# Billy's Lookout - Stage 11 Geotechnical Assessment

## Fishermans Drive & Pitt Street, Teralba

NEW15P-0070B-AI
29 November 2018

Qualtest
LABORATORY (NSW) PTY LTD

GEOTECHNICAL I LABORATORY I EARTHWORKS I QUARRY I CONSTRUCTION MATERIAL TESTING

29 November 2018

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 – STAGE 11**
**FISHERMANS DRIVE & PITT STREET, TERALBA**
**SITE CLASSIFICATION (LOTS 1101 TO 1117)**

Please find enclosed our geotechnical report for Stage 11 of the Billy's Lookout residential subdivision, located at Pitt Street and Fishermans Drive, Teralba.

The report includes recommendations on Site Classification in accordance with AS2870-2011, "*Residential Slabs and Footings*" for Stage 11 (Lots 1101 to 1117).

If you have any questions regarding this report, please do not hesitate to contact 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 report on behalf of McCloy Development Management Pty Ltd (McCloy), for Stage 11 of the Billy's Lookout residential subdivision, located at Pitt Street and Fishermans Drive, Teralba.

Based on the Brief and Staging Plan Sheet (Ref: GCA Engineering Solutions, Project No. 16653C, Drawing No. C02, Revision 2) provided in an email from McCloy, the development is understood to comprise subdivision into a total of 17 residential lots (Lots 1101 to 1117), as shown on Figure AI1.

The scope of work for the geotechnical investigation included providing Site Classification to AS2870-2011, "*Residential Slabs and Footings*" for Stage 11 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:

- Level 1 Site Re-Grade Assessment Report – 'Proposed Subdivision, Billys Lookout – Stage 11, Pitt Street, Teralba' (Ref. No. NEW16P-0109-AB, dated 26/11/2018);
- Geotechnical Assessment Report, 'Proposed Subdivision, Billys Lookout - Stage 11, Pitt Street, Teralba' (Report Ref: NEW15P-0070B-AA, dated 16 June 2017); and,
- Site Classification Report – Proposed Subdivision, Billys Lookout – Stage 8, Fishermans Drive, Teralba, (Report Ref: NEW15P-0070A-AC, dated 17 June 2016).

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 30 October 2018, and comprised of:

- DBYD search of proposed test locations was undertaken to check 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;
- Excavation of 9 test pits (TP1101 to TP1109) using a 2.5 tonne excavator equipped with a 450mm wide bucket. Test pits were terminated at depths of between 1.00m and 2.40m;
- Undisturbed samples (U50 tubes) and small bag samples 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.

Engineering logs of the test pits are presented in Appendix A.

Approximate test pit locations are shown on the attached Figure AI1. Test pits were located in the field by handheld GPS and relative to existing site features including topographic features, lot boundaries, existing developments, and trees.

# 4.0 Site Description

## 4.1 Site Regrade Works

Site re-grading works were conducted on 2 February 2016 to 1 July 2016, 16 July 2017 to 28 August 2017, and 25 October 2018 to 31 October 2018.

The initial re-grading works consisted of the cutting and filling of residential lots within Stage 11 (Lots 1101 to 1104), and the construction of Pitt Street embankment works between Ch. 900m and 1050m. Subsequent regrading included filling Lots 1105, 1106 and 1112 to 1116, construction of Fisherman's Drive, and associated detention basin.

Further re-grading works were performed between 25 October 2018 and 31 October 2018 within Lots 1101 and 1102, where lots were raised a further 0.6m.

Refer to attached Figure AI1 for approximate limit of lot regrade works for the project.

Prior to filling, re-grade areas were stripped of all topsoil and unsuitable material to expose suitable natural residual 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, and Clayey Sandy GRAVEL, 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 0.1m to 3.6m. 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 regrade areas (Lots 1101 to 1106, and 1111 to 1116), 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*'.

For full details on site regrade works, reference should be made to Qualtest site regrade letter (Ref. No. NEW16P-0109-AB, dated 26/11/2018).

The recommendations of this report are based on the understanding that any existing lot re-grade works are limited to the controlled earthworks works supervised by Qualtest, and placement of low reactivity topsoil material such that total topsoil depths do 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, relatively large fill stockpiles with heights greater than 0.4m were present on Lots 1108 to 1110, and 1114 to 1116. During a site visit carried out on 26 November 2018, removal of the fill mounds was witnessed and documented Qualtest.

## 4.2 Surface Conditions

The site comprises Stage 11 of the subdivision known as Billy's Lookout located at Pitt Street and Fishermans Drive, Teralba, as shown on Figure AI1 attached.

The site is located within a region of gently to moderately undulating topography. Ground levels are generally in the range from roughly RL 23m (AHD) at the southern end of the site, falling to roughly RL 10m (AHD) in the northern end of the site. Site slopes generally vary from about 3° to 5° towards the north. Some areas have been roughly levelled by site earthworks.

The site generally comprises undeveloped lots, with concrete block retaining walls and underground service near / at some lot boundaries. Most areas had surface covered with a thin layer of mulch. Several Lots contained fill and/or mulch stockpiles with heights in excess of 0.40m on the day of field work, which have subsequently been removed.

On the day of the investigation, the site was judged to be reasonably well drained primarily by way of downhill surface runoff towards the drainage reserve to the north. Trafficability was judged to be good by way of 4WD vehicle along the existing sealed pavement (Fishermans Drive and Pitt Street). Photographs of the site taken on the day of the site investigations are shown below.

**Photograph 1:** From near northern corner of Lot 1101, facing southeast.

**Photograph 2:** From near northern corner of Lot 1101, facing southwest.

**Photograph 3:** From near north boundary of Lot 1114, facing southeast.

**Photograph 4:** From near north boundary of Lot 1114, facing south.

**Photograph 5:** From near southern boundary of Lot 1109, facing west.

**Photograph 6:** From near southern boundary of Lot 1109, facing north.

**Photograph 7:** From near southern boundary of Lot 1117, facing west.

**Photograph 8:** From near southern boundary of Lot 1117, facing north.

## 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, and the Moon Island Beach Subgroup of the Newcastle Coal Measures, which are characterised by Conglomerate, Sandstone, Siltstone, Claystone, Tuff and Coal rock types.

Table 1 presents a summary of the typical soil types encountered at test pit locations during the field investigation, divided into representative geotechnical units.

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

No groundwater levels or water inflows were encountered in the test pits during the limited time that they remained open on the day of the field investigations.

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.

**TABLE 1 – SUMMARY OF GEOTECHNICAL UNITS AND SOIL TYPES**

| Unit | Soil Type | Description |
|---|---|---|
| 1A | FILL - TOPSOIL | Gravelly Silty SAND, Silty SAND, Clayey SAND – fine to coarse grained, dark grey-brown, fine to medium grained angular to sub-angular gravel, fines of low plasticity, root affected.<br>Sandy CLAY – low plasticity, dark grey-brown, fine to coarse grained (mostly fine to medium grained), trace fine to medium grained rounded to sub-rounded gravel.<br>With tree mulch on surface in places. |
| 1B | UNCONTROLLED FILL | Sandy CLAY – low to medium plasticity, dark grey, fine to medium grained sand, with small pockets of Gravelly SAND.<br>Silty Sandy GRAVEL – fine to medium grained, pale grey-brown, fine to coarse grained (mostly fine to medium grained) sand, fines of low plasticity. |

| Unit | Soil Type | Description |
|---|---|---|
| 1C | CONTROLLED FILL | Gravelly Sandy CLAY, Sandy CLAY – low to medium plasticity, brown to pale grey-brown and pale orange-brown, fine to coarse grained sand, fine to medium grained sub-rounded to sub-angular gravel. Trace cobbles in places.<br>Gravelly Clayey SAND, Clayey SAND – fine to medium grained, dark grey-brown, fines of low plasticity, with some fine to medium grained sub-rounded to sub-angular gravel, mulch on top 50mm. |
| 2 | TOPSOIL | Silty SAND / Clayey SAND – fine to coarse grained (mostly fine to medium grained), grey to dark grey, fines of low plasticity, with some fine to medium grained sub-angular to sub-rounded gravel in places, root affected. |
| 3 | COLLUVIUM / SLOPEWASH | Gravelly Silty SAND / Clayey SAND - fine to medium grained, grey-brown and dark grey, fines of low plasticity, some tree roots in places, fine to medium grained gravel in places.<br>Sandy CLAY / Clayey SAND – low plasticity, dark grey to grey-brown, fine to medium grained sand, with some roots in places. |
| 4 | RESIDUAL SOIL | Sandy CLAY / Clayey SAND - medium and medium to high plasticity, colour varies with combinations of orange-brown and grey, pale grey, grey, and brown to red, fine to medium grained sand. Typically, of very stiff to hard consistency.<br>CLAY / Silty CLAY – high plasticity, mostly pale grey with some red-brown in places. |
| 5 | EXTREMELY WEATHERED (XW) ROCK with soil properties | Extremely Weathered Silty Sandstone / Sandstone, breaks down into Silty SAND / Clayey SAND – fine grained, pale grey-white and orange-brown, fines of low to medium plasticity, with highly weathered pockets.<br>Extremely Weathered Siltstone, breaks down into Silty CLAY – high plasticity, pale grey to white. |
| 6 | HIGHLY WEATHERED (HW) ROCK | Silty SANDSTONE / Sandy SILTSTONE – fine to medium grained, pale grey and orange-brown, estimated low strength, with extremely weathered pockets.<br>SANDSTONE - fine to coarse grained, pale grey to white and pale orange, estimated strength of medium to high.<br>Pebbly SANDSTONE and Sandy SILTSTONE in places. Extremely to Highly Weathered in places. |

