Salinity Management Plan

SALINITY MANAGEMENT PLAN FOR
12-14 ZOUCH ROAD, DENHAM COURT NSW

Prepared for:

NASTASI & ASSOCIATES

Reference: P1702_ 02

1 August 2019

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1 INTRODUCTION

Morrow Geotechnics Pty Ltd have been commissioned by Nastasi & Associates Pty Ltd to prepare a plan for the on-site management of saline soil for the proposed development of 12-14 Zouch Road, Denham Court NSW. As part of the re-development of the site it is understood that it will be necessary to disturb natural underlying saline soils.

Morrow Geotechnics have carried out a geotechnical investigation, referenced P1702_01 rev1 and dated 29 July 2019. This Salinity Management Plan has been prepared by Morrow Geotechnics to ensure appropriate management of saline soils is incorporated into all aspects of the development.

2 BACKGROUND

Saline soils are naturally occurring sediments and soils containing salts. Saline soils occur naturally and are derived from weathering of naturally saline parent material, such as shale, which are marine (saltwater) deposits, or via other natural processes such as deposition of salts via rainwater, through groundwater movement, or a combination of one or more of the above processes. Undisturbed saline soils may not provide any indicators of their presence, however, when saline soils are disturbed during site development they can produce numerous problems due to the release of salts, which can affect plant growth, building materials including pavements and roads, erosion and water quality.

Changes or development that can exacerbate problems associated with saline soils and produce salinity problems include but are not limited to:

- Cut and fill operations that expose the underlying more saline soil horizons or intercept saline groundwater;
- Cut and fill operations that block or impede natural drainage pathways, which may lead to water logging;
- Changes in site hydrology that may increase interaction of surface water with saline soils; and
- Increased groundwater recharge and rising water table via increased infiltration due to excess watering, clearing of vegetation, or water ponding in poorly drained areas

As noted in Department of Infrastructure, Planning and Natural Resources (DIPNR, 2003b):

> “The key to the salinity process is that salt is soluble in water. As water gains access to our buildings and infrastructure, salt can be carried with it. When water evaporates, salt crystallises and can cause physical stress on the building material as the crystals expand.”

This is not only true for dissolved salts transported into building materials but is also true for dissolved salts that move through natural materials such as soil, as evaporation from saline soil can lead to the breakdown of soil structure and erosion.

There are a number of management options used to minimise potential impacts when developing land situated on saline soils that are discussed in **Section 6** of this plan.

3 OBJECTIVES AND SCOPE

The principal objective of this plan is to provide recommendations to manage saline soils in an environmentally responsible manner during site development. The objectives of the plan are as follows:

1. Identification of potential saline soils on-site;
2. Identification of management strategies for saline soils on the site;
3. Provide an outline of management methods for the site; and
4. Prepare a conceptual environmental management plan to minimise the impact of works on the surrounding environment.

4 SITE INFORMATION

4.1 Site Identification

The site is located on Zouch Road, Denham Court and comprises a single lot, Lot 2 in Deposited Plan (DP) 1111318.

4.2 Site Description

The eastern end of the site is developed with religious use and industrial use buildings. The western end of the site is largely undeveloped rural grazing land. The site is situated within an area of low, rolling hills. A good vegetation cover is present on the site and consists of moderately grazed grass.

Several large dams are present on the site with some evidence of regrading of areas of the site for ram drainage and recreational playing fields.

4.3 Regional Geology and Soils

Review of the Penrith 1:100 000 Geological Series Sheet 9130 (DMR, 1983) indicated that the site is underlain by the Middle Triassic Bringelly Shale Formation of the Wianamatta Group which typically consists of ‘shale, carbonaceous claystone, claystone, laminite, fine to medium grained lithic sandstone, rare coal and tuff’. The Bringelly Shale, with a maximum thickness of 257 m at Razorback, near Campbelltown, grades upwards from a lagoonal coastal marsh sequence at the base to increasingly terrestrial, alluvial plain sediments towards the top of the formation. The formation was deposited in a broad, low lying coastal plain consisting of swamplands cut by meandering estuarine and alluvial channels.

Review of the Penrith 1:100 000 Soil Landscape Series map (SCS, 1972) indicated that the site was situated on the residual soils of the Blacktown soil landscape group. As described by the soil map, the landscape in which soils of the Blacktown soil landscape group are found comprises gently undulating rises with broad rounded crests and ridges with gently inclined slopes on Wianamatta Group shale. Local relief is to 30 metres with slopes usually less than 5 %.

Soils of the Blacktown soil landscape group are described as shallow to moderately deep (<100cm) red and brown podzolic soils on crests and well drained areas, grading to deep yellow podzolic soils on lower slopes and in areas of poor drainage.

4.4 Site Stratigraphy

The stratigraphy at the site is characterised by topsoil and fill overlying residual clay and shale bedrock. Observations taken during the investigation have been used to produce a stratigraphic model of the site. The observed stratigraphy has been divided into four geotechnical units.

A summary of the subsurface conditions across the site, interpreted from the investigation results, is presented in **Tables 1** and **2**. More detailed descriptions of subsurface conditions at the test locations are available in the borehole logs presented in **Appendix A**. The details of the method of soil and rock classification, explanatory notes and abbreviations adopted in the borehole logs are also presented in **Appendix A**.

TABLE 1 SUMMARY OF INFERRED SUBSURFACE CONDITIONS

Unit	Material	Comments
1	**Topsoil / Fill**	Generally low to medium plasticity silt topsoil with some sand, and silty clay fill. Unit 1 fill is inferred to be uncontrolled and poorly compacted.
2	**Natural Clay**	Generally medium to high plasticity silty clay with some sand and some fine to medium ironstone gravel. Unit 2 is generally of firm to hard consistency.
3	**Extremely Weathered Shale**	Generally extremely weathered, extremely low to very low strength shale.
4	**Class IV Shale**	Generally moderately weathered, very low to low strength shale grading stronger with depth.

TABLE 2 ENCOUNTERED GEOTECHNICAL CONDITIONS

Material		Unit 1 Fill	Unit 2 Residual Soil	Unit 3 Class V Shale	Unit 4 Class IV Shale
Approx. Depth Range of Unit [1] mBGL	**BH01**	0.0 to 0.2	0.2 to 1.7	1.7 to 2.1	2.1 +
	BH02	0.0 to 0.2	0.2 to 2.0	2.0 to 2.3	2.3 +
	BH03	0.0 to 0.2	0.2 to 1.8	1.8 to 2.7	2.7 +
	BH04	0.0 to 0.1	0.1 to 3.0	-	-
	BH05	0.0 to 0.1	0.1 to 1.8	1.8 to 2.6	2.6 +
	BH06	0.0 to 0.4	0.4 to 3.0	-	-
	BH07	0.0 to 1.2	1.2 to 3.0	-	-
	BH08	0.0 to 0.5	0.5 to 3.0	-	-
	BH09	0.0 to 0.2	0.2 to 1.1	1.1 to 2.2	2.2 +
	BH10	0.0 to 0.1	0.1 to 2.0	-	2.0 +
	BH11	0.0 to 0.2	0.2 to 1.3	-	1.3 +

Notes:

1 Depths shown are based on material observed within test locations and will vary across the site.

4.5 Regional Hydrogeology

Groundwater associated with the Wianamatta Shale is characterised by high salinity (Wooley, 1980; Krumins et al., 1998) and elevated ammonia concentrations (>10 mg L-1, Old, 1942). Naturally occurring high levels of these parameters reflect the deposition of organic-rich sediment in low energy coastal environments. Rates of groundwater movement are likely to be low as a result of low relief, low altitude (an average of approximately 30 m AHD) and low permeability of the Wianamatta Shale (Herbert, 1980).

The exact direction of permanent groundwater flow could not be determined from the available information and was not assessed in this investigation. However, it is likely that any groundwater will follow the general topography of the area and flow toward the large dam at the centre of the property.

No groundwater was encountered throughout the depth of the Morrow Geotechnics geotechnical investigation, which extended to practical tungsten carbide drilling bit refusal in bedrock.

4.6 Soil Salinity Risk

A review of the map of Salinity Potential in Western Sydney 2002 (Department of Infrastructure, Planning and Natural Resources) indicated the site is located in an area of moderate salinity potential. Information provided on the map indicated that areas of moderate salinity potential are located on Wianamatta Group Shales and Tertiary Alluvial Terraces. The map further indicated that scattered areas of scalding and indicator vegetation have been noted but that concentrations have not been mapped. Saline areas may occur in this zone, which have not yet been identified or may occur if risk factors change adversely.

5 SITE CHARACTERISATION

5.1 Salinity Assessment

As previously mentioned, Morrow Geotechnics carried out a salinity assessment as part of their geotechnical assessment of the site in July 2019. In summary the salinity assessments included:

- A review of available salinity information for the region;
- A walkover inspection of the site to observe salinity indicators such as salt tolerant plant species, erosion and salt deposits;
- Collection of soil samples at depth from boreholes and at the near surface;
- Submission of samples to a NATA accredited analytical laboratory for 1:5 soil extracts and measurement of the 1:5 extract for Electrical Conductivity; and
- Assessment of the analytical results against guidelines.

The inspection carried out by Morrow Geotechnics did not identify obvious signs of salinity such as salt-tolerant plant species, areas of erosion and/or salt deposits.

The results of laboratory analysis of Electrical Conductivity (EC) on 1:5 extracts of the soil samples, together with the Extract Electrical Conductivity (ECe) determined by CES and NG, using multiplication factors dependant upon the samples soil texture group (clays, sands, etc), are provided in **Table 3**

It should be noted that the values for degree of soil salinity summarised in DLWC (2002) Site Investigations for Urban Salinity (Appendix One, Table 6.2 of that publication) and summarised in **Table 3** were derived for agricultural purposes and relate to growing crops and are not necessarily relevant to corrosivity or agressivity of the saline soil (Refer to **Section 5.2**). However, the results of laboratory analysis indicate that saline soils are present at the site and as such all aspects of the proposed site development should take into consideration potential impacts from saline soil and be managed appropriately.

To assist with practical on-site management of the saline soils, Morrow Geotechnics has graphed the ECe results with respect to depth (**Figure 1**). As shown in **Figure 1,** there is an increase in soil salinity with depth, particularly within the upper, weathered shale material. The ECe results obtained for the site soils is as would be expected with more saline soil at depth, where salts tend to accumulate.

