Residential Subdivision Billy's Lookout - Part Stage 23 (Lots 2301 to 2315) Site Classification

Fishermans Drive, Teralba

NEW15P-0070I-AA
29 January 2020

Qualtest
LABORATORY (NSW) PTY LTD

GEOTECHNICAL I LABORATORY I EARTHWORKS I QUARRY I CONSTRUCTION MATERIAL TESTING

29 January 2020

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

Attention: Harry Thomson

Dear Sir,

RE: RESIDENTIAL SUBDIVISION – BILLY'S LOOKOUT – PART STAGE 23
FISHERMANS DRIVE, TERALBA
SITE CLASSIFICATION (LOTS 2301 to 2315)

Please find enclosed our geotechnical report for part of Stage 23 (comprising Lots 2301 to 2315) of the 'Billy's Lookout' residential subdivision, located at Fishermans Drive, Teralba.

The report provides site classification with respect to reactive soils, in accordance with the requirements of AS2870-2011 '*Residential Slabs and Footings*', following the completion of site regrading earthworks on Lots 2301 to 2315.

If you have any questions regarding this report, please do not hesitate to contact Ben Bunting, 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 part of Stage 23 of the 'Billy's Lookout' residential subdivision, located at Fishermans Drive, Teralba.

Based on the brief and drawing provided by the client, Stage 23 is understood to comprise of 23 residential allotments (Lots 2301 to 2323). The scope of this report includes only Lots 2301 to 2315, as Lots 2316 to 2323 were covered by large fill stockpiles at the time of investigation.

The scope of work included providing site classification with respect to reactive soils, in accordance with the requirements of AS2870-2011 '*Residential Slabs and Footings*', for part of Stage 23 (Lots 2301 to 2315) 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:

- Site Classification report, 'Proposed Subdivision, Billy's Lookout – Stage 21, Fishermans Drive, Teralba, (Report Reference: NEW15P-0070C-AB, dated 27 February 2019);
- Site Classification report, 'Proposed Subdivision, Billy's Lookout – Stage 12, Fishermans Drive, Teralba, (Report Reference: NEW15P-0070A-AL, dated 5 April 2018);
- Site Classification report, 'Proposed Subdivision, Billy's Lookout – Stages 5 to 9, Fishermans Drive, Teralba, (Report Reference: NEW15P-0070A-AA, dated 16 February 2016);
- Site Classification report, 'Proposed Subdivision, Billy's Lookout – Stage 5, Fishermans Drive, Teralba, (Report Reference: NEW15P-0070A-AB, dated 16 June 2016);
- Level 1 Site Re-grade Assessment Report, 'Proposed Subdivision, Billy's Lookout – Stage 23, Fishermans Drive, Teralba (Report Reference: NEW17P-0183-AA, dated 11 April 2018); and
- Level 1 Site Re-grade Assessment Report, 'Proposed Subdivision, Billy's Lookout – Stage 23, Fishermans Drive, Teralba (Report Reference: NEW17P-0183-AB, dated 22 January 2020).

3.0 Field Work

Field work investigations were carried out on 30 October 2019, comprising of:

- Excavation of 9 test pits (TP2301 to TP2309) using a 2.7 tonne excavator with a 0.45m wide toothed bucket, to depths of between 1.20m and 2.10m;
- Undisturbed samples (U50 tubes) were taken for subsequent laboratory testing; and,
- Test pits were backfilled with the excavation spoil and compacted using the excavator bucket and tracks.

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

Approximate test pit locations are shown on the attached Figure AA1. Engineering logs of the test pits are presented in Appendix A.

4.0 Site Description

4.1 Site Regrade Works

The first stage of site re-grading works was conducted between 26 September 2017 and 5 March 2018. The re-grading works consisted of the cutting and filling of proposed residential lots within Stage 23 (Lots 2311 to 2323), and construction of Fishermans Drive road pavement to proposed subgrade level between Ch. 275m and 600m.

The second stage of site re-grading works was conducted between 15 February 2019 and 21 June 2019. The re-grading works consisted of the cutting and filling of proposed residential lots within Stage 23 of the subdivision (Lot 2301 to 2310).

Prior to filling, re-grade areas were stripped of all topsoil and unsuitable material to expose suitable natural foundation profile. Re-grade works then consisted of filling with approved site fill to finish design levels.

Filling was performed using site material won from excavations cut from around the site. The fill material could generally be described as mixtures of Gravelly Sandy CLAY, of low to medium plasticity, fine to coarse grained sand, and fine to coarse grained gravel.

The approximate depth of fill placed ranged in the order of about 0.3m to 4.0m in depth. These maximum depths were generally encountered within existing dry water courses and gullies, which traversed the site, and along the batter running the length of the project adjacent to the Main Northern Railway corridor.

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 re-grading works performed within the relevant part of Stage 23 of the development (i.e. the filling of Lots 2301 to 2315) 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 site regrade letters referenced in Section 2.0 for further details.

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, 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.

4.2 Surface Conditions

The site comprises part of proposed Stage 23 (Lots 2301 to 2315) of the Billy's Lookout subdivision, located off Fishermans Drive, Teralba, as shown on Figure AA1.

The site is located within a region of gently to moderately undulating topography, on the south to southwest facing mid to lower slopes of a prominent hill formation which rises to the north of the site. Extensive filling has been carried out on the site, primarily at the southern and southwestern boundary, which has made the slopes less steep for use as residential allotments.

The site is bounded to the north by previous Stages 12, 13, and 14, of the Billys Lookout subdivision, to the east by previous Stages 7 and 21, to the south by the Main Northern Railway, and to the west by Lots 2316 to 2323 of Stage 23.

On the day of the field investigations, Lots 2301 to 2315 had been cleared, and associated retaining walls and pavements had been constructed. Topsoil had not been placed on Lots 2301 to 2310, however Lots 2311 to 2315 had been topsoiled at the time of inspection. The adjacent Lots 2316 to 2323 had also been filled, but not topsoiled, associated pavements had not been constructed, and the lots were covered by large fill stockpiles.

The majority of the site was judged to be moderately drained by way of surface runoff and inter-allotment drainage, towards drainage reserves between residential allotments. Infiltration and ponded water from recent wet weather had caused isolated wet and boggy areas in the near surface soils at the southwestern boundaries of some the lots (Lots 2311 to 2315).

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 western boundary of Lot 2302, facing northeast.

Photograph 2: From western boundary of Lot 2302, facing southeast.

Photograph 3: From north-eastern boundary of Lots 2304 & 2305, facing southwest.

Photograph 4: From north-eastern boundary of Lots 2304 & 2305, facing northwest.

Photograph 5: From northern corner of Lot 2310, facing southeast.

Photograph 6: From northern corner of Lot 2310, facing southwest.

Photograph 7: From near south-eastern corner of Lot 2311, facing northwest.

Photograph 8: From near south-eastern corner of Lot 2311, facing northeast.

