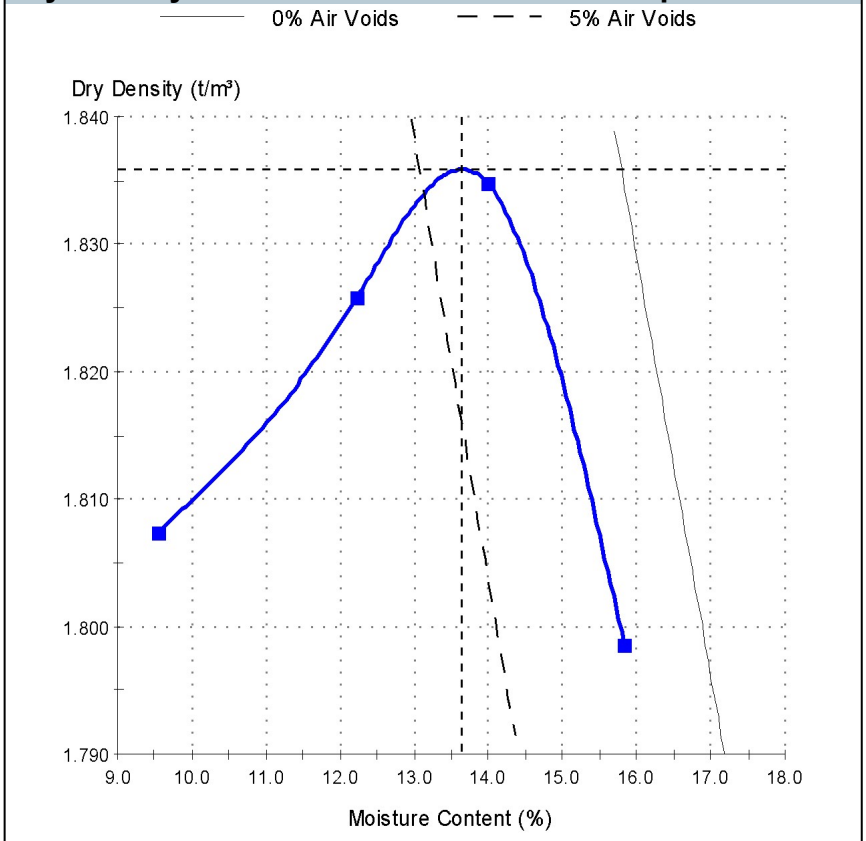
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Ketankumar Patel
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 12/07/2016

Sample Details

Sample ID:	ABTM16S-03263	**Sampling Method:**	Submitted by client
Date Sampled:	1/07/2016	**Material:**	
Date Submitted:	1/07/2016	**Source:**	
Date Tested:	11/07/2016	**Specification:**	No Specification
Project Location:			
Sample Location:	TP9 (2.0-3.0m)		

Dry Density - Moisture Content Relationship



Test Results

AS 1289.5.1.1

Standard MDD (t/m³): **1.84**
Standard OMC (%): **13.5**
Retained Sieve 19mm (%): 5

Comments

Abbotsford, Melbourne Laboratory

Coffey Corporate Services Pty Ltd
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Abbotsford VIC 3067

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Report No: MDD:ABTM16S-03264
Issue No: 1

Maximum Dry Density Report

Client:	Coffey Corporate Services Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	
Project No.:	INFOABTM00688AA
Project Name:	GEOTWOLL03957AA - West Nowra Recycling and Waste Facility
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

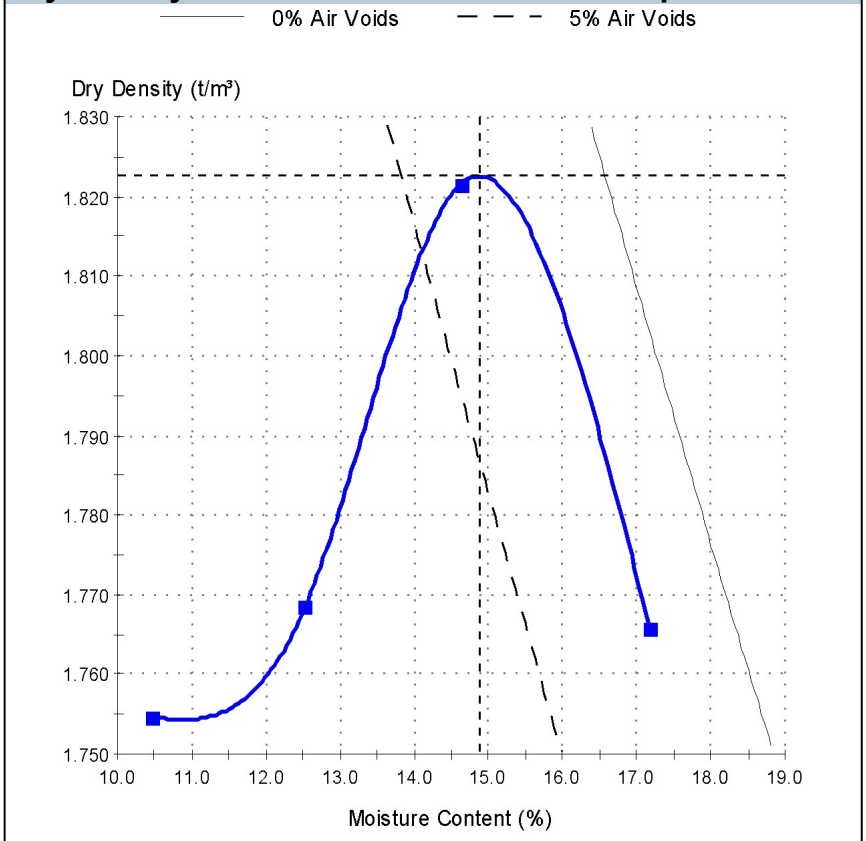
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Ketankumar Patel
(Senior Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 12/07/2016

Sample Details

Sample ID:	ABTM16S-03264	**Sampling Method:**	Submitted by client
Date Sampled:	1/07/2016	**Material:**	
Date Submitted:	1/07/2016	**Source:**	
Date Tested:	11/07/2016	**Specification:**	No Specification
Project Location:			
Sample Location:	TP10 (1.0- 1.5m)		

Dry Density - Moisture Content Relationship



Test Results

AS 1289.5.1.1

Standard MDD (t/m³): **1.82**
Standard OMC (%): **15.0**
Retained Sieve 19mm (%): 0

Comments

Artarmon/ Melrose Park Laboratory
Coffey Testing Pty Ltd
31 Hope Street
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Permeability Test Report

(Constant head method using a flexible wall permeameter)

Report No.: IOLT 8739

Issue No.: 1

Client:	COFFEY GEOTECHNICS PTY LTD
Principal:	
Project:	GEOTWOLL03957AA - WEST NOWRA LANDFILL EXTENSION
Location:	WEST NOWRA, NSW
Job No:	INFOARTA01460AA

Approved Signatory: Garry K Collins
(Specialty Testing Manager, Sydney)
NATA Accredited Laboratory Number: 431
Date of Issue: 13/07/2016

Sample Details

Test Procedure:	AS1289.6.7.3
Sample ID:	ARTA16S-00270
Client sample ID:	**BH04 (5.50 to 7.00 m)**
Date Sampled:	-
Sample type:	Recompacted to Standard Maximum Dry Density and at +2% to 3% of Standard Optimum Moisture Content.
Material:	(CL/CI) SANDY SILTY CLAY - low to medium plasticity, yellow brown, fine to coarse sand.
Sample Location:	BH04 (5.50 to 7.00 m)

Test conditions

Cell pressure	**kPa**	925
Inlet pressure	**kPa**	900
Outlet pressure	**kPa**	890
Mean effective stress	**kPa**	30
Applied Pressure	**kPa**	10
Permeant used		**Distilled Water**

Test Results

Specimen height	**mm**	125.5
Specimen Diameter	**mm**	63.6
height to diameter ratio		1.97
Recompacted Specimen wet density	**t/m^3**	2.18
Recompacted Specimen moisture content	**%**	13.0
Recompacted Specimen dry density	**t/m^3**	1.93
Saturation (Bar B Response)	**%**	1.00
Recompacted Specimen moisture content (after test)	**%**	13.6
Coefficient of permeability	**(m/sec)**	**2.0×10^{-09}**

Comments: Standard Maximum Dry Density = 2.01 t/m3; Standard Optimum Moisture Content = 11.0%

Artarmon/ Melrose Park Laboratory
Coffey Testing Pty Ltd
31 Hope Street
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Permeability Test Report

(Constant head method using a flexible wall permeameter)

Report No.: IOLT 8738

Issue No.: 1

Client:	COFFEY GEOTECHNICS PTY LTD
Principal:	
Project:	GEOTWOLL03957AA - WEST NOWRA LANDFILL EXTENSION
Location:	WEST NOWRA, NSW
Job No:	INFOARTA01460AA

Approved Signatory: Garry K Collins
(Specialty Testing Manager, Sydney)
NATA Accredited Laboratory Number: 431
Date of Issue: 13/07/2016

Sample Details

Test Procedure:	AS1289.6.7.3
Sample ID:	ARTA16S-00271
Client sample ID:	**BH06 (5.50 to 7.00 m)**
Date Sampled:	-
Sample type:	Recompacted to Standard Maximum Dry Density and at +2% to 3% of Standard Optimum Moisture Content.
Material:	(CL/CI) SANDY SILTY CLAY - low to medium plasticity, yellow brown, fine to coarse sand.
Sample Location:	BH06 (5.50 to 7.00 m)

Test conditions

Cell pressure	**kPa**	925
Inlet pressure	**kPa**	900
Outlet pressure	**kPa**	890
Mean effective stress	**kPa**	30
Applied Pressure	**kPa**	10
Permeant used		**Distilled Water**

Test Results

Specimen height	**mm**	125.5
Specimen Diameter	**mm**	63.6
height to diameter ratio		1.97
Recompacted Specimen wet density	**t/m^3**	2.18
Recompacted Specimen moisture content	**%**	13.4
Recompacted Specimen dry density	**t/m^3**	1.92
Saturation (Bar B Response)	**%**	1.00
Recompacted Specimen moisture content (after test)	**%**	13.8
Coefficient of permeability	**(m/sec)**	**5.2×10^{-09}**

Comments: Standard Maximum Dry Density = 2.01 t/m3; Standard Optimum Moisture Content = 11.0%

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Permeability Test Report

(Constant head method using a flexible wall permeameter)

Report No.: PERM:ABTM16S-03258

Issue No.: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong)
Principal:	
Job No.:	INFOABTM00688AA
Project:	GEOTWOLO03957AA West Nowra Recycling and Waste Facility
Location:	
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests,calibrations and /or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Gayani Samaradiwakara
(Associate Engineering Technician)
NATA Accredited Laboratory Number: 431
Date of Issue: 21/07/2016

Sample Details

Test Procedure: AS1289.6.7.3
Sample ID: ABTM16S-03258
Client sample ID TP1 (1-2m)
Date Sampled: 28/06/2016
Sample Type Remoulded
Sample Material Sandy silty clay
Sampling Method: Submitted by client

Other Sample Details:

Test conditions

Cell pressure	**kPa**	600
Inlet pressure	**kPa**	520
Outlet pressure	**kPa**	480
Mean effective stress	**kPa**	100
Saturation	**%**	96
Permeant used		De-aired Water

Test Results

Specimen height	**mm**	62.2
Specimen Diameter	**mm**	63.2
height to diameter ratio		0.98
Specimen wet density	**t/m^3**	2.11
Specimen moisture content	**%**	18.8
Specimen dry density	**t/m^3**	1.77
Laboratory density ratio	**%**	99
Laboratory moisture ratio	**%**	102
Coefficient of permeability	**(m/sec)**	**3 x 10 $^{-10}$**

Comments: Remoulded condition: Sample remoulded to target of 100% SMDD and 2% -3% of SOMC. Compaction data provided in report MDD:ABTM16S-03258. SMDD=1.8 t/m3, SOMC=16 % (AS1289.5.1.1)

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Permeability Test Report

(Constant head method using a flexible wall permeameter)

Report No.: PERM:ABTM16S-03259

Issue No.: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong)
Principal:	
Job No.:	INFOABTM00688AA
Project:	GEOTWOLO03957AA West Nowra Recycling and Waste Facility
Location:	
Lot No.:	**TRN:**

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WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025.

The results of the tests,calibrations and /or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Gayani Samaradiwakara
(Associate Engineering Technician)
NATA Accredited Laboratory Number: 431
Date of Issue: 21/07/2016

Sample Details

Test Procedure: AS1289.6.7.3
Sample ID: ABTM16S-03259
Client sample ID TP2 (4-5m)
Date Sampled: 28/06/2016
Sample Type Remoulded
Sample Material Sandy silty clay
Sampling Method: Submitted by client

Other Sample Details:

Test conditions

Cell pressure	**kPa**	600
Inlet pressure	**kPa**	520
Outlet pressure	**kPa**	480
Mean effective stress	**kPa**	100
Saturation	**%**	96
Permeant used		De-aired Water

Test Results

Specimen height	**mm**	61.5
Specimen Diameter	**mm**	63.4
height to diameter ratio		0.97
Specimen wet density	**t/m^3**	2.05
Specimen moisture content	**%**	18.0
Specimen dry density	**t/m^3**	1.74
Laboratory density ratio	**%**	99
Laboratory moisture ratio	**%**	100
Coefficient of permeability	**(m/sec)**	**5 x 10 $^{-10}$**

Comments: Remoulded condition: Sample remoulded to target of 100% SMDD and 2% -3% of SOMC. Compaction data provided in report MDD:ABTM16S-03259. SMDD=1.76 t/m3, SOMC=15.5 % (AS1289.5.1.1)

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Permeability Test Report

(Constant head method using a flexible wall permeameter)

Report No.: PERM:ABTM16S-03260

Issue No.: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong)
Principal:	
Job No.:	INFOABTM00688AA
Project:	GEOTWOLO03957AA West Nowra Recycling and Waste Facility
Location:	
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests,calibrations and /or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Gayani Samaradiwakara
(Associate Engineering Technician)
NATA Accredited Laboratory Number: 431
Date of Issue: 21/07/2016

Sample Details

Test Procedure: AS1289.6.7.3
Sample ID: ABTM16S-03260
Client sample ID TP3 (3-4m)
Date Sampled: 28/06/2016
Sample Type Remoulded
Sample Material Sandy silty clay
Sampling Method: Submitted by client

Other Sample Details:

Test conditions

Cell pressure	**kPa**	600
Inlet pressure	**kPa**	520
Outlet pressure	**kPa**	480
Mean effective stress	**kPa**	100
Saturation	**%**	96
Permeant used		De-aired Water

Test Results

Specimen height	**mm**	62.3
Specimen Diameter	**mm**	63.3
height to diameter ratio		0.98
Specimen wet density	**t/m^3**	2.07
Specimen moisture content	**%**	19.3
Specimen dry density	**t/m^3**	1.73
Laboratory density ratio	**%**	99
Laboratory moisture ratio	**%**	99
Coefficient of permeability	**(m/sec)**	**2 x 10 $^{-10}$**

Comments: Remoulded condition: Sample remoulded to target of 100% SMDD and 2% -3% of SOMC. Compaction data provided in report MDD:ABTM16S-03260. SMDD=1.75 t/m3, SOMC=17 % (AS1289.5.1.1)

Abbotsford, Melbourne Laboratory

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Permeability Test Report

(Constant head method using a flexible wall permeameter)

Report No.: PERM:ABTM16S-03261

Issue No.: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong)
Principal:	
Job No.:	INFOABTM00688AA
Project:	GEOTWOLO03957AA West Nowra Recycling and Waste Facility
Location:	
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests,calibrations and /or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Gayani Samaradiwakara
(Associate Engineering Technician)
NATA Accredited Laboratory Number: 431
Date of Issue: 21/07/2016

Sample Details

Test Procedure: AS1289.6.7.3
Sample ID: ABTM16S-03261
Client sample ID TP4 (2-3m)
Date Sampled: 28/06/2016
Sample Type Remoulded
Sample Material Sandy silty clay
Sampling Method: Submitted by client

Other Sample Details:

Test conditions

Cell pressure	**kPa**	600
Inlet pressure	**kPa**	520
Outlet pressure	**kPa**	480
Mean effective stress	**kPa**	100
Saturation	**%**	96
Permeant used		De-aired Water

Test Results

Specimen height	**mm**	62.4
Specimen Diameter	**mm**	63.3
height to diameter ratio		0.99
Specimen wet density	**t/m^3**	2.06
Specimen moisture content	**%**	21.0
Specimen dry density	**t/m^3**	1.70
Laboratory density ratio	**%**	99
Laboratory moisture ratio	**%**	102
Coefficient of permeability	**(m/sec)**	**2 x 10 $^{-10}$**

Comments: Remoulded condition: Sample remoulded to target of 100% SMDD and 2% -3% of SOMC. Compaction data provided in report MDD:ABTM16S-03261. SMDD=1.72 t/m3, SOMC=18 % (AS1289.5.1.1)

Abbotsford, Melbourne Laboratory

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Permeability Test Report

(Constant head method using a flexible wall permeameter)

Report No.: PERM:ABTM16S-03262

Issue No.: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong)
Principal:	
Job No.:	INFOABTM00688AA
Project:	GEOTWOLO03957AA West Nowra Recycling and Waste Facility
Location:	
Lot No.:	**TRN:**

NATA
WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025.

The results of the tests,calibrations and /or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Gayani Samaradiwakara
(Associate Engineering Technician)
NATA Accredited Laboratory Number: 431
Date of Issue: 21/07/2016

Sample Details

Test Procedure: AS1289.6.7.3
Sample ID: ABTM16S-03262
Client sample ID TP5 (2-3m)
Date Sampled: 28/06/2016
Sample Type Remoulded
Sample Material Sandy silty clay
Sampling Method: Submitted by client

Other Sample Details:

Test conditions

Cell pressure	**kPa**	600
Inlet pressure	**kPa**	520
Outlet pressure	**kPa**	480
Mean effective stress	**kPa**	100
Saturation	**%**	96
Permeant used		De-aired Water

Test Results

Specimen height	**mm**	62.0
Specimen Diameter	**mm**	63.3
height to diameter ratio		0.98
Specimen wet density	**t/m^3**	2.16
Specimen moisture content	**%**	14.7
Specimen dry density	**t/m^3**	1.88
Laboratory density ratio	**%**	99
Laboratory moisture ratio	**%**	105
Coefficient of permeability	**(m/sec)**	**1 x 10 $^{-9}$**

Comments: Remoulded condition: Sample remoulded to target of 100% SMDD and 2% -3% of SOMC. Compaction data provided in report MDD:ABTM16S-03262. SMDD=1.91 t/m3, SOMC=11.5 % (AS1289.5.1.1)

Abbotsford, Melbourne Laboratory

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Permeability Test Report

(Constant head method using a flexible wall permeameter)

Report No.: PERM:ABTM16S-03263

Issue No.: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong)
Principal:	
Job No.:	INFOABTM00688AA
Project:	GEOTWOLO03957AA West Nowra Recycling and Waste Facility
Location:	
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests,calibrations and /or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Gayani Samaradiwakara
(Associate Engineering Technician)
NATA Accredited Laboratory Number: 431
Date of Issue: 21/07/2016

Sample Details

Test Procedure: AS1289.6.7.3
Sample ID: ABTM16S-03263
Client sample ID TP9 (2-3m)
Date Sampled: 28/06/2016
Sample Type Remoulded
Sample Material Sandy silty clay
Sampling Method: Submitted by client

Other Sample Details:

Test conditions

Cell pressure	**kPa**	600
Inlet pressure	**kPa**	520
Outlet pressure	**kPa**	480
Mean effective stress	**kPa**	100
Saturation	**%**	96
Permeant used		De-aired Water

Test Results

Specimen height	**mm**	61.4
Specimen Diameter	**mm**	63.3
height to diameter ratio		0.97
Specimen wet density	**t/m^3**	2.14
Specimen moisture content	**%**	16.8
Specimen dry density	**t/m^3**	1.83
Laboratory density ratio	**%**	100
Laboratory moisture ratio	**%**	105
Coefficient of permeability	**(m/sec)**	**4 x 10 $^{-10}$**

Comments: Remoulded condition: Sample remoulded to target of 100% SMDD and 2% -3% of SOMC. Compaction data provided in report MDD:ABTM16S-03263. SMDD=1.84 t/m3, SOMC=13.5 % (AS1289.5.1.1)

Abbotsford, Melbourne Laboratory

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Permeability Test Report

(Constant head method using a flexible wall permeameter)

Report No.: PERM:ABTM16S-03264

Issue No.: 1

Client:	Coffey Corporate Services Pty Ltd (Wollongong)
Principal:	
Job No.:	INFOABTM00688AA
Project:	GEOTWOLO03957AA West Nowra Recycling and Waste Facility
Location:	
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025.

The results of the tests,calibrations and /or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Gayani Samaradiwakara
(Associate Engineering Technician)
NATA Accredited Laboratory Number: 431
Date of Issue: 21/07/2016

Sample Details

Test Procedure: AS1289.6.7.3
Sample ID: ABTM16S-03264
Client sample ID TP10 (1-1.5m)
Date Sampled: 28/06/2016
Sample Type Remoulded
Sample Material Sandy silty clay
Sampling Method: Submitted by client

Other Sample Details:

Test conditions

Cell pressure	**kPa**	600
Inlet pressure	**kPa**	520
Outlet pressure	**kPa**	480
Mean effective stress	**kPa**	100
Saturation	**%**	97
Permeant used		De-aired Water

Test Results

Specimen height	**mm**	63.5
Specimen Diameter	**mm**	63.3
height to diameter ratio		1.00
Specimen wet density	**t/m^3**	2.12
Specimen moisture content	**%**	17.9
Specimen dry density	**t/m^3**	1.80
Laboratory density ratio	**%**	99
Laboratory moisture ratio	**%**	102
Coefficient of permeability	**(m/sec)**	**7 x 10 $^{-10}$**

Comments: Remoulded condition: Sample remoulded to target of 100% SMDD and 2% -3% of SOMC. Compaction data provided in report MDD:ABTM16S-03264. SMDD=1.82 t/m3, SOMC=15 % (AS1289.5.1.1)

APPENDIX C

Concept Design Drawings

0 50m 100m 200m 300m

SCALE 1:5,000

DRAWING LIST:

FIGURE 00 - GENERAL ARRANGEMENT AND DRAWING LIST
FIGURE 01 - MASTER PLAN LAYOUT
FIGURE 02 - EXISTING SITE SURVEY LAYOUT
FIGURE 03 - PROPOSED LANDFILL EXTENSION LOCATION & BUFFER LAYOUT
FIGURE 04 - PROPOSED BASE OF LANDFILL CELLS LAYOUT
FIGURE 05 - PROPOSED FINAL LANDFORM LAYOUT
FIGURE 06 - TYPICAL SECTIONS THROUGH STAGE 4
FIGURE 07 - TYPICAL LINING SYSTEM SECTIONS
FIGURE 08 - PROPOSED LEACHATE DRAINAGE LAYOUT
FIGURE 09 - LEACHATE DRAINAGE TYPICAL SECTIONS
FIGURE 10 - FILLING PLAN STAGE 4 CELL 1
FIGURE 11 - FILLING PLAN STAGE 4 CELL 2
FIGURE 12 - FILLING PLAN STAGE 4 CELL 3
FIGURE 13 - FILLING PLAN STAGE 4 CELL 4
FIGURE 14 - FILLING PLAN STAGE 4 CELL 5
FIGURE 15 - FILLING PLAN STAGE 4 CELL 6
FIGURE 16 - PROPOSED LANDFILL BASE 3D LAYOUT
FIGURE 17 - PROPOSED FINAL LANDFORM 3D LAYOUT
FIGURE 18 - MONITORING LOCATIONS LAYOUT
FIGURE 19 - TYPICAL GAS MANAGEMENT LAYOUT AND DETAILS
FIGURE 20 - DISTURBANCE FOOTPRINT FOR LANDFILL AND FIREBREAK LAYOUT
FIGURE 21 - PROPOSED FILLING PLAN LAYOUTS
FIGURE 22 - TOTAL DISTURBANCE AREA STAGE 4 EXTENSION LAYOUT
FIGURE 23 - CONCEPTUAL EROSION SEDIMENT CONTROL PLAN
FIGURE 24 - PROPOSED LEACHATE IRRIGATION AREA RELOCATION PLAN

Shoalhaven City Council

NOTE:
1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.