TABLE 3 SOIL SALINITY / SODICITY INTERPRETATION

Sample ID	BH03 DS3	BH03 DS4	BH03 DS5	BH03 DS6	BH05 DS2	BH05 DS3	BH05 DS4	BH08 DS1	BH09 DS2	BH09 DS3	BH09 DS4	BH09 DS5
Conductivity (µS/cm)	170	1100	390	290	390	460	-	470	160	230	340	690
Corrected Electrical Conductivity (dS/m)	1.19	7.7	2.73	2.03	2.73	3.22	-	3.29	1.12	1.61	2.38	4.83
Exchangeable Sodium Percentage (%)	-	-	-	-	-	-	32.4	-	22.0	-	-	-
Cation Exchange Capacity (meq/100g)	-	-	-	-	-	-	4.1	-	2.9	-	-	-
Assessed Sodicity / Salinity	**Non Saline**	**Moderately Saline**	**Slightly Saline**	**Slightly Saline**	**Slightly Saline**	**Slightly Saline**	**Highly Sodic**	**Slightly Saline**	**Highly Sodic**	**Non Saline**	**Slightly Saline**	**Moderately Saline**

On the basis of laboratory testing undertaken as part of this investigation the site is assessed to be slightly to moderately saline and highly sodic.

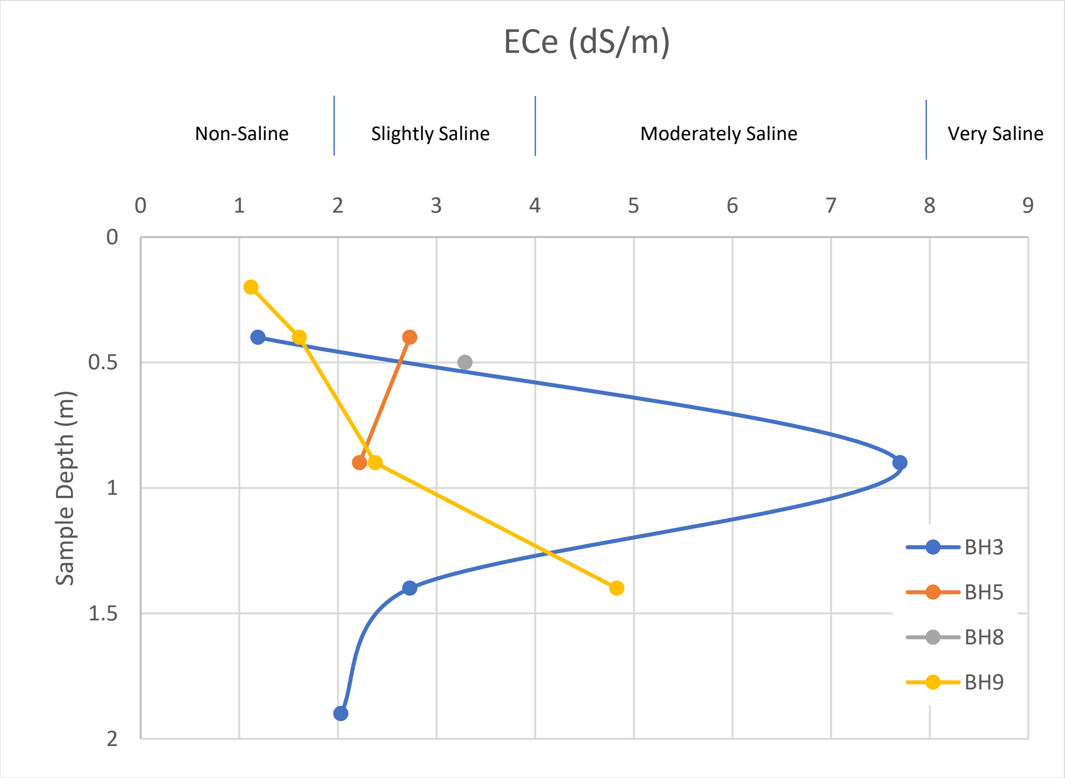

Figure 1 – Salinity Profile from Borehole Testing Results

In general, the site is typically non-saline to slightly saline to a nominal depth of about 0.5 m. Moderately saline conditions were encountered at BH3 and BH9 at depths generally between 0.5 and 1.5 m.

5.2 Aggressivity Assessment

As part of geotechnical investigation at the site, three samples representative of the residual soil and weathered shale bedrock encountered across the site, were collected and submitted to a NATA accredited laboratory for assessment of the corrosivity or agressivity of the saline soil on concrete and or steel structures.

To determine the aggressivity of the soil and water environment on concrete or steel piles, the chemical test results are compared to Table 6.4.2(C) and 6.5.2(C) from Section 6 of the Australian Standard AS 2159-2009 Piling Design and Installation. This section provides assessment criteria to assess the 'exposure classification' for a concrete or steel pile. The Standard has two classes of soil conditions:

(A) – high permeability soils below groundwater; and
(B) – low permeability soils and all soils above groundwater.

For this site, condition 'B' is relevant. Based on this soil condition and the chemical testing results, the standard provides the following range of 'exposure classifications':

- Non-Aggressive;
- Mild;
- Moderate:
- Severe; and
- Very Severe.

For the range of chemical conditions in the soil surrounding the structure, the condition leading to the most severe aggressive conditions is adopted.

Analysis of the pH, chloride & sulfate content and electrical conductivity of the soil against the guidelines provided in AS2159-2009 indicates:

- ‘mildly aggressive’ to buried concrete structural elements; and
- ‘mildly aggressive’ to buried steel structural elements.

Laboratory test certificates for aggressivity testing are included in **Appendix B**.

5.3 Sodicity Assessment

Sodic soils may be affected by very severe surface crusting, very low infiltration and hydraulic conductivity, very hard and dense subsoils, high susceptibility to gully erosion and tunnel erosion. Sodicity also affects the shrink – swell properties of a soil. Sodic soils are assed on Exchangeable Sodium Percentage (ESP %)

The general rating of sodicity as shown in the DLWC (2002) publication Site Investigations for Urban Salinity, 2002 is given below:

- ESP % < 5% - Non-Sodic
- ESP % 5-15% - Sodic
- ESP % > 15% - Highly Sodic

Soil samples tested from BH5 and BH9 assessed the site to be Highly Sodic.

6 SALINE SOILS MANAGEMENT OPTIONS AND STRATEGY

On the basis of the current and previous studies and site observations, it is considered reasonable to assign the following characteristics to the subject site:

- Soils are generally non-saline to slightly saline across the majority of the site, but may be moderately saline at depths generally between than 0.5 m to 1.5 m; and
- Soils are generally sodic to highly sodic.

Development at the site should apply recommendations for development in saline soils provided in:

- Department of Infrastructure, Planning and Natural Resources (2003a): Building in a Saline Environment;
- Department of Infrastructure, Planning and Natural Resources (2003b): Roads and Salinity;
- Department of Infrastructure, Planning and Natural Resources (2004): Waterwise Parks and Gardens;
- Department of Land and Water Conservation (2002): Site Investigations for Urban Salinity; and
- Western Sydney Regional Organisation of Councils Ltd (WSROC, 2003, Ammended 2004) Western Sydney Salinity Code of Practice.

Based on the recommended strategies for the management of saline soils (DLWC, 2002), for the present project it will not be possible to avoid disturbing the saline soils.

Management options for displaced saline soils and to minimise impact from disturbance of saline soils, as noted in DLWC (2002), will include where possible:

- minimising cut and fill;
- ensure soils are replaced in original order when cut and fill is undertaken;
- ensure good compaction of cut and fill areas to minimise infiltration of water to saline soils;
- minimising infiltration of stormwater;
- minimising irrigation of plants or landscaped areas;
- ensuring the site is well drained;
- careful installation of damp proof courses beneath building slabs; and
- use of higher strength concrete with adequate cover over steel reinforcement.

The management options for saline soils provided in this section of the report are not a prescription for undertaking the required works. Rather the recommendations have been made for consideration by the relevant specialist sub-contractors designing and directing the various aspects of the development and will include, but will not necessarily be limited to, the civil and structural engineers, the geotechnical engineer, the hydrologist and the landscape architect.

The management options for the various aspects of the development are discussed in the following sections. Where ideal management options cannot be applied, alternative methods for saline soil management have been provided.

6.1 Civil Works/Earthworks

Cut and fill operations are an integral part of the proposed development, therefore, cut and fill of the site is required. The key to minimising the potential impact of saline soils in site development when cut and fill is necessary is to avoid reversal of the soil profile. That is, soils excavated from the bottom of the profile should be placed at the bottom of the profile in the fill area.

As indicated in Table 2 and Figure 1, the average ECe values of the upper 0.5 m are general non-saline to slightly saline. Moderately Saline soils are encountered between 0.5 m depth and 1.5 m depth. Soils excavated from depths greater than 0.5 m to 1.5 m should preferably be re-used within the same zone, or elsewhere within the site at depths of greater than 1 m below final grade. Where the soils from the this depth cannot be re-used as above, use some form of surface treatment such as topsoil (loam), sandy materials, crushed rock or soils treated with gypsum. These measures are designed to reduce the potential for scour (given also the sodic nature of the soils) and improve soil structure (i.e. through the use of gypsum).

During fill operations, stockpiled materials will be re-instated in the order of removal with soils excavated at greater depth placed and compacted prior to placement of shallower soils to limit exposure of more saline soils to surface water and contact with construction materials. Additionally, as detailed in the geotechnical report for the site, the soils will be compacted to exclude voids and minimise the potential for infiltration of surface water into the fill to minimise possible interaction of surface water with the saline soils and potential mobilisation of salts.

When filling, the soil should be placed in horizontal layers not more than 0.25m loose thickness over prepared subgrade and compacted to a dry density ratio not less than 95% Standard beneath pavements and 98% Standard beneath structures.. The moisture content during compaction should be maintained at ±2% of Standard Optimum. Filling operations should generally be carried out under a Level 1 inspection and testing source as defined in AS3798 – 1996 Guidelines on Earthworks for Commercial and Residential Developments.

In accordance with AS3798-1996, a commercial site greater than 1500 m2 requires a testing frequency of not less than:

- 1 test per layer or 200 mm thickness per material type; or
- 1 test per 500 m2 distributed evenly throughout full depth and area; or
- 3 tests per site visit;

whichever requires the most tests.

An Erosion and Sediment Control Plan must be developed by the appointed earthworks contractor and implemented in accordance with the NSW Department of Housing document "Managing Urban Stormwater: Soils and Construction" (1998). All sediment and erosion controls proposed by the Erosion and Sediment Control Plan are to be installed prior to commencement of any excavation or construction works.