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

| Location | Unit 1A FILL: Topsoil | Unit 1B Uncontrolled Fill | Unit 1C Controlled Fill | Unit 2 Topsoil | Unit 3 Slopewash / Colluvium | Unit 4 Residual Soil | Unit 5 XW Rock | Unit 6 HW Rock |
|---|---|---|---|---|---|---|---|---|
| | Depth in metres (m) | | | | | | | |
| **Current Investigation (Ref: NEW15P-0070B-AI, November 2018)** | | | | | | | | |
| TP1101 | - | - | 0.00 - 2.10 | - | - | - | - | - |
| TP1102 | 0.00 - 0.25 | - | 0.25 - 0.80 | - | - | 0.80 - 1.30 | 1.30 - 1.38 | 1.38 - 1.40* |
| TP1103 | 0.00 - 0.25 | - | - | - | - | 0.25 - 0.90 | - | 0.90 - 1.00* |
| TP1104 | 0.00 - 0.25 | - | - | - | - | 0.25 - 0.85 | 0.85 - 0.95 | 0.95 - 1.00* |
| TP1105 | 0.00 - 0.25 | - | - | - | - | 0.25 - 1.20 | - | 1.20 - 1.25* |
| TP1106 | - | - | - | 0.00 - 0.20 | 0.20 - 0.45 | 0.45 - 1.50 | 1.50 - 1.75 | 1.75 - 1.85* |
| TP1107 | - | 0.00 - 0.10 | 0.10 - 1.20 | - | - | 1.20 - 1.40 | 1.40 - 1.55 | 1.55 - 1.70* |
| TP1108 | 0.00 - 0.20 | - | 0.20 - 1.20 | - | 1.20 - 1.40 | 1.40 - 2.00 | - | - |
| TP1109 | - | - | 0.00 - 1.20 | - | 1.20 - 1.80 | 1.80 - 2.10 | - | - |
| Note: * = Very slow progress, practical refusal or refusal of 2.5 tonne excavator met on Highly Weathered Rock. | | | | | | | | |

| Location | Unit 1A<br>FILL: Topsoil | Unit 1B<br>Uncontrolled Fill | Unit 1C<br>Controlled Fill | Unit 2<br>Topsoil | Unit 3<br>Colluvium / Slopewash | Unit 4<br>Residual Soil | Unit 5<br>XW Rock | Unit 6<br>HW Rock |
|---|---|---|---|---|---|---|---|---|
| | Depth in metres (m) | | | | | | | |
| **Previous Investigation (Ref: NEW15P-0070B-AA, June 2017)** | | | | | | | | |
| TP401 | 0.00 - 0.20 | - | 0.20 - 1.00 | - | 1.00 - 1.20 | 1.20 - 2.60 | - | - |
| TP402 | 0.00 - 0.08 | 0.08 - 0.70 | - | - | - | 0.70 - 1.45 | - | 1.45 - 1.50***** |
| TP403 | - | - | - | 0.00 - 0.20 | - | 0.20 - 0.65 | - | 0.65 - 0.80***** |
| TP404 | - | - | - | 0.00 - 0.14 | - | 0.14 - 1.10 | - | 1.10 - 1.15***** |
| TP405 | - | - | - | 0.00 - 0.10 | 0.10 - 0.30 | 0.30 - 0.80 | 0.80 - 1.10 | 1.10 - 1.15***** |
| Note: ***** = Practical refusal or refusal of 8 tonne excavator met on Highly Weathered Rock. | | | | | | | | |
| **Previous Investigation (Ref: NEW15P-0070A-AC, June 2016)** | | | | | | | | |
| TP120 | - | - | - | 0.00 - 0.20 | 0.20 - 0.75 | 0.75 - 3.10 | - | - |
| TP123 | - | - | - | 0.00 - 0.30 | - | 0.30 - 1.35 | - | 1.35 - 1.40* |
| Note: * = Practical refusal or refusal of 22 tonne excavator met on Highly Weathered Rock. | | | | | | | | |

Uncontrolled filling was encountered on Lots 1114 to 1116 during the previous investigation in 2017. It is understood that the uncontrolled fill was removed as part of subsequent controlled filling works on an area including those lots, as described in Section 4.1

# 5.0 Laboratory Testing

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

- (8 no.) Shrink / Swell test; and,
- (1 no.) Atterberg Limits test.

Proposed Shrink/Swell testing for one of the samples was replaced by an Atterberg Limit classification test due to the friable nature of the site fill.

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 Assessments carried out by Qualtest.

**TABLE 3 – SUMMARY OF SHRINK/SWELL TESTING RESULTS**

| Location | Depth (m) | Material Description | $I_{ss}$ (%) |
|---|---|---|---|
| **Current Investigation (Ref: NEW15P-0070B-AI, November 2018)** | | | |
| TP1101 | 0.30 - 0.70 | FILL: (CI) Gravelly Sandy CLAY | 0.6 |
| TP1102 | 0.80 - 1.15 | Residual: (CH) Sandy CLAY | 2.6 |
| TP1103 | 0.30 - 0.50 | Residual: (CH) Sandy CLAY | 2.1 |
| TP1104 | 0.40 - 0.65 | Residual: (CH) Sandy CLAY | 2.2 |
| TP1105 | 0.40 - 0.65 | Residual: (CH) Sandy CLAY | 3.1 |
| TP1106 | 0.60 - 0.85 | Residual: (CH) Silty CLAY | 1.5 |
| TP1107 | 0.40 - 0.50 | FILL: (CH) Sandy CLAY | 4.0 |
| TP1108 | 1.40 - 1.60 | Residual: (CH) Sandy CLAY | 1.8 |
| **Previous Investigation (Ref: NEW15P-0070B-AA, June 2017)** | | | |
| TP405 | 0.60 – 0.70 | (CH) Sandy CLAY- Residual | 4.3 |
| **Previous Geotechnical Assessment (Ref: NEW15P-0070A-AC, June 2016)** | | | |
| TP120 | 0.90 – 1.20 | (CH) Sandy CLAY- Residual | 2.1 |

**TABLE 4 – SUMMARY OF ATTERBERG LIMITS TESTING RESULTS**

| Location | Depth (m) | Material Description | Liquid Limit (%) | Plastic Limit (%) | Plasticity Index (%) | Linear Shrinkage (%) |
|---|---|---|---|---|---|---|
| **Current Investigation (November 2018)** | | | | | | |
| TP1109 | 0.30 – 0.40 | FILL: (CI) Gravelly Sandy CLAY | 36 | 17 | 19 | 6.5 |
| **Previous Investigation (Ref: NEW15P-0070B-AA, June 2017)** | | | | | | |
| TP401 | 0.40 – 0.60 | FILL: (CI) Sandy CLAY | 40 | 17 | 23 | 4.5 |
| TP402 | 0.90 – 1.10 | (CH) Sandy CLAY | 36 | 15 | 21 | 7.0 |
| TP403 | 0.30 – 0.65 | (CH) Sandy CLAY | 67 | 25 | 42 | 12.0 |
| TP404 | 0.40 – 0.70 | (CH) Sandy CLAY | 69 | 24 | 45 | 9.0 |

The results of the Shrink/Swell and Atterberg Limits laboratory testing indicate that the residual soils tested from the site generally contain fines of medium to high plasticity, whilst the re-blended regrade fill material is generally of low to medium plasticity.

## 6.0 Site Classification to AS2870-2011

Based on the results of the field work and laboratory testing, and Level 1 site regrade work to AS3798-2007 carried out, residential lots located within the Billy's Lookout subdivision Stage 11, located off Pitt Street and Fishermans Drive, Teralba, as shown on Figure AI1, 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**

| Lot Numbers | Site Classification |
|---|---|
| 1107 to 1111 and 1117 | **M** |
| 1101 to 1106, 1112 to 1116 | **H1** |

A characteristic free surface movement of 20mm to 40mm is estimated for lots classified as **Class 'M'** in their existing condition.

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; 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 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

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.

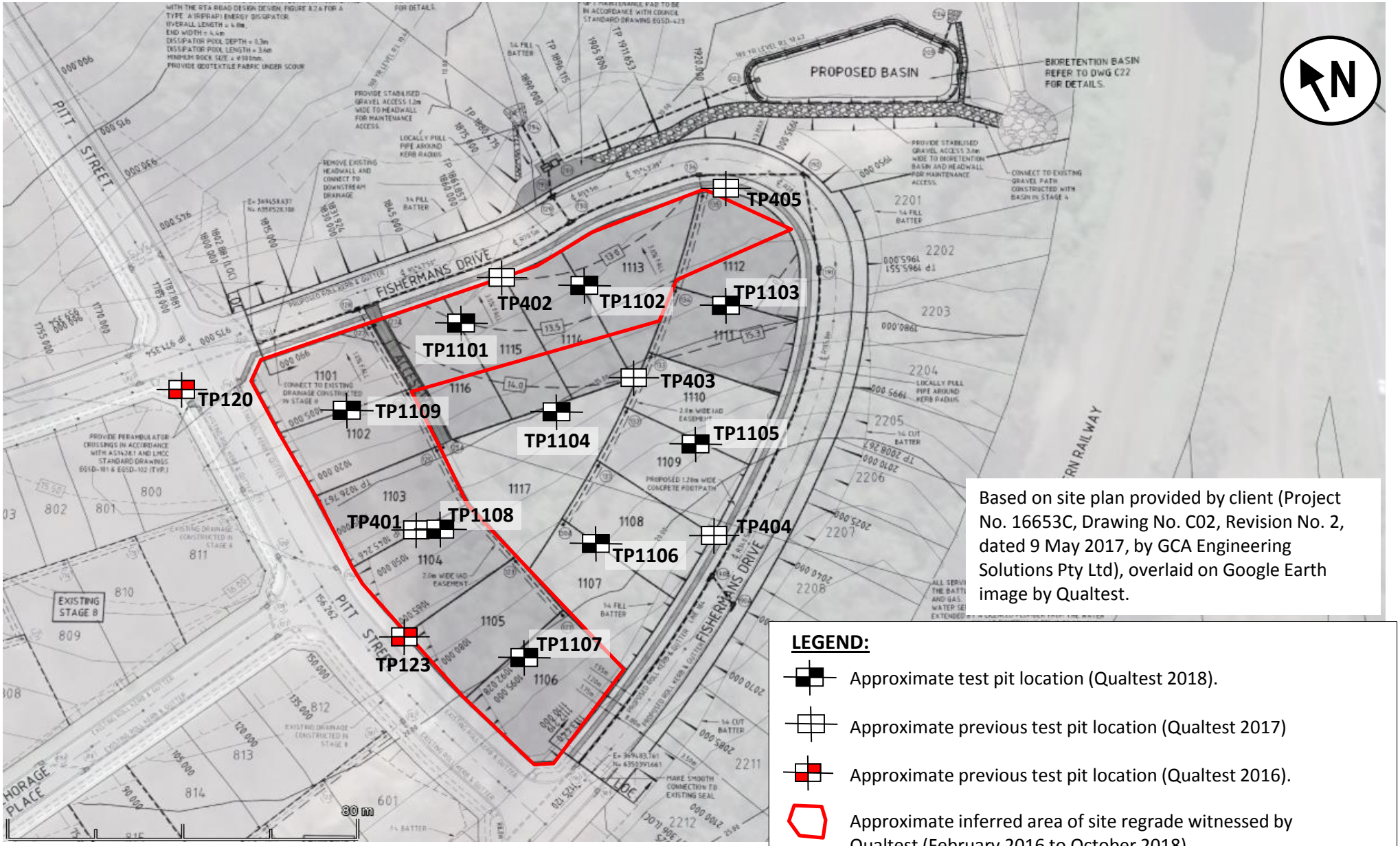
If you have any further questions regarding this report, please do not hesitate to contact Shannon Kelly or the undersigned.

