Proposed Subdivision
Billy's Lookout – Stage 24
Site Classification

Outrigger Drive, Teralba

NEW15P-0070F-AF
24 July 2023

Qualtest
LABORATORY (NSW) PTY LTD

GEOTECHNICAL I LABORATORY I EARTHWORKS I QUARRY I CONSTRUCTION MATERIAL TESTING

24 July 2023

McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
NEWCASTLE NSW 2300

Attention: Mr Harry Thomson

Dear Sir

RE: RESIDENTIAL SUBDIVISION – BILLY'S LOOKOUT – STAGE 24
OUTRIGGER DRIVE, TERALBA
SITE CLASSIFICATION (LOTS 2401 TO 2417)

Please find enclosed our geotechnical report for Stage 24 of the 'Billy's Lookout' residential subdivision, located at Outrigger Drive, Teralba.

The report provides site classification with respect to reactive soils, in accordance with the requirements of AS2870-2011 '*Residential Slabs and Footings*', for Stage 24 (Lots 2401 to 2417).

If you have any questions regarding this report, please do not hesitate to contact Ben Edwards, Shannon Kelly, or the undersigned.

For and on behalf of Qualtest Laboratory (NSW) Pty Ltd

Jason Lee
Principal Geotechnical Engineer

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Attachments:

1.0 Introduction

Qualtest Laboratory NSW Pty Ltd (Qualtest) is pleased to present this geotechnical site classification report on behalf of McCloy Development Management Pty Ltd (McCloy), for Stage 24 of the 'Billy's Lookout' residential subdivision, located at Outrigger Drive, Teralba.

Based on the brief and drawing provided by the client, Stage 24 is understood to comprise of 17 residential allotments (Lots 2401 to 2417).

The scope of work for the geotechnical investigation included site classification with respect to reactive soils, in accordance with the requirements of AS2870-2011 '*Residential Slabs and Footings*', for Stage 24, following completion of site regrade works.

This report presents the results of the field work investigations and laboratory testing, and provides recommendations for the scope outlined above.

2.0 Desktop Study

The scope of work has included a review of the following reports completed by Qualtest or others, as noted below:

- Level 1 Site Re-grade Assessment Report, 'Billy's Lookout Subdivision – Stage 16, 17 & 24, Teralba, (Qualtest Report Reference: NEW22P-0067-AA, dated 13 June 2023); and,
- Geotechnical Assessment report by Qualtest, 'Proposed Subdivision, Billy's Lookout - Stages 10, 16 & 17, Outrigger Drive, Teralba, (Report Reference: NEW15P-0070F-AA, dated 22 November 2019).

This report includes a summary of selected results from the previous reports where applicable.

3.0 Field Work

Field work investigations were carried out on 23 June 2023 and comprised of:

- DBYD search and visual check of proposed test locations for the presence of underground services;
- Site walkover to make observations of surface features at the property and in the immediate surrounding area;
- Drilling 9 boreholes (BH2401 to BH2409) using a 2.7 tonne excavator equipped with a 300mm diameter auger attachment. Boreholes were terminated at depths of between 2.00m and 2.10m;
- Undisturbed samples (U50 tubes) and small bag samples were taken for subsequent laboratory testing; and,
- Boreholes were backfilled with the excavation spoil and compacted using the excavator auger and tracks.

Investigations were carried out by an experienced Geotechnical Engineer from Qualtest who located the boreholes, carried out the testing and sampling, produced field logs of the boreholes, and made observations of the site surface conditions.

Engineering logs of the boreholes are presented in Appendix A.

Approximate borehole locations are shown on the attached Figure AF1. Boreholes were located in the field by handheld GPS and relative to existing site features.

4.0 Site Description

4.1 Site Regrade Works

Following an initial site visit, stripping assessments and recommendations performed on 12 April 2022 (Qualtest Site Record Form ref. NEW22P-0067-S01, dated 20/04/22, and multiple subsequent visits throughout the project), site re-grading works within Stage 24 were conducted between 19 April 2022 and 2 February 2023.

Re-grade works included filling within all (or portions) of proposed residential lots 2401 to 2418, along with filling works for proposed noise walls, retaining walls and infrastructure works for access to the Teralba Train Station.

Prior to filling, re-grade areas were stripped of topsoil and unsuitable material to expose the suitable natural foundation profile. Preparation works were then performed, which consisted of tyning, re-conditioning and re-compaction of the stripped surface, prior to filling with approved site fill to design finish levels.

Filling was generally performed using site material won from excavations within the cut areas of the development. The fill material could generally be described as mixtures of Residual (CI-CH) Sandy CLAY, medium to high plasticity, brown / red / grey in colour, with fine to coarse grained Sand and Gravel, along with Extremely Weathered (EW) Conglomerate / Sandstone, pale yellow / brown in colour, blended with minor quantities of on-site pale brown Colluvium.

The approximate depth of fill placed ranged in the order of 0.1m to about 4.5m, with the deepest areas associated with the access to the Teralba Train Station, and along the rear of Stage 24 lots, adjacent to the noise wall and existing rail corridor.

The approximate range of fill placed within each stage (excluding topsoil), was in the order of:

- Lots 2401 to 2406 – 0.6m to 2.5m;
- Lots 2407 to 2418 – 1.0m to 3.5m;
- Noise Wall – 0.7m to 1.2m.

The fill was compacted in maximum lifts of 0.3m thickness. Any unsuitable or deleterious material within the fill was removed by hand or mechanical means prior to final compaction of the material.

As the geotechnical testing authority engaged for the project, Qualtest state that the filling performed for the re-grade areas within Stage 24 (as detailed in the site regrade report), was carried out to Level 1 criteria as defined in Clause 8.2 – Section 8 of AS3798-2007, "*Guidelines on Earthworks for Commercial and Residential Developments*".

Refer to Qualtest Level 1 Site Re-grade Assessment Report (Ref. NEW22P-0067-AA, dated 13 June 2023) for further details including the approximate limit of filling works for this stage of the project.

The recommendations of this report are based on the understanding that any existing lot re-grade works are limited to the controlled earthworks supervised by Qualtest, placement of the fill material observed to depths of 0.4m or less within boreholes, and placement of low reactivity topsoil material such that total depth of topsoil and uncontrolled fill does not exceed 0.4m. Qualtest should be informed without delay if additional earthworks are known to have been carried out.

At the time of the field investigations, stockpiled topsoil was present on lots 2410 to 2414. It is understood and expected that fill stockpiles will be removed prior to development on lots.

4.2 Surface Conditions

The site comprises proposed Stage 24 of the Billy's Lookout subdivision, located off Outrigger Drive, Teralba, as shown on Figure AF1.

Following completion of the site regrade works (generally comprising fill), the site gently slopes towards to the east and south-east. Natural topography of the area could be generally characterised as a region of moderately sloping topography, on the eastern facing mid-slopes of a broad hill formation peaking to the west of the site.

The site is bounded to the north and west by future and existing stages of the Billys Lookout subdivision (existing Stage 16, and future Stage 18), by the Main Northern Railway to the east, and to the south by existing OSD basin.

On the day of the field investigations, the site had been cleared, associated retaining walls had been constructed, and topsoil had been placed in most areas of the lots.

The majority of the site was judged to be moderately drained by way inter-allotment drainage systems located at the rear (eastern end) of allotments.

Trafficability was judged to be good by way of 4WD vehicle along the existing pavement at the front of the lots.

Selected photographs of the site taken on the day of the site investigations are shown below.

Photograph 1: From boundary of Lots 2401 and 2402, (near BH2401), facing south.

Photograph 2: From boundary of Lots 2401 and 2402, (near BH2401), facing southwest.

Photograph 3: From boundary of Lots 2407 and 2408, (near BH2404), facing south. Showing topsoil stockpile on Lots 2410 to 2414.

Photograph 4: From boundary of Lots 2407 and 2408, (near BH2404), facing northwest.

Photograph 5: From near corner of Lots 2415 and 2416, (approx. 10m west of BH2408), facing north.

Photograph 6: From near corner of Lots 2415 and 2416, (approx. 10m west of BH2408), facing southeast.

4.3 Subsurface Conditions

Reference to the 1:100,000 Newcastle Coalfield Regional Geology Sheet indicates the site to be underlain by the Moon Island Beach Subgroup of the Newcastle Coal Measures, which is characterised by Conglomerate, Sandstone, Siltstone, Claystone, Tuff and Coal rock types.

Table 1 presents a summary of the typical soil types encountered on site during the field investigations, divided into representative geotechnical units.

Table 2 contains a summary of the distribution of the above geotechnical units at the borehole locations.

TABLE 1 – SUMMARY OF GEOTECHNICAL UNITS AND SOIL TYPES

Unit	Soil Type	Description
1A	FILL – TOPSOIL	Sandy CLAY – low plasticity, grey, fine to coarse grained (mostly fine to medium grained) sand, trace fine to medium grained angular to sub-angular gravel.
1B	FILL – Controlled	Sandy CLAY / Clayey SAND – low to medium plasticity, pale brown, fine to coarse grained (mostly fine grained) sand, trace fine to medium grained angular to sub-angular gravel. Gravelly Sandy CLAY - low to medium plasticity, pale orange to pale brown and pale grey, fine to coarse grained sand, fine to coarse grained rounded to sub-rounded gravel. CLAY – medium plasticity, pale grey to grey, with some fine to medium grained sand. Gravelly Clayey SAND – fine to coarse grained, pale orange to pale brown, fines of low to medium plasticity, fine to medium grained rounded to sub-rounded gravel. Clayey Sandy GRAVEL – fine to coarse grained, rounded to sub-rounded, pale brown to pale orange and pale grey, fines of low to medium plasticity, fine to coarse grained sand.
2	TOPSOIL	Not Encountered within current investigation.
3	SLOPEWASH / COLLUVIUM	Not Encountered within current investigation.
4	RESIDUAL SOIL	CLAY – medium to high plasticity, pale brown, trace fine grained sand. Sandy CLAY – medium plasticity, pale orange with pale grey, fine to medium grained sand. Sandy CLAY / Clayey SAND – low to medium plasticity, pale brown, fine to coarse grained (mostly fine grained) sand, trace fine to medium grained angular to sub-angular gravel.
5	EXTREMELY WEATHERED (XW) ROCK with soil properties	Not Encountered within current investigation.
6	HIGHLY WEATHERED (HW) ROCK	SANDSTONE – fine to medium grained, orange with some pale grey, estimated very low strength. Silty SANDSTONE – fine to medium grained, grey to white, estimated medium to high strength. Pebbly SANDSTONE – fine to coarse grained, pale brown to orange and pale grey to grey, estimated very low to low strength.