ISSUED FOR INFORMATION ONLY

REFERENCE		REVISIONS					
-	-	-	-	-	-	-	
-	-	-	-	-	-	-	
-	-	-	-	-	-	-	
-	-	-	-	-	-	-	
-	-	-	-	-	-	-	
-	-	-	-	-	-	-	
-	-	-	-	-	-	-	
-	-	C	13.06.17	ADDITIONAL FIGURE ADDED	AB	-	
-	-	B	29.11.16	REVISED AFTER SCC FEEDBACK	AB	AD	
-	-	A	30.03.16	ISSUED FOR INFORMATION	AB	AD	
DWG. NUMBER	TITLE	No.	DATE	DESCRIPTION	BY	CHKD	

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APPROVED		
DEPT.	DATE	SIGN
Civil	-	-
Engineering	-	-
Production	-	-
PROJ. ENG.	-	-
PROJ. MNG.	-	-

	DATE	NAME
DRAWN BY:	NOV 2016	AB
CHECKED:	NOV 2016	AD
APPROVED:	-	-

SHOALHAVEN CITY COUNCIL

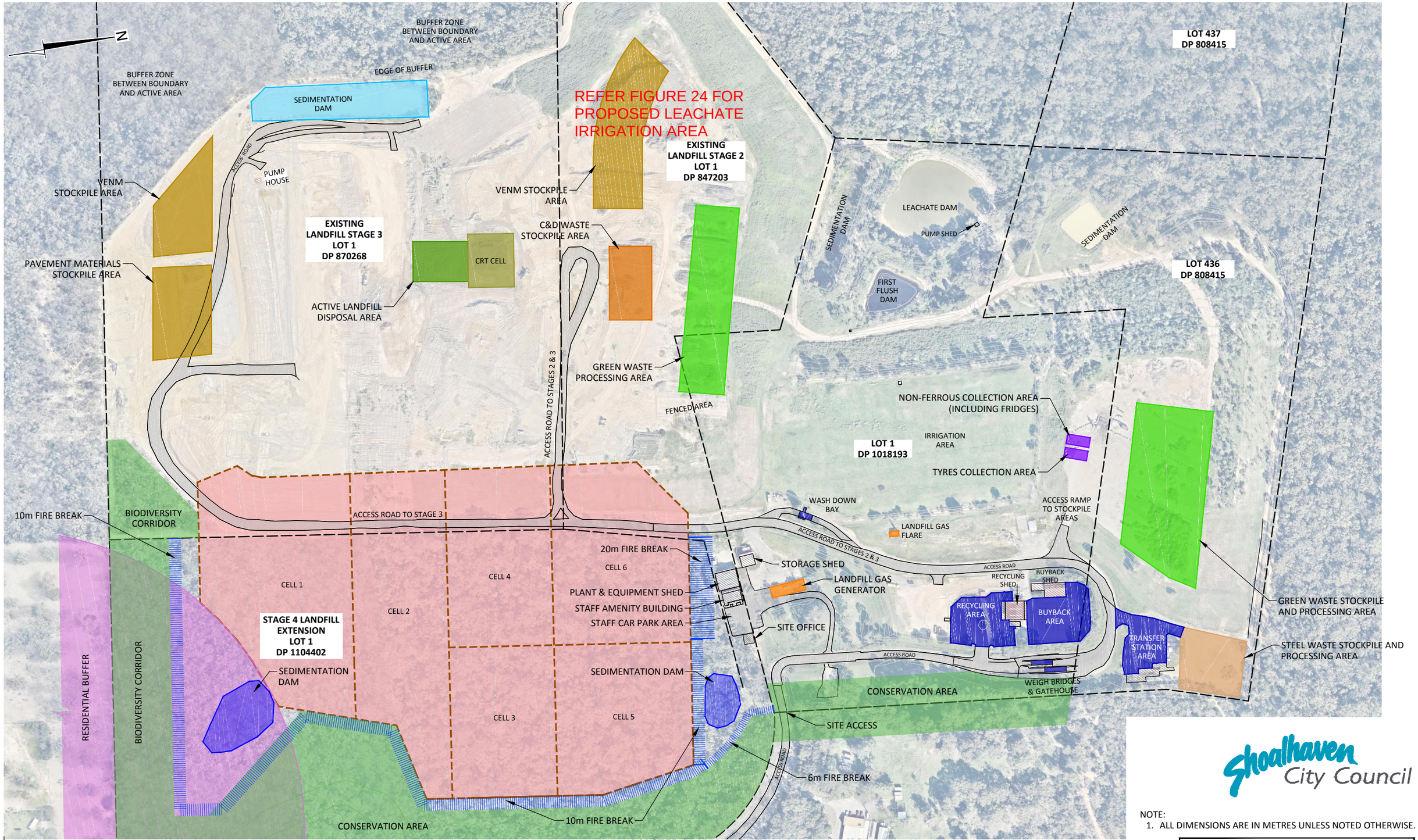
WEST NOWRA RECYLING AND WASTE FACILITY

GENERAL ARRANGEMENT & DRAWING LIST

SCALE: SHOWN

SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 DRAWING NUMBER: FIGURE 00 REV: C



MASTER PLAN LAYOUT
SCALE 1:3000

Shoalhaven City Council

NOTE:
1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.

ISSUED FOR INFORMATION ONLY

REFERENCE		REVISIONS				
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-	-	A	30.03.16	ISSUED FOR INFORMATION	AB	AD
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Production	-	-
PROJ. ENG.	-	-
PROJ. MNG.	-	-
	DATE	NAME
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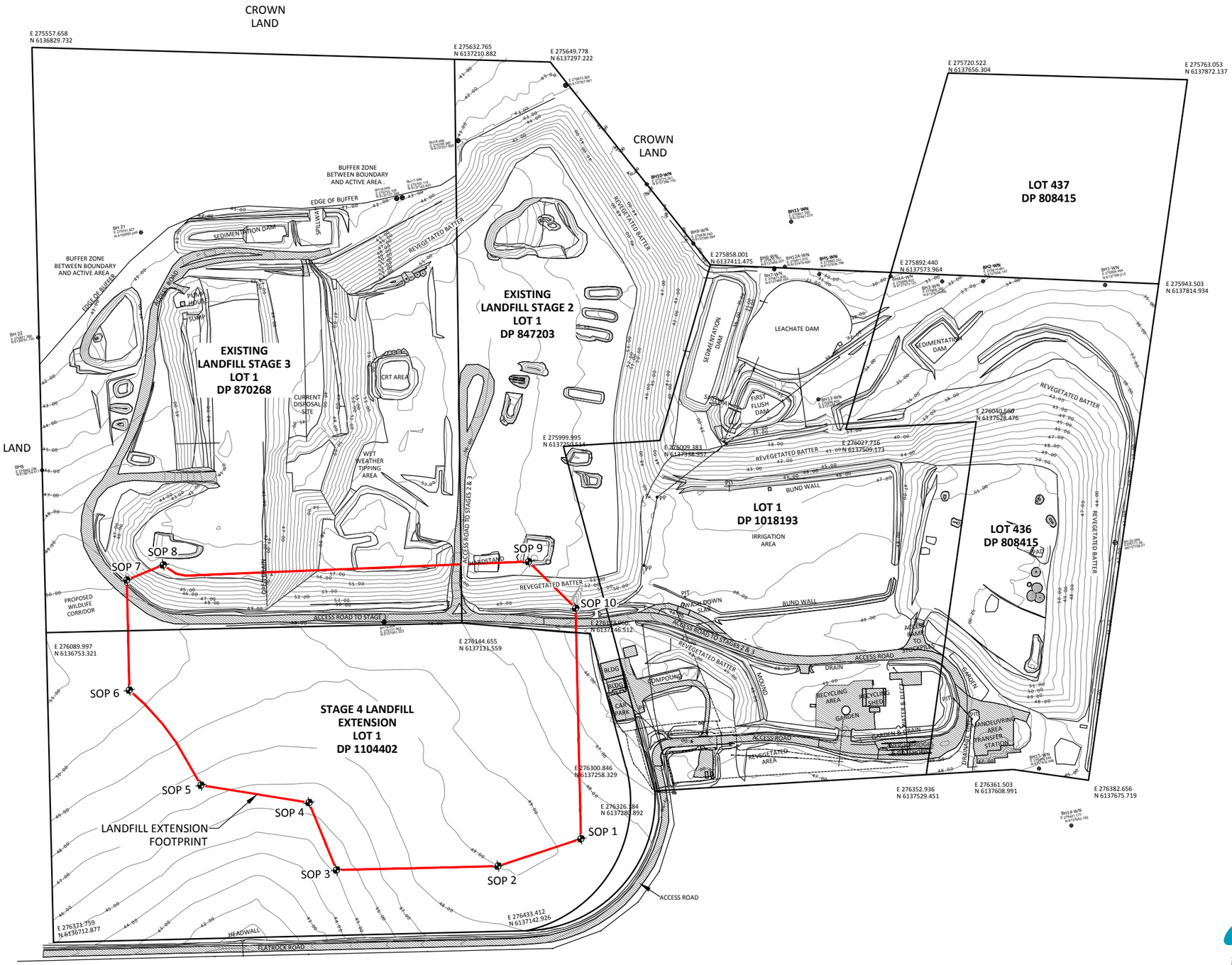
SHOALHAVEN CITY COUNCIL
.
WEST NOWRA RECYLING AND WASTE FACILITY
.
MASTER PLAN LAYOUT

SCALE: 1:3000
SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 01 | REV: A



EXISTING SITE SURVEY
SCALE 1:4000

LANDFILL EXTENSION FOOTPRINT SETTING OUT		
SET OUT POINT REF	EASTING	NORTHING
SOP 1	276,358.40	6,137,206.59
SOP 2	276,370.53	6,137,127.26
SOP 3	276,349.41	6,136,980.26
SOP 4	276,284.16	6,136,965.64
SOP 5	276,251.85	6,136,870.35
SOP 6	276,154.85	6,136,819.87
SOP 7	276,054.65	6,136,834.35
SOP 8	276,046.55	6,136,869.62
SOP 9	276,099.27	6,137,201.42
SOP 10	276,148.68	6,137,236.90

Shoalhaven City Council

NOTE:
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-	-	B	29.11.16	REVIDSED AFTER SCC FEEDBACK	AB	AD
-	-	A	30.03.16	ISSUED FOR INFORMATION	AB	AD
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Production	-	-
PROJ. ENG.	-	-
PROJ. MNG.	-	-
	DATE	NAME
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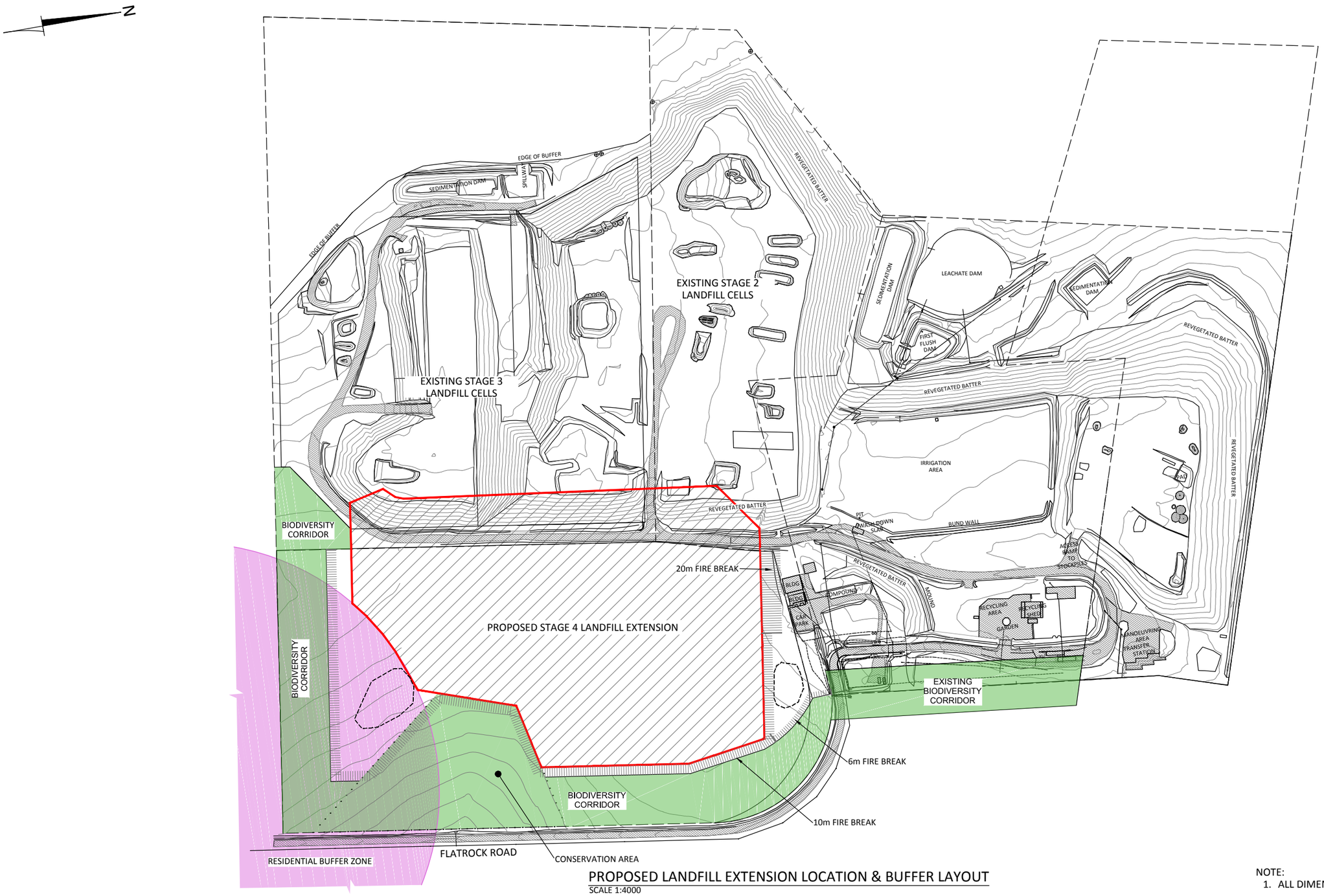
SHOALHAVEN CITY COUNCIL
.
WEST NOWRA RECYLING AND WASTE FACILITY
.
EXISTING SITE SURVEY LAYOUT

SCALE: 1:4000
SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 02 | REV: B



PROPOSED LANDFILL EXTENSION LOCATION & BUFFER LAYOUT

SCALE 1:4000

Shoalhaven City Council

NOTE:
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-	-	B	29.11.16	REVISED AFTER COMMENTS FROM SCC	AB	AD	
-	-	A	30.03.16	ISSUED FOR INFORMATION	AB	AD	
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PROJ. MNG.	-	-

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SHOALHAVEN CITY COUNCIL

WEST NOWRA RECYLING AND WASTE FACILITY

PROPOSED LANDFILL EXTENSION LOCATION & BUFFER LAYOUT

SCALE: 1:4000

SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 03 | REV: B

0 20m 50m 100m 150m

SCALE 1:2,500

EXCAVATION DESIGN LAYOUT

SCALE 1:2,500

NOTE:
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REFERENCE		REVISIONS					
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-	-	A	30.03.16	ISSUED FOR INFORMATION	AB	AD	
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SHOALHAVEN CITY COUNCIL

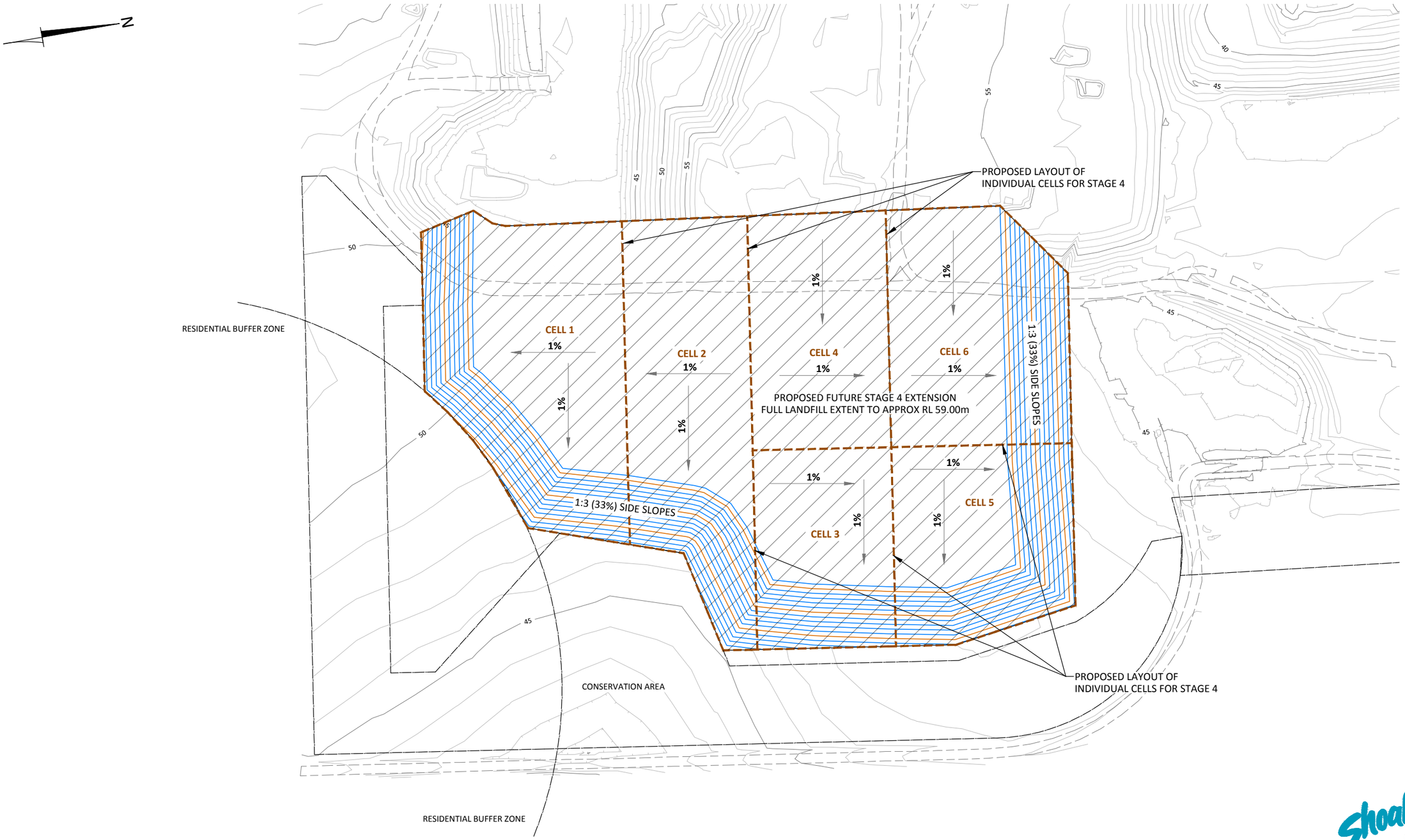
WEST NOWRA RECYLING AND WASTE FACILITY

PROPOSED BASE OF LANDFILL CELLS LAYOUT

SCALE: SHOWN

SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 04 | REV: B



0 20m 50m 100m 150m

SCALE 1:2,500

LANDFILL DESIGN LAYOUT

SCALE 1:2,500

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-	-	A	30.03.16	ISSUED FOR INFORMATION	AB	AD
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Production	-	-
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PROJ. MNG.	-	-
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SHOALHAVEN CITY COUNCIL

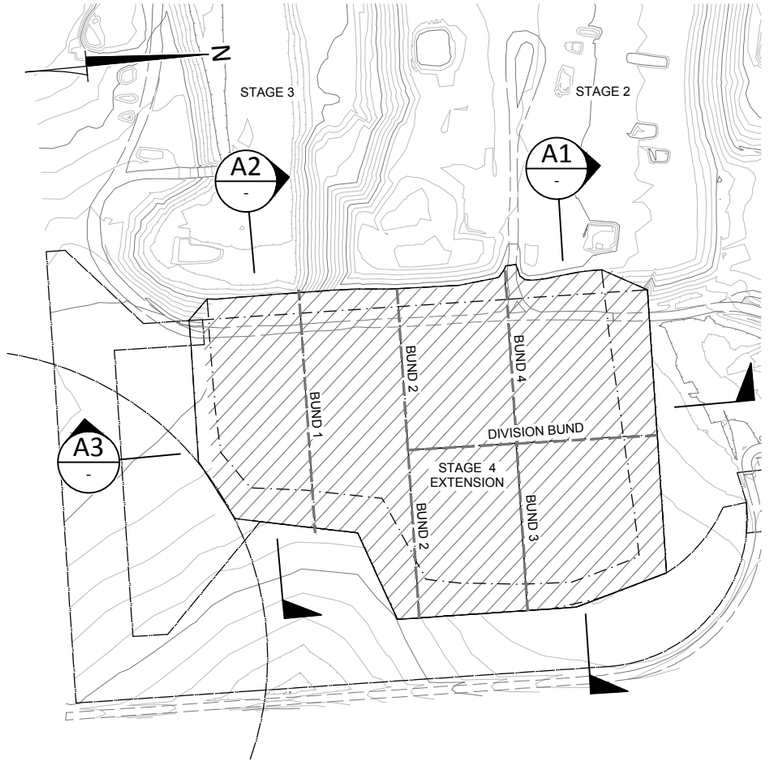
WEST NOWRA RECYLING AND WASTE FACILITY

PROPOSED FINAL LANDFORM LAYOUT

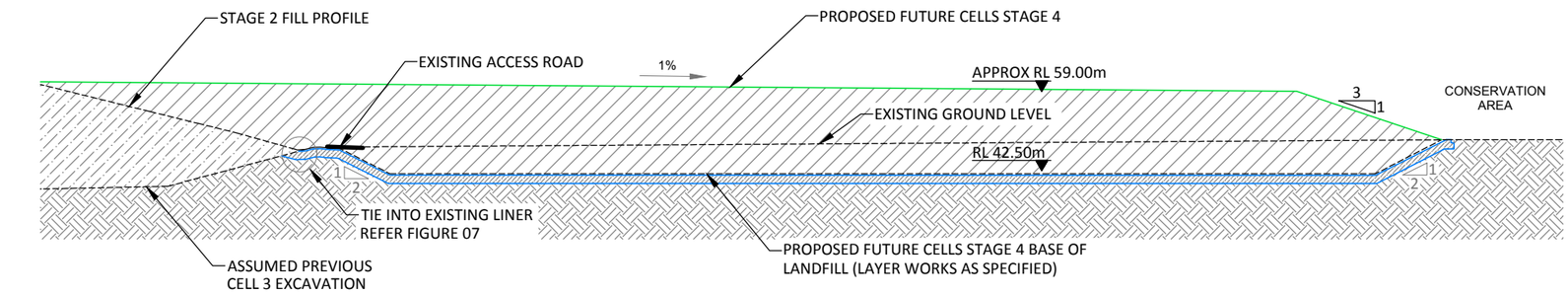
SCALE: SHOWN

SHEET: 1 of 1

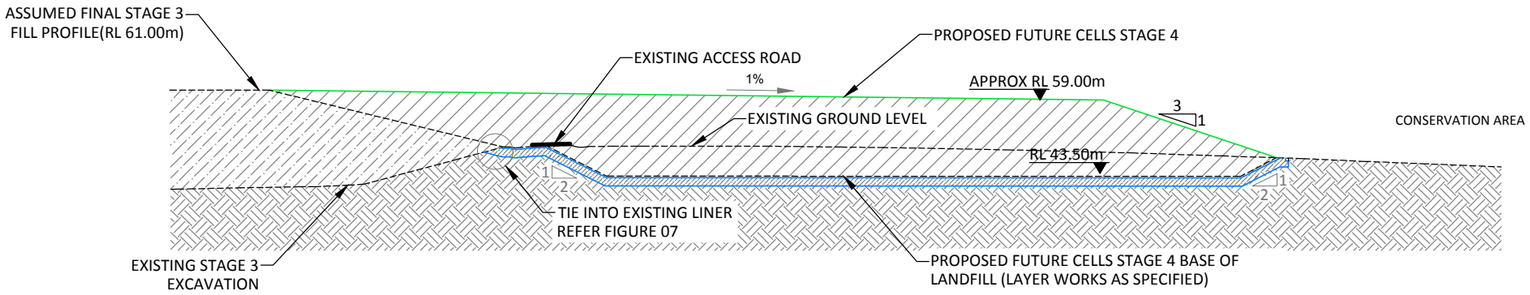
SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 05 | REV: B