The potential erosion hazard developed by the presence of sodic soils will be kept as low as possible by limiting the construction area size at any one time and clearly defining the area by barrier fencing upslope and sediment fencing down slope (to be incorporated into the Erosion and Sediment Control Plan).

The programming of development road works and major excavations should minimise the time of soil exposure, and should coincide with periods of anticipated lower rainfall (wherever possible).

6.2 Building Construction

The most important consideration in protecting any building or structure in saline soil areas is to prevent saline soils contacting the structure. As discussed in **Section 6.1** this primarily involves stripping and re-instatement of soils in the correct order, that is more saline soil placed at the base of fill operations with non-saline soils re-instated at the levelled surface. However, it is important to note that there may be some contact with some saline soil, particularly with foundations extending below the ground surface. Consequently, the aggresivity and corrosivity of the subsurface soils must be considered.

As discussed in **Section 5.2**, it is recommended that structures be designed based on a mildly aggressive soil exposure classification relating to concrete, and a mildly aggressive soil exposure classification with respect to unprotected steel. It is noted that these exposure classifications as defined in AS2159-2009 Piling – Design and Installation, relate to concrete and/or steel piles, however, can equally be used for other concrete and steel structures which may be in contact with soil.

All construction should be carried out in accordance with mandatory requirements for building on saline soils set out in the Building Code of Australia. Guidance for construction in saline environments is provided in the following Australian Standards:

- AS 2159 – 2009 Piling – Design and Installation;
- AS 2870 – 2011 Residential Slabs and Footings – Construction;
- AS 3600 – 2001 Concrete Structures; and
- AS 3700 – 2001 Masonry Structures.

General recommendations based on the above standards includes the use of a damp proof course beneath the building slabs or as recommended by the structural engineer.

As noted in the Department of Infrastructure, Planning and Natural Resources (DIPNR, 2003a) Building in a Saline Environment, care should be taken when installing the damp-proof membrane to ensure it extends completely under the whole slab and up the sides to at least finished ground level to prevent movement of moisture through the sides or gaps. Furthermore AS 2870 sets requirements for lapping of joints and taping of penetrations of pipes or plumbing fittings. Damp proof courses should not be breached by gardens or paving that would allow moisture bypassing the damp proof membrane. Exposure class masonry units must be used below the damp proof course.

The external finished surface should be graded away from the building to prevent moisture accumulating around buildings and minimise the potential for it to seep and accumulate beneath the slabs.

For slab-on-ground construction, a layer of bedding sand of at least 50 mm thickness under the slab must be provided, provided the ground surface is initially well compacted and smoothed to remove any protruding materials that could potentially puncture the overlying membrane. This layer will permit free drainage of water beneath the slab, minimising the possibility of pooling or trapping water that might potentially be carrying salts. Consideration should be given to increasing this layer to 100 mm if a sufficiently smooth ground surface cannot be achieved.

Adequate drainage of down pipes must be provided to divert water away from structures and prevent cyclic wetting and drying. Service connections and stormwater runoffs should be checked to avoid leaking pipes which may affect off site areas further down slope and increase groundwater recharge resulting in increases in groundwater levels.

6.3 Services

The WSROC publication notes that salinity resistant materials need to be considered when choosing material for underground services. It notes that metal pipes are susceptible to corrosion, so plastic pipes, such as polybutylene or polyethylene are more suitable materials for water supply in areas with a salinity problem. Unplasticised polyvinyl chloride (uPVC), polypropylene or copper piping is recommended for plumbing pipes.

Similarly, plastic rather than concrete pipes should be used for stormwater, since concrete will be susceptible to attack from saline soils.

It is noted that services may require cathodic protection systems to minimise corrosion.

The WSROC publication also notes that aggresivity and corrosivity of the soils (Refer to **Section 5.2**) needs to be considered in the choice of materials for power supply, power poles, and underground cables and is discussed in the booklet “Corrosion in the Electrical Supply Industry’, which is available from the Electrical Association of NSW.

Service trenches should be well drained to avoid ponding of water in the trenches. The depth to groundwater at the site is relatively deep (> 5m) therefore is not expected to be an issue for service trenches.

6.4 Stormwater and Drainage

Consideration should be given to site drainage and infiltration of stormwater, as one of the main areas in which salinity occurs is where there is continuous wetting and drying. All areas immediately surrounding buildings and slabs should be graded to slope away from these features to minimise ponding and the potential for increased infiltration.

Taps, water pipes or downpipes adjacent to buildings can make these areas susceptible to salinity problems, particularly if there are leaks in the system. Leaking sewer pipes can cause similar problems.

Avoid water collecting in low lying areas, depressions, behind fill embankments or near trenches on the uphill sides of roads. This can lead to water logging of the soils, evaporative concentration of salts, and eventual breakdown in soil structure resulting in accelerated erosion. Preferably design the surface water drainage system for the subdivision to coincide with pre-existing drainage pathways, thus minimising the disruption of existing surface water flows. Avoid filling or blocking preferential drainage pathways (refer Drawing 2). Piping can be used to maintain drainage lines.

6.5 Landscaped Areas

Landscaped areas should be constructed in accordance with recommendations made in the DIPNR (2004) Waterwise Parks and Gardens.

Recommendations for the preparation of landscaped areas that should be applied to the site include, but are not limited to:

- raising beds and installing drainage lines to ensure areas are not permanently waterlogged;
- mulching to minimise drying and concentrations of salts in the upper soil layers; and
- mulching to decrease the need for irrigation while plants are establishing.

Landscaped areas should be constructed where possible with soils sourced on-site. Should it be necessary to use imported material in landscaped areas, soils should comply with specifications provided in AS 4419, Soils for Landscaping and Garden Use, which recommends use of low density and organic soils with an electrical conductivity of 2.5dS/m, or 1.2dS/m for soil blends and natural soils. As noted in DIPNR (2004), soils used in landscaped areas should be keyed into rather than placed over compacted soil, to ensure roots and nutrients can move from the new soil into the underlying land surface.

Should it be necessary to provide irrigation to the landscaped areas, WSROC (2003) notes that the irrigation system installed should respond to soil moisture and climate conditions to ensure that over-watering is avoided.

Topsoil or other suitable landscaping material should be an adequate depth above saline soils in landscaped areas to ensure healthy plant growth.

Landscaping and garden designs should preferably not be placed against walls and be designed to minimise the use of water on site.

6.6 Roads

As noted in WSROC (2003) the key to building salt resistant roads is in keeping water and salt out of the layers that comprise the road.

As noted in Section 4.5, groundwater was not encountered during the geotechnical investigation at the site, therefore, construction of the road is unlikely to impact groundwater flow. The main issue with road construction at the site is to ensure good drainage is maintained on any road verge to minimise infiltration and possible migration of moisture and salts into the road layers. Consideration should be given to the selection of materials to resist potential corrosion from the salts present.

Where possible materials and waters used in the construction of roads and fill embankments should be selected to contain minimal or no salt. Such materials should preferably be sourced from the non-saline to slightly saline areas within the site. Where the use of soils from the moderately saline zones is unavoidable, use some form of surface treatment such as topsoil (loam), sandy materials, crushed rock or soils treated with gypsum. These measures are designed to reduce the potential for scour (given also the sodic nature of the soils) and improve soil structure (i.e. through the use of gypsum).

7 STATEMENT OF LIMITATIONS

The adopted investigation scope was limited by the investigation intent. Further geotechnical inspections should be carried out during construction to confirm both the geotechnical model and the design parameters provided in this report.

Your attention is drawn to the document "Important Information", which is included in **Appendix B** of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Morrow Geotechnics, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

8 REFERENCES

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Department of Infrastructure, Planning and Natural Resources (2003b): Introduction to Urban Salinity.

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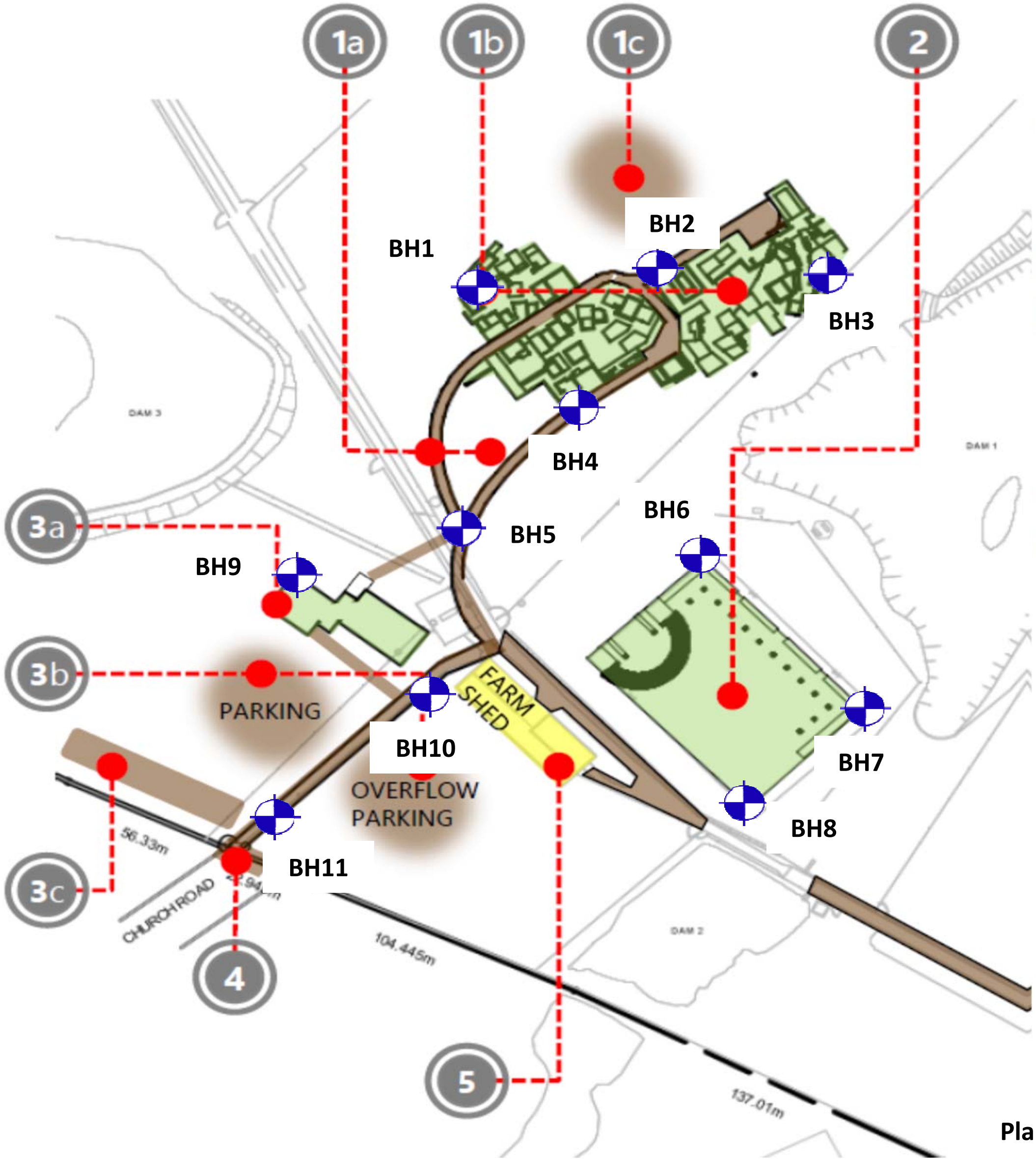
9 CLOSURE

Please do not hesitate to contact Morrow Geotechnics if you have any questions about the contents of this report.