4.3 Subsurface Conditions

Reference to the 1:100,000 Newcastle Coalfield Regional Geology Sheet indicates the site to be underlain by the Clifton Subgroup of the Narrabeen Group, which is characterised by Conglomerate, Sandstone, Siltstone and Claystone 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 1 – SUMMARY OF GEOTECHNICAL UNITS AND SOIL TYPES

Unit	Soil Type	Description
1A	FILL – TOPSOIL & MULCH	Mulch – In TP2308 and TP2309, overlying; Gravelly Sandy CLAY, Sandy CLAY – low plasticity, grey-brown, fine to medium/coarse grained sand. Clayey SAND – fine to medium/coarse grained, pale grey-brown, fines of low plasticity, with some sticks.
1B	FILL - Controlled	Gravelly Sandy CLAY – medium plasticity, brown, pale orange-brown, grey-brown, fine to coarse grained sand, fine to coarse grained angular to sub-angular gravel, trace cobbles in places.
2	TOPSOIL	Not encountered within TP2301 to TP2309.
3	SLOPEWASH / COLLUVIUM	Not encountered within TP2301 to TP2309.
4	RESIDUAL SOIL	CLAY - medium to high plasticity, pale orange-brown, fine to medium grained (mostly fine grained) sand.
5	EXTREMELY WEATHERED (XW) ROCK	Not encountered within TP2301 to TP2309.
6	HIGHLY WEATHERED (HW) ROCK	SANDSTONE – fine to medium grained, red-brown and orange-brown with some pale grey, estimated medium to high strength.

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

TABLE 2 – SUMMARY OF GEOTECHNICAL UNITS ENCOUNTERED AT TEST PIT LOCATIONS

TEST PIT No.	UNIT 1A Fill - Topsoil & Mulch	UNIT 1B Fill - Controlled	Unit 2 Topsoil	Unit 3 Slopewash / Colluvium	Unit 4 Residual Soil	Unit 5 XW Rock	Unit 6 HW Rock
	Depth (m)						
Current Investigation (30 October 2019, After Site Regrade Works)							
TP2301	0.00 - 0.40	0.40 - 1.00	-	-	1.00 - 1.15	-	1.15 - 1.20*
TP2302	-	0.00 - 2.00	-	-	-	-	-
TP2303	-	0.00 - 2.10	-	-	-	-	-
TP2304	0.00 - 0.05	0.05 - 2.00	-	-	-	-	-
TP2305	0.00 - 0.15	0.15 - 2.00	-	-	-	-	-
TP2306	0.00 - 0.10	0.10 - 2.00	-	-	-	-	-
TP2307	0.00 - 0.10	0.10 - 2.00	-	-	-	-	-
TP2308	0.00 - 0.40	0.40 - 2.00	-	-	-	-	-
TP2309	0.00 - 0.40	0.40 - 2.00	-	-	-	-	-
Previous Geotechnical Investigation (Stage 21, Ref: NEW15P-0070C-AB, dated 27 February 2019)							
TP21B13	0.00 - 0.20	0.20 - 0.60	-	-	0.60 - 0.80	0.80 - 1.00*	-
TP21B14	0.00 - 0.15	-	-	-	0.15 - 0.25	-	0.25 - 0.30*
Previous Geotechnical Investigation (Stage 12, Ref: NEW15P-0070-AL, dated 5 April 2018)							
TP1203	0.00 - 0.15	-	-	-	0.15 - 1.00	1.00 - 1.30	1.30 - 1.35*
TP1204	0.00 - 0.03	-	-	-	0.03 - 0.90	0.90 - 1.30	1.30 - 1.50^

TEST PIT No.	UNIT 1A Fill - Topsoil & Mulch	UNIT 1B Fill - Controlled	Unit 2 Topsoil	Unit 3 Slopewash / Colluvium	Unit 4 Residual Soil	Unit 5 XW Rock	Unit 6 HW Rock
	Depth (m)						
Previous Geotechnical Investigation (Ref:NEW15P-0070B-AB, dated 26 June 2017) – Prior to Site Regrade Works							
TP312	-		0.00 - 0.17	-	0.17 - 1.70	-	1.70 - 1.80*
TP313	-		0.00 - 0.05	0.05 - 0.20	0.20 - 0.45	0.45 - 2.05	2.05 - 2.10*
TP316	-		0.00 - 0.10	0.10 - 0.24	1.00 - 1.90	0.24 - 1.00	-
TP319	-		0.00 - 0.15	0.15 - 0.90	0.90 - 2.30	-	-
TP320	-		0.00 - 0.10	0.10 - 1.50	1.50 - 2.20	-	-
TP323	-		0.00 - 0.13	0.13 - 0.30	0.30 - 0.50	0.50 - 1.80^	-
Previous Geotechnical Assessment (Ref: NEW15P-0070A-AA, February 2016) – Prior to Site Regrade Works							
TP102	-		0.00 - 0.60	-	-	0.60 - 1.10	-
TP105	-		-	0.00 - 0.25	-	0.25 - 1.00	-
Notes:	* = Practical refusal of 2.7 tonne excavator on Highly Weathered Rock. ^ = Very slow progress, close to practical refusal.						

No groundwater was encountered in the 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 Warabrook Laboratory for testing which comprised of:

- (5 no.) Shrink / Swell test; and,
- (4 no.) Atterberg Limits tests.

Results of the laboratory testing are included in Appendix B, with a summary of the Shrink/Swell and Atterberg Limits tests presented in Table 3 and Table 4, respectively.

TABLE 3 – SUMMARY OF SHRINK / SWELL TESTING RESULTS

Location	Depth (m)	Material Description	I_{ss} (%)
Current Investigation			
TP2301	0.60 – 0.70	FILL: (CI) Gravelly Sandy CLAY	2.4
TP2302	0.10 – 0.25	FILL: (CI) Gravelly Sandy CLAY	1.1
TP2306	0.30 – 0.50	FILL: (CI) Gravelly Sandy CLAY	1.8
TP2308	1.10 – 1.25	FILL: (CI) Gravelly Sandy CLAY	0.9
TP2309	0.40 – 0.55	FILL: (CI) Gravelly Sandy CLAY	1.1
Previous Geotechnical Investigation (Ref: NEW15P-0070C-AB, dated 27 February 2019)			
TP21B13	0.60 – 0.80	(CI) Sandy CLAY	1.1
Previous Geotechnical Investigation (Ref: NEW15P-0070B-AB, 26 June 2017)			
TP316	1.00 – 1.20	(CH) Silty CLAY	2.5

TABLE 4 – SUMMARY OF ATTERBERG LIMITS TESTING RESULTS

Location	Depth (m)	Material Description	Liquid Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)
Current Investigation					
TP2303	0.60 – 0.80	FILL: (CI) Gravelly Sandy CLAY	30	13	6.0
TP2304	0.15 – 0.30	FILL: (CI) Gravelly Sandy CLAY	38	22	9.0
TP2305	0.40 – 0.60	FILL: (CI) Gravelly Sandy CLAY	31	17	5.5
TP2307	0.10 – 0.25	FILL: (CI) Gravelly Sandy CLAY	29	16	5.0
Previous Geotechnical Investigation (Ref: NEW15P-0070A-AL, dated 5 April 2018)					
TP1203	0.40 – 0.60	(CH) Silty CLAY	37	20	7.0
TP1204	0.30 – 0.50	(CH) Silty CLAY	37	18	7.5

Location	Depth (m)	Material Description	Liquid Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)
Previous Geotechnical Investigation (Ref: NEW15P-0070B-AB, 26 June 2017)					
TP305	0.80 – 1.00	(CH) Sandy CLAY	48	27	10.0
TP313	0.20 – 0.40	(CH) Sandy CLAY	45	24	8.5
TP319	1.10 – 1.40	(CI) Sandy CLAY	31	17	5.0
TP320	0.50 – 0.80	(SC) Clayey SAND	21	6	3.0
TP320	1.60 – 1.80	(CH) Sandy CLAY	43	24	6.5

6.0 Site Classification to AS2870-2011

Based on the results of the field work and laboratory testing, residential lots located within the part of Stage 23 of the Billy's Lookout subdivision located at Fishermans Drive, Teralba, as shown on Figure AB1, 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	Lot Numbers	Site Classification
23	2301 to 2315	**H1**

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

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 the type of fill and 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; and,
- 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 regardless of their site classification should be supported on footings founded beneath all uncontrolled fill, layers of inadequate bearing capacity, soft/loose, or other potentially deleterious material.