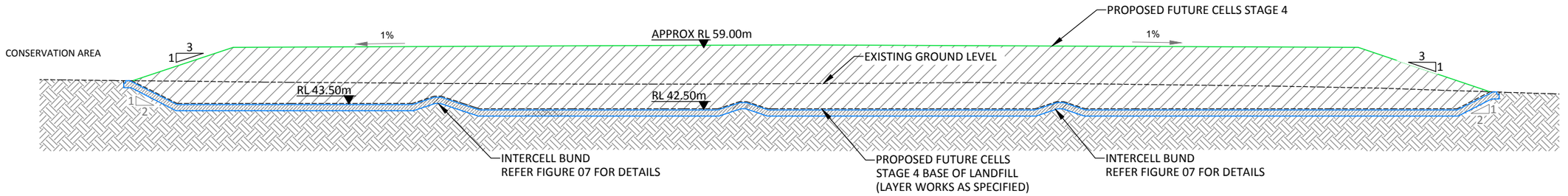
SECTION LAYOUT
SCALE 1:5,000



SECTION A1 - SECTION THROUGH EXISTING STAGE 2 CELL/PROPOSED STAGE 4 CELL
SCALE 1:1,250



SECTION A2 - SECTION THROUGH PROPOSED STAGE 3 CELL/PROPOSED STAGE 4 CELL
SCALE 1:1,250



SECTION A3 - SECTION THROUGH PROPOSED STAGE 4 CELL
SCALE 1:1,250

0 50m 100m 200m 300m
SCALE 1:5,000

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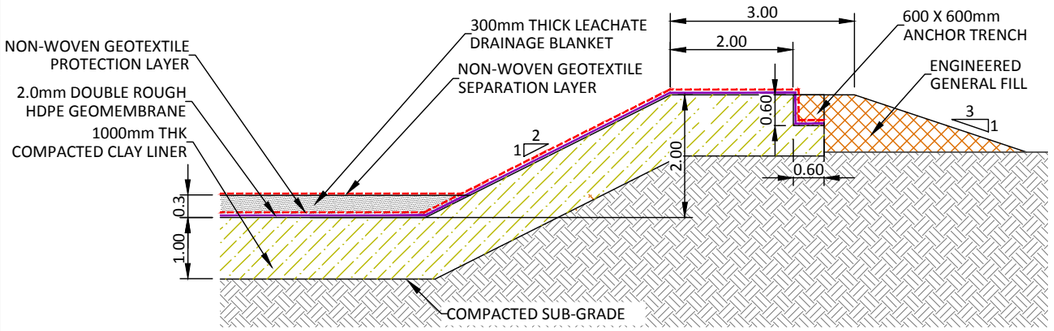
WEST NOWRA RECYLING AND WASTE FACILITY
.
TYPICAL SECTIONS THROUGH STAGE 4

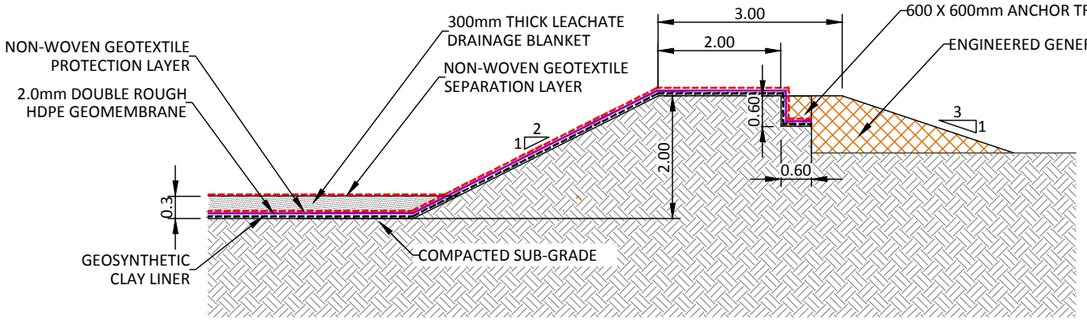
SCALE: SHOWN
SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 06 | REV: B



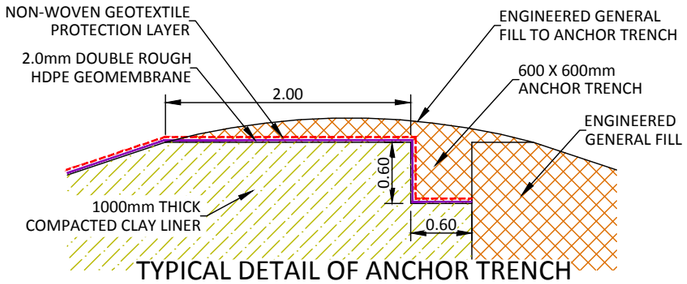
TYPICAL SECTION THROUGH INTERCELL BUND WITH COMPACTED CLAY LINER

SCALE 1:100



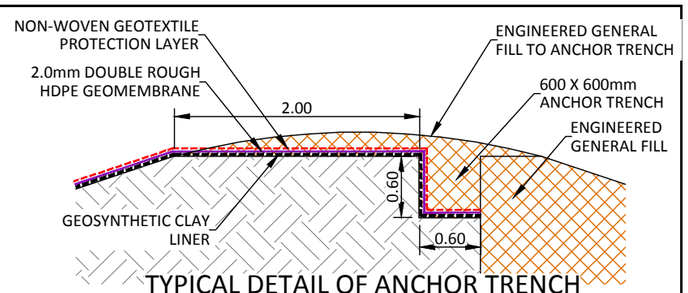
TYPICAL SECTION THROUGH INTERCELL BUND WITH GEOSYNTHETIC CLAY LINER

SCALE 1:100



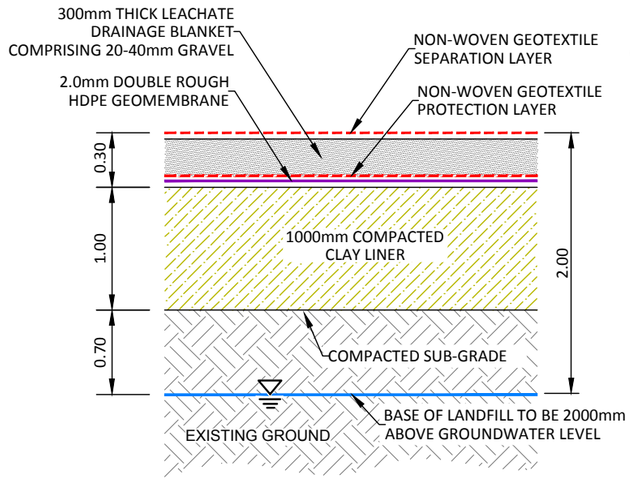
TYPICAL DETAIL OF ANCHOR TRENCH WITH COMPACTED CLAY LINER

SCALE 1:50



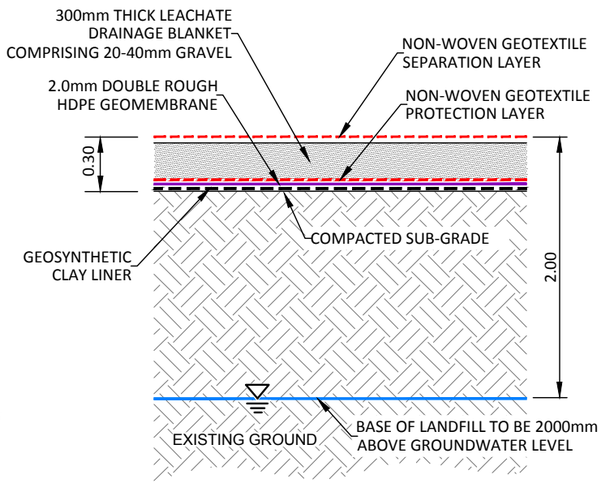
TYPICAL DETAIL OF ANCHOR TRENCH WITH GEOSYNTHETIC CLAY LINER

SCALE 1:50



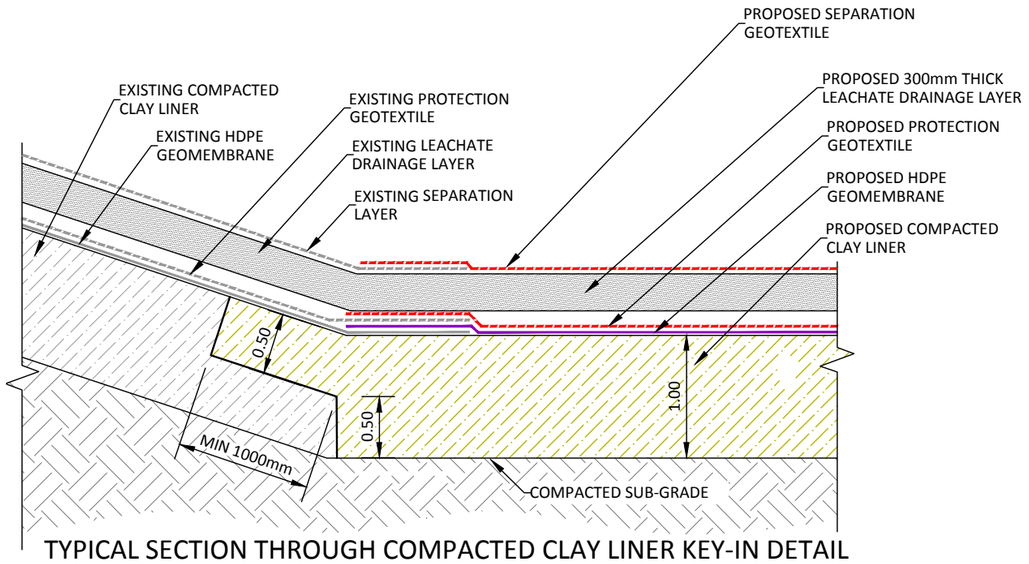
TYPICAL SECTION THROUGH COMPACTED CLAY LINING SYSTEM

SCALE 1:50



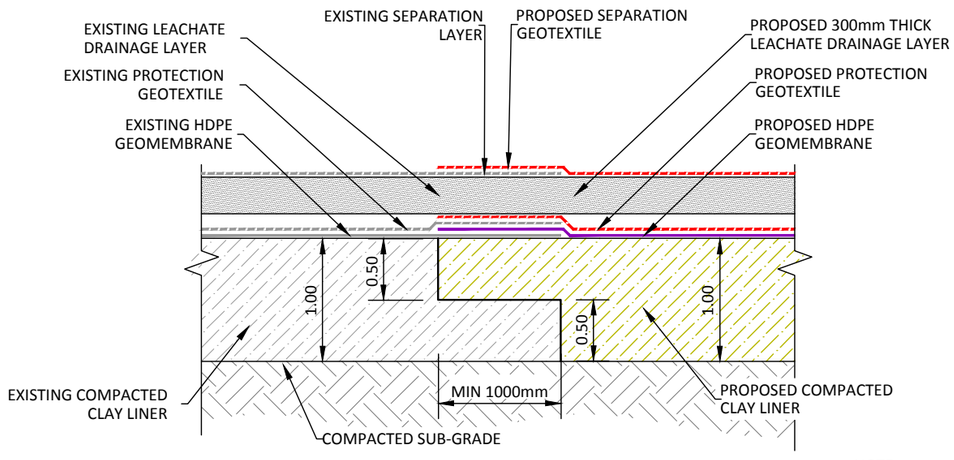
TYPICAL SECTION THROUGH GEOSYNTHETIC CLAY LINING SYSTEM

SCALE 1:50



TYPICAL SECTION THROUGH COMPACTED CLAY LINER KEY-IN DETAIL TO EXISTING STAGES 2 AND 3

SCALE 1:50



TYPICAL SECTION THROUGH COMPACTED CLAY LINER KEY-IN DETAIL BETWEEN CELLS

SCALE 1:50

NOTE:
1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.

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SHOALHAVEN CITY COUNCIL

WEST NOWRA RECYLING AND WASTE FACILITY

TYPICAL LINING SYSTEM SECTIONS

SCALE: SHOWN

SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 07 | REV: B

N

REFER TO FIGURE 24 FOR PROPOSED LEACHATE IRRIGATION AREA AND INFRASTRUCTURE

EXISTING STAGE 3 LANDFILL CELLS

EXISTING STAGE 2 LANDFILL CELLS

SEDIMENTATION DAM

EXISTING LEACHATE DAM

FIRST FLUSH DAM

LEACHATE COLLECTION PUMP LINE TO EXISTING LEACHATE INFRASTRUCTURE

LEACHATE COLLECTION SUMP

MAIN LEACHATE SPINE DRAIN

LEACHATE SIDE RISER

3%

1%

20m TYPICAL

SPUR DRAIN HIGH POINTS

LANDFILL STAGE 4 EXTENSION

LEACHATE SPUR DRAINS

CONSERVATION AREA

0 20m 50m 100m 150m

SCALE 1:2,500

TYPICAL LEACHATE DRAINS DESIGN LAYOUT

SCALE 1:2,500

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PROJ. MNG.	-	-

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SHOALHAVEN CITY COUNCIL

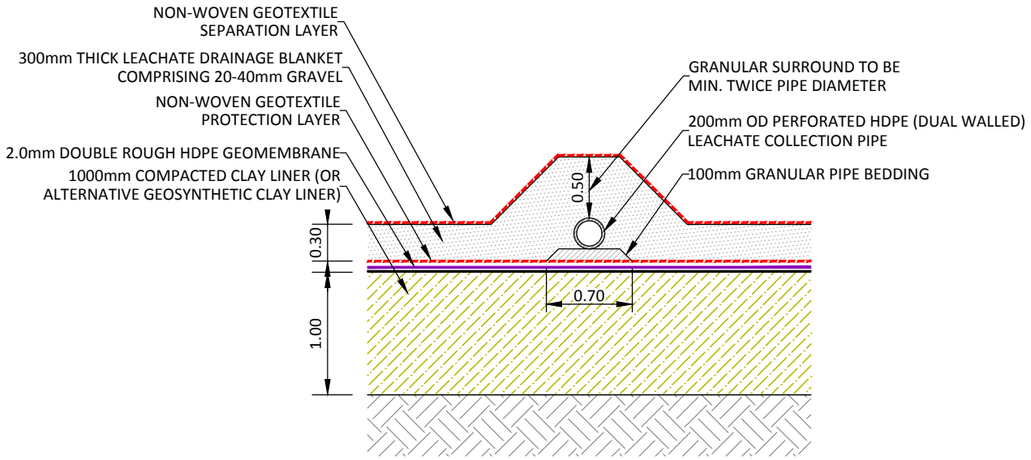
WEST NOWRA RECYLING AND WASTE FACILITY

PROPOSED LEACHATE DRAINAGE LAYOUT

SCALE: SHOWN

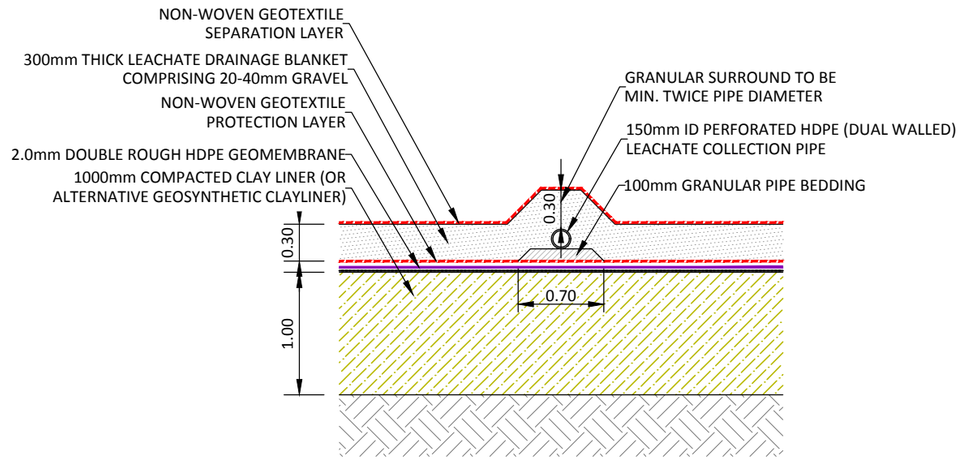
SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 08 | REV: B



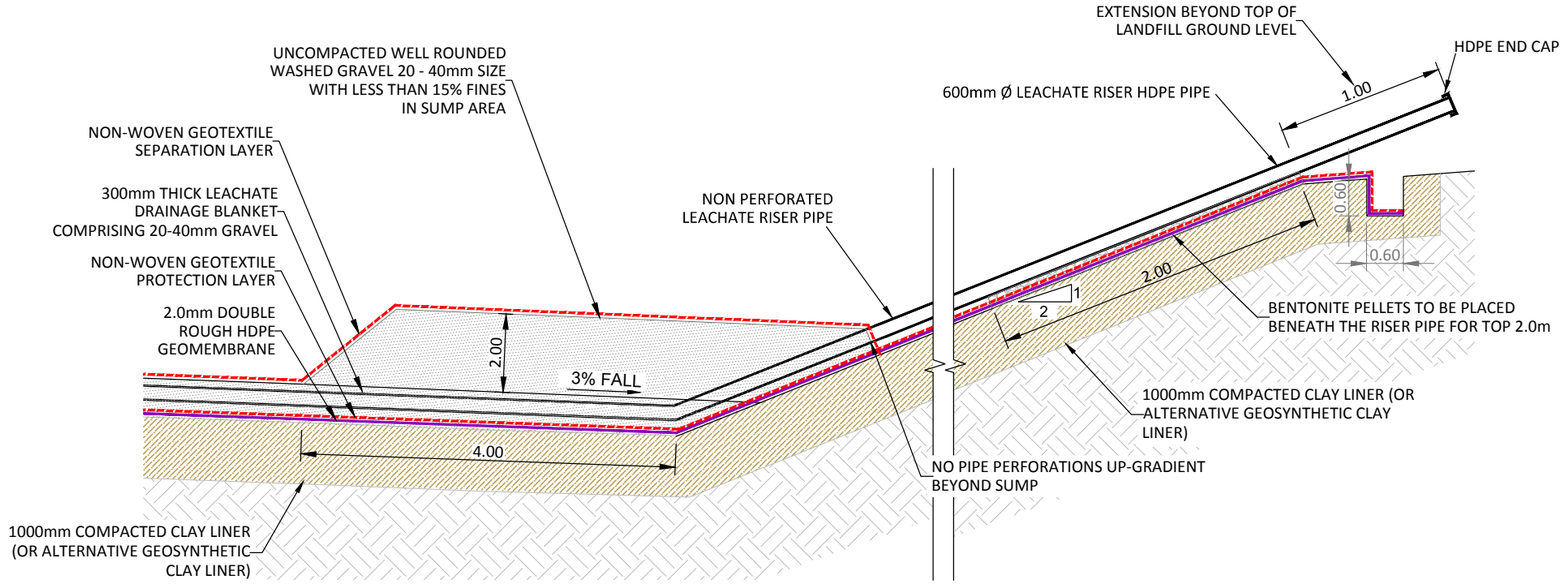
TYPICAL SECTION THROUGH LEACHATE SPINE DRAIN

SCALE 1:50



TYPICAL SECTION THROUGH LEACHATE SPUR DRAIN

SCALE 1:50



TYPICAL SECTION THROUGH LEACHATE RISER AND SUMP

SCALE 1:100

0 0.5m 1m 2m 3m

SCALE 1:50

Shoalhaven City Council

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PROJ. MNG.	-	-
	DATE	NAME
DRAWN BY:	NOV 2016	AB
CHECKED:	NOV 2016	AD
APPROVED:	-	-

SHOALHAVEN CITY COUNCIL

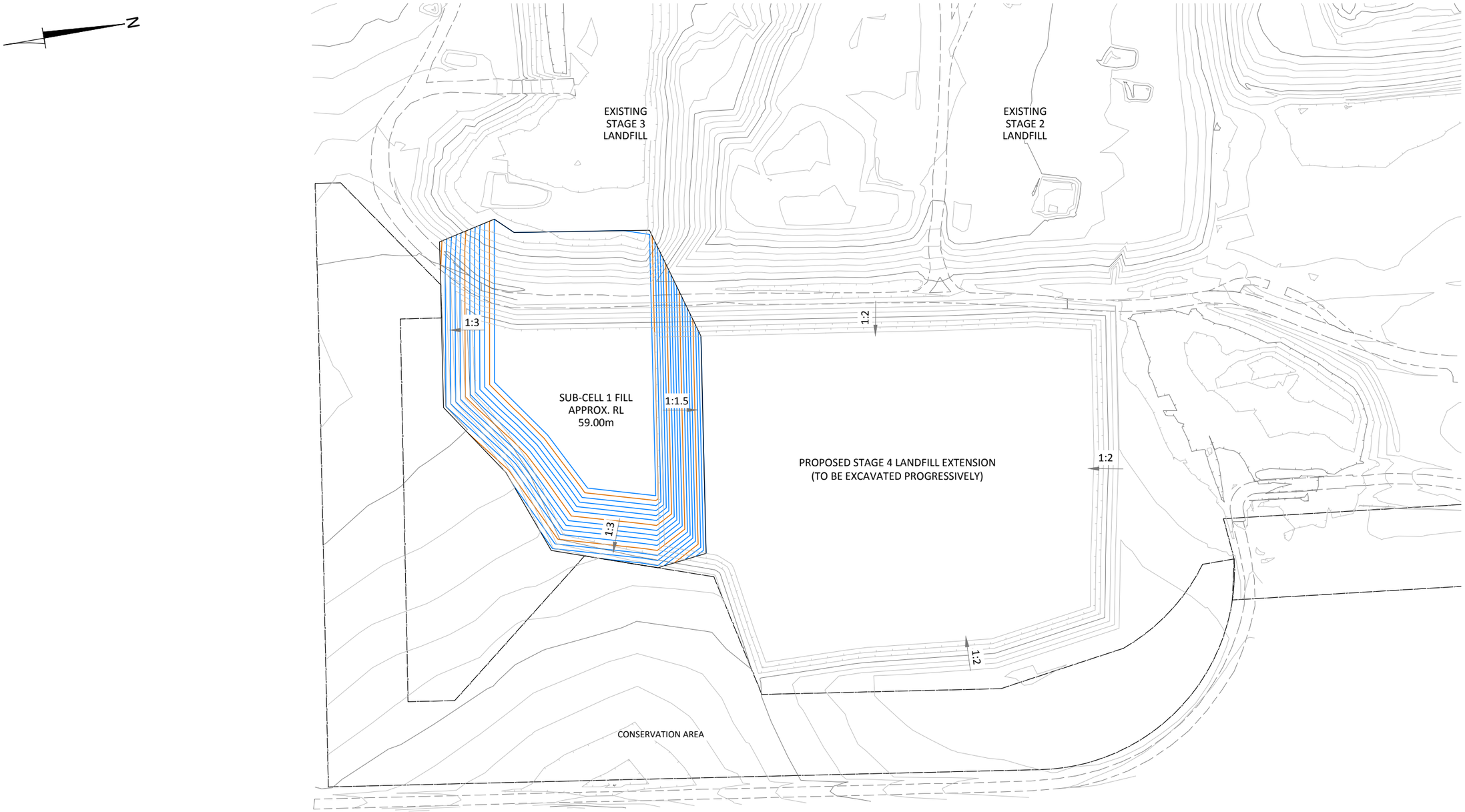
WEST NOWRA RECYLING AND WASTE FACILITY

LEACHATE DRAINAGE
TYPICAL SECTIONS

SCALE: SHOWN

SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 09 | REV: B



0 20m 50m 100m 150m

SCALE 1:2,500

FILLING PLAN LAYOUT

SCALE 1:2,500

ISSUED FOR INFORMATION ONLY

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B	29.11.16	REVISED AFTER COMMENTS FROM SCC	AB	AD
A	30.03.16	ISSUED FOR INFORMATION	AB	AD
No.	DATE	DESCRIPTION	BY	CHKD

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Consulting Engineers & Scientists
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Jolimont 6014
Western Australia
Tel : +61 8 9422 5900
Fax : +61 8 9422 5901

APPROVED		
DEPT.	DATE	SIGN
Civil	-	-
Engineering	-	-
Production	-	-
PROJ. ENG.	-	-
PROJ. MNG.	-	-
	DATE	NAME
DRAWN BY:	NOV 2016	AB
CHECKED:	NOV 2016	AD
APPROVED:	-	-

SHOALHAVEN CITY COUNCIL

.

