Preliminary Geotechnical Assessment

24 Duckenfield Road, Chisholm, NSW

Prepared for: AVID Property Group C/- ADW Johnson Pty Ltd
EP2681.003 28 February 2023

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AVID Property Group C/- ADW Johnson Pty Ltd
Level 3, 88 Cumberland Street
The Rocks, NSW 2000

28 February 2023

Our Ref: EP2681.003

LIMITATIONS

This Preliminary Geotechnical Assessment was conducted on the behalf of AVID Property Group C/- ADW Johnson Pty Ltd for the purpose/s stated in **Section 1**.

EP Risk has prepared this document in good faith, but is unable to provide certification outside of areas over which EP Risk had some control or were reasonably able to check. The report also relies upon information provided by third parties. EP Risk has undertaken all practical steps to confirm the reliability of the information provided by third parties and do not accept any liability for false or misleading information provided by these parties.

It is not possible in a Preliminary Geotechnical Assessment to present all data, which could be of interest to all readers of this report. Readers are referred to any referenced investigation reports for further data.

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1 Introduction

1.1 Overview

EP Risk Management Pty Ltd (EP Risk) was engaged by ADW Johnson Pty Ltd C/- AVID Property Group (AVID) to undertake a Preliminary Desktop Geotechnical Assessment (GA) for a property located at Lot 112 D.P. 734271 Duckenfield Road Berry Park, New South Wales (NSW) (the Site). It is understood that the Site is proposed to be redeveloped into a two hundred and eighty-two (282) lot residential subdivision (future Stage of the Waterford Residential Estate).

EP Risk have undertaken geotechnical and environmental assessment including intrusive sampling of the Property. The results of the assessment are reported in EP Risk Report "E*nvironmental & Geotechnical Due Diligence 24 Duckenfield Road, Berry Park, NSW*" reference EP2681.001 dated 13 June 2022, which is referenced herein along with "*Preliminary Site Investigation 24 Duckenfield Road, Berry Park, NSW*" EP2681.002 dated 8 November 2022.

Draft Plans of "lot Number and Areas" Lot 112 of DP 734271 by ADW Reference 190433 SK -284 and 290-296 undated were provided and are attached as **Appendix A – Draft Plans.**

1.2 Objective

A geotechnical assessment was required to inform preliminary design and identify potential constraints including:

1. Provide a copy of Geotechnical Report and Civil Design for the following:
1.1 Pavement Design
1.2 Basin Design including any required clay core requirements
1.3 As fill is greater than 2m in some areas, the geotechnical report shall also address settlement of fill both short and long terms and construction methodology.

1.3 Site Description

The Site comprises of a large irregular portion of land, approximately 6.17 Ha, located on the southern portion of Lot 112 of DP 734271. A Principal Geotechnical Scientist and an Environmental Engineer, from EP Risk, attended the Site on 01 June 2022 to undertake a site walkover, visual inspection, and intrusive investigation.

General site features observed include two stockpiles (SP03 and SP04) of anthropogenic materials (wood, mattresses, metal, plastic) in the southern portion of the Site; two imported fill stockpiles (SP01 and SP02) were identified next to the eastern boundary of the Site (SP01 is located near a former dam that was backfilled around the year of 2006); scattered anthropogenic materials; a dam in the central portion of the Site; scattered native vegetation; and an existing underground water main runs along the western boundary of the Site. Several small excavations (<1m3) in the southern gully of unknown origin. A white silvery shape in the drainage line appears in the 1988 Arial photo. Inspection did not show any reason for this occurrence and may be a surface reflection.

The southeast portion of the Site is on the crest northwest facing slope of a broad hill which gradually slopes toward the northwest toward low lying wetlands. Site drainage was via surface contours draining towards the low-lying wetlands to the northwest and three (3) broad gullies, one on the southern boundary and two located in the central portion of the site. There is evidence of water from the wetland ponding at lower elevations across the western boundary of the Site and poor trafficability would be expected following heavy rain. There were areas of the site where standing water was observed at the time of inspection within the Site boundary including the three gullies and at the eastern boundary at the top of the site. The Site was devoid of any permanent or temporary structures.

2 Investigation Methodology

Subsurface investigation was undertaken on the Site on 1 June 2022 and included the following:

- Thirteen (13) test pits to a maximum depth of 2.5m or prior rock refusal
- Dynamic Cone Penetrometer (DCP) testing adjacent to each test pit location to assess the consistency of the substrata.

The field investigation was carried out by and experienced EP Risk Geotechnical Engineer who logged the subsurface profile in each test pit and obtained bulk, disturbed, and undisturbed soil samples for subsequent laboratory testing and soil/rock identification purposes.

All test locations were established based on the current proposed development layout. The locations of the investigations were identified on site using a handheld GPS unit. The locations of the geotechnical investigation tests are shown in **Appendix B – Geotechnical Investigation Locations**.

The subsurface conditions are summarised in Section 4.2 and detailed test pit engineering logs, which are attached in **Appendix C – Test Pit Logs**, together with explanatory notes.

A summary of the geotechnical testing schedule is presented in Table 1.

Table 1. Summary of Geotechnical Testing Schedule

Media	Soil/Rock Tests
Soil	• (6B) California Bearing Ratio (CBR) • (2D) Atterberg Limits • (2D) Particle Size Distribution (PSD)
B – bulk samples; D – disturbed samples; U – undisturbed samples	

3 Investigation Findings

3.1 Site Geology

Based on geological data sourced from the NSW Department of Industry, Resources and Energy (www.minview.geoscience.nsw.gov.au) the Site is underlain by the Lopingian Age Tomago Coal Measures, of the Singleton Supergroup. The Tomago Coal Measures are known to contain very fine to medium grained, grey lithic sandstone, laminated carbonaceous shale and mudstone, siltstone, coal with sporadic interbeds of carbonaceous shale, claystone, sideritic bands, and rare pebble paraconglomerate. An excerpt of the geological map is shown in Figure 1.

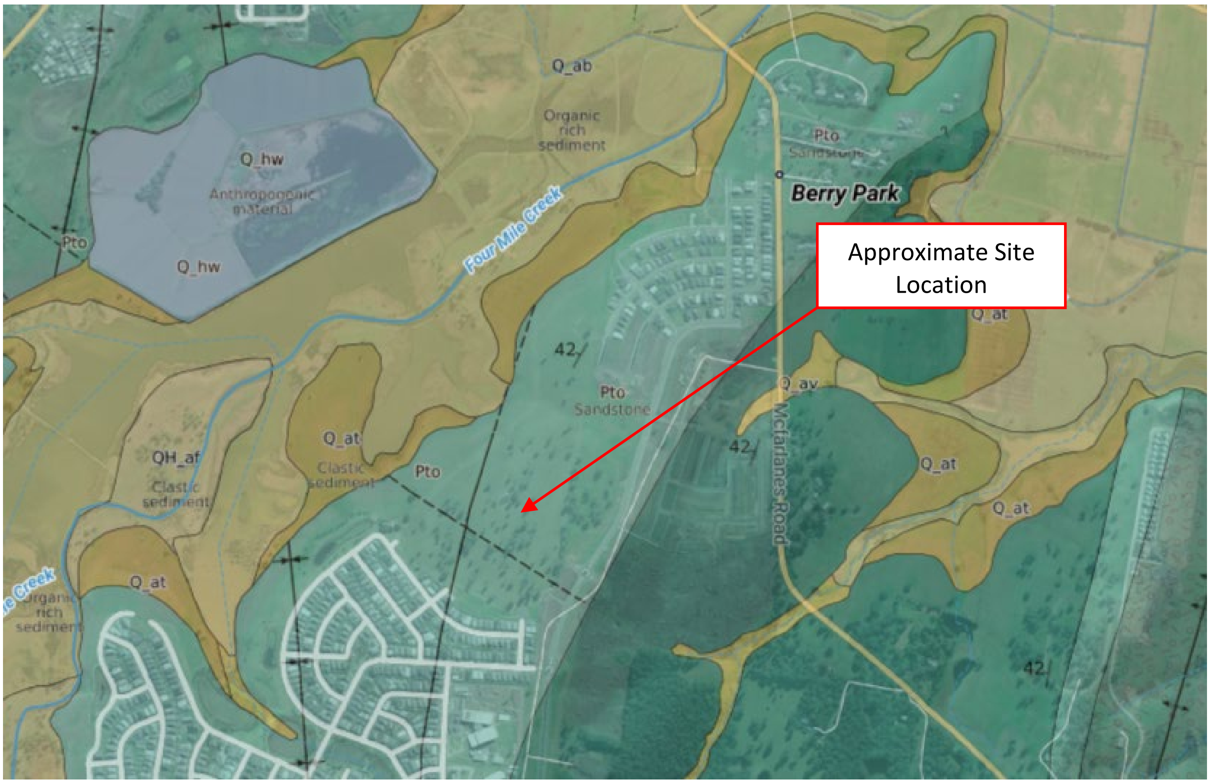


Figure 1. Geological Map Excerpt

3.2 Soil Landscape

With reference to the NSW Department of Industry, Resources and Energy, onsite soil landscapes have been identified to comprise of 9232be, Beresfield.

The landscape comprises of undulating low hills and rises, with local relief of 10-50m, elevations ranging between 20-50m, and slopes gradients of 3-15%. The vegetation is predominantly partially cleared tall open forest. Some limitations of the Beresfield soils include high foundation hazard, water erosion hazard, mine subsidence district, seasonal waterlogging, high run-on on localised lower slopes, and high acidic soils of low fertility. An excerpt of the soil landscapes map is shown in Figure 2.

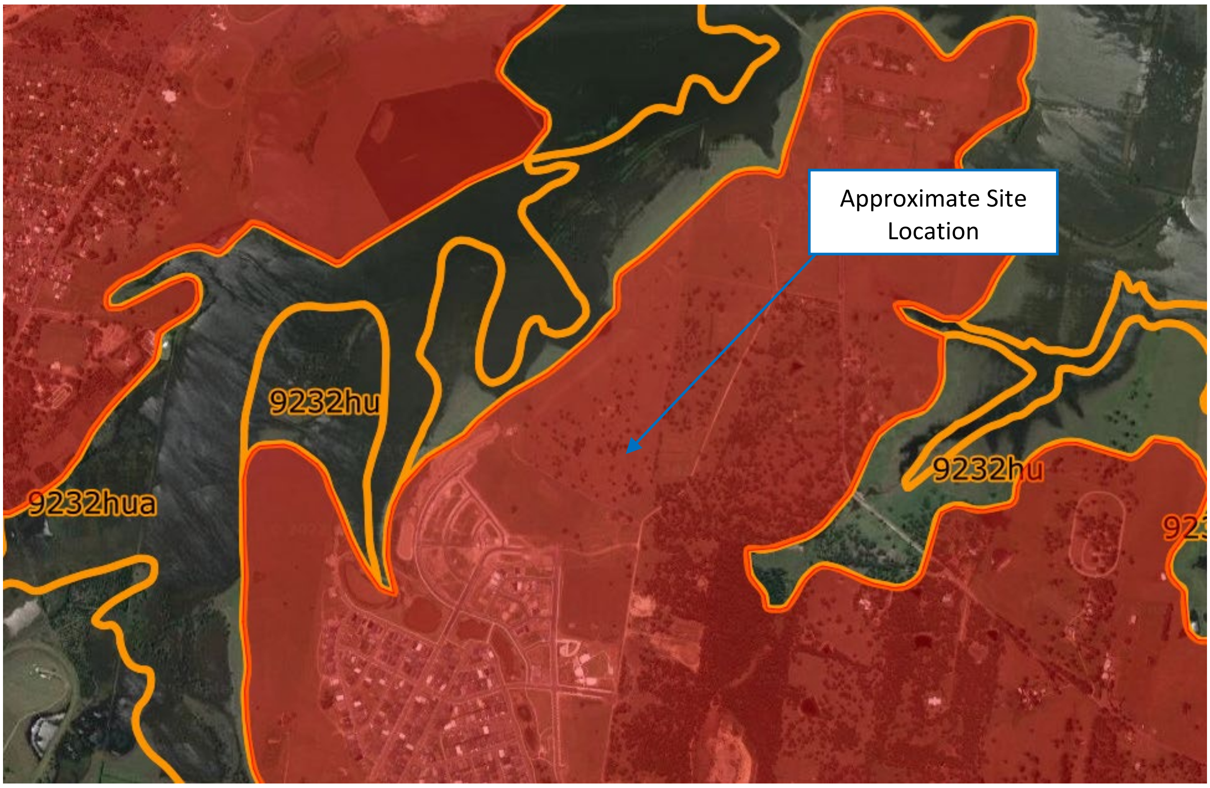


Figure 2. Soil Landscape Map Excerpt

3.3 Mine Subsidence

With reference to the Mine Subsidence District Data Source, the Site is not located within a Mine Subsidence District. However, there are underground mine workings located to the eastern of the Site on stage 62.

3.4 Subsurface Conditions

The subsurface conditions encountered in the Test Pits advanced across the Site (TP01 – TP13) are detailed on the attached log sheets in **Appendix C – Test Pit Logs**. These should be read in conjunction with the general notes preceding them, which explain the descriptive terms and classification methods used in the report. A summary of the subsurface conditions is presented in Table 2. In general, the subsurface conditions in the Test Pits (TP01 – TP08) can be summarised as follows:

- 1A: TOPSOIL: Silty SAND: Dark brown, fine to coarse grained sand, dry, organic material.
- 2A: RESIDUAL: Sandy CLAY: Mottled orange, grey and red, high plasticity, near plastic limit, fine to coarse grained sand.
- 3A: Extremely weathered (XW) SANDSTONE: Recovered as Clayey SAND: Grey and red, fine to coarse grained sand, dry.

In general, the subsurface conditions in the Test Pits (TP09 – TP13) can be summarised as follows:

- 1B FILL: Sandy CLAY with Gravel: Mottled grey, red and orange, medium to high plasticity, dry of plastic limit, fine to coarse grained sand, fine to medium grained, sub angular gravels.
- 1A: TOPSOIL: Silty SAND: Dark brown, fine to coarse grained sand, dry, organic material.

The depth to extremely weathered rock varies across the Site ranging from 0.7 m (TP05 and TP08) to 1.8 m BGL (TP06) in the test pits across the Site as indicated in Table 2. The target depth of 2.3 m BGL was reached in three

(3) of the test pits advanced across the Site and prior bedrock refusal was encountered in five (5) of the test pits advanced across the Site ranging from 0.9 m to 1.4 m BGL as shown on the attached logs in **Appendix C – Test Pit Logs**.

A general summary of the subsurface conditions encountered across the Site is presented in Table 2.

Table 2. Summary of Subsurface Conditions

Test Pit ID	Depth of Topsoil / FILL (m BGL)	Depth to Rock (m BGL)	Test Pit Depth (m BGL)	Summary of subsurface profile
TP01	0.2	0.8	1.0	TOPSOIL (silty SAND) / Residual Sandy CLAY / XW SANDSTONE
TP02	0.1	1.2	1.4	TOPSOIL (silty SAND) / Residual Sandy CLAY / XW SANDSTONE
TP03	0.1	1.4	2.3	TOPSOIL (silty SAND) / Residual Sandy CLAY / XW SANDSTONE
TP04	0.1	1.4	2.3	TOPSOIL (silty SAND) / Residual Sandy CLAY / XW SANDSTONE
TP05	0.1	0.7	0.9	TOPSOIL (silty SAND) / Residual Sandy CLAY / XW SANDSTONE
TP06	0.2	1.8	2.3	TOPSOIL (silty SAND) / Residual Sandy CLAY / XW SANDSTONE
TP07	0.1	0.9	1.0	TOPSOIL (silty SAND) / Residual Sandy CLAY / XW SANDSTONE
TP08	0.1	0.7	0.9	TOPSOIL (silty SAND) / Residual Sandy CLAY / XW SANDSTONE
TP09	**1.4**	N/A	1.55	FILL (Sandy CLAY) / TOPSOIL (silty SAND)
TP10	**0.6**	N/A	0.75	FILL (Sandy CLAY) / TOPSOIL (silty SAND)
TP11	**0.4**	N/A	0.5	FILL (Sandy CLAY) / TOPSOIL (silty SAND)
TP12	**0.8**	N/A	0.95	FILL (Sandy CLAY) / TOPSOIL (silty SAND)
TP13	**0.7**	N/A	0.9	FILL (Sandy CLAY) / TOPSOIL (silty SAND)

NB: Bold indicates Fill

3.5 Groundwater

Groundwater was not encountered in any of the test pits across the Site at the time of the investigation. It should be noted that the groundwater conditions will vary with seasonal and weather conditions along with construction related site conditions.

