REPORT TO

TERROIR

ON

GEOTECHNICAL INVESTIGATION

FOR

PROPOSED RESOURCE RECOVERY LEARNING CENTRE

AT

120 FLATROCK ROAD, MUNDAMIA, NSW

Date: 27 February 2023
Ref: 35556LTrpt

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DOCUMENT REVISION RECORD

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1 INTRODUCTION

This report presents the results of a geotechnical investigation for the proposed resource recovery learning centre at 120 Flatrock Road, Mundamia, NSW. The location of the site is shown in Figure 1. The investigation was commissioned by Gerard Reinmuth by signed Acceptance of Proposal dated 13 October 2022. The commission was on the basis of our fee proposal dated 8 June 2022, Ref: P56626LT.

We understand from the supplied preliminary investigation report prepared by Terroir, dated 20 December 2022, that the proposed resource recovery learning centre will comprise three detached single-level buildings arrayed around a suspended deck to be used as an outdoor learning area. The proposed floor level of the buildings and outdoor learning area are generally indicated to be at or above existing surface levels. Around the eastern and southern sides of the buildings some gabion feature walls are proposed. South of the learning centre, a new carpark is proposed which we assume will be constructed close to existing surface levels.

The purpose of the investigation was to obtain geotechnical information on the subsurface conditions, and to use this as a basis for comments and recommendations on excavations, subgrade preparation, footings and pavements.

This geotechnical investigation was carried out in conjunction with a Preliminary Site Investigation (PSI) by our environmental division, JK Environments (JKE). Reference should be made to the separate report by JKE, Ref: E35556PDrpt, for the results of the environmental site assessment.

2 INVESTIGATION PROCEDURE

The fieldwork was completed on 4 and 5 January 2023, and comprised the drilling of eight boreholes (BH1 to BH8 inclusive) to depths ranging from 4.5m to 7.5m below existing surface levels, using our track-mounted JK309 drilling rig. The boreholes were advanced through the soils and weathered bedrock using spiral auger drilling techniques and a Tungsten Carbide (TC) bit.

The grid coordinates and surface level of each borehole were measured using our differential GPS survey system to Map Grid Australia (MGA2020) and AHD, respectively. The order of accuracy in all directions is expected to be within 50mm. The measured surface RL's are presented on the attached borehole logs. The borehole locations are shown on the attached Figure 2.

The apparent compaction of the fill and strength of the cohesive soils were assessed from Standard Penetration Test (SPT) 'N' values, augmented by hand penetrometer tests carried out on cohesive soils recovered from the SPT split tube sampler. The strength of the bedrock was assessed from observation of the drilling resistance using the TC drill bit attached to the augers, tactile examination of rock cuttings, and correlation with the results of subsequent laboratory moisture content tests. It should be noted that strengths assessed in this way are approximate and variances of at least one strength order should not be unexpected.

Selected soil samples were returned to Soil Test Services Pty Ltd (STS) and Envirolab Services Pty Ltd, both NATA accredited laboratories. STS completed moisture content, Atterberg limits, shrink-swell index and CBR testing and the results of these tests are provided in the attached STS Tables A, B and C. Soil aggression testing was completed by Envirolab Services Pty Ltd and the results are provided in the attached Certificate of Analysis No. 314269.

Groundwater observations were recorded in all boreholes during and on completion of auger drilling. Standpipe piezometers was installed in BH3, BH5 and BH8 to allow for longer-term groundwater monitoring. No further groundwater monitoring has been carried out since the fieldwork was completed.

Our geotechnical engineer was present on a full-time basis during the fieldwork, to nominate testing and sampling and prepare the borehole logs. The borehole logs, which include field test results and groundwater observations, are attached, together with a set of explanatory notes which describe the investigation techniques, and their limitations and define the logging terms and symbols used.

3 RESULTS OF INVESTIGATION

3.1 Site History

Prior to 1969, the site appears to have comprised bushland. We understand from the supplied report, prepared by Maunsell Pty Ltd 'Landfills Leachate Study' dated March 1991, that prior to 1975 portions of the current West Nowra Recycling & Waste Deport property was used by Council as a quarry. The extent of quarrying appears to have been west of the site area. Landfilling operations, based on the plan within the Leachate Study report, appear to have encroached close to the northern edge of the site. These landfill cells have subsequently been covered. The inferred extent of the landfill and deeper soil fill, based on the borehole logs, is presented as Figure 3. Figure 3 is based on an aerial image, from Historical Imagery, of the site in 1984 and also shows an overlay of the Leachate Study landfill cell plan. The areas to the east and south of the site, although developed, do not appear to have been extensively excavated/filled.

3.2 Site Description

The site is located in gently sloping topography associated with the foothills on the eastern side of the Illawarra Plateau, characterised by maximum slopes in the order of about 5°. Surface levels across the site generally slope to the north-west at approximately 3°.

The site, as shown on Figure 1, is located towards the eastern edge of the West Nowra Recycling and Waste Depot. The site primarily comprises areas of grass with shrubs and medium to large size trees located within the central portion of the site. A couple of asphalt surfaced car parks are present within the southern portion of the site and a gravel driveway extends from the western carpark to Flatrock Road through the site.

North of the site, surface levels grade up through a 4.5m high grassed embankment which slopes at approximately 13° up to the north. A number of small to medium sized trees are present within the embankment.

West of the site are multiple steel framed structures and a gas extractor. These structures appeared to be in good condition based on our cursory observations. Surface levels to the west are similar to the site.

South of the site are a number of single-storey demountable buildings and a couple of concrete block buildings as well as the southern portions of the carparks within the site. Further to the south, beyond the demountable buildings, and carpark, is a vacant site from which vegetation has been cleared.

The site has an eastern frontage with Flatrock Road which grades down to the south at approximately 3°.

3.3 Subsurface Conditions

The Nowra-Toolijooa 1:50,000 Geological Series Sheet 9028 II-III indicates that the site is underlain by Nowra Sandstone comprising *"quartzose sandstone"*. This profile does not take into account in-situ weathering of the bedrock or earthworks. The boreholes encountered a generalised profile of fill with highly variable depth, overlying residual soils grading to weathered sandstone bedrock. The more pertinent details of the materials encountered are provided below. Reference should be made to the borehole logs for detailed descriptions of the subsurface conditions encountered.

Fill

Fill was encountered from the surface in all boreholes, except BH7. The fill ranged from 0.2m to deeper than 5.3m below existing surface levels. In BH7, no fill was encountered and the surface comprised a 50mm thick asphaltic concrete pavement. Deeper fill was encountered in BH1 (>5.3m), BH2 (3.2m), BH3 (>4.5m) and BH4 (2.5m). The deeper fill is considered to be due to the landfill operations that have occurred on and adjacent to the site. Landfill was encountered below depths of 2.4m and 2m in BH1 and BH3 respectively. The landfill in BH1 was primarily a silty clay, while the landfill in BH3 comprised waste material including plastic, metal, fabric and roots. The landfill was overlain by a 'capping layer' of silty clay. Elsewhere on the site, the fill generally comprised silty clay of variable plasticity with inclusions of igneous and ironstone gravel. Below the asphaltic concrete pavement in BH7, a 0.15m thick layer of granular 'road base' was present. Based on the limited testing, the fill generally appears to be poorly compacted.

Residual Silty Clay

Underlying the fill in all boreholes, except BH1 and BH3, residual silty clay was encountered. The silty clay was generally of very stiff or hard strength, although a 0.5m thick layer of stiff clay was encountered just below the fill in BH6. The residual clays ranged from high to low plasticity, with the higher plasticity clay typically within the upper residual silty clay profile. The residual silty clays contained inclusions of ironstone gravel.

Weathered Sandstone Bedrock

Weathered sandstone bedrock was encountered in all boreholes except BH1 and BH3. The top of the bedrock ranged from 1.5m to 6m below surface levels, which correlates to approximately RL44.4m (BH8) to RL38.4m (BH2). Therefore, it appears that the bedrock surface generally dips down to the north-west. The sandstone bedrock profile generally comprised an upper extremely weathered layer. The sandstone generally appears to increase in strength with depth with the boreholes in the southern half of the site (BH5, BH6, BH7 and BH8) encountering sandstone of at least medium strength at their termination depth.

Groundwater

Groundwater was encountered during and/or on completion of drilling in all boreholes except BH5. The depths to groundwater and times of monitoring are summarised in the table below:

Borehole	Depth to Groundwater (m)	Groundwater Level (mAHD)	Time of Measurement
1	0.8	42.4	On completion of drilling
2	3.9	40.5	On completion of drilling
3	0.7	42.2	8 hours after completion of drilling
4	2.0	42.5	30 minutes after completion of drilling
5	n/a	n/a	Groundwater not encountered
6	2.2	41.1	30 minutes after completion of drilling
7	3.4	41.1	On completion of drilling
8	2.8	43.1	6 hours after completion of drilling

From the above groundwater levels it appears that there is a hydraulic gradient down towards the north-west.

3.4 Laboratory Test Results

The moisture content and Atterberg Limits confirmed our field classification of the site soils. The Atterberg Limits and linear shrinkage test results indicated that the sampled residual clays are of either medium or high plasticity and therefore will have a moderate to high potential for shrink-swell movements with changes in moisture content.

The shrink-swell index tests on the residual clays returned instability index values ranging from 1.13% to 3.05% indicating a moderate potential for shrink-swell movements with variations in moisture content.

The four-day soaked CBR tests on the residual clay returned values of 4% and 7%. During soaking, the clay sample from BH5 swelled by 1.5% confirming its reactivity with respect to variations in moisture content.

The following table summarises the soil aggression tests.

Borehole	Depth (m)	Sample Type	pH	Sulphates SO_4 (ppm)	Chlorides Cl (ppm)	Resistivity (ohm.cm)
BH1	1.5-1.95	Silty clay FILL	5.4	<10	10	40,000
BH4	3.0-3.42	RESIDUAL Silty Clay	4.9	34	10	32,000
BH5	2.5-2.6	RESIDUAL Silty Clay	4.6	<10	240	6,100

4 COMMENTS AND RECOMMENDATIONS

4.1 Geotechnical Issues

The main geotechnical issue for development of this site is the presence of landfill within the north-western portion of the site, the inferred extent of which is shown on Figure 3. It appears from the supplied drawings that the proposed buildings are generally to be suspended above existing surface levels. We strongly recommend that buildings are relocated so that their footings are not located over the deep landfill areas encountered in BH1 and BH3. Any structures founded within the landfill in the north-western area would be at significant risk due to potentially large settlements and ongoing movement from secondary consolidation and possibly collapse settlements, which would impact the performance of overlying structures. We recommend that additional investigations be carried out to define the extent of the landfill in more detail, so that proposed structures can be appropriately located away from landfill areas.