TABLE 2 – SUMMARY OF GEOTECHNICAL UNITS ENCOUNTERED AT TEST LOCATIONS

Location	UNIT 1A Fill - Topsoil	UNIT 1B Fill - Uncontrolled	UNIT 1C Fill - Controlled	UNIT 2 Topsoil	Unit 4 Residual Soil	Unit 5 XW Rock	Unit 6 HW Rock
	Depth (m)						
BH2401	0.00 - 0.20	-	0.20 - 1.70	-	1.70 - 2.00	-	-
BH2402	0.00 - 0.20	-	0.20 - 0.90	-	0.90 - 1.20	-	1.20 - 2.00
BH2403	0.00 - 0.15	-	0.15 - 0.90	-	0.90 - 1.50	-	1.50 - 2.10
BH2404	0.00 - 0.20	-	0.20 - 1.60	-	1.60 - 2.00	-	-
BH2405	0.00 - 0.20	-	0.20 - 2.10	-	-	-	-
BH2406	0.00 - 0.20	-	0.20 - 2.00	-	-	-	-
BH2407	0.00 - 0.20	-	0.20 - 2.00	-	-	-	-
BH2408	0.00 - 0.20	-	0.20 - 2.00	-	-	-	-
BH2409	0.00 - 0.20	-	0.20 - 2.00	-	-	-	-
Previous investigation (Ref. NEW15P-0070F-AA, dated 22/11/2019) – Prior to Site Regrade / Site Filling							
TPP10	-	-	-	0.00 - 0.20	0.20 - 0.80	0.80 - 1.10	1.10 - 1.20*
TPP11	-	-	-	0.00 - 0.20	0.20 - 0.80	0.80 - 1.00	1.00 - 1.10*
TPP12	0.00 - 0.15	0.15 - 0.25	-	-	0.25 - 0.90	0.90 - 1.10	1.10 - 1.15*
TPP14	0.00 - 0.40	-	-	-	0.40 - 1.60	1.60 - 2.00	-
TPP15	0.00 - 0.05	-	-	0.05 - 0.20	0.20 - 1.10	1.10 - 1.65	1.65 - 1.70*
TPP16	0.00 - 0.05	0.05 - 0.20	-	-	0.20 - 1.20	1.20 - 1.45	1.45 - 1.55*
TPP17	0.00 - 0.05	-	-	0.05 - 0.15	0.15 - 1.00	1.00 - 1.25	1.25 - 1.40*

Notes: * = Refusal or Practical refusal of 2.7 tonne excavator on Highly Weathered Rock.

No groundwater was encountered in the boreholes or test pits during the limited time that they remained open on the day of the field investigation.

It should be noted that groundwater conditions can vary due to rainfall and other influences including regional groundwater flow, temperature, permeability, recharge areas, surface condition, and subsoil drainage.

5.0 Laboratory Testing

Samples collected during the field investigations were returned to our NATA accredited Newcastle Laboratory for testing which comprised of:

- (9 no.) Shrink / Swell tests; and,
- (3 no.) Atterberg Limits tests.

Proposed shrink/swell testing for a number of samples were replaced by Atterberg Limits classification tests due to the friable nature of the site soils.

Results of the laboratory testing are presented in Appendix B, with a summary of the test results presented in Table 3 and Table 4.

The tables also include a summary of laboratory testing information where applicable from the previous Geotechnical Assessment carried out by Qualtest.

TABLE 3 – SUMMARY OF SHRINK/SWELL TESTING RESULTS

Location	Depth (m)	Material Description	I_{ss} (%)
Current Investigation			
BH2402	0.30 - 0.52	FILL: (CI) CLAY	1.9
BH2402	0.90 - 1.05	(CI) Sandy CLAY	1.0
BH2403	0.50 - 0.67	FILL: (CI) CLAY	2.4
BH2403	0.90 - 1.04	(CL) Sandy CLAY	0.8
BH2406	0.50 - 0.65	FILL: (CL) Sandy CLAY	0.6
BH2406	1.00 - 1.15	FILL: (CL) Sandy Gravelly CLAY	1.0
BH2407	0.80 - 0.95	FILL: (CL) Gravelly Sandy CLAY	0.4
BH2408	0.50 - 0.70	FILL: (CL) Gravelly Sandy CLAY	0.9
BH2409	0.70 - 0.85	FILL: (CI) Sandy Gravelly CLAY	0.3
Previous investigation (Ref. NEW15P-0070F-AA, dated 22/11/2019)			
TPP10	0.25 - 0.55	(CI) Sandy CLAY	1.8
TPP12	0.30 - 0.50	(CH) Sandy CLAY	3.6

TABLE 4 – SUMMARY OF ATTERBERG LIMITS TESTING RESULTS

Location	Depth (m)	Material Description	Liquid Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)
BH2401	0.50 - 0.65	FILL: (CL) Sandy CLAY	32	10	4.0
BH2404	0.40 - 0.50	FILL: (CL) Sandy CLAY	29	7	2.5
BH2405	0.60 - 0.70	FILL: (GC) Sandy Clayey GRAVEL	37	18	5.5

6.0 Site Classification to AS2870-2011

Based on the results of the field work and laboratory testing carried out, proposed residential lots located within Billy's Lookout Stage 24 at Outrigger Drive, Teralba, as shown on Figure AF1, are classified in their current condition in accordance with AS2870-2011 '*Residential Slabs and Footings*', as shown in Table 5.

TABLE 5 – SITE CLASSIFICATION TO AS2870-2011

Stage No.	Lot Numbers	Site Classification
24	2401 to 2417	**H1**

A characteristic free surface movement of 40mm to 60mm is estimated for lots classified as **Class 'H1'** in their existing condition.

The effects of changes to the soil profile by additional cutting and filling and the effects of past and future trees should be considered in selection of the design value for differential movement.

If site re-grading works involving cutting or filling are performed after the date of this assessment, the classification may change and further advice should be sought.

Final site classification will be dependent on a number of factors, including depth of topsoil, depth of fill and residual soil, reactivity of the natural soil and any fill material placed, and the level of supervision carried out. Re-classification of lots should be confirmed by the geotechnical authority at the time of construction following any site re-grade works.

Footings for the proposed development should be designed and constructed in accordance with the requirements of AS2870-2011.

The classification presented above assumes that:

- All footings are founded in controlled fill (if applicable) or in the residual clayey soils or rock below all non-controlled fill, topsoil material and root zones, and fill under slab panels meets the requirements of AS2870-2011, in particular, the root zone must be removed prior to the placement of fill materials beneath slabs.
- The performance expectations set out in Appendix B of AS2870-2011 are acceptable, and that site foundation maintenance is undertaken to avoid extremes of wetting and drying.

- Footings are to be founded outside of or below all zones of influence resulting from existing or future service trenches.
- The constructional and architectural requirements for reactive clay sites set out in AS2870-2011 are followed.
- Adherence to the detailing requirement outlined in Section 5 of AS2870-2011 '*Residential Slabs and Footings*' is essential, in particular Section 5.6, '*Additional requirements for Classes M, H1, H2 and E sites*' including architectural restrictions, plumbing and drainage requirements.
- Site maintenance complies with the provisions of CSIRO Sheet BTF 18, "*Foundation Maintenance and Footing Performance: A Homeowner's Guide*", a copy of which is attached in Appendix C.

All structural elements on all lots should be supported on footings founded beneath all uncontrolled fill, layers of inadequate bearing capacity, soft/loose, wet or other potentially deleterious material.

If any localised areas of uncontrolled fill of depths greater than 0.4m are encountered during construction, footings should be designed in accordance with engineering principles for Class 'P' sites.

7.0 Limitations

This report comprises the results of an investigation carried out for a specific purpose and client as defined in the document. The report should not be used by other parties or for purposes or projects other than those assumed and stated within the report, as it may not contain adequate or appropriate information for applications other than those assumed or advised at the time of its preparation. The contents of the report are for the sole use of the client and no responsibility or liability will be accepted to any third party. The report should not be reproduced either in part or in full, without the express permission of Qualtest.

Geotechnical site investigation is based on data collection, judgment, experience, and opinion. By its nature, it is less exact than other engineering disciplines. The findings presented in the report and used as the basis for recommendations presented herein were obtained using normal, industry accepted geotechnical design practices and standards. To our knowledge, they represent a reasonable interpretation of the general conditions of the site. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points.

The recommended depth and properties of any soil, rock, groundwater, or other material referred to in this report is an engineering estimate based on the information available at the time of its writing. The estimate is influenced and limited by the fieldwork method and testing carried out in the site investigation, and other relevant information as has been made available. In cases where information has been provided to Qualtest for the purposes of preparing this report, it has been assumed that the information is accurate and appropriate for such use. No responsibility is accepted by Qualtest for inaccuracies within any data supplied by others.

The extent of testing associated with this assessment is limited to discrete test locations. It should be noted that subsurface conditions between and away from the test locations may be different to those observed during the field work and used as the basis of the recommendations contained in this report.

If site conditions encountered during construction differ from those given in this report, further advice should be sought without delay.

This report alone should not be used by contractors as the basis for preparation of tender documents or project estimates. Contractors using this report as a basis for preparation of tender documents should avail themselves of all relevant background information regarding the site before deciding on selection of construction materials and equipment.