3.6 Laboratory Results

Geotechnical laboratory testing was carried out on selected bulk, disturbed and undisturbed samples collected during the site investigation. All testing was performed by Coffey Testing (Newcastle) and Eurofins - NATA accredited laboratories in accordance with the relevant Australian Standards and technical procedures. The detailed results of laboratory testing are presented in **Appendix D – Laboratory Test Results** and are summarised in the following sections.

3.6.1 California Bearing Ratio (CBR)

CBR tests were undertaken on six (6) soil samples to inform the design CBR for the proposed pavement areas. The results of the testing are summarised in Table 3**.**

Table 3. California Bearing Ratio Test Results

Test ID	Depth (m BGL)	Sample Description	W[1] (%)	SOMC[2] (%)	SMDD[3] (t/m³)	Swell (%)	CBR[4] (%)
TP03	0.5-1.0	Sandy CLAY	25.5	25.0	1.52	3.0	2.5
TP04	0.5-1.0	Sandy CLAY	28.8	26.5	1.48	1.5	2.5
TP05	0.2-0.7	Sandy CLAY	22.7	22.0	1.60	0.5	3.0
TP06	0.5-1.0	Sandy CLAY	22.6	20.0	1.65	3.5	4.0
TP07	0.2-0.7	Sandy CLAY	26.6	24.5	1.53	0.5	3.0
TP08	0.1-0.6	Sandy CLAY	21.3	21.5	1.63	1.5	3.5

[1] Field Moisture Content
[2] Standard Optimum Moisture Content
[3] Standard Maximum Dry Density
[4] CBR at 2.5mm (%)

CBR samples were remoulded to a target of 100% relative density at approximately standard optimum moisture content (SOMC). The samples were surcharged with 4.5kg and soaked for four days prior to penetration. According to Table 5.2: Guide to classification of expansive soils (Austroads, 2017) the soil samples tested for CBR have a moderate to high potential for expansive volume change.

3.6.2 Atterberg Limits

A summary of Atterberg Limits and Linear Shrinkage test results are presented in Table 4 and are plotted graphically in Figure 3. Testing indicates that the clayey materials range from medium to high plasticity.

Table 4. Atterberg Limits Test Results

Test Pit ID	Soil	Classification	Depth (m BGL)	Atterberg Limits			Linear Shrinkage (%)
				LL (%)	PL (%)	PI (%)	
TP01	CLAY with Sand	CH	0.3-0.8	63	23	40	17.5
TP02	CLAY with Sand	CH	0.5-1.0	52	23	29	16.0

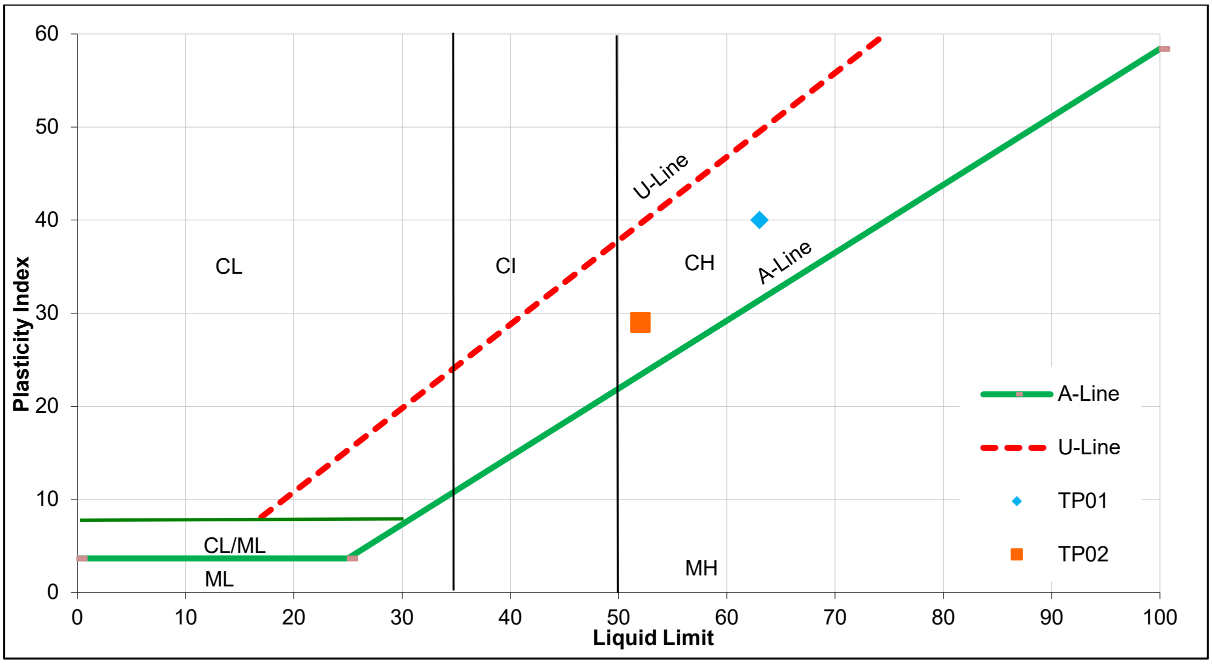


Figure 3. Atterberg Limits Graphical Plot

3.6.3 Particle Size Distribution

Particle Size Distribution (PSD) test results undertaken on samples of subgrade containing Residual Soils and Slope wash are presented in Table 5 and confirms the material description on the test pit logs.

Table 5. Particle Size Distribution Test Results

Test Pit ID	Depth (m BGL)	% Passing 2.36 mm sieve	% Passing 75 µm sieve	Sample Description
TP01	0.3-0.8	98	74	CLAY with Sand
TP02	0.5-1.0	100	71	CLAY with Sand

4 Pavement Design

4.1 Design Traffic Loadings

Design traffic loadings and pavement thickness design calculation has been undertaken by EP Risk in general accordance with *Maitland City Council – Manual of Engineering Standards* for the roads and in the proposed development for the expected traffic volumes and type. The design traffic data has been determined based on the following assumptions in Table 6.

Table 6. Recommended Road Type and Design ESA's

Roads Identification	Road Type	Design ESA's
All roads within proposed subdivision	Local - Primary	5×10^5
Silverwater Parade	Collector- Secondary	1×10^6

Where traffic data varies from the above assumptions a review of pavement design may be required, particularly considering connectivity with adjacent developments.

4.2 In-Situ Testing

The DCP test can be used to provide a correlation with in-situ (field) CBR in accordance with Austroads (2017). In-situ California Bearing Ratio - Dynamic Cone Penetrometer Penetration (mm) was plotted against number of cumulative hammer blows, and different layers were identified based on the gradient of the plot. The average penetration rate was calculated for each identified layer, and subsequently, the CBR value was determined using the following equation:

$$CBR = 326.956416 * r^{-1.145703} \tag{1}$$

where CBR = equivalent California Bearing Ratio value

r = average penetration rate for the corresponding layer (mm/blow)

It should be noted that the correlation is valid up to 10 DCP blows / 100 mm (i.e., CBR < 20%). The in-situ CBR values for substrata for the pavement test pits are presented in Figure 4 and the correspondent field CBR versus laboratory CBR values are presented in Table 7.

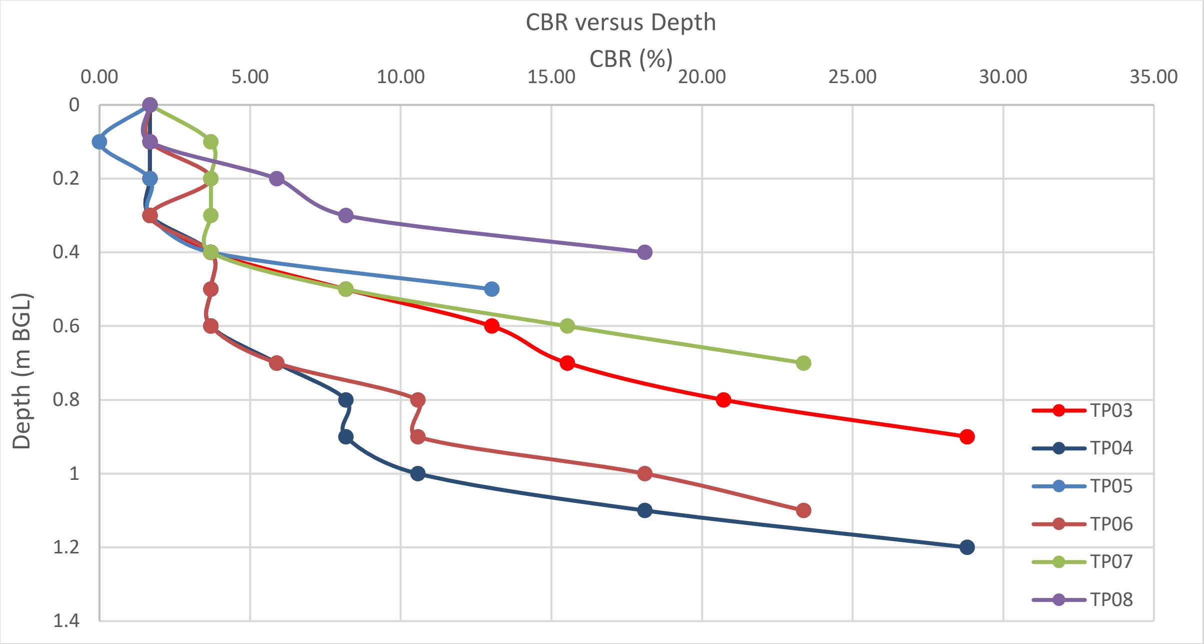


Figure 4. In-Situ CBR values

Table 7. Inferred field CBR (%) Values Versus Laboratory Results

Test Pit ID	Material Description	Depth (m BGL)		Average Field CBR (%) *	Laboratory CBR (%)
		Top	Bottom		
TP03	Sandy CLAY	0.5	1.0	5.0	2.5
TP04	Sandy CLAY	0.5	1.0	3.1	2.5
TP05	Sandy CLAY	0.2	0.7	5.0	3.0
TP06	Sandy CLAY	0.5	1.0	4.7	4.0
TP07	Sandy CLAY	0.2	0.7	8.8	3.0
TP08	Sandy CLAY	0.1	0.6	7.1	3.5
* In-situ estimated CBR at anticipated design subgrade level (DSL)					

4.3 Design Parameters

Pavement thickness has been undertaken in accordance with Austroads AGPT02-17 Guide to Pavement Technology, Part 2: Pavement Structural Design based on the following parameters for site materials.

- Design subgrade CBR of 3.0% for Sandy CLAY soil materials encountered and engineering fill placed as controlled fill.
- Design subgrade CBR of 8.0% where uniform rock subgrade exists.

The design subgrade has been determined in accordance with Section 5 of Austroads 2017 based on both laboratory and field-testing results.

The CBR Swell results when compared to Table 5.2 Guide to pavement Technology Part 2: Pavement Structural Design indicate that the soils tested have a moderate to high expansive nature and specific strategies may be required to address potential volume change due to moisture variation in the subgrade. This will largely be dependent on the vertical alignment of roads and the material present within 0.5 m of design subgrade level (DSL).

Where filling is undertaken greater than 0.5 m depth, the CBR of the fill material should be considered for the design CBR. All fill materials should be a minimum of CBR 3.0% based on 4-day soak when compacted to 100% standard relative density and SOMC.

4.4 Pavement Design

4.4.1 Option 1 – Flexible Unbound Pavement (Clay Subgrade CBR 3.0% and Rock Subgrade CBR 8.0%)

The option of pavement construction utilising flexible unbound pavement materials for sandy/silty CLAY subgrade with CBR 3% and weather rock subgrade of CBR 8% is detailed in

Table 8.

Table 8. Recommended Flexible Pavement Composition

Pavement Layer	Road Type - Local Road & (Secondary Collector)	Road Type – Local (with Select for Highly Expansive Subgrade)	Road Type – Secondary Collector with Select for Highly Expansive Subgrade)
Wearing Course (mm)	30 AC10 (45 AC14) with 7mm primer seal	30 AC10 with 7mm primer seal	45 AC14 with 7mm primer seal
Basecourse (mm)	160	160	160
Subbase (mm)	125	125	125
Select* (mm) where high expansive subgrade exists	-	300	300
Total Thickness (mm)	315 (330)	615	630
Subgrade CBR (%)	min 8%	min 3%	min 3%
Allowable DESA	5 x 10^5 (1 x 10^6)	5 x 10^5	1 x 10^6
* Where reactive clay has a CBR swell ≥ 2.5%, the pavement option using a select subgrade should be adopted. ( ) bracket number reflects design for secondary collector road category			

A minimum of fourteen days duration shall apply prior to application of asphalt layer. That period may be extended or shortened subject to approval by Council. Based on expected site conditions following regrade, pavement design based on a design subgrade CBR of 3.0% is considered appropriate with confirmatory testing required following completion of Site regrade activities.

For areas where the clay subgrade has a CBR swell ≥ 2.5%, it is recommended that the pavement design incorporate a 300mm select layer with minimum CBR of 30%.

Pavement configuration/thickness will be dependent on the subgrade exposed following regrade activities.

4.5 Subgrade Preparation

For construction of the new pavement, subgrade preparation should be in general accordance with the following procedures and Maitland City Council – Manual of Engineering Standards.

- Stripping of topsoil.
- Excavation of residual soil to design subgrade level.
- Ripping the insitu subgrade 300-350mm below DSL and recompact to a minimum 100% of SMDD. Moisture content should be within 70% to 90% of SOMC (generally -3% to -1% dry of SOMC) care is

required not to compact the subgrade at high levels of relative compaction at moisture significantly dry of SOMC as this will create swell potential, particularly in reactive/expansive clay subgrades.

- Static proof-rolling of the exposed subgrade using a heavy (minimum 10 tonne) roller under the direction of an experienced geotechnical consultant.
- Weathered rock encountered at design subgrade will require ripping and recompacting (300mm).
- Loose or yielding areas should be excavated and replaced with compacted select fill or suitable subgrade replacement comprising of material of similar consistency to the subgrade.
- Subgrade should be compacted high of DSL with pad marks trimmed to spoil.
- Testing of the subgrade by soaked CBR testing to confirm the design parameters.

Where filling or subgrade replacement is required, the materials employed should be free of organics or other deleterious material. The material should also have a maximum particle size of 100mm or one third of the layer thickness, with a soaked CBR > 3.0%. Following satisfactory preparation of the subgrade, the pavement should be placed in accordance with the designer’s recommendations.

Following satisfactory preparation of the subgrade, the pavement should be constructed in accordance with the recommendations or this report and Maitland City Council – Manual of Engineering Standards-Construction. In case of discrepancy clarification should be sort from Council.

4.6 Drainage

The moisture regime associated with a pavement has a major influence on the performance considering the stiffness/strength of the pavement materials is dependent on the moisture content of the material used. Accordingly, to protect the pavement materials from wetting up and softening, particular care would be required to provide a waterproof seal for the pavement materials, together with adequate surface and sub-surface drainage of the pavement and adjacent areas.

It is recommended that subsoil drainage be installed at, or below subgrade level along both sides of the road. This is consistent with Council specifications, which states that subsoil drainage shall be provided on both sides of the road pavements and in all road stormwater pipe trenches in accordance with Council’s drawings SD003 & SD035 attached as **Appendix E – Council Subsoil Drainage Standard Drawings**.

The subgrade should be constructed with sufficient cross fall (in general 3%) to assist in reducing retention time for moisture entering the pavement. The subsoil drains should be located below or behind the kerb to intercept any moisture ingress from outside and within the road alignment. The drains will require flush-out points and regular maintenance to ensure their correct operation. Council guidelines specify that flush-out points should be provided generally at the crest point of the road and adjacent to drainage pits or at intervals of approximately 60 metres. The flush points shall be plastic screwcaps with concrete surrounds, placed behind the kerb and gutter in urban areas, or in road shoulders in rural areas. They are not to be placed within stormwater pits.

Where highly expansive clay soils are encountered design measures to control movement of the subgrade are required for pavements over expansive soils classified “high” or “very high”. Design measures and subsurface drainage are discussed in Austroads Pavement Guide to Pavement Technology – Set and the relevant Transport for New South Wales Supplement(s). Preferred measures shall also be discussed with Council’s Representative prior to adoption in any pavement construction. It is noted that two (2) samples were highly expansive, TP03 and TP06.

The pavement thickness designs presented above assume drained pavement conditions. The selection, construction and maintenance of appropriate drainage mechanisms will be required for adequate performance. The selection of appropriate construction materials that are relatively insensitive to moisture change is also essential in area subject to periodic inundation, even if for a relatively short period of time.

4.7 Materials

4.7.1 Specifications and Compaction Requirements

Pavement materials and compaction requirements for new pavement construction should conform to Council requirements and the following requirements outlined in Table 9.