Additionally, environmental constraints including contaminated soils (including asbestos), landfill gas and potentially contaminated groundwater would likely result in high construction costs where buildings are constructed in the landfill area. Reference should be made to the PSI report prepared by JKE, Ref: E35556PDrpt, for comments and recommendations regarding development of the site.

Outside the landfill area the site generally appears suitable, from a geotechnical perspective, for the proposed development, provided footings are founded either uniformly within the residual soils or uniformly within the weathered bedrock.

4.2 Excavation Conditions

The following comments and recommendations in regard to excavation are on the basis that excavation up to a maximum of 1.5m may be required.

Based on the encountered subsurface conditions any excavations will likely encounter soils. Excavation of the soils should be achievable using conventional earthmoving equipment, such as the buckets of hydraulic excavators. Ripping hooks or tynes may be required to break-up 'hard' bands within the soil profile.

Excavations to no more than 1.5m outside the landfill area are not anticipated to encounter groundwater. Excavation within the deeper fill/landfill areas should be avoided as these areas are likely to encounter shallow groundwater and problematic soils. Further specific advice should be sought from the geotechnical engineers if excavations are proposed in these areas.

Excavated spoil for off-site disposal will need to be suitably classified for waste disposal purposes. Reference should be made to the PSI investigation report prepared by JK Environments.

4.3 Subgrade Preparation

Based on the current drawings provided, it appears that the proposed new buildings will be suspended above existing ground surface levels, and therefore no specific subgrade preparation will be required. Therefore the following comments and recommendations apply to new external pavements that are constructed on existing grade at the southern end of the site where the depth of fill is not greater than 0.5m (i.e areas in the vicinity of BH5, BH6, BH7 and BH8). For on-grade pavements we recommend that the following subgrade preparation be completed.

- Strip all vegetation, existing pavements, root-affected soils and deleterious fill from the proposed pavement areas. Root-affected soils and deleterious fill will not be suitable for reuse as engineered fill however root-affected soils could be reused in landscaped areas. Granular 'road base' below existing pavements should be stockpiled separately as these materials, subject to being free of deleterious substances, will be suitable for reuse as engineered fill.
- The exposed subgrade, which we anticipate will generally comprise the residual silty clay or a shallow surface layer of silty clay fill should be proof rolled with 8 passes of a minimum 12t static smooth drum roller. The proof rolling should be carried out in the presence of a geotechnical engineer or experienced earthworks technician.
- Any soft or heaving areas should be locally removed down to a sound base and then backfilled with engineered fill. Generally, from the boreholes within the southern portion of the site, where the subgrade will comprise a shallow surface fill or the residual clay, we do not expect significant soft or heaving areas to occur provided good site drainage is maintained and the earthworks are not carried out following a period of wet weather. However, some areas requiring treatment should still be expected, particularly where the subgrade comprises the existing fill.
- Engineered fill should preferably comprise a good quality granular material, such as crushed sandstone or 'road-base' material, free of deleterious substances and with a maximum particle size of 75mm. Engineered fill should be compacted in horizontal layers with a maximum 200mm loose thickness to at least 98% of Standard Maximum Dry Density (SMDD). For backfilling confined excavations such as service trenches, a similar compaction to engineered fill should be adhered to, but if light compaction equipment is used then the layer thickness should be limited to 100mm loose thickness or alternatively a material not requiring compaction such as stabilised sand may be used.
- The existing granular 'road base' fill may also be used as engineered fill, so long as it is free of deleterious substances and meets the maximum particle size limit. The residual clays may also be reused although this will require additional control such that this material is compacted to between 98% and 102% of Standard Maximum Dry Density (SMDD) and to within ±2% of Standard Optimum Moisture Content (SOMC). If the existing site soils are to be adopted for use as an engineered fill, where the existing moisture content is less than the plastic limit (as was observed in each of the samples tested), then they will require moisture conditioning to allow them to be placed and compacted as engineered fill. We note that where the residual clays are re-used as engineered fill then there will also be an increased potential for shrink-swell movements.

- Density testing should be regularly carried out on any engineered fill. Regular density testing in accordance with Level 2 requirements of AS3798-2007 *'Guidelines on Earthworks for Commercial and Residential Developments'* are recommended.

4.4 Footings

As stated in Section 4.1, we strongly recommend that new buildings be relocated away from the landfill areas identified in BH1 and BH3. The proposed structures including the gabion feature walls are anticipated to have low to moderate loads and be relatively flexible, and therefore, where they are fully located outside the area of deeper fill may be designed to found on either shallow pad/strip footings or piles within the residual clay or weathered bedrock. Shallow pad/strip footings founded within the residual clays of at least very stiff strength may be designed based on an allowable bearing pressure (ABP) of 150kPa.

Alternatively, pile footings could be adopted. We consider that steel screw piles will be the most suitable piling option to avoid construction difficulties associated with groundwater within bored piles. Screw piles with a length to diameter ratio of at least 4 and founded within the residual clays of at least very stiff strength may be designed for an ABP of 300kPa. If steel screw piles are taken down and founded within the extremely weathered sandstone of at least hard strength they may be designed for a maximum allowable end bearing pressure of 450kPa. Where steel screw piles are adopted, and due to the variability in fill depth across the site, we recommend further borehole investigations to define founding depths more accurately.

At least the initial stages of footing excavation and/or pile drilling should be inspected by a geotechnical engineer to confirm that the recommended founding stratum has been reached, and to check initial assumptions about foundation conditions and possible variations that may occur between borehole locations. We note that the founding material for steel screw piles cannot be inspected and so the geotechnical inspections for steel screw piles would only be to confirm that pile depths are consistent with known borehole data. The piling contractor would need to certify their own piles. The need for further inspections can be assessed following the initial visit.

If pile footings are to be adopted and the building floor level is at grade, then void formers at least 75m thickness should be placed below floors to provide some allowance for swell movements of the subgrade soils.

4.5 Pavements

The pavement subgrade should be prepared as recommended in Sections 4.3. Based on the investigation results, we recommend that any new pavements with a subgrade of residual clay may be designed using a soaked CBR of 4%. Rigid pavements may be designed using a modulus of subgrade reaction 30kPa/mm (750mm plate).

Flexible pavements should be underlain by a good quality base-course layer comprising crushed rock to TfNSW QA specification 3051 unbound base material, compacted to at least 100% of SMDD.

Concrete pavements should have a subbase layer of at least 100mm thickness of crushed rock to TfNSW QA Specification 3051 unbound base material (or equivalent good quality and durable fine crushed rock), which is compacted to at least 100% of SMDD. Concrete pavements should be designed with an effective shear transmission at all joints by way of either doweled or keyed joints.

During construction care should be taken to ensure adequate cross-falls are maintained across exposed subgrade areas to assist drainage as clay subgrades may become untrafficable if wet. We recommend that subsoil drains be placed around the perimeter of the new pavements. The subsoil drains should extend to a depth of at least 0.3m below the subgrade level and the drains should have adequate falls to reduce ponding in the drains.

4.6 Exposure Classification

The soil aggression test results have indicated that in accordance with Table 4.8.1 of AS3600:2018 'Concrete Structures', the exposure classification to concrete elements in contact with the ground is 'A2'. In accordance with Tables 6.4.2(C) and 6.5.2(C) of AS2159:2009 'Piling design and installation', the exposure classification to concrete and steel piles is 'Mild' and 'Non-aggressive' respectively.

The above exposure classifications should only be adopted outside the landfill areas. In areas underlain by landfill, or where contaminated groundwater may occur, then a more severe exposure classification will apply which should be checked with the relevant standard.

4.7 Additional Investigations

As discussed in Section 4.1 and 4.4, we recommend that an additional geotechnical investigation be completed to better define the extent of the landfill and fill depths within the northern half of the site. The additional boreholes should be drilled at a reasonably close spacing to more accurately define the edge of the landfill to allow for avoidance of this area. Where landfill is encountered then the boreholes could be terminated a short depth within the landfill. Boreholes drilled outside the landfill should extend at least 2m into the natural soils below the existing deeper fill to provide greater confidence on the depths required for screw piles if they are to be adopted. The investigation should comprise augered boreholes drilled with a specialised investigation rig. Only minimal additional investigation, if any, would be required within the southern half of the site, where generally shallow fill was encountered within the current boreholes.

5 GENERAL COMMENTS

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. As an example, special treatment of soft spots may be required as a result of their discovery during proof-rolling, etc. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and

JK Geotechnics accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

The long term successful performance of pavements is dependent on the satisfactory completion of the earthworks. In order to achieve this, the quality assurance program should not be limited to routine compaction density testing only. Other critical factors associated with the earthworks may include subgrade preparation, selection of fill materials, control of moisture content and drainage, etc. The satisfactory control and assessment of these items may require judgment from an experienced engineer. Such judgment often cannot be made by a technician who may not have formal engineering qualifications and experience. In order to identify potential problems, we recommend that a pre-construction meeting be held so that all parties involved understand the earthworks requirements and potential difficulties. This meeting should clearly define the lines of communication and responsibility.

Occasionally, the subsurface conditions between the completed boreholes may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact this office.

This report provides advice on geotechnical aspects for the proposed civil and structural design. As part of the documentation stage of this project, Contract Documents and Specifications may be prepared based on our report. However, there may be design features we are not aware of or have not commented on for a variety of reasons. The designers should satisfy themselves that all the necessary advice has been obtained. If required, we could be commissioned to review the geotechnical aspects of contract documents to confirm the intent of our recommendations has been correctly implemented.

A waste classification is required for any soil and/or bedrock excavated from the site prior to offsite disposal. Subject to the appropriate testing, material can be classified as Virgin Excavated Natural Material (VENM), Excavated Natural Material (ENM), General Solid, Restricted Solid or Hazardous Waste. Analysis can take up to seven to ten working days to complete, therefore, an adequate allowance should be included in the construction program unless testing is completed prior to construction. If contamination is encountered, then substantial further testing (and associated delays) could be expected. We strongly recommend that this requirement is addressed prior to the commencement of excavation on site.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. If there is any change in the proposed development described in this report then all recommendations should be reviewed. Copyright in this report is the property of JK Geotechnics. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE A
MOISTURE CONTENT, ATTERBERG LIMITS AND LINEAR SHRINKAGE TEST REPORT

Client:	JK Geotechnics	**Report No.:**	35556LT - A
Project:	Proposed Resource Recovery Learning Centre	**Report Date:**	25/01/2023
Location:	120 Flatrock Road, Mundamia, NSW	**Page 1 of 1**	

AS 1289	TEST METHOD	2.1.1	3.1.2	3.2.1	3.3.1	3.4.1
BOREHOLE NUMBER	**DEPTH m**	**MOISTURE CONTENT %**	**LIQUID LIMIT %**	**PLASTIC LIMIT %**	**PLASTICITY INDEX %**	**LINEAR SHRINKAGE %**
2	0.50 - 0.95	6.9	-	-	-	-
2	1.00 - 1.45	5.1	-	-	-	-
4	1.00 - 1.20	15.6	41	15	26	11.5
5	4.30 - 5.00	4.7	-	-	-	-
6	1.00 - 1.37	14.3	55	17	38	16.0
6	7.20 - 7.50	7.3	-	-	-	-

Notes:

- The test sample for liquid and plastic limit was air-dried & dry-sieved
- The linear shrinkage mould was 125mm
- Refer to appropriate notes for soil descriptions
- Date of receipt of sample: 11/01/2023.
- Sampled and supplied by client. Samples tested as received.