If you have any further questions regarding this report, please do not hesitate to contact Ben Edwards, Shannon Kelly, or the undersigned.

For and on behalf of Qualtest Laboratory (NSW) Pty Ltd.

Jason Lee
Principal Geotechnical Engineer

FIGURE AF1:

Site Plan and Approximate Test Locations

SALE PLAN FOR BILLY'S LOOKOUT STAGE 24

LOCALITY PLAN

McCLOYGROUP

BILLY'S LOOKOUT

Based on Sale Plan for Billy's Lookout Stage 24 provided by client.

LEGEND:

Approximate borehole location.

Approximate test pit location (Qualtest, 2019).

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Client:	MCCLOY GROUP	Drawing No:	FIGURE AF1
Project:	BILLYS LOOKOUT - STAGE 24	Project No:	NEW15P-0070F
Location:	OUTRIGGER DRIVE, TERALBA	Scale:	AS SHOWN
Title:	SITE PLAN AND APPROXIMATE TEST LOCATIONS	Date:	20/07/2023

APPENDIX A:

Results of Field Investigations

ENGINEERING LOG - BOREHOLE

CLIENT: MCCLOY GROUP
PROJECT: RESIDENTIAL SUBDIVISION - STAGE 24
LOCATION: BILLY'S LOOKOUT, TERALBA

BOREHOLE NO: BH2401
PAGE: 1 OF 1
JOB NO: NEW15P-0070F
LOGGED BY: BE
DATE: 23/6/23

DRILL TYPE: 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**
BOREHOLE DIAMETER: 300 mm **DATUM:**

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
AD/T	Not Encountered	0.20m				CL	FILL-TOPSOIL: Sandy CLAY - low plasticity, grey, fine to coarse grained (mostly fine to medium grained) sand, trace fine to medium grained angular to sub-angular gravel.	M > w_P				FILL - TOPSOIL
		D 0.30m					0.20m					FILL-CONTROLLED
		0.50m		0.5			FILL: Sandy CLAY / Clayey SAND - low to medium plasticity, pale brown, fine to coarse grained (mostly fine grained) sand, trace fine to medium grained angular to sub-angular gravel. 0.30m: With sandstone cobble.					
		U50 0.65m										
				1.0		CL		M < w_P	H / Fb			
				1.5			1.4m: With sandstone cobbles.					
		1.70m					1.70m					
		D 1.90m				CH	CLAY - medium to high plasticity, pale brown, trace fine grained sand.	M > w_P	St	HP	150	RESIDUAL SOIL
				2.0			2.00m					
							Hole Terminated at 2.00 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

QT LIB 1.1.GLB Log NON-CORED BOREHOLE - TEST PIT NEW15P-0070F BOREHOLE LOGS -STAGES 24.GPJ <<DrawingFile>> 19/07/2023 17:53 10.03.00.09 Datgel Lab and In Situ Tool

ENGINEERING LOG - BOREHOLE

CLIENT: MCCLOY GROUP
PROJECT: RESIDENTIAL SUBDIVISION - STAGE 24
LOCATION: BILLY'S LOOKOUT, TERALBA

BOREHOLE NO: BH2402
PAGE: 1 OF 1
JOB NO: NEW15P-0070F
LOGGED BY: BE
DATE: 23/6/23

DRILL TYPE: 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**
BOREHOLE DIAMETER: 300 mm **DATUM:**

Drilling and Sampling					Material description and profile information					Field Test		Structure and additional observations
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	
AD/T	Not Encountered					CL	FILL-TOPSOIL: Sandy CLAY - low plasticity, grey, fine to coarse (mostly fine to medium) grained sand, trace fine to medium grained angular to sub-angular gravel.					FILL - TOPSOIL
							0.20m					
		0.30m				CI	FILL: CLAY - medium plasticity, pale grey to grey, with fine to medium grained sand.	M > w_P	St	HP	180	FILL-CONTROLLED
		U50 0.52m		0.5						HP	180	
		0.90m					0.90m			HP	160	
		U50 1.05m		1.0		CI	Sandy CLAY - medium plasticity, pale orange, with pale grey, fine to medium grained sand.		VSt	HP	250	RESIDUAL SOIL
							1.20m					
				1.5			SANDSTONE - fine to medium grained, orange, with pale grey, estimated very low strength. 1.4m: Silty SANDSTONE band (approximately 100mm thick) - fine to medium grained, pale grey-white and grey, estimated medium to high strength.	D				EXTREMELY TO HIGHLY WEATHERED ROCK
							1.90m					
				2.0			Silty SANDSTONE - fine to medium grained, pale grey-white and grey, estimated medium to high strength.					HIGHLY WEATHERED ROCK
							2.00m Hole Terminated at 2.00 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

QT LIB 1.1.GLB Log NON-CORED BOREHOLE - TEST PIT NEW15P-0070F BOREHOLE LOGS -STAGES 24.GPJ <<DrawingFile>> 19/07/2023 17:53 10.03.00.09 Datgel Lab and In Situ Tool

ENGINEERING LOG - BOREHOLE

CLIENT: MCCLOY GROUP
PROJECT: RESIDENTIAL SUBDIVISION - STAGE 24
LOCATION: BILLY'S LOOKOUT, TERALBA

BOREHOLE NO: BH2403
PAGE: 1 OF 1
JOB NO: NEW15P-0070F
LOGGED BY: BE
DATE: 23/6/23

DRILL TYPE: 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**
BOREHOLE DIAMETER: 300 mm **DATUM:**

Drilling and Sampling					Material description and profile information					Field Test		Structure and additional observations
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	
AD/T	Not Encountered					CL	FILL-TOPSOIL: Sandy CLAY - low plasticity, grey, fine to coarse grained (mostly fine to medium grained) sand, trace fine to medium grained angular to sub-angular gravel.					FILL - TOPSOIL
							0.15m					
						CL	FILL: Sandy CLAY / Clayey SAND - low to medium plasticity, pale brown, fine to coarse grained (mostly fine grained) sand, trace fine to medium grained angular to sub-angular gravel.			HP	260	FILL-CONTROLLED
							0.30m					
							FILL: CLAY - medium plasticity, pale grey and grey, with fine to medium grained sand.			HP	200	
		0.50m		0.5					VSt			
		U50 0.67m				Cl		$M > w_P$		HP	250	
		0.90m					0.90m					
		U50 1.04m		1.0			Sandy CLAY / Clayey SAND - low to medium plasticity, pale brown, fine to coarse grained (mostly fine grained) sand, trace fine to medium grained angular to sub-angular gravel.			HP	250	RESIDUAL SOIL
						CL			VSt / Fb			
				1.5			1.50m					
							Pebbly SANDSTONE - fine to coarse grained, pale brown to pale orange and pale grey to grey, estimated very low to low strength.	D				HIGHLY WEATHERED ROCK
				2.0			2.10m					
							Hole Terminated at 2.10 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

QT LIB 1.1.GLB Log NON-CORED BOREHOLE - TEST PIT NEW15P-0070F BOREHOLE LOGS -STAGES 24.GPJ <<DrawingFile>> 19/07/2023 17:53 10.03.00.09 Datgel Lab and In Situ Tool

ENGINEERING LOG - BOREHOLE

BOREHOLE NO: BH2404
PAGE: 1 OF 1
JOB NO: NEW15P-0070F
LOGGED BY: BE
DATE: 23/6/23

CLIENT: MCCLOY GROUP
PROJECT: RESIDENTIAL SUBDIVISION - STAGE 24
LOCATION: BILLY'S LOOKOUT, TERALBA

DRILL TYPE: 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**
BOREHOLE DIAMETER: 300 mm **DATUM:**

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
AD/T	Not Encountered	0.40m U50 0.50m 0.90m D 1.00m		0.5 1.0 1.5 2.0		CL CL SC GC CH	FILL-TOPSOIL: Sandy CLAY - low plasticity, grey, fine to coarse grained (mostly fine to medium grained) sand, trace fine to medium grained angular to sub-angular gravel. 0.20m FILL: Sandy CLAY / Clayey SAND - low to medium plasticity, pale brown, fine to coarse grained (mostly fine grained) sand, trace fine to medium grained angular to sub-angular gravel. Trace Sandstone cobbles. 0.80m FILL: Gravelly Clayey SAND - fine to coarse grained, pale orange to pale brown, fines of low to medium plasticity, fine to medium grained rounded to sub-rounded gravel. 1.00m FILL: Sandy Clayey GRAVEL - fine to coarse grained, rounded to sub-rounded, pale brown, fines of low to medium plasticity, fine to coarse grained sand. 1.60m CLAY - medium to high plasticity, pale brown, trace fine grained sand. 2.00m Hole Terminated at 2.00 m	M ~ w_P M M > w_P	VSt St	HP HP HP HP	350 350 150 150	FILL - TOPSOIL FILL-CONTROLLED RESIDUAL SOIL

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

QT LIB 1.1.GLB Log NON-CORED BOREHOLE - TEST PIT NEW15P-0070F BOREHOLE LOGS -STAGES 24.GPJ <<DrawingFile>> 19/07/2023 17:53 10.03.00.09 Datgel Lab and In Situ Tool

ENGINEERING LOG - BOREHOLE

CLIENT: MCCLOY GROUP
PROJECT: RESIDENTIAL SUBDIVISION - STAGE 24
LOCATION: BILLY'S LOOKOUT, TERALBA

BOREHOLE NO: BH2405
PAGE: 1 OF 1
JOB NO: NEW15P-0070F
LOGGED BY: BE
DATE: 23/6/23

DRILL TYPE: 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**
BOREHOLE DIAMETER: 300 mm **DATUM:**