If any 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

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.

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

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

Data and opinions contained within the report may not be used in other contexts or for any other purposes without prior review and agreement by Qualtest. If this report is reproduced, it must be in full.

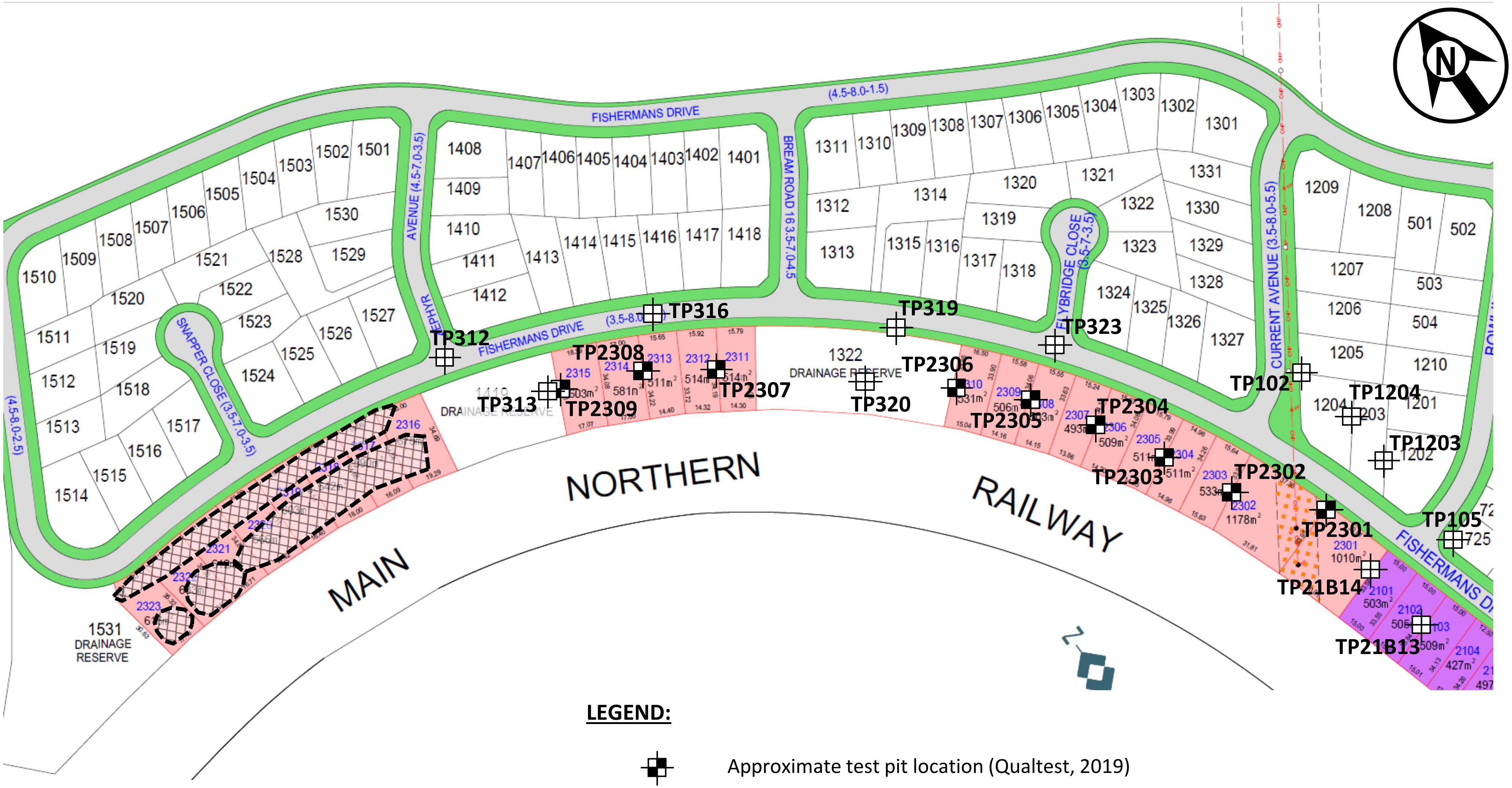
If you have any further questions regarding this report, please do not hesitate to contact Ben Bunting, Shannon Kelly, or the undersigned.

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

Jason Lee
Principal Geotechnical Engineer

FIGURES:

Figure AA1 – Site Plan and Approximate Test Locations



LEGEND:

Approximate test pit location (Qualtest, 2019)

Approximate test pit location (Various previous investigations, Qualtest, 2016 - 2019)

Approximate location of fill stockpiles with approximate depths > 0.4m

Based on plans prepared by High Definition Design Pty Ltd
(Project No. HD16, Dwg No. RA2, Rev. 7, dated 08/03/2018)

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Client:	MCCLOY GROUP	Drawing No:	FIGURE AA1
Project:	PROPOSED SUBDIVISION, BILLYS LOOKOUT - PART STAGE 23	Project No:	NEW15P-0070I
Location:	FISHERMANS DRIVE, TERALBA	Scale:	N.T.S.
Title:	SITE PLAN AND APPROXIMATE TEST LOCATIONS	Date:	29/01/2020

APPENDIX A:

Engineering Logs of Test Pits

ENGINEERING LOG - TEST PIT

TEST PIT NO: TP2301
PAGE: 1 OF 1
JOB NO: NEW15P-0070I
LOGGED BY: BB
DATE: 30/10/19

CLIENT: MCCLOY GROUP PTY LTD
PROJECT: BILLYS LOOKOUT - STAGE 23
LOCATION: FISHERMANS DRIVE, TERALBA

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
SURFACE RL:
DATUM:

METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics, colour, minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Field Test: Test Type	Field Test: Result	Structure and additional observations
E	Not Encountered			0.00–0.40m	CL	FILL-TOPSOIL: Sandy CLAY - low plasticity, grey-brown, fine to coarse grained (mostly fine to medium grained) sand, with some fine to coarse grained (mostly fine to medium grained) sub-angular to angular gravel, trace sticks.	M ~ Wp				FILL - TOPSOIL
		0.60m U50 0.70m		0.40m–1.00m	CI	FILL: Gravelly Sandy CLAY - medium plasticity, pale orange-brown and grey, fine to coarse grained (mostly fine to medium grained) sand, fine to coarse grained angular to sub-angular gravel, trace cobbles.	M ~ Wp (to ~0.80m); M > Wp	VSt - H (to ~0.80m); St - VSt	HP HP HP HP HP	450 480 360 250 180	FILL - CONTROLLED
				1.00m–1.15m	CH	CLAY - medium to high plasticity, pale orange-brown, fine to medium grained (mostly fine grained) sand.	M < Wp	H	HP	>600	RESIDUAL SOIL
				1.20m		SANDSTONE - fine to medium grained, red-brown and orange-brown with some pale grey, estimated medium to high strength.	D				HIGHLY WEATHERED ROCK

Hole Terminated at 1.20 m
Practical Refusal

Depth scale: 0.5, 1.0, 1.5, 2.0

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%

ENGINEERING LOG - TEST PIT

CLIENT: MCCLOY GROUP PTY LTD
PROJECT: BILLYS LOOKOUT - STAGE 23
LOCATION: FISHERMANS DRIVE, TERALBA

TEST PIT NO: TP2302
PAGE: 1 OF 1
JOB NO: NEW15P-0070I
LOGGED BY: BB
DATE: 30/10/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
SURFACE RL:
DATUM:

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
E	Not Encountered	0.10m U50 0.25m		0.0 – 2.0		CI	FILL: Gravelly Sandy CLAY - medium plasticity, pale orange-brown, fine to coarse grained (mostly fine to medium grained) sand, fine to coarse grained sub-angular to angular gravel.	M ~ W_P	H	HP	>600	FILL - CONTROLLED
							Pale brown, trace cobbles.	M < W_P		HP	>600	
										HP	>600	
				0.5						HP	>600	
				1.0						HP	>600	
										HP	>600	
				1.5						HP	>600	
										HP	>600	
										HP	>600	
				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%

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT:	MCCLOY GROUP PTY LTD	TEST PIT NO:	TP2303
PROJECT:	BILLYS LOOKOUT - STAGE 23	PAGE:	1 OF 1
LOCATION:	FISHERMANS DRIVE, TERALBA	JOB NO:	NEW15P-0070I
		LOGGED BY:	BB
		DATE:	30/10/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR **SURFACE RL:**
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **DATUM:**

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
E	Not Encountered			0.0 – 2.10		CI	FILL: Gravelly Sandy CLAY - medium plasticity, pale orange-brown, fine to coarse grained (mostly fine to medium grained) sand, fine to coarse grained (mostly fine to medium grained) sub-angular to angular gravel.	M ~ W_P	H	HP	>600	FILL - CONTROLLED
										HP	>600	
		0.60m U50 0.80m		0.5			Grey-brown, fine to coarse grained gravel, with some cobbles.	M < W_P		HP	>600	
										HP	>600	
				1.0						HP	>600	
										HP	>600	
				1.5						HP	>600	
										HP	>600	
				2.0			2.10m			HP	>600	
							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	

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%

ENGINEERING LOG - TEST PIT

CLIENT:	MCCLOY GROUP PTY LTD	**TEST PIT NO:**	**TP2304**
PROJECT:	BILLYS LOOKOUT - STAGE 23	**PAGE:**	1 OF 1
LOCATION:	FISHERMANS DRIVE, TERALBA	**JOB NO:**	NEW15P-0070I
		LOGGED BY:	BB
		DATE:	30/10/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR **SURFACE RL:**
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **DATUM:**

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
E	Not Encountered			0.05m		CL	FILL-TOPSOIL: Gravelly Sandy CLAY - low to medium plasticity, grey-brown, fine to coarse grained sand, fine to coarse grained sub-angular to angular gravel, trace sticks.	D				FILL - TOPSOIL
		0.15m U50 0.30m				CI	FILL: Gravelly Sandy CLAY - medium plasticity, pale brown, fine to coarse grained sand, fine to coarse grained sub-angular to angular gravel.	M ~ w_P	H	HP	>600	FILL - CONTROLLED
										HP	>600	
				0.5			Grey-brown to brown.			HP	>600	
										HP	>600	
							Pale brown.					
				1.0						HP	>600	
										HP	>600	
										HP	>600	
				1.5						HP	>600	
										HP	>600	
				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%

ENGINEERING LOG - TEST PIT

CLIENT:	MCCLOY GROUP PTY LTD	**TEST PIT NO:**	**TP2305**
PROJECT:	BILLYS LOOKOUT - STAGE 23	**PAGE:**	1 OF 1
LOCATION:	FISHERMANS DRIVE, TERALBA	**JOB NO:**	NEW15P-0070I
		LOGGED BY:	BB
		DATE:	30/10/19

Qualtest LABORATORY (NSW) PTY LTD

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR **SURFACE RL:**
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **DATUM:**

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
E	Not Encountered			0.15m		CL	FILL-TOPSOIL: Clayey SAND - fine to coarse grained (mostly fine grained), pale grey-brown, fines of low plasticity, with some sticks.	D				FILL - TOPSOIL
		0.40m U50 0.60m		0.5, 1.0, 1.5, 2.00m		CI	FILL: Gravelly Sandy CLAY - medium plasticity, brown to grey-brown, fine to coarse grained sand, fine to coarse grained sub-angular to angular gravel, with some cobbles.	M ~ W_p	H	HP HP HP HP HP HP HP HP HP	>600 >600 >600 >600 >600 >600 >600 >600 >600	FILL - CONTROLLED
							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%

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT:	MCCLOY GROUP PTY LTD	TEST PIT NO:	TP2306
PROJECT:	BILLYS LOOKOUT - STAGE 23	PAGE:	1 OF 1
LOCATION:	FISHERMANS DRIVE, TERALBA	JOB NO:	NEW15P-0070I
		LOGGED BY:	BB
		DATE:	30/10/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR **SURFACE RL:**
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **DATUM:**

METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
E	Not Encountered			0.00–0.10m	CL	FILL-TOPSOIL: Clayey SAND - fine to medium grained (mostly fine grained), pale grey-brown, fines of low plasticity, trace sticks.	D - M				FILL - TOPSOIL
		0.30m U50 0.50m		0.10–2.00m	CI	FILL: Gravelly Sandy CLAY - medium plasticity, pale brown, fine to coarse grained sand, fine to coarse grained sub-angular to angular gravel, with some cobbles.	M ~ W_P	VSt	HP	330	FILL - CONTROLLED
							M ~ W_P	VSt	HP	280	
							M > W_P	St	HP	150	
							M > W_P	St	HP	180	
							M ~ W_P	VSt	HP	320	
							M ~ W_P	VSt	HP	360	
							M < W_P	H	HP	450	
							M < W_P	H	HP	500	
							M < W_P	H	HP	450	
							M < W_P	H	HP	>600	
							M < W_P	H	HP	>600	
				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%

ENGINEERING LOG - TEST PIT

CLIENT:	MCCLOY GROUP PTY LTD	TEST PIT NO:	TP2307
PROJECT:	BILLYS LOOKOUT - STAGE 23	PAGE:	1 OF 1
LOCATION:	FISHERMANS DRIVE, TERALBA	JOB NO:	NEW15P-0070I
		LOGGED BY:	BB
		DATE:	30/10/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR **SURFACE RL:**
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **DATUM:**