NATA
NATA Accredited Laboratory
Number:1327

25/01/2023
Authorised Signature / Date
(D. Treweek)

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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE B
FOUR DAY SOAKED CALIFORNIA BEARING RATIO TEST REPORT

Client: JK Geotechnics
Project: Proposed Resource Recovery Learning Centre
Location: 120 Flatrock Road, Mundamia, NSW

Report No.: 35556LT - B
Report Date: 24/01/2023
Page 1 of 1

BOREHOLE NUMBER	BH 5	BH 7
DEPTH (m)	1.00 - 2.00	1.00 - 1.50
Surcharge (kg)	4.5	4.5
Maximum Dry Density (t/m^3)	1.64 STD	1.78 STD
Optimum Moisture Content (%)	20.6	16.8
Moulded Dry Density (t/m^3)	1.60	1.74
Sample Density Ratio (%)	98	98
Sample Moisture Ratio (%)	102	100
Moisture Contents		
Insitu (%)	22.1	14.1
Moulded (%)	21.0	16.8
After soaking and		
After Test, Top 30mm(%)	23.7	19.0
Remaining Depth (%)	23.1	18.4
Material Retained on 19mm Sieve (%)	0	0
Swell (%)	1.5	0.0
C.B.R. value: @2.5mm penetration	4.0	7

NOTES: Sampled and supplied by client. Samples tested as received.
- Refer to appropriate Borehole logs for soil descriptions
- Test Methods : AS 1289 6.1.1, 5.1.1 & 2.1.1.
- Date of receipt of sample: 11/01/2023.

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Accredited for compliance with ISO/IEC 17025 - Testing.
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the items tested or sampled.

24/01/2023
Authorised Signature / Date
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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE C
SHRINK - SWELL TEST REPORT
TEST METHOD: AS1289 7.1.1

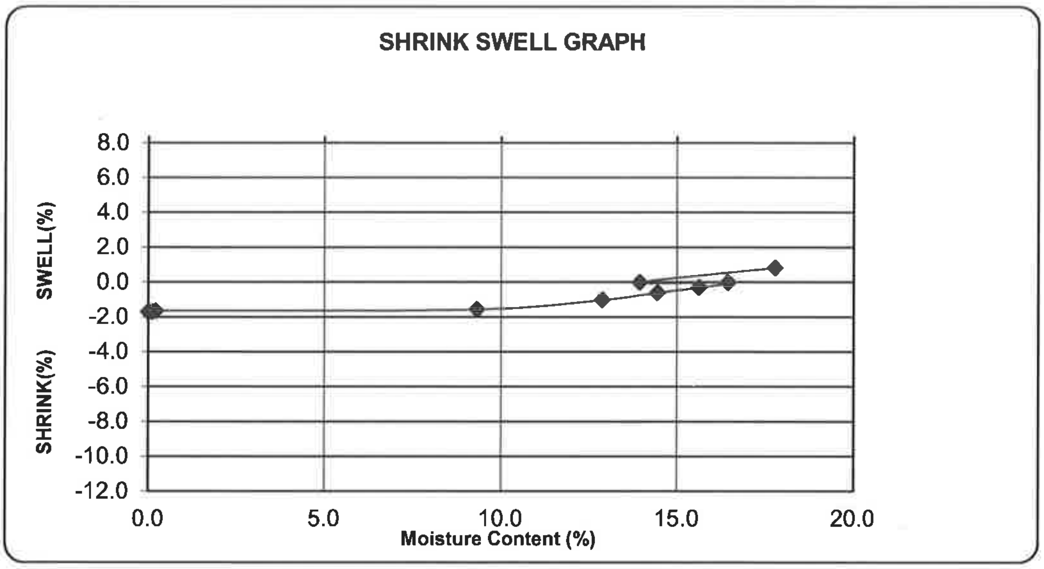
Client: JK Geotechnics
Project: Proposed Resource Recovery Learning Centre
Location: 120 Flatrock Road, Mundamia, NSW

Report No.: 35556LT - C
Report Date: 20/01/2023
Page 1 of 3

Borehole No.: 4 Depth: 1.00 - 1.20m

MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH	
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST
13.9%	17.8%	160,300 kPa	310,320 kPa

LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION	SWELL ON SATURATION	SHRINKAGE
25	-0.9%	0.8%	1.7%



SHRINK SWELL INDEX
1.16 %/pF

Notes: Sampled and supplied by client. Sample tested as received.
- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Visually estimated inclusions by volume = 0-5%
- Shrinkage Cracking = Moderate
- Soil Crumbling = none
- Date of receipt of sample: 11/01/2023.

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North Ryde, Bc 1670
Telephone: 02 9888 5000
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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE C
SHRINK - SWELL TEST REPORT
TEST METHOD: AS1289 7.1.1

Client: JK Geotechnics
Project: Proposed Resource Recovery Learning Centre
Location: 120 Flatrock Road, Mundamia, NSW

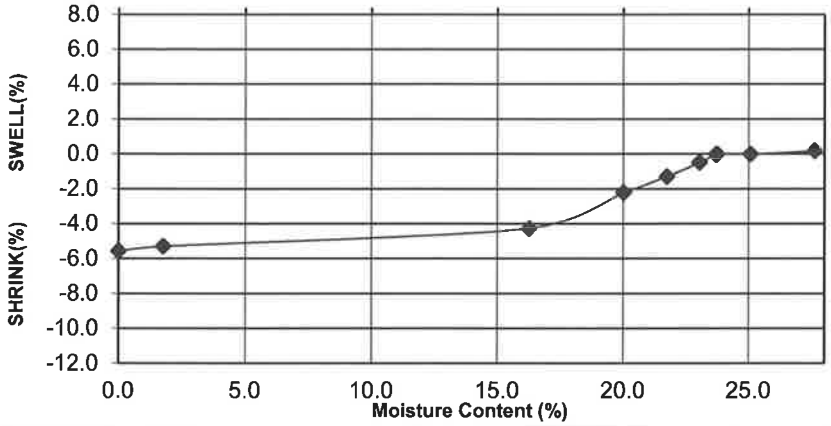
Report No.: 35556LT - C
Report Date: 20/01/2023
Page 2 of 3

Borehole No.: 5 Depth: 1.00 - 1.40m

MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH	
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST
25.1%	27.6%	200,270,420 kPa	260,310 kPa

LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION	SWELL ON SATURATION	SHRINKAGE
25	-0.8%	0.2%	5.4%

SHRINK SWELL GRAPH



SHRINK SWELL INDEX
3.05 %/pF

Notes: Sampled and supplied by client. Sample tested as received.
- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Visually estimated inclusions by volume = 0-5%
- Shrinkage Cracking = Moderate
- Soil Crumbling = none
- Date of receipt of sample: 11/01/2023.

NATA
NATA Accredited Laboratory
Number:1327

Accredited for compliance with ISO/IEC 17025 - Testing.
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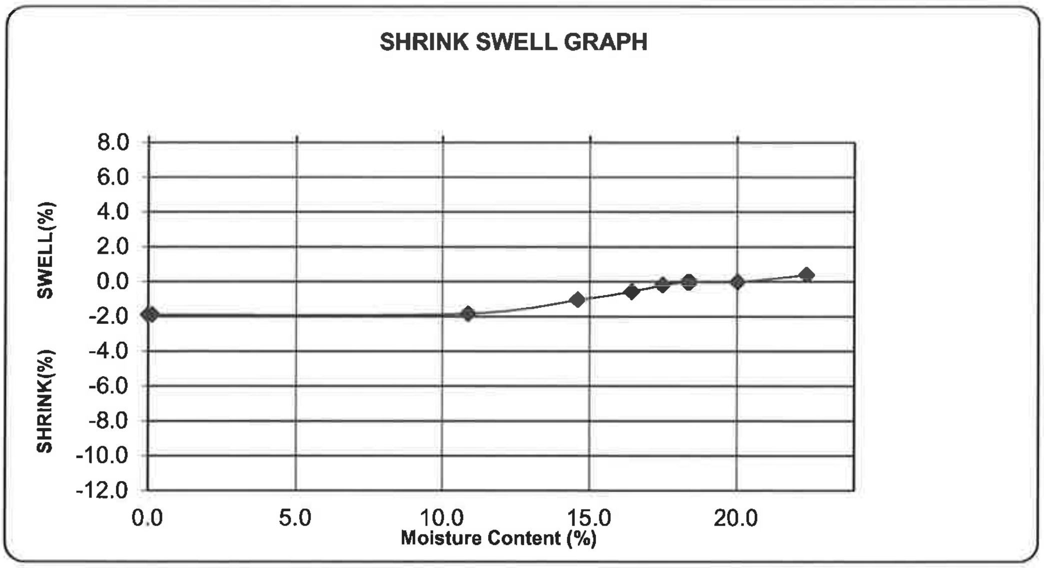
In full without approval of the laboratory. Results relate only to
the items tested or sampled.

Authorised Signature / Date
(D. Treweek)
20/1/23

TABLE C
SHRINK - SWELL TEST REPORT
TEST METHOD: AS1289 7.1.1

Client:	JK Geotechnics	**Report No.:**	35556LT - C
Project:	Proposed Resource Recovery Learning Centre	**Report Date:**	20/01/2023
Location:	120 Flatrock Road, Mundamia, NSW	**Page**	3 of 3

Borehole No.: 6	Depth: 1.00 - 1.37m		
MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH	
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST
20.0%	22.4%	190,280,240 kPa	240,310 kPa
LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION	SWELL ON SATURATION	SHRINKAGE
25	-0.5%	0.4%	1.8%


SHRINK SWELL GRAPH

SHRINK SWELL INDEX
1.13 %/pF

Notes: Sampled and supplied by client. Sample tested as received.
- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Visually estimated inclusions by volume = 0-5%
- Shrinkage Cracking = Moderate
- Soil Crumbling = none
- Date of receipt of sample: 11/01/2023.