Table 9. Material Specification and Compaction Requirements

Pavement Course	Material Specification	Compaction Requirements
Base Course DGB20 (Class 2) & NGB20*	Material complying with Council Specifications with CBR > 80%, with PI ≤ 6%	Min 98% Modified (AS 1289 5.2.1)
Subbase Subbase quality crushed rock (DGS20, DGS40, GMS40, NGS20, NGS40)	Material complying with Council Specifications with CBR >30% with PI ≥2≤ 10%	Min 95% Modified (AS 1289 5.2.1)
Select Granular material	Well graded granular material with CBR min 30% and PI ≤15%	Min 100% Standard (AS 1289 5.1.1)
Subgrade or replacement	Minimum CBR ≥3% or 5% as appropriate for the design option.	Min 100% Standard (AS 1289 5.1.1)
*NGB and NGS material cannot be used on collector category road or higher due to higher design traffic. Class 1 material should be used on Sub-Arterial category roads.		

Minimum testing on all potential imported pavement materials should be in accordance with TfNSW 3051 Ed 7. Pre-treatment of material prior to testing would be advisable for materials subject to breakdown.

4.7.2 Wearing Course

Wearing courses should be in accordance with Maitland City Council (Council) Manual of Engineering Standards with reference to Austroads AGPT04B-07 Guide to Pavement Technology, Part 4B: Asphalt.

The design and construction of wearing courses should be in in consultation with the preferred supplier considering traffic volume and type. All pavement surfaces should be primer sealed prior to the application of the asphaltic concrete (‘AC’) wearing course. A minimum delay of 14 days is required after the primer seal before placement of the AC wearing course. The delay period on application of the wearing course following primer seal may be altered following discussion with the supplier. Council specifies a minimum asphaltic concrete thickness of 30 mm.

4.7.3 Inspections

The subgrade will require inspection by an experienced geotechnical consultant after boxing out or filling to design subgrade level. The purpose of inspections is to confirm design parameters, assess the suitability of the subgrade to support the pavement, and delineate areas which may require subgrade replacement or remedial treatment prior to construction. Soaked CBR testing will be required following the completion of bulk earthworks and site regrade activities to confirm the assumed design parameters and appropriate pavement thickness.

All works and materials used in construction should be constructed in accordance with Council Specifications and as specified in this report. Where discrepancies may occur, clarification should be sought from Council.

5 Preliminary Site Classification

Australian Standard AS 2870-2011 establishes performance requirements and specific designs for common foundation conditions as well as providing guidance on the design of footing systems using engineering principles. Site classes as defined on Table 2.1 and 2.3 of AS 2870 are presented in Table 10.

Table 10. General Definition of Site Classes

Site Class	Foundation	Characteristic Surface Movement
A	Most sand and rock sites with little or no ground movement from moisture changes	-
S	Slightly reactive clay sites, which may experience only slight ground movement from moisture changes	0 – 20 mm
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes	20 – 40 mm
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes	40 – 60 mm
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes	60 – 75 mm
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes	> 75 mm
A to P	Filled sites (refer to clause 2.4.6 of AS 2870)	-
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise.	

Reactive sites are sites consisting of clay soils that swell on wetting and shrink on drying, resulting in ground movements that can damage lightly loaded structures. The amount of ground movement is related to the physical properties of the clay and environmental factors such as climate, vegetation, and watering. A higher probability of damage can occur on reactive sites where abnormal moisture conditions occur, as defined in AS 2870, due to factors such as:

- Presence of trees on the building site or adjacent site, removal of trees prior to or after construction, and the growth of trees too close to a footing. The proximity of mature trees and their effect on foundations should be considered when determining building areas within each allotment (refer to AS 2870).
- Failure to provide adequate site drainage or lack of maintenance of site drainage, failure to repair plumbing leaks and excessive or irregular watering of gardens.
- Unusual moisture conditions caused by removal of structures, ground covers (such as pavements), drains, dams, swimming pools, tanks etc.

Regarding the performance of footings systems, AS 2870 states “footing systems designed and constructed in accordance with this Standard on a normal site (see Clause 1.3.2) that is:

a) not subject to abnormal moisture conditions; and

b) maintained such that the original site classification remains valid and abnormal moisture conditions do not develop are expected to usually experience no damage, a low incidence of damage category 1 and an occasional incidence of damage category 2."

Damage categories are defined in Appendix C of AS 2870, which is reproduced in CSIRO Information Sheet BTF 18, Foundation Maintenance and Footing Performance: A Homeowner's Guide attached as **Appendix F – Foundation Maintenance and Footing Performance**.

The laboratory Atterberg limits test results summarised Table 4 indicated that the tested CLAY soils returned I_{ss} correlation values ranging from 3.1% (in TP01) to 2.3% (in TP02) which are moderately reactive. The swell results from CBR testing indicate that site subgrades range from low to highly expansive.

The classification of sites with controlled fill of depths greater than 0.4m (deep fill) comprising of material other than sand would be Class P. An alternative classification may however be given to sites with controlled fill where consideration is made to the potential for movement of the fill and underlying soil based on the moisture conditions at the time of construction and the long-term equilibrium moisture conditions.

Based on the subsurface profiles encountered during the Site inspection and in accordance with the AS 2870-2011; the Site in its existing condition and in the absence of abnormal moisture conditions would likely be classified as detailed in Table 11.

Table 11. Anticipated Site Classifications

Lot	Site Classification
Lot 112 D.P. 734271 Duckenfield Road Berry Park following regrade	**Class M**, moderately reactive to **Class H2**, highly reactive

A characteristic surface movement (y_s) in the range of 35mm to 70mm has been calculated for the site dependent on the soil profile, and the depth of design suction (Hs) change of 1.8 m used. Actual site classifications will be dependent on regrade activities including depth to rock and filling depth along with the materials utilised as fill.

The above site classifications and footing recommendations are for the site conditions present at the time of fieldwork and consequently the site classification may need to be reviewed with consideration of any site works that may be undertaken after the investigation and this report.

Site works may include:

- Changes to the existing soil profile by cutting and filling
- Landscaping, including trees removed or planted in the general building area; and
- Drainage and watering systems.

Designs and design methods presented in AS 2870-2011 are based on the performance requirement that significant damage can be avoided if site conditions are properly maintained. Performance requirements and foundation maintenance are outlined in Appendix B of AS 2870. The above site classification assumes that the performance requirements as set out in Appendix B of AS 2870 are acceptable and that site foundation maintenance is undertaken to avoid extremes of wetting and drying.

Details on appropriate site and foundation maintenance practices are presented in Appendix B of AS 2870-2011 and in CSIRO Information Sheet BTF 18, Foundation Maintenance and Footing Performance: A Homeowner's Guide. Adherence to the detailing requirement outlined in Section 5 of AS 2870-2011 is essential, Section 5.6. Additional requirements for Classes M, H1, H2 and E sites, including architectural restrictions, plumbing and drainage requirements.

6 General Construction Considerations

6.1 Excavation Assessment and Excavations Stability

Practical machine refusal for the 5-tonne excavator was encountered on extremely weathered sandstone in test pits TP01-TP08, at depths ranging from 0.8 m to 2.3 m BGL. The depth to extremely weathered sandstone was variable across the Site. Due to this variability, achievable depths of excavations are difficult to similar sized earthmoving equipment. Excavations below 1.0 m deep in areas where shallow refusal was observed during the investigation, may require bigger size excavators fitted with tiger teeth buckets, single ripper attachments or rock hammers. Considerable caution should be taken during rock excavation using hydraulic rock hammers or jack hammers in proximity to existing structures/services due to the potential for direct transmission of ground vibration to structures or underground services within close proximity.

The excavatability conditions have not been assessed beyond the depths to which the test pits were excavated.

6.2 Retaining Walls

All retaining walls should be designed by an engineer. Design of retaining walls should:

- Consider surcharge loading from slopes and structures above the wall.
- Take into account loading from any proposed compaction of fill behind the wall.
- Provide adequate surface and subsurface drainage behind all retaining walls, including a free draining granular backfill to prevent the build-up of hydrostatic pressures behind the wall.
- Utilise materials that are not susceptible to deterioration.
- Ensure walls are founded in materials appropriate for the loading conditions.

Footings for proposed retaining walls should be founded below any topsoil within stiff or better clay or weathered rock. It is recommended to avoid founding retaining walls in the quaternary sediment encountered in the northern section of the site.

6.3 Filling

Fill should be placed and compacted in accordance with AS 3798-2007. It is expected that construction of a suitable fill platform to support structural loads, such as pavements, ground slabs, footing and stiffened raft slabs, would include the following:

- Stripping of topsoil.
- Wet material where encountered will likely require treatment or moisture re-conditioning (drying and blending with dryer fill material) prior to placement and compaction.
- Proof rolling of the exposed subgrade to detect any weak or deforming areas of subgrade that should be excavated and replaced with compacted fill.
- Placement of fill in horizontal layers with compaction of each layer to a minimum dry density ratio of 95% Standard Relative Density (Australian Standard AS 1289 Clause 5.1.1) at moisture contents of 85-115% of SOMC and 98% Standard for fill in ≥2m depth. Fill within 0.5m of design subgrade in road alignments is to be compacted to 100% standard relative density at a 70-100% of SOMC. Reactive / Expansive clay materials (if encountered) should be placed as close to SOMC as practical to minimise their swell potential and preferentially placed in lower level of the deeper fill areas.

All fill materials should be supported by properly designed and constructed retaining walls or else battered at a slope of 2H:1V or flatter and protected against erosion by vegetation or similar and the provision of adequate drainage.

Materials excavated on Site apart from topsoil and other deleterious materials are considered suitable for re-use as engineering fill. Some materials will likely require treatment such as blending and moisture re-conditioning to produce suitable structural fill, subject to further assessment and weather conditions prior to and during construction. It is noted that sandy clays were encountered in areas of the Site. While these materials have suitable bearing capacity when dry they are prone to softening (loss or strength) when wet and can present trafficability and compaction issues when at elevated moisture contents. The sandy material may also prove difficult from an earthworks perspective and should be either stripped and replaced as surficial layers or blended with more cohesive materials. Material should be managed during regrade to allow use of higher CBR and lower reactivity material in the top 300mm of design subgrade and 0.9m of finished level in lot fill areas to provide better pavement and classification outcomes.

6.4 Potential Settlement

Due to the relatively shallow depth of filling proposed across the site (up to 2.0m on Silverwater Parade) and the shallow depth to rock. Settlement is not considered to be of significance.

Settlement analysis was undertaken for Stage 39 Waterford currently under construction in EP Risk Report “Fill Settlement Assessment Waterford Stage 39, Chisholm, NSW” Reference EP2646.001.2 dated 14 June 2022. The results of settlement calculation for Stage 39 where a maximum depth of fill of 5m concluded that a total settlement of 33mm could be anticipated of which 19mm occurring during construction and half the creep within a few months following placement.

The calculated predicted settlement for filling depth of 5m using the latest Rocscience software is not considered excessive and in consistent with predicted settlements in published research paper: “Settlement characteristic of Deep Engineered Fills” by Peter J. Waddell and Patrick K. Wong (Coffey Geosciences Pty Ltd) in Australian Geomechanics Journal Vol 40 No 4 December 2005.

As filling will be significantly less than in Stage 39 and generally <2m depth the potential for settlement for material placed in accordance with Australian Standard AS3798-2007-Guideline on earthworks for commercial and residential development at a minimum density ratio of 95% standard relative density (SRD) at a moisture content of 85- 115% of Standard Optimum Moisture Content (SOMC) will be minimal. Filling greater that 2m in depth should be placed at 98% SRD. Placement of material significantly dry or wet of SOMC should be avoided.

Due to the relatively small, predicted settlement, which will predominantly occur during construction, there is no need for any delay in construction of the subdivision including pavements, structures and installation of inground services due to excessive or differential settlement where construction is undertaken in accordance with the recommendations of this report.

7 Basin Construction

7.1 Laboratory Testing Basin

7.1.1 Emerson Class Test Results

Soil samples collected at the proposed location the basin have been tested for Emerson class to determine whether the soil requires stabilisation. Results of the testing are detailed in the laboratory reports attached in **Appendix D - Laboratory Certificates** and summarised in Table 12.

Table 12. Emerson Class Test Result

Test pit	Depth (m BGL)	Sample Description	Emerson Class
TP01	0.3-0.8	Sandy CLAY	2*
TP02	0.5-1.0	Sandy CLAY	2*
Class 2 materials are mildly dispersive and can generally be controlled by moisture and compaction specification. Gypsum stabilisation should be considered for the core of the embankment.			

Permanent and temporary sediment and water detention basin should be designed and constructed in accordance with Council guidelines with reference to Table 13.

Table 13. Drainage Basin materials and compaction requirements

Zone	Material Specifications	Compaction Requirements
1- Clay Core / Clay Liner & Embankment Material	Liquid limit >50% 10% < Plasticity Index (PI) < 50%, Permeability <10^{-9}m/s Emerson Class >4 Maximum Particle Size <50mm Percentage Clay Content >25	98% standard relative density AS1289 5.7.1 at a moisture content of -1 to +3% of standard optimum moisture
2 - Outer Embankment Material (lower standard)	10%< PI <50%, Permeability < 10^{-7}m/s Emerson Class >2 Maximum Particle Size <75mm Percentage Clay Content >20 %	95% standard relative density AS1289 5.7.1 at a moisture content of -2 to +2% of standard optimum moisture
Topsoil	Suitable for sustaining planned vegetation plantings	Not applicable
Cut-Off Trench / Keyway	Minimum Stiff (CL-CH) Clay or better.	Minimum 2.4m wide and keyed into a minimum depth of 0.5 m into impervious material (compaction as per Zone 1)
Batter Slopes	1 Vertical: 6 Horizontal (Impoundment) 1 Vertical: 3 Horizontal (External)	
Spillway	Constructed in accordance with Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia (Geoscience Australia), 2019.	

Embankments should be battered at a slope of 1V:3H or flatter for downstream batters or for batters above the permanent water level and 1V:6H for impoundment areas below the permanent water level or as otherwise agreed with Council or handrails installed to assist egress.

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

Table 13 provides material requirements guidelines and compaction specifications for the construction of a zoned or non-zoned basin embankment. A zoned embankment can be considered where material of specified quality is limited. In this case attention will be required to the location of the core and how it interfaces with the existing embankment.

7.1.2 Foundation Preparation for Embankments

Foundation preparation for new embankments could generally be expected to comprise the following:

- Removal of topsoil and excavation of the cut-off trench into stiff or better impervious material to a minimum depth of 0.5m.
- Inspection by an experienced geotechnical consultant shall be conducted to confirm the suitability of the foundation.
- Proof rolling of the exposed foundation area under the embankment with a heavy (minimum 10 tonne static) roller. Soft or weak areas detected during the proof rolling should be excavated and replaced with compacted fill / subgrade replacement comprising low permeability clay.
- Compaction of the various zones to achieve a minimum dry density ratio as detailed in Table 13.
- Protection of the prepared foundation to prevent excessive wetting or drying prior to placement of embankment fill material; and
- Formation of the embankment in accordance with the above recommendations and specifications contained herein.

It is recommended that trafficking of the material exposed at foundation level be minimised during construction to prevent the permanent deformation of the subgrade.

Any abrupt changes between founding conditions, e.g., transition from rock to soil should be eliminated during foundation preparation. This could be expected to involve foundation preparation practices such as selective grading or mixing of material to provide a transition between material types and moisture / density control of subgrade compaction. This is particularly relevant where Clayey SAND bands/SANDSTONE/SHALE are observed as they will provide potential pathways for groundwater to enter the embankment.

7.1.3 Impoundment Area

The finished surface of the impoundment area should be treated as indicated below following excavation:

- Ripping of impoundment area excluding constructed embankments to a depth of 300mm and re-compaction as per Zone 1.
- Where rock is exposed (not anticipated) at the surface; subject to geotechnical inspection it will either require ripping and re-compaction or over excavation and lining with a minimum of 300mm of Zone 1 material, and;
- Protection of subgrade to prevent excessive drying and desiccation cracking of the subgrade prior to filling of the basin.

7.1.4 Cut off Trench/Keyway

A critical aspect is the construction of the cut-off trench. A cut-off trench or keyway as it is otherwise referred should be a minimum of 2.4 m width or 1.5 times the height of the Basin at the bottom of the trench. This keyway will minimise seepage under the embankment and increase the stability of the Basin embankment. It should be taken down to a minimum of 500 mm into stiff or better impervious clay or rock and backfilled with the appropriate quality clay that is thoroughly compacted to the specification requirements. Gypsum treatment of the keyway and clay core material should be considered if slightly dispersive soils are encountered/imported.