Drilling and Sampling					Material description and profile information					Field Test		Structure and additional observations
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	
AD/T	Not Encountered					CL	FILL-TOPSOIL: Sandy CLAY - low plasticity, grey, fine to coarse (mostly fine to medium) grained sand, trace fine to medium grained angular to sub-angular gravel.	M > w_P				FILL - TOPSOIL
							0.20m					FILL-CONTROLLED
				0.5		GC	FILL: Sandy Clayey GRAVEL / Sandy Gravelly CLAY - fine to coarse grained, rounded to sub-rounded, pale brown to pale orange and pale grey, fines of low to medium plasticity, fine to coarse grained sand.					
		0.60m					Pale orange, with pale grey.					
		D 0.70m						M				
				1.0								
		1.30m					1.30m					
		D 1.50m		1.5		CL	FILL: Sandy CLAY - low to medium plasticity, grey, fine to coarse grained sand, trace fine to medium grained rounded to sub-rounded gravel.	M > w_P	St	HP	120	
							1.80m					
				2.0		SC	FILL: Gravelly Clayey SAND - fine to coarse grained, pale orange to pale brown, fines of low to medium plasticity, fine to medium grained rounded to sub-rounded gravel.	M				
							2.10m					
							Hole Terminated at 2.10 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

QT LIB 1.1.GLB Log NON-CORED BOREHOLE - TEST PIT NEW15P-0070F BOREHOLE LOGS -STAGES 24.GPJ <<DrawingFile>> 19/07/2023 17:53 10.03.00.09 Datgel Lab and In Situ Tool

ENGINEERING LOG - BOREHOLE

CLIENT: MCCLOY GROUP
PROJECT: RESIDENTIAL SUBDIVISION - STAGE 24
LOCATION: BILLY'S LOOKOUT, TERALBA

BOREHOLE NO: BH2406
PAGE: 1 OF 1
JOB NO: NEW15P-0070F
LOGGED BY: BE
DATE: 23/6/23

DRILL TYPE: 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**
BOREHOLE DIAMETER: 300 mm **DATUM:**

Drilling and Sampling					Material description and profile information					Field Test		Structure and additional observations
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	
AD/T	Not Encountered					CL	FILL-TOPSOIL: Sandy CLAY - low plasticity, grey, fine to coarse (mostly fine to medium) grained sand, trace fine to medium grained angular to sub-angular gravel.	M > w_P				FILL - TOPSOIL
							0.20m					
						GC	FILL: Sandy Clayey GRAVEL - fine to coarse grained, rounded to sub-rounded, pale brown to pale orange and pale grey, fines of low to medium plasticity, fine to coarse grained sand.	M				FILL-CONTROLLED
							0.40m					
		0.50m		0.5		CL	FILL: Sandy CLAY / Clayey SAND - low to medium plasticity, pale brown, fine to coarse grained (mostly fine grained) sand, trace fine to medium grained angular to sub-angular gravel.		St	HP	150	
		U50 0.65m								HP	200	
							0.90m					
		1.00m		1.0		CL	FILL: Gravelly Sandy CLAY - low to medium plasticity, pale orange to pale brown and pale grey, fine to coarse grained sand, fine to coarse grained rounded to sub-rounded gravel.	M > w_P	VSt / Fb	HP	250	
		U50 1.15m										
				1.5								
				2.0			2.00m					
							Hole Terminated at 2.00 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

QT LIB 1.1.GLB Log NON-CORED BOREHOLE - TEST PIT NEW15P-0070F BOREHOLE LOGS -STAGES 24.GPJ <<DrawingFile>> 19/07/2023 17:53 10.03.00.09 Datgel Lab and In Situ Tool

ENGINEERING LOG - BOREHOLE

CLIENT: MCCLOY GROUP
PROJECT: RESIDENTIAL SUBDIVISION - STAGE 24
LOCATION: BILLY'S LOOKOUT, TERALBA

BOREHOLE NO: BH2407
PAGE: 1 OF 1
JOB NO: NEW15P-0070F
LOGGED BY: BE
DATE: 23/6/23

DRILL TYPE: 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**
BOREHOLE DIAMETER: 300 mm **DATUM:**

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
AD/T	Not Encountered	0.50m D 0.60m		0.5		CL	FILL-TOPSOIL: Sandy CLAY - low plasticity, grey, fine to coarse grained (mostly fine to medium grained) sand, trace fine to medium grained angular to sub-angular gravel.	M > w_P				FILL - TOPSOIL
							0.20m					
						GC	FILL: Sandy Clayey GRAVEL / Sandy Gravelly CLAY - fine to coarse grained, rounded to sub-rounded, pale brown to pale orange and pale grey, fines of low to medium plasticity, fine to coarse grained sand.	M				FILL-CONTROLLED
							0.60m					
		0.80m U50 0.95m		1.0		CL	FILL: Gravelly Sandy CLAY - low to medium plasticity, pale orange to pale brown and pale grey, fine to coarse grained sand, fine to coarse grained rounded to sub-rounded gravel.	M > w_P	St / Fb	HP HP HP	100 100 120	
				1.5						HP HP	120 120	
				2.0			2.00m					
							Hole Terminated at 2.00 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

QT LIB 1.1.GLB Log NON-CORED BOREHOLE - TEST PIT NEW15P-0070F BOREHOLE LOGS -STAGES 24.GPJ <<DrawingFile>> 19/07/2023 17:53 10.03.00.09 Datgel Lab and In Situ Tool

ENGINEERING LOG - BOREHOLE

BOREHOLE NO: BH2408

CLIENT: MCCLOY GROUP
PAGE: 1 OF 1
PROJECT: RESIDENTIAL SUBDIVISION - STAGE 24
JOB NO: NEW15P-0070F
LOCATION: BILLY'S LOOKOUT, TERALBA
LOGGED BY: BE
DATE: 23/6/23

DRILL TYPE: 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**
BOREHOLE DIAMETER: 300 mm **DATUM:**

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
AD/T	Not Encountered					CL	FILL-TOPSOIL: Sandy CLAY - low plasticity, grey, fine to coarse (mostly fine to medium) grained sand, trace fine to medium grained angular to sub-angular gravel.	M > w_P				FILL - TOPSOIL
							0.20m					
						GC	FILL: Sandy Clayey GRAVEL / Sandy Gravelly CLAY - fine to coarse grained, rounded to sub-rounded, pale brown to pale orange and pale grey, fines of low to medium plasticity, fine to coarse grained sand.	M				FILL-CONTROLLED
							0.40m					
		0.50m		0.5			FILL: Gravelly Sandy CLAY - low to medium plasticity, pale orange to pale brown and pale grey, fine to coarse grained sand, fine to coarse grained rounded to sub-rounded gravel.			HP	100	
		U50				CL						
		0.70m										
				1.0			1.00m					
							FILL: Sandy Gravelly CLAY / Clayey GRAVEL - medium plasticity, pale brown to brown and grey, trace orange, fine to coarse grained rounded to sub-rounded gravel, fine to coarse grained sand.			HP	100	
								M > w_P	St / Fb	HP	120	
				1.5		Cl						
				2.0			2.00m					
							Hole Terminated at 2.00 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

QT LIB 1.1.GLB Log NON-CORED BOREHOLE - TEST PIT NEW15P-0070F BOREHOLE LOGS -STAGES 24.GPJ <<DrawingFile>> 19/07/2023 17:53 10.03.00.09 Datgel Lab and In Situ Tool

ENGINEERING LOG - BOREHOLE

CLIENT: MCCLOY GROUP
PROJECT: RESIDENTIAL SUBDIVISION - STAGE 24
LOCATION: BILLY'S LOOKOUT, TERALBA

BOREHOLE NO: BH2409
PAGE: 1 OF 1
JOB NO: NEW15P-0070F
LOGGED BY: BE
DATE: 23/6/23

DRILL TYPE: 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**
BOREHOLE DIAMETER: 300 mm **DATUM:**

Drilling and Sampling					Material description and profile information					Field Test		Structure and additional observations
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	
AD/T	Not Encountered	0.70m U50 0.85m		0.5 1.0 1.5 2.0		CL Cl CL	FILL-TOPSOIL: Sandy CLAY - low plasticity, grey, fine to coarse grained (mostly fine to medium grained) sand, trace fine to medium grained angular to sub-angular gravel. 0.20m FILL: Sandy Gravelly CLAY / Clayey GRAVEL - medium plasticity, pale brown to brown and grey, trace orange, fine to coarse grained rounded to sub-rounded gravel, fine to coarse grained sand. 1.70m FILL: Gravelly Sandy CLAY - low to medium plasticity, pale orange to pale brown and pale grey, fine to coarse grained sand, fine to coarse grained rounded to sub-rounded gravel. 2.00m Hole Terminated at 2.00 m	$M > w_P$	St / Fb	HP HP HP HP	120 120 110 150	FILL - TOPSOIL FILL-CONTROLLED

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

QT LIB 1.1.GLB Log NON-CORED BOREHOLE - TEST PIT NEW15P-0070F BOREHOLE LOGS -STAGES 24.GPJ <<DrawingFile>> 19/07/2023 17:53 10.03.00.09 Datgel Lab and In Situ Tool

APPENDIX B:

Results of Laboratory Testing

QUALTEST Laboratory (NSW) Pty Ltd (20708)
2 Murray Dwyer Circuit, Mayfield West, NSW 2304
T: 02 4968 4468
F: 02 4960 9775
E: admin@qualtest.com.au
W: www.qualtest.com.au
ABN: 98 153 268 896

Report No: MAT:NEW23W-3146-S01
Issue No: 1

Material Test Report

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Project No.: NEW15P-0070F
Project Name: Billy's Lookout - Stages 16, 17 & 24
Project Location: Teralba, NSW

Accredited for compliance with ISO/IEC 17025 - Testing.
Results provided relate only to the items tested or sampled.
This report shall not be reproduced except in full.