For and on behalf of Morrow Geotechnics Pty Ltd,

Alan Morrow
Senior Geotechnical Engineer



1. **BACKLOT PADDOCK** | a) access road
| b) avs project set
| c) screening mound
2. **PLAYING FIELD** | avs project set
3. **PADDOCK** | a) backlot production support
| b) new car parking (25 space + 25 overflow)
| c) landscaping (for screening)*
4. **BACK GATE** | upgrade branch access
5. **FARM SHED** | project storage (existing layout)

Plan Source: Site Plan - Project Overview, Branch Comittee, 21 June 2019

morrow

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Drawn	JB
Approved	AM
Date	08/07/2019
Scale	NTS

Nastasi & Associates
12-14 Zouch Road, Denham Court NSW
Geotechnical Investigation
Borehole Location Plan

Figure:
1

Project: P1702

Appendix A

BOREHOLE LOGS AND EXPLANATORY NOTES

Project No: P1702
Client: Nastasi & Associates
Project: 12-14 Zouch Road
Denham Court NSW

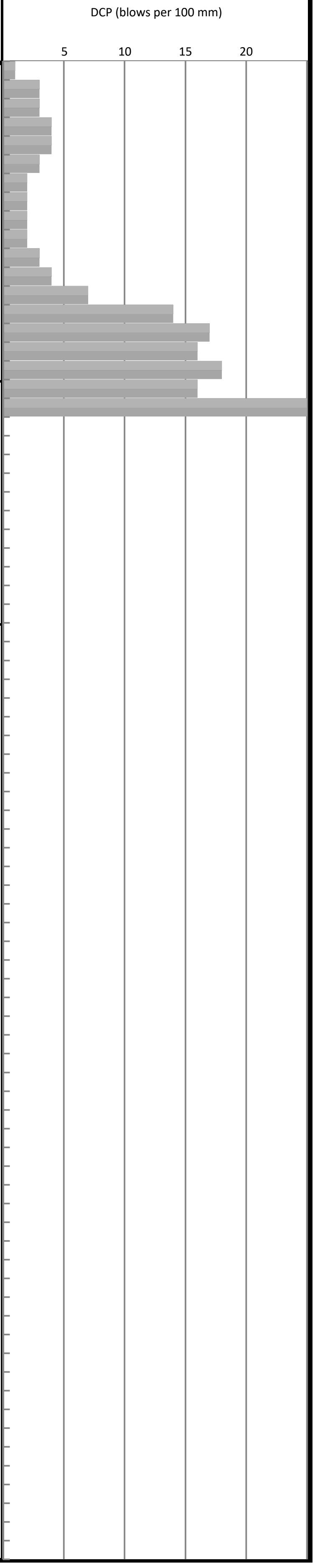
Contractor: Ideal Geotech
Drill Rig: Ute-mounted rig

Sheet 1 of 1
Logged: JB
Date: 27/06/2019

morrow

BH01

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture
ADT	L	GWNE		MI		TOPSOIL - SILT, low to medium plasticity, dark brown, root fibres present	F	M< PL
				CI-CH	0.5 1.0	Silty CLAY, medium to high plasticity, red-brown, trace of fine sub-angular gravel (ironstone), (RESIDUAL SOIL) - becoming red-brown mottled pale grey from 0.6 m - becoming pale grey mottled red-brown from 0.9 m	St	
				CI	1.5	- medium plasticity, becoming pale grey, trace of fine to medium sub-rounded gravel (ironstone) from 1.2 m	H	
	M			-	2.0	SHALE, pale grey, trace of clay bands, trace of ironstone bands, extremely weathered, inferred extremely low strength	-	-
	M-H				2.5	SHALE, brown, distinctly weathered, inferred very low strength		
					3.0	SHALE, brown, distinctly weathered, inferred low strength		
					3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0	End BH01 at 3.0 m Reached Target Depth		



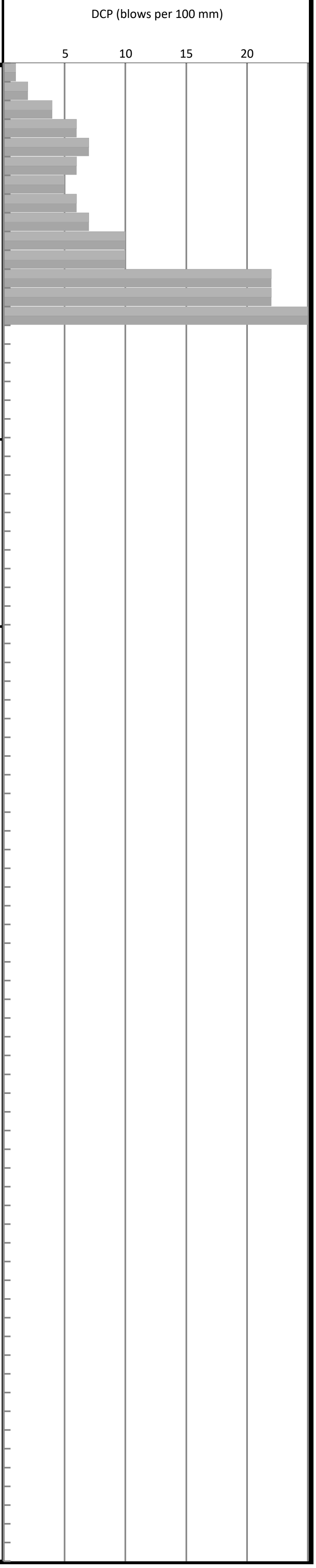
Project No: P1702
Client: Nastasi & Associates
Project: 12-14 Zouch Road
Denham Court NSW

Contractor: Ideal Geotech
Drill Rig: Ute-mounted rig

Sheet 1 of 1
Logged: JB
Date: 27/06/2019

BH02

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture
ADT	L	GWNE		MI		TOPSOIL - Sandy SILT, low to medium plasticity, fine grained sand, dark brown, root fibres present	F	M< PL
			BDS02-1 0.2-0.7 m	CI-CH	0.5	Silty CLAY, medium to high plasticity, orange-brown, trace of fine to medium sub-angular gravel (ironstone), (RESIDUAL SOIL)	St	
						- becoming mottled pale grey from 0.6 m		
					1.0			
							H	
					1.5			
				CL-CI		- low to medium plasticity, becoming brown from 1.6 m		
					2.0			
	M			-		SHALE, pale grey / brown, extremely weathered, inferred extremely low strength	-	-
	M-H				2.5	SHALE, dark brown, distinctly weathered, inferred very low to low strength		
					3.0			
						End BH02 at 3.0 m Reached Target Depth		
					3.5			
					4.0			
					4.5			
					5.0			
					5.5			
					6.0			
					6.5			
					7.0			
					7.5			
					8.0			



Project No: P1702
Client: Nastasi & Associates
Project: 12-14 Zouch Road
Denham Court NSW

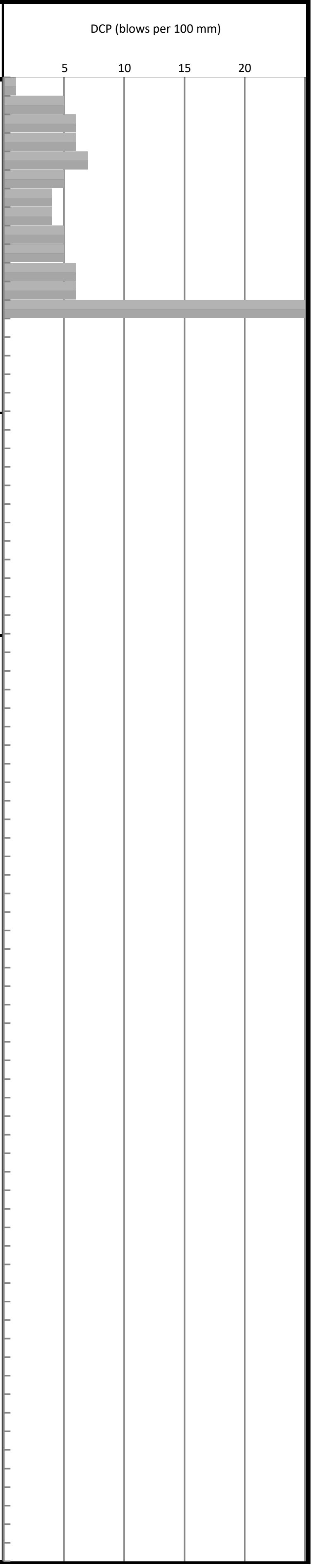
Contractor: Ideal Geotech
Drill Rig: Ute-mounted rig

Sheet 1 of 1
Logged: JB
Date: 27/06/2019

morrow

BH03

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture
ADT	L	GWNE	DS03-1 0.1-0.2 m	MI		TOPSOIL - Sandy SILT, low to medium plasticity, fine grained sand, dark brown, root fibres present	St	M< PL
			DS03-2 0.2-0.3 m DS03-3 0.4-0.5 m DS03-4 0.9-1.0 m	CI-CH	0.5 1.0	Silty CLAY, medium to high plasticity, red-brown mottled grey, trace of fine to medium sub-angular gravel (ironstone), RESIDUAL SOIL)		
			DS03-5 1.4-1.5 m	CI	1.5	Silty CLAY, medium plasticity, brown / grey, trace of fine sub-angular gravel (ironstone), (RESIDUAL SOIL)	-	
	M		DS03-6 1.9-2.0 m	-	2.0 2.5	SHALE, grey, extremely weathered, inferred extremely low strength		-
	M-H				3.0	SHALE, dark grey, distinctly weathered, inferred very low strength		
					3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0	End BH03 at 3.0 m Reached Target Depth		