7.1.5 Vegetation

Topsoil should be spread over the exposed surfaces of the embankment to a depth of at least 150 mm and sown with pasture grass to establish a good cover as soon as possible. Never allow any vegetation larger than pasture grass to become established on or near the embankment. Tree roots, especially eucalyptus tree roots can cause the core to crack resulting in the failure of the basin. As a rule of thumb, trees and shrubs should be kept to a minimum distance of 1.5 times the height of the tree away from the embankment of the Basins. This especially applies to eucalypts.

7.1.6 Basin Construction References

All works and materials used in construction of the basins should be designed and constructed in accordance with Council's specific requirements detailed in their Engineering Design and Construction Guidelines or as specified within this report. Where discrepancies occur clarification should be sought from Council on their requirements.

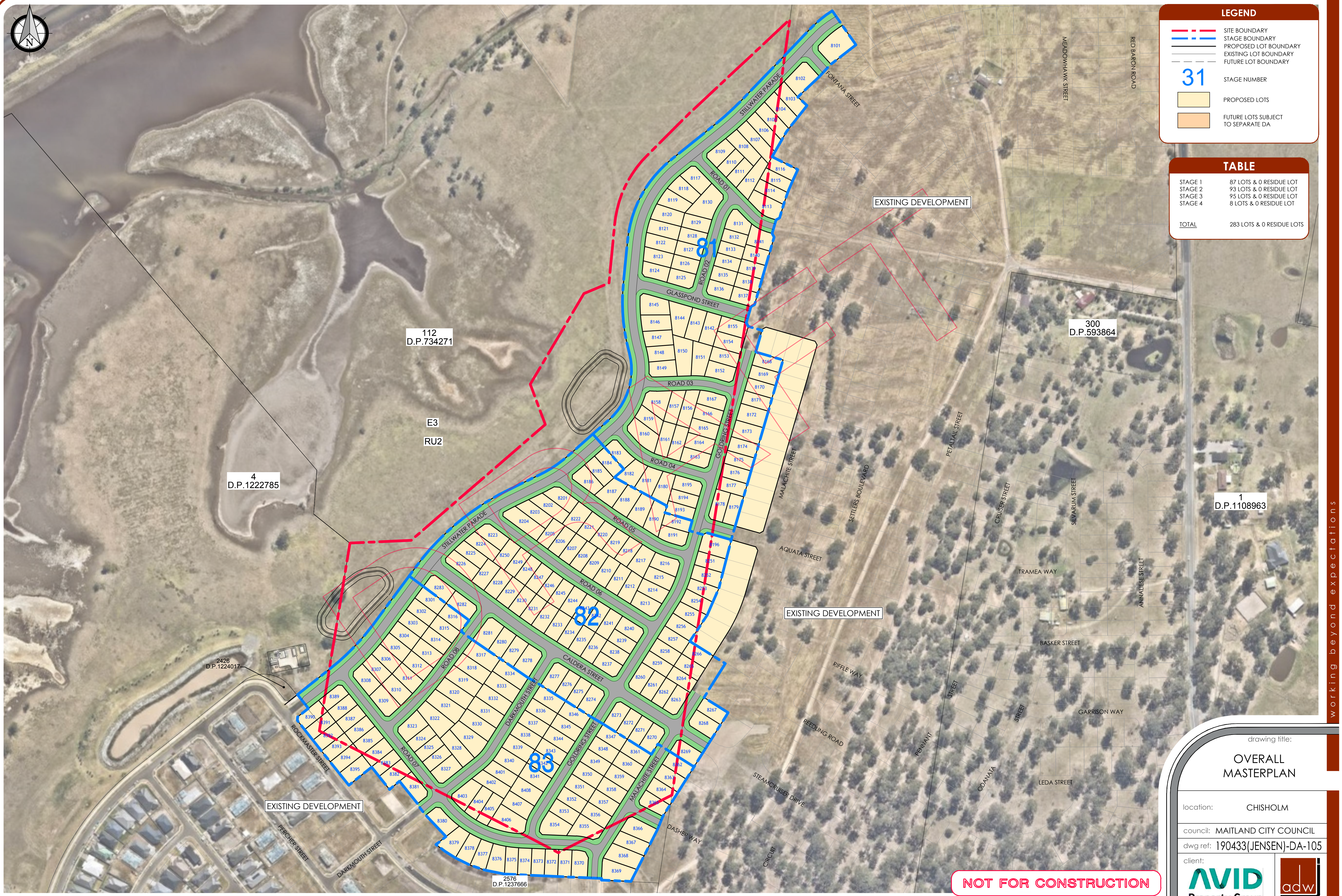
Earthworks and testing should generally be undertaken in accordance with AS3798-2007 "Guidelines on Earthworks for Commercial and Residential Developments".

8 References

- Austroads AGPT02-17, “Guide to Pavement Technology Part 2: Pavement Structural Design,” Austroads Ltd, 2017
- Austroads AGPT04B-07, Guide to Pavement Technology Part 4B: Asphalt, Austroads Ltd, May 2007
- Austroads AGPT05-11, “Guide to Pavement Technology Part 5: Pavement Evaluation and Treatment Design,” Austroads Ltd, October 2011
- Austroads APRG Report No. 18, “Selection & design of asphalt mixes: Australian provisional guide,” Austroads, May 1997
- MinView, NSW Government website (https://minview.geoscience.nsw.gov.au)
- eSPADE, Online website of NSW Office of Environment and heritage (www.environment.nsw.gov.au)
- Maitland City Council, Manual of Engineering Standards: Maitland City Council
- NSW Department of Planning and Environment, Resources and Geoscience (www.resourcesandgeoscience.nsw.gov.au)
- TfNSW QA Specification 3051 (Ed 7 Rev 0), “Granular Base and Subbase Materials for Surfaced Road Pavements,” Roads and Maritime Services, April 2011
- TfNSW Supplement Version 2.1, “Austroads Supplement for Guide to Pavement Structural Design,” TfNSW, 2015
- Safe Work Australia, Excavation Work Code of Practice, July 2012
- Standards Australia, AS 1726 - Geotechnical site investigations, 2017
- Standards Australia AS2870-2011. Residential Slabs and Footings. Standards Australia, 2011
- Standards Australia, AS1289 - Methods of testing soils for engineering purposes, 2017
- Standards Australia AS3798-2007, “Guidelines on Earthworks for Commercial and Residential Structures,” Standards Australia, 2007
- Standards Australia, HB 160 – Soils Testing, 2006
- TfNSW QA Specification R44 (Ed 5 Rev 0), “Earthworks,” Roads and Maritime Services, September 2014

Appendix A

DRAFT PLANS



LEGEND

▬ · ▬	SITE BOUNDARY
▬ · ▬	STAGE BOUNDARY
━━	PROPOSED LOT BOUNDARY
──	EXISTING LOT BOUNDARY
— — —	FUTURE LOT BOUNDARY
31	STAGE NUMBER
▭	PROPOSED LOTS
▭	FUTURE LOTS SUBJECT TO SEPARATE DA

TABLE

STAGE 1	87 LOTS & 0 RESIDUE LOT
STAGE 2	93 LOTS & 0 RESIDUE LOT
STAGE 3	95 LOTS & 0 RESIDUE LOT
STAGE 4	8 LOTS & 0 RESIDUE LOT
TOTAL	283 LOTS & 0 RESIDUE LOTS

NOT FOR CONSTRUCTION

drawing title:

OVERALL MASTERPLAN

location: CHISHOLM

council: MAITLAND CITY COUNCIL

dwg ref: 190433(JENSEN)-DA-105

client: AVID Property Group

adw johnson

ver.	date	comment	drawn	pm	level information	scale (A1 original size)	notes
A	WIP	INITIAL ISSUE	MF	MK	DATUM: ***PICK ONE**** CONTOUR INTERVAL: N/A	0 50 100m A1 1:2000 A3 1:4000	NOTE : PLANS ARE PREPARED IN COLOUR

central coast office ph: (02) 4305 4300
hunter office ph: (02) 4978 5100
sydney office ph: (02) 8046 7411
www.adwjohnson.com.au

Plotted By: Michael Finnie Plot Date: 15/02/23 4:48:59PM Cad File: C:_PDF_WORK\WATERFORD\JENSEN\190433(JENSEN)-DA-105.DWG

This plan includes coloured information. If you have a black and white copy you do not have all of the information. This note is coloured RED.

Appendix B

GEOTECHNICAL TEST LOCATIONS

EP RISK

www.eprisk.com.a

Environmental Due Deligence
24 Duckenfield Drive, Berry Park, NSW

Figure 2 - Sampling Locations

Job No:
EP2681.001
Date: 09/06/2022
Drawing Ref: Fig 1
Version No: v1

N

0 30 60 90 m

Approximate Scale Only

Coordinate System: MGA 56
Drawn by: LK Checked by: PS
Scale of regional map not shown
Source: Near Maps

Appendix C

TEST PIT LOGS

TEST PIT TP01

PROJECT NUMBER EP2681.001
PROJECT NAME Environmental Due Deligence
CLIENT AVID Property Group
ADDRESS 24 Duckenfield Drive, Berry Park, NSW

DRILLING DATE 01/06/2022
DRILLING METHOD 5 t Excavator
TOTAL DEPTH 1.0 m BGL

LOGGED BY LK
CHECKED BY JY
EASTING 372274.00
NORTHING 6375695.0

COMMENTS

Depth (m)	Samples	DCP	PID (ppm)	Graphic Log	Material Description	Consistency	Additional Observations
0.0–0.1	TP01_0.1	1			TOPSOIL: Silty SAND: Dark brown, fine to coarse sand, dry, organic material.		
0.1–0.2		1	<1				
0.2–0.3		1			Sandy CLAY: Orange, grey and red mottled, high plasticity, near plastic limit, fine to coarse sand, residual.	Firm to Stiff	
0.3–0.4	TP01_0.3-0.8	2					
0.4–0.5	TP01_0.5	2					
0.5–0.6		4	<1				
0.6–0.7		7				Very stiff to hard	
0.7–0.8		10					
0.8–0.9		REF			XW SANDSTONE recovered as clayey SAND: Grey and red, fine to coarse sand, dry.		
0.9–1							
1					Refusal on rock 1.0 m BGL		

Disclaimer: This log is intended for environmental and geotechnical purposes.

produced by ESlog.ESdat.net on 08 Jun 2022

TEST PIT TP02

PROJECT NUMBER EP2681.001
PROJECT NAME Environmental Due Deligence
CLIENT AVID Property Group
ADDRESS 24 Duckenfield Drive, Berry Park, NSW

DRILLING DATE 01/06/2022
DRILLING METHOD 5 t Excavator
TOTAL DEPTH 1.4 m BGL

LOGGED BY LK
CHECKED BY JY
EASTING 372261.00
NORTHING 6376172.00

COMMENTS

Depth (m)	Samples	DCP	PID (ppm)	Graphic Log	Material Description	Consistency	Additional Observations
		1			TOPSOIL: Silty SAND: Dark brown, fine to coarse sand, dry, organic material.		
0.1	TP02_0.1	1			Sandy CLAY: Orange, grey and red mottled, high plasticity, near plastic limit, fine to coarse sand, residual.	Firm to Stiff	
0.2		1	<1				
0.3		2					
0.4		2					
0.5	TP02_0.5 TP02_0.5-1.0	4	<1				
0.6		4					
0.7		5				Very stiff to hard	
0.8		6					
0.9		6					
1	TP02_1.0	8	<1				
1.1		12					
1.2		REF			XW SANDSTONE recovered as clayey SAND: Grey and red, fine to coarse sand, dry.		
1.3							
1.4					Refusal on rock 1.4 m BGL		
1.5							
1.6							
1.7							
1.8							
1.9							
2							
2.1							
2.2							
2.3							
2.4							

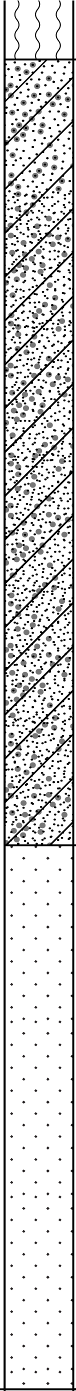
TEST PIT TP03

PROJECT NUMBER EP2681.001
PROJECT NAME Environmental Due Deligence
CLIENT AVID Property Group
ADDRESS 24 Duckenfield Drive, Berry Park, NSW

DRILLING DATE 01/06/2022
DRILLING METHOD 5 t Excavator
TOTAL DEPTH 2.3 m BGL

LOGGED BY LK
CHECKED BY JY
EASTING 372269.00
NORTHING 6376072.00

COMMENTS

Depth (m)	Samples	DCP	PID (ppm)	Graphic Log	Material Description	Consistency	Additional Observations
	TP03_0.1	1			TOPSOIL: Silty SAND: Dark brown, fine to coarse sand, dry, organic material.		
0.1		1			Sandy CLAY: Orange, grey and red mottled, high plasticity, near plastic limit, fine to coarse sand, residual.	Firm to Stiff	
0.2		1	<1				
0.3		1					
0.4	TP03_0.5	2					
0.5	TP03_0.5-1.0	4	<1				
0.6		6				Very stiff to hard	
0.7		7					
0.8		9					
0.9	TP03_1.0	12					
1		REF	<1				
1.1							
1.2							
1.3							
1.4					XW SANDSTONE recovered as clayey SAND: Grey and red, fine to coarse sand, dry.		
1.5			<1				
1.6							
1.7							
1.8							
1.9							
2							
2.1							
2.2							
2.3					End of investigation at 2.3 m		
2.4							

TEST PIT TP04

PROJECT NUMBER EP2681.001
PROJECT NAME Environmental Due Deligence
CLIENT AVID Property Group
ADDRESS 24 Duckenfield Drive, Berry Park, NSW

DRILLING DATE 01/06/2022
DRILLING METHOD 5 t Excavator
TOTAL DEPTH 2.3 m BGL

LOGGED BY LK
CHECKED BY JY
EASTING 372271.00
NORTHING 6375875.00

COMMENTS

Depth (m)	Samples	DCP	PID (ppm)	Graphic Log	Material Description	Consistency	Additional Observations
	TP04_0.1	1			TOPSOIL: Silty SAND: Dark brown, fine to coarse sand, dry, organic material.		
0.1		1			Sandy CLAY: Orange, grey and red mottled, high plasticity, near plastic limit, fine to coarse sand, residual.	Firm to Stiff	
0.2		1	<1				
0.3		1					
0.4	TP04_0.5	2					
0.5	TP04_0.5-1.0	2	<1				
0.6		2					
0.7		3					
0.8		4				Very stiff to hard	
0.9	TP04_1.0	4					
1		5	<1				
1.1		8					
1.2		12					
1.3		REF					
1.4					XW SANDSTONE recovered as clayey SAND: Grey and red, fine to coarse sand, dry.		
1.5			<1				
1.6							
1.7							
1.8							
1.9							
2							
2.1							
2.2							
2.3					End of investigation at 2.3 m		
2.4							

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TEST PIT TP05

PROJECT NUMBER EP2681.001
PROJECT NAME Environmental Due Deligence
CLIENT AVID Property Group
ADDRESS 24 Duckenfield Drive, Berry Park, NSW

DRILLING DATE 01/06/2022
DRILLING METHOD 5 t Excavator
TOTAL DEPTH 0.8 m BGL

LOGGED BY LK
CHECKED BY JY
EASTING 372047.00
NORTHING 6375703.00

COMMENTS

Depth (m)	Samples	DCP	PID (ppm)	Graphic Log	Material Description	Consistency	Additional Observations
0.1	TP05_0.1	1			TOPSOIL: Silty SAND: Dark brown, fine to coarse sand, dry, organic material.		
0.2		0			Sandy CLAY: Orange, grey and red mottled, high plasticity, near plastic limit, fine to coarse sand, residual.	Soft to Stiff	
0.3	TP05_0.2-0.7	1	<1				
0.4		1					
0.5	TP05_0.5	2					
0.6		6	<1			Very stiff to hard	
0.7		REF					
0.8					XW SANDSTONE recovered as clayey SAND: Grey and red, fine to coarse sand, dry.		
0.9					Refusal on rock 0.8 m BGL		
1							
1.1							
1.2							
1.3							
1.4							
1.5							
1.6							
1.7							
1.8							
1.9							
2							
2.1							
2.2							
2.3							
2.4							

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TEST PIT TP06

PROJECT NUMBER EP2681.001
PROJECT NAME Environmental Due Deligence
CLIENT AVID Property Group
ADDRESS 24 Duckenfield Drive, Berry Park, NSW