NATA
NATA Accredited Laboratory
Number:1327

Authorised Signature / Date
(D. Treweek)
20/1/23

Envirolab Services Pty Ltd
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CERTIFICATE OF ANALYSIS 314269

Client Details

Client	JK Geotechnics
Attention	N Phung
Address	PO Box 976, North Ryde BC, NSW, 1670

Sample Details

Your Reference	**35556LT, Mundamia**
Number of Samples	3 Soil
Date samples received	11/01/2023
Date completed instructions received	11/01/2023

Analysis Details

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

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

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

Report Details

Date results requested by	18/01/2023
Date of Issue	18/01/2023

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Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Misc Inorg - Soil				
Our Reference		314269-1	314269-2	314269-3
Your Reference	UNITS	1	4	5
Depth		1.5-1.95	3.0-3.42	2.5-2.6
Date Sampled		05/01/2023	05/01/2023	04/01/2023
Type of sample		Soil	Soil	Soil
Date prepared	-	11/01/2023	11/01/2023	11/01/2023
Date analysed	-	12/01/2023	12/01/2023	12/01/2023
pH 1:5 soil:water	pH Units	5.4	4.9	4.6
Chloride, Cl 1:5 soil:water	mg/kg	10	10	240
Sulphate, SO4 1:5 soil:water	mg/kg	<10	34	<10
Resistivity in soil*	ohm m	400	320	61

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity (non NATA). Resistivity (calculated) may not correlate with results otherwise obtained using Resistivity-Current method, depending on the nature of the soil being analysed.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			11/01/2023	[NT]	[NT]	[NT]	[NT]	11/01/2023	[NT]
Date analysed	-			12/01/2023	[NT]	[NT]	[NT]	[NT]	12/01/2023	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	[NT]	[NT]	98	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	112	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	117	[NT]
Resistivity in soil*	ohm m	1	Inorg-002	<1	[NT]	[NT]	[NT]	[NT]	101	[NT]

Result Definitions

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

Quality Control Definitions

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

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

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

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

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

Spikes for Physical and Aggregate Tests are not applicable.

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

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

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

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

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

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

Where matrix spike recoveries fall below the lower limit of the acceptance criteria (e.g. for non-labile or standard Organics <60%), positive result(s) in the parent sample will subsequently have a higher than typical estimated uncertainty (MU estimates supplied on request) and in these circumstances the sample result is likely biased significantly low.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

BOREHOLE LOG

Borehole No.
1
1/1

Client: TERROIR
Project: PROPOSED RESOURCE RECOVERY LEARNING CENTRE
Location: 120 FLATROCK ROAD, MUNDAMIA, NSW

Job No.: 35556LT
Method: SPIRAL AUGER
R.L. Surface: 43.2m
Date: 5/1/23
Datum: AHD
Plant Type: JK309
Logged/Checked by: N.A.P./A.B.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	■			■		0	▨		FILL: Silty clay, low to medium plasticity, dark brown and light orange brown, trace of fine to medium grained ironstone gravel, and root fibres.	w≈PL			GRASS COVER APPEARS POORLY COMPACTED
▼ ON COMPLETION	■			■	N = 3 3,2,1		▨					100 110 100	
				■	N = 3 3,2,1	1	▨		FILL: Silty clay, low to medium plasticity, grey, dark brown and light orange brown, with fine to medium grained ironstone gravel, trace of igneous gravel, and root fibres.	w>PL		120 150 90	
				■	N = 10 9,6,4		▨					350 330 300	
						2	▨		FILL: Silty clay, low to medium plasticity, dark brown, with plastic and fabric fragments.				
▶	■					3	▨						
						4	▨						
						5	▨						
									END OF BOREHOLE AT 5.3m				'TC' BIT REFUSAL ON OBSTRUCTION IN FILL
						6							
						7							

JKGeotechnics

BOREHOLE LOG

Borehole No.
2
1/2

Client: TERROIR
Project: PROPOSED RESOURCE RECOVERY LEARNING CENTRE
Location: 120 FLATROCK ROAD, MUNDAMIA, NSW

Job No.: 35556LT **Method:** SPIRAL AUGER **R.L. Surface:** 44.4m
Date: 5/1/23 **Datum:** AHD
Plant Type: JK309 **Logged/Checked by:** N.A.P./A.B.

Groundwater Record	SAMPLES ES U50 DB DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			FILL: Silty clay, low plasticity, grey, trace of fine to medium grained ironstone gravel, and root fibres.	w<PL			GRASS COVER APPEARS POORLY TO MODERATELY COMPACTED
		N = 14 4,7,7				as above, but brown and grey, with fine to medium grained ironstone gravel.				
		N = 5 5,3,2	1			FILL: Sandy silty clay, low plasticity, brown, light grey and orange brown, trace of fine to medium grained ironstone gravel, and plastic fragments.				
		N = 16 4,8,8				FILL: Silty clay, high plasticity, light grey mottled red brown, trace of fine to medium grained ironstone gravel, and fine grained sand.	w>PL			
			2			FILL: Silty clay, medium plasticity, red brown mottled light grey, trace of fine to medium grained ironstone gravel and plastic fragments.	w<PL			
			3		CI	Silty CLAY: medium plasticity, light grey, trace of fine to medium grained ironstone and quartz gravel.	w≈PL	Hd		RESIDUAL
▼ ON COMPLETION		N > 10 8,7,3/ 100mm REFUSAL	4		CL	Silty CLAY: low plasticity light grey, trace of fine grained sand, and fine to medium grained ironstone gravel.	w<PL		450 450 500	
▶			5 6		-	Extremely Weathered sandstone: silty sandy CLAY, low plasticity, orange brown.	XW	(Hd)		NOWRA SANDSTONE
			7							

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BOREHOLE LOG

Borehole No.
2
2/2

Client: TERROIR
Project: PROPOSED RESOURCE RECOVERY LEARNING CENTRE
Location: 120 FLATROCK ROAD, MUNDAMIA, NSW

Job No.: 35556LT **Method:** SPIRAL AUGER **R.L. Surface:** 44.4m
Date: 5/1/23 **Datum:** AHD
Plant Type: JK309 **Logged/Checked by:** N.A.P./A.B.

Groundwater Record	SAMPLES ES	 U50	 DB	 DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
				■					Extremely Weathered sandstone: silty sandy CLAY, low plasticity, orange brown.	XW	(Hd)		
									END OF BOREHOLE AT 7.5m				
						8							
						9							
						10							
						11							
						12							
						13							
						14							

JKGeotechnics

BOREHOLE LOG

Borehole No.
3
1/1

Client: TERROIR
Project: PROPOSED RESOURCE RECOVERY LEARNING CENTRE
Location: 120 FLATROCK ROAD, MUNDAMIA, NSW

Job No.: 35556LT
Method: SPIRAL AUGER
R.L. Surface: 42.9m
Date: 5/1/23
Datum: AHD
Plant Type: JK309
Logged/Checked by: N.A.P./A.B.

Groundwater Record	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
		0			FILL: Silty clay, low plasticity, light brown and dark brown, trace of fine to medium grained igneous sand ironstone gravel, brick and plastic fragments, roots and root fibres.	w≈PL			GRASS COVER APPEARS POORLY COMPACTED
▼ AFTER 8 HRS	N = 4 2,1,3				FILL: Silty clay, low plasticity, light red brown and dark brown, with fine to medium grained ironstone gravel, trace of root fibres.			210 200 120	
	N = 4 2,2,2	1			as above, but light red brown and dark brown, trace of fine to medium grained ironstone gravel.				
	N = 11 4,5,6				as above, but high plasticity, red brown and dark grey.	w>PL		430 450 480	
▶		2			FILL: Waste material, plastic, metal, fabric fragments and roots.				LANDFILL
	N = 6 2,3,3	3							
		4							'TC' BIT REFUSAL ON OBSTRUCTION IN FILL
		5			END OF BOREHOLE AT 4.5m				GROUNDWATER MONITORING WELL INSTALLED TO 4.5m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 1.5m TO 4.5m. CASING 1.5m TO 0.1m. 2mm SAND FILTER PACK 1.2m TO 4.5m. BENTONITE SEAL 0.2m TO 1.2m. THE SURFACE. COMPLETED WITH A CONCRETED GATIC COVER.
		6							
		7							

SAMPLES: ES, U50, DB, DS

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BOREHOLE LOG

Borehole No.
4
1/2

Client: TERROIR
Project: PROPOSED RESOURCE RECOVERY LEARNING CENTRE
Location: 120 FLATROCK ROAD, MUNDAMIA, NSW

Job No.: 35556LT **Method:** SPIRAL AUGER **R.L. Surface:** 44.5m
Date: 5/1/23 **Datum:** AHD
Plant Type: JK309 **Logged/Checked by:** N.A.P./A.B.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	■			■		0	▨		FILL: Silty clay, low to medium plasticity, light brown, brown and red brown, trace of fine to medium grained igneous and ironstone gravel, and root fibres.	w≈PL			GRASS COVER APPEARS POORLY COMPACTED
	■			■	N = 4 4,3,1		▨		as above, but brown, yellow brown and red brown.			400 450 300	
		■		■	N = 2 1,1,1	1	▨		FILL: Silty clay, medium plasticity, light brown and red brown, trace of fine grained ironstone gravel.	w>PL		90 100 110	
	■			■	N = 0 0,0,0		▨						
▼ AFTER 30 MINS					SUNK	2	▨						
	■		■	■			▧	CI	Silty CLAY: medium plasticity, light grey mottled red brown, trace of fine grained ironstone gravel.	w≈PL	VSt-Hd		RESIDUAL
				■	N > 20 8,9,11/ 30mm REFUSAL	3	▧	CL	as above, but low plasticity, trace of fine grained sand.	w<PL		300 350 330	
						4	▧						
							⁘	-	Extremely Weathered sandstone: silty clay, low plasticity, light grey, trace of fine to coarse grained sand, and very low to low strength iron indurated bands.	XW	Hd		NOWRA SANDSTONE VERY LOW 'TC' BIT RESISTANCE
				■	N > 2 12,2/ 100mm REFUSAL	5	⁘						
▶				■	N = SPT 5/150mm REFUSAL	6	⁘						
						7	⁘						

JKGeotechnics

BOREHOLE LOG

Borehole No.
4
2/2

Client: TERROIR
Project: PROPOSED RESOURCE RECOVERY LEARNING CENTRE
Location: 120 FLATROCK ROAD, MUNDAMIA, NSW

Job No.: 35556LT
Method: SPIRAL AUGER
R.L. Surface: 44.5m
Date: 5/1/23
Datum: AHD
Plant Type: JK309
Logged/Checked by: N.A.P./A.B.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
				■					Extremely Weathered sandstone: silty clay, low plasticity, light grey, trace of fine to coarse grained sand, and very low to low strength iron indurated bands.	XW	Hd		
									END OF BOREHOLE AT 7.5m				
						8							
						9							
						10							
						11							
						12							
						13							
						14							

BOREHOLE LOG

Borehole No.
5
1/1

Client: TERROIR
Project: PROPOSED RESOURCE RECOVERY LEARNING CENTRE
Location: 120 FLATROCK ROAD, MUNDAMIA, NSW