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

Jason Lee
Principal Geotechnical Engineer

# FIGURE AI1:

## Site Plan and Approximate Test Locations




Based on site plan provided by client (Project No. 16653C, Drawing No. C02, Revision No. 2, dated 9 May 2017, by GCA Engineering Solutions Pty Ltd), overlaid on Google Earth image by Qualtest.

**LEGEND:**

- Approximate test pit location (Qualtest 2018).
- Approximate previous test pit location (Qualtest 2017)
- Approximate previous test pit location (Qualtest 2016).
- Approximate inferred area of site regrade witnessed by Qualtest (February 2016 to October 2018).

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| | | | |
|---|---|---|---|
| Client: | McCLOY DEVELOPMENT MANAGEMENT PTY LTD | Drawing No: | FIGURE AI1 |
| Project: | BILLY'S LOOKOUT - STAGE 11 | Project No: | NEW15P-0070B |
| Location: | PITT STREET AND FISHERMANS DRIVE, TERALBA | Scale: | AS SHOWN |
| Title: | SITE PLAN AND APPROXIMATE TEST LOCATIONS | Date: | 29/11/2018 |

# APPENDIX A:

## Results of Field Investigations

# ENGINEERING LOG - TEST PIT

**CLIENT:** MCCLOY GROUP PTY LTD
**PROJECT:** BILLYS LOOKOUT SUBDIVISION - STAGE 11
**LOCATION:** FISHERMANS DRIVE, TERALBA

**TEST PIT NO:** TP1101
**PAGE:** 1 OF 1
**JOB NO:** NEW15P-0070B
**LOGGED BY:** BB
**DATE:** 30/10/18

**EQUIPMENT TYPE:** 2.5 TONNE EXCAVATOR
**TEST PIT LENGTH:** 2.0 m **WIDTH:** 0.5 m
**SURFACE RL:**
**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 |
| E | Not Encountered | 0.30m | | | | CL | FILL: Sandy CLAY - low plasticity, grey-brown, fine to medium grained sand, fine grained rounded to sub-rounded gravel. | M < $w_P$ | | | | FILL - CONTROLLED |
| | | | | | | | 0.30m | | | | | |
| | | U50 | | 0.5 | | | FILL: Gravelly Sandy CLAY - medium plasticity, pale brown with some pale grey pale orange-brown and red-brown, fine to coarse grained sand, fine to coarse grained angular to sub-angular gravel, with some sub-angular cobbles of up to ~200mm in diameter. Becoming pale grey-brown, no cobbles. | | | HP | 420 | |
| | | | | | | | | | | HP | >600 | |
| | | | | | | | | | | HP | 530 | |
| | | 0.70m | | | | | | | | HP | 380 | |
| | | | | | | | Becoming pale brown, with some pale grey pale orange-brown and red-brown, with some sub-angular cobbles of up to ~200mm in diameter. | | | | | |
| | | | | 1.0 | | | Becoming pale grey-brown, no cobbles. | | | HP | 480 | |
| | | | | | | CI | | M ~ $w_P$ | VSt - H | HP | 370 | |
| | | | | | | | Becoming pale brown, with some pale grey pale orange-brown and red-brown, with some sub-angular cobbles of up to ~200mm in diameter. | | | | | |
| | | | | | | | | | | HP | 500 | |
| | | | | 1.5 | | | Becoming grey-brown. | | | | | |
| | | | | | | | | | | HP | 530 | |
| | | | | | | | Becoming pale grey-brown. | | | | | |
| | | | | 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 |

# ENGINEERING LOG - TEST PIT

**TEST PIT NO:** TP1102

**CLIENT:** MCCLOY GROUP PTY LTD
**PAGE:** 1 OF 1
**PROJECT:** BILLYS LOOKOUT SUBDIVISION - STAGE 11
**JOB NO:** NEW15P-0070B
**LOCATION:** FISHERMANS DRIVE, TERALBA
**LOGGED BY:** BB
**DATE:** 30/10/18

**EQUIPMENT TYPE:** 2.5 TONNE EXCAVATOR
**SURFACE RL:**
**TEST PIT LENGTH:** 2.0 m **WIDTH:** 0.5 m
**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 |
| E | Not Encountered | | | | | CL | FILL-TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine to coarse grained (mostly fine to medium grained) sand, trace fine to medium grained rounded to sub-rounded gravel. | M ~ $w_P$ | | | | FILL - TOPSOIL |
| | | | | | | | 0.25m | | | | | |
| | | | | 0.5 | | CL | FILL: Gravelly Sandy CLAY - low to medium plasticity, brown to pale orange-brown, fine to coarse grained sand, fine to coarse grained angular to sub-angular gravel, trace sub-angular cobbles up to ~200mm in diameter. | M < $w_P$ | VSt - H | HP | 290 | FILL - CONTROLLED |
| | | | | | | | | | | HP | 420 | |
| | | | | | | | Becoming grey-brown. | | | HP | 380 | |
| | | | | | | | | | | HP | 500 | |
| | | 0.80m | | | | | 0.80m | | | HP | 320 | |
| | | U50 | | 1.0 | | CH | Sandy CLAY - medium to high plasticity, pale brown, fine to coarse grained sand, trace roots. | M > $w_P$ | VSt | HP | 280 | RESIDUAL SOIL |
| | | | | | | | Becoming pale grey. | | | | | |
| | | 1.15m | | | | | | | | HP | 350 | |
| | | | | | | | 1.30m | | | | | |
| | | | | | | SC | Extremely Weathered Silty Sandstone with soil properties; breaks down into Clayey SAND - fine to medium grained, pale grey, fines of low to medium plasticity. | D | VD | | | EXTREMELY WEATHERED ROCK |
| | | | | | | | 1.38m<br>1.40m | | | | | HIGHLY WEATHERED ROCK |
| | | | | 1.5 | | | Silty SANDSTONE - fine to medium grained, pale grey, estimated low to medium strength. | | | | | |
| | | | | | | | Hole Terminated at 1.40 m<br>Very slow progress | | | | | |
| | | | | 2.0 | | | | | | | | |

QT LIB 1.1.GLB Log NON-CORED BOREHOLE - TEST PIT TEMPLATE LOGS SHEET GPJ <<DrawingFile>> 28/11/2018 13:37 10.0.000 Datgel Lab and In Situ Tool

**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 |

# ENGINEERING LOG - TEST PIT

**CLIENT:** MCCLOY GROUP PTY LTD
**PROJECT:** BILLYS LOOKOUT SUBDIVISION - STAGE 11
**LOCATION:** FISHERMANS DRIVE, TERALBA

**TEST PIT NO:** TP1103
**PAGE:** 1 OF 1
**JOB NO:** NEW15P-0070B
**LOGGED BY:** BB
**DATE:** 30/10/18

**EQUIPMENT TYPE:** 2.5 TONNE EXCAVATOR
**TEST PIT LENGTH:** 2.0 m **WIDTH:** 0.5 m
**SURFACE RL:**
**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 |
| E | Not Encountered | 0.30m<br>U50<br>0.50m | | 0.5<br>1.0<br>1.5<br>2.0 | | SC<br>CH<br>Cl | FILL-TOPSOIL: Clayey SAND - fine to coarse grained (mostly fine to medium grained), dark grey-brown, fines of low plasticity, trace fine to medium grained sub-rounded to sub-angular gravel.<br>0.25m<br>Sandy CLAY - medium to high plasticity, pale brown to pale grey-brown, fine to medium grained sand.<br>0.70m<br>Sandy CLAY / Clayey SAND - medium plasticity, pale brown to pale grey-brown, fine to medium grained sand. Pockets of Clayey SAND and Extremely Weathered Silty Sandstone.<br>0.90m<br>Silty SANDSTONE - fine to medium grained, pale grey and pale orange-brown, estimated low to medium strength.<br>1.00m<br>Hole Terminated at 1.00 m<br>Very slow progress | D - M<br>M > $w_P$<br>M ~ $w_P$<br>D | VSt - H<br>H | HP<br>HP<br>HP<br>HP | 380<br>420<br>550<br>>600 | FILL - TOPSOIL<br>RESIDUAL SOIL<br>RESIDUAL SOIL / EXTREMELY WEATHERED ROCK<br>HIGHLY WEATHERED ROCK |