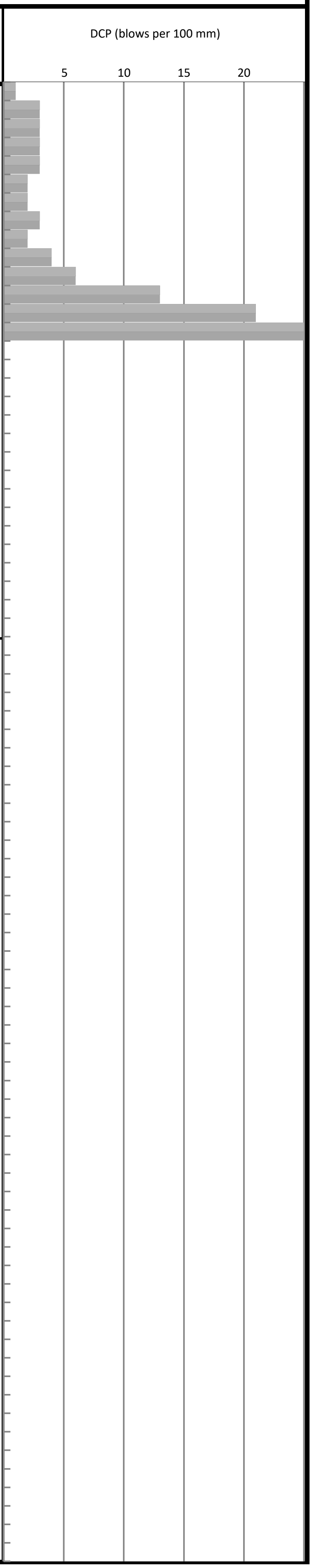
Project No: P1702
Client: Nastasi & Associates
Project: 12-14 Zouch Road
Denham Court NSW

Contractor: Ideal Geotech
Drill Rig: Ute-mounted rig

Sheet 1 of 1
Logged: JB
Date: 27/06/2019

BH04

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture
ADT	L	GWNE		MI		TOPSOIL - SILT, low to medium plasticity, dark brown, root fibres present	S	M< PL
				CI-CH		Silty CLAY, medium to high plasticity, red-brown, trace of fine to medium sub-angular gravel (ironstone), (RESIDUAL SOIL)	St	
					0.5			
						- becoming red-brown mottled grey from 0.8 m		
					1.0			
							H	
					1.5			
					2.0		-	
					2.5			
						- with fine to coarse sub-rounded gravel (ironstone) from 2.7 m		
					3.0			
						End BH04 at 3.0 m Reached Target Depth		
					3.5			
					4.0			
					4.5			
					5.0			
					5.5			
					6.0			
					6.5			
					7.0			
					7.5			
					8.0			



Project No: P1702
Client: Nastasi & Associates
Project: 12-14 Zouch Road
Denham Court NSW

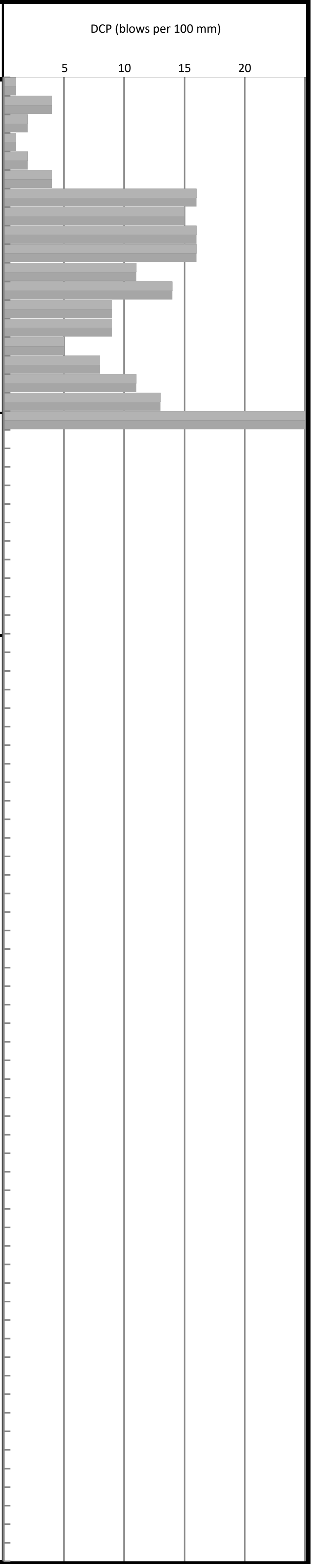
Contractor: Ideal Geotech
Drill Rig: Ute-mounted rig

Sheet 1 of 1
Logged: JB
Date: 27/06/2019

morrow

BH05

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture
ADT	L	GWNE		MI		TOPSOIL - SILT, low to medium plasticity, dark brown, root fibres present	S	M< PL
			DS05-1 0.1-0.2 m BDS05-1 0.2-0.7 m	CI- CH		Silty CLAY, medium to high plasticity, red-brown, trace of fine sub-angular gravel (ironstone), (RESIDUAL SOIL)	F-St	
			DS05-2 0.4-0.5 m		0.5	- with fine to coarse sub-angular gravel from 0.5 m	H	
			DS05-3 0.9-1.0 m		1.0			
			DS05-4 1.4-1.5 m	CI	1.5	- medium plasticity, becoming pale grey from 1.5 m	VSt- H	
	M		DS05-5 1.9-2.0 m	-	2.0	SHALE, grey, extremely weathered, inferred extremely low strength	-	-
					2.5	SHALE, brown, distinctly weathered inferred very low strength		
					3.0	End BH05 at 3.0 m Reached Target Depth		
					3.5			
					4.0			
					4.5			
					5.0			
					5.5			
					6.0			
					6.5			
					7.0			
					7.5			
					8.0			



Project No: P1702
Client: Nastasi & Associates
Project: 12-14 Zouch Road
Denham Court NSW

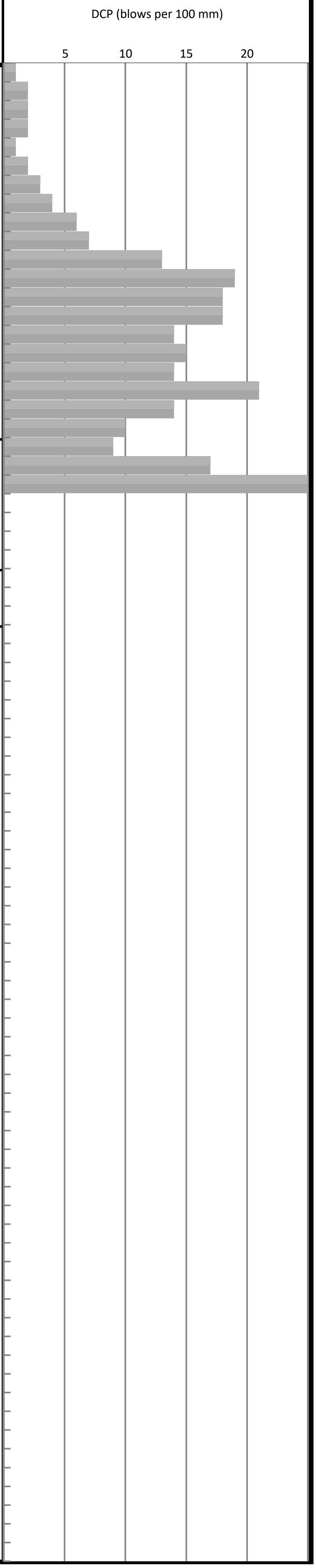
Contractor: Ideal Geotech
Drill Rig: Ute-mounted rig

Sheet 1 of 1
Logged: JB
Date: 27/06/2019

morrow

BH06

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture
ADT	L			CI-CH		FILL - Silty CLAY, medium to high plasticity, grey-brown, charcoal present	F	M~ PL
					0.5	Silty CLAY, medium to high plasticity, red-brown mottled grey, trace of fine sub-angular gravel (ironstone), (RESIDUAL SOIL)		
							St	
					1.0		H	
		Moderate seeoage 1.3 m				- with fine to medium sub-rounded gravel (ironstone) from 1.3 m		
					1.5	Silty CLAY, medium to high plasticity, pale grey, trace of fine sub-angular gravel (ironstone), (RESIDUAL SOIL)		
				CI	2.0	- medium plasticity from 2.0 m		M< PL
							-	
					2.5			
				CI-CH		Silty CLAY, medium to high plasticity, grey / dark grey, trace of fine sub-angular gravel (ironstone), (RESIDUAL SOIL)		M~ PL
					3.0	End BH06 at 3.0 m Reached Target Depth		
					3.5			
					4.0			
					4.5			
					5.0			
					5.5			
					6.0			
					6.5			
					7.0			
					7.5			
					8.0			



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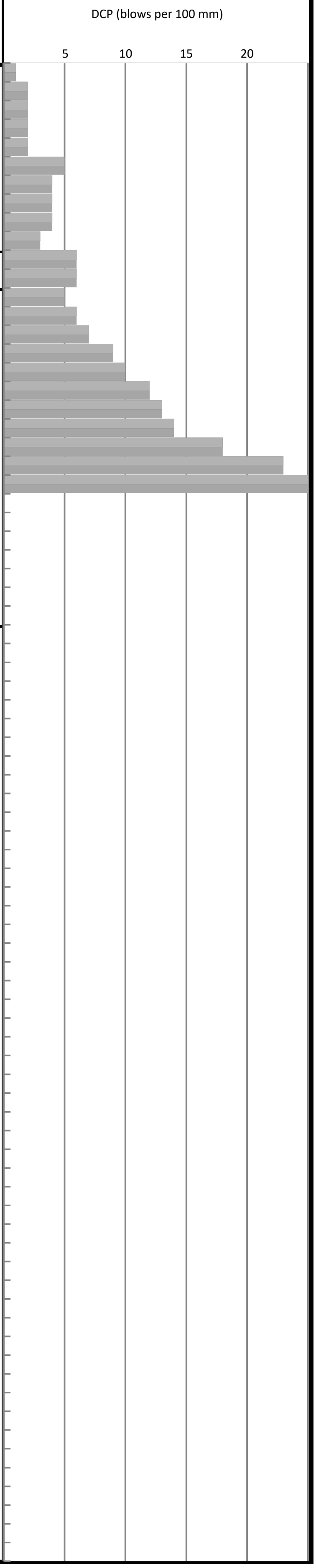
BH07