Job No.: 35556LT
Method: SPIRAL AUGER
R.L. Surface: 43.3m
Date: 4/1/23
Datum: AHD
Plant Type: JK309
Logged/Checked by: N.A.P./A.B.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION						0			FILL: Silty clay, low plasticity, dark grey, trace of igneous gravel, plastic and glass fragments, ash, roots and root fibres.	w<PL			GRASS COVER
								CH	Silty CLAY: high platicity, light grey mottled orange brown, trace of fine grained ironstone gravel, ash, roots and root fibres.	w>PL	VSt		RESIDUAL
					N = 8 4,3,4							200 210 250	
					N = 9 4,3,6	1						310 350 380	
					N = 19 5,8,11						VSt-Hd	350 350 400	
						2							GROUNDWATER MONITORING WELL INSTALLED TO 6.0m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 3.0m TO 6.0m. CASING 3.0m TO 0.1m. 2mm SAND FILTER PACK 3.2m TO 6.0m. BENTONITE SEAL 0.2m TO 3.2m. COMPLETED WITH A CONCRETED GATIC COVER.
								CI	Silty CLAY: medium plasticity, light grey mottled red brown, trace of fine grained ironstone gravel.	w≈PL			
					N = 22 9,9,13	3		CL	as above, but low plasticity, trace of fine grained sand.		Hd	400 420 470	
						4							
								-	SANDSTONE: fine to medium grained, orange brown and red brown.	DW	L		NOWRA SANDSTONE LOW 'TC' BIT RESISTANCE
						5							
									SANDSTONE: fine grained, orange brown.		M-H		MODERATE RESISTANCE
						6			END OF BOREHOLE AT 6.0m				
						7							

BOREHOLE LOG

Borehole No.
6
1/2

Client: TERROIR
Project: PROPOSED RESOURCE RECOVERY LEARNING CENTRE
Location: 120 FLATROCK ROAD, MUNDAMIA, NSW

Job No.: 35556LT
Method: SPIRAL AUGER
R.L. Surface: 43.3m
Date: 5/1/23
Datum: AHD
Plant Type: JK309
Logged/Checked by: N.A.P./A.B.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0		FILL: Silty clay, low plasticity, brown and red brown, with fine to medium grained ironstone gravel, trace of igneous and quartz gravel, roots and root fibres.	w>PL			GRASS COVER
					N = 8 4,5,3		CI	Silty CLAY: medium plasticity, light grey mottled orange brown, trace of fine to medium grained ironstone gravel.	w>PL	St	110 150 130	RESIDUAL
					N = 25 5,10,15 N = 20 3,5,15	1	CH	Gravelly silty CLAY: high plasticity, light grey mottled red brown, and fine to medium grained ironstone gravel.	w<PL	Hd	440 450 >600 >600 >600	
▼ AFTER 30 MINS						2	CI	Silty CLAY: medium plasticity, light grey mottled red brown, with fine to medium grained ironstone gravel.	w≈PL			
					N = 25 8,13,12 N = SPT 15/150mm REFUSAL N = SPT 10/150mm REFUSAL	3 4 5 6 7	-	Extremely Weathered sandstone: silty CLAY, low plasticity, light grey, trace of fine grained sand, with very low strength red brown and orange brown ironstone bands.	XW	Hd	>600 >600 >600	NOWRA SANDSTONE VERY LOW 'TC' BIT RESISTANCE

JKGeotechnics

BOREHOLE LOG

Borehole No.
6
2/2

Client: TERROIR
Project: PROPOSED RESOURCE RECOVERY LEARNING CENTRE
Location: 120 FLATROCK ROAD, MUNDAMIA, NSW

Job No.: 35556LT **Method:** SPIRAL AUGER **R.L. Surface:** 43.3m
Date: 5/1/23 **Datum:** AHD
Plant Type: JK309 **Logged/Checked by:** N.A.P./A.B.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
▶									Extremely Weathered sandstone: as above	XW	Hd		
				■				-	SANDSTONE: fine to medium grained, grey.	DW	M-H		MODERATE 'TC' BITRESISTANCE
									END OF BOREHOLE AT 7.5m				
						8							
						9							
						10							
						11							
						12							
						13							
						14							

JKGeotechnics

BOREHOLE LOG

Borehole No.
7
1/1

Client: TERROIR
Project: PROPOSED RESOURCE RECOVERY LEARNING CENTRE
Location: 120 FLATROCK ROAD, MUNDAMIA, NSW

Job No.: 35556LT
Method: SPIRAL AUGER
R.L. Surface: 44.5m
Date: 4/1/23
Datum: AHD
Plant Type: JK309
Logged/Checked by: N.A.P./A.B.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			ASPHALTIC CONCRETE: 50mm.t				
									ROADBASE: 150mm.t				
								CL-CI	Silty CLAY: low to medium plasticity, orange brown, trace of fine to medium grained ironstone gravel.	w<PL	Hd		RESIDUAL
					N > 19 9,9,10/ 50mm REFUSAL			CH	Silty CLAY: high plasticity, yellow brown and red brown, with fine to medium grained ironstone gravel.			>600 >600 >600	
					N = SPT 10/50mm REFUSAL	1			Silty CLAY: high plasticity,light grey and red brown, with iron indurated bands.				
					N = 23 13,12,11	2			Silty CLAY: high plasticity, light grey.			>600 >600 >600	
								-	Extremely Weathered sandstone: sandy CLAY, low to medium plasticity, light grey, with fine to medium grained sand.	XW	Hd		NOWRA SANDSTONE VERY LOW 'TC' BIT RESISTANCE
▶					N > 6 12/100mm REFUSAL	3							
▼ ON COMPLETION													
						4			SANDSTONE: fine to medium grained, orange brown, trace of quartz.	DW	M		MODERATE RESISTANCE
						5					H		HIGH RESISTANCE
						6			END OF BOREHOLE AT 6.0m				
						7							

JKGeotechnics

BOREHOLE LOG

Borehole No.
8
1/1

Client: TERROIR

Project: PROPOSED RESOURCE RECOVERY LEARNING CENTRE

Location: 120 FLATROCK ROAD, MUNDAMIA, NSW

Job No.: 35556LT **Method:** SPIRAL AUGER **R.L. Surface:** 45.9m

Date: 4/1/23 **Datum:** AHD

Plant Type: JK309 **Logged/Checked by:** N.A.P./A.B.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Silty clay, low plasticity, light orange brown, trace of fine to medium grained sand, fine to medium grained igneous and sandstone gravel.	w≈PL			GRASS COVER
					N = 8 4,3,4 N > 26 8,11, 15/20mm REFUSAL	1		CH	Silty CLAY: high plasticity, yellow brown and red brown, with fine to medium grained ironstone gravel.	w<PL	Hd	>600 >600 >600	RESIDUAL
AFTER 6 HRS						2 3		-	Extremely Weathered sandstone: silty CLAY: low plasticity, red brown and light grey, with ironstone bands, trace of quartz gravel.	XW	Hd	>600 >600 >600 450 450 420	NOWRA SANDSTONE VERY LOW 'TC' BIT RESISTANCE GROUNDWATER MONITORING WELL INSTALLED TO 6.0m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 3.0m TO 6.0m. CASING 3.0m TO 0.1m. 2mm SAND FILTER PACK 3.4m TO 6.0m. BENTONITE SEAL 0.2m TO 3.4m. COMPLETED WITH A CONCRETED GATIC COVER.
						4 5			SANDSTONE: fine to medium grained, orange brown and red brown.	DW	L M		LOW RESISTANCE MODERATE RESISTANCE
						6 7			END OF BOREHOLE AT 6.0m				

SOURCE: http://www.whereis.com/

AERIAL IMAGE SOURCE: MAPS.AU.NEARMAP.COM

This plan should be read in conjunction with the JK Geotechnics report.

Title:

SITE LOCATION PLAN

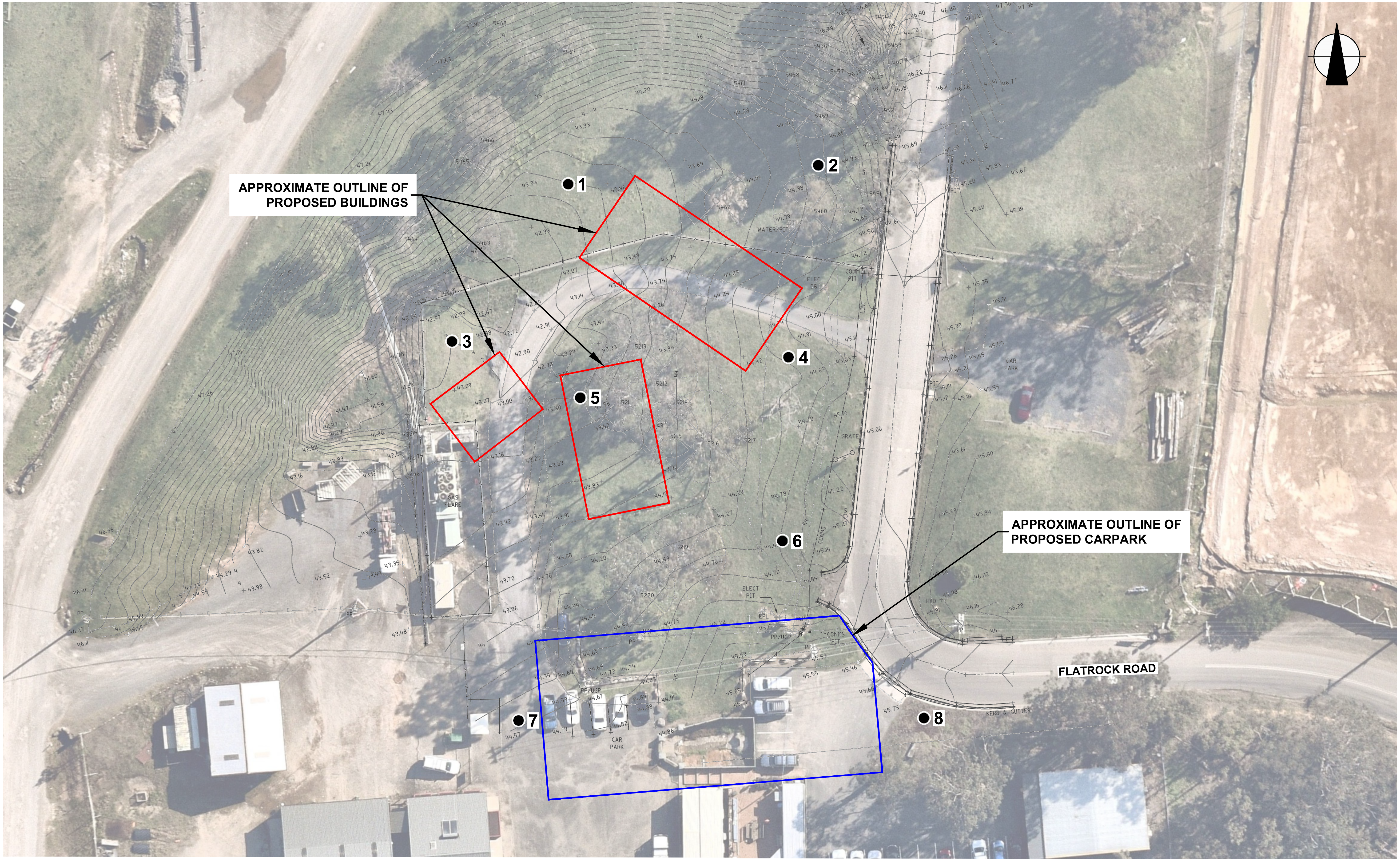
Location: 120 FLATROCK ROAD, MUNDAMIA, NSW

Report No: 35556LT

Figure No: 1

JKGeotechnics

PLOT DATE: 17/02/2023 12:29:19 PM DWG FILE: S:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\35000'S\35556LT MUNDAMIA\CAD\35556LT.DWG



AERIAL IMAGE SOURCE: MAPS.AU.NEARMAP.COM

0 5 10 15 20 25

SCALE 1:500 @A3 METRES

This plan should be read in conjunction with the JK Geotechnics report.