**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 |

# ENGINEERING LOG - TEST PIT

**TEST PIT NO:** TP1104

**CLIENT:** MCCLOY GROUP PTY LTD
**PAGE:** 1 OF 1
**PROJECT:** BILLYS LOOKOUT SUBDIVISION - STAGE 11
**JOB NO:** NEW15P-0070B
**LOCATION:** FISHERMANS DRIVE, TERALBA
**LOGGED BY:** BB
**DATE:** 30/10/18

**EQUIPMENT TYPE:** 2.5 TONNE EXCAVATOR
**SURFACE RL:**
**TEST PIT LENGTH:** 2.0 m **WIDTH:** 0.5 m
**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 |
| | | | | | | CL | FILL-TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine to coarse grained (mostly fine to medium grained) sand, mulch on top 50mm. | D - M | | | | FILL - TOPSOIL |
| | | | | | | | 0.25m | | | | | |
| E | Not Encountered | 0.40m | | | | CH | Sandy CLAY - medium to high plasticity, orange-brown to red-brown with some pale brown, fine to coarse grained sand, trace fine to medium grained sub-rounded to sub-angular gravel. | M > $w_P$ | VSt | HP | 380 | RESIDUAL SOIL |
| | | U50 | | 0.5 | | | | | | HP | 520 | |
| | | 0.65m | | | | | | | | HP | >600 | |
| | | | | | | | Becoming pale grey and pale orange-brown. | M ~ $w_P$ | H | HP | >600 | |
| | | | | | | | | | | HP | 530 | |
| | | | | | | | 0.85m | | | HP | >600 | |
| | | | | | | CI | Extremely Weathered Silty Sandstone with soil properties; breaks down into Sandy CLAY - medium plasticity, pale grey, fine to coarse grained sand, trace fine grained rounded gravel. | M < $w_P$ | | | | EXTREMELY WEATHERED ROCK |
| | | | | | | | 0.95m | | | | | |
| | | | | 1.0 | | | 1.00m | D | | | | HIGHLY WEATHERED ROCK |
| | | | | | | | Silty SANDSTONE - fine to medium grained, pale grey with some pale brown, estimated low to medium strength. | | | | | |
| | | | | | | | Hole Terminated at 1.00 m<br>Practical Refusal | | | | | |
| | | | | 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 | |

**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 |

# ENGINEERING LOG - TEST PIT

**TEST PIT NO:** TP1105

**CLIENT:** MCCLOY GROUP PTY LTD
**PAGE:** 1 OF 1
**PROJECT:** BILLYS LOOKOUT SUBDIVISION - STAGE 11
**JOB NO:** NEW15P-0070B
**LOCATION:** FISHERMANS DRIVE, TERALBA
**LOGGED BY:** BB
**DATE:** 30/10/18

**EQUIPMENT TYPE:** 2.5 TONNE EXCAVATOR
**SURFACE RL:**
**TEST PIT LENGTH:** 2.0 m **WIDTH:** 0.5 m
**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 |
| E | Not Encountered | 0.40m<br>U50<br>0.65m | | 0.5<br>1.0<br>1.5<br>2.0 | | SM<br>Cl | FILL-TOPSOIL: Silty SAND - fine to coarse grained, dark grey-brown, fines of low plasticity, with some fine grained angular gravel.<br>0.25m<br>Sandy CLAY - medium plasticity, orange-brown to red-brown, fine to coarse grained sand, trace fine to medium grained rounded to sub-rounded gravel.<br>Becoming pale grey to white, with some fine to medium grained rounded to sub-rounded gravel.<br>1.20m<br>1.25m Silty SANDSTONE - fine to medium grained, pale grey to white, estimated medium strength.<br>Hole Terminated at 1.25 m<br>Practical Refusal | M<br>M > $w_P$<br>M ~ $w_P$<br>D | VSt | HP<br>HP<br>HP<br>HP | 270<br>320<br>290<br>350 | FILL - TOPSOIL<br>RESIDUAL SOIL<br>HIGHLY WEATHERED SANDSTONE |

**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 |

# ENGINEERING LOG - TEST PIT

**TEST PIT NO:** TP1106

**CLIENT:** MCCLOY GROUP PTY LTD
**PAGE:** 1 OF 1
**PROJECT:** BILLYS LOOKOUT SUBDIVISION - STAGE 11
**JOB NO:** NEW15P-0070B
**LOCATION:** FISHERMANS DRIVE, TERALBA
**LOGGED BY:** BB
**DATE:** 30/10/18

**EQUIPMENT TYPE:** 2.5 TONNE EXCAVATOR
**SURFACE RL:**
**TEST PIT LENGTH:** 2.0 m **WIDTH:** 0.5 m
**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 |
| E | Not Encountered | 0.60m U50 0.85m | | 0.5 1.0 1.5 | | SC | TOPSOIL: Clayey SAND - fine to coarse grained (mostly fine to medium grained), dark grey-brown, fines of low plasticity, with some fine to medium grained rounded to sub-rounded gravel. | D - M | | | | TOPSOIL |
| | | | | | | | 0.20m | | | | | |
| | | | | | | CI | Sandy CLAY - medium plasticity, dark grey to grey, fine to medium grained sand. | M < $w_P$ | H | HP | >600 | COLLUVIUM |
| | | | | | | | 0.45m | | | | | |
| | | | | | | CH | Silty CLAY - high plasticity, pale grey to white. | | | HP | 550 | RESIDUAL SOIL |
| | | | | | | | | | | HP | >600 | |
| | | | | | | | | | | HP | 530 | |
| | | | | | | | | | | HP | 580 | |
| | | | | | | | | | | HP | >600 | |
| | | | | | | | | | | HP | >600 | |
| | | | | | | | | | | HP | >600 | |
| | | | | | | CH | Extremely Weathered Siltstone with soil properties; breaks down into Silty CLAY - high plasticity, pale grey to white. | | | | | EXTREMELY WEATHERED ROCK |
| | | | | | | | 1.75m | | | | | |
| | | | | | | | SILTSTONE - pale grey to white, estimated low strength. | D | | | | HIGHLY WEATHERED ROCK |
| | | | | | | | 1.85m | | | | | |
| | | | | 2.0 | | | Hole Terminated at 1.85 m<br>Very slow progress | | | | | |

**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

**TEST PIT NO:** TP1107

**CLIENT:** MCCLOY GROUP PTY LTD
**PAGE:** 1 OF 1
**PROJECT:** BILLYS LOOKOUT SUBDIVISION - STAGE 11
**JOB NO:** NEW15P-0070B
**LOCATION:** FISHERMANS DRIVE, TERALBA
**LOGGED BY:** BB
**DATE:** 30/10/18

**EQUIPMENT TYPE:** 2.5 TONNE EXCAVATOR
**SURFACE RL:**
**TEST PIT LENGTH:** 2.0 m **WIDTH:** 0.5 m
**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 |
| E | Not Encountered | 0.40m<br>U50<br>0.50m | | 0.5<br>1.0<br>1.5<br>2.0 | | GM<br>CI<br>CH<br>CI<br>CI<br>SC | 0.10m FILL: Silty Sandy GRAVEL - fine to medium grained, pale grey-brown, fine to coarse grained (mostly fine to medium grained) sand, fines of low plasticity.<br>FILL: Gravelly Sandy CLAY - medium plasticity, brown to grey-brown, fine to coarse grained sand, fine to medium grained rounded to sub-rounded gravel.<br>0.40m<br>FILL: Sandy CLAY - medium to high plasticity, orange-brown to red-brown with some grey-brown, fine to coarse grained (mostly fine to medium grained) sand, trace fine to medium grained rounded to sub-angular gravel.<br>0.60m<br>FILL: Sandy CLAY - medium plasticity, grey-brown, fine to coarse grained sand, with some fine to coarse grained sub-angular gravel, trace cobbles up to ~200mm in diameter.<br>1.20m<br>Sandy CLAY - medium plasticity, pale grey to grey, fine to coarse grained sand.<br>1.40m<br>Extremely Weathered Silty Sandstone with soil properties; breaks down into Clayey SAND - fine to coarse grained (mostly fine to medium grained), pale grey, fines of low to medium plasticity.<br>1.55m<br>Silty SANDSTONE - fine to medium grained, pale grey, estimated low to medium strength.<br>1.70m<br>Hole Terminated at 1.70 m<br>Practical Refusal | D<br>M < $w_P$<br>M ~ $w_P$<br>M > $w_P$<br>D | H<br>VD | HP<br>HP<br>HP<br>HP | >600<br>420<br>>600<br>>600 | FILL<br>FILL - CONTROLLED<br>RESIDUAL SOIL<br>EXTREMELY WEATHERED ROCK<br>HIGHLY WEATHERED ROCK |

**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 |

# ENGINEERING LOG - TEST PIT

**CLIENT:** MCCLOY GROUP PTY LTD
**PROJECT:** BILLYS LOOKOUT SUBDIVISION - STAGE 11
**LOCATION:** FISHERMANS DRIVE, TERALBA