Project No:	P1702	Contractor:	Ideal Geotech
Client:	Nastasi & Associates	Drill Rig:	Ute-mounted rig
Project:	12-14 Zouch Road Denham Court NSW	Sheet	1 of 1
		Logged:	JB
		Date:	27/06/2019

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture
ADT	L	GWNE		ML-MI	0.5	FILL - Sandy SILT, low to medium plasticity, fine to medium grained sand, dark brown, root fibres present	St	M< PL
				CI	1.0	FILL - Silty CLAY, medium plasticity, brown / grey-brown, trace of fine to coarse sub-rounded gravel (ironstone), finet to medium grained sand pockets, and charcoal present		
				MI		TOPSOIL - Sandy SILT, low to medium plasticity, fine to medium grained, grey / brown		M> PL
				CI-CH	1.5 2.0	Silty CLAY, medium to high plasticity, red-brown, trace of fine sub-angular gravel (ironstone), (RESIDUAL SOIL)	VSt H	M< PL
					2.5 3.0	Silty CLAY, medium to high plasticity, orange-brown, with fine to medium sub-rounded gravel (ironstone), trace of fine grained sand, (RESIDUAL SOIL)	-	
					3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0	End BH07 at 3.0 m Reached Target Depth		



Project No:	P1702	Contractor:	Ideal Geotech
Client:	Nastasi & Associates	Drill Rig:	Ute-mounted rig
Project:	12-14 Zouch Road Denham Court NSW	Sheet	1 of 1
		Logged:	JB
		Date:	27/06/2019

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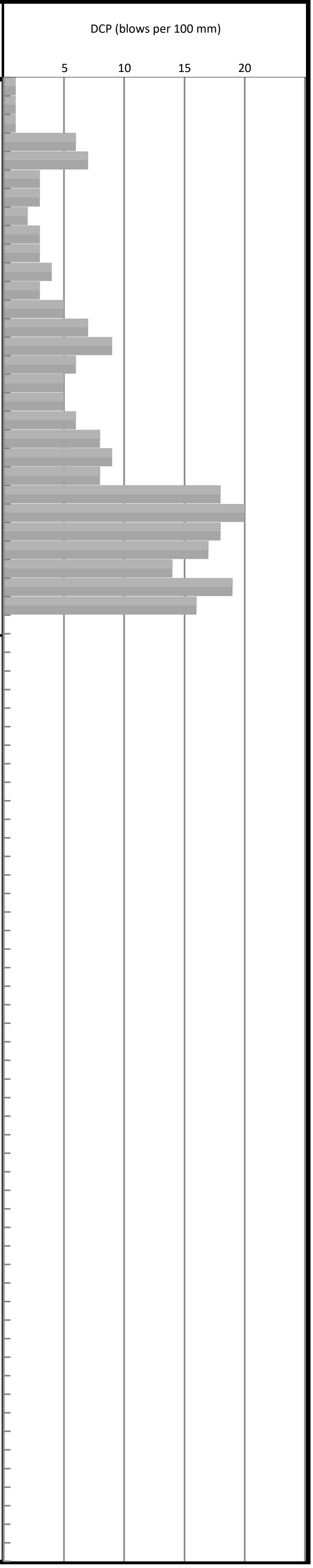
BH08

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture
ADT	L	GWNE		MI		FILL - Sandy SILT, low to medium plasticity, fine to medium grained sand, dark brown, root fibres present	F	M< PL
				CI	0.5	FILL - Silty CLAY, medium plasticity, brown / grey-brown, trace of fine to coarse sub-rounded gravel (ironstone), finet to medium grained sand pockets, and charcoal present		
			DS08-1 0.5-0.6 m	CI- CH	1.0 1.5	Silty CLAY, medium to high plasticity, red-brown, trace of fine sub-angular gravel (ironstone), (RESIDUAL SOIL)	St	
					2.0	- becoming orange-brown mottled grey from 1.7 m	VSt	
					2.5 3.0	Silty CLAY, medium to high plasticity, orange-brown, with fine to medium sub-rounded gravel (ironstone), trace of fine grained sand, (RESIDUAL SOIL)	H	
					3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0	End BH08 at 3.0 m Reached Target Depth		



Project No:	P1702	Contractor:	Ideal Geotech
Client:	Nastasi & Associates	Drill Rig:	Ute-mounted rig
Project:	12-14 Zouch Road Denham Court NSW	Sheet	1 of 1
		Logged:	JB
		Date:	27/06/2019

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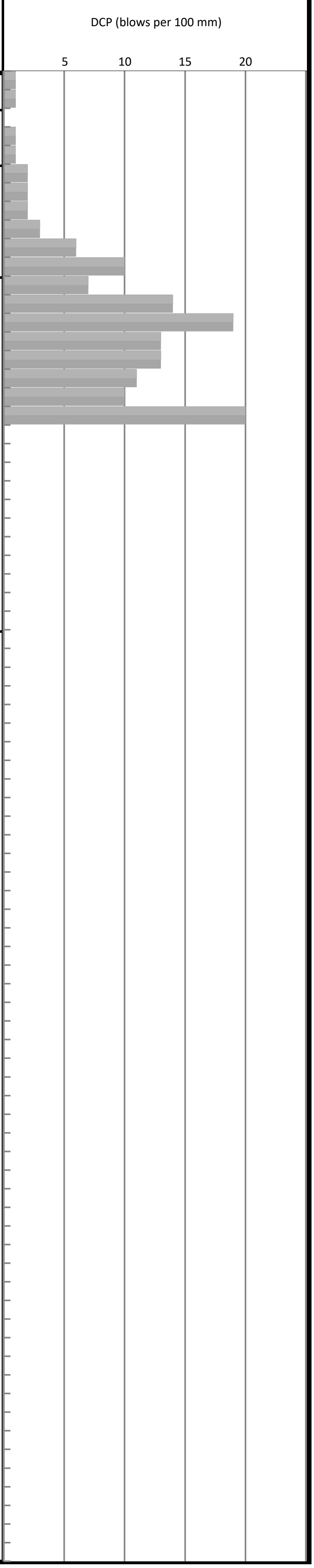
BH09

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture
ADT	L	GWNE	DS09-1 0.1-0.2 m	MI		TOPSOIL - SILT, low to medium plasticity, dark brown, root fibres present	VS	M> PL
			DS09-2 0.2-0.3 m DS09-3 0.4-0.5 m DS09-4 0.9-1.0 m	CI-CH	0.5 1.0	Silty CLAY, medium to high plasticity, red-brown, trace of fine sub-angular gravel (ironstone), (RESIDUAL SOIL) - becoming pale grey mottled red-brown from 0.4 m	St VSt	M~ PL M< PL
	L-M		DS09-5 1.4-1.5 m DS09-6 1.9-2.0 m	-	1.5 2.0	SHALE, grey, with clay bands, extremely weathered, inferred extremely low strength	H -	-
	M				2.5 3.0	SHALE, dark grey, distinctly weathered, inferred low strength		
					3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0	End BH09 at 3.0 m Reached Target Depth		

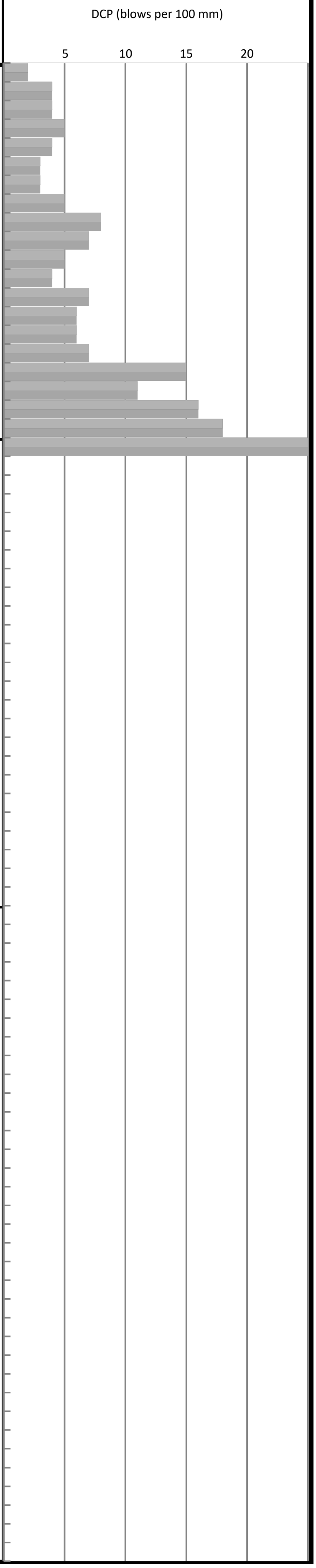


Project No:	P1702	Contractor:	Ideal Geotech
Client:	Nastasi & Associates	Drill Rig:	Ute-mounted rig
Project:	12-14 Zouch Road Denham Court NSW		
		Sheet	1 of 1
		Logged:	JB
		Date:	27/06/2019

morrow

BH10

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture
ADT	L	GWNE		MI		TOPSOIL - SILT, low to medium plasticity, dark brown, trace of fine grained sand, root fibres present	St	M< PL
				CI-CH	0.5	Silty CLAY, medium to high plasticity, red-brown, trace of fine sub-angular gravel (ironstone), (RESIDUAL SOIL)		
						- becoming red-brown mottled grey from 0.7 m		
					1.0	- becoming pale grey, trace of fine to medium sub-rounded gravel from 1.0 m		
				CI	1.5	- medium plasticity from 1.5 m	VSt	
							H	
	M			-	2.0	SHALE, brown, distinctly weathered, inferred very low strength	-	-
					2.5			
	M-H				3.0	SHALE, dark grey, distinctly weathered, inferred low strength		
					3.5			
					4.0			
					4.5	End BH10 at 4.5 m Reached Target Depth		
					5.0			
					5.5			
					6.0			
					6.5			
					7.0			
					7.5			
					8.0			