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
E	Not Encountered	0.10m				CL	FILL-TOPSOIL: Sandy CLAY - low plasticity, grey-brown, fine to coarse grained (mostly fine to medium grained) sand, trace fine grained rounded to sub-rounded gravel, with some sticks.	M < Wp				FILL - TOPSOIL
		U50 0.25m		0.10m		CI	FILL: Gravelly Sandy CLAY - medium plasticity, pale brown to pale orange-brown, fine to coarse grained sand, fine to coarse grained sub-angular to angular gravel, trace cobbles.	M ~ Wp	H	HP	>600	FILL - CONTROLLED
										HP	>600	
				0.5						HP	>600	
										HP	>600	
				1.0						HP	>600	
							Grey-brown.			HP	>600	
				1.5						HP	>600	
										HP	>600	
										HP	>600	
				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%

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT: MCCLOY GROUP PTY LTD
PROJECT: BILLYS LOOKOUT - STAGE 23
LOCATION: FISHERMANS DRIVE, TERALBA

TEST PIT NO: TP2308
PAGE: 1 OF 1
JOB NO: NEW15P-0070I
LOGGED BY: BB
DATE: 30/10/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
SURFACE RL:
DATUM:

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
E	Not Encountered			0.00–0.20			FILL: MULCH	M				FILL - MULCH
				0.20–0.40		CL	FILL-TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine to medium grained sand, with some sticks.	M > W_p				FILL - TOPSOIL
		U50 1.10m–1.25m		0.40–2.00		CI	FILL: Gravelly Sandy CLAY - medium plasticity, pale brown, fine to coarse grained sand, fine to coarse grained sub-angular to angular gravel. Pale orange-brown. Grey-brown.	M > W_p (to ~0.5 m); M ~ W_p	H	HP HP HP HP HP HP HP HP	>600 >600 >600 >600 >600 >600 >600 >600	FILL - CONTROLLED
				2.00			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%

ENGINEERING LOG - TEST PIT

CLIENT:	MCCLOY GROUP PTY LTD	**TEST PIT NO:**	**TP2309**
PROJECT:	BILLYS LOOKOUT - STAGE 23	**PAGE:**	1 OF 1
LOCATION:	FISHERMANS DRIVE, TERALBA	**JOB NO:**	NEW15P-0070I
		LOGGED BY:	BB
		DATE:	30/10/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR **SURFACE RL:**
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **DATUM:**

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
E	Not Encountered						FILL: MULCH	M				FILL - MULCH
		0.40m U50 0.55m		0.40m		CI	FILL: Gravelly Sandy CLAY - medium plasticity, pale brown, fine to coarse grained sand, fine to coarse grained sub-angular to angular gravel, trace cobbles.	M ~ W_P	H	HP	>600	FILL - CONTROLLED
				0.5						HP	>600	
										HP	>600	
				1.0						HP	>600	
										HP	>600	
				1.5						HP	>600	
										HP	>600	
										HP	>600	
				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%

APPENDIX B:

Results of Laboratory Testing

QUALTEST Laboratory (NSW) Pty Ltd (20708)
8 Ironbark Close Warabrook 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:NEW19W-3827--S01
Issue No: 1

Shrink Swell Index Report

Client:	McCloy Development Management Pty Ltd Suite 2, Ground Floor, 317 Hunter Street Newcastle NSW 2300
Principal:	
Project No.:	NEW15P-0070I
Project Name:	Billy's Lookout - Stage 23

NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 13/11/2019

Sample Details

Sample ID:	NEW19W-3827--S01	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	Sampled by Engineering Department
Material:	Gravelly Sandy CLAY	**Date Sampled:**	30/10/2019
Source:	On-Site	**Date Submitted:**	7/11/2019
Specification:	No Specification		
Project Location:	Teralba, NSW		
Sample Location:	TP23-01 - 0.60 to 0.70m		
Borehole Number:	TP23-01		
Borehole Depth (m):	0.60 - 0.70		

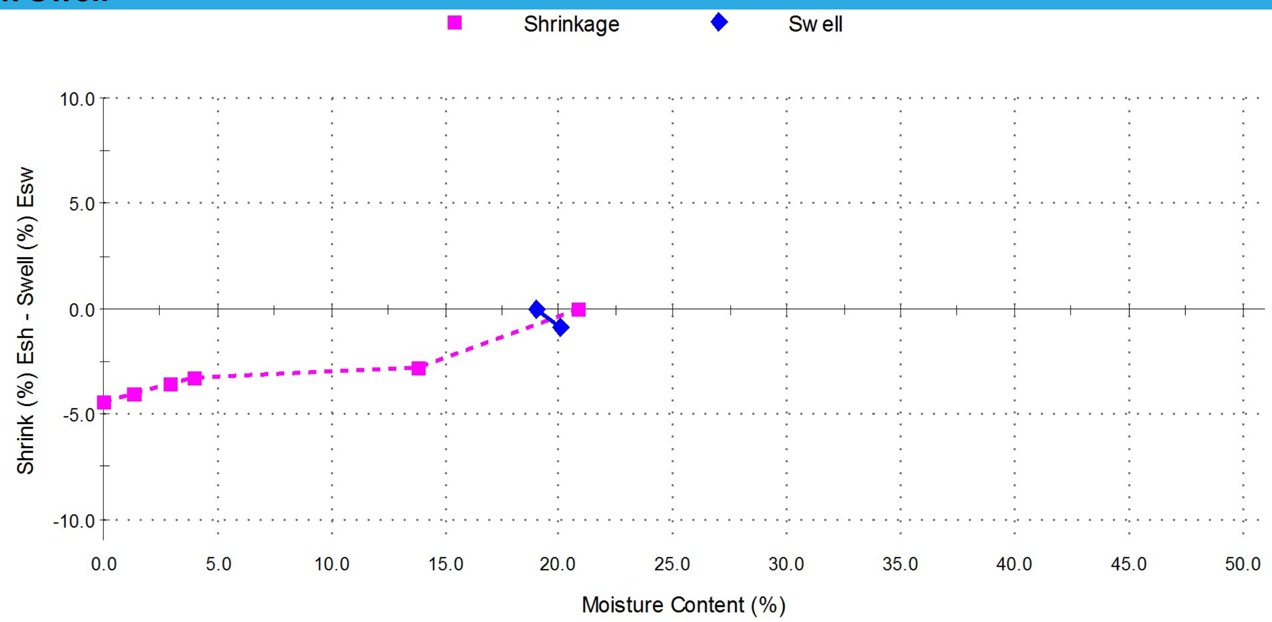
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.9
Moisture Content before (%):	19.0
Moisture Content after (%):	20.1
Est. Unc. Comp. Strength before (kPa):	250
Est. Unc. Comp. Strength after (kPa):	200

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	4.4
Shrinkage Moisture Content (%):	20.8
Est. inert material (%):	3.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Nil

Shrink Swell



Shrink Swell Index - Iss (%): 2.4

Comments

The results outlined above apply to the sample as received

QUALTEST Laboratory (NSW) Pty Ltd (20708)
8 Ironbark Close Warabrook 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:NEW19W-3827--S02
Issue No: 1