WEST NOWRA RECYLING AND WASTE FACILITY

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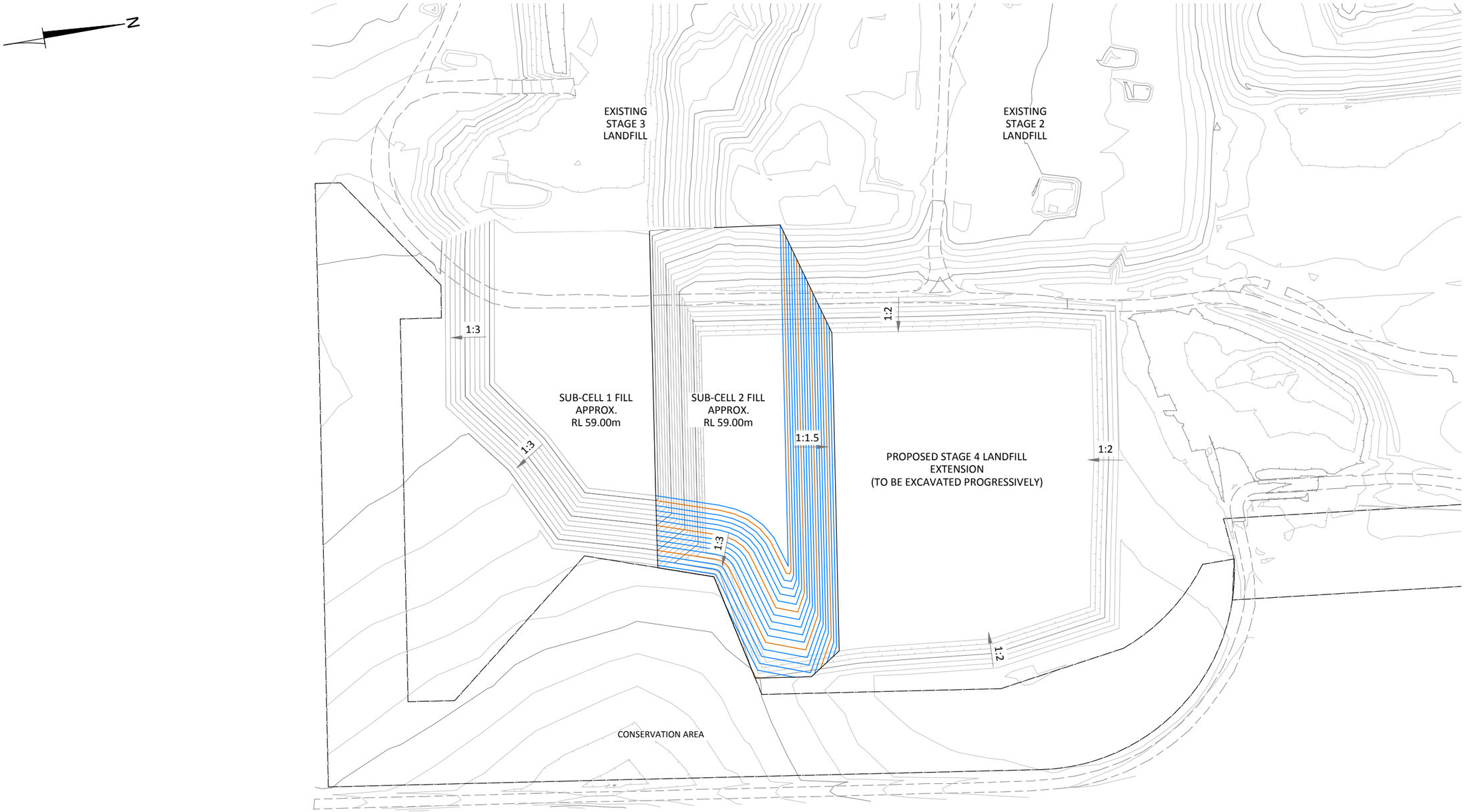
FILLING PLAN
STAGE 4 CELL 1

SCALE: SHOWN

SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 10 | REV: B



0 20m 50m 100m 150m

SCALE 1:2,500

FILLING PLAN LAYOUT

SCALE 1:2,500

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-	-	A	30.03.16	ISSUED FOR INFORMATION	AB	AD	
DWG. NUMBER	TITLE	No.	DATE	DESCRIPTION	BY	CHKD	

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DEPT.	DATE	SIGN
Civil	-	-
Engineering	-	-
Production	-	-
PROJ. ENG.	-	-
PROJ. MNG.	-	-
	DATE	NAME
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SHOALHAVEN CITY COUNCIL

.

WEST NOWRA RECYLING AND WASTE FACILITY

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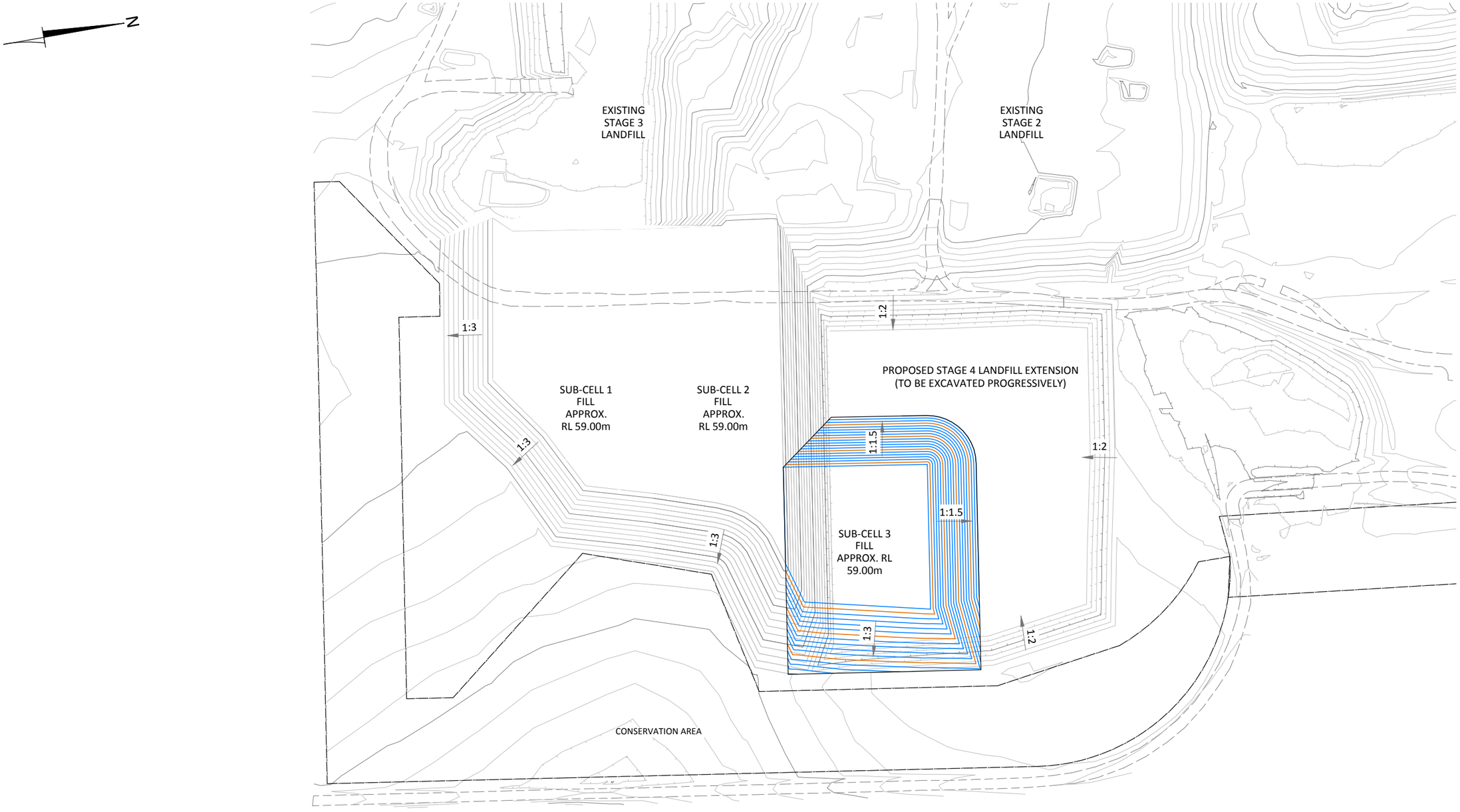
FILLING PLAN
STAGE 4 CELL 2

SCALE: SHOWN

SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 11 | REV: B



FILLING PLAN LAYOUT

SCALE 1:2,500

0 20m 50m 100m 150m

SCALE 1:2,500

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-	-	A	30.03.16	ISSUED FOR INFORMATION	AB	AD
DWG. NUMBER	TITLE	No.	DATE	DESCRIPTION	BY	CHKD

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DEPT.	DATE	SIGN
Civil	-	-
Engineering	-	-
Production	-	-
PROJ. ENG.	-	-
PROJ. MNG.	-	-
	DATE	NAME
DRAWN BY:	NOV 2016	AB
CHECKED:	NOV 2016	AD
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SHOALHAVEN CITY COUNCIL

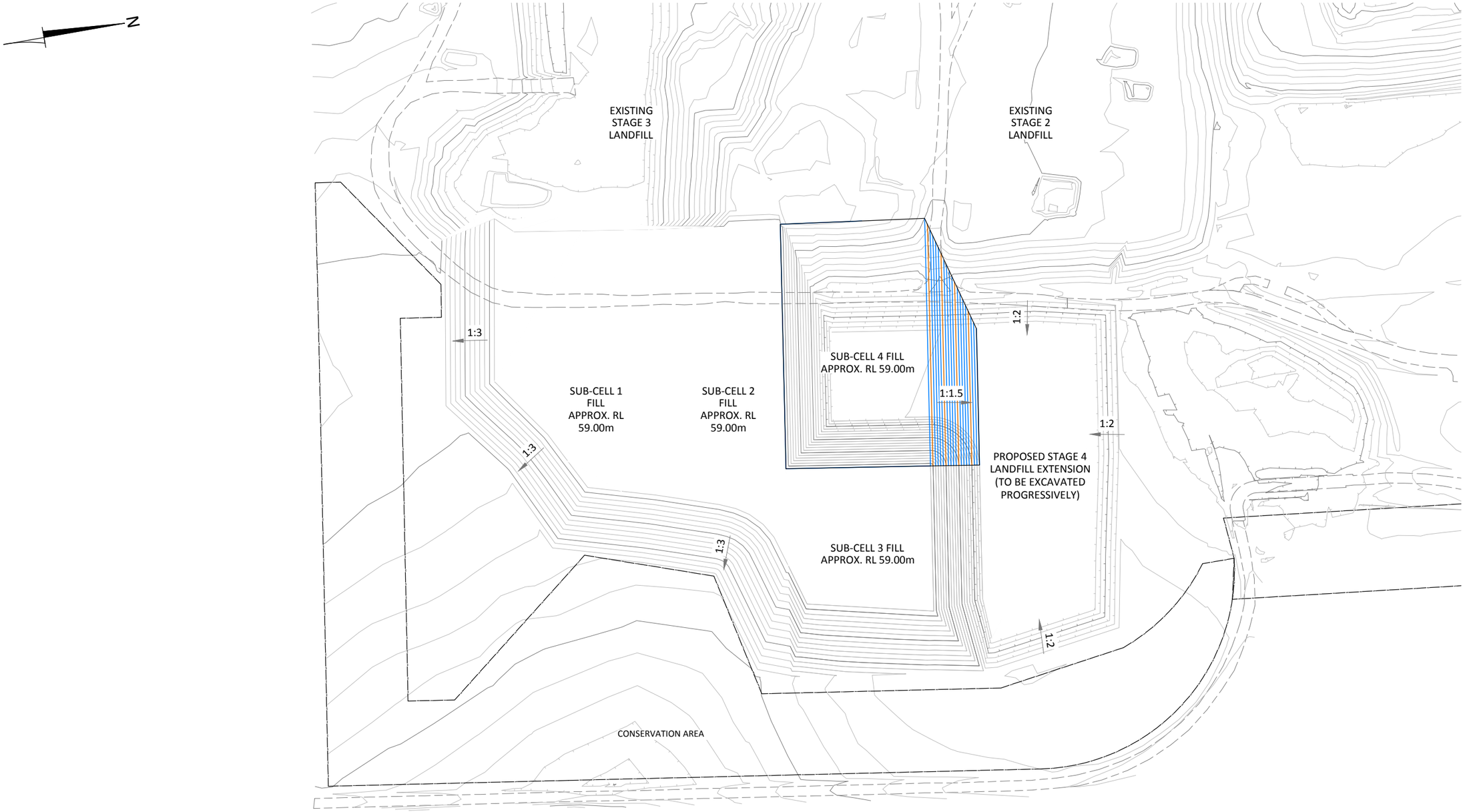
WEST NOWRA RECYLING AND WASTE FACILITY

FILLING PLAN
STAGE 4 CELL 3

SCALE: SHOWN

SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 12 | REV: B



FILLING PLAN LAYOUT
SCALE 1:2,500

0 20m 50m 100m 150m
SCALE 1:2,500

ISSUED FOR INFORMATION ONLY

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DWG. NUMBER	TITLE

REVISIONS				
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B	29.11.16	REVISED AFTER COMMENTS FROM SCC	AB	AD
A	30.03.16	ISSUED FOR INFORMATION	AB	AD
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APPROVED		
DEPT.	DATE	SIGN
Civil	-	-
Engineering	-	-
Production	-	-
PROJ. ENG.	-	-
PROJ. MNG.	-	-
	DATE	NAME
DRAWN BY:	NOV 2016	AB
CHECKED:	NOV 2016	AD
APPROVED:	-	-

SHOALHAVEN CITY COUNCIL

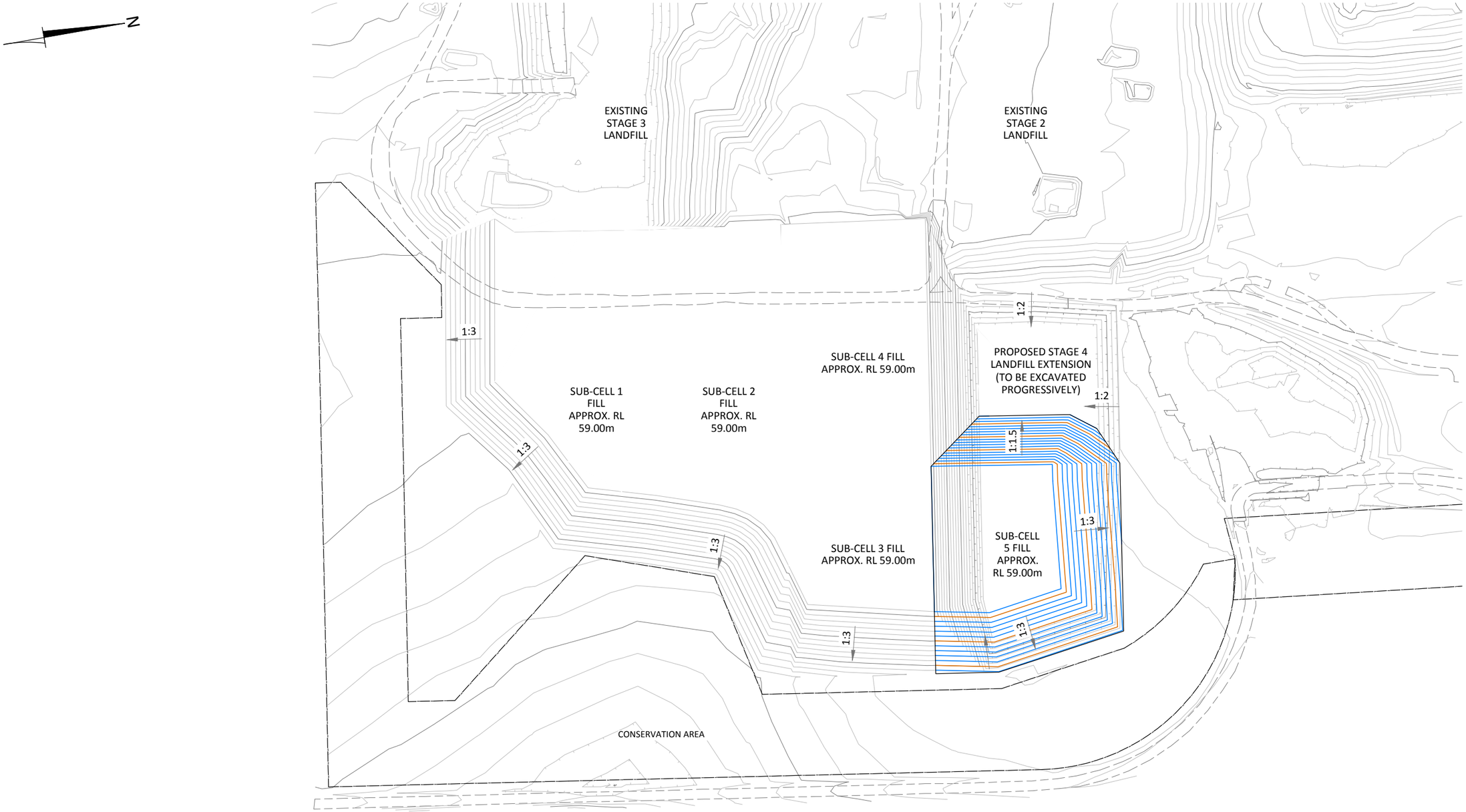
WEST NOWRA RECYLING AND WASTE FACILITY

FILLING PLAN
STAGE 4 CELL 4

SCALE: SHOWN

SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 13 | REV: B



FILLING PLAN LAYOUT
SCALE 1:2,500

0 20m 50m 100m 150m
SCALE 1:2,500

ISSUED FOR INFORMATION ONLY

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DWG. NUMBER	TITLE

REVISIONS				
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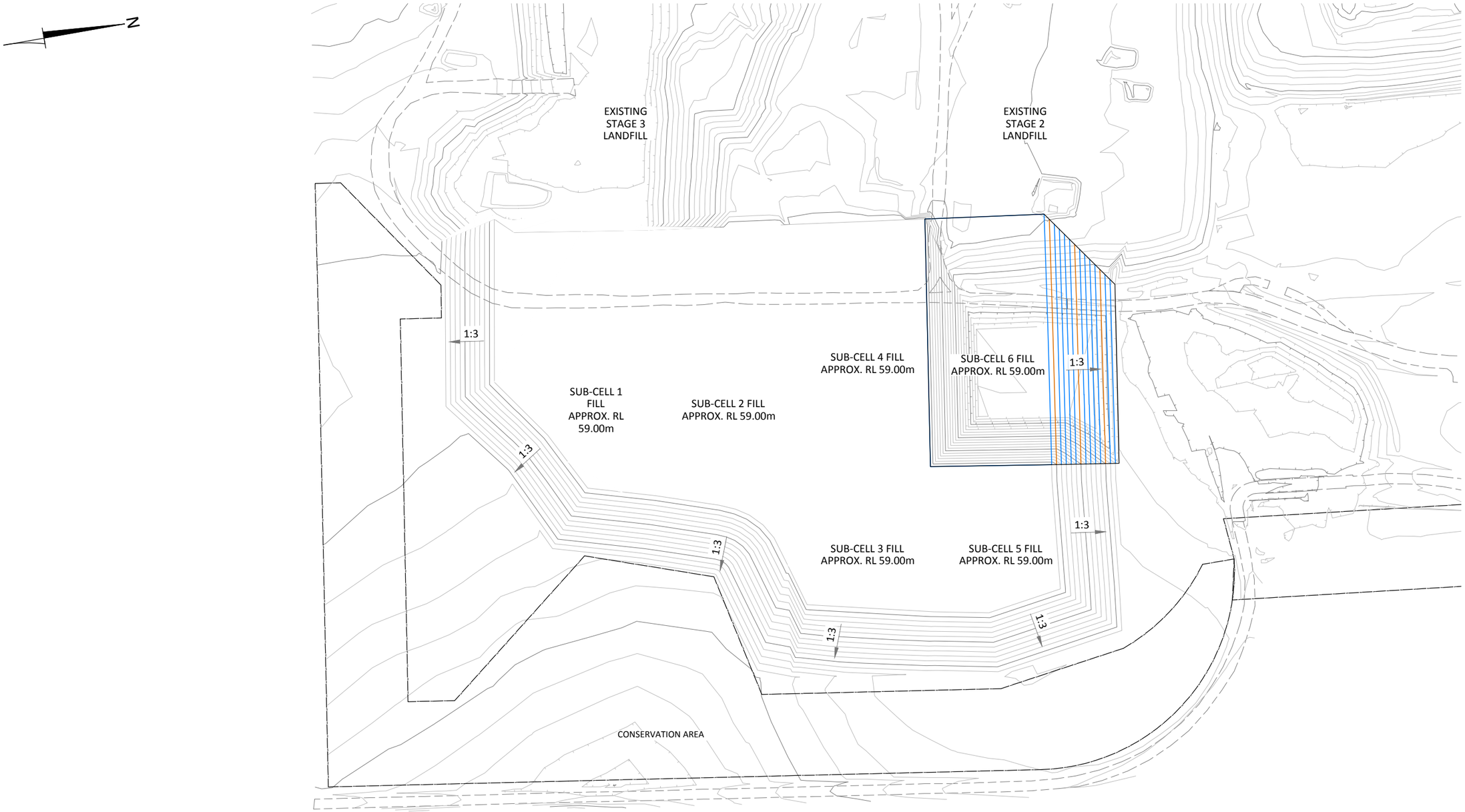
APPROVED		
DEPT.	DATE	SIGN
Civil	-	-
Engineering	-	-
Production	-	-
PROJ. ENG.	-	-
PROJ. MNG.	-	-
	DATE	NAME
DRAWN BY:	NOV 2016	AB
CHECKED:	NOV 2016	AD
APPROVED:	-	-

SHOALHAVEN CITY COUNCIL
.
WEST NOWRA RECYLING AND WASTE FACILITY
.
.
FILLING PLAN
STAGE 4 CELL 5

SCALE: SHOWN
SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 14 | REV: B



0 20m 50m 100m 150m

SCALE 1:2,500

FILLING PLAN LAYOUT

SCALE 1:2,500

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REVISIONS				
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Western Australia
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Fax : +61 8 9422 5901

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DEPT.	DATE	SIGN
Civil	-	-
Engineering	-	-
Production	-	-
PROJ. ENG.	-	-
PROJ. MNG.	-	-
	DATE	NAME
DRAWN BY:	NOV 2016	AB
CHECKED:	NOV 2016	AD
APPROVED:	-	-

SHOALHAVEN CITY COUNCIL

.

WEST NOWRA RECYLING AND WASTE FACILITY

.

.

FILLING PLAN
STAGE 4 CELL 6

SCALE: SHOWN

SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 15 | REV: B

0 20m 50m 100m 150m

SCALE 1:2,500

NOTE:
1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.

ISSUED FOR INFORMATION ONLY

REFERENCE	
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B	29.11.16	REVISED AFTER COMMENTS FROM SCC	AB	AD
A	30.03.16	ISSUED FOR INFORMATION	AB	AD
No.	DATE	DESCRIPTION	BY	CHKD

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589 Hay Street
Jolimont 6014
Western Australia
Tel : +61 8 9422 5900
Fax : +61 8 9422 5901

APPROVED		
DEPT.	DATE	SIGN
Civil	-	-
Engineering	-	-
Production	-	-
PROJ. ENG.	-	-
PROJ. MNG.	-	-
	DATE	NAME
DRAWN BY:	NOV 2016	AB
CHECKED:	NOV 2016	AD
APPROVED:	-	-

SHOALHAVEN CITY COUNCIL

WEST NOWRA RECYLING AND WASTE FACILITY

PROPOSED LANDFILL BASE
3D LAYOUT

SCALE: SHOWN

SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 16 | REV: B

0 20m 50m 100m 150m

SCALE 1:2,500

Shoalhaven City Council

NOTE:
1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.

ISSUED FOR INFORMATION ONLY

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B	29.11.16	REVISED AFTER COMMENTS FROM SCC	AB	AD	
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No.	DATE	DESCRIPTION	BY	CHKD	

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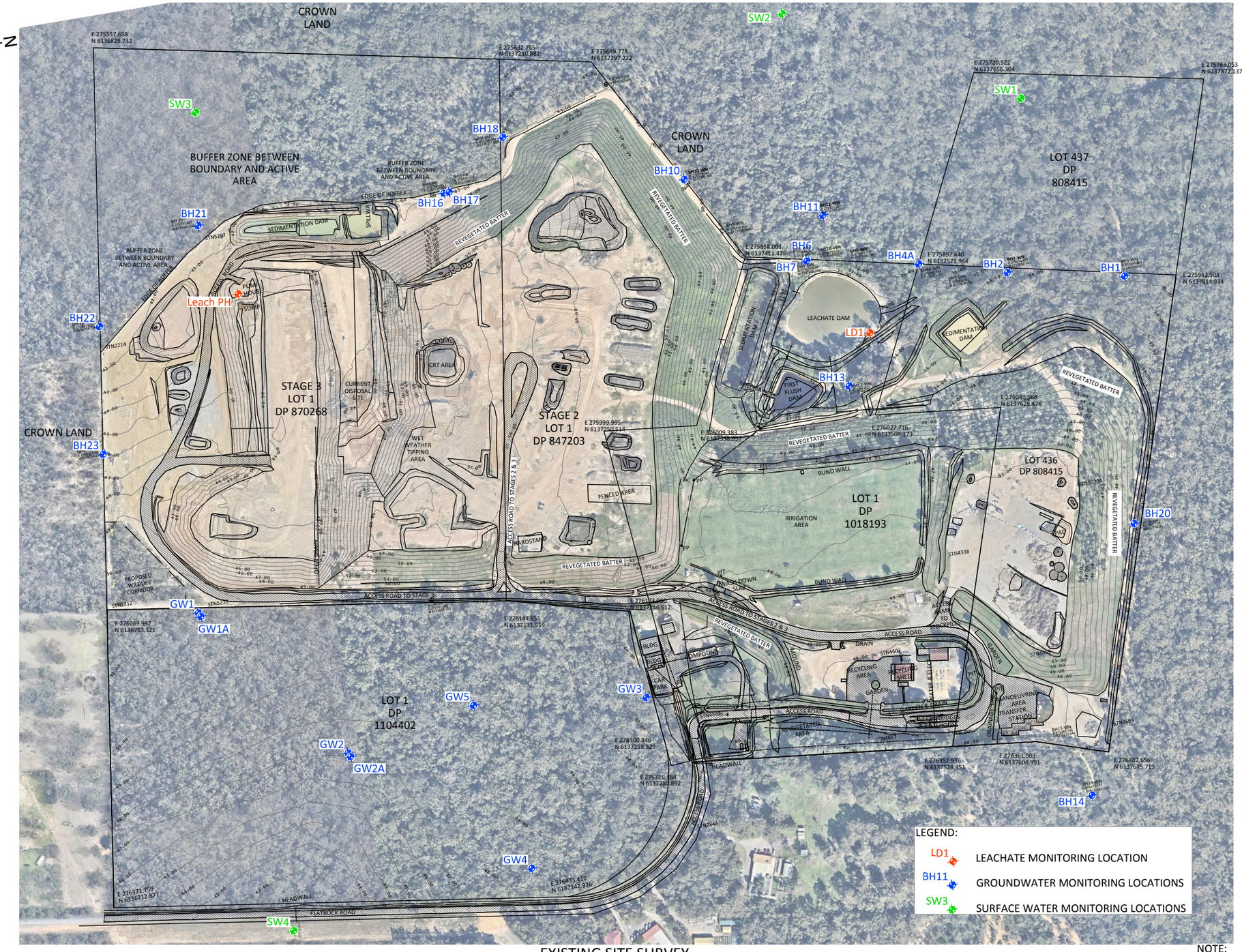
APPROVED		
DEPT.	DATE	SIGN
Civil	-	-
Engineering	-	-
Production	-	-
PROJ. ENG.	-	-
PROJ. MNG.	-	-
	DATE	NAME
DRAWN BY:	NOV 2016	AB
CHECKED:	NOV 2016	AD
APPROVED:	-	-

SHOALHAVEN CITY COUNCIL
.
WEST NOWRA RECYLING AND WASTE FACILITY
.
.
PROPOSED FINAL LANDFORM
3D LAYOUT

SCALE: SHOWN

SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 17 | REV: B



EXISTING SITE SURVEY
SCALE 1:4000

LEGEND:

- LD1 — LEACHATE MONITORING LOCATION
- BH11 — GROUNDWATER MONITORING LOCATIONS
- SW3 — SURFACE WATER MONITORING LOCATIONS

STAGE 4
MONITORING LOCATION COORDINATES

SETTING OUT POINT	EASTING	NORTHING	GROUND LEVEL
GW1	276,107.00	6,136,839.00	50.37
GW1A	276,111.00	6,136,841.00	50.39
GW2	276,263.00	6,136,958.00	47.08
GW2A	276,267.00	6,136,960.00	46.97
GW3	276,258.00	6,137,248.00	46.25
GW4	276,401.00	6,137,113.00	48.49
GW5	276,238.00	6,137,084.00	49.13

Shoalhaven City Council

NOTE:
1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.