**TEST PIT NO:** TP1108
**PAGE:** 1 OF 1
**JOB NO:** NEW15P-0070B
**LOGGED BY:** BB
**DATE:** 30/10/18

**EQUIPMENT TYPE:** 2.5 TONNE EXCAVATOR
**TEST PIT LENGTH:** 2.0 m **WIDTH:** 0.5 m
**SURFACE RL:**
**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 | |
| | | | | | | SC | FILL-TOPSOIL: Clayey SAND - fine to medium grained, dark grey-brown, fines of low plasticity, with some fine to medium grained sub-rounded to sub-angular gravel, mulch on top 50mm. | M | | | | FILL - TOPSOIL |
| | | | | | | | 0.20m | | | | | |
| | | | | | | | FILL: Gravelly Sandy CLAY - medium plasticity, pale brown, fine to coarse grained sand, fine to coarse grained angular to sub-angular gravel. | | | | | FILL - CONTROLLED |
| | | | | | | | | | | HP | 500 | |
| | | | | | | | | | | HP | 450 | |
| | | | | 0.5 | | | | | | | | |
| | | 0.60m | | | | | | | | HP | >600 | |
| | | D | | | | CI | | M < $w_P$ | H | | | |
| | | 0.70m | | | | | | | | | | |
| | | | | | | | | | | HP | 490 | |
| E | Not Encountered | | | 1.0 | | | | | | | | |
| | | | | | | | | | | HP | 530 | |
| | | | | | | | 1.20m | | | | | |
| | | | | | | | | | | HP | 90 | |
| | | | | | | CL | Sandy CLAY / Clayey SAND - low plasticity, grey to grey-brown, fine to coarse grained (mostly fine to medium grained), with some roots. | M ~ $w_P$ | F - St | HP | 180 | COLLUVIUM |
| | | 1.40m | | | | | 1.40m | | | | | |
| | | | | | | | Sandy CLAY - medium to high plasticity, pale orange-brown to pale brown with some red-brown and pale grey, fine to coarse grained sand. | | | | | RESIDUAL SOIL |
| | | | | 1.5 | | | | | | HP | 360 | |
| | | U50 | | | | | | | | HP | 290 | |
| | | 1.60m | | | | CH | | M > $w_P$ | VSt | | | |
| | | | | | | | Becoming grey and red-brown to pale orange-brown. | | | HP | 310 | |
| | | | | | | | | | | HP | 340 | |
| | | | | 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 |

# ENGINEERING LOG - TEST PIT

**TEST PIT NO:** TP1109

**CLIENT:** MCCLOY GROUP PTY LTD
**PAGE:** 1 OF 1
**PROJECT:** BILLYS LOOKOUT SUBDIVISION - STAGE 11
**JOB NO:** NEW15P-0070B
**LOCATION:** FISHERMANS DRIVE, TERALBA
**LOGGED BY:** BB
**DATE:** 30/10/18

**EQUIPMENT TYPE:** 2.5 TONNE EXCAVATOR
**SURFACE RL:**
**TEST PIT LENGTH:** 2.0 m **WIDTH:** 0.5 m
**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 |
| E | Not Encountered | 0.30m D 0.40m | | | | CI | FILL: Gravelly Sandy CLAY - medium plasticity, pale brown to brown, fine to coarse grained sand, fine to coarse grained angular to sub-angular gravel. | M ~ $w_P$ | VSt - H | HP | 500 | FILL - CONTROLLED |
| | | | | | | | | | | HP | 360 | |
| | | | | 0.5 | | SC | FILL: Gravelly Clayey SAND - fine to coarse grained, pale orange-brown, fines of low to medium plasticity, fine to coarse grained sub-angular to angular gravel, pockets of cobbles of up to ~200mm diameter. | D | | | | |
| | | 1.00m D 1.10m | | 1.0 | | | | | | | | |
| | | | | | | | Sandy CLAY / Clayey SAND - low plasticity, dark grey-brown, fine to medium grained sand, with some roots. | | | HP | 150 | COLLUVIUM |
| | | | | | | | | | | HP | 230 | |
| | | | | 1.5 | | CL | | M ~ $w_P$ | | HP | 180 | |
| | | | | | | | | | St - VSt | HP | 250 | |
| | | | | | | | | | | HP | 210 | |
| | | | | | | | | | | HP | 120 | |
| | | | | | | | Sandy CLAY - medium plasticity, grey, fine to medium grained sand. | | | | | RESIDUAL SOIL |
| | | | | 2.0 | | CI | | M > $w_P$ | | HP | 300 | |
| | | | | | | | 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 |

# ENGINEERING LOG - TEST PIT

**CLIENT:** McCLOY DEVELOPMENT MANAGEMENT PTY LTD
**PROJECT:** PROPOSED SUBDIVISION - STAGE 11
**LOCATION:** PITT STREET, TERALBA

**TEST PIT NO:** TP401
**PAGE:** 1 OF 1
**JOB NO:** NEW15P-0070B
**LOGGED BY:** BE
**DATE:** 18-5-17

**EQUIPMENT TYPE:** 8 Tonne Excavator
**TEST PIT LENGTH:** 2.0 m **WIDTH:** 0.5 m
**SURFACE RL:**
**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 |
| E | Not Encountered | 0.40m D 0.60m | | 0.5 | | SM | FILL: Gravelly Silty SAND - fine to coarse grained, dark grey, fine to medium grained gravel, angular to sub-angular, root affected, with tree mulch on surface. | D - M | | | | FILL: TOPSOIL |
| | | | | | | | 0.20m | | | | | |
| | | | | | | CL | FILL: Sandy CLAY - low to medium plasticity, brown, fine to coarse grained sand, with fine to coarse grained gravel, sub-rounded to sub-angular. | M ~ $w_P$ | H | HP<br>HP | 480<br>>600 | FILL - CONTROLLED |
| | | 1.00m D 1.20m | | 1.0 | | | 1.00m | | | | | |
| | | | | | | SC | Clayey SAND - fine to medium grained, dark grey, fines of low plasticity. | D - M | D | | | COLLUVIUM |
| | | 1.30m D 1.50m | | 1.5 | | | 1.20m | | | | | |
| | | | | | | CI | Sandy CLAY - medium plasticity, orange-brown and grey, fine to medium grained sand. | | VSt | HP | 300 | RESIDUAL SOIL |
| | | | | | | | 1.70m | | | | | |
| | | 2.00m D 2.20m | | 2.0 | | CH | CLAY - high plasticity, pale grey and red-brown, with sandy nodules. | M ~ $w_P$ | H | HP<br>HP | 500<br>550 | |
| | | | | 2.5 | | | 2.60m | | | | | |
| | | | | | | | Hole Terminated at 2.60 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 |

# ENGINEERING LOG - TEST PIT

**TEST PIT NO:** TP402

**CLIENT:** McCLOY DEVELOPMENT MANAGEMENT PTY LTD
**PAGE:** 1 OF 1

**PROJECT:** PROPOSED SUBDIVISION - STAGE 11
**JOB NO:** NEW15P-0070B

**LOCATION:** PITT STREET, TERALBA
**LOGGED BY:** BE

**DATE:** 18-5-17

**EQUIPMENT TYPE:** 8 Tonne Excavator
**SURFACE RL:**

**TEST PIT LENGTH:** 2.0 m **WIDTH:** 0.5 m
**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 | |
| | | | | | | SP | 0.08m FILL: SAND - fine to medium grained, brown, with fine to medium grained gravel, angular to sub-angular, trace clay. | D - M | | | | FILL: TOPSOIL |
| | | | | | | CL | FILL: Sandy CLAY - low to medium plasticity, dark grey, fine to medium grained sand, with small pockets of Gravelly SAND. | M ~ $w_P$ | | HP | >600 | FILL - UNCONTROLLED |
| | | | | | | | | | | HP | 100 | |
| | | 0.40m | | | | | 0.40m | | | HP | >600 | |
| | | D 0.50m | | 0.5 | | SM | Gravelly Silty SAND - fine to medium grained, dark grey, fine to medium grained gravel, sub-angular to sub-rounded, with tree roots/mulch. | M | D | | | COLLUVIUM / POSSIBLE FILL |
| E | Not Encountered | | | | | | 0.70m | | | | | |
| | | | | | | | Sandy CLAY - medium to high plasticity, pale grey and orange-brown, fine to medium grained sand. | | | HP | 210 | RESIDUAL SOIL |
| | | 0.90m | | | | | | | | HP | 280 | |
| | | U50 1.10m | | 1.0 | | CH | | M > $w_P$ | VSt | HP | 280 | |
| | | | | | | | 1.45m | | | | | |
| | | | | 1.5 | | | 1.50m Sandy SILTSTONE - pale grey and orange-brown, estimated low strength, with extremely weathered pockets. | D | | | | HIGHLY WEATHERED ROCK |
| | | | | | | | Hole Terminated at 1.50 m<br>Practical Excavator Refusal | | | | | |
| | | | | 2.0 | | | | | | | | |
| | | | | 2.5 | | | | | | | | |

**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 |

# ENGINEERING LOG - TEST PIT

**CLIENT:** McCLOY DEVELOPMENT MANAGEMENT PTY LTD
**PROJECT:** PROPOSED SUBDIVISION - STAGE 11
**LOCATION:** PITT STREET, TERALBA

**TEST PIT NO:** TP403
**PAGE:** 1 OF 1
**JOB NO:** NEW15P-0070B
**LOGGED BY:** BE
**DATE:** 18-5-17

**EQUIPMENT TYPE:** 8 Tonne Excavator
**TEST PIT LENGTH:** 2.0 m **WIDTH:** 0.5 m
**SURFACE RL:**
**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 |
| E | Not Encountered | 0.30m | | | | SM | Gravelly Silty SAND - fine to medium grained, dark grey, root affected. | D - M | | | | TOPSOIL |
| | | | | | | | 0.20m | | | HP | >600 | RESIDUAL SOIL |
| | | U50 | | 0.5 | | Cl | Sandy CLAY - medium to high plasticity, orange-brown and brown, fine to medium grained sand, with some fine to medium grained gravel, sub-angular to sub-rounded. | M < $w_P$ | H | HP | >600 | |
| | | 0.65m | | | | | 0.65m | | | | | |
| | | | | | | | SANDSTONE - fine to coarse grained, pale grey-white and pale orange, estimated medium to high strength, with extremely weathered pockets. | D | | | | HIGHLY WEATHERED ROCK |
| | | | | | | | 0.80m | | | | | |
| | | | | 1.0 | | | Hole Terminated at 0.80 m<br>Practical Excavator Refusal | | | | | |
| | | | | 1.5 | | | | | | | | |
| | | | | 2.0 | | | | | | | | |
| | | | | 2.5 | | | | | | | | |