Shrink Swell Index Report

Client:	McCloy Development Management Pty Ltd Suite 2, Ground Floor, 317 Hunter Street Newcastle NSW 2300
Principal:	
Project No.:	NEW15P-0070I
Project Name:	Billy's Lookout - Stage 23

NATA WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 13/11/2019

Sample Details

Sample ID:	NEW19W-3827--S02	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	Sampled by Engineering Department
Material:	Gravelly Sandy CLAY	**Date Sampled:**	30/10/2019
Source:	On-Site	**Date Submitted:**	7/11/2019
Specification:	No Specification		
Project Location:	Teralba, NSW		
Sample Location:	TP23-02 - 0.10 to 0.25m		
Borehole Number:	TP23-02		
Borehole Depth (m):	0.10 - 0.25		

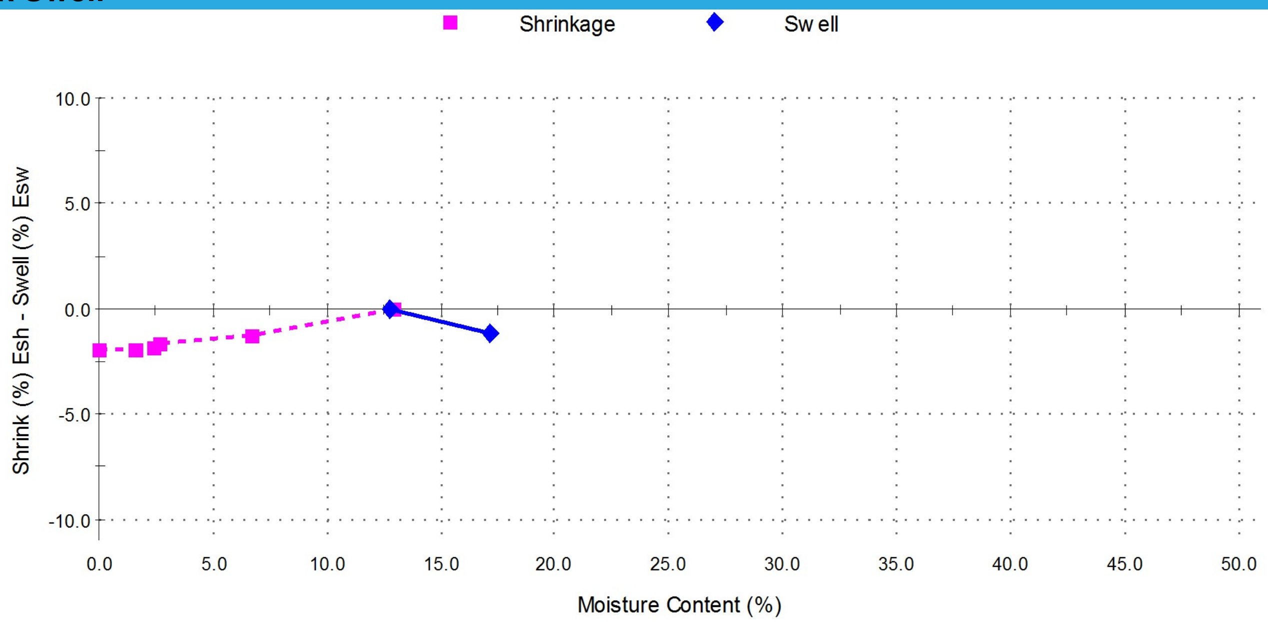
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-1.2
Moisture Content before (%):	12.7
Moisture Content after (%):	17.1
Est. Unc. Comp. Strength before (kPa):	> 600
Est. Unc. Comp. Strength after (kPa):	> 600

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	1.9
Shrinkage Moisture Content (%):	12.9
Est. inert material (%):	10.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Nil

Shrink Swell



Shrink Swell Index - Iss (%): 1.1

Comments

The results outlined above apply to the sample as received

QUALTEST Laboratory (NSW) Pty Ltd (20708)
8 Ironbark Close Warabrook 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:NEW19W-3827--S03
Issue No: 1

Material Test Report

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

Principal:
Project No.: NEW15P-0070I
Project Name: Billy's Lookout - Stage 23

NATA WORLD RECOGNISED ACCREDITATION

Approved Signatory: Alan Cullen
(Principal Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 15/11/2019

Sample Details

Sample ID: NEW19W-3827--S03
Client Sample ID: -
Sampling Method: Sampled by Engineering Department
Date Sampled: 30/10/2019
Source: On-Site
Material: Gravelly Sandy CLAY
Specification: No Specification
Project Location: Teralba, NSW
TRN -
Sample Location: TP23-03 - 0.60 to 0.80m

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	6.0	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	30	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	17	
Plasticity Index (%)	AS 1289.3.3.1	13	

Comments

The results outlined above apply to the sample as received

QUALTEST Laboratory (NSW) Pty Ltd (20708)
8 Ironbark Close Warabrook 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:NEW19W-3827--S04
Issue No: 1

Material Test Report

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

Principal:
Project No.: NEW15P-0070I
Project Name: Billy's Lookout - Stage 23

WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 13/11/2019

Sample Details

Sample ID: NEW19W-3827--S04
Client Sample ID: -
Sampling Method: Sampled by Engineering Department
Date Sampled: 30/10/2019
Source: On-Site
Material: Gravelly Sandy CLAY
Specification: No Specification
Project Location: Teralba, NSW
TRN -
Sample Location: TP23-04 - 0.15 to 0.30m

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	9.0	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Cracking		No	
Liquid Limit (%)	AS 1289.3.1.1	38	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	16	
Plasticity Index (%)	AS 1289.3.3.1	22	

Comments

The results outlined above apply to the sample as received

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Report No: MAT:NEW19W-3827--S05
Issue No: 1

Material Test Report

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

Principal:
Project No.: NEW15P-0070I
Project Name: Billy's Lookout - Stage 23

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 13/11/2019

Sample Details

Sample ID: NEW19W-3827--S05
Client Sample ID: -
Sampling Method: Sampled by Engineering Department
Date Sampled: 30/10/2019
Source: On-Site
Material: Gravelly Sandy CLAY
Specification: No Specification
Project Location: Teralba, NSW
TRN -
Sample Location: TP23-05 - 0.40 to 0.60m

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	5.5	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Cracking		No	
Liquid Limit (%)	AS 1289.3.1.1	31	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	14	
Plasticity Index (%)	AS 1289.3.3.1	17	

Comments

The results outlined above apply to the sample as received

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Report No: SSI:NEW19W-3827--S06
Issue No: 1

Shrink Swell Index Report

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

Principal:
Project No.: NEW15P-0070I
Project Name: Billy's Lookout - Stage 23

NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 13/11/2019

Sample Details

Sample ID:	NEW19W-3827--S06	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	Sampled by Engineering Department
Material:	Gravelly Sandy CLAY	**Date Sampled:**	30/10/2019
Source:	On-Site	**Date Submitted:**	7/11/2019
Specification:	No Specification		
Project Location:	Teralba, NSW		
Sample Location:	TP23-06 - 0.30 to 0.50m		
Borehole Number:	TP23-06		
Borehole Depth (m):	0.30 - 0.50		