Approved Signatory: Brent Cullen
(Engineering Geologist)
NATA Accredited Laboratory Number: 18686
Date of Issue: 12/07/2023

Sample Details

Sample ID: NEW23W-3146-S01
Date Sampled: 27/06/2023
Date Received: 28/06/2023
Source: On-Site Insitu
Material: Sandy Clay
Specification: No Specification
The results outlined below apply to the sample as received
Sample Location: BH2401 - (0.50 - 0.65m)

Test Results

Description	Method	Result	Limits
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	4.0	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	32	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	22	
Plasticity Index (%)	AS 1289.3.3.1	10	
Date Tested		11/07/2023	

Comments

N/A

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QUALTEST Laboratory (NSW) Pty Ltd (20708)
2 Murray Dwyer Circuit, Mayfield West, NSW 2304
T: 02 4968 4468
F: 02 4960 9775
E: admin@qualtest.com.au
W: www.qualtest.com.au
ABN: 98 153 268 896

Report No: SSI:NEW23W-3146-S02
Issue No: 1

Shrink Swell Index Report

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Project No.: NEW15P-0070F
Project Name: Billy's Lookout - Stages 16, 17 & 24
Project Location: Teralba, NSW

Accredited for compliance with ISO/IEC 17025 - Testing.
Results provided relate only to the items tested or sampled.
This report shall not be reproduced except in full.

Approved Signatory: Brent Cullen
(Engineering Geologist)
NATA Accredited Laboratory Number: 18686
Date of Issue: 7/07/2023

Sample Details

Sample ID: NEW23W-3146-S02
Sampling Method: The results outlined below apply to the sample as received
Material: Sandy Clay
Source: On-Site Insitu
Specification: No Specification
Sample Location: BH2402 - (0.30 - 0.52m)
Date Tested: 3/07/2023
Date Sampled: 27/06/2023
Date Submitted: 28/06/2023

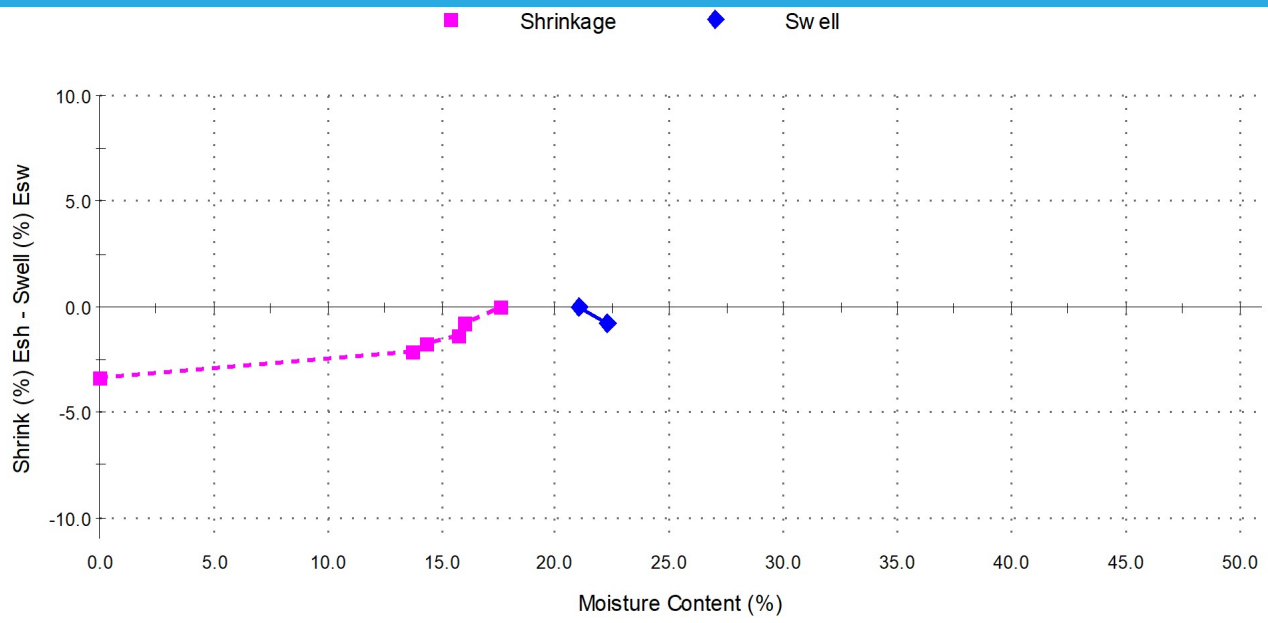
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.8
Moisture Content before (%):	21.0
Moisture Content after (%):	22.2
Est. Unc. Comp. Strength before (kPa):	320
Est. Unc. Comp. Strength after (kPa):	260

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	3.4
Shrinkage Moisture Content (%):	17.6
Est. inert material (%):	2%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Moderate

Shrink Swell



Shrink Swell Index - Iss (%): 1.9

Comments

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Report No: SSI:NEW23W-3146-S03
Issue No: 1

Shrink Swell Index Report

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Project No.: NEW15P-0070F
Project Name: Billy's Lookout - Stages 16, 17 & 24
Project Location: Teralba, NSW

Accredited for compliance with ISO/IEC 17025 - Testing.
Results provided relate only to the items tested or sampled.
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Approved Signatory: Brent Cullen
(Engineering Geologist)
NATA Accredited Laboratory Number: 18686
Date of Issue: 7/07/2023

Sample Details

Sample ID: NEW23W-3146-S03
Sampling Method: The results outlined below apply to the sample as received
Material: Clay
Source: On-Site Insitu
Specification: No Specification
Sample Location: BH2402 - (0.90 - 1.05m)
Date Tested: 3/07/2023
Date Sampled: 27/06/2023
Date Submitted: 28/06/2023

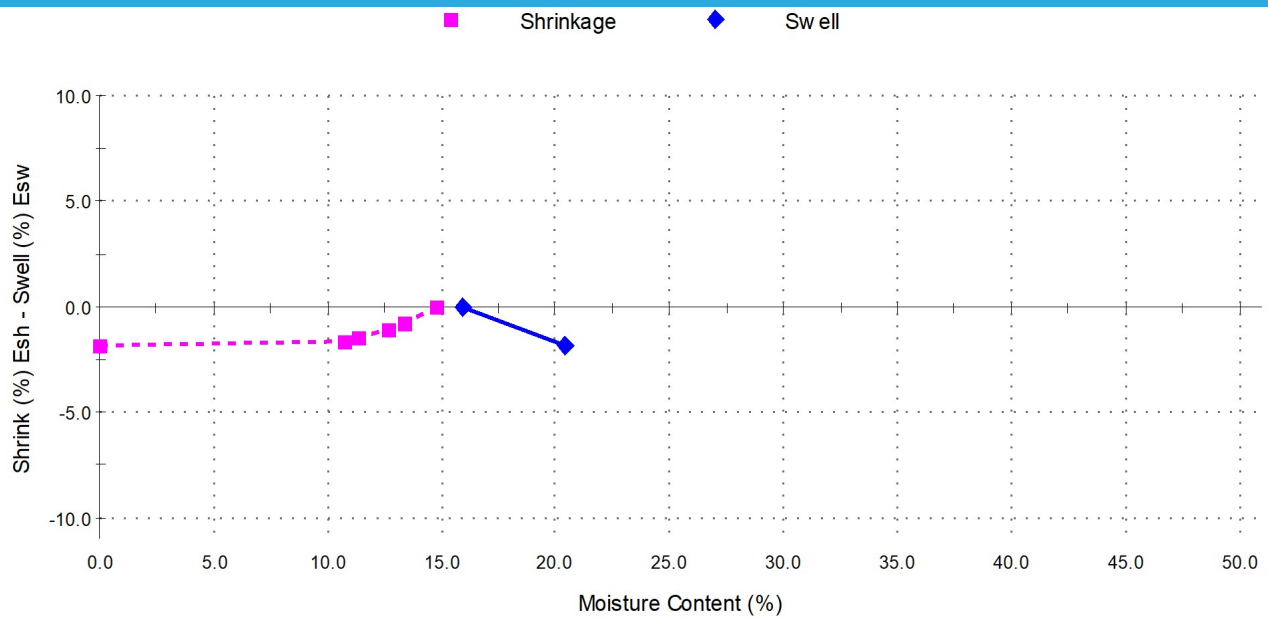
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-1.9
Moisture Content before (%):	15.9
Moisture Content after (%):	20.4
Est. Unc. Comp. Strength before (kPa):	350
Est. Unc. Comp. Strength after (kPa):	400

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	1.8
Shrinkage Moisture Content (%):	14.8
Est. inert material (%):	1%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 1.0

Comments

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Report No: SSI:NEW23W-3146-S04
Issue No: 1

Shrink Swell Index Report

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Project No.: NEW15P-0070F
Project Name: Billy's Lookout - Stages 16, 17 & 24
Project Location: Teralba, NSW

Accredited for compliance with ISO/IEC 17025 - Testing.
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Approved Signatory: Brent Cullen
(Engineering Geologist)
NATA Accredited Laboratory Number: 18686
Date of Issue: 7/07/2023

Sample Details

Sample ID: NEW23W-3146-S04
Sampling Method: The results outlined below apply to the sample as received
Material: Sandy Clay
Source: On-Site Insitu
Specification: No Specification
Sample Location: BH2403 - (0.50 - 0.67m)
Date Tested: 3/07/2023
Date Sampled: 27/06/2023
Date Submitted: 28/06/2023