**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

**TEST PIT NO:** TP404

**CLIENT:** McCLOY DEVELOPMENT MANAGEMENT PTY LTD
**PAGE:** 1 OF 1
**PROJECT:** PROPOSED SUBDIVISION - STAGE 11
**JOB NO:** NEW15P-0070B
**LOCATION:** PITT STREET, TERALBA
**LOGGED BY:** BE
**DATE:** 18-5-17

**EQUIPMENT TYPE:** 8 Tonne Excavator
**SURFACE RL:**
**TEST PIT LENGTH:** 2.0 m **WIDTH:** 0.5 m
**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 |
| E | Not Encountered | 0.40m<br>U50<br>0.70m | | 0.5<br>1.0<br>1.5<br>2.0<br>2.5 | | SM<br>CH | Silty SAND - fine grained, dark grey, trace fine grained gravel, sub-angular, root affected.<br>0.14m<br>Silty CLAY - medium to high plasticity, pale grey. | D - M<br>M < $w_P$ | <br>H | HP<br>HP<br>HP | >600<br>>600<br>>600 | TOPSOIL<br>RESIDUAL SOIL |
| | | | | | | | 1.10m<br>1.15m Pebbly SANDSTONE - fine to coarse grained, pale grey-white, estimated high strength.<br>Hole Terminated at 1.15 m<br>Refusal | D | | | | HIGHLY WEATHERED ROCK |

**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 |

# ENGINEERING LOG - TEST PIT

**CLIENT:** McCLOY DEVELOPMENT MANAGEMENT PTY LTD
**PROJECT:** PROPOSED SUBDIVISION - STAGE 11
**LOCATION:** PITT STREET, TERALBA

**TEST PIT NO:** TP405
**PAGE:** 1 OF 1
**JOB NO:** NEW15P-0070B
**LOGGED BY:** BE
**DATE:** 18-5-17

**EQUIPMENT TYPE:** 8 Tonne Excavator
**TEST PIT LENGTH:** 2.0 m **WIDTH:** 0.5 m
**SURFACE RL:**
**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 |
| E | Not Encountered | 0.60m CBR U50 0.80m | | 0.5 1.0 1.5 2.0 2.5 | | SM | Silty SAND - fine to medium grained, grey, with fine to medium grained gravel, angular to sub-angular, root affected. | D - M | | | | TOPSOIL / SLOPE WASH |
| | | | | | | SM | 0.10m Gravelly Silty SAND - fine to medium grained, grey-brown, fine to medium grained gravel, rounded to sub-rounded. | M | D | | | COLLUVIUM |
| | | | | | | CH | 0.30m Sandy CLAY - medium to high plasticity, grey-brown and orange-brown, fine to medium grained sand. | M > $w_P$ | VSt | HP<br>HP<br>HP | 360<br>360<br>390 | RESIDUAL SOIL |
| | | | | | | SM | 0.80m Extremely Weathered SANDSTONE with soil properties: excavates as Silty SAND - fine grained, pale grey-white and orange-brown, with highly weathered pockets. | D - M | VD | | | EXTREMELY WEATHERED ROCK |
| | | | | | | | 1.10m<br>1.15m SANDSTONE - fine to coarse grained, pale grey-white and orange-brown, estimated medium to high strength. | D | | | | HIGHLY WEATHERED ROCK |
| | | | | | | | Hole Terminated at 1.15 m<br>Practical Excavator Refusal | | | | | |

**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 |

# ENGINEERING LOG - TEST PIT

**CLIENT:** MCCLOY GROUP
**PROJECT:** PROPOSED SUBDIVISION - STAGES 5 TO 9
**LOCATION:** PITT STREET, TERALBA

**TEST PIT NO:** TP120
**PAGE:** 1 OF 2
**JOB NO:** NEW15P-0070A
**LOGGED BY:** SJK
**DATE:** 13-1-16

**EQUIPMENT TYPE:** 22 tonne excavator
**TEST PIT LENGTH:** 3.0 m **WIDTH:** 1.5 m
**SURFACE RL:** 13.5 m
**DATUM:** Assumed

| 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 |
| E | ~2L/min inflow from NE corner. | 0.30m | | | | SM | Silty SAND - fine to coarse grained, brown to grey, fines of low plasticity, root affected. | | | | | TOPSOIL |
| | | | | | | | 0.20m | | | | | |
| | | | | | | | Silty Clayey SAND - fine to coarse grained, pale brown, fines of low to medium plasticity, some fine to medium grained gravel with gravelly pockets, some tree roots. | M | | | | COLLUVIUM |
| | | CBR | 13.0 | 0.5 | | SC | | M to W | | | | |
| | | 0.70m | | | | | 0.75m | | | | | |
| | | 0.90m | | | | | Sandy CLAY - medium plasticity, pale brown to orange and pale grey, fine to coarse grained sand. | | | | | RESIDUAL SOIL |
| | | CBR + U50 | 12.5 | 1.0 | | | | M > $w_P$ | VSt | HP | 250 | |
| | | 1.20m | | | | | | | | | | |
| | | | 12.0 | 1.5 | | CI | | | | | | |
| | | | 11.5 | 2.0 | | | | M < $w_P$ | H | HP | >600 | |
| | | | 11.0 | 2.5 | | | | | | | | |
| | | | | | | | 2.80m | | | | | |
| | | | | | | CH | CLAY - medium to high plasticity, grey with some brown, some fine to medium grained sand, appears to have some relict rock structure. | M ~ $w_P$ | | HP | 550 | |

**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 |

# ENGINEERING LOG - TEST PIT

**TEST PIT NO:** TP120

**CLIENT:** MCCLOY GROUP
**PAGE:** 2 OF 2
**PROJECT:** PROPOSED SUBDIVISION - STAGES 5 TO 9
**JOB NO:** NEW15P-0070A
**LOCATION:** PITT STREET, TERALBA
**LOGGED BY:** SJK
**DATE:** 13-1-16

**EQUIPMENT TYPE:** 22 tonne excavator
**SURFACE RL:** 13.5 m
**TEST PIT LENGTH:** 3.0 m **WIDTH:** 1.5 m
**DATUM:** Assumed

| 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 |
| E | | | | | | CH | 3.10m | | H | | | |
| | | | | | | | Hole Terminated at 3.10 m | | | | | |
| | | | 10.0 | 3.5 | | | | | | | | |
| | | | 9.5 | 4.0 | | | | | | | | |
| | | | 9.0 | 4.5 | | | | | | | | |
| | | | 8.5 | 5.0 | | | | | | | | |
| | | | 8.0 | 5.5 | | | | | | | | |

**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 |

# ENGINEERING LOG - TEST PIT

**CLIENT:** MCCLOY GROUP
**PROJECT:** PROPOSED SUBDIVISION - STAGES 5 TO 9
**LOCATION:** PITT STREET, TERALBA

**TEST PIT NO:** TP123
**PAGE:** 1 OF 1
**JOB NO:** NEW15P-0070A
**LOGGED BY:** SJK
**DATE:** 12-1-16

**EQUIPMENT TYPE:** 22 tonne excavator
**TEST PIT LENGTH:** 3.0 m **WIDTH:** 1.5 m
**SURFACE RL:** 18.5 m
**DATUM:** Assumed

| 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 |
| | | | | | | SC | Clayey SAND - fine to coarse grained, dark brown to grey, fines of low to medium plasticity, trace of fine grained gravel, root affected. | M | | | | TOPSOIL |
| | | | | | | | 0.30m | | | | | |
| E | Not Encountered | 0.40m<br>CBR<br>0.70m | 18.0 | 0.5 | | CH | Sandy CLAY - medium to high plasticity, pale grey to white and orange to pale brown, fine to coarse grained sand, trace of fine grained subrounded gravel. | M > $w_P$ | St | HP | 160 | RESIDUAL SOIL |
| | | | 17.5 | 1.0 | | | Becoming weakly cemented. | | St / VSt | HP | 200 | |
| | | | | | | | 1.35m | | | | | |
| | | | | | | | 1.40m PEBBLY SANDSTONE - fine to coarse grained, pale grey to white and orange to pale brown, fine to medium grained subrounded gravel, estimated medium to high strength, few joints. | M | | | | HIGHLY WEATHERED ROCK |
| | | | 17.0 | 1.5 | | | Hole Terminated at 1.40 m<br>Practical Refusal | | | | | |
| | | | 16.5 | 2.0 | | | | | | | | |
| | | | 16.0 | 2.5 | | | | | | | | |

**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 |

# 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

# Shrink Swell Index Report

**Report No: SSI:NEW18W-3526--S01**
**Issue No: 1**

**Client:** McCloy Development Management Pty Ltd
Suite 1 Level 3, 426 King Street
Newcastle West NSW 2300

**Principal:**
**Project No.:** NEW15P-0070B
**Project Name:** Billys Lookout - Stage 11



Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 19/11/2018

## Sample Details

| | | | |
|---|---|---|---|
| **Sample ID:** | NEW18W-3526--S01 | **Client Sample ID:** | - |
| **Test Request No.:** | - | **Sampling Method:** | AS1289.1.2.1 cl 6.5 |
| **Material:** | Sandy Clay | **Date Sampled:** | 30/10/2018 |
| **Source:** | On-Site | **Date Submitted:** | 31/10/2018 |
| **Specification:** | No Specification | | |
| **Project Location:** | Teralba, NSW | | |
| **Sample Location:** | TP1101 - (0.3 - 0.7m) | | |
| **Borehole Number:** | TP1101 | | |
| **Borehole Depth (m):** | 0.3 - 0.7 | | |