Title:
BOREHOLE LOCATION PLAN

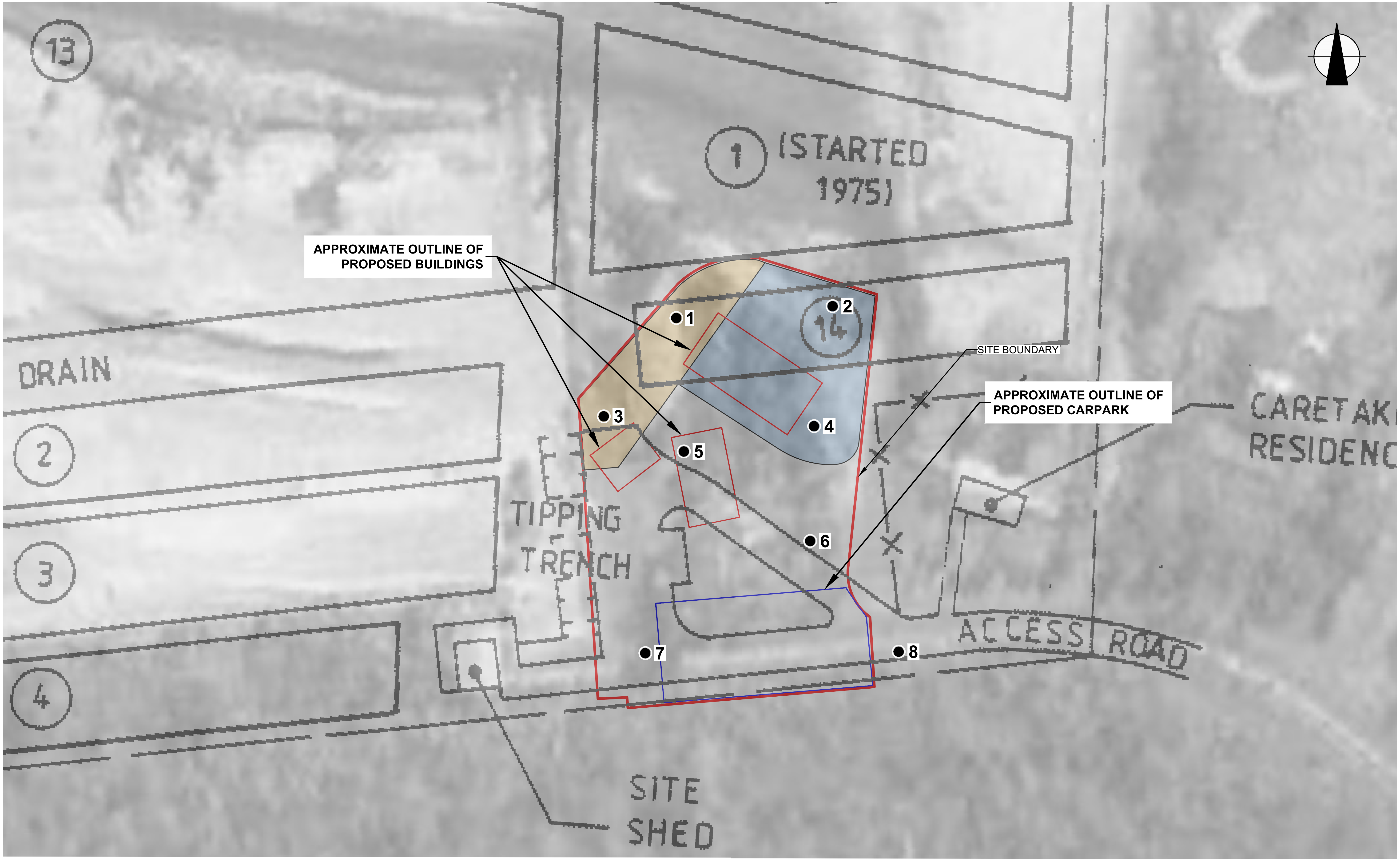
Location: 120 FLATROCK ROAD, MUNDAMIA, NSW

Report No: 35556LT

Figure No: 2

JKGeotechnics

PLOT DATE: 24/02/2023 12:22:01 PM DWG FILE: S:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\35000'S\35556LT MUNDAMIA\CAD\35556LT.DWG



LEGEND

🟧 INFERRED EXTENT OF LANDFILL

🟦 INFERRED EXTENT OF DEEPER SOIL FILL

NOTES:
1. LANDFILL CELL PLAN IS FROM 'LANDFILLS LEACHATE STUDY' PREPARED BY MAUNSELL PTY LTD, MARCH 1991.
2. BASE IMAGE IS A 1984 AERIAL IMAGE FROM HISTORICAL IMAGERY.

AERIAL IMAGE SOURCE: MAPS.AU.NEARMAP.COM

0 8 16 24 32 40

SCALE 1:800 @A3 METRES

This plan should be read in conjunction with the JK Geotechnics report.

Title: **INFERRED FILL EXTENT PLAN**

Location: 120 FLATROCK ROAD, MUNDAMIA, NSW

Report No: 35556LT

Figure No: 3

JKGeotechnics

PLOT DATE: 24/02/2023 2:39:45 PM DWG FILE: S:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\35000'S\35556LT MUNDAMIA\CAD\35556LT.DWG

REPORT EXPLANATION NOTES

INTRODUCTION

These notes have been provided to amplify the geotechnical report in regard to classification methods, field procedures and certain matters relating to the Comments and Recommendations section. Not all notes are necessarily relevant to all reports.

The ground is a product of continuing natural and man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Geotechnical engineering involves gathering and assimilating limited facts about these characteristics and properties in order to understand or predict the behaviour of the ground on a particular site under certain conditions. This report may contain such facts obtained by inspection, excavation, probing, sampling, testing or other means of investigation. If so, they are directly relevant only to the ground at the place where and time when the investigation was carried out.

DESCRIPTION AND CLASSIFICATION METHODS

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726:2017 *'Geotechnical Site Investigations'*. In general, descriptions cover the following properties – soil or rock type, colour, structure, strength or density, and inclusions. Identification and classification of soil and rock involves judgement and the Company infers accuracy only to the extent that is common in current geotechnical practice.

Soil types are described according to the predominating particle size and behaviour as set out in the attached soil classification table qualified by the grading of other particles present (eg. sandy clay) as set out below:

Soil Classification	Particle Size
Clay	< 0.002mm
Silt	0.002 to 0.075mm
Sand	0.075 to 2.36mm
Gravel	2.36 to 63mm
Cobbles	63 to 200mm
Boulders	> 200mm

Non-cohesive soils are classified on the basis of relative density, generally from the results of Standard Penetration Test (SPT) as below:

Relative Density	SPT 'N' Value (blows/300mm)
Very loose (VL)	< 4
Loose (L)	4 to 10
Medium dense (MD)	10 to 30
Dense (D)	30 to 50
Very Dense (VD)	> 50

Cohesive soils are classified on the basis of strength (consistency) either by use of a hand penetrometer, vane shear, laboratory testing and/or tactile engineering examination. The strength terms are defined as follows.

Classification	Unconfined Compressive Strength (kPa)	Indicative Undrained Shear Strength (kPa)
Very Soft (VS)	≤ 25	≤ 12
Soft (S)	> 25 and ≤ 50	> 12 and ≤ 25
Firm (F)	> 50 and ≤ 100	> 25 and ≤ 50
Stiff (St)	> 100 and ≤ 200	> 50 and ≤ 100
Very Stiff (VSt)	> 200 and ≤ 400	> 100 and ≤ 200
Hard (Hd)	> 400	> 200
Friable (Fr)	Strength not attainable – soil crumbles	

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc. Where relevant, further information regarding rock classification is given in the text of the report. In the Sydney Basin, 'shale' is used to describe fissile mudstone, with a weakness parallel to bedding. Rocks with alternating inter-laminations of different grain size (eg. siltstone/claystone and siltstone/fine grained sandstone) is referred to as 'laminite'.

SAMPLING

Sampling is carried out during drilling or from other excavations to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content, minor constituents and, depending upon the degree of disturbance, some information on strength and structure. Bulk samples are similar but of greater volume required for some test procedures.

Undisturbed samples are taken by pushing a thin-walled sample tube, usually 50mm diameter (known as a U50), into the soil and withdrawing it with a sample of the soil contained in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shrink-swell behaviour, strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling used are given on the attached logs.

INVESTIGATION METHODS

The following is a brief summary of investigation methods currently adopted by the Company and some comments on their use and application. All methods except test pits, hand auger drilling and portable Dynamic Cone Penetrometers require the use of a mechanical rig which is commonly mounted on a truck chassis or track base.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils and 'weaker' bedrock if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for a large excavator. Limitations of test pits are the problems associated with disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

Hand Auger Drilling: A borehole of 50mm to 100mm diameter is advanced by manually operated equipment. Refusal of the hand auger can occur on a variety of materials such as obstructions within any fill, tree roots, hard clay, gravel or ironstone, cobbles and boulders, and does not necessarily indicate rock level.

Continuous Spiral Flight Augers: The borehole is advanced using 75mm to 115mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling and insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface by the flights or may be collected after withdrawal of the auger flights, but they can be very disturbed and layers may become mixed. Information from the auger sampling (as distinct from specific sampling by SPTs or undisturbed samples) is of limited reliability due to mixing or softening of samples by groundwater, or uncertainties as to the original depth of the samples. Augering below the groundwater table is of even lesser reliability than augering above the water table.