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REFERENCE			REVISIONS					
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-	-		B	29.11.16	REVISED AFTER COMMENTS FROM SCC	AB	AD	
-	-		A	30.03.16	ISSUED FOR INFORMATION	AB	AD	
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Western Australia
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Fax : +61 8 9422 5901

APPROVED		
DEPT.	DATE	SIGN
Civil	-	-
Engineering	-	-
Production	-	-
PROJ. ENG.	-	-
PROJ. MNG.	-	-

	DATE	NAME
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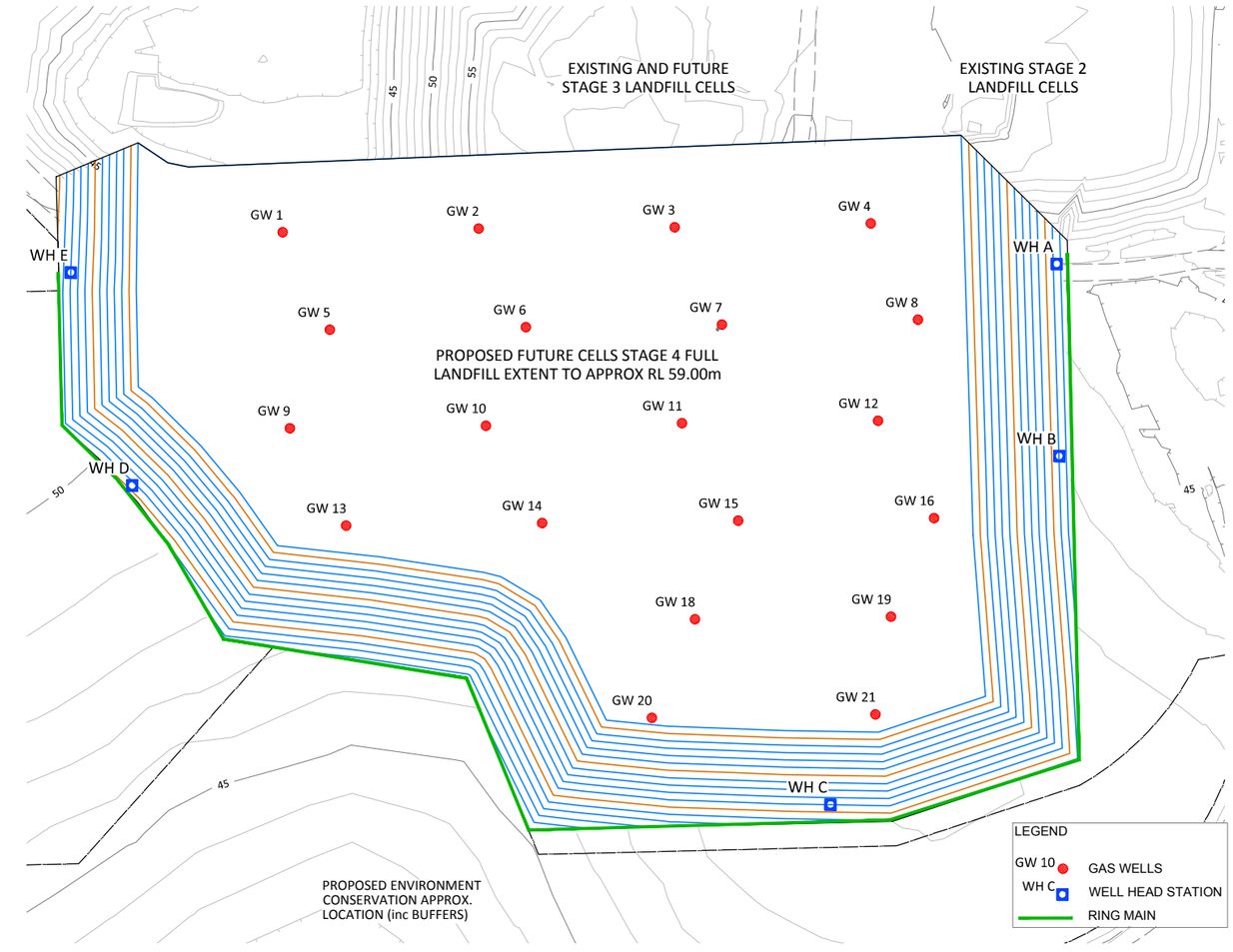
CHECKED:	NOV 2016	AD
APPROVED:	-	-

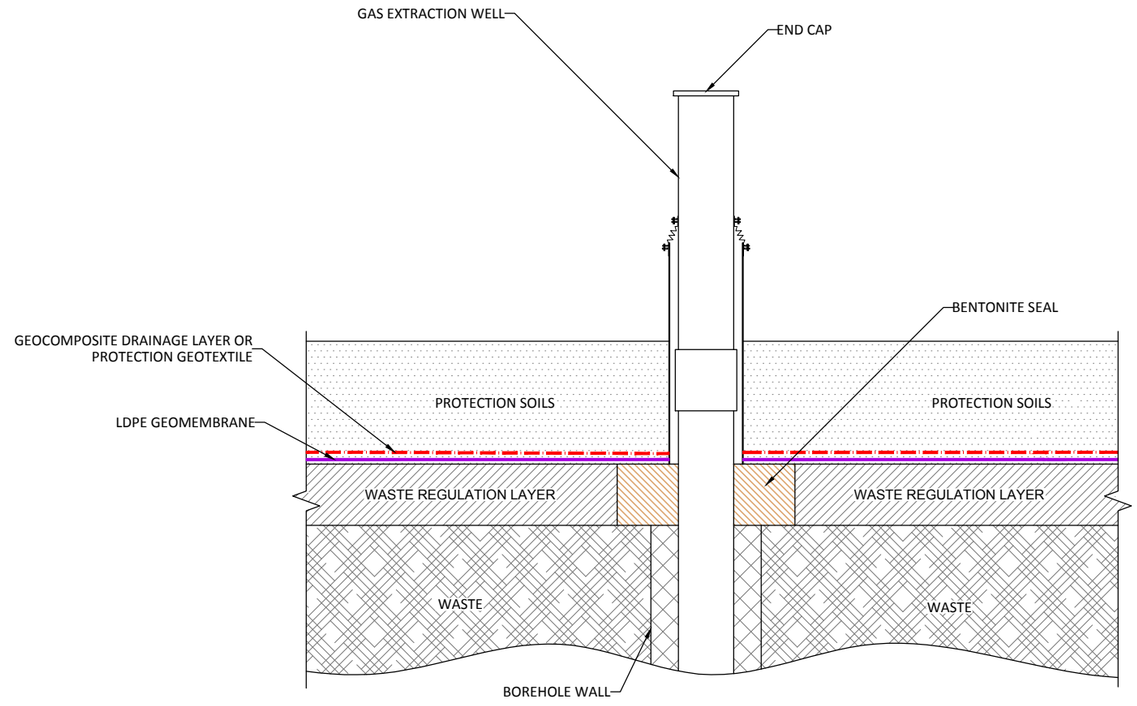
SHOALHAVEN CITY COUNCIL
.
WEST NOWRA RECYLING AND WASTE FACILITY
.
MONITORING LOCATIONS LAYOUT

SCALE: 1:4000
SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 18 | REV: B



TYPICAL LANDFILL GAS MANAGEMENT LAYOUT
SCALE 1:2,500



TYPICAL SECTION THROUGH SEALING DETAIL
AROUND GAS EXTRACTION POINT
SCALE 1:25

0 20m 50m 100m 150m
SCALE 1:2,500

Shoalhaven City Council

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REFERENCE		REVISIONS					
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-	-	A	30.03.16	ISSUED FOR INFORMATION	AB	AD	
DWG. NUMBER	TITLE	No.	DATE	DESCRIPTION	BY	CHKD	

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DEPT.	DATE	SIGN
Civil	-	-
Engineering	-	-
Production	-	-
PROJ. ENG.	-	-
PROJ. MNG.	-	-
	DATE	NAME
DRAWN BY:	NOV 2016	AB
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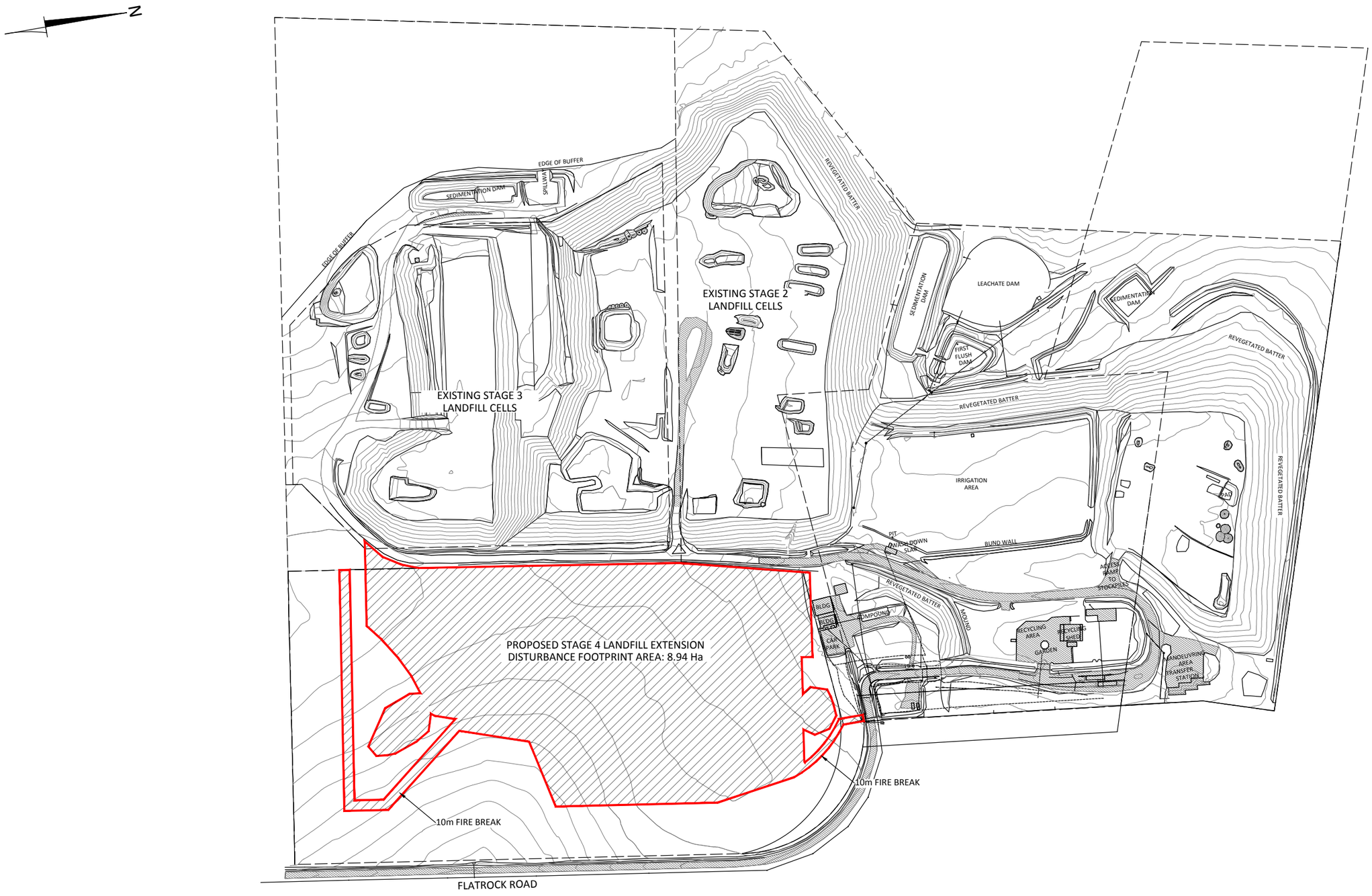
APPROVED:	-	-

SHOALHAVEN CITY COUNCIL
.
WEST NOWRA RECYLING AND WASTE FACILITY
.
TYPICAL GAS MANAGEMENT
LAYOUT & DETAILS

SCALE: SHOWN
SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 19 | REV: B



DISTURBANCE FOOTPRINT LAYOUT

SCALE 1:4000

Shoalhaven City Council

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REFERENCE		REVISIONS					
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-	-	A	30.03.16	ISSUED FOR INFORMATION	AB	AD	
DWG. NUMBER	TITLE	No.	DATE	DESCRIPTION	BY	CHKD	

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Fax : +61 8 9422 5901

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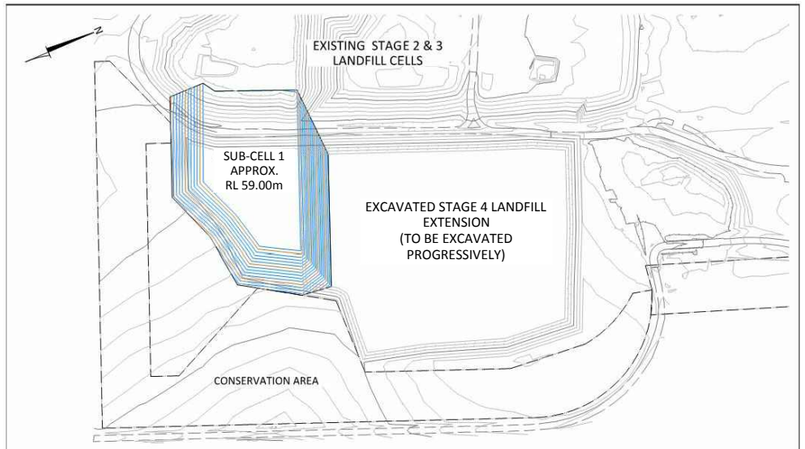
DEPT.	DATE	SIGN
Civil	-	-
Engineering	-	-
Production	-	-
PROJ. ENG.	-	-
PROJ. MNG.	-	-
	DATE	NAME
DRAWN BY:	NOV 2016	AB
CHECKED:	NOV 2016	AD
APPROVED:	-	-

SHOALHAVEN CITY COUNCIL
.
WEST NOWRA RECYLING AND WASTE FACILITY
.
DISTURBANCE FOOTPRINT FOR LANDFILL AND FIREBREAK LAYOUT

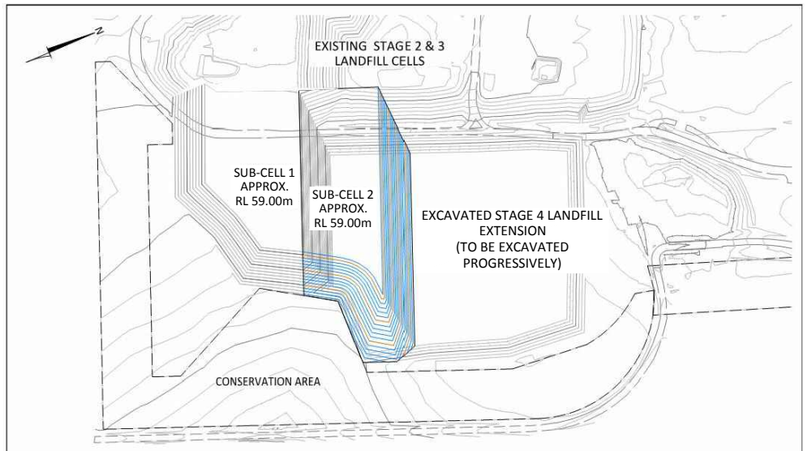
SCALE: 1:4000

SHEET: 1 of 1

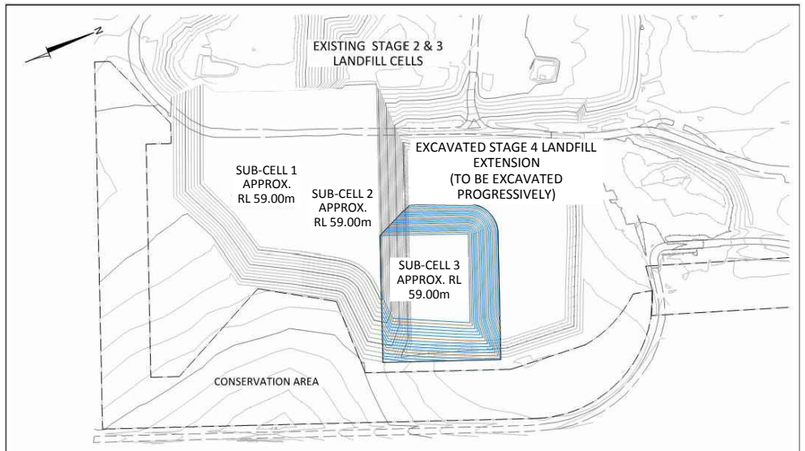
SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 20 | REV: A



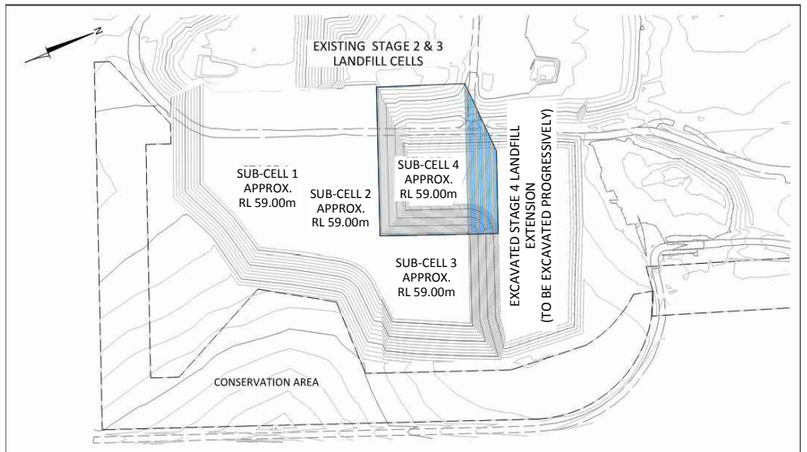
STAGE 1 FILL (NTS)



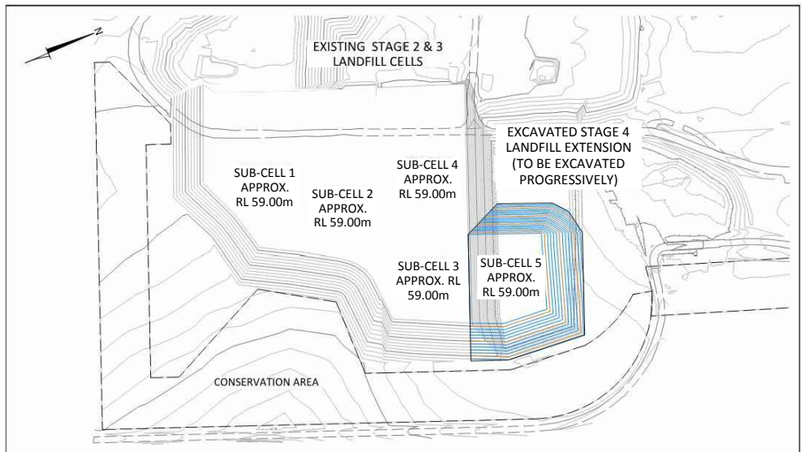
STAGE 2 FILL (NTS)



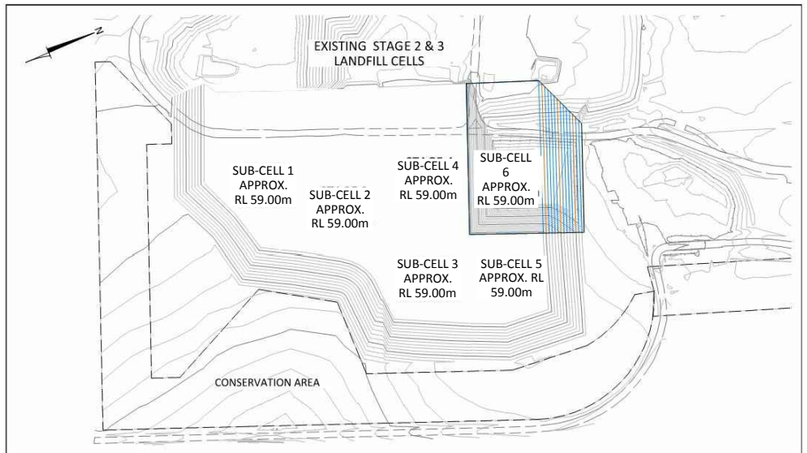
STAGE 3 FILL (NTS)



STAGE 4 FILL (NTS)



STAGE 5 FILL (NTS)



STAGE 6 FILL (NTS)

Shoalhaven City Council

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A	30.03.16	ISSUED FOR INFORMATION	AB	AD
No.	DATE	DESCRIPTION	BY	CHKD

SLR Consulting Australia Pty Ltd
Consulting Engineers & Scientists
589 Hay Street
Jolimont 6014
Western Australia
Tel : +61 8 9422 5900
Fax : +61 8 9422 5901

APPROVED		
DEPT.	DATE	SIGN
Civil	-	-
Engineering	-	-
Production	-	-
PROJ. ENG.	-	-
PROJ. MNG.	-	-
	DATE	NAME
DRAWN BY:	NOV 2016	AB
CHECKED:	NOV 2016	AD
APPROVED:	-	-