DRILLING DATE 01/06/2022
DRILLING METHOD 5 t Excavator
TOTAL DEPTH 2.3 m BGL

LOGGED BY LK
CHECKED BY JY
EASTING 371992.00
NORTHING 6375870.00

COMMENTS

Depth (m)	Samples	DCP	PID (ppm)	Graphic Log	Material Description	Consistency	Additional Observations
	TP06_0.1 QC01 QC02	1			TOPSOIL: Silty SAND: Dark brown, fine to coarse sand, dry, organic material.		
0.1		1					
0.2		2	<1		Sandy CLAY: Orange, grey and red mottled, high plasticity, near plastic limit, fine to coarse sand, residual.	Firm to Stiff	
0.3		1					
0.4		2					
0.5	TP06_0.5 TP06_0.5-1.0	2	<1				
0.6		2					
0.7		3					
0.8		5				Very stiff to hard	
0.9		5					
1	TP06_1.0	8	<1				
1.1		10					
1.2		REF					
1.3							
1.4							
1.5			<1				
1.6							
1.7							
1.8					XW SANDSTONE recovered as clayey SAND: Grey and red, fine to coarse sand, dry.		
1.9							
2							
2.1							
2.2							
2.3					End of investigation at 2.3 m		
2.4							

Disclaimer: This log is intended for environmental and geotechnical purposes.

produced by ESlog.ESdat.net on 08 Jun 2022

TEST PIT TP07

PROJECT NUMBER EP2681.001
PROJECT NAME Environmental Due Deligence
CLIENT AVID Property Group
ADDRESS 24 Duckenfield Drive, Berry Park, NSW

DRILLING DATE 01/06/2022
DRILLING METHOD 5 t Excavator
TOTAL DEPTH 1.0 m BGL

LOGGED BY LK
CHECKED BY JY
EASTING 372382.00
NORTHING 6376123.00

COMMENTS

Depth (m)	Samples	DCP	PID (ppm)	Graphic Log	Material Description	Consistency	Additional Observations
0.1	TP07_0.1	1			TOPSOIL: Silty SAND: Dark brown, fine to coarse sand, dry, organic material.		
0.2		2			Sandy CLAY: Orange, grey and red mottled, high plasticity, near plastic limit, fine to coarse sand, residual.	Firm to Stiff	
0.3	TP07_0.2-0.7	2	<1				
0.4		2					
0.5	TP07_0.5	2					
0.6		4	<1			Very stiff to hard	
0.7		7					
0.8		10					
0.9		REF					
1					XW SANDSTONE recovered as clayey SAND: Grey and red, fine to coarse sand, dry.		
1.1					Refusal on rock 1.0 m BGL		
1.2							
1.3							
1.4							
1.5							
1.6							
1.7							
1.8							
1.9							
2							
2.1							
2.2							
2.3							
2.4							

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TEST PIT TP08

PROJECT NUMBER EP2681.001
PROJECT NAME Environmental Due Deligence
CLIENT AVID Property Group
ADDRESS 24 Duckenfield Drive, Berry Park, NSW

DRILLING DATE 01/06/2022
DRILLING METHOD 5 t Excavator
TOTAL DEPTH 0.9 m BGL

LOGGED BY LK
CHECKED BY JY
EASTING 372345.00
NORTHING 6376316.00

COMMENTS

Depth (m)	Samples	DCP	PID (ppm)	Graphic Log	Material Description	Consistency	Additional Observations
0.1	TP08_0.1	1			TOPSOIL: Silty SAND: Dark brown, fine to coarse sand, dry, organic material.		
0.2	TP08_0.1-0.6	1	<1		Sandy CLAY: Orange, grey and red mottled, high plasticity, near plastic limit, fine to coarse sand, residual.	Firm to Stiff	
0.3		3					
0.4		4				Very stiff to hard	
0.5	TP08_0.5	8	<1				
0.6		REF					
0.7							
0.8					XW SANDSTONE recovered as clayey SAND: Grey and red, fine to coarse sand, dry.		
0.9							
1					Refusal on rock 0.9 m BGL		
1.1							
1.2							
1.3							
1.4							
1.5							
1.6							
1.7							
1.8							
1.9							
2							
2.1							
2.2							
2.3							
2.4							

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TEST PIT TP09

PROJECT NUMBER EP2681.001
PROJECT NAME Environmental Due Deligence
CLIENT AVID Property Group
ADDRESS 24 Duckenfield Drive, Berry Park, NSW

DRILLING DATE 01/06/2022
DRILLING METHOD 5 t Excavator
TOTAL DEPTH 1.55 m BGL

LOGGED BY LK
CHECKED BY JY
EASTING 372329.00
NORTHING 6376350.00

COMMENTS

Depth (m)	Samples	PID (ppm)	Graphic Log	Material Description	Consistency	Additional Observations
0.1				FILL: Sandy CLAY with gravel: Grey, red, orange mottled, medium to high plasticity, dry of plastic limit, fine to coarse sand, fine to medium sub angular gravels.		Some anthropogenic materials encountered (Plastic bags and tiles)
0.2		<1				
0.3	TP09_0.3					
0.4						
0.5	TP09_0.5	<1				
0.6						
0.7						
0.8						
0.9						
1						
1.1						
1.2						
1.3						
1.4				TOPSOIL: Silty SAND: Dark brown, fine to coarse sand, dry, organic material.		
1.5	TP09_1.5	<1				
1.6				End of Investigation 1.55 m BGL		
1.7						
1.8						
1.9						
2						
2.1						
2.2						
2.3						
2.4						

produced by ESlog.ESdat.net on 08 Jun 2022

TEST PIT TP10

PROJECT NUMBER EP2681.001
PROJECT NAME Environmental Due Deligence
CLIENT AVID Property Group
ADDRESS 24 Duckenfield Drive, Berry Park, NSW

DRILLING DATE 01/06/2022
DRILLING METHOD 5 t Excavator
TOTAL DEPTH 0.75 m BGL

LOGGED BY LK
CHECKED BY JY
EASTING 372313.00
NORTHING 6376339.00

COMMENTS

Depth (m)	Samples	PID (ppm)	Graphic Log	Material Description	Consistency	Additional Observations
0.1			▨	FILL: Sandy CLAY with gravel: Grey, red, orange mottled, medium to high plasticity, dry of plastic limit, fine to coarse sand, fine to medium sub angular gravels.		
0.2		<1	▨			
0.3	TP10_0.3		▨			
0.4	TP10_0.4		▨			
0.5		<1	▨			
0.6			▨			
0.7	TP10_0.7		≀	TOPSOIL: Silty SAND: Dark brown, fine to coarse sand, dry, organic material.		
0.8				End of Investigation 0.75 m BGL		
0.9						
1						
1.1						
1.2						
1.3						
1.4						
1.5						
1.6						
1.7						
1.8						
1.9						
2						
2.1						
2.2						
2.3						
2.4						

produced by ESlog.ESdat.net on 08 Jun 2022

TEST PIT TP11

PROJECT NUMBER EP2681.001
PROJECT NAME Environmental Due Deligence
CLIENT AVID Property Group
ADDRESS 24 Duckenfield Drive, Berry Park, NSW

DRILLING DATE 01/06/2022
DRILLING METHOD 5 t Excavator
TOTAL DEPTH 0.5 m BGL

LOGGED BY LK
CHECKED BY JY
EASTING 372337.00
NORTHING 6376330.00

COMMENTS

Depth (m)	Samples	PID (ppm)	Graphic Log	Material Description	Consistency	Additional Observations
0.1			▨	FILL: Sandy CLAY with gravel: Grey, red, orange mottled, medium to high plasticity, dry of plastic limit, fine to coarse sand, fine to medium sub angular gravels.		
0.2	TP11_0.2	<1	▨			
0.3	TP11_0.3		▨			
0.4	TP11_0.45		≈	TOPSOIL: Silty SAND: Dark brown, fine to coarse sand, dry, organic material.		
0.5		<1		End of Investigation 0.5 m BGL		
0.6						
0.7						
0.8						
0.9						
1						
1.1						
1.2						
1.3						
1.4						
1.5						
1.6						
1.7						
1.8						
1.9						
2						
2.1						
2.2						
2.3						
2.4						

produced by ESlog.ESdat.net on 08 Jun 2022

TEST PIT TP12

PROJECT NUMBER EP2681.001
PROJECT NAME Environmental Due Deligence
CLIENT AVID Property Group
ADDRESS 24 Duckenfield Drive, Berry Park, NSW

DRILLING DATE 01/06/2022
DRILLING METHOD 5 t Excavator
TOTAL DEPTH 0.95 m BGL

LOGGED BY LK
CHECKED BY JY
EASTING 372306.00
NORTHING 6376318.00

COMMENTS

Depth (m)	**Samples**	**PID (ppm)**	**Graphic Log**	**Material Description**	**Consistency**	**Additional Observations**
0.1			▩	FILL: Sandy CLAY with gravel: Grey, red, orange mottled, medium to high plasticity, dry of plastic limit, fine to coarse sand, fine to medium sub angular gravels.		
0.2		<1	▩			
0.3	TP12_0.3		▩			
0.4			▩			
0.5	TP12_0.5	<1	▩			
0.6			▩			
0.7			▩			
0.8			≀	TOPSOIL: Silty SAND: Dark brown, fine to coarse sand, dry, organic material.		
0.9	TP12_0.9		≀			
1				End of Investigation 0.95 m BGL		
1.1						
1.2						
1.3						
1.4						
1.5						
1.6						
1.7						
1.8						
1.9						
2						
2.1						
2.2						
2.3						
2.4						

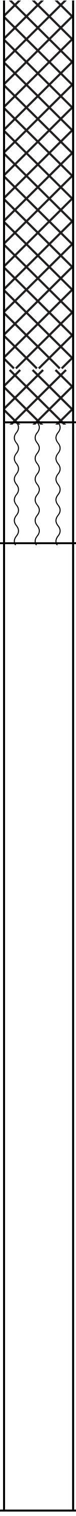
TEST PIT TP13

PROJECT NUMBER EP2681.001
PROJECT NAME Environmental Due Deligence
CLIENT AVID Property Group
ADDRESS 24 Duckenfield Drive, Berry Park, NSW

DRILLING DATE 01/06/2022
DRILLING METHOD 5 t Excavator
TOTAL DEPTH 0.9 m BGL

LOGGED BY LK
CHECKED BY JY
EASTING 372322.00
NORTHING 6376303.00

COMMENTS



Depth (m)	Samples	PID (ppm)	Graphic Log	Material Description	Consistency	Additional Observations
0.1				FILL: Sandy CLAY with gravel: Grey, red, orange mottled, medium to high plasticity, dry of plastic limit, fine to coarse sand, fine to medium sub angular gravels.		
0.2		<1				
0.3	TP13_0.3					
0.4	TP13_0.4					
0.5		<1				
0.6						
0.7				TOPSOIL: Silty SAND: Dark brown, fine to coarse sand, dry, organic material.		
0.8						
0.9	TP13_0.9			End of Investigation 0.9 m BGL		
1						
1.1						
1.2						
1.3						
1.4						
1.5						
1.6						
1.7						
1.8						
1.9						
2						
2.1						
2.2						
2.3						
2.4						

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Appendix D

LABORATORY TEST RESULTS

Newcastle Laboratory

Coffey Testing Pty Ltd
ABN 92 114 364 046
16 Callistemon Close
Warabrook NSW 2304

Phone: +61 2 4016 2300

California Bearing Ratio Test Report

Report No: CBR:NEWC22S-04561
Issue No: 1

Client: EP Risk Management
PO Box 57
Lochinvar NSW 2321

Principal:
Project No.: TESTNEWC00729AA
Project Name: EP2681 - Chisholm Drive Diligence
Lot No.: - **TRN:** -

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

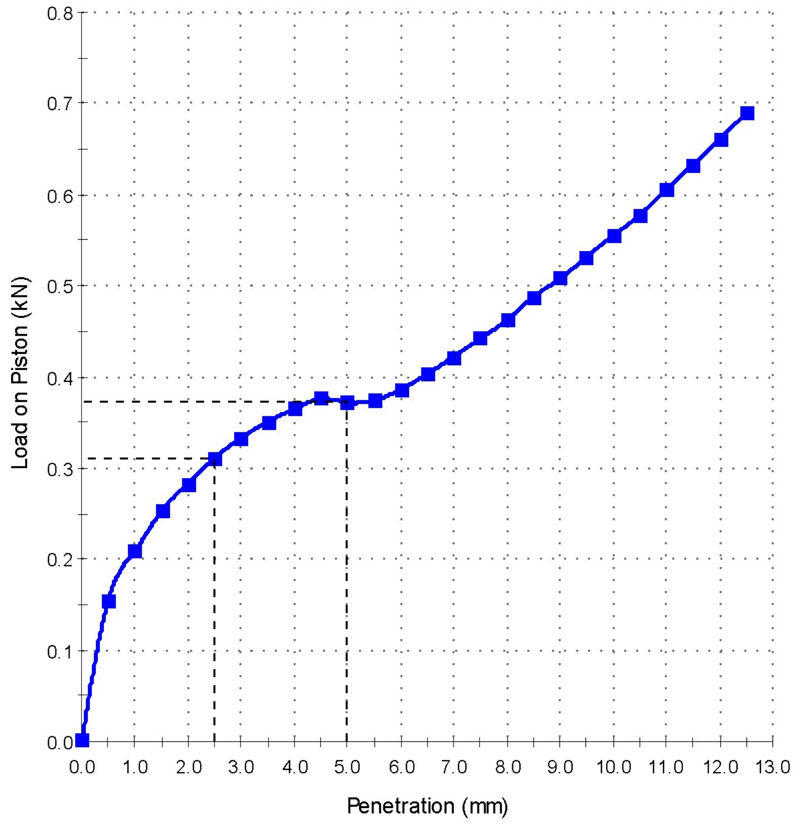
Approved Signatory: Chris Blackford
(Construction Materials Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 24/06/2022

Sample Details

Sample ID: NEWC22S-04561
Client ID: -
Date Sampled: 1/06/2022
Date Submitted: 2/06/2022
Date Tested: 10/06/2022
Project Location: 24 Duckenfield Rd, Berry Park
Sample Location: TP03 - 0.5 - 1.0m

Sampling Method: Submitted by client*
Material: Existing Ground
Source: On-Site
Specification: No Specification

Load vs Penetration



Test Results

AS 1289.6.1.1

CBR at 2.5mm (%):	**2.5**
Dry Density before Soaking (t/m³):	1.51
Density Ratio before Soaking (%):	99.0
Moisture Content before Soaking (%):	24.9
Moisture Ratio before Soaking (%):	99.5
Dry Density after Soaking (t/m³):	1.46
Density Ratio after Soaking (%):	96.0
Swell (%):	3.0
Moisture Content of Top 30mm (%):	35.6
Moisture Content of Remaining Depth (%):	26.7
Compaction Hammer Used:	Standard AS 1289.5.1.1
Surcharge Mass (kg):	4.50
Period of Soaking (Days):	4
Retained on 19 mm Sieve (%):	0
CBR Moisture Content Method:	AS 1289.2.1.1
Sample Curing Time (h):	96
Plasticity Determination Method:	Visual/Tactile

——— AS 1289.2.1.1 ———

In Situ (Field) Moisture Content (%):	25.5

Comments

*Results relate only to the items tested or sampled.