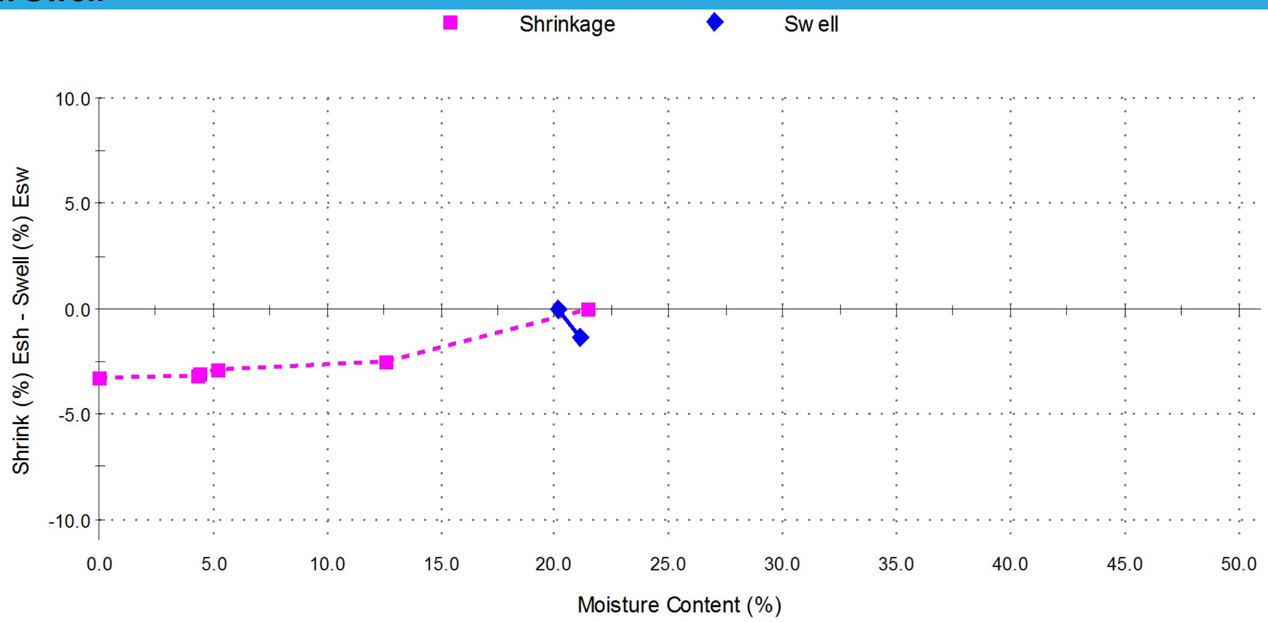
Swell Test — AS 1289.7.1.1

Swell on Saturation (%):	-1.4
Moisture Content before (%):	20.2
Moisture Content after (%):	21.1
Est. Unc. Comp. Strength before (kPa):	200
Est. Unc. Comp. Strength after (kPa):	100

Shrink Test — AS 1289.7.1.1

Shrink on drying (%):	3.3
Shrinkage Moisture Content (%):	21.5
Est. inert material (%):	10.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Moderate

Shrink Swell



Shrink Swell Index - Iss (%): 1.8

Comments

The results outlined above apply to the sample as received

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Report No: MAT:NEW19W-3827--S07
Issue No: 1

Material Test Report

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

Principal:
Project No.: NEW15P-0070I
Project Name: Billy's Lookout - Stage 23

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Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 13/11/2019

Sample Details

Sample ID: NEW19W-3827--S07
Client Sample ID: -
Sampling Method: Sampled by Engineering Department
Date Sampled: 30/10/2019
Source: On-Site
Material: Gravelly Sandy CLAY
Specification: No Specification
Project Location: Teralba, NSW
TRN -
Sample Location: TP23-07 - 0.10 to 0.25m

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	5.0	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Cracking		No	
Liquid Limit (%)	AS 1289.3.1.1	29	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	13	
Plasticity Index (%)	AS 1289.3.3.1	16	

Comments

The results outlined above apply to the sample as received

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Report No: SSI:NEW19W-3827--S08
Issue No: 1

Shrink Swell Index Report

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

Principal:
Project No.: NEW15P-0070I
Project Name: Billy's Lookout - Stage 23

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Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 13/11/2019

Sample Details

Sample ID:	NEW19W-3827--S08	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	Sampled by Engineering Department
Material:	Gravelly Sandy CLAY	**Date Sampled:**	30/10/2019
Source:	On-Site	**Date Submitted:**	7/11/2019
Specification:	No Specification		
Project Location:	Teralba, NSW		
Sample Location:	TP23-08 - 1.10 to 1.25m		
Borehole Number:	TP23-08		
Borehole Depth (m):	1.10 - 1.25		

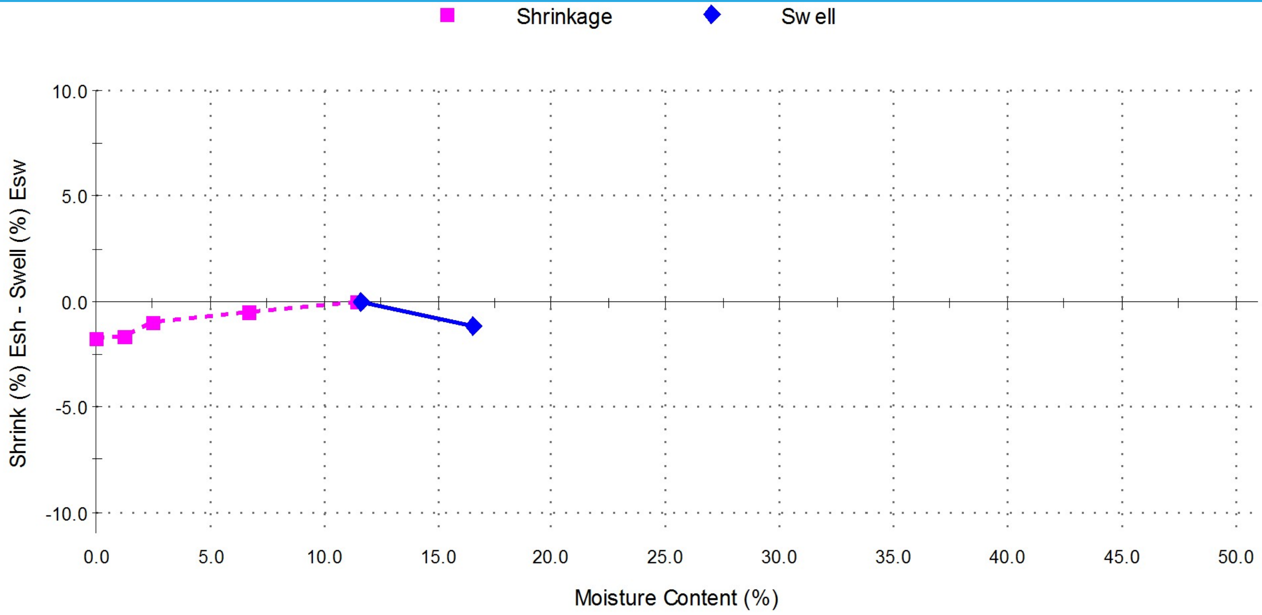
Swell Test — AS 1289.7.1.1

Swell on Saturation (%):	-1.2
Moisture Content before (%):	11.6
Moisture Content after (%):	16.5
Est. Unc. Comp. Strength before (kPa):	> 600
Est. Unc. Comp. Strength after (kPa):	500