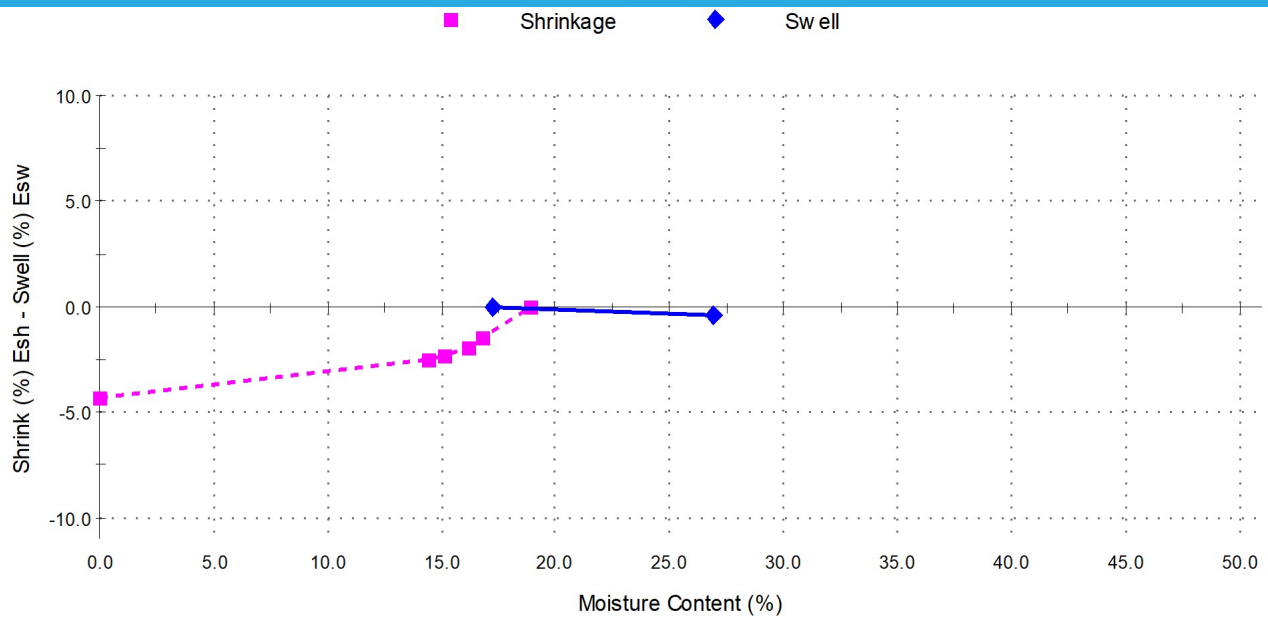
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.4
Moisture Content before (%):	17.2
Moisture Content after (%):	26.9
Est. Unc. Comp. Strength before (kPa):	350
Est. Unc. Comp. Strength after (kPa):	170

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	4.3
Shrinkage Moisture Content (%):	18.9
Est. inert material (%):	1%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 2.4

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Report No: SSI:NEW23W-3146-S05
Issue No: 1

Shrink Swell Index Report

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Project No.: NEW15P-0070F
Project Name: Billy's Lookout - Stages 16, 17 & 24
Project Location: Teralba, NSW

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Approved Signatory: Brent Cullen
(Engineering Geologist)
NATA Accredited Laboratory Number: 18686
Date of Issue: 6/07/2023

Sample Details

Sample ID: NEW23W-3146-S05
Sampling Method: The results outlined below apply to the sample as received
Material: Clay
Source: On-Site Insitu
Specification: No Specification
Sample Location: BH2403 - (0.90 - 1.04m)
Date Tested: 3/07/2023
Date Sampled: 27/06/2023
Date Submitted: 28/06/2023

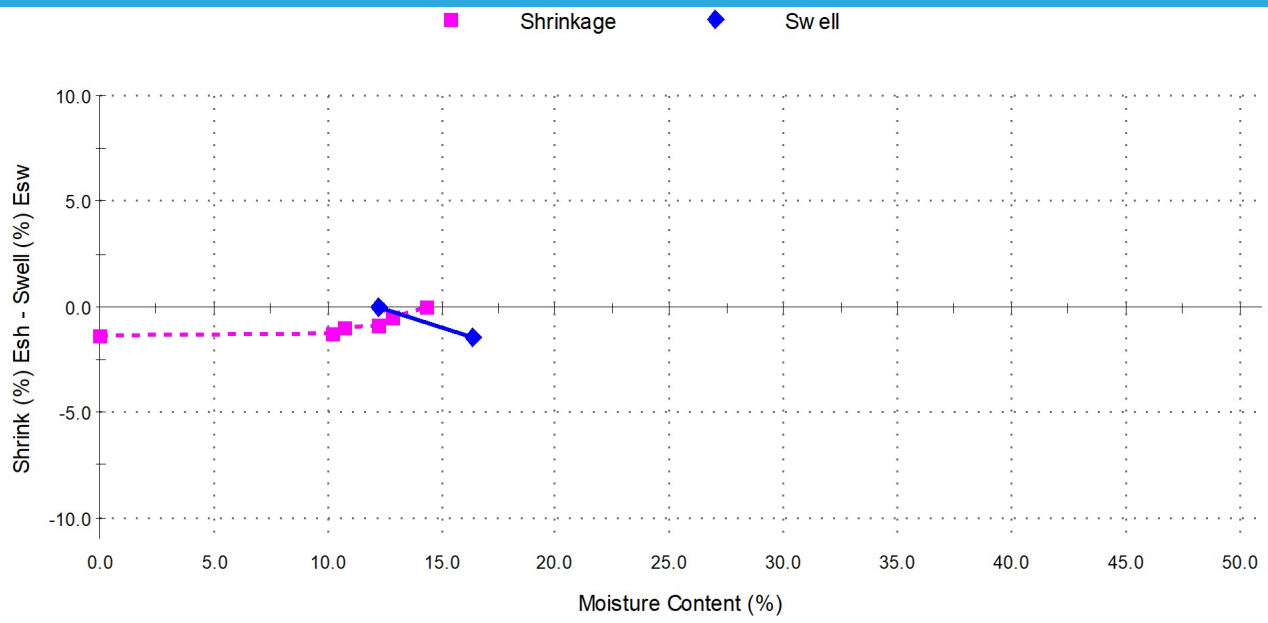
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-1.4
Moisture Content before (%):	12.2
Moisture Content after (%):	16.3
Est. Unc. Comp. Strength before (kPa):	220
Est. Unc. Comp. Strength after (kPa):	360

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	1.4
Shrinkage Moisture Content (%):	14.4
Est. inert material (%):	1%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Nil

Shrink Swell



Shrink Swell Index - Iss (%): 0.8

Comments

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Report No: MAT:NEW23W-3146-S06
Issue No: 1

Material Test Report

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Project No.: NEW15P-0070F
Project Name: Billy's Lookout - Stages 16, 17 & 24
Project Location: Teralba, NSW

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Results provided relate only to the items tested or sampled.
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Approved Signatory: Brent Cullen
(Engineering Geologist)
NATA Accredited Laboratory Number: 18686
Date of Issue: 12/07/2023

Sample Details

Sample ID: NEW23W-3146-S06
Date Sampled: 27/06/2023
Date Received: 28/06/2023
Source: On-Site Insitu
Material: Sandy Clay
Specification: No Specification
The results outlined below apply to the sample as received
Sample Location: BH2404 - (0.40 - 0.50m)

Test Results

Description	Method	Result	Limits
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	2.5	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	29	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	22	
Plasticity Index (%)	AS 1289.3.3.1	7	
Date Tested		11/07/2023	

Comments

N/A

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ABN: 98 153 268 896

Report No: MAT:NEW23W-3146-S07
Issue No: 1

Material Test Report

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Project No.: NEW15P-0070F
Project Name: Billy's Lookout - Stages 16, 17 & 24
Project Location: Teralba, NSW

Accredited for compliance with ISO/IEC 17025 - Testing.
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Approved Signatory: Brent Cullen
(Engineering Geologist)
NATA Accredited Laboratory Number: 18686
Date of Issue: 12/07/2023

Sample Details

Sample ID: NEW23W-3146-S07
Date Sampled: 27/06/2023
Date Received: 28/06/2023
Source: On-Site Insitu
Material: Sandy Clayey Gravel
Specification: No Specification
The results outlined below apply to the sample as received
Sample Location: BH2405 - (0.60 - 0.70m)

Test Results

Description	Method	Result	Limits
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	5.5	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	37	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	19	
Plasticity Index (%)	AS 1289.3.3.1	18	
Date Tested		11/07/2023	

Comments

N/A

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Report No: SSI:NEW23W-3146-S08
Issue No: 1

Shrink Swell Index Report

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Project No.: NEW15P-0070F
Project Name: Billy's Lookout - Stages 16, 17 & 24
Project Location: Teralba, NSW

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Approved Signatory: Brent Cullen
(Engineering Geologist)
NATA Accredited Laboratory Number: 18686
Date of Issue: 7/07/2023

Sample Details

Sample ID: NEW23W-3146-S08
Sampling Method: The results outlined below apply to the sample as received
Material: Sandy Clay
Source: On-Site Insitu
Specification: No Specification
Sample Location: BH2406 - (0.50 - 0.65m)
Date Tested: 3/07/2023
Date Sampled: 27/06/2023
Date Submitted: 28/06/2023

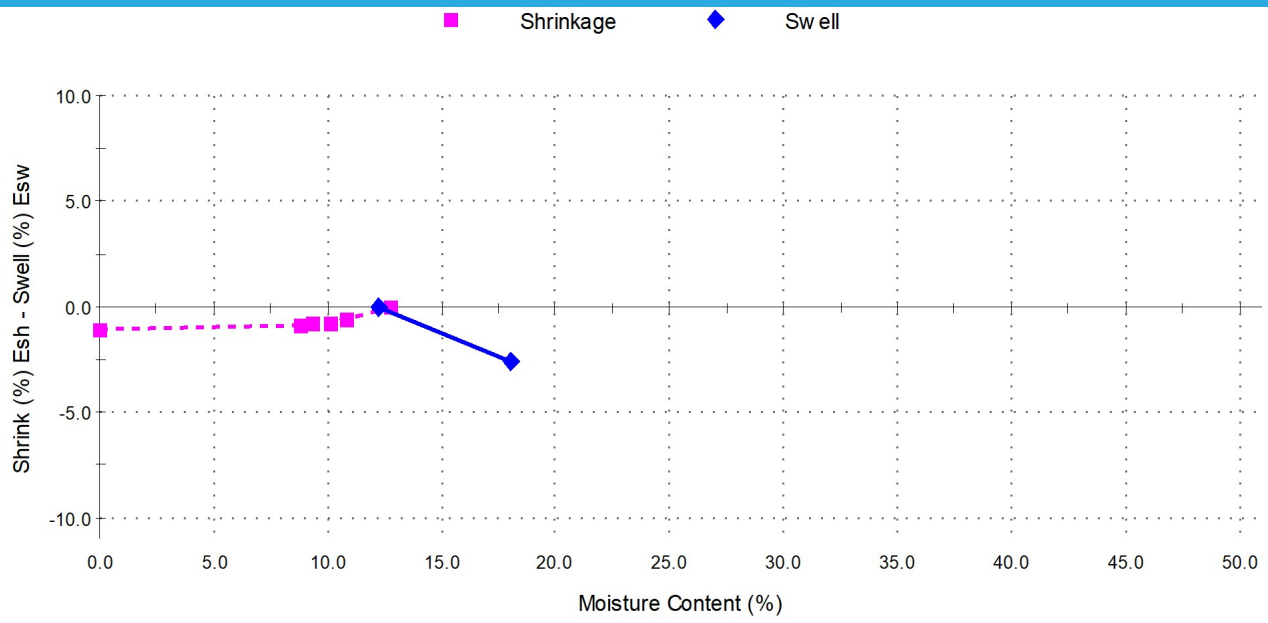
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-2.6
Moisture Content before (%):	12.2
Moisture Content after (%):	18.0
Est. Unc. Comp. Strength before (kPa):	200
Est. Unc. Comp. Strength after (kPa):	340