Rock Augering: Use can be made of a Tungsten Carbide (TC) bit for auger drilling into rock to indicate rock quality and continuity by variation in drilling resistance and from examination of recovered rock cuttings. This method of investigation is quick and relatively inexpensive but provides only an indication of the likely rock strength and predicted values may be in error by a strength order. Where rock strengths may have a significant impact on construction feasibility or costs, then further investigation by means of cored boreholes may be warranted.

Wash Boring: The borehole is usually advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be assessed from the cuttings, together with some information from "feel" and rate of penetration.

Mud Stabilised Drilling: Either Wash Boring or Continuous Core Drilling can use drilling mud as a circulating fluid to stabilise the borehole. The term 'mud' encompasses a range of products ranging from bentonite to polymers. The mud tends to mask the cuttings and reliable identification is only possible from intermittent intact sampling (eg. from SPT and U50 samples) or from rock coring, etc.

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. Provided full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, NMLC or HQ triple tube core barrels, which give a core of about 50mm and 61mm diameter, respectively, is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as NO CORE. The location of NO CORE recovery is determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the bottom of the drill run.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils, as a means of indicating density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289.6.3.1–2004 (R2016) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Penetration Resistance of a Soil – Standard Penetration Test (SPT)'*.

The test is carried out in a borehole by driving a 50mm diameter split sample tube with a tapered shoe, under the impact of a 63.5kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

- In the case where full penetration is obtained with successive blow counts for each 150mm of, say, 4, 6 and 7 blows, as

  N = 13
  4, 6, 7

- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm, as

  N > 30
  15, 30/40mm

The results of the test can be related empirically to the engineering properties of the soil.

A modification to the SPT is where the same driving system is used with a solid 60° tipped steel cone of the same diameter as the SPT hollow sampler. The solid cone can be continuously driven for some distance in soft clays or loose sands, or may be used where damage would otherwise occur to the SPT. The results of this Solid Cone Penetration Test (SCPT) are shown as 'N_c' on the borehole logs, together with the number of blows per 150mm penetration.

Cone Penetrometer Testing (CPT) and Interpretation: The cone penetrometer is sometimes referred to as a Dutch Cone. The test is described in Australian Standard 1289.6.5.1–1999 (R2013) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Static Cone Penetration Resistance of a Soil – Field Test using a Mechanical and Electrical Cone or Friction-Cone Penetrometer'*.

In the tests, a 35mm or 44mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with a hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm or 165mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are electrically connected by wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck. The CPT does not provide soil sample recovery.

As penetration occurs (at a rate of approximately 20mm per second), the information is output as incremental digital records every 10mm. The results given in this report have been plotted from the digital data.

The information provided on the charts comprise:

- Cone resistance – the actual end bearing force divided by the cross sectional area of the cone – expressed in MPa. There are two scales presented for the cone resistance. The lower scale has a range of 0 to 5MPa and the main scale has a range of 0 to 50MPa. For cone resistance values less than 5MPa, the plot will appear on both scales.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio – the ratio of sleeve friction to cone resistance, expressed as a percentage.

  The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and occasionally very soft clays, rising to 4% to 10% in stiff clays and peats. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Correlations between CPT and SPT values can be developed for both sands and clays but may be site specific.

Interpretation of CPT values can be made to empirically derive modulus or compressibility values to allow calculation of foundation settlements.

Stratification can be inferred from the cone and friction traces and from experience and information from nearby boreholes etc. Where shown, this information is presented for general guidance, but must be regarded as interpretive. The test method provides a continuous profile of engineering properties but, where precise information on soil classification is required, direct drilling and sampling may be preferable.

There are limitations when using the CPT in that it may not penetrate obstructions within any fill, thick layers of hard clay and very dense sand, gravel and weathered bedrock. Normally a 'dummy' cone is pushed through fill to protect the equipment. No information is recorded by the 'dummy' probe.

Flat Dilatometer Test: The flat dilatometer (DMT), also known as the Marchetti Dilometer comprises a stainless steel blade having a flat, circular steel membrane mounted flush on one side.

The blade is connected to a control unit at ground surface by a pneumatic-electrical tube running through the insertion rods. A gas tank, connected to the control unit by a pneumatic cable, supplies the gas pressure required to expand the membrane. The control unit is equipped with a pressure regulator, pressure gauges, an audio-visual signal and vent valves.

The blade is advanced into the ground using our CPT rig or one of our drilling rigs, and can be driven into the ground using an SPT hammer. As soon as the blade is in place, the membrane is inflated, and the pressure required to lift the membrane (approximately 0.1mm) is recorded. The pressure then required to lift the centre of the membrane by an additional 1mm is recorded. The membrane is then deflated before pushing to the next depth increment, usually 200mm down. The pressure readings are corrected for membrane stiffness.

The DMT is used to measure material index (I_D), horizontal stress index (K_D), and dilatometer modulus (E_D). Using established correlations, the DMT results can also be used to assess the 'at rest' earth pressure coefficient (K_o), over-consolidation ratio (OCR), undrained shear strength (C_u), friction angle (ϕ), coefficient of consolidation (C_h), coefficient of permeability (K_h), unit weight (γ), and vertical drained constrained modulus (M).

The seismic dilatometer (SDMT) is the combination of the DMT with an add-on seismic module for the measurement of shear wave velocity (V_s). Using established correlations, the SDMT results can also be used to assess the small strain modulus (G_o).

Portable Dynamic Cone Penetrometers: Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a 16mm diameter rod with a 20mm diameter cone end with a 9kg hammer dropping 510mm. The test is described in Australian Standard 1289.6.3.2–1997 (R2013) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Penetration Resistance of a Soil – 9kg Dynamic Cone Penetrometer Test'*.

The results are used to assess the relative compaction of fill, the relative density of granular soils, and the strength of cohesive soils. Using established correlations, the DCP test results can also be used to assess California Bearing Ratio (CBR).

Refusal of the DCP can occur on a variety of materials such as obstructions within any fill, tree roots, hard clay, gravel or ironstone, cobbles and boulders, and does not necessarily indicate rock level.

Vane Shear Test: The vane shear test is used to measure the undrained shear strength (C_u) of typically very soft to firm fine grained cohesive soils. The vane shear is normally performed in the bottom of a borehole, but can be completed from surface level, the bottom and sides of test pits, and on recovered undisturbed tube samples (when using a hand vane).

The vane comprises four rectangular blades arranged in the form of a cross on the end of a thin rod, which is coupled to the bottom of a drill rod string when used in a borehole. The size of the vane is dependent on the strength of the fine grained cohesive soils; that is, larger vanes are normally used for very low strength soils. For borehole testing, the size of the vane can be limited by the size of the casing that is used.

For testing inside a borehole, a device is used at the top of the casing, which suspends the vane and rods so that they do not sink under self-weight into the 'soft' soils beyond the depth at which the test is to be carried out. A calibrated torque head is used to rotate the rods and vane and to measure the resistance of the vane to rotation.

With the vane in position, torque is applied to cause rotation of the vane at a constant rate. A rate of 6° per minute is the common rotation rate. Rotation is continued until the soil is sheared and the maximum torque has been recorded. This value is then used to calculate the undrained shear strength. The vane is then rotated rapidly a number of times and the operation repeated until a constant torque reading is obtained. This torque value is used to calculate the remoulded shear strength. Where appropriate, friction on the vane rods is measured and taken into account in the shear strength calculation.

LOGS

The borehole or test pit logs presented herein are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on the frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will enable the most reliable assessment, but is not always practicable or possible to justify on economic grounds. In any case, the boreholes or test pits represent only a very small sample of the total subsurface conditions.

The terms and symbols used in preparation of the logs are defined in the following pages.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than 'straight line' variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

GROUNDWATER

Where groundwater levels are measured in boreholes, there are several potential problems:

- Although groundwater may be present, in low permeability soils it may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes and may not be the same at the time of construction.
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must be washed out of the hole or 'reverted' chemically if reliable water observations are to be made.

More reliable measurements can be made by installing standpipes which are read after the groundwater level has stabilised at intervals ranging from several days to perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from perched water tables or surface water.

FILL

The presence of fill materials can often be determined only by the inclusion of foreign objects (eg. bricks, steel, etc) or by distinctly unusual colour, texture or fabric. Identification of the extent of fill materials will also depend on investigation methods and frequency. Where natural soils similar to those at the site are used for fill, it may be difficult with limited testing and sampling to reliably assess the extent of the fill.

The presence of fill materials is usually regarded with caution as the possible variation in density, strength and material type is much greater than with natural soil deposits. Consequently, there is an increased risk of adverse engineering characteristics or behaviour. If the volume and quality of fill is of importance to a project, then frequent test pit excavations are preferable to boreholes.

LABORATORY TESTING

Laboratory testing is normally carried out in accordance with Australian Standard 1289 *'Methods of Testing Soils for Engineering Purposes'* or appropriate NSW Government Roads & Maritime Services (RMS) test methods. Details of the test procedure used are given on the individual report forms.

ENGINEERING REPORTS

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. a three storey building) the information and interpretation may not be relevant if the design proposal is changed (eg. to a twenty storey building). If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

Reasonable care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions – the potential for this will be partially dependent on borehole spacing and sampling frequency as well as investigation technique.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of persons or contractors responding to commercial pressures.
- Details of the development that the Company could not reasonably be expected to anticipate.

If these occur, the Company will be pleased to assist with investigation or advice to resolve any problems occurring.

SITE ANOMALIES

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Copyright in all documents (such as drawings, borehole or test pit logs, reports and specifications) provided by the Company shall remain the property of Jeffery and Katauskas Pty Ltd. Subject to the payment of all fees due, the Client alone shall have a licence to use the documents provided for the sole purpose of completing the project to which they relate. Licence to use the documents may be revoked without notice if the Client is in breach of any obligation to make a payment to us.

REVIEW OF DESIGN

Where major civil or structural developments are proposed or where only a limited investigation has been completed or where the geotechnical conditions/constraints are quite complex, it is prudent to have a joint design review which involves an experienced geotechnical engineer/engineering geologist.

SITE INSPECTION

The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related.

Requirements could range from:

i) a site visit to confirm that conditions exposed are no worse than those interpreted, to

ii) a visit to assist the contractor or other site personnel in identifying various soil/rock types and appropriate footing or pile founding depths, or

iii) full time engineering presence on site.