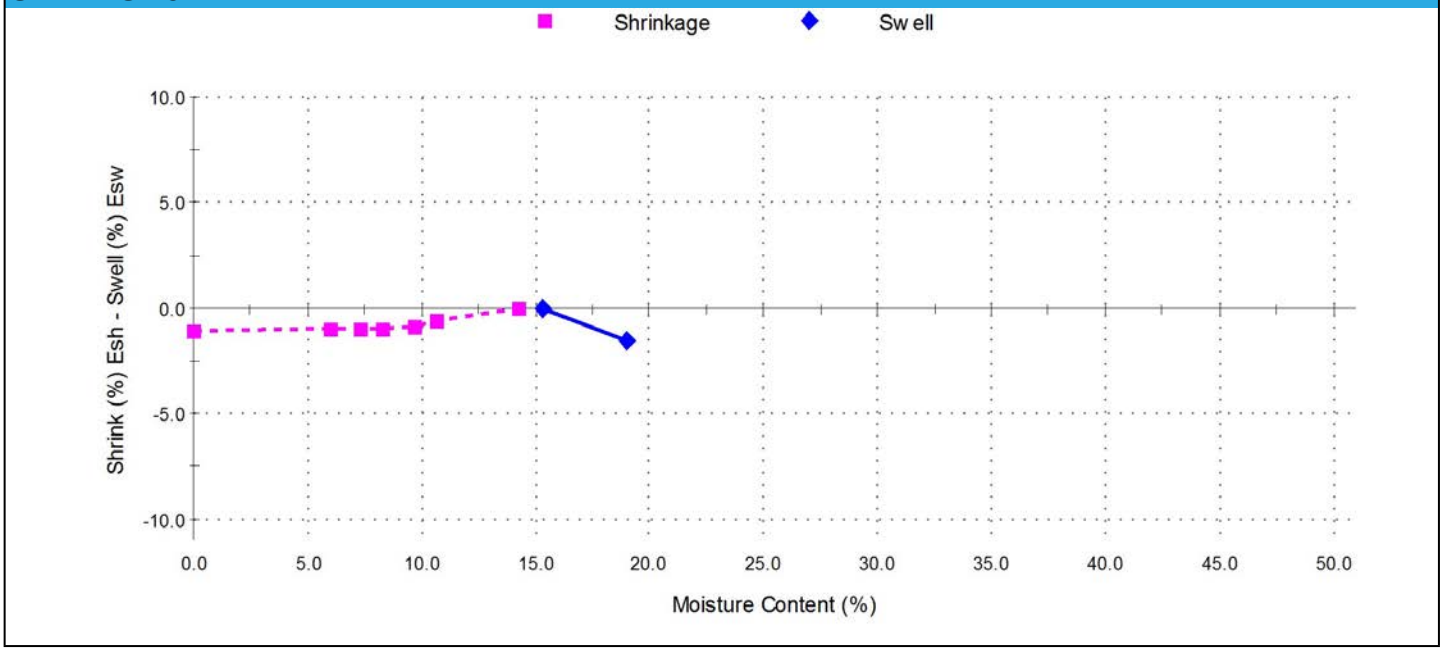
## Swell Test AS 1289.7.1.1

| | |
|---|---|
| **Swell on Saturation (%):** | -1.5 |
| **Moisture Content before (%):** | 15.3 |
| **Moisture Content after (%):** | 19.0 |
| **Est. Unc. Comp. Strength before (kPa):** | 290 |
| **Est. Unc. Comp. Strength after (kPa):** | 200 |

## Shrink Test AS 1289.7.1.1

| | |
|---|---|
| **Shrink on drying (%):** | 1.1 |
| **Shrinkage Moisture Content (%):** | 14.3 |
| **Est. inert material (%):** | 10.0 |
| **Crumbling during shrinkage:** | Nil |
| **Cracking during shrinkage:** | Minor |

## Shrink Swell




**Shrink Swell Index - Iss (%):** 0.6

## Comments

**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
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ABN: 98 153 268 896

# Shrink Swell Index Report

**Report No: SSI:NEW18W-3526--S02**
**Issue No: 1**

**Client:** McCloy Development Management Pty Ltd
Suite 1 Level 3, 426 King Street
Newcastle West NSW 2300

**Principal:**
**Project No.:** NEW15P-0070B
**Project Name:** Billys Lookout - Stage 11



Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 20/11/2018

## Sample Details

| | | | |
|---|---|---|---|
| **Sample ID:** | NEW18W-3526--S02 | **Client Sample ID:** | - |
| **Test Request No.:** | - | **Sampling Method:** | AS1289.1.2.1 cl 6.5 |
| **Material:** | Sandy Clay | **Date Sampled:** | 30/10/2018 |
| **Source:** | On-Site | **Date Submitted:** | 31/10/2018 |
| **Specification:** | No Specification | | |
| **Project Location:** | Teralba, NSW | | |
| **Sample Location:** | TP1102 - (0.8 - 1.15m) | | |
| **Borehole Number:** | TP1102 | | |
| **Borehole Depth (m):** | 0.8 - 1.15 | | |

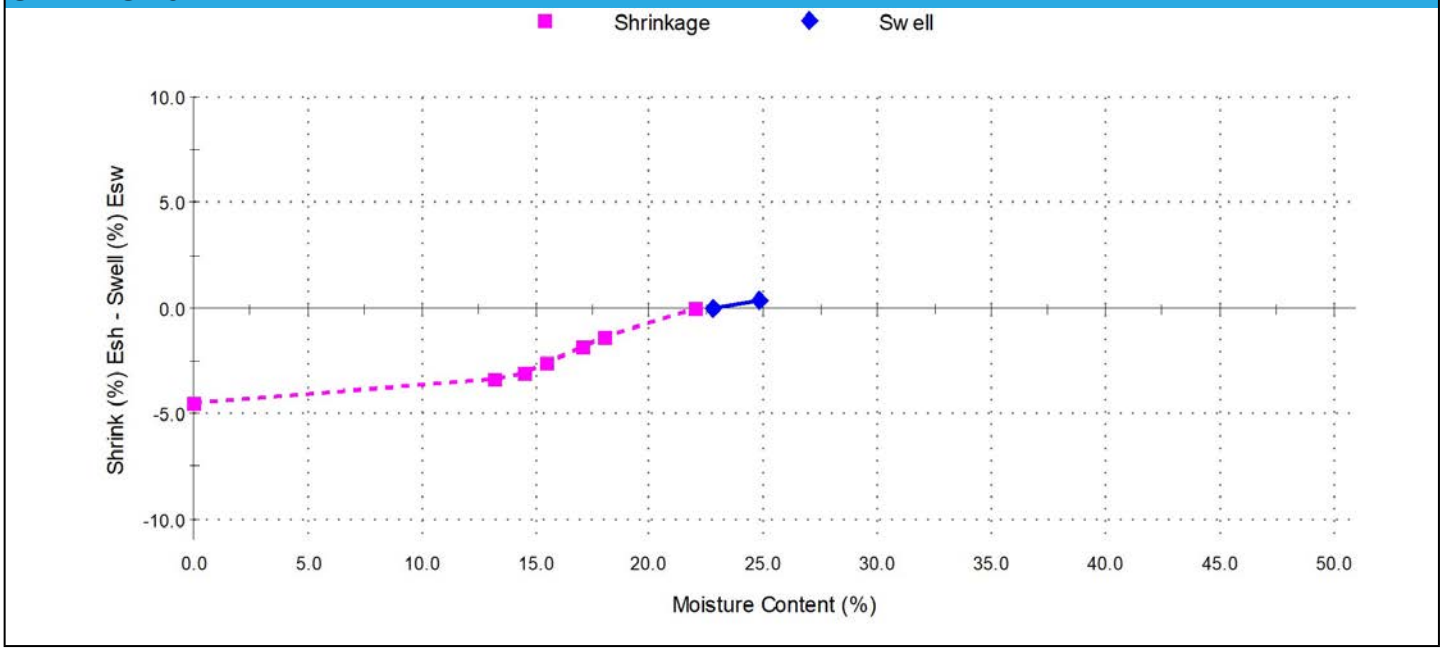
## Swell Test — AS 1289.7.1.1

| | |
|---|---|
| **Swell on Saturation (%):** | 0.3 |
| **Moisture Content before (%):** | 22.7 |
| **Moisture Content after (%):** | 24.8 |
| **Est. Unc. Comp. Strength before (kPa):** | 350 |
| **Est. Unc. Comp. Strength after (kPa):** | 280 |

## Shrink Test — AS 1289.7.1.1

| | |
|---|---|
| **Shrink on drying (%):** | 4.5 |
| **Shrinkage Moisture Content (%):** | 22.0 |
| **Est. inert material (%):** | 1.0 |
| **Crumbling during shrinkage:** | Nil |
| **Cracking during shrinkage:** | Nil |

## Shrink Swell




**Shrink Swell Index - Iss (%):** 2.6

## Comments

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
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# Shrink Swell Index Report

**Report No: SSI:NEW18W-3526--S03**
**Issue No: 1**

**Client:** McCloy Development Management Pty Ltd
Suite 1 Level 3, 426 King Street
Newcastle West NSW 2300

**Principal:**
**Project No.:** NEW15P-0070B
**Project Name:** Billys Lookout - Stage 11



Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 20/11/2018

## Sample Details

| | | | |
|---|---|---|---|
| **Sample ID:** | NEW18W-3526--S03 | **Client Sample ID:** | - |
| **Test Request No.:** | - | **Sampling Method:** | AS1289.1.2.1 cl 6.5 |
| **Material:** | Sandy Clay | **Date Sampled:** | 30/10/2018 |
| **Source:** | On-Site | **Date Submitted:** | 31/10/2018 |
| **Specification:** | No Specification | | |
| **Project Location:** | Teralba, NSW | | |
| **Sample Location:** | TP1103 - (0.3 - 0.5m) | | |
| **Borehole Number:** | TP1103 | | |
| **Borehole Depth (m):** | 0.3 - 0.5 | | |