SHOALHAVEN CITY COUNCIL

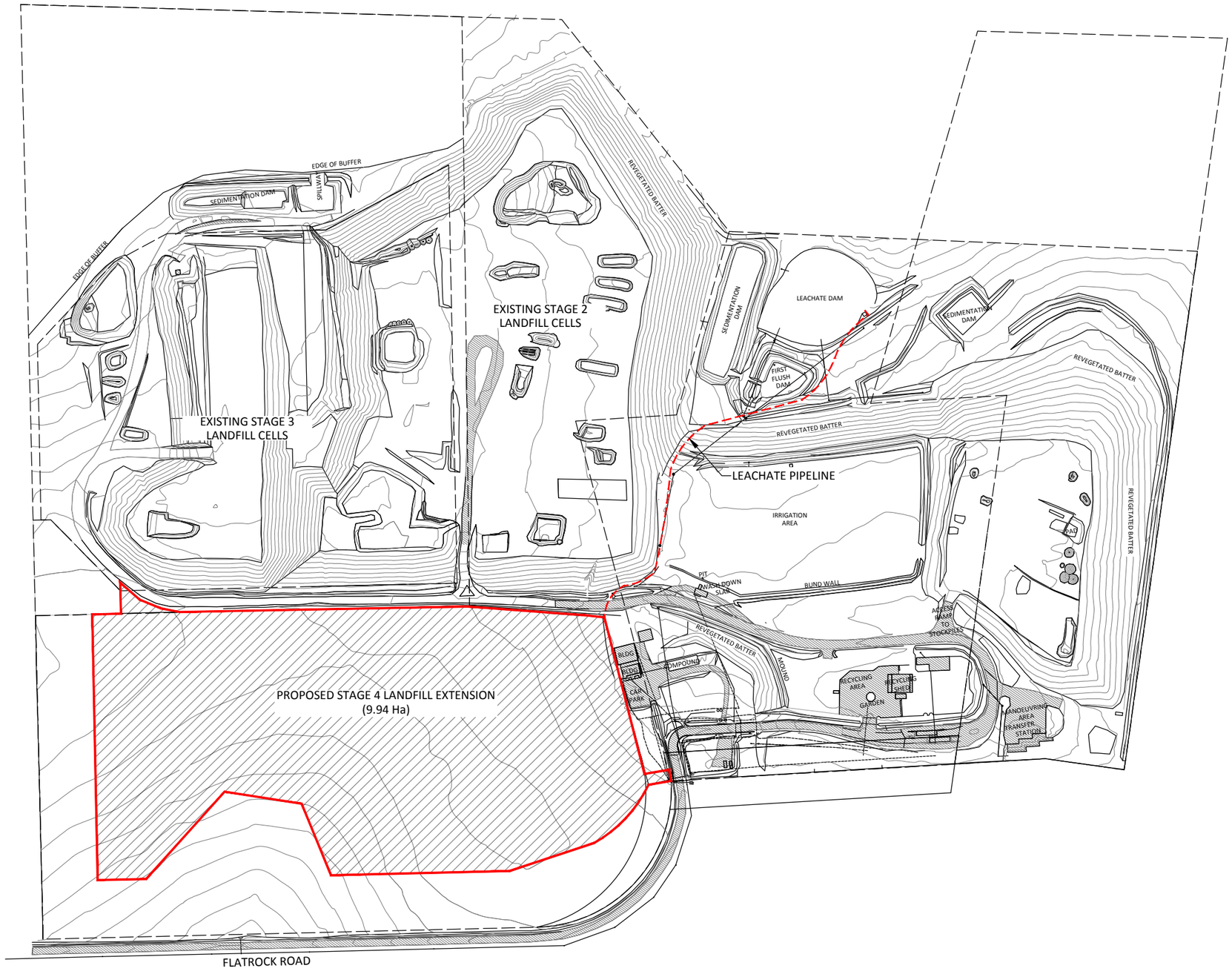
WEST NOWRA RECYLING AND WASTE FACILITY

PROPOSED FILLING PLAN LAYOUTS

SCALE: SHOWN

SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 21 | REV: A



DISTURBANCE FOOTPRINT LAYOUT

SCALE 1:4000

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Civil	-	-
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PROJ. MNG.	-	-
	DATE	NAME
DRAWN BY:	NOV 2016	AB
CHECKED:	NOV 2016	AD
APPROVED:	-	-

SHOALHAVEN CITY COUNCIL

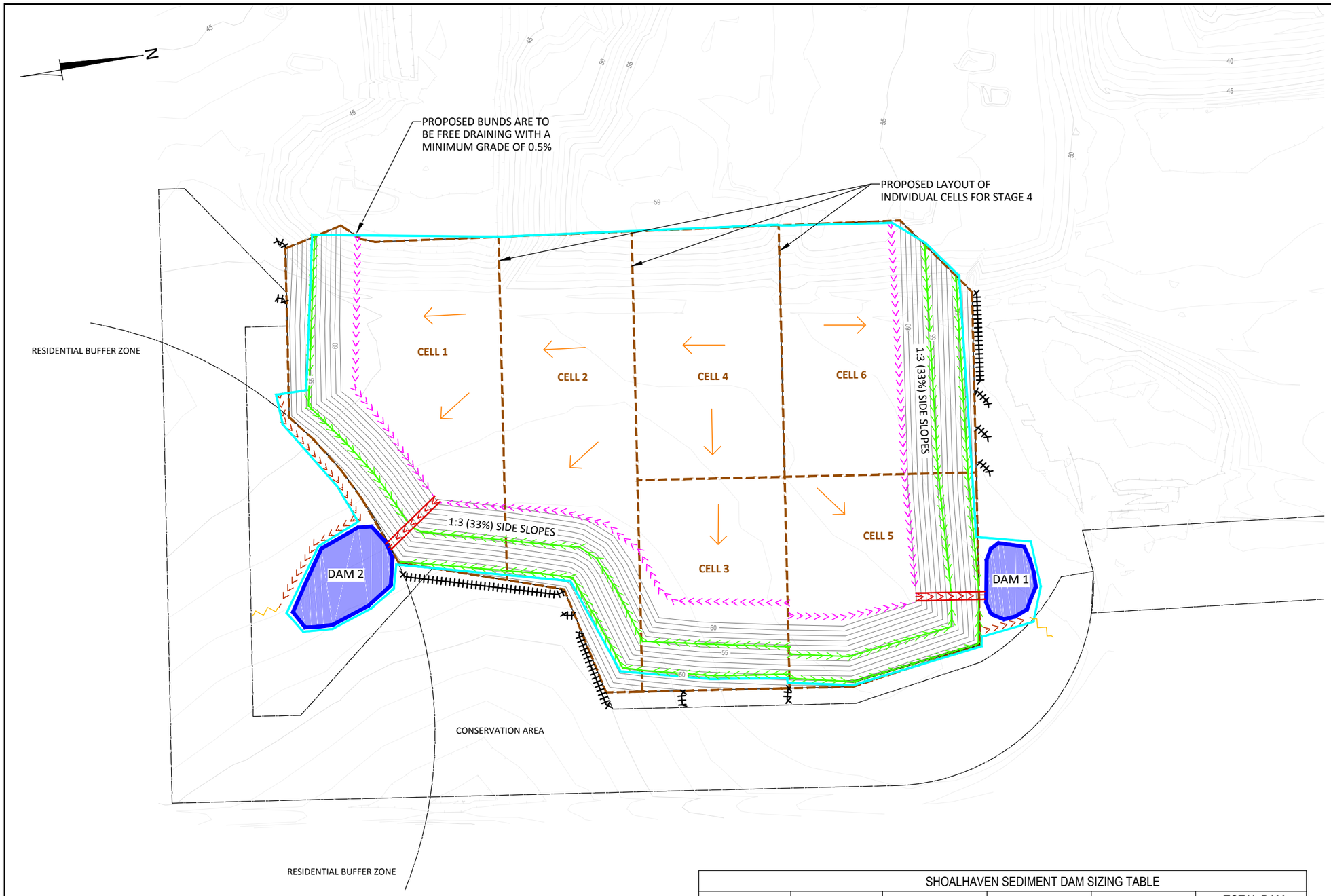
WEST NOWRA RECYLING AND WASTE FACILITY

TOTAL DISTURBANCE AREA
STAGE 4 EXTENSION
LAYOUT

SCALE: 1:4000

SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 22 | REV: A



LEGEND

- EXISTING CONTOURS (1m INTERVALS)
- DESIGN CONTOURS (1m INTERVALS)
- SEDIMENT FENCE
- PROPOSED SEDIMENT DAM
- SEDIMENT DAM CATCHMENT AREA
- PROPOSED PASTURE FURROWS
- PROPOSED DROP STRUCTURE
- PROPOSED BUND
- PROPOSED BACK-PUSH BANK
- INDICATIVE SURFACE WATER FLOW DIRECTION
- PROPOSED LEVEL SPREADER

NOTE:
FOR DETAILS REFER TO FIGURE 2.

NOTES

1. THE ESC MEASURES HAVE BEEN DESIGNED IN ACCORDANCE WITH THE Blue Book' (MANAGING URBAN STORMWATER: SOILS AND CONSTRUCTION VOL. 1, 4TH EDITION AND VOL. 2B WASTE LANDFILLS (LANDCOM, 2004 AND DECC, 2008)).
2. ESC MEASURE LOCATIONS ARE INDICATIVE ONLY. FINAL LOCATIONS TO BE DETERMINED DURING THE DETAILED DESIGN PHASE OF THE WORKS.
3. ALL ESC MEASURES SHALL BE INSPECTED ON A DAILY BASIS AND MAINTAINED AS REQUIRED THROUGHOUT THE COURSE OF THE WORKS AND FOLLOWING EACH INCIDENCE OF RAIN.
4. ALL SEDIMENT COLLECTED SHALL BE REGULARLY REMOVED AND IF UNSUITABLE FOR REUSE DISPOSED OF IN AN APPROVED MANNER.
5. ESC MEASURES SHALL BE INSTALLED PRIOR TO ANY GROUND DISTURBANCE.
6. ALL TEMPORARY ESC MEASURES SHALL BE REMOVED WHEN NO LONGER REQUIRED (I.E. 70% GRASS COVERAGE HAS BEEN ACHIEVED).
7. THE PROPOSED DROP STRUCTURES AND SEDIMENT DAM SPILLWAYS ARE TO BE DESIGNED DURING THE DETAILED DESIGN PHASE OF THE WORKS.

LANDFILL DESIGN LAYOUT
SCALE 1:2,500

0 20m 50m 100m 150m
SCALE 1:2,500

SHOALHAVEN SEDIMENT DAM SIZING TABLE

DAM	DESIGN STORM EVENT	CATCHMENT AREA (ha)	SETTLEMENT ZONE (ML)	SETTLING ZONE VOLUME (ML)	TOTAL DAM STORAGE VOLUME (ML)
Dam 1	5 day, 90 Percentile	3.0	1.58	0.79	2.37
Dam 2	5 day, 90 Percentile	6.5	3.46	1.73	5.19

NOTE:
1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.

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REFERENCE		REVISIONS				
DWG. NUMBER	TITLE	No.	DATE	DESCRIPTION	BY	CHKD
-	-	C	13.02.2017	PRELIMINARY ISSUE	MS	DB
-	-	B	25.01.2017	ISSUED FOR INFORMATION	MS	DB
-	-	A	18.01.2017	ISSUED FOR INFORMATION	MS	DB

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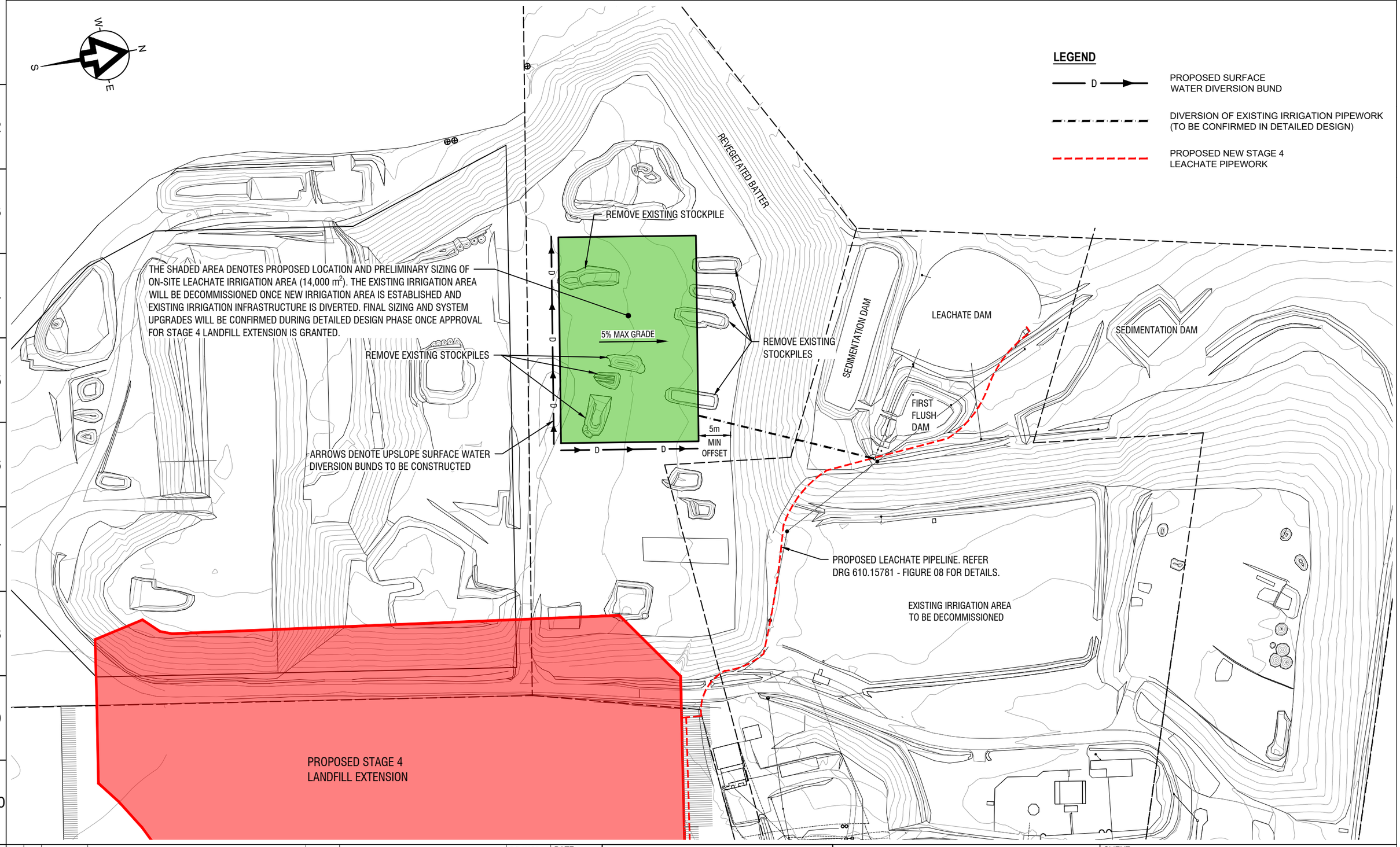
DEPT.	DATE	SIGN
Civil	-	-
Engineering	-	-
Production	-	-
PROJ. ENG.	-	-
PROJ. MNG.	-	-
	DATE	NAME
DRAWN BY:	JAN 2017	MS
CHECKED:	JAN 2017	DB
APPROVED:	-	-

SHOALHAVEN CITY COUNCIL
.
WEST NOWRA RECYLING AND WASTE FACILITY
.
CONCEPTUAL EROSION SEDIMENT CONTROL PLAN

SCALE: SHOWN
SHEET: 1 of 1

SLR PROJECT NUMBER: 610.15781 | DRAWING NUMBER: FIGURE 23 | REV: C



PLOT DATE Fri Nov 30 14:50:06 2018

REVISIONS

	DATE	DESCRIPTION	
A	30.11.2018	ISSUED FOR INFORMATION	OR

Responsible Principal Signature	Date
-	-

DRAWN:	OR	DATE:	NOV 2018
DESIGN:	JP	DATE:	NOV 2018
DRG. CHECK:	-	DATE:	-
DES. CHECK:	-	DATE:	-

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DIAL 1100 BEFORE YOU DIG

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SCALE 1:2500

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IF IN DOUBT ASK

CLIENT: SHOALHAVEN CITY COUNCIL

PROJECT: WEST NOWRA RECYCLING AND WASTE FACILITY

DRAWING TITLE: PROPOSED LEAC□ATE IRRIGATION AREA

DRAWING NUMBER: 610.15781 - FIGURE 24

ISSUE: A

APPENDIX D

SLR Leachate Management Memo 2018

Memorandum

To:	Zoe Wood	**At:**	Arcadis Australia Pacific Pty Ltd
From:	Sam Butler	**At:**	SLR Consulting Australia Pty Ltd
Date:	7 December 2018	**Ref:**	610.15781.00000-M01-v0.3_edits.docx
Subject:	West Nowra Recycling and Waste Facility		

1 Introduction

Arcadis has engaged SLR Consulting (SLR) to determine suitable leachate management options for the West Nowra Recycling and Waste Facility (the Facility) as a result of Stage 4 landfilling activities.

1.1 Background

It is understood that the Facility is divided into several stages and leachate is managed as follows:

- Stage 1: "Old" unlined landfill, stockpile and irrigation areas, and landfill gas extraction comprising the northern portion of the Facility. It is understood that Stage 1 landfilling occurred in unlined trenches. A combination of gravel and concrete drains discharge leachate to the existing leachate dam.
- Stage 2: Completed lined landfill areas, are now used for stockpiling and landfill gas extraction. It is understood that Stage 2 leachate is currently discharged to the existing leachate dam.
- Stage 3: Active lined landfilling of solid waste and wet weather tipping areas, and future landfill gas extraction area. It is understood that Stage 3 leachate is currently discharged to the existing leachate dam.
- Stage 4: Proposed lined landfilling areas for solid waste, and future landfill gas extraction. Leachate management for Stage 4 is to be determined.

1.2 Site Leachate Management Infrastructure

Existing leachate management infrastructure at the Facility is detailed within Table 1.

Table 1: Existing Leachate Infrastructure

Parameter	Comment
Existing Irrigation System	On average since December 2015, Council has pumped 1257.84 m^3 of leachate to the irrigation area per year. (Shoalhaven City Council, 15/10/18)
Existing Leachate Storage Pond	Maximum storage capacity of Pond of 8.9 ML (Memorandum to David Hojem from Giordano Bianco 14/9/17)

2 Leachate Generation

2.1 Existing Site Data

Council provided leachate generation data from Landfill Stages 1 - 3 (2013 - 2014) for potential use within the Site leachate generation water balance. Council also notes that no data was available for landfill Stages 1 and 2 (old unlicensed areas, and prior to any record keeping). Several months within the historical data set were noted to be missing with other years not available.

It is considered that due to the historical and incomplete nature of the site leachate generation data, estimates of leachate produced by Stages 1 – 3 should instead be determined by the use of the Hydrologic Evaluation of Landfill Performance (HELP) computer program.

2.2 HELP Input Parameters

HELP input parameters developed for the Site leachate generation assessment is included within **Appendix A**.

2.3 Stage 1 - 3 Leachate Generation Summary

For the purposes of leachate generation modelling the HELP model conservatively incorporates 90th percentile annual rainfall volumes from historically wetter years. The monthly infiltration percentage rates are in accordance with associated capping arrangements (detailed within **Table 11**) and the monthly rainfall.

Where areas have been temporarily capped, an infiltration rate of 25 – 30% is typically attained and infiltration rates in restored (final capping areas) are typically in the range of 2 – 10% (Environmental Protection Agency, 2000).

Estimated leachate generation produced by Stages 1 – 3 is detailed Table 2.

Table 2 Leachate Generation Summary – Stages 1 - 3

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual Total (m^3)
	Monthly Precipitation (mm)	63.5	81.5	83.4	96.0	87.3	70.5	98.5	121.5	138.3	108.0	106.8	115.6	1170.9
Stage 1 Closure Area	Leakage (mm)	3.24	3.2	3.1	3.24	3.12	3.19	3.21	2.9	3.26	3.15	3.28	3.19	
	Monthly Infiltration Percentage (%)	4.8%	3.0%	3.2%	2.8%	2.6%	3.6%	2.3%	1.6%	1.7%	2.0%	2.4%	1.8%	
	Leachate Production (m^3)	92.34	91.2	88.35	92.34	88.92	90.915	91.485	82.65	92.91	89.775	93.48	90.915	1,085.28
Stage 2 Closure Area	Leakage (mm)	1.3	0.93	1.66	1.36	0.9	0.46	0.73	0.73	1.08	1.17	1.78	1.36	
	Monthly Infiltration Percentage (%)	2.0%	1.1%	2.0%	1.4%	1.0%	0.7%	0.7%	0.6%	0.8%	1.1%	1.7%	1.2%	
	Leachate Production (m^3)	115.7	82.77	147.74	121.04	80.1	40.94	64.97	64.97	96.12	104.13	158.42	121.04	1,197.9
Stage 3 Closure Area	Leakage (mm)	1.03	1.04	1.52	1.43	1.02	0.66	0.8	0.69	0.86	1.01	1.37	1.23	
	Monthly Infiltration Percentage (%)	1.6%	1.3%	1.8%	1.5%	1.2%	0.9%	0.8%	0.6%	0.6%	0.9%	1.3%	1.1%	
	Leachate Production (m^3)	91.67	92.56	135.28	127.27	90.78	58.74	71.2	61.41	76.54	89.89	121.93	109.47	1,126.7
Stage 3 Operational Area	Leakage (mm)	26.5	23.1	20.2	23.1	25.7	27.9	27.2	25.6	28.5	26	26.6	27.1	
	Monthly Infiltration Percentage (%)	41.73%	28.34%	24.22%	24.06%	29.44%	39.57%	27.61%	21.07%	20.61%	24.07%	24.91%	23.44%	

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual Total (m^3)
	Leachate Production (m^3)	212	184.8	161.6	184.8	205.6	223.2	217.6	204.8	228	208	212.8	216.8	2460
Estimated Monthly Stage 1 -3 leachate production (m^3)		511.7	451.3	533.0	525.5	465.4	413.8	445.3	413.8	493.6	491.8	586.6	538.2	5869.96

2.4 Stage 4 Leachate Generation Summary

The monthly infiltration percentage rates vary in accordance with associated capping arrangements (detailed within **Table 11**) and the associated monthly rainfall. Estimated leachate generation produced by Stage 4 is detailed in Table 3.

Table 3 Leachate Generation Summary – Stage 4

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual Total (m^3)
	Precipitation (mm)	63.5	81.5	83.4	96.0	87.3	70.5	98.5	121.5	138.3	108.0	106.8	115.6	
Closure 8.9 Ha	Leakage (mm)	4.75	4.73	4.57	4.72	4.54	4.65	4.63	4.23	4.68	4.55	4.75	4.6	
	Monthly Infiltration Percentage (%)	7.5%	5.8%	5.5%	4.9%	5.2%	6.6%	4.7%	3.5%	3.4%	4.2%	4.4%	4.0%	
	Leachate Production (m^3)	422.75	420.97	406.73	420.08	404.06	413.85	412.07	376.47	416.52	404.95	422.75	409.4	4930.6
Operational 0.8 Ha	Leakage (mm)	26.5	23.1	20.2	23.1	25.7	27.9	27.2	25.6	28.5	26	26.6	27.1	
	Monthly Infiltration Percentage (%)	41.73%	28.34%	24.22%	24.06%	29.44%	39.57%	27.61%	21.07%	20.61%	24.07%	24.91%	23.44%	

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	**Annual Total (m^3)**
	Leachate Production (m^3)	212	184.8	161.6	184.8	205.6	223.2	217.6	204.8	228	208	212.8	216.8	2460
Stage 4 monthly leachate production (m^3)		634.75	605.77	568.33	604.88	609.66	637.05	629.67	581.27	644.52	612.95	635.55	626.2	7390.6

3 Leachate Management Options

A summary of feasible leachate management options including typical advantages and disadvantages are listed within Table 4.

It should be noted that re-circulation is not considered a feasible leachate reduction option within this assessment, as once the absorptive capacity within the waste mass is reached, no source reduction of leachate is achieved.

Table 4 Leachate Management Option Summary

Option	Option Description	Advantages	Disadvantages
1	Leachate Storage Pond	**Simple** – A storage pond provides a relatively simple and effective method of managing leachate **Storage** - A leachate storage pond can be utilised in conjunction with other alternate leachate treatment methods such as physico-chemical treatment or thermal treatment.	**Cost** - Ponds are required to be lined to the equivalent performance standard as the landfill and are subject to the same landfill construction approvals and auditing requirements. **Odour** - If leachate ponds become anaerobic, or where odour is particularly critical due to surrounding sensitive land uses, leachate odours can become an issue. Where odour is an actual or potential issue, then the leachate pond may need to be covered or mechanically aerated. Other associated leachate measures such as irrigation will provide some source reduction, lowering the amount of leachate stored in the leachate storage pond, but should not be relied upon to reduce odour issues. **Pond size** – Large storage pond is necessary to ensure sufficient sizing in accordance with best practice NSW EPA requirements.
2	Reverse Osmosis (RO) Plant – leachate treatment	**Leachate reduction** – Can achieve moderate reduction in leachate for the site estimated at ~60%, dependant on leachate quality.	**Cost** – High capital expenditure and potentially requiring a separate approval from EPA. **Power** –High power consumption for operation **Maintenance** –Involves regular on-going maintenance **Leachate concentrate** – Moderate levels of by-product volumes of leachate concentrate produced (~40%) **Not a standalone system** - Must be utilised in conjunction with other leachate management measures, such as leachate pond storage
3	Direct Evaporation Treatment System - Leachate is evaporated by the combustion of landfill gas.	**Leachate reduction** - High reduction in leachate feed volume ~90%. Leachate treatment rate of 35m^3/day.	**Maintenance** – Maintenance required, albeit minimal. **Not a standalone system** - Must be utilised in conjunction with other leachate management measures, such as leachate pond storage.