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	1.1
Shrinkage Moisture Content (%):	12.7
Est. inert material (%):	1%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 0.6

Comments

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Report No: SSI:NEW23W-3146-S09
Issue No: 1

Shrink Swell Index Report

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Project No.: NEW15P-0070F
Project Name: Billy's Lookout - Stages 16, 17 & 24
Project Location: Teralba, NSW

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Approved Signatory: Brent Cullen
(Engineering Geologist)
NATA Accredited Laboratory Number: 18686
Date of Issue: 7/07/2023

Sample Details

Sample ID: NEW23W-3146-S09
Sampling Method: The results outlined below apply to the sample as received
Material: Sandy Gravelly Clay
Source: On-Site Insitu
Specification: No Specification
Sample Location: BH2406 - (1.00 - 1.15m)
Date Tested: 3/07/2023
Date Sampled: 27/06/2023
Date Submitted: 28/06/2023

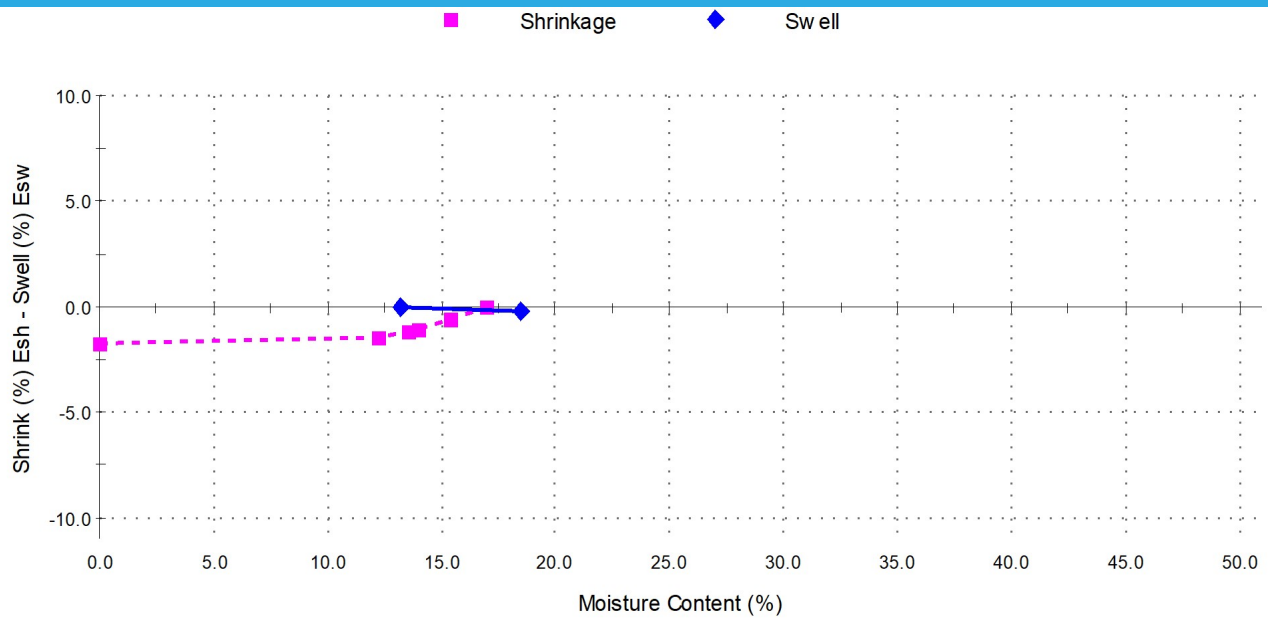
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.2
Moisture Content before (%):	13.2
Moisture Content after (%):	18.5
Est. Unc. Comp. Strength before (kPa):	230
Est. Unc. Comp. Strength after (kPa):	210

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	1.7
Shrinkage Moisture Content (%):	17.0
Est. inert material (%):	2%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 1.0

Comments

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Report No: SSI:NEW23W-3146-S10
Issue No: 1

Shrink Swell Index Report

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Project No.: NEW15P-0070F
Project Name: Billy's Lookout - Stages 16, 17 & 24
Project Location: Teralba, NSW

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Approved Signatory: Brent Cullen
(Engineering Geologist)
NATA Accredited Laboratory Number: 18686
Date of Issue: 7/07/2023

Sample Details

Sample ID: NEW23W-3146-S10
Sampling Method: The results outlined below apply to the sample as received
Material: Gravelly Sandy Clay
Source: On-Site Insitu
Specification: No Specification
Sample Location: BH2407 - (0.80 - 0.95m)
Date Tested: 3/07/2023
Date Sampled: 27/06/2023
Date Submitted: 28/06/2023

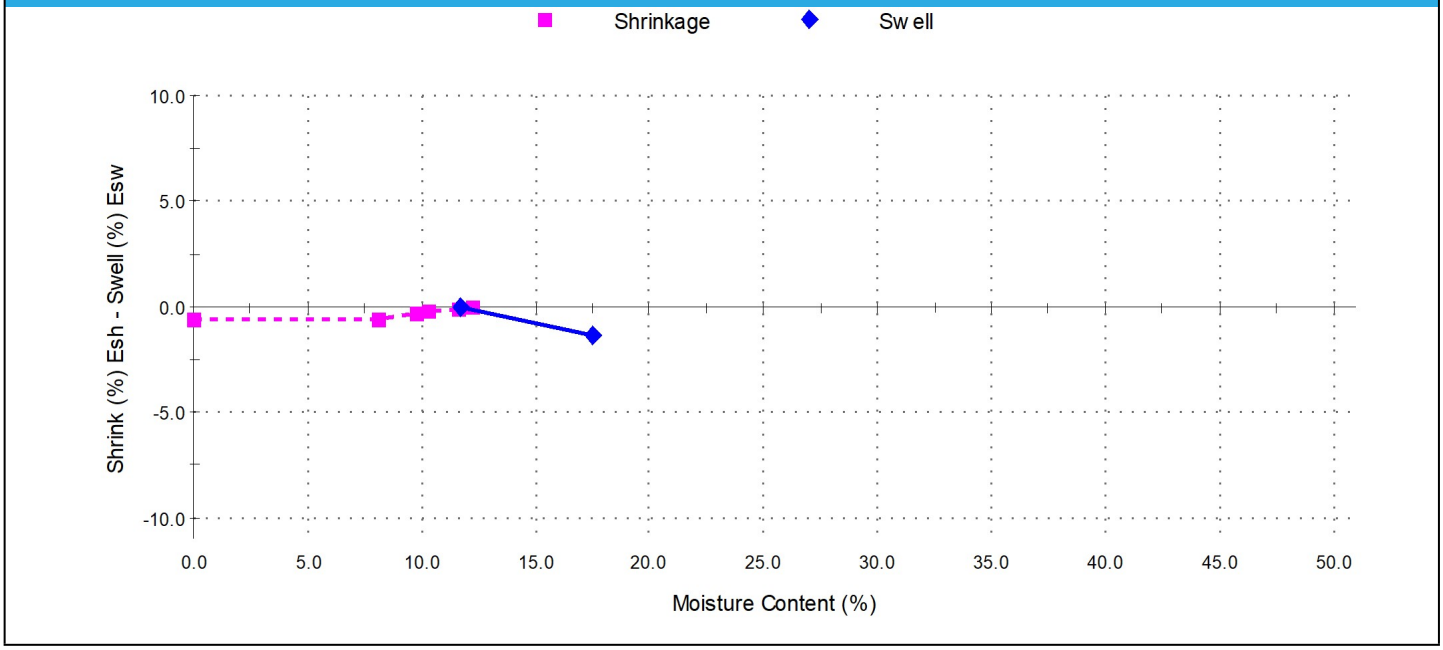
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-1.3
Moisture Content before (%):	11.7
Moisture Content after (%):	17.5
Est. Unc. Comp. Strength before (kPa):	>60
Est. Unc. Comp. Strength after (kPa):	390

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	0.6
Shrinkage Moisture Content (%):	12.2
Est. inert material (%):	3%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 0.4

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Report No: SSI:NEW23W-3146-S11
Issue No: 1

Shrink Swell Index Report

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Project No.: NEW15P-0070F
Project Name: Billy's Lookout - Stages 16, 17 & 24
Project Location: Teralba, NSW

Accredited for compliance with ISO/IEC 17025 - Testing.
Results provided relate only to the items tested or sampled.
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Approved Signatory: Brent Cullen
(Engineering Geologist)
NATA Accredited Laboratory Number: 18686
Date of Issue: 7/07/2023

Sample Details

Sample ID: NEW23W-3146-S11
Sampling Method: The results outlined below apply to the sample as received
Material: Gravelly Sandy Clay
Source: On-Site Insitu
Specification: No Specification
Sample Location: BH2408 - (0.50 - 0.70m)
Date Tested: 3/07/2023
Date Sampled: 27/06/2023
Date Submitted: 28/06/2023