SYMBOL LEGENDS

SOIL

▩	FILL
≋	TOPSOIL
▨	CLAY (CL, CI, CH)
▥	SILT (ML, MH)
░	SAND (SP, SW)
⁘	GRAVEL (GP, GW)
▨	SANDY CLAY (CL, CI, CH)
▨	SILTY CLAY (CL, CI, CH)
▨	CLAYEY SAND (SC)
░	SILTY SAND (SM)
▨	GRAVELLY CLAY (CL, CI, CH)
▨	CLAYEY GRAVEL (GC)
▥	SANDY SILT (ML, MH)
⁂	PEAT AND HIGHLY ORGANIC SOILS (Pt)

ROCK

⁘	CONGLOMERATE
░	SANDSTONE
▤	SHALE/MUDSTONE
▥	SILTSTONE
▤	CLAYSTONE
■	COAL
▥	LAMINITE
▦	LIMESTONE
≋	PHYLLITE, SCHIST
▤	TUFF
⁖	GRANITE, GABBRO
+	DOLERITE, DIORITE
∨	BASALT, ANDESITE
≈	QUARTZITE

OTHER MATERIALS

▦	BRICKS OR PAVERS
▵	CONCRETE
■	ASPHALTIC CONCRETE

CLASSIFICATION OF COARSE AND FINE GRAINED SOILS

Major Divisions		Group Symbol	Typical Names	Field Classification of Sand and Gravel	Laboratory Classification	
Coarse grained soil (more than 65% of soil excluding oversize fraction is greater than 0.075mm)	GRAVEL (more than half of coarse fraction is larger than 2.36mm	GW	Gravel and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	$C_u > 4$ $1 < C_c < 3$
		GP	Gravel and gravel-sand mixtures, little or no fines, uniform gravels	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	Fails to comply with above
		GM	Gravel-silt mixtures and gravel-sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	Fines behave as silt
		GC	Gravel-clay mixtures and gravel-sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	Fines behave as clay
	SAND (more than half of coarse fraction is smaller than 2.36mm)	SW	Sand and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	$C_u > 6$ $1 < C_c < 3$
		SP	Sand and gravel-sand mixtures, little or no fines	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	Fails to comply with above
		SM	Sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	N/A
		SC	Sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	

Major Divisions		Group Symbol	Typical Names	Field Classification of Silt and Clay			Laboratory Classification
				Dry Strength	Dilatancy	Toughness	% < 0.075mm
ine grained soils (more than 35% of soil excluding oversize fraction is less than 0.075mm)	SILT and CLAY (low to medium plasticity)	ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or silt with low plasticity	None to low	Slow to rapid	Low	Below A line
		CL, CI	Inorganic clay of low to medium plasticity, gravelly clay, sandy clay	Medium to high	None to slow	Medium	Above A line
		OL	Organic silt	Low to medium	Slow	Low	Below A line
	SILT and CLAY (high plasticity)	MH	Inorganic silt	Low to medium	None to slow	Low to medium	Below A line
		CH	Inorganic clay of high plasticity	High to very high	None	High	Above A line
		OH	Organic clay of medium to high plasticity, organic silt	Medium to high	None to very slow	Low to medium	Below A line
	Highly organic soil	Pt	Peat, highly organic soil	–	–	–	–

Laboratory Classification Criteria

A well graded coarse grained soil is one for which the coefficient of uniformity $Cu > 4$ and the coefficient of curvature $1 < C_c < 3$. Otherwise, the soil is poorly graded. These coefficients are given by:

$$C_U = \frac{D_{60}}{D_{10}} \quad and \quad C_C = \frac{(D_{30})^2}{D_{10}\,D_{60}}$$

Where D_{10}, D_{30} and D_{60} are those grain sizes for which 10%, 30% and 60% of the soil grains, respectively, are smaller.

NOTES:

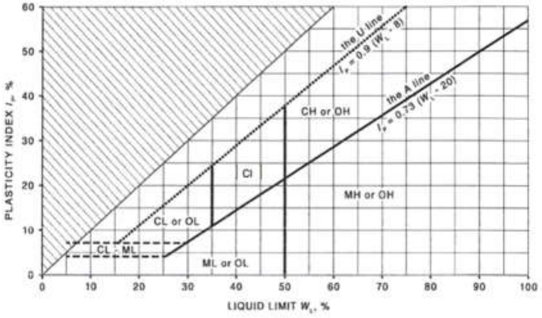
1 For a coarse grained soil with a fines content between 5% and 12%, the soil is given a dual classification comprising the two group symbols separated by a dash; for example, for a poorly graded gravel with between 5% and 12% silt fines, the classification is GP-GM.

2 Where the grading is determined from laboratory tests, it is defined by coefficients of curvature (C_c) and uniformity (C_u) derived from the particle size distribution curve.

3 Clay soils with liquid limits > 35% and ≤ 50% may be classified as being of medium plasticity.

4 The U line on the Modified Casagrande Chart is an approximate upper bound for most natural soils.

Modified Casagrande Chart for Classifying Silts and Clays according to their Behaviour



LOG SYMBOLS

Log Column	**Symbol**	**Definition**		
Groundwater Record	▼	Standing water level. Time delay following completion of drilling/excavation may be shown.		
	—C—	Extent of borehole/test pit collapse shortly after drilling/excavation.		
	▶—	Groundwater seepage into borehole or test pit noted during drilling or excavation.		
Samples	ES	Sample taken over depth indicated, for environmental analysis.		
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.		
	DB	Bulk disturbed sample taken over depth indicated.		
	DS	Small disturbed bag sample taken over depth indicated.		
	ASB	Soil sample taken over depth indicated, for asbestos analysis.		
	ASS	Soil sample taken over depth indicated, for acid sulfate soil analysis.		
	SAL	Soil sample taken over depth indicated, for salinity analysis.		
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'Refusal' refers to apparent hammer refusal within the corresponding 150mm depth increment.		
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60° solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.		
	VNS = 25	Vane shear reading in kPa of undrained shear strength.		
	PID = 100	Photoionisation detector reading in ppm (soil sample headspace test).		
Moisture Condition (Fine Grained Soils)	$w > PL$	Moisture content estimated to be greater than plastic limit.		
	$w \approx PL$	Moisture content estimated to be approximately equal to plastic limit.		
	$w < PL$	Moisture content estimated to be less than plastic limit.		
	$w \approx LL$	Moisture content estimated to be near liquid limit.		
	$w > LL$	Moisture content estimated to be wet of liquid limit.		
(Coarse Grained Soils)	D	DRY – runs freely through fingers.		
	M	MOIST – does not run freely but no free water visible on soil surface.		
	W	WET – free water visible on soil surface.		
Strength (Consistency) Cohesive Soils	VS	VERY SOFT – unconfined compressive strength ≤ 25kPa.		
	S	SOFT – unconfined compressive strength > 25kPa and ≤ 50kPa.		
	F	FIRM – unconfined compressive strength > 50kPa and ≤ 100kPa.		
	St	STIFF – unconfined compressive strength > 100kPa and ≤ 200kPa.		
	VSt	VERY STIFF – unconfined compressive strength > 200kPa and ≤ 400kPa.		
	Hd	HARD – unconfined compressive strength > 400kPa.		
	Fr	FRIABLE – strength not attainable, soil crumbles.		
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other assessment.		
Density Index/ Relative Density (Cohesionless Soils)			**Density Index (I_D) Range (%)**	**SPT 'N' Value Range (Blows/300mm)**
	VL	VERY LOOSE	≤ 15	0 – 4
	L	LOOSE	> 15 and ≤ 35	4 – 10
	MD	MEDIUM DENSE	> 35 and ≤ 65	10 – 30
	D	DENSE	> 65 and ≤ 85	30 – 50
	VD	VERY DENSE	> 85	> 50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other assessment.		
Hand Penetrometer Readings	300 250	Measures reading in kPa of unconfined compressive strength. Numbers indicate individual test results on representative undisturbed material unless noted otherwise.		

Log Column	Symbol	Definition
Remarks	‘V’ bit	Hardened steel ‘V’ shaped bit.
	‘TC’ bit	Twin pronged tungsten carbide bit.
	T_{60}	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.
	Soil Origin	The geological origin of the soil can generally be described as: RESIDUAL – soil formed directly from insitu weathering of the underlying rock. No visible structure or fabric of the parent rock. EXTREMELY WEATHERED – soil formed directly from insitu weathering of the underlying rock. Material is of soil strength but retains the structure and/or fabric of the parent rock. ALLUVIAL – soil deposited by creeks and rivers. ESTUARINE – soil deposited in coastal estuaries, including sediments caused by inflowing creeks and rivers, and tidal currents. MARINE – soil deposited in a marine environment. AEOLIAN – soil carried and deposited by wind. COLLUVIAL – soil and rock debris transported downslope by gravity, with or without the assistance of flowing water. Colluvium is usually a thick deposit formed from a landslide. The description ‘slopewash’ is used for thinner surficial deposits. LITTORAL – beach deposited soil.

Classification of Material Weathering

Term		Abbreviation		Definition
Residual Soil		RS		Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.
Extremely Weathered		XW		Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible.
Highly Weathered	Distinctly Weathered (Note 1)	HW	DW	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Moderately Weathered		MW		The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.
Slightly Weathered		SW		Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.
Fresh		FR		Rock shows no sign of decomposition of individual minerals or colour changes.

NOTE 1: The term 'Distinctly Weathered' is used where it is not practicable to distinguish between 'Highly Weathered' and 'Moderately Weathered' rock. 'Distinctly Weathered' is defined as follows: *'Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores'*. There is some change in rock strength.

Rock Material Strength Classification

Term	Abbreviation	Uniaxial Compressive Strength (MPa)	Guide to Strength	
			Point Load Strength Index $I_{s(50)}$ (MPa)	Field Assessment
Very Low Strength	VL	0.6 to 2	0.03 to 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30mm thick can be broken by finger pressure.
Low Strength	L	2 to 6	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium Strength	M	6 to 20	0.3 to 1	Scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High Strength	H	20 to 60	1 to 3	A piece of core 150mm long by 50mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High Strength	VH	60 to 200	3 to 10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
Extremely High Strength	EH	> 200	> 10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

Abbreviations Used in Defect Description

Cored Borehole Log Column		Symbol Abbreviation	Description
Point Load Strength Index		• 0.6	Axial point load strength index test result (MPa)
		x 0.6	Diametral point load strength index test result (MPa)
Defect Details	– Type	Be	Parting – bedding or cleavage
		CS	Clay seam
		Cr	Crushed/sheared seam or zone
		J	Joint
		Jh	Healed joint
		Ji	Incipient joint
		XWS	Extremely weathered seam
	– Orientation	Degrees	Defect orientation is measured relative to normal to the core axis (ie. relative to the horizontal for a vertical borehole)
	– Shape	P	Planar
		C	Curved
		Un	Undulating
		St	Stepped
		Ir	Irregular
	– Roughness	Vr	Very rough
		R	Rough
		S	Smooth
		Po	Polished
		Sl	Slickensided
	– Infill Material	Ca	Calcite
		Cb	Carbonaceous
		Clay	Clay
		Fe	Iron
		Qz	Quartz
		Py	Pyrite
	– Coatings	Cn	Clean
		Sn	Stained – no visible coating, surface is discoloured
		Vn	Veneer – visible, too thin to measure, may be patchy
		Ct	Coating ≤ 1mm thick
		Filled	Coating > 1mm thick
	– Thickness	mm.t	Defect thickness measured in millimetres