Option	Option Description	Advantages	Disadvantages
	Leachate combustion machines can either be portable or placed in fixed locations for long-term service. The system can be operated on a variety of fuels – natural gas, methane, propane, fuel oil or waste oil.	**Leachate concentrate** – Low by-product levels of leachate concentrate produced (~10%) **Operational Area** – Minimal space requirements in comparison to other infrastructure, i.e. in comparison to an additional leachate storage pond	**Landfill gas use** –Consumption of landfill gas (180 m^3/hr of LFG consumption for 35m^3/day of leachate reduction) **Leachate concentrate –** Further management measures may be required to deal with the high strength leachate concentrate. **Moderate Cost –** Moderate capital expenditure (~ $0.5M). Cost effective in comparison to an RO plant
4	Surface irrigation of leachate over suitable areas at the landfill	**Cost effective –** Low construction and installation cost in comparison to other treatment systems. **Leachate reduction** - Moderate levels of leachate reduction. Source reduction – Surface irrigation increases the level of evapotranspiration.	**Moderate application rate**- The irrigation application rate must not exceed the capacity of the land to absorb the nutrient, salt, organic and hydraulic loadings supplied by the leachate. It must not compromise any future use of the land or productivity of the soil. The application rate must minimise runoff. It should not cause spray drift of leachate. **Must be utilised in conjunction with other measures** - Occupiers must have contingency measures in place, should irrigation become unviable for any reason. This must include one or more of the other options discussed in this section, such as a leachate dam. **Effectiveness** - Spray irrigation over the active landfill surface may not be as effective in distributing the leachate throughout the waste mass in comparison to re-injection. It may also pose risks of increased odour impacts, surface runoff, and spray drift.
5	Solar system in conjunction with an RO Treatment Plant	**Leachate reduction** – High levels of leachate reduction achievable, leachate treatment rate of up to 100m^3/day.	**Cost** – High capital expenditure for Reverse Osmosis Plant and potentially requiring a separate approval from EPA. **Power** –Moderate to high power consumption for operation **Maintenance** –Involves regular on-going maintenance of filtration units **Leachate concentrate** – Moderate levels of by-product volumes of leachate concentrate produced (~20-40%) **Not a standalone system** - Must be utilised in conjunction with other leachate management measures, such as leachate pond storage

Option	Option Description	Advantages	Disadvantages
6	Leachate Storage Tank	**Simple** – A storage tank provides a relatively simple and effective method of managing leachate **Storage** - A leachate storage pond can be utilised in conjunction with other alternate leachate treatment methods such as physico-chemical treatment or thermal treatment.	**Cost** – High capital expenditure required for the installation of suitably sized storage tanks. **Bunding** - Tanks and associated connection points must be surrounded by a bund with a capacity of at least 110% of the tanks. **No Evaporation –** If the storage tank is enclosed, no evaporation (source reduction) will occur.
7	Discharge to public sewer	**Low impact** – Sewer discharge typically has a low environmental impact for the landfill operation and does not have the same odour issues typically associated with leachate pond storage or irrigation.	**Approval** - requires the approval of the local sewerage authority and a Trade Waste Agreement, which may impose restrictions on the quality of leachate permitted to be discharged **Location** – Assessment of feasibility required **Cost** – Connection costs and sewer discharge rates may make sewer discharge unfeasible. **Treatment -** Sewer discharge and treatment at the wastewater treatment plant can encounter issues if the leachate contains high levels of contaminants.

3.1 Leachate Management Recommendations

The performance rating for each criterion is determined as detailed within Table 5. Each leachate management option is rated using an Ordinal scale: 5 (*Excellent*) to 0 (*Very Poor*). Each criterion is weighted evenly in this brief analysis.

Table 5 Leachate Management Multi-Criteria Analysis

Option		Criteria				Total Score
		Leachate Reduction	Capital Expenditure	On-going Maintenance	Energy Consumption	
1	Leachate Storage Pond	2	25	4	4	12
2	Reverse Osmosis (RO) Plant – leachate treatment	3	1	2	1	7
3	Direct Evaporation Treatment System - Leachate is evaporated by the combustion of landfill gas	4	2	4	3	13
4	Surface irrigation of treated leachate on suitable areas of the landfill subject to salinity management	3	4	4	4	15

Option		Criteria				Total Score
		Leachate Reduction	Capital Expenditure	On-going Maintenance	Energy Consumption	
5	Solar system in conjunction with an RO Treatment Plant	5	21	2	2	110
6	Leachate Storage tank	1	2	4	5	12
7	Discharge to public sewer	4	1	4	3	12

Based upon **Table 5**, it is recommended that the following leachate management measures are given further consideration in conjunction with Option 1 within a Site Water Balance:

- Option 4 - Construction of an Irrigation System (Constructed on-top of Cell 2)
- Option 3 - Direct Evaporation Treatment System - Evaporation by the combustion of landfill gas

4 Water Balance

A water balance is developed for the analysis of alternate leachate management scenarios at the Site. In accordance with NSW EPA Environmental Guidelines: Solid Waste Landfills, the water balance was conducted over a period of two consecutive wet years (90th percentile) to ensure that the proposed system has sufficient capacity to deal with all leachate generated during both the operational and closure periods of the landfill.

The site water balance considers the following scenarios, as described in Table 6.

Table 6: Scenario Summary

Scenario	Scenario Detail
1	Utilisation of the existing leachate storage pond (Option 1) and the construction of an irrigation system on the crest of Stage 2 (Option 4).
2	Utilisation of the existing leachate storage pond (Option 1) and the use of a direct evaporation treatment system (Option 3).

4.1 Design Parameters

The design parameters appropriate for this water balance assessment as defined within Section 2.3 of the NSW EPA Environmental Guidelines: Solid Waste Landfills, are summarised within **Table 7**.

Table 7 Water balance design parameters

Item	Requirement
General	Collected leachate must be stored in appropriately sized dams or tanks and disposed of so as not to cause environmental harm. There must be sufficient leachate disposal capacity to prevent the build-up of leachate and an increase in the risks of water pollution and offensive odours.
Water balance requirement	The model should account for all predicted leachate inputs and outputs from the leachate management system. The model should be run by using monthly time intervals, and it should estimate the changes in the cumulative volume with each month. The maximum cumulative volume may not be reached until many months into the landfill's operation.
Water balance duration	In deciding on any of the above management options, a water balance should be modelled over at least two consecutive wet years (90th percentile) to ensure that the proposed system has sufficient capacity to deal with all leachate generated over the operational life of the landfill.
Pan Coefficient	The evaporation from the leachate dam should be estimated by using a pan coefficient of 70%.
Storage	The dam must have a freeboard that can accept rainfall directly on the dam from a 24hour rainfall event with a 1-in-25-year average recurrence interval without overflowing.

4.2 Water Balance Scenarios

4.2.1 Scenario 1: Option 1 (Existing Leachate Storage Pond) and Option 4 (Proposed Irrigation Area over Stage 2)

An existing water balance is developed for Stages 1 – 4 to determine the sufficiency of the existing leachate storage pond and the construction of an irrigation system on the crown of Stage 2 to accommodate two consecutive wet years (90th percentile rainfall) and predicted leachate generation from Stages 1 - 4.

Parameters for the Scenario 1 water balance are provided within **Table 8**.

Table 8 Scenario 1 Water Balance Parameters

Scenario	Purpose	Assumptions
1	Determine the sufficiency of the existing leachate management system to accommodate two consecutive wet years (90th percentile rainfall) and predicted leachate generation from Stages 1 – 4.	1. Leachate management by the use of the existing leachate storage pond and a revised irrigation system constructed on Stage 2 (ie Option 1 and Option 4). 2. Irrigation system is able to dispose of 730mm/m^2 over the irrigation area per year at a rate of (851 m^3/month). 3. The clay cap where the irrigation system is proposed for Cell 2 requires removal and is to be re-instated with 1400mm depth of silty sand and 200mm of topsoil to allow for infiltration.

Input parameters for Scenario 1 are provided within **Table 9**.

Table 9 Water Balance Inputs

Inputs												
	January	February	March	April	May	June	July	August	September	October	November	December
Average Rainfall	396	719	339	343	178	427	322	265	249	376	316	403
90th Percentile Rainfall	427	547	560	645	586	474	662	816	929	726	717	777
Leachate from cell (m^3)	1151	1064	1109	1139	1082	1056	1080	999	1142	1110	1228	1171
Outputs												
Dam Evap (m^3)	908	724	642	483	376	316	358	488	604	749	800	953
Irrigation Use (m^3/month)	852	852	852	852	852	852	852	852	852	852	852	852

4.2.1.1 Preliminary Irrigation Area Sizing

The irrigation area was iteratively sized in accordance with the findings of the SEEP/W model. The irrigation modelling determined 730mm of leachate per m^2 can be applied over the irrigation area. The irrigation system to be constructed Stage 2 is required to be at least 14,000 m^2 in size. The findings of the preliminary irrigation modelling and conceptual sizing of the disposal area are included in **Appendix B**. The water balance (average and 90th percentile rainfall events) for Scenario 1 is depicted within **Figure 1**.

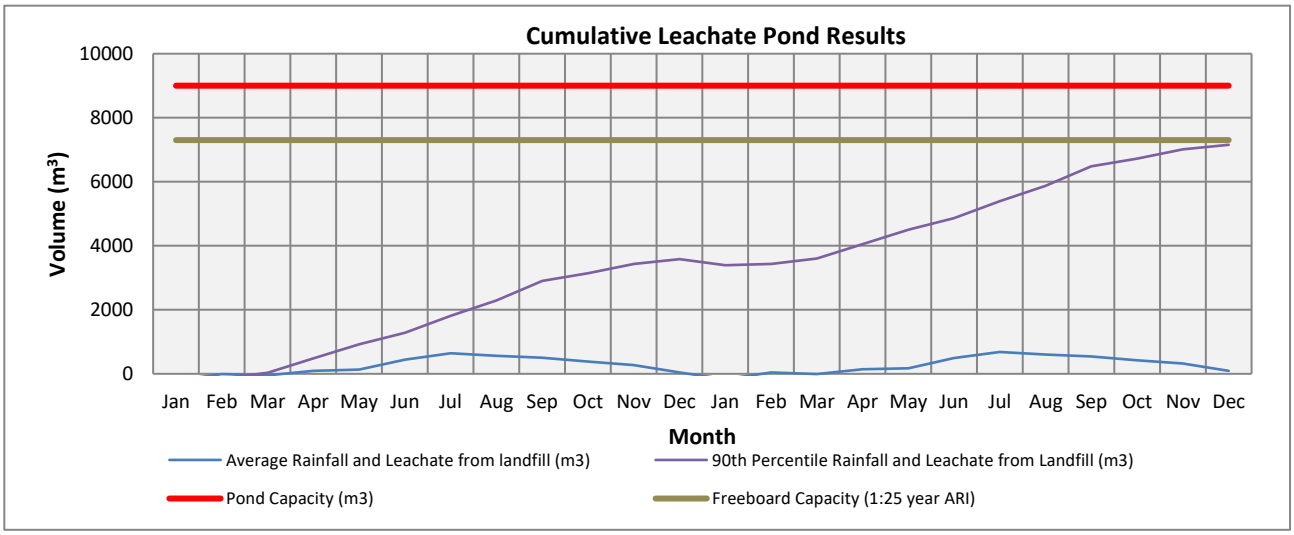

Figure 1 Scenario 1 Results

As shown in **Figure 1**, the water balance for Scenario 1 confirms sufficient capacity of the current leachate storage pond to accommodate two consecutive 90th percentile rainfall years and leachate generated by Stages 1-4 if a new irrigation area of 14,000m^2 is constructed

4.2.2 Scenario 2 Option 1 (Existing Leachate Storage Pond) and Option 3 (Direct Evaporation Treatment System)

As included within **Table 6**, a water balance is developed for Stages 1 - 4 including the use of the existing leachate storage pond and a direct evaporation treatment system. Parameters and assumptions used for the Scenario 2 water balance is provided within **Table 10**.

Table 10 Scenario 2 Water Balance Parameters

Scenario	Purpose	Assumptions
2	Determine if the evaporation treatment system in conjunction with the existing leachate storage pond is able to accommodate two consecutive wet years (90th percentile rainfall) and leachate generation from Stages 1 - 4.	1. Leachate management by the use of the existing leachate storage pond (Option 1) and a Direct Evaporation Treatment System (Option 3)- Evaporation of leachate by the combustion of landfill gas is included within this scenario. The evaporation rate of removal is 35m^3/day. 2. Disposal via irrigation not required in this scenario

Input parameters for Scenario 1 are provided within **Table 11**.

Table 11 Water Balance Inputs

Inputs	January	February	March	April	May	June	July	August	September	October	November	December
Average Rainfall	396	719	339	343	178	427	322	265	249	376	316	403
90th Percentile Rainfall	427	547	560	645	586	474	662	816	929	726	717	777
Leachate from cell (m^3)	1151	1064	1109	1139	1082	1056	1080	999	1142	1110	1228	1171
Outputs												
Dam Evap (m^3)	908	724	642	483	376	316	358	488	604	749	800	953
Direct Evaporation Treatment System (m^3/month)	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050

Leachate generation for average and 90th percentile rainfall events for Stages 1 - 4 is depicted within **Figure 2**.

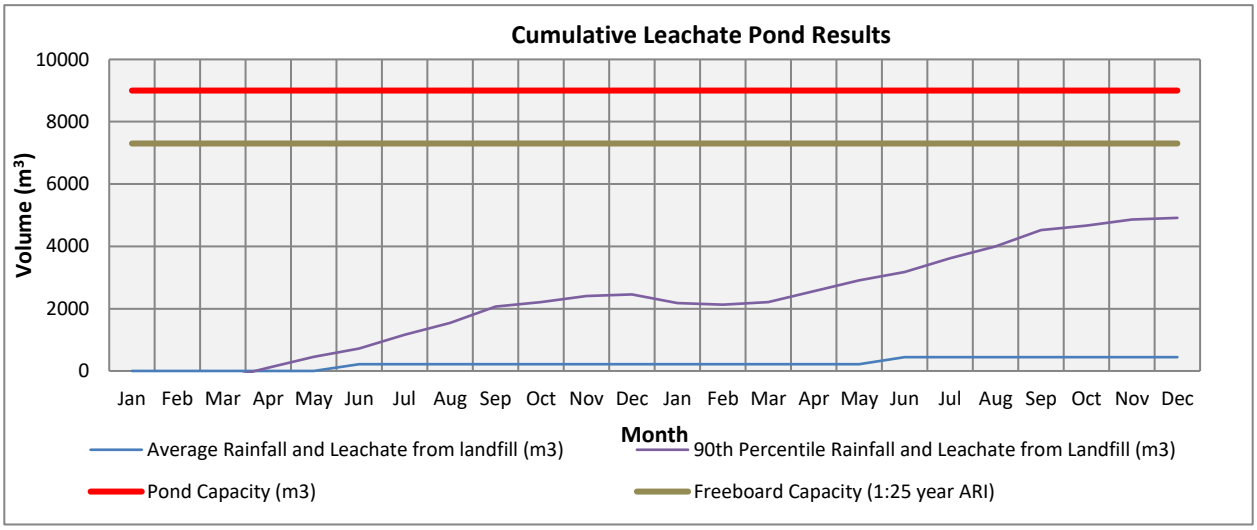

Figure 2: Scenario 2 Results

In this scenario, leachate generated by Stages 1 - 4 would be sufficiently dealt with via the direct evaporation treatment system and existing leachate storage pond.

5 Recommendation

Preliminary water balance modelling indicates that leachate volumes produced by Stages 1-4 is able to be managed by one of the following scenarios, as described in Table 12.

Table 12 Leachate Management Recommendations

Scenario	Description	Notes
1	Construction of an irrigation system on top of Cell 2. The irrigation system is to be utilised in conjunction with the existing leachate storage pond.	The clay cap where the irrigation system is proposed for Cell 2 will require removal and is to be re-instated with 1400mm of silty sand and 200mm of topsoil. The irrigation disposal area is required to be at least 14,000m^2 in size with a maximum annual leachate application rate of 730mm/m^2 at a rate of 851 m^3/month over the irrigation area per year. Refer to Appendix B for proposed irrigation area preliminary assessment and concept design.
2	Installation of a direct evaporation treatment system The evaporation system is to be utilised in conjunction with the existing leachate storage pond.	Evaporation treatment is recommended as an alternate leachate management measure to provide high levels of leachate source reduction and low levels of leachate concentrate.

6 Bibliography

Environmental Protection Agency. (2000). *Landfill Manuals: Landfill Site Design.*

NSW EPA. (2016). Environmental Guidelines: Solid Waste Landfills.

SLR Consulting. (2017). West Nowra Recycling and Waste Facility Proposed Stage 4 Landfill Extension Concept Design Report.

SLR Consulting. (2017). West Nowra Recycling and Waste Facility Proposed Stage 4 Landfill Extension Soil, Water and Leachate Assessment.

APPENDIX A

HELP INPUT PARAMETERS

HELP Input Parameters

A water balance was conducted over a period of two consecutive wet years (90th percentile) as recommended within the NSW EPA landfill guidelines, to ensure that the proposed system has sufficient capacity to deal with all leachate generated during both the operational and closure periods of the landfill.

The following section contains the input parameters used within the Hydrological Evaluation of Landfill Performance (HELP) model.

Capping Arrangements

The capping arrangements for Stages 1 – 4 for the purposes of HELP generation modelling are detailed within Table 13.

Table 13 Capping arrangements

Stage	Estimated Landfilled Area (ha)	Barrier Arrangement	Reference
1	9.5	Stage 1 Landfill is assumed to be covered with a compacted clay liner 600mm thick with a permeability of 10^{-9} m/s. Note: It is understood that Stage 1 landfilling occurred prior to regulatory licensing requirements, in unlined trenches. A combination of gravel and concrete drains discharge leachate to the existing leachate dam. It is estimated 30% of leachate produced is captured by the retro-fitted leachate system and discharged into the existing leachate storage pond.	Shoalhaven City Council (12th/10/18)
2	8.2	Stage 2 is assumed to be covered with a compacted clay liner with a permeability of 10^{-9} m/s and a geomembrane of 10^{-11} m/s.	
3	10	Stage 3 lining is a combination of clay lining and synthetic lining. For the purposes of this assessment, it is assumed the barrier layer comprises a permeability of 10^{-9} m/s.	
	0.8	300mm intermediate cover soils assumed to be a compacted liner with a permeability of 10^{-6} m/s.	
4	9.7	A seal bearing surface 300mm thick A sealing layer comprising: A 2mm low density polyethylene flexible membrane (i.e. LDPE) or approved alternative; and A Geosynthetic Clay Liner; A 1,000 mm revegetation layer	West Nowra Recycling and Waste Facility Proposed Stage 4 Landfill Extension Concept Design Report (SLR, 2017)
	0.8	300mm intermediate cover soils	

Climate Data

Climate data for the model was obtained from SILO (Scientific Information for Land Owners) which contains a database of historical climate records for Australia, hosted by the Science Delivery Division of the Department of Science, Information Technology and Innovation. SILO contains Australian climate data from 1889 to the present date of this assessment. SILO datasets are constructed from observational records provided by the

Bureau of Meteorology. SILO was utilized to process the raw data, which may contain missing values, to derive a dataset for the Site which is both spatially and temporally complete.

SILO data was obtained for, maximum and minimum temperature, pan evaporation, vapor pressure, and relative humidity at the times of maximum and minimum temperature.

Rainfall

A data set of over 25 years was obtained for this assessment, including solar radiation, daily rainfall and average temperature.

Evaporative zone depth

The evaporative zone depth is the maximum depth from which water may be removed by evapotranspiration. The value specified influences the storage of water near the surface and therefore directly affects the computations for evapotranspiration and runoff. Where surface vegetation is present, the evaporative depth should at least equal the expected average depth of root penetration. The depth specified should be characteristic of the maximum depth to which the moisture changes near the surface due to drying over the course of a year, typically occurring during peak evaporative demand or when peak quantity of vegetation is present. It is assumed that the evaporative zone depth for the purpose of this assessment is 10 cm.

Maximum leaf area index

Leaf area index (LAI) is defined as the dimensionless ratio of the leaf area of actively transpiring vegetation to the nominal surface area of the land on which the vegetation is growing. The LAI for this assessment is 1.0 (poor stand of grass, utilised for the operational landfilled areas) and 3.5 (good stand of grass, utilised for the closed/rehabilitated landfilled areas).

Growing Season

The growing season input parameter influences the evapotranspiration rate within the HELP model. The start of the growing season is based on mean daily temperature and plant species. Typically, the start of the growing season for grasses is the Julian date (day of the year) when the normal mean daily temperature rises above 10 to 13 degrees Celsius. For the purpose of this assessment, the growing season is considered to be year-round.

Other Climate Data Inputs

Other climate data properties incorporated into the HELP model include the average yearly average wind speed is 12.4 km/hr and average relative humidity for the area is described within Table 14.

Table 14 Average relative humidity

Quarter	Average Relative Humidity (%)
First Quarter	66
Second Quarter	62.7
Third Quarter	55.3
Fourth Quarter	58.0

APPENDIX B

PRELIMINARY LEACHATE IRRIGATION AREA ASSESSMENT

Introduction

Arcadis has engaged SLR Consulting (SLR) to determine suitable leachate management options for the West Nowra Recycling and Waste Facility (the Facility) as a result of the proposed Stage 4 landfilling activities. As part of this scope of work a preliminary assessment of the volume of leachate that can be applied to the proposed irrigation area over the existing Stage 2 area has been carried out.

The purpose of the desk based irrigation assessment was to determine a preliminary sizing of the required on-site leachate irrigation area to adequately manage irrigation waters and to inform the concept design for the EIS stage of the proposed landfill extension. This assessment has not included any site specific investigations and does not cover detailed irrigation system design, which shall be carried out in the detailed design phase, once approval has been granted.

Background

To assess the quantity of leachate that can be applied to an area without generating run-off a water balance of the soil system should be developed, which takes into consideration:

- Precipitation;
- Evapotranspiration;
- Surface runoff;
- Topography;
- Soil and vegetation characteristics; and
- Soil moisture storage.

The soil system is considered to be in balance when the precipitation entering the soil equals the amount leaving through evapotranspiration. In this case the irrigation volume will contribute to the water balance of the soil.

The area proposed to be utilised for irrigation is located in the central area of Stage 2, as shown in **Figure 3** below. This area was previously used for waste disposal and has a liner underlying the waste. The area has been capped with 200mm topsoil, 800mm silty sand, and 600mm clay.

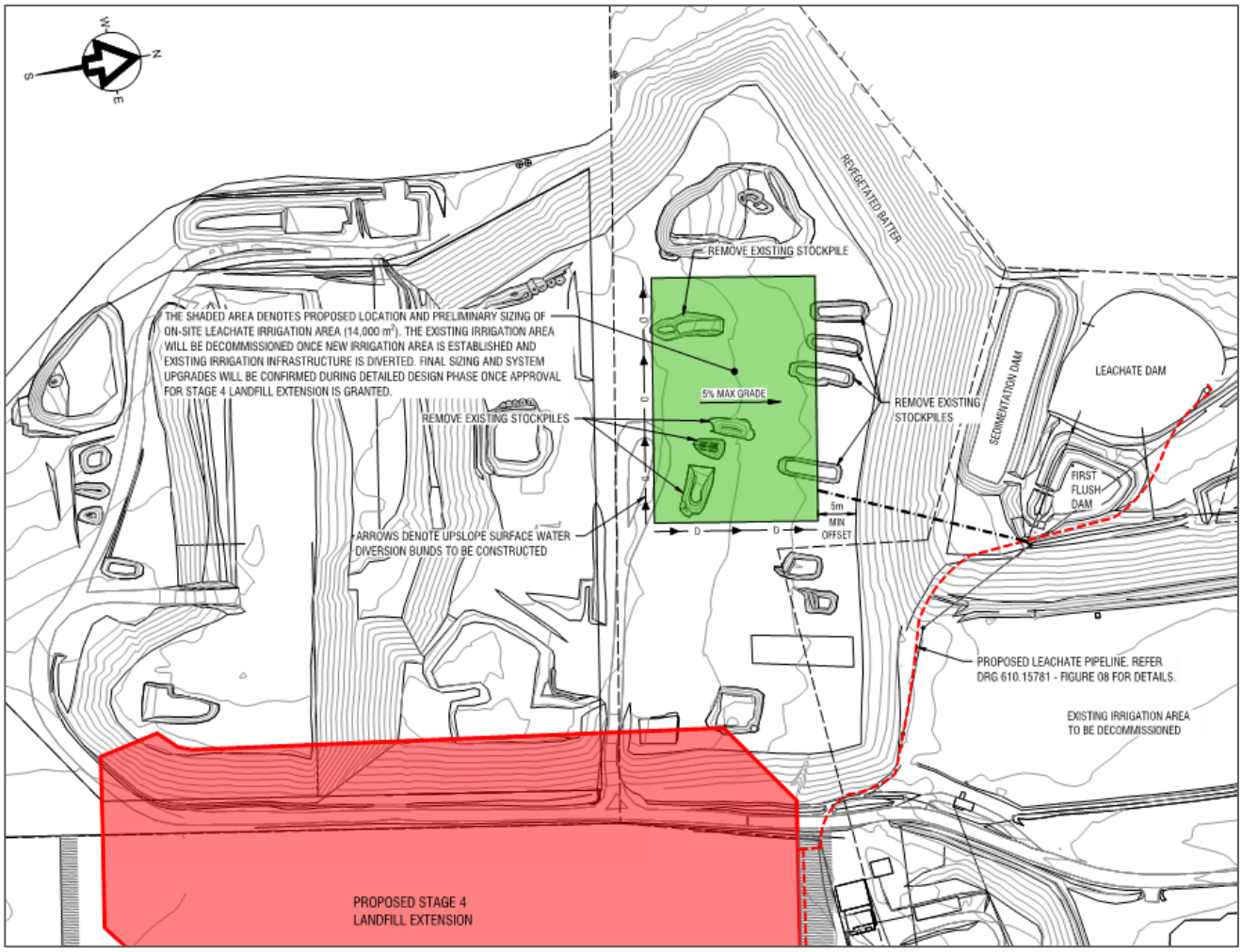

Figure 3 Proposed preliminary irrigation area

Climate

Climate data for the model was obtained from SILO (Scientific Information for Land Owners) which contains a database of historical climate records for Australia, hosted by the Science Delivery Division of the Department of Science, Information Technology and Innovation. SILO contains Australian climate data from 1889 to the present date of this assessment. SILO datasets are constructed from observational records provided by the Bureau of Meteorology. SILO was utilized to process the raw data, which may contain missing values, to derive a dataset for the Site which is both spatially and temporally complete.