Project No: P1702
Client: Nastasi & Associates
Project: 12-14 Zouch Road
Denham Court NSW

Contractor: Ideal Geotech
Drill Rig: Ute-mounted rig

Sheet 1 of 1
Logged: JB
Date: 27/06/2019

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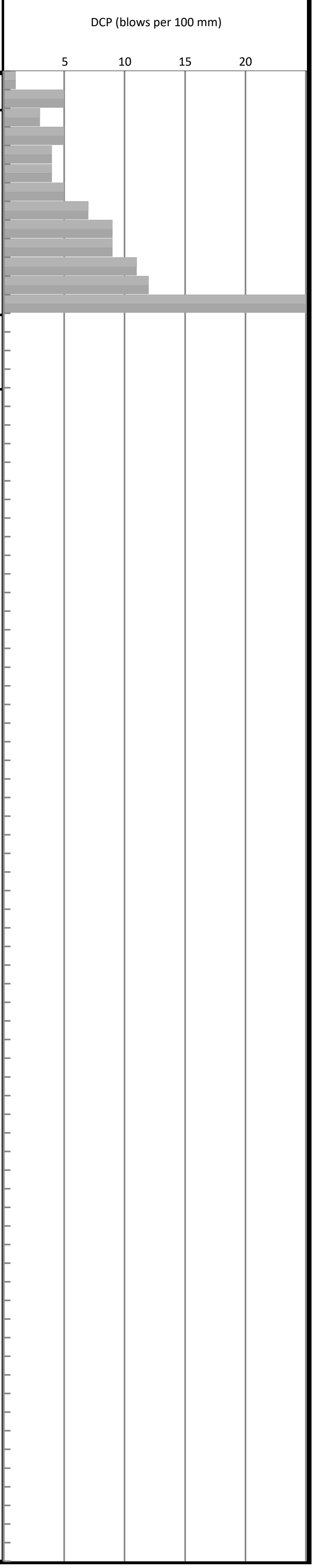
BH11

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture
ADT	L	GWNE		MI		TOPSOIL - Sandy SILT, low to medium plasticity, fine grained sand, brown, trace of fine sub-angular gravel (ironstone), root fibres present	S	D
			BDS11-1 0.2-0.7 m	CI-CH	0.5 1.0	Silty CLAY, medium to high plasticity, red-brown, trace of fine sub-angular gravel (ironstone), (RESIDUAL SOIL)	St VSt H	M< PL
	H			-	1.5	SHALE, dark grey / brown, distinctly weathered, inferred very low strength	-	-
					2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0	End BH11 at 1.7 m Practical Auger Refusal on Weathered Shale		



Soil and Rock Logging Explanatory Notes

GENERAL

Information obtained from site investigations is recorded on log sheets. The “Cored Drill Hole Log” presents data from an operation where a core barrel has been used to recover material - commonly rock. The “Non-Core Drill Hole - Geological Log” presents data from an operation where coring has not been used and information is based on a combination of regular sampling and insitu testing. The material penetrated in non-core drilling is commonly soil but may include rock. The “Excavation - Geological Log” presents data and drawings from exposures of soil and rock resulting from excavation of pits, trenches, etc.

The heading of the log sheets contains information on Project Identification, Hole or Pit Identification, Location and Elevation. The main section of the logs contains information on methods and conditions, material substance description and structure presented as a series of columns in relation to depth below the ground surface which is plotted on the left side of the log sheet. The common depth scale is 8m per drill log sheet and about 3-5m for excavation logs sheets.

As far as is practicable the data contained on the log sheets is factual. Some interpretation is inevitable in the identification of material boundaries in areas of partial sampling, the location of areas of core loss, description and classification of material, estimation of strength and identification of drilling induced fractures. Material description and classifications are based on SAA Site Investigation Code AS 1726 - 1993 with some modifications as defined below.

These notes contain an explanation of the terms and abbreviations commonly used on the log sheets.

DRILLING

Drilling & Casing

ADV	Auger Drilling with V-Bit
ADT	Auger Drilling with TC Bit
WB	Wash-bore drilling
RR	Rock Roller
NMLC	NMLC core barrel
NQ	NQ core barrel
HMLC	HMLC core barrel
HQ	HQ core barrel

Drilling Fluid/Water

The drilling fluid used is identified and loss of return to the surface estimated as a percentage.

Drilling Penetration/Drill Depth

Core lifts are identified by a line and depth with core loss per run as a percentage. Ease of penetration in non-core drilling is abbreviated as follows:

VE	Very Easy
E	Easy
M	Medium
H	High
VH	Very High

Groundwater Levels

Date of measurement is shown.

Standing water level measured in completed borehole

Level taken during or immediately after drilling

D	Disturbed
B	Bulk
U	Undisturbed
SPT	Standard Penetration Test
N	Result of SPT (sample taken)
PBT	Plate Bearing Test
PZ	Piezometer Installation
HP	Hand Penetrometer Test

EXCAVATION LOGS

Explanatory notes are provided at the bottom of drill log sheets. Information about the origin, geology and pedology may be entered in the “Structure and other Observations” column. The depth of the base of excavation (for the logged section) at the appropriate depth in the “Material Description” column. Refusal of excavation plant is noted should it occur. A sketch of the exposure may be added.

MATERIAL DESCRIPTION - SOIL

Classification Symbol - In accordance with the Unified Classification System (AS 1726-1993, Appendix A, Table A1)

Material Description - In accordance with AS 1726-1993, Appendix A2.3

Moisture Condition

D	Dry, looks and feels dry
M	Moist, No free water on remoulding
W	Wet, free water on remoulding

Consistency - In accordance with AS 1726-1993, Appendix A2.5

VS	Very Soft	< 12.5 kPa
S	Soft	12.5 – 25 kPa
F	Firm	25 – 50 kPa
St	Stiff	50 – 100 kPa
VSt	Very Stiff	100 – 200 kPa
H	Hard	> 200 kPa

Strength figures quoted are the approximate range of undrained shear strength for each class.

Density Index. (%) is estimated or is based on SPT results.

VL	Very Loose	< 15 %
L	Loose	15 – 35 %
MD	Medium Dense	35 – 65 %
D	Dense	65 – 85 %
VD	Very Dense	> 85 %

MATERIAL DESCRIPTION -ROCK

Material Description

Identification of rock type, composition and texture based on visual features in accordance with AS 1726-1993, Appendix A3.1-A3.3 and Tables A6a, A6b and A7.

Core Loss

Is shown at the bottom of the run unless otherwise indicated.

Bedding

Thinly Laminated	< 6 mm
Laminated	6 - 20
Very Thinly Bedded	20 - 60
Thinly Bedded	60 - 200
Medium Bedded	200 – 600
Thickly Bedded	600 – 2000
Very Thickly Bedded	> 2000

Weathering - No distinction is made between weathering and alteration. Weathering classification assists in identification but does not imply engineering properties.

Fresh (F)	Rock substance unaffected by weathering
Slightly Weathered (SW)	Rock substance partly stained or discoloured. Colour and texture of fresh rock recognisable.
Moderately Weathered (MW)	Staining or discolouration extends throughout rock substance. Fresh rock colour not recognisable.
Highly Weathered (HW)	Stained or discoloured throughout. Signs of chemical or physical alteration. Rock texture retained.
Extremely Weathered (EW)	Rock texture evident but material has soil properties and can be remoulded.

Strength - The following terms are used to described rock strength:

Rock Strength Class	Abbreviation	Point Load Strength Index, Is(50) (MPa)
Extremely Low	EL	< 0.03
Very Low	VL	0.03 to 0.1
Low	L	0.1 to 0.3
Medium	M	0.3 to 1
High	H	1 to 3
Very High	VH	3 to 10
Extremely High	EH	≥ 10

Strengths are estimated and where possible supported by Point Load Index Testing of representative samples. Test results are plotted on the graphical estimated strength by using:

° Diametral Point Load Test

Axial Point Load Test

Where the estimated strength log covers more than one range it indicates the rock strength varies between the limits shown.

MATERIALS STRUCTURE/FRACTURES

ROCK

Natural Fracture Spacing - A plot of average fracture spacing excluding defects known or suspected to be due to drilling, core boxing or testing. Closed or cemented joints, drilling breaks and handling breaks are not included in the Natural Fracture Spacing.

Visual Log - A diagrammatic plot of defects showing type, spacing and orientation in relation to core axis.

Defects	────────	Defects open in-situ or clay sealed
	- - - - - -	Defects closed in-situ
	…………………	Breaks through rock substance

Additional Data - Description of individual defects by type, orientation, in-filling, shape and roughness in accordance with AS 1726-1993, Appendix A Table A10, notes and Figure A2.

Orientation - angle relative to the plane normal to the core axis.

Type	BP	Bedding Parting
	JT	Joint
	SM	Seam
	FZ	Fracture Zone
	SZ	Shear Zone
	VN	Vein
	FL	Foliation
	CL	Cleavage
	DL	Drill Lift
	HB	Handling Break
	DB	Drilling Break
Infilling	CN	Clean
	X	Carbonaceous
	Clay	Clay
	KT	Chlorite
	CA	Calcite
	Fe	Iron Oxide
	Qz	Quartz
	MS	Secondary Mineral
	MU	Unidentified Mineral
Shape	PR	Planar
	CU	Curved
	UN	Undulose
	ST	Stepped
	IR	Irregular
	DIS	Discontinuous
Rougness	POL	Polished
	SL	Slickensided
	S	Smooth
	RF	Rough
	VR	Very Rough

SOIL

Structures - Fissuring and other defects are described in accordance with AS 1726-1993, Appendix A2.6, using the terminology for rock defects.

Origin - Where practicable an assessment is provided of the probable origin of the soil, eg fill, topsoil, alluvium, colluvium, residual soil.

Appendix B

LABORATORY CERTIFICATES

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS

Contact	Alan Morrow
Client	MORROW GEOTECHNICS PTY LTD
Address	UNIT 5 12 WINCHESTER STREET CARLTON NSW 2218
Telephone	(Not specified)
Facsimile	(Not specified)
Email	alan@morrowgeo.com.au
Project	**P1702 Denham Court**
Order Number	(Not specified)
Samples	12

LABORATORY DETAILS

Manager	Huong Crawford
Laboratory	SGS Alexandria Environmental
Address	Unit 16, 33 Maddox St Alexandria NSW 2015
Telephone	+61 2 8594 0400
Facsimile	+61 2 8594 0499
Email	au.environmental.sydney@sgs.com
SGS Reference	**SE194811 R0**
Date Received	28 Jun 2019
Date Reported	05 Jul 2019

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(4354).