Shrink Test — AS 1289.7.1.1

Shrink on drying (%):	1.7
Shrinkage Moisture Content (%):	11.5
Est. inert material (%):	10.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 0.9

Comments

The results outlined above apply to the sample as received

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ABN: 98 153 268 896

Report No: SSI:NEW19W-3827--S09
Issue No: 1

Shrink Swell Index Report

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

Principal:
Project No.: NEW15P-0070I
Project Name: Billy's Lookout - Stage 23

NATA WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 13/11/2019

Sample Details

Sample ID:	NEW19W-3827--S09	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	Sampled by Engineering Department
Material:	Gravelly Sandy CLAY	**Date Sampled:**	30/10/2019
Source:	On-Site	**Date Submitted:**	7/11/2019
Specification:	No Specification		
Project Location:	Teralba, NSW		
Sample Location:	TP23-09 - 0.40 to 0.55m		
Borehole Number:	TP23-09		
Borehole Depth (m):	0.40 - 0.55		

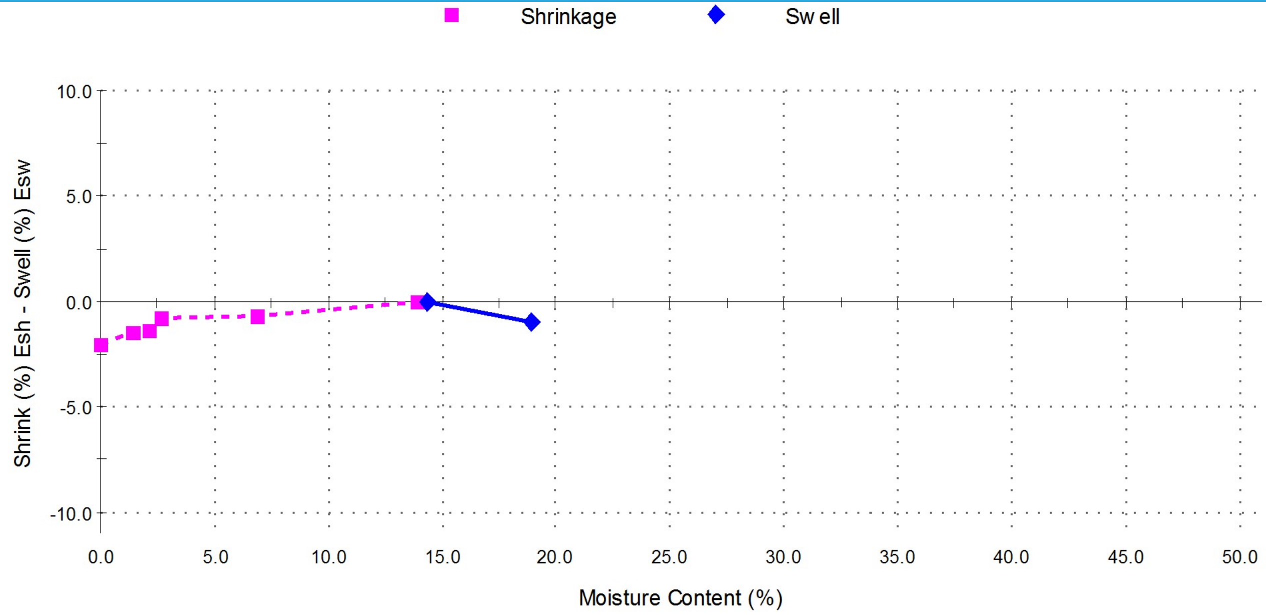
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-1.0
Moisture Content before (%):	14.3
Moisture Content after (%):	18.9
Est. Unc. Comp. Strength before (kPa):	> 600
Est. Unc. Comp. Strength after (kPa):	520

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	2.0
Shrinkage Moisture Content (%):	13.9
Est. inert material (%):	10.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Nil

Shrink Swell



Shrink Swell Index - Iss (%): 1.1

Comments

The results outlined above apply to the sample as received

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).

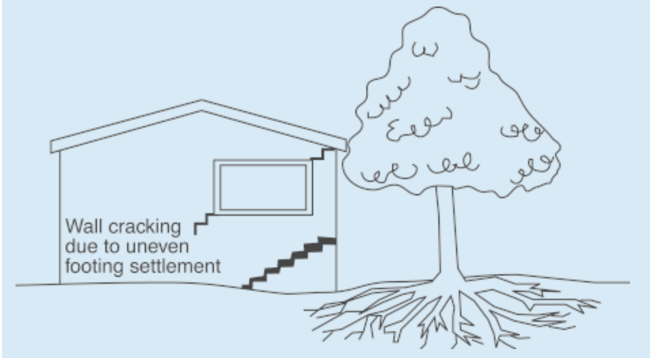
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

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.

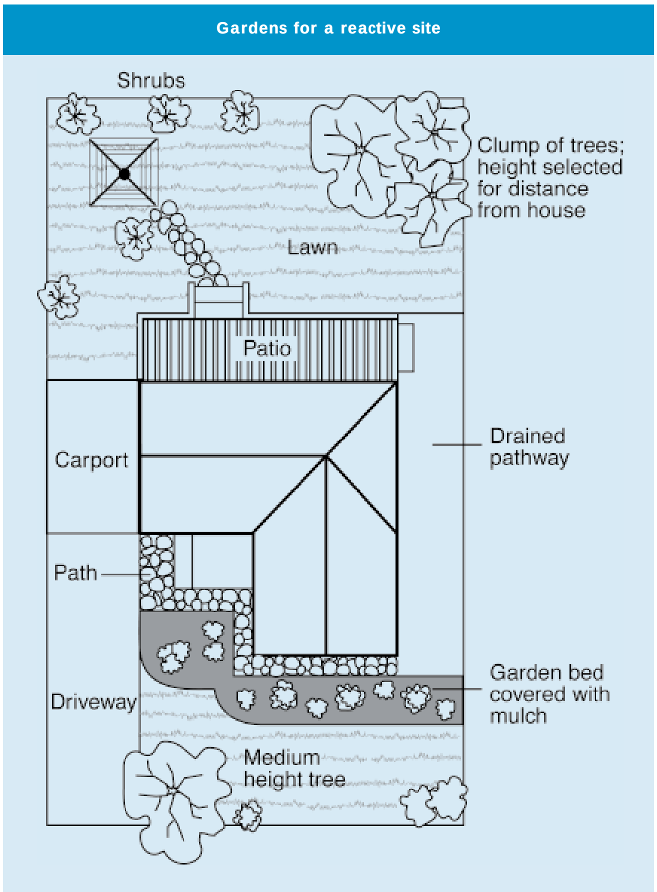
It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

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



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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