SILO data was obtained for, maximum and minimum temperature, pan evaporation, vapor pressure, and relative humidity at the times of maximum and minimum temperature. SILO provides daily climate values which are required for input into the modelling programme.

Data for humidity, temperature, and solar radiation were obtained from the BOM website, with different stations providing different data sets:

- Humidity data was calculated quarterly using monthly percentages obtained for Nowra RAN Air Station AWS station (068072);
- Temperature data was obtained for Ulladulla AWS station (069138); and
- Solar radiation was obtained for Nowra Boat Shed station (068213).

Methodology

Geostudio is an integrated, multi-physics numerical analysis tool that has four components that simulate the flow of energy/mass. Geostudio SEEP/W coupled with thermal functionality has been utilised to simulate an average year of weather to the current layout of the Stage 2 capping profile. A 1D analysis of the soil profile can provide inputs to the evaporation potential of the system allowing for an estimate of additional loading to the system that can be undertaken. As this is a preliminary assessment to inform the concept design, no vegetation has been incorporated into this model, as it has been assumed that vegetation will not have been established at the outset of irrigation.

To ensure a conservative calculation of soil saturation potential prior to run off generation the profile utilised is shown in **Figure 2.2.1.** The current profile has an approximate slope of 3% and an approximate embankment slope of 23%. A land climate interaction boundary specifying the site specific climate data detailed in **Section 02,** has been applied to assess the evaporation potential of the soil system.

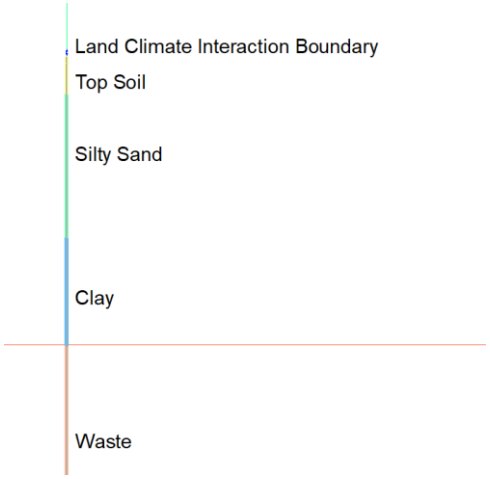

Figure 4: 1 Dimensional Analysis of the Capping Evaporation Potential

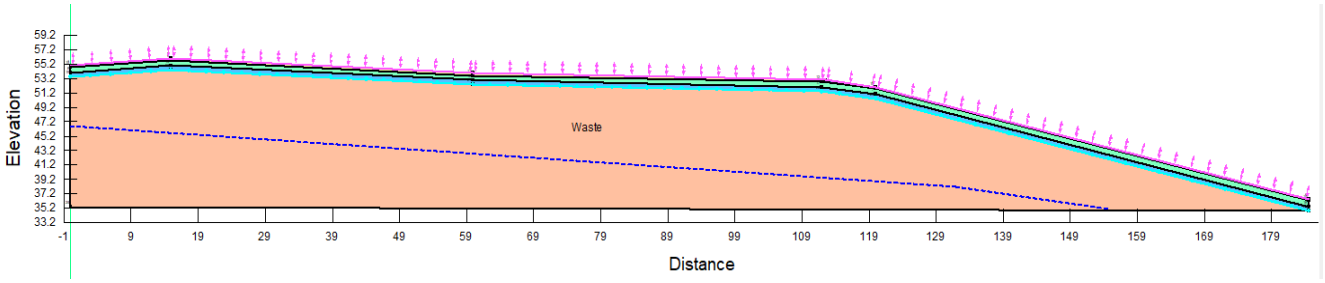

Figure 2.2 Shoalhaven Stage 2 landform profile modelled

It should be noted that site specific soil data for soil moisture curves were not provided and estimates established in literature have been used. Soil moisture curves provide the soil suction parameters of the model, which is the soils ability to retain water in an under unsaturated conditions. Confirmation of soil type and vegetation characteristics shall be carried out in the detail design phase.

Results

1D Soil Profile Analysis – Base Conditions

The cumulative runoff of the 1D soil column is indicative of the soil water balance, and whether the current system without additional irrigation would have any runoff generated. Based on the analysis the soil water balance the cumulative rainfall exceeds the cumulative evaporation; however, this does not mean that there is runoff generation as net percolation into the underlying soil layers contribute to the runoff potential and soil storage, **Figure 5**. Note that positive cumulative net infiltration is indicative of water moving into the soil and negative is indicative of water moving out of the soil.

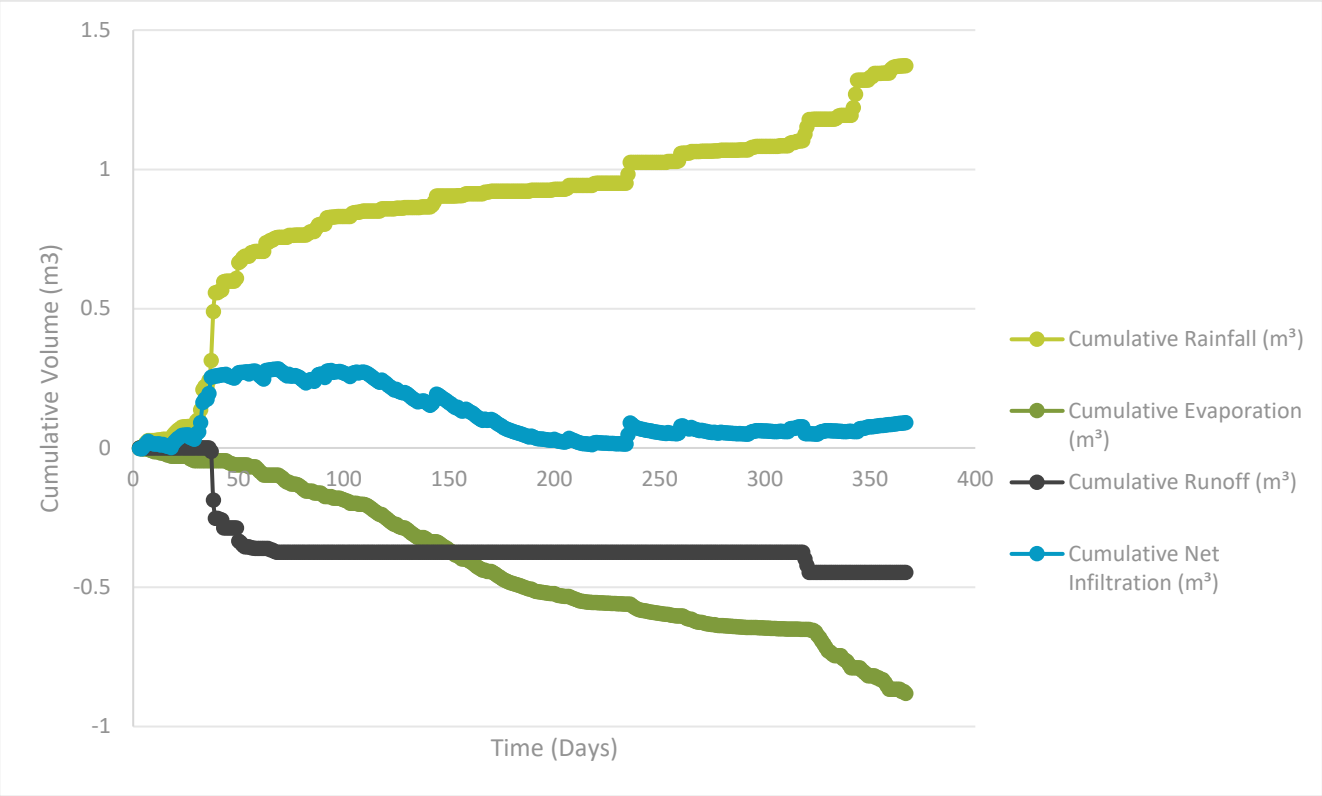

Figure 5 Cumulative climate and infiltration rates

The soil saturation degree is shown in **Figure 6** below. The soil saturation has been set at the top node of the analysis to determine when the system would generate runoff and be capable of taking additional leachate. As can be seen in the Figure 4, the system has periods where the soil is saturated and would generate some runoff as a result of rain exceeding the storage capacity and evaporation potential of the system. These instances are the result of rain events that are sustained over periods of 24 hours or greater.

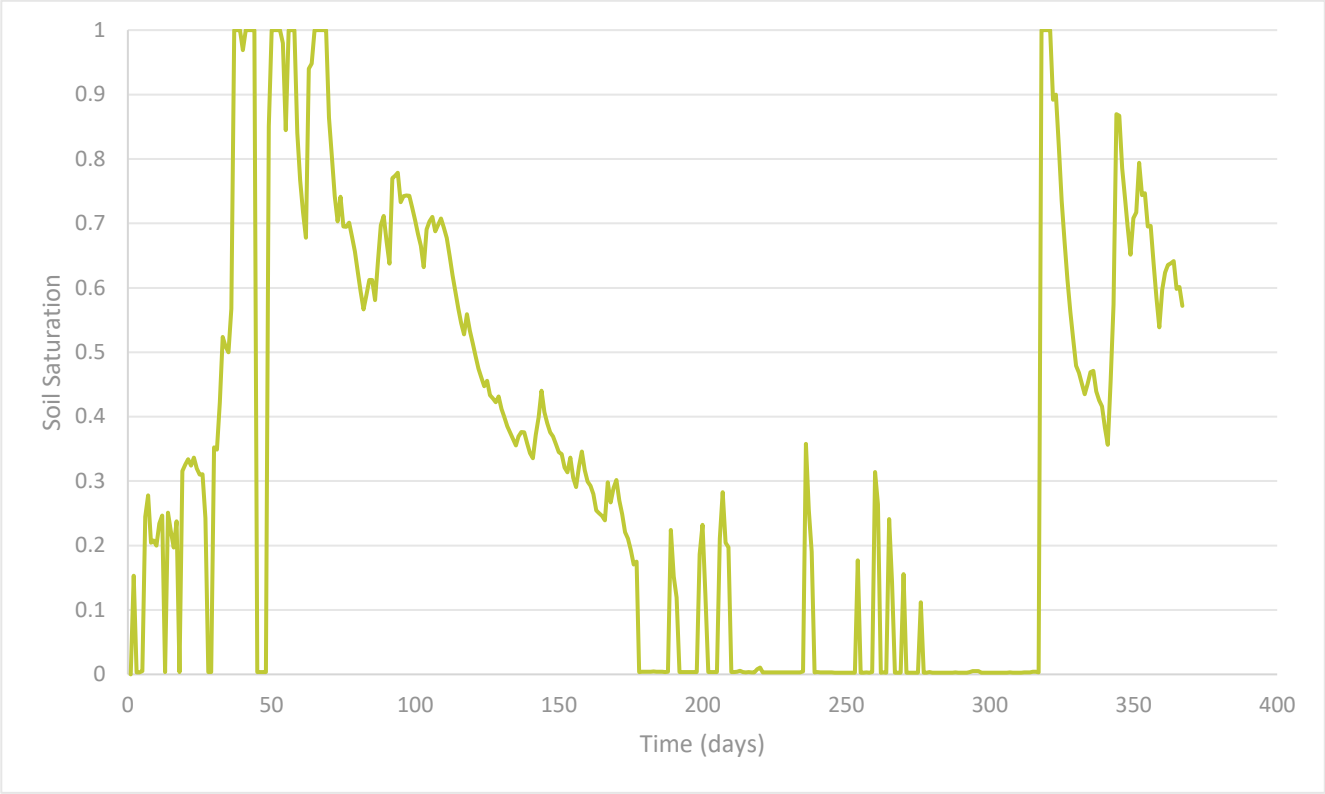

Figure 6 Soil Saturation over modelling period of 365 days

Application of leachate to the area at a rate 0.1mm per day over the course of the year, with days of precipitation excluded was modelled to assess the soil saturation with increased wetting. These results show that increasing the wetting of the soil horizon continually creates significantly greater soil saturation conditions, which are shown in **Figure 7**.

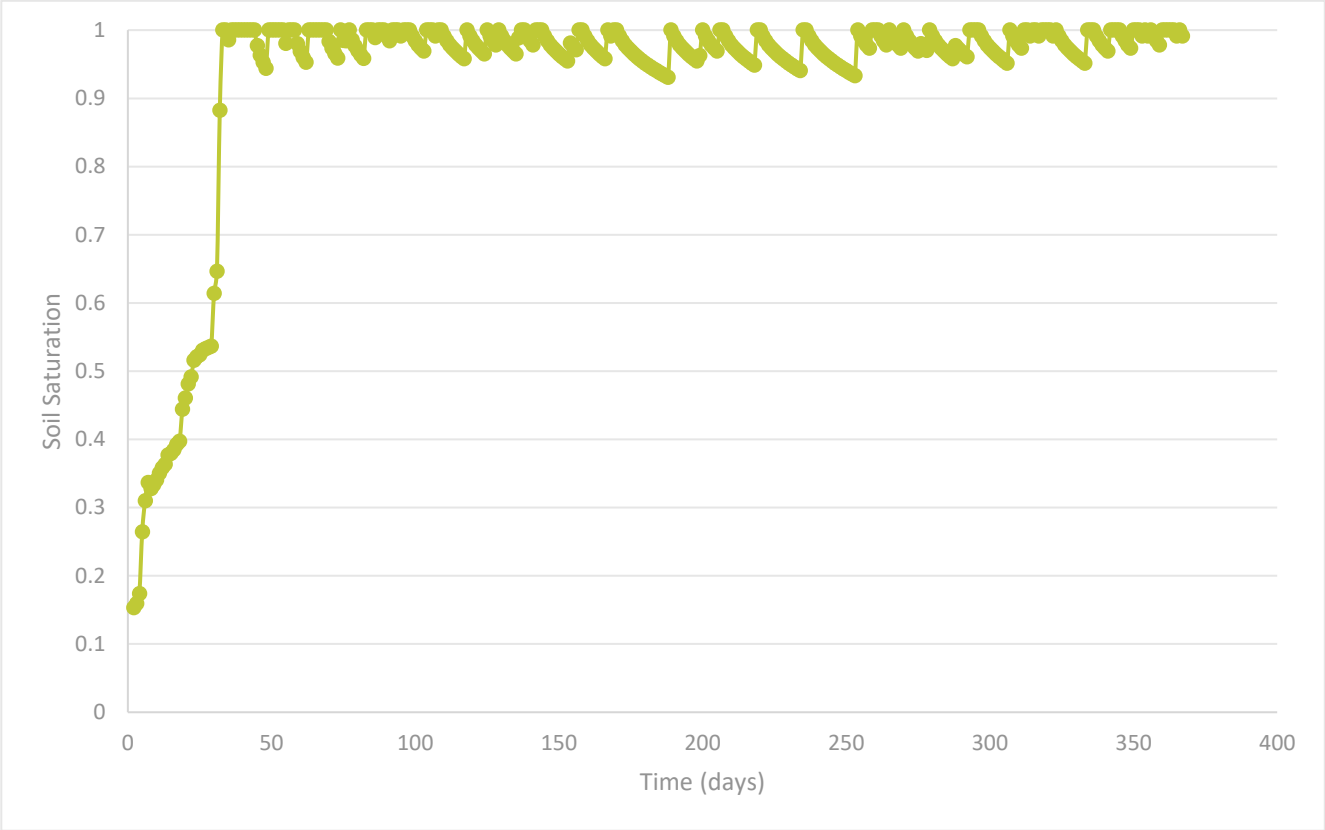

Figure 7 Soil Saturation at 0.1mm leachate application to the 1D column

The system was also modelled removing the clay liner component and replacing it with silty sand, the results of the degree of soil saturation running this simulation with just the environmental conditions are shown in **Figure 8** below. The simulation was also run with an application of 5mm of leachate applied to the area over each day that precipitation did not occur; these results are shown in **Figure 9** below. The results from the application of leachate at 2mm/day over 365 days show that run off is not likely to be generated.

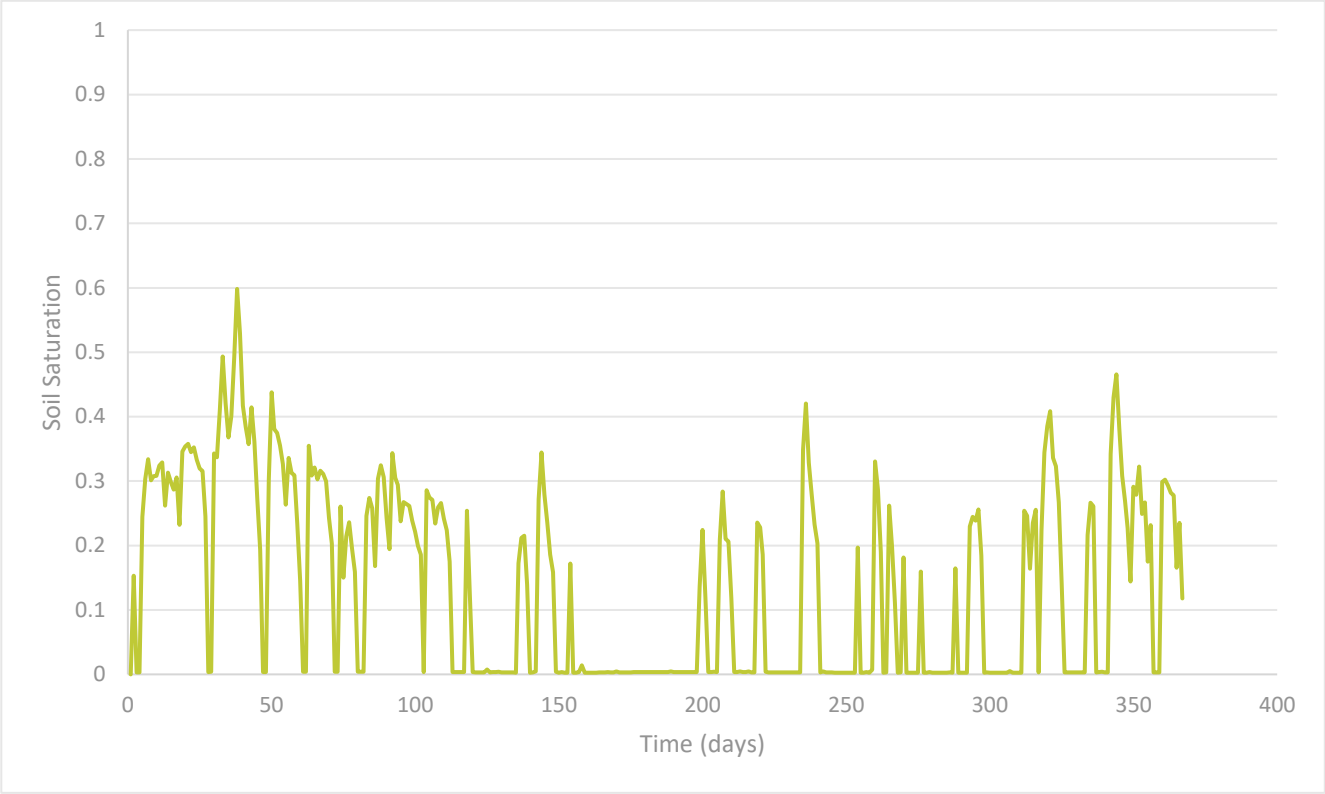

Figure 8 Degree of Soil Saturation with clay removed from capping system

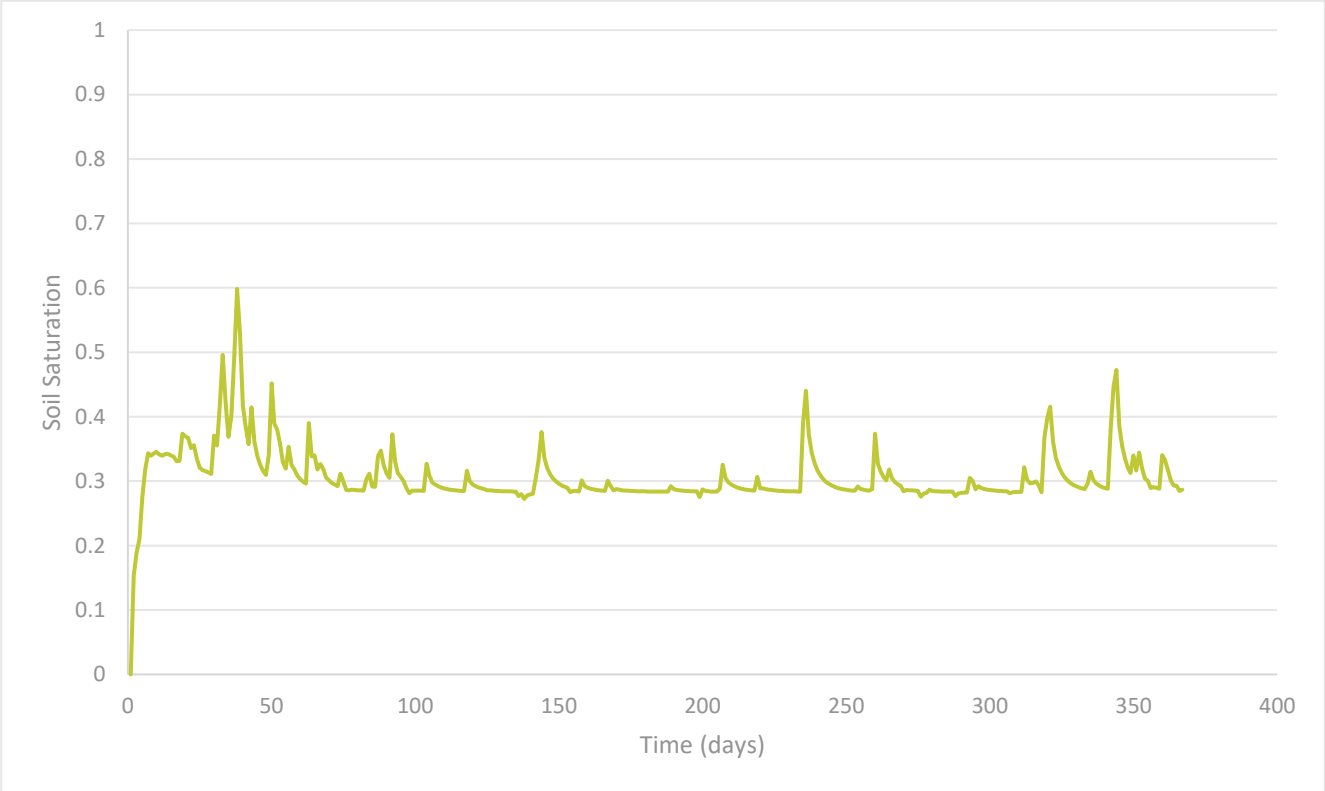

Figure 9 Degree of Soil Saturation with clay removed and 2mm of leachate applied daily (except on days with rainfall)

Recommendations

Based on the modelling that was performed in Geostudio SEEP/W an accumulative application of 730mm of leachate over the selected irrigation area per year would be acceptable with the clay cap removed. It should be noted that leachate irrigation should be avoided on days that rainfall has occurred to reduce the potential for run-off. The irrigation area should be monitored to ensure the establishment of healthy flora and that the oversaturation of the ground is not an issue.

If the clay cap remains in place the area is unlikely to be able have leachate application without risk of leachate run off generation. Additionally, creating saturated soil conditions would result in difficult flora establishment.

Furthermore, it would be advisable that a buffer zone of 5m between the crest of the embankment and the irrigation zone be established and 0.5m bunding be placed on the downslope portions of the irrigation area. The bunding would prevent run-off leaving the area in the event that rainfall occurred on the same day that leachate irrigation had taken place.

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