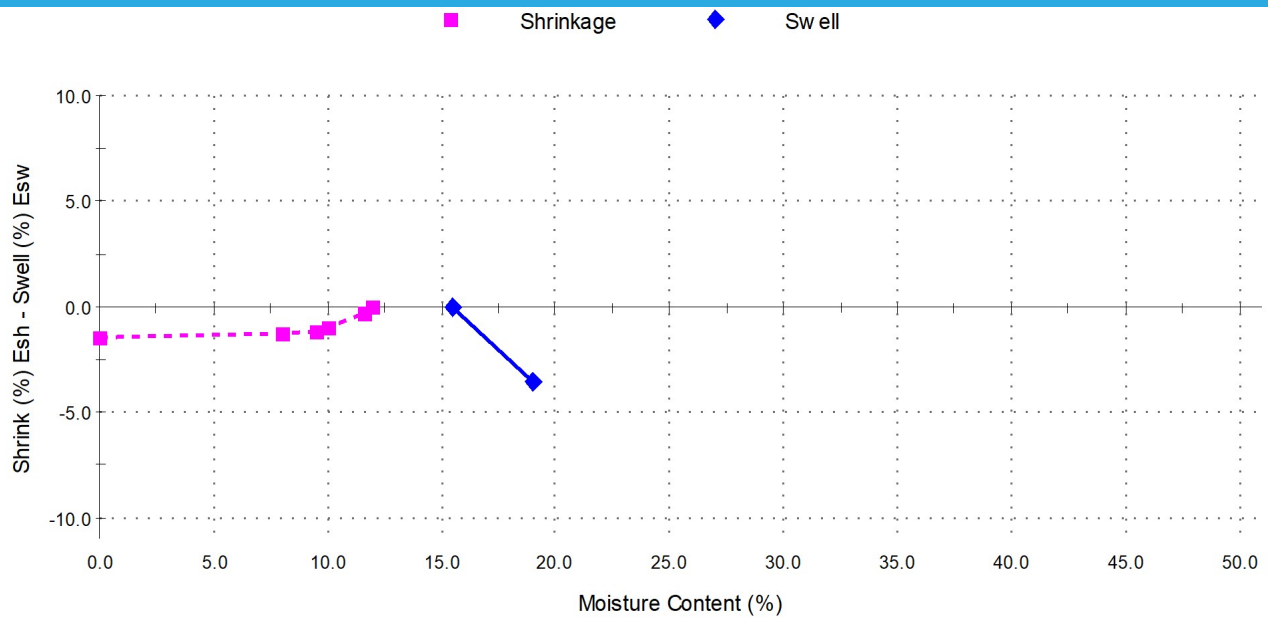
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-3.5
Moisture Content before (%):	15.5
Moisture Content after (%):	19.0
Est. Unc. Comp. Strength before (kPa):	410
Est. Unc. Comp. Strength after (kPa):	210

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	1.5
Shrinkage Moisture Content (%):	12.0
Est. inert material (%):	2%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 0.9

Comments

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Report No: SSI:NEW23W-3146-S12
Issue No: 1

Shrink Swell Index Report

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Project No.: NEW15P-0070F
Project Name: Billy's Lookout - Stages 16, 17 & 24
Project Location: Teralba, NSW

Accredited for compliance with ISO/IEC 17025 - Testing.
Results provided relate only to the items tested or sampled.
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Approved Signatory: Brent Cullen
(Engineering Geologist)
NATA Accredited Laboratory Number: 18686
Date of Issue: 7/07/2023

Sample Details

Sample ID: NEW23W-3146-S12
Sampling Method: The results outlined below apply to the sample as received
Material: Sandy Gravelly Clay
Source: On-Site Insitu
Specification: No Specification
Sample Location: BH2409 - (0.70 - 0.85m)
Date Tested: 3/07/2023
Date Sampled: 27/06/2023
Date Submitted: 28/06/2023

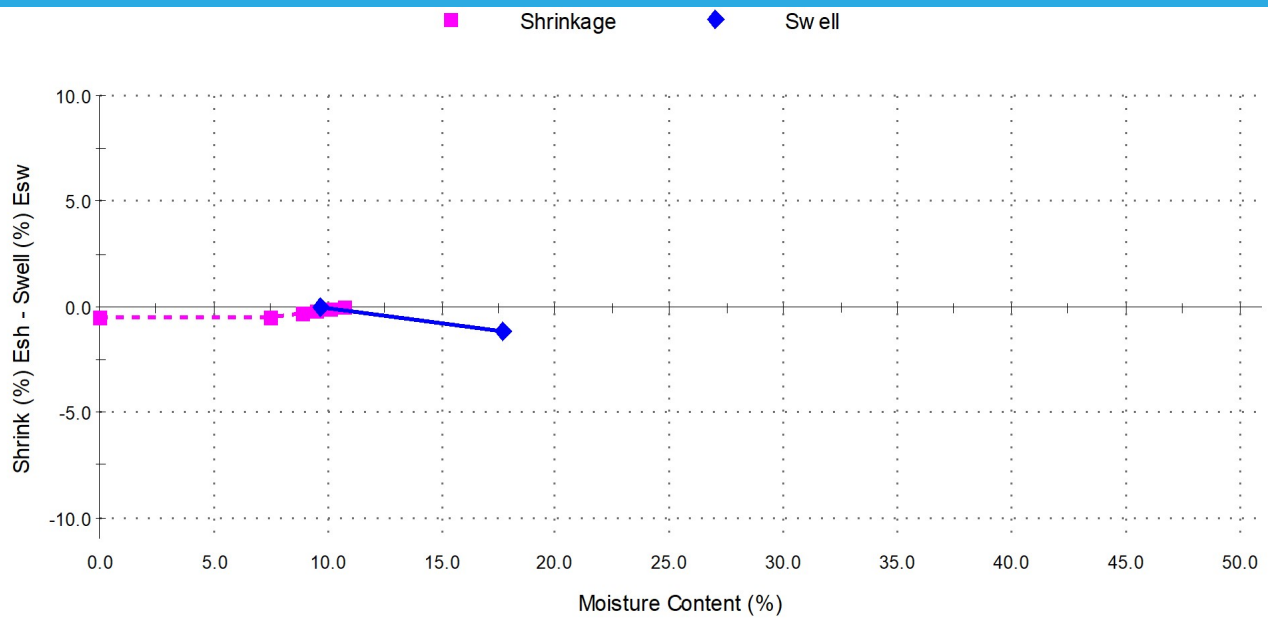
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-1.2
Moisture Content before (%):	9.6
Moisture Content after (%):	17.7
Est. Unc. Comp. Strength before (kPa):	210
Est. Unc. Comp. Strength after (kPa):	260

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	0.5
Shrinkage Moisture Content (%):	10.7
Est. inert material (%):	2%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 0.3

Comments

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APPENDIX C:

CSIRO Sheet BTF 18

Foundation Maintenance and Footing Performance: A Homeowner's Guide

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.

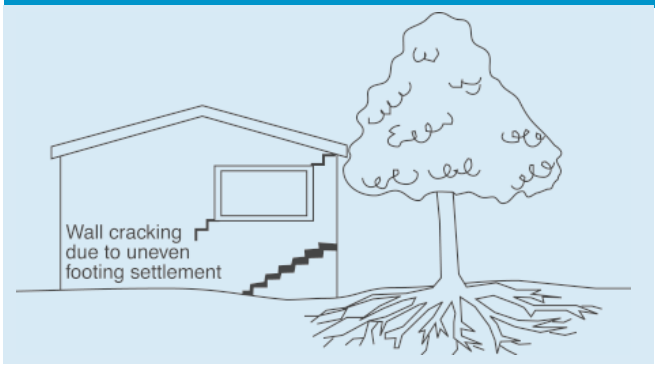
Seasonal swelling/shrinkage in clay

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.

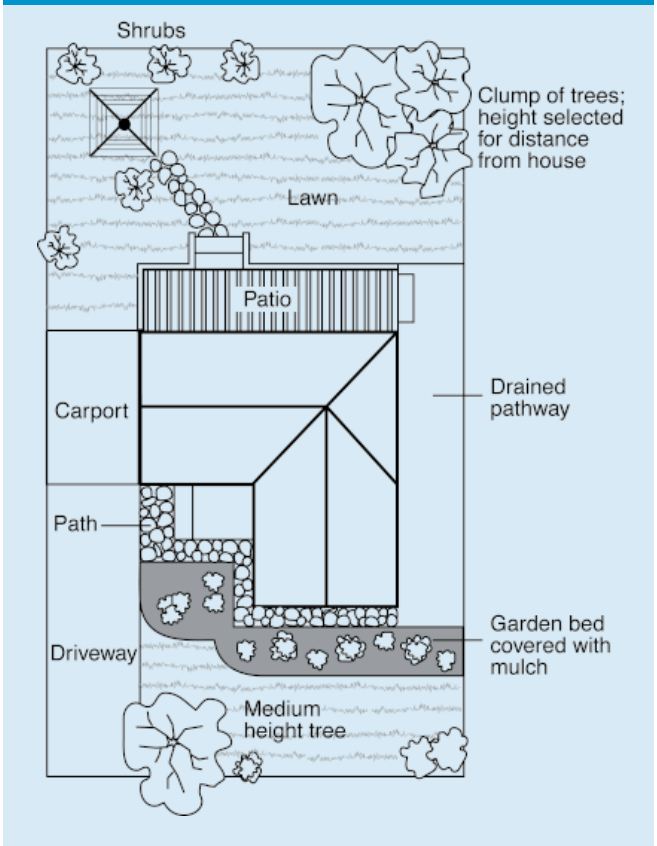
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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.

The information in this and other issues in the series was derived from various sources and was believed to be correct when published.

The information is advisory. It is provided in good faith and not claimed to be an exhaustive treatment of the relevant subject.

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