Newcastle Laboratory

Coffey Testing Pty Ltd
ABN 92 114 364 046
16 Callistemon Close
Warabrook NSW 2304

Phone: +61 2 4016 2300

Report No: CBR:NEWC22S-04562
Issue No: 1

California Bearing Ratio Test Report

Client: EP Risk Management
PO Box 57
Lochinvar NSW 2321

Principal:
Project No.: TESTNEWC00729AA
Project Name: EP2681 - Chisholm Drive Diligence
Lot No.: - **TRN:** -

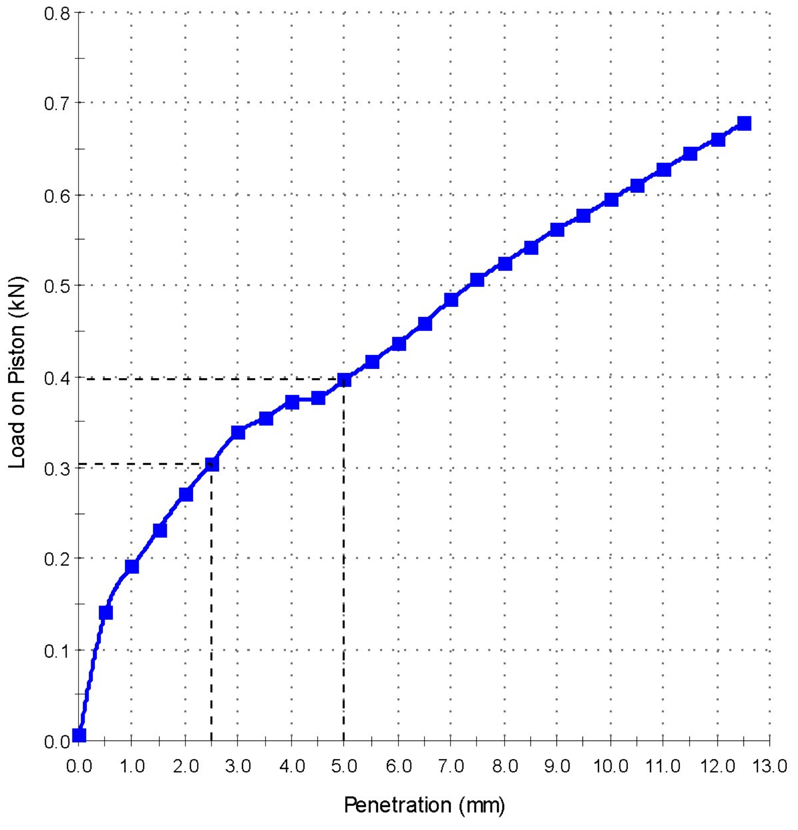
Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Approved Signatory: Chris Blackford
(Construction Materials Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 24/06/2022

Sample Details

Sample ID: NEWC22S-04562
Client ID: -
Date Sampled: 1/06/2022
Date Submitted: 2/06/2022
Date Tested: 17/06/2022
Project Location: 24 Duckenfield Rd, Berry Park
Sample Location: TP04 - 0.5 - 1.0m
Sampling Method: Submitted by client*
Material: Existing Ground
Source: On-Site
Specification: No Specification

Load vs Penetration



Test Results

AS 1289.6.1.1

CBR at 2.5mm (%):	**2.5**
Dry Density before Soaking (t/m³):	1.48
Density Ratio before Soaking (%):	100.0
Moisture Content before Soaking (%):	26.4
Moisture Ratio before Soaking (%):	100.5
Dry Density after Soaking (t/m³):	1.46
Density Ratio after Soaking (%):	98.5
Swell (%):	1.5
Moisture Content of Top 30mm (%):	30.2
Moisture Content of Remaining Depth (%):	27.0
Compaction Hammer Used:	Standard AS 1289.5.1.1
Surcharge Mass (kg):	4.50
Period of Soaking (Days):	4
Retained on 19 mm Sieve (%):	0
CBR Moisture Content Method:	AS 1289.2.1.1
Sample Curing Time (h):	168
Plasticity Determination Method:	Visual/Tactile

——— AS 1289.2.1.1 ———

In Situ (Field) Moisture Content (%):	28.8

Comments

*Results relate only to the items tested or sampled.

Newcastle Laboratory

Coffey Testing Pty Ltd
ABN 92 114 364 046
16 Callistemon Close
Warabrook NSW 2304

Phone: +61 2 4016 2300

California Bearing Ratio Test Report

Report No: CBR:NEWC22S-04563
Issue No: 1

Client: EP Risk Management
PO Box 57
Lochinvar NSW 2321

Principal:
Project No.: TESTNEWC00729AA
Project Name: EP2681 - Chisholm Drive Diligence
Lot No.: - **TRN:** -

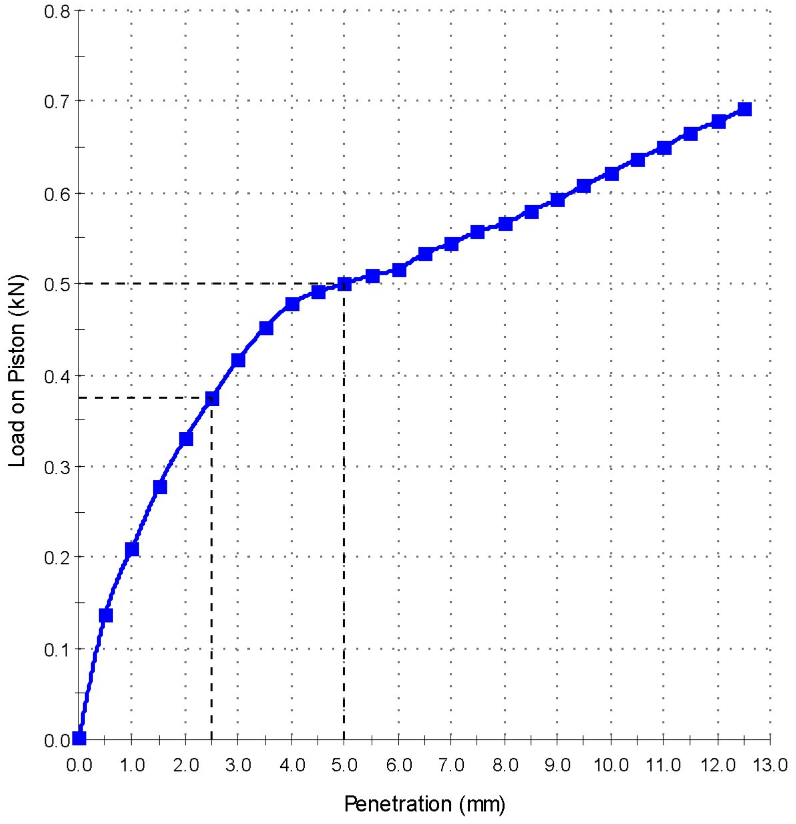
Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Approved Signatory: Chris Blackford
(Construction Materials Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 24/06/2022

Sample Details

Sample ID:	NEWC22S-04563	**Sampling Method:**	Submitted by client*
Client ID:	-	**Material:**	Existing Ground
Date Sampled:	1/06/2022	**Source:**	On-Site
Date Submitted:	2/06/2022	**Specification:**	No Specification
Date Tested:	17/06/2022		
Project Location:	24 Duckenfield Rd, Berry Park		
Sample Location:	TP05 - 0.2 - 0.7m		

Load vs Penetration



Test Results

AS 1289.6.1.1

CBR at 2.5mm (%):	**3.0**
Dry Density before Soaking (t/m³):	1.62
Density Ratio before Soaking (%):	101.0
Moisture Content before Soaking (%):	22.0
Moisture Ratio before Soaking (%):	100.0
Dry Density after Soaking (t/m³):	1.60
Density Ratio after Soaking (%):	100.0
Swell (%):	0.5
Moisture Content of Top 30mm (%):	24.1
Moisture Content of Remaining Depth (%):	22.7
Compaction Hammer Used:	Standard AS 1289.5.1.1
Surcharge Mass (kg):	4.50
Period of Soaking (Days):	4
Retained on 19 mm Sieve (%):	0
CBR Moisture Content Method:	AS 1289.2.1.1
Sample Curing Time (h):	102
Plasticity Determination Method:	Visual/Tactile

——— AS 1289.2.1.1 ———

In Situ (Field) Moisture Content (%):	22.7

Comments

*Results relate only to the items tested or sampled.

Newcastle Laboratory

Coffey Testing Pty Ltd
ABN 92 114 364 046
16 Callistemon Close
Warabrook NSW 2304

Phone: +61 2 4016 2300

California Bearing Ratio Test Report

Report No: CBR:NEWC22S-04564
Issue No: 1

Client: EP Risk Management
PO Box 57
Lochinvar NSW 2321

Principal:
Project No.: TESTNEWC00729AA
Project Name: EP2681 - Chisholm Drive Diligence
Lot No.: - **TRN:** -

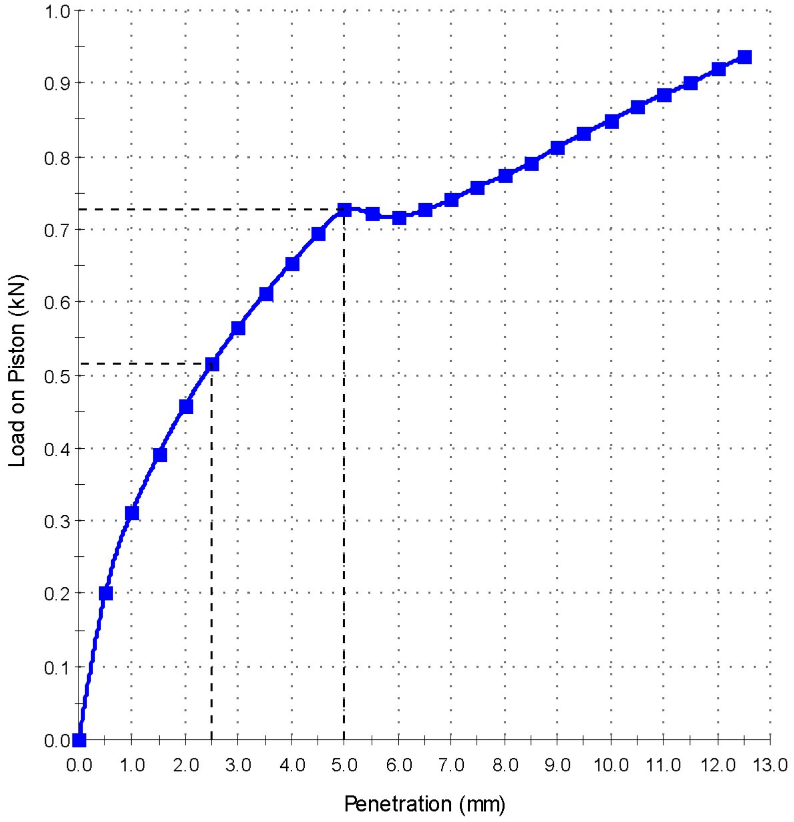
Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Approved Signatory: Chris Blackford
(Construction Materials Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 24/06/2022

Sample Details

Sample ID:	NEWC22S-04564	**Sampling Method:**	Submitted by client*
Client ID:	-	**Material:**	Existing Ground
Date Sampled:	1/06/2022	**Source:**	On-Site
Date Submitted:	2/06/2022	**Specification:**	No Specification
Date Tested:	17/06/2022		
Project Location:	24 Duckenfield Rd, Berry Park		
Sample Location:	TP06 - 0.5 - 1.0m		

Load vs Penetration



Test Results

AS 1289.6.1.1

CBR at 2.5mm (%):	**4.0**
Dry Density before Soaking (t/m³):	1.64
Density Ratio before Soaking (%):	99.0
Moisture Content before Soaking (%):	19.7
Moisture Ratio before Soaking (%):	98.5
Dry Density after Soaking (t/m³):	1.58
Density Ratio after Soaking (%):	96.0
Swell (%):	3.5
Moisture Content of Top 30mm (%):	28.3
Moisture Content of Remaining Depth (%):	22.9
Compaction Hammer Used:	Standard AS 1289.5.1.1
Surcharge Mass (kg):	4.50
Period of Soaking (Days):	4
Retained on 19 mm Sieve (%):	0
CBR Moisture Content Method:	AS 1289.2.1.1
Sample Curing Time (h):	99
Plasticity Determination Method:	Visual/Tactile

——— AS 1289.2.1.1 ———

In Situ (Field) Moisture Content (%):	22.6

Comments

*Results relate only to the items tested or sampled.

Newcastle Laboratory

Coffey Testing Pty Ltd
ABN 92 114 364 046
16 Callistemon Close
Warabrook NSW 2304

Phone: +61 2 4016 2300

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Report No: CBR:NEWC22S-04565

Issue No: 1

California Bearing Ratio Test Report

Client: EP Risk Management
PO Box 57
Lochinvar NSW 2321

Principal:
Project No.: TESTNEWC00729AA
Project Name: EP2681 - Chisholm Drive Diligence
Lot No.: - **TRN:** -

NATA

ilac-MRA

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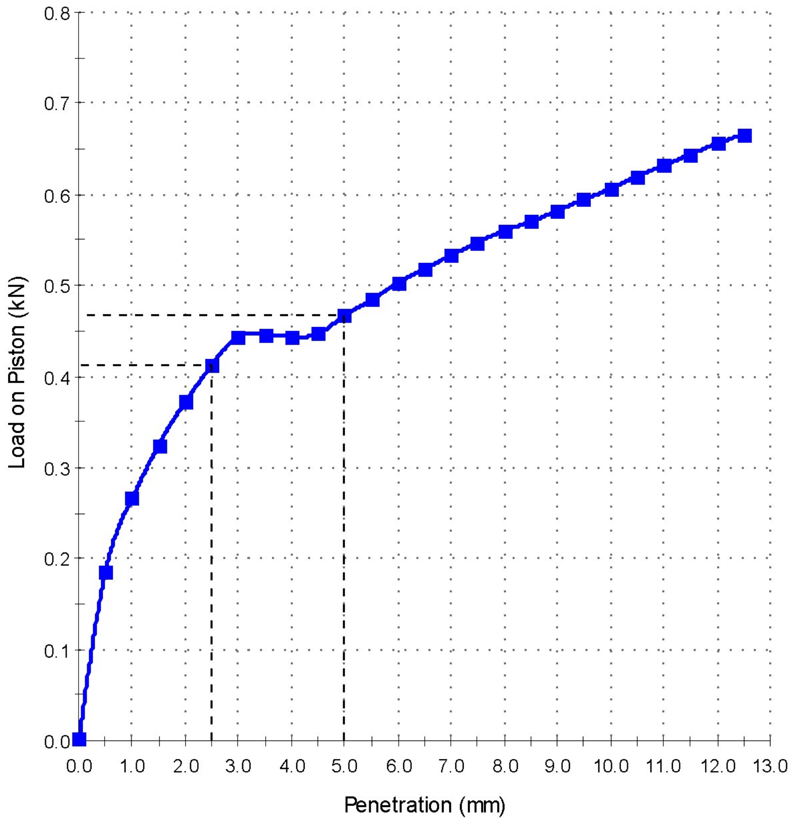
Approved Signatory: Chris Blackford
(Construction Materials Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 24/06/2022

Sample Details

Sample ID: NEWC22S-04565
Client ID: -
Date Sampled: 1/06/2022
Date Submitted: 2/06/2022
Date Tested: 17/06/2022
Project Location: 24 Duckenfield Rd, Berry Park
Sample Location: TP07 - 0.2 - 0.2

Sampling Method: Submitted by client*
Material: Existing Ground
Source: On-Site
Specification: No Specification

Load vs Penetration



Test Results

AS 1289.6.1.1

CBR at 2.5mm (%):	**3.0**
Dry Density before Soaking (t/m³):	1.53
Density Ratio before Soaking (%):	100.0
Moisture Content before Soaking (%):	24.9
Moisture Ratio before Soaking (%):	101.0
Dry Density after Soaking (t/m³):	1.52
Density Ratio after Soaking (%):	99.5
Swell (%):	0.5
Moisture Content of Top 30mm (%):	27.5
Moisture Content of Remaining Depth (%):	25.3
Compaction Hammer Used:	Standard
	AS 1289.5.1.1
Surcharge Mass (kg):	4.50
Period of Soaking (Days):	4
Retained on 19 mm Sieve (%):	0
CBR Moisture Content Method:	AS 1289.2.1.1
Sample Curing Time (h):	100
Plasticity Determination Method:	Visual/Tactile

——— AS 1289.2.1.1 ———

In Situ (Field) Moisture Content (%):	26.6

Comments

*Results relate only to the items tested or sampled.