SIGNATORIES

Bennet Lo
Senior Organic Chemist/Metals Chemis

Dong Liang
Metals/Inorganics Team Leader

		Sample Number	SE194811.001	SE194811.002	SE194811.003	SE194811.004
		Sample Matrix	Soil	Soil	Soil	Soil
		Sample Date	28 Jun 2019	28 Jun 2019	28 Jun 2019	28 Jun 2019
		Sample Name	DS 3-3 0.4-0.5m	DS 3-4 0.9-1.0m	DS 3-5 1.4-1.5m	DS 3-6 1.9-2.0m
Parameter	**Units**	**LOR**				
Soluble Anions in Soil from 1:2 DI Extract by Ion Chromatography Method: AN245 Tested: 5/7/2019						
Chloride	mg/kg	0.25	-	640	-	-
Sulfate	mg/kg	0.5	-	360	-	-
pH in soil (1:2) Method: AN101 Tested: 4/7/2019						
pH (1:2)	pH Units	-	-	4.5	-	-
pH in soil (1:5) Method: AN101 Tested: 4/7/2019						
pH	pH Units	0.1	5.7	-	5.1	5.2
Conductivity (1:2) in soil Method: AN106 Tested: 4/7/2019						
Conductivity (1:2) @25 C*	µS/cm	1	-	1100	-	-
Resistivity (1:2)*	ohm cm	-	-	930	-	-
Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 4/7/2019						
Conductivity of Extract (1:5 as received)	µS/cm	1	140	-	350	260
Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	170	-	390	290
Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 5/7/2019						
Exchangeable Sodium, Na	mg/kg	2	-	-	-	-
Exchangeable Sodium, Na	meq/100g	0.01	-	-	-	-
Exchangeable Sodium Percentage*	%	0.1	-	-	-	-

Parameter	Units	LOR	SE194811.001 Soil 28 Jun 2019 DS 3-3 0.4-0.5m	SE194811.002 Soil 28 Jun 2019 DS 3-4 0.9-1.0m	SE194811.003 Soil 28 Jun 2019 DS 3-5 1.4-1.5m	SE194811.004 Soil 28 Jun 2019 DS 3-6 1.9-2.0m
Moisture Content Method: AN002 Tested: 3/7/2019						
% Moisture	%w/w	0.5	15	16	11	8.7

Row labels of header: Sample Number / Sample Matrix / Sample Date / Sample Name

		Sample Number	SE194811.005	SE194811.006	SE194811.007	SE194811.008
		Sample Matrix	Soil	Soil	Soil	Soil
		Sample Date	28 Jun 2019	28 Jun 2019	28 Jun 2019	28 Jun 2019
		Sample Name	DS 5-2 0.4-0.5m	DS 5-3 0.9-1.0m	DS 5-4 1.4-1.5m	DS 8-1 0.5-0.6m
Parameter	Units	LOR				

Soluble Anions in Soil from 1:2 DI Extract by Ion Chromatography Method: AN245 Tested: 5/7/2019

Chloride	mg/kg	0.25	-	-	-	140
Sulfate	mg/kg	0.5	-	-	-	230

pH in soil (1:2) Method: AN101 Tested: 4/7/2019

pH (1:2)	pH Units	-	-	-	-	6.2

pH in soil (1:5) Method: AN101 Tested: 4/7/2019

pH	pH Units	0.1	5.3	5.0	-	-

Conductivity (1:2) in soil Method: AN106 Tested: 4/7/2019

Conductivity (1:2) @25 C*	µS/cm	1	-	-	-	470
Resistivity (1:2)*	ohm cm	-	-	-	-	2100

Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 4/7/2019

Conductivity of Extract (1:5 as received)	µS/cm	1	330	410	-	-
Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	390	460	-	-

Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 5/7/2019

Exchangeable Sodium, Na	mg/kg	2	-	-	940	-
Exchangeable Sodium, Na	meq/100g	0.01	-	-	4.1	-
Exchangeable Sodium Percentage*	%	0.1	-	-	32.4	-

Parameter	Units	LOR	SE194811.005 Soil 28 Jun 2019 DS 5-2 0.4-0.5m	SE194811.006 Soil 28 Jun 2019 DS 5-3 0.9-1.0m	SE194811.007 Soil 28 Jun 2019 DS 5-4 1.4-1.5m	SE194811.008 Soil 28 Jun 2019 DS 8-1 0.5-0.6m
Sample Number			SE194811.005	SE194811.006	SE194811.007	SE194811.008
Sample Matrix			Soil	Soil	Soil	Soil
Sample Date			28 Jun 2019	28 Jun 2019	28 Jun 2019	28 Jun 2019
Sample Name			DS 5-2 0.4-0.5m	DS 5-3 0.9-1.0m	DS 5-4 1.4-1.5m	DS 8-1 0.5-0.6m
Moisture Content Method: AN002 Tested: 3/7/2019						
% Moisture	%w/w	0.5	13	12	13	5.2

Parameter	Units	LOR	SE194811.009 Soil 28 Jun 2019 DS 9-2 0.2-0.3m	SE194811.010 Soil 28 Jun 2019 DS 9-3 0.4-0.5m	SE194811.011 Soil 28 Jun 2019 DS 9-4 1.9-1.0m	SE194811.012 Soil 28 Jun 2019 DS 9-5 1.4-1.5m
Sample Number / Sample Matrix / Sample Date / Sample Name						

Soluble Anions in Soil from 1:2 DI Extract by Ion Chromatography Method: AN245 Tested: 5/7/2019

Chloride	mg/kg	0.25	-	75	-	-
Sulfate	mg/kg	0.5	-	81	-	-

pH in soil (1:2) Method: AN101 Tested: 4/7/2019

pH (1:2)	pH Units	-	-	4.8	-	-

pH in soil (1:5) Method: AN101 Tested: 4/7/2019

pH	pH Units	0.1	5.2	-	5.0	5.2

Conductivity (1:2) in soil Method: AN106 Tested: 4/7/2019

Conductivity (1:2) @25 C*	µS/cm	1	-	230	-	-
Resistivity (1:2)*	ohm cm	-	-	4300	-	-

Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 4/7/2019

Conductivity of Extract (1:5 as received)	µS/cm	1	130	-	280	510
Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	160	-	340	590

Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 3/7/2019

Exchangeable Sodium, Na	mg/kg	2	660	-	-	-
Exchangeable Sodium, Na	meq/100g	0.01	2.9	-	-	-
Exchangeable Sodium Percentage*	%	0.1	22.0	-	-	-

Parameter	Units	LOR	Sample Number Sample Matrix Sample Date Sample Name	SE194811.009 Soil 28 Jun 2019 DS 9-2 0.2-0.3m	SE194811.010 Soil 28 Jun 2019 DS 9-3 0.4-0.5m	SE194811.011 Soil 28 Jun 2019 DS 9-4 1.9-1.0m	SE194811.012 Soil 28 Jun 2019 DS 9-5 1.4-1.5m
Moisture Content Method: AN002 Tested: 3/7/2019							
% Moisture	%w/w	0.5		19	3.3	18	13

QC SUMMARY

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Conductivity (1:2) in soil Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity (1:2) @25 C*	LB177731	µS/cm	1	<1	7%	102%
Resistivity (1:2)*	LB177731	ohm cm	-		7%	NA

Conductivity and TDS by Calculation - Soil Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity of Extract (1:5 as received)	LB177730	µS/cm	1	<1	10%	98%
Conductivity of Extract (1:5 dry sample basis)	LB177730	µS/cm	1		10%	98%

Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: ME-(AU)-[ENV]AN122

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
Exchangeable Sodium, Na	LB177619	mg/kg	2		99%
Exchangeable Sodium, Na	LB177619	meq/100g	0.01	<0.01	NA
Exchangeable Sodium Percentage*	LB177619	%	0.1		NA

pH in soil (1:2) Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	DUP %RPD	LCS %Recovery
pH (1:2)	LB177731	pH Units	-	2%	100%

pH in soil (1:5) Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	DUP %RPD	LCS %Recovery
pH	LB177730	pH Units	0.1	0%	100%

Soluble Anions in Soil from 1:2 DI Extract by Ion Chromatography Method: ME-(AU)-[ENV]AN245

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Chloride	LB177694	mg/kg	0.25	<0.25	59%	102%
Sulfate	LB177694	mg/kg	0.5	<0.5	16%	99%

METHOD SUMMARY

METHOD	METHODOLOGY SUMMARY
AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode and is calibrated against 3 buffers purchased commercially. For soils, sediments and sludges, an extract with water (or 0.01M CaCl2) is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Salinity can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. Reference APHA 2510 B.
AN106	Resistivity of the extract is reported on the extract basis and is the reciprocal of conductivity. Salinity and TDS can be calculated from the extract conductivity and is reported back to the soil basis.
AN122	Exchangeable Cations, CEC and ESP: Soil sample is extracted in 1M Ammonium Acetate at pH=7 (or 1M Ammonium Chloride at pH=7) with cations (Na, K, Ca & Mg) then determined by ICP OES/ICP MS and reported as Exchangeable Cations. For saline soils, these results can be corrected for water soluble cations and reported as Exchangeable cations in meq/100g or soil can be pre-treated (aqueous ethanol/aqueous glycerol) prior to extraction. Cation Exchange Capacity (CEC) is the sum of the exchangeable cations in meq/100g.
AN122	The Exchangeable Sodium Percentage (ESP) is calculated as the exchangeable sodium divided by the CEC (all in meq/100g) times 100. ESP can be used to categorise the sodicity of the soil as below: ESP < 6% non-sodic ESP 6-15% sodic ESP >15% strongly sodic Method is referenced to Rayment and Lyons, 2011, sections 15D3 and 15N1.-
AN245	Anions by Ion Chromatography: A water sample or extract is injected into an eluent stream that passes through the ion chromatographic system where the anions of interest ie Br, Cl, NO2, NO3 and SO4 are separated on their relative affinities for the active sites on the column packing material. Changes to the conductivity and the UV-visible absorbance of the eluent enable identification and quantitation of the anions based on their retention time and peak height or area. APHA 4110 B

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
**	Indicative data, theoretical holding time exceeded.	QFL	QC result is below the lower tolerance
		-	The sample was not analysed for this analyte
		NVL	Not Validated

Unless it is reported that sampling has been performed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au.pv.sgsvr/en-gb/environment.

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Appendix C

IMPORTANT INFORMATION

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