Newcastle Laboratory

Coffey Testing Pty Ltd
ABN 92 114 364 046
16 Callistemon Close
Warabrook NSW 2304

Phone: +61 2 4016 2300

Report No: CBR:NEWC22S-04566
Issue No: 1

California Bearing Ratio Test Report

Client: EP Risk Management
PO Box 57
Lochinvar NSW 2321

Principal:
Project No.: TESTNEWC00729AA
Project Name: EP2681 - Chisholm Drive Diligence
Lot No.: - **TRN:** -

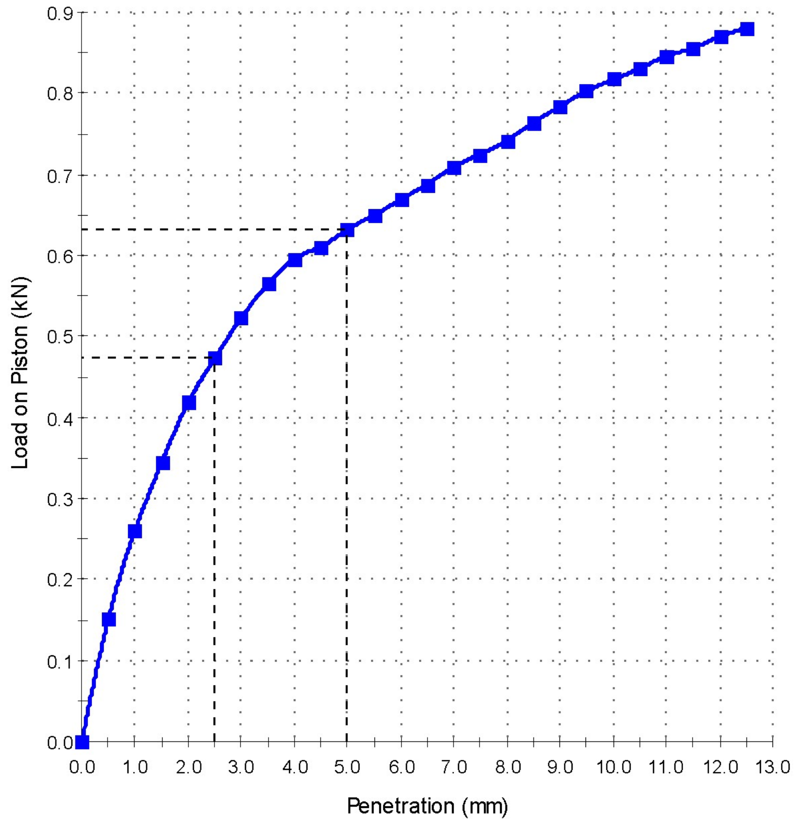
Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Approved Signatory: Chris Blackford
(Construction Materials Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 20/06/2022

Sample Details

Sample ID:	NEWC22S-04566	**Sampling Method:**	Submitted by client*
Client ID:	-	**Material:**	Existing Ground
Date Sampled:	1/06/2022	**Source:**	On-Site
Date Submitted:	2/06/2022	**Specification:**	No Specification
Date Tested:	10/06/2022		
Project Location:	24 Duckenfield Rd, Berry Park		
Sample Location:	TP08 - 0.1 - 0.6m		

Load vs Penetration



Test Results

AS 1289.6.1.1

CBR at 2.5mm (%):	**3.5**
Dry Density before Soaking (t/m³):	1.62
Density Ratio before Soaking (%):	100.0
Moisture Content before Soaking (%):	21.1
Moisture Ratio before Soaking (%):	99.0
Dry Density after Soaking (t/m³):	1.60
Density Ratio after Soaking (%):	98.5
Swell (%):	1.5
Moisture Content of Top 30mm (%):	25.9
Moisture Content of Remaining Depth (%):	23.2
Compaction Hammer Used:	Standard AS 1289.5.1.1
Surcharge Mass (kg):	4.50
Period of Soaking (Days):	4
Retained on 19 mm Sieve (%):	0
CBR Moisture Content Method:	AS 1289.2.1.1
Sample Curing Time (h):	31
Plasticity Determination Method:	Visual/Tactile

——— AS 1289.2.1.1 ———

In Situ (Field) Moisture Content (%):	21.3

Comments

*Results relate only to the items tested or sampled.

Newcastle Laboratory

Coffey Testing Pty Ltd
ABN 92 114 364 046
16 Callistemon Close
Warabrook NSW 2304

Phone: +61 2 4016 2300

Report No: NEWC22S-04559-1
Issue No: 1

Material Test Report

Client: EP Risk Management
PO Box 57
Lochinvar NSW 2321

Principal:
Project No.: TESTNEWC00729AA
Project Name: EP2681 - Chisholm Drive Diligence
Lot No.: - **TRN:** -

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Approved Signatory: Chris Blackford
(Construction Materials Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 23/06/2022

Sample Details

Sample ID / Client ID: NEWC22S-04559 / -
Date Sampled: 01/06/2022
Source: On-Site
Material: Existing Ground
Specification: No Specification
Sampling Method: Submitted by client*
Project Location: 24 Duckenfield Rd, Berry Park
Sample Location: TP01 - 0.3 - 0.8m

Other Test Results

Description	Method	Result	Limits
Sample History	AS 1289.1.1	Air-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	17.5	
Mould Length (mm)		250	
Crumbling		No	
Curling		Yes	
Cracking		No	
Liquid Limit (%)	AS 1289.3.1.1	63	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	23	
Plasticity Index (%)	AS 1289.3.3.1	40	
Date Tested		20/06/2022	
Emerson Class Number	AS 1289.3.8.1	2	
Soil Description		Clay, High plasticity, Grey.	
Type of Water		Distilled	
Date Tested		8/06/2022	

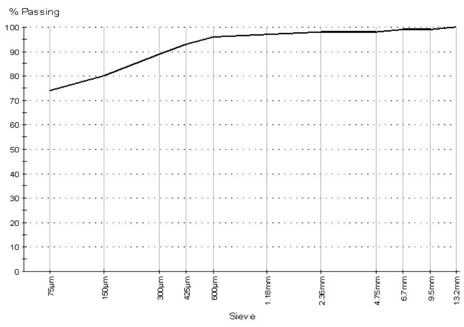
Particle Size Distribution

Method: AS 1289.3.6.1
Drying by: Oven
Date Tested: 10/06/2022

Note: Sample Washed

Sieve Size	% Passing	Limits
13.2mm	100	
9.5mm	99	
6.7mm	99	
4.75mm	98	
2.36mm	98	
1.18mm	97	
600µm	96	
425µm	93	
300µm	89	
150µm	80	
75µm	74	

Chart



Comments

*Results relate only to the items tested or sampled.

Newcastle Laboratory

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ABN 92 114 364 046
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Warabrook NSW 2304

Phone: +61 2 4016 2300

Report No: NEWC22S-04560-1
Issue No: 1

Material Test Report

Client: EP Risk Management
PO Box 57
Lochinvar NSW 2321

Principal:
Project No.: TESTNEWC00729AA
Project Name: EP2681 - Chisholm Drive Diligence
Lot No.: - **TRN:** -

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Approved Signatory: Chris Blackford
(Construction Materials Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 23/06/2022

Sample Details

Sample ID / Client ID: NEWC22S-04560 / -
Date Sampled: 01/06/2022
Source: On-Site
Material: Existing Ground
Specification: No Specification
Sampling Method: Submitted by client*
Project Location: 24 Duckenfield Rd, Berry Park
Sample Location: TP02 - 0.5 - 1.0m

Other Test Results

Description	Method	Result	Limits
Sample History	AS 1289.1.1	Air-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	16.0	
Mould Length (mm)		250	
Crumbling		No	
Curling		Yes	
Cracking		No	
Liquid Limit (%)	AS 1289.3.1.1	52	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	23	
Plasticity Index (%)	AS 1289.3.3.1	29	
Date Tested		20/06/2022	
Emerson Class Number	AS 1289.3.8.1	2	
Soil Description		Clay, High plasticity, brown.	
Type of Water		Distilled	
Date Tested		8/06/2022	

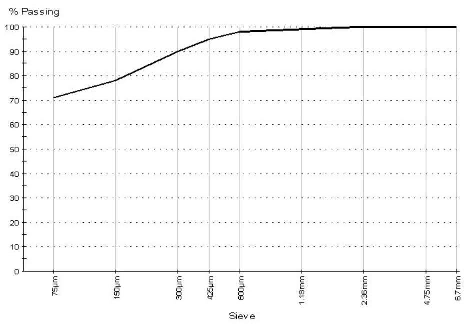
Particle Size Distribution

Method: AS 1289.3.6.1
Drying by: Oven
Date Tested: 11/06/2022

Note: Sample Washed

Sieve Size	% Passing	Limits
6.7mm	100	
4.75mm	100	
2.36mm	100	
1.18mm	99	
600µm	98	
425µm	95	
300µm	90	
150µm	78	
75µm	71	

Chart



Comments

*Results relate only to the items tested or sampled.

Newcastle Laboratory

Coffey Testing Pty Ltd
ABN 92 114 364 046
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Warabrook NSW 2304

Phone: +61 2 4016 2300

Material Test Report

Report No: NEWC22S-04561-1
Issue No: 1

Client: EP Risk Management
PO Box 57
Lochinvar NSW 2321

Principal:
Project No.: TESTNEWC00729AA
Project Name: EP2681 - Chisholm Drive Diligence
Lot No.: - **TRN:** -

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Approved Signatory: Chris Blackford
(Construction Materials Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 24/06/2022

Sample Details

Sample ID / Client ID: NEWC22S-04561 / -
Date Sampled: 01/06/2022
Source: On-Site
Material: Existing Ground
Specification: No Specification
Sampling Method: Submitted by client*
Project Location: 24 Duckenfield Rd, Berry Park
Sample Location: TP03 - 0.5 - 1.0m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	25.5	
Date Tested		6/06/2022	
Standard MDD (t/m³)	AS 1289.5.1.1	**1.52**	
Standard OMC (%)		**25.0**	
Retained Sieve (mm)		19	
Oversize Material (%)		0	
Curing Time (h)		50	
LL Method		Visual / Tactile Assessment	
Date Tested		8/06/2022	
CBR at 2.5mm (%)	AS 1289.6.1.1	**2.5**	
Dry Density before Soaking (t/m³)		1.51	
Density Ratio before Soaking (%)		99.0	
Moisture Content before Soaking (%)		24.9	
Moisture Ratio before Soaking (%)		99.5	
Dry Density after Soaking (t/m³)		1.46	
Density Ratio after Soaking (%)		96.0	
Swell (%)		3.0	
Moisture Content of Top 30mm (%)		35.6	
Moisture Content of Remaining Depth (%)		26.7	
Compaction Hammer Used		Standard	
Surcharge Mass (kg)		4.50	
Period of Soaking (Days)		4	
Retained on 19 mm Sieve (%)		0	
CBR Moisture Content Method		AS 1289.2.1.1	
Sample Curing Time (h)		96	
Plasticity Method		Visual/Tactile Assessment	
Sample Moisture Content		AS 1289.2.1.1	
Date Tested		10/06/2022	

Comments

*Results relate only to the items tested or sampled.

Newcastle Laboratory

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Warabrook NSW 2304

Phone: +61 2 4016 2300

Material Test Report

Report No: NEWC22S-04562-1
Issue No: 1

Client:	EP Risk Management PO Box 57 Lochinvar NSW 2321
Principal:	
Project No.:	TESTNEWC00729AA
Project Name:	EP2681 - Chisholm Drive Diligence
Lot No.:	-
TRN:	-

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Approved Signatory: Chris Blackford
(Construction Materials Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 24/06/2022

Sample Details

Sample ID / Client ID: NEWC22S-04562 / -
Date Sampled: 01/06/2022
Source: On-Site
Material: Existing Ground
Specification: No Specification
Sampling Method: Submitted by client*
Project Location: 24 Duckenfield Rd, Berry Park
Sample Location: TP04 - 0.5 - 1.0m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	28.8	
Date Tested		6/06/2022	
Standard MDD (t/m³)	AS 1289.5.1.1	**1.48**	
Standard OMC (%)		**26.5**	
Retained Sieve (mm)		19	
Oversize Material (%)		0	
Curing Time (h)		71	
LL Method		Visual / Tactile Assessment	
Date Tested		9/06/2022	
CBR at 2.5mm (%)	AS 1289.6.1.1	**2.5**	
Dry Density before Soaking (t/m³)		1.48	
Density Ratio before Soaking (%)		100.0	
Moisture Content before Soaking (%)		26.4	
Moisture Ratio before Soaking (%)		100.5	
Dry Density after Soaking (t/m³)		1.46	
Density Ratio after Soaking (%)		98.5	
Swell (%)		1.5	
Moisture Content of Top 30mm (%)		30.2	
Moisture Content of Remaining Depth (%)		27.0	
Compaction Hammer Used		Standard	
Surcharge Mass (kg)		4.50	
Period of Soaking (Days)		4	
Retained on 19 mm Sieve (%)		0	
CBR Moisture Content Method		AS 1289.2.1.1	
Sample Curing Time (h)		168	
Plasticity Method		Visual/Tactile Assessment	
Sample Moisture Content		AS 1289.2.1.1	
Date Tested		17/06/2022	

Comments

*Results relate only to the items tested or sampled.

Newcastle Laboratory

Coffey Testing Pty Ltd
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16 Callistemon Close
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Phone: +61 2 4016 2300

Material Test Report

Report No: NEWC22S-04563-1
Issue No: 1

Client: EP Risk Management
PO Box 57
Lochinvar NSW 2321

Principal:
Project No.: TESTNEWC00729AA
Project Name: EP2681 - Chisholm Drive Diligence
Lot No.: - **TRN:** -

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Approved Signatory: Chris Blackford
(Construction Materials Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 24/06/2022

Sample Details

Sample ID / Client ID: NEWC22S-04563 / -
Date Sampled: 01/06/2022
Source: On-Site
Material: Existing Ground
Specification: No Specification
Sampling Method: Submitted by client*
Project Location: 24 Duckenfield Rd, Berry Park
Sample Location: TP05 - 0.2 - 0.7m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	22.7	
Date Tested		6/06/2022	
Standard MDD (t/m³)	AS 1289.5.1.1	**1.60**	
Standard OMC (%)		**22.0**	
Retained Sieve (mm)		19	
Oversize Material (%)		0	
Curing Time (h)		73	
LL Method		Visual / Tactile Assessment	
Date Tested		9/06/2022	
CBR at 2.5mm (%)	AS 1289.6.1.1	**3.0**	
Dry Density before Soaking (t/m³)		1.62	
Density Ratio before Soaking (%)		101.0	
Moisture Content before Soaking (%)		22.0	
Moisture Ratio before Soaking (%)		100.0	
Dry Density after Soaking (t/m³)		1.60	
Density Ratio after Soaking (%)		100.0	
Swell (%)		0.5	
Moisture Content of Top 30mm (%)		24.1	
Moisture Content of Remaining Depth (%)		22.7	
Compaction Hammer Used		Standard	
Surcharge Mass (kg)		4.50	
Period of Soaking (Days)		4	
Retained on 19 mm Sieve (%)		0	
CBR Moisture Content Method		AS 1289.2.1.1	
Sample Curing Time (h)		102	
Plasticity Method		Visual/Tactile Assessment	
Sample Moisture Content		AS 1289.2.1.1	
Date Tested		17/06/2022	

Comments

*Results relate only to the items tested or sampled.

Newcastle Laboratory

Coffey Testing Pty Ltd
ABN 92 114 364 046
16 Callistemon Close
Warabrook NSW 2304

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Material Test Report

Report No: NEWC22S-04564-1
Issue No: 1

Client:	EP Risk Management PO Box 57 Lochinvar NSW 2321
Principal:	
Project No.:	TESTNEWC00729AA
Project Name:	EP2681 - Chisholm Drive Diligence
Lot No.:	-
TRN:	-

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Approved Signatory: Chris Blackford
(Construction Materials Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 24/06/2022

Sample Details

Sample ID / Client ID:	NEWC22S-04564 / -
Date Sampled:	01/06/2022
Source:	On-Site
Material:	Existing Ground
Specification:	No Specification
Sampling Method:	Submitted by client*
Project Location:	24 Duckenfield Rd, Berry Park
Sample Location:	TP06 - 0.5 - 1.0m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	22.6	
Date Tested		6/06/2022	
Standard MDD (t/m³)	AS 1289.5.1.1	**1.65**	
Standard OMC (%)		**20.0**	
Retained Sieve (mm)		19	
Oversize Material (%)		0	
Curing Time (h)		96	
LL Method		Visual / Tactile Assessment	
Date Tested		10/06/2022	
CBR at 2.5mm (%)	AS 1289.6.1.1	**4.0**	
Dry Density before Soaking (t/m³)		1.64	
Density Ratio before Soaking (%)		99.0	
Moisture Content before Soaking (%)		19.7	
Moisture Ratio before Soaking (%)		98.5	
Dry Density after Soaking (t/m³)		1.58	
Density Ratio after Soaking (%)		96.0	
Swell (%)		3.5	
Moisture Content of Top 30mm (%)		28.3	
Moisture Content of Remaining Depth (%)		22.9	
Compaction Hammer Used		Standard	
Surcharge Mass (kg)		4.50	
Period of Soaking (Days)		4	
Retained on 19 mm Sieve (%)		0	
CBR Moisture Content Method		AS 1289.2.1.1	
Sample Curing Time (h)		99	
Plasticity Method		Visual/Tactile Assessment	
Sample Moisture Content		AS 1289.2.1.1	
Date Tested		17/06/2022	

Comments

*Results relate only to the items tested or sampled.

Newcastle Laboratory

Coffey Testing Pty Ltd
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Phone: +61 2 4016 2300

Material Test Report

Report No: NEWC22S-04565-1
Issue No: 1

Client:	EP Risk Management PO Box 57 Lochinvar NSW 2321
Principal:	
Project No.:	TESTNEWC00729AA
Project Name:	EP2681 - Chisholm Drive Diligence
Lot No.:	-
TRN:	-

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Approved Signatory: Chris Blackford
(Construction Materials Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 24/06/2022

Sample Details

Sample ID / Client ID:	NEWC22S-04565 / -
Date Sampled:	01/06/2022
Source:	On-Site
Material:	Existing Ground
Specification:	No Specification
Sampling Method:	Submitted by client*
Project Location:	24 Duckenfield Rd, Berry Park
Sample Location:	TP07 - 0.2 - 0.2

Test Results

Description	**Method**	**Result**	**Limits**
Moisture Content (%)	AS 1289.2.1.1	26.6	
Date Tested		6/06/2022	
Standard MDD (t/m³)	AS 1289.5.1.1	**1.53**	
Standard OMC (%)		**24.5**	
Retained Sieve (mm)		19	
Oversize Material (%)		0	
Curing Time (h)		97	
LL Method		Visual / Tactile Assessment	
Date Tested		10/06/2022	
CBR at 2.5mm (%)	AS 1289.6.1.1	**3.0**	
Dry Density before Soaking (t/m³)		1.53	
Density Ratio before Soaking (%)		100.0	
Moisture Content before Soaking (%)		24.9	
Moisture Ratio before Soaking (%)		101.0	
Dry Density after Soaking (t/m³)		1.52	
Density Ratio after Soaking (%)		99.5	
Swell (%)		0.5	
Moisture Content of Top 30mm (%)		27.5	
Moisture Content of Remaining Depth (%)		25.3	
Compaction Hammer Used		Standard	
Surcharge Mass (kg)		4.50	
Period of Soaking (Days)		4	
Retained on 19 mm Sieve (%)		0	
CBR Moisture Content Method		AS 1289.2.1.1	
Sample Curing Time (h)		100	
Plasticity Method		Visual/Tactile Assessment	
Sample Moisture Content		AS 1289.2.1.1	
Date Tested		17/06/2022	

Comments

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Newcastle Laboratory

Coffey Testing Pty Ltd
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Material Test Report

Report No: NEWC22S-04566-1
Issue No: 1

Client: EP Risk Management
PO Box 57
Lochinvar NSW 2321

Principal:
Project No.: TESTNEWC00729AA
Project Name: EP2681 - Chisholm Drive Diligence
Lot No.: - **TRN:** -

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Approved Signatory: Chris Blackford
(Construction Materials Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 20/06/2022

Sample Details

Sample ID / Client ID: NEWC22S-04566 / -
Date Sampled: 01/06/2022
Source: On-Site
Material: Existing Ground
Specification: No Specification
Sampling Method: Submitted by client*
Project Location: 24 Duckenfield Rd, Berry Park
Sample Location: TP08 - 0.1 - 0.6m

Test Results

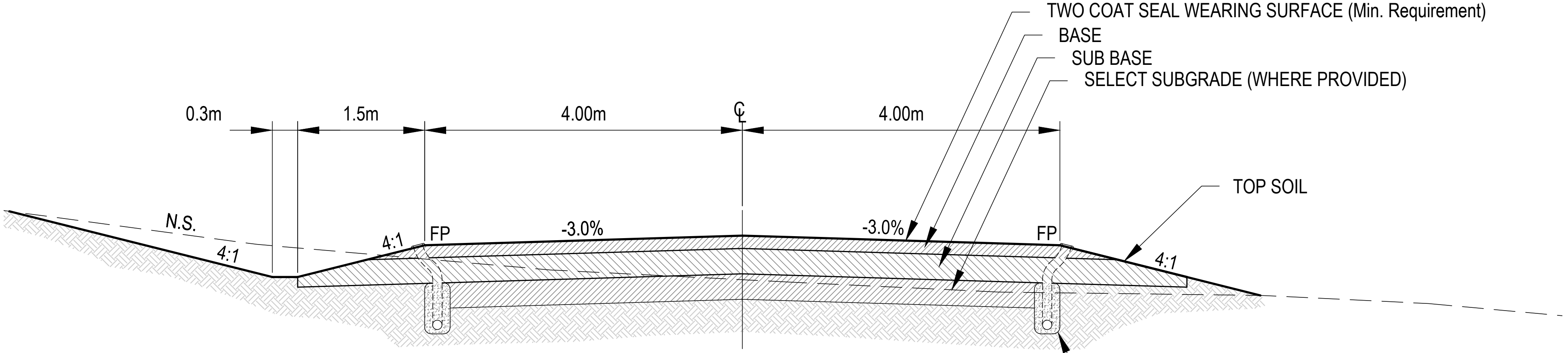
Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	21.3	
Date Tested		6/06/2022	
Standard MDD (t/m³)	AS 1289.5.1.1	**1.63**	
Standard OMC (%)		**21.5**	
Retained Sieve (mm)		19	
Oversize Material (%)		0	
Curing Time (h)		48	
LL Method		Visual / Tactile Assessment	
Date Tested		8/06/2022	
CBR at 2.5mm (%)	AS 1289.6.1.1	**3.5**	
Dry Density before Soaking (t/m³)		1.62	
Density Ratio before Soaking (%)		100.0	
Moisture Content before Soaking (%)		21.1	
Moisture Ratio before Soaking (%)		99.0	
Dry Density after Soaking (t/m³)		1.60	
Density Ratio after Soaking (%)		98.5	
Swell (%)		1.5	
Moisture Content of Top 30mm (%)		25.9	
Moisture Content of Remaining Depth (%)		23.2	
Compaction Hammer Used		Standard	
Surcharge Mass (kg)		4.50	
Period of Soaking (Days)		4	
Retained on 19 mm Sieve (%)		0	
CBR Moisture Content Method		AS 1289.2.1.1	
Sample Curing Time (h)		31	
Plasticity Method		Visual/Tactile Assessment	
Sample Moisture Content		AS 1289.2.1.1	
Date Tested		10/06/2022	

Comments

*Results relate only to the items tested or sampled.

Appendix E

COUNCIL SUBSOIL DRAINAGE STANDARD DRAWINGS



TYPICAL RURAL CROSS SECTION

NOTE:

1. EROSION & SEDIMENTATION CONTROL MEASURES ARE TO BE IMPLEMENTED ON TABLE DRAINS, BATTER SLOPES & ANY AREAS DISTURBED DURING CONSTRUCTION IN ACCORDANCE WITH THE "BLUE BOOK" & COUNCIL'S "MANUAL OF ENGINEERING STANDARDS". APPROPRIATE MEASURES SHALL BE IMPLEMENTED FOR BOTH CONSTRUCTION & POST CONSTRUCTION PERIODS.
   TYPICALLY, TABLE DRAINS ARE TO BE PROTECTED WITH TURF, SEED IMPREGNATED JUTE MESH OR OTHER MEASURES APPROVED BY COUNCIL. ALL DISTURBED AREAS ARE TO BE TOPSOIL & SEEDED.
2. DRIVEWAYS SHALL CONFORM TO SD013.
3. FOR ALTERNATIVE WEARING SURFACE TREATMENTS REFER TO COUNCIL'S "MANUAL OF ENGINEERING STANDARDS".
4. FOR SUBSOIL DRAINAGE REFER TO ARRB "UNSEALED ROAD MANUAL".

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infrastructure & works

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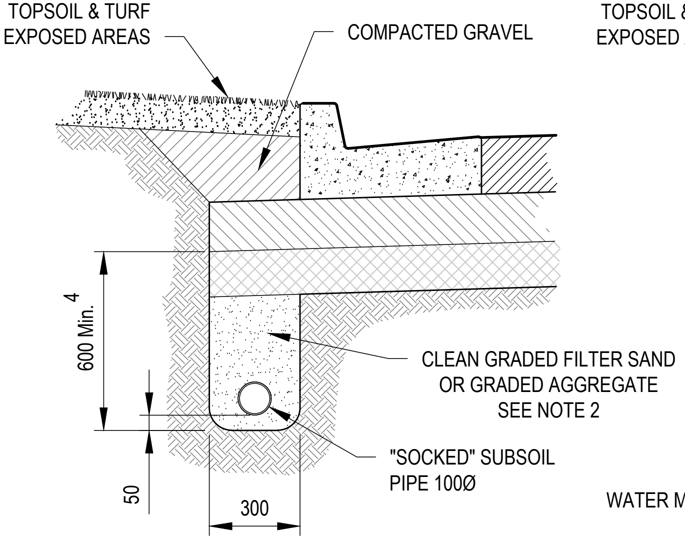
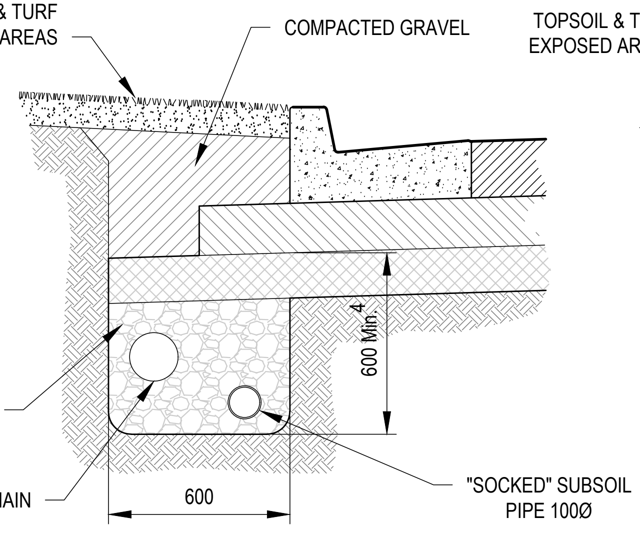
TYPICAL CROSS SECTION
RURAL RESIDENTIAL ROADS - NEW SUBDIVISIONS

MANUAL OF ENGINEERING STANDARDS - STANDARD DRAWINGS

Rev: 01/07/15
SD003
SHEET 01 of 01

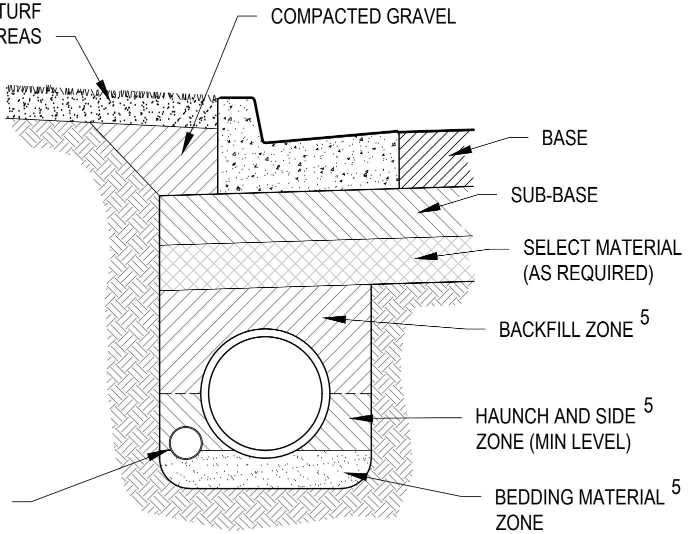


TYPICAL INSTALLATION



SHARED TRENCH

(WITH WATER MAIN)

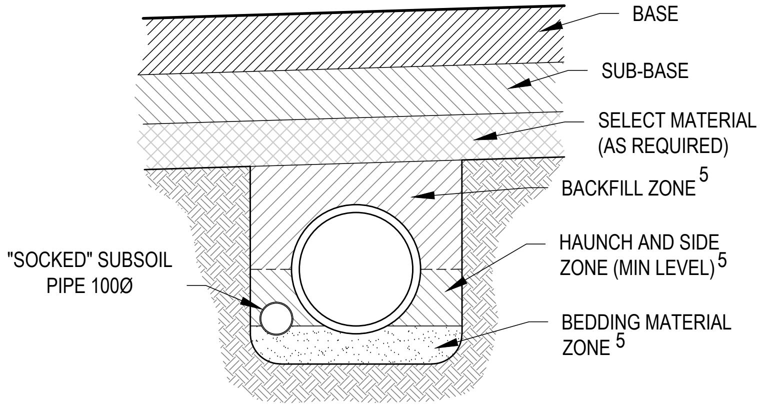


STORMWATER TRENCH

(ALL STORMWATER PIPES)

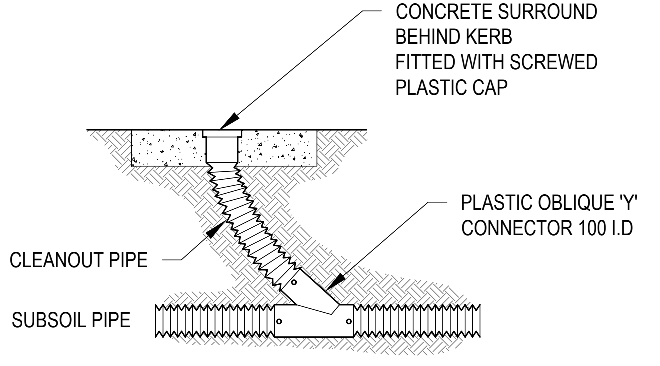
NOTE:

1. TYPE, LOCATION AND EXTENT OF ADDITIONAL SUBSOIL DRAINAGE SHALL BE IN ACCORDANCE WITH A GEOTECHNICAL CONSULTANT'S ASSESSMENT.
2. A NOMINAL SIZE AGGREGATE (10mm MAXIMUM) MAY BE SUBSTITUTED FOR THE FILTER SAND
3. FLUSH POINTS SHALL BE PROVIDED AT UPSTREAM DEAD ENDS & CRESTS & AT MAXIMUM OF 60m CTRS.
4. DEPTH MAY BE VARIED IN A ROCK SUBGRADE.
5. SEE THE CONSTRUCTION SECTION OF THE MANUAL OF ENGINEERING STANDARDS FOR TRENCH MATERIAL SPECIFICATION. EACH ZONE MAY BE ONE HOMOGENEOUS APPROVED MATERIAL.



STORMWATER TRENCH UNDER ROAD

(ALL STORMWATER PIPES)



FLUSH POINT

maitland city council
infrastructure & works

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SUB-SOIL DRAINAGE

MANUAL OF ENGINEERING STANDARDS - STANDARD DRAWINGS

Rev: 22/07/2019
SD035
SHEET 01 of 01

Appendix F

FOUNDATION MAINTENANCE AND FOOTING PERFORMANCE

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

BTF 18 replaces Information Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth

Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation

Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

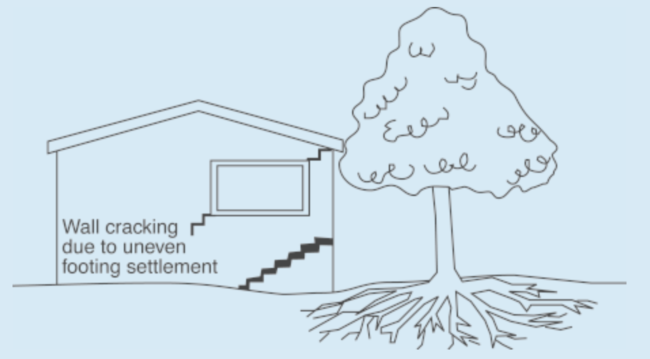
Seasonal swelling/shrinkage in clay

Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots

In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself

Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures

Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures

Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures

Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.

Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing

Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage

In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

Protection of the building perimeter

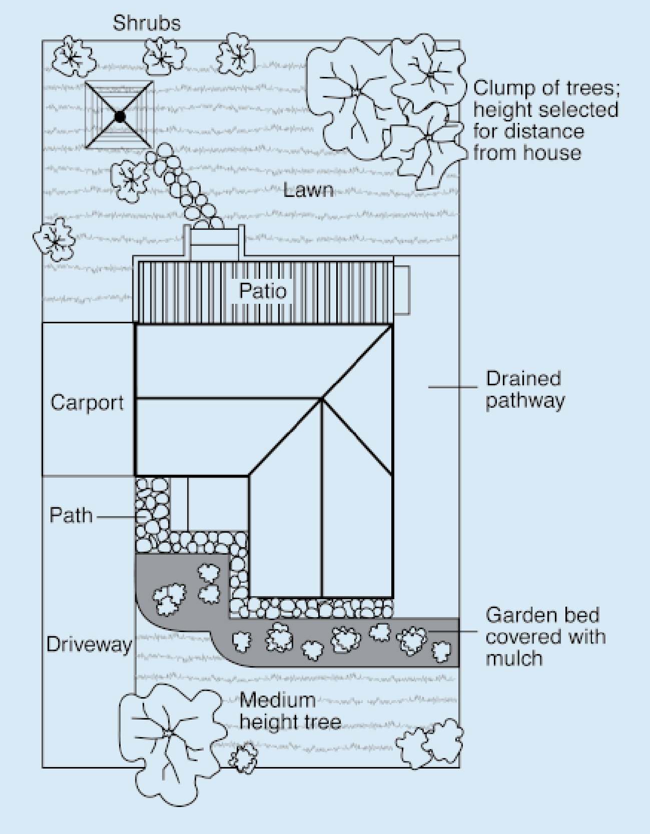
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4

Gardens for a reactive site



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

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