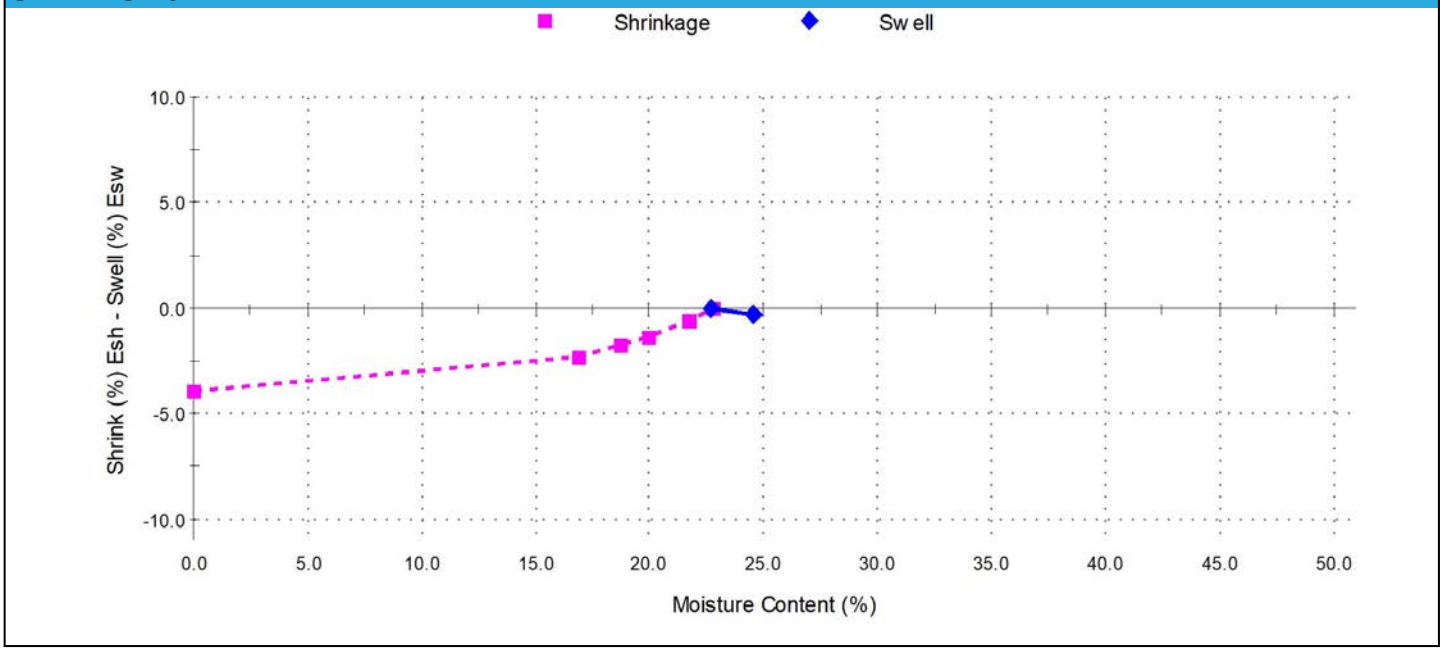
## Swell Test — AS 1289.7.1.1

| | |
|---|---|
| **Swell on Saturation (%):** | -0.3 |
| **Moisture Content before (%):** | 22.7 |
| **Moisture Content after (%):** | 24.6 |
| **Est. Unc. Comp. Strength before (kPa):** | 540 |
| **Est. Unc. Comp. Strength after (kPa):** | 370 |

## Shrink Test — AS 1289.7.1.1

| | |
|---|---|
| **Shrink on drying (%):** | 3.9 |
| **Shrinkage Moisture Content (%):** | 22.7 |
| **Est. inert material (%):** | 5.0 |
| **Crumbling during shrinkage:** | Nil |
| **Cracking during shrinkage:** | Nil |

## Shrink Swell




**Shrink Swell Index - Iss (%):** 2.1

## Comments

**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

# Shrink Swell Index Report

**Report No: SSI:NEW18W-3526--S04**
**Issue No: 1**

**Client:** McCloy Development Management Pty Ltd
Suite 1 Level 3, 426 King Street
Newcastle West NSW 2300

**Principal:**
**Project No.:** NEW15P-0070B
**Project Name:** Billys Lookout - Stage 11



Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 20/11/2018

## Sample Details

| | | | |
|---|---|---|---|
| **Sample ID:** | NEW18W-3526--S04 | **Client Sample ID:** | - |
| **Test Request No.:** | - | **Sampling Method:** | AS1289.1.2.1 cl 6.5 |
| **Material:** | Sandy Clay | **Date Sampled:** | 30/10/2018 |
| **Source:** | On-Site | **Date Submitted:** | 31/10/2018 |
| **Specification:** | No Specification | | |
| **Project Location:** | Teralba, NSW | | |
| **Sample Location:** | TP1104 - (0.4 - 0.65m) | | |
| **Borehole Number:** | TP1104 | | |
| **Borehole Depth (m):** | 0.4 - 0.65 | | |

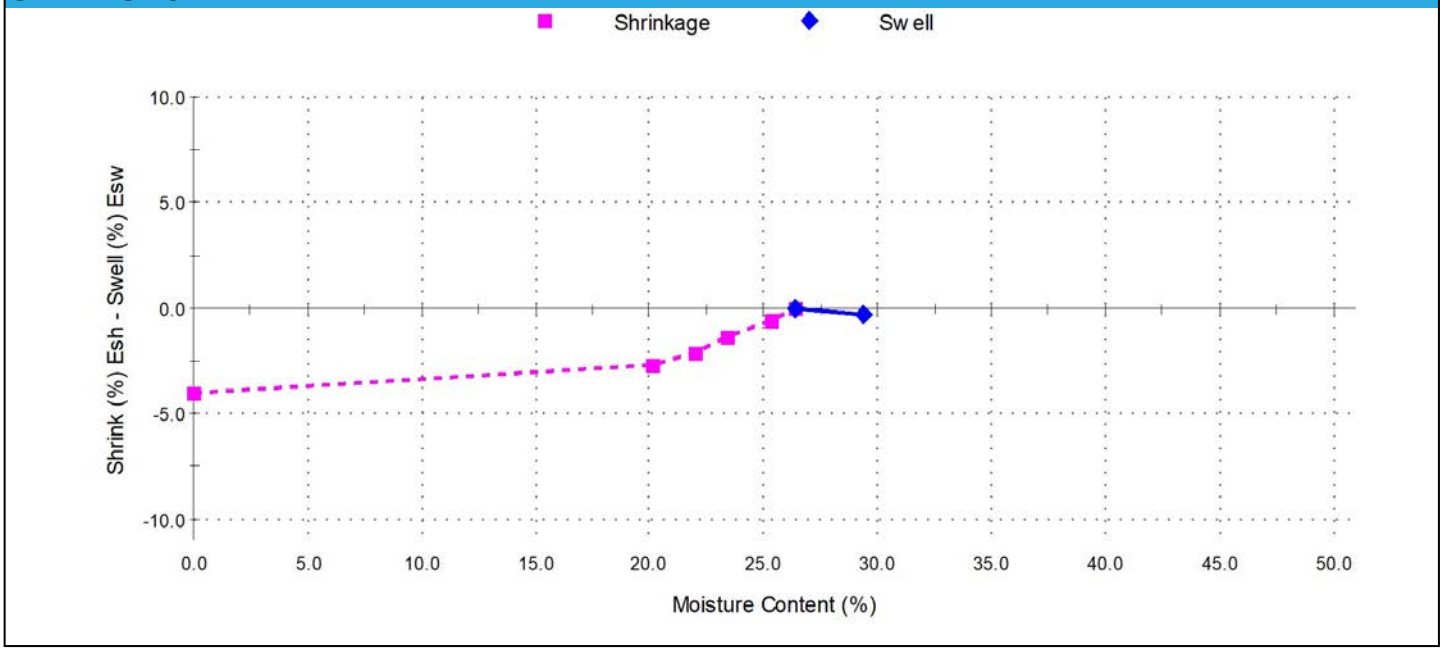
## Swell Test — AS 1289.7.1.1

| | |
|---|---|
| **Swell on Saturation (%):** | -0.3 |
| **Moisture Content before (%):** | 26.4 |
| **Moisture Content after (%):** | 29.3 |
| **Est. Unc. Comp. Strength before (kPa):** | 480 |
| **Est. Unc. Comp. Strength after (kPa):** | 350 |

## Shrink Test — AS 1289.7.1.1

| | |
|---|---|
| **Shrink on drying (%):** | 4.0 |
| **Shrinkage Moisture Content (%):** | 26.4 |
| **Est. inert material (%):** | 10.0 |
| **Crumbling during shrinkage:** | Nil |
| **Cracking during shrinkage:** | Major |

## Shrink Swell




**Shrink Swell Index - Iss (%):** 2.2

## Comments

**QUALTEST Laboratory (NSW) Pty Ltd (20708)**
**8 Ironbark Close Warabrook NSW 2304**
T: 02 4968 4468
F: 02 4960 9775
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W: www.qualtest.com.au
ABN: 98 153 268 896

**Report No: SSI:NEW18W-3526--S05**
**Issue No: 1**

# Shrink Swell Index Report

**Client:** McCloy Development Management Pty Ltd
Suite 1 Level 3, 426 King Street
Newcastle West NSW 2300

**Principal:**
**Project No.:** NEW15P-0070B
**Project Name:** Billys Lookout - Stage 11



Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 20/11/2018

## Sample Details

| | | | |
|---|---|---|---|
| **Sample ID:** | NEW18W-3526--S05 | **Client Sample ID:** | - |
| **Test Request No.:** | - | **Sampling Method:** | AS1289.1.2.1 cl 6.5 |
| **Material:** | Sandy Clay | **Date Sampled:** | 30/10/2018 |
| **Source:** | On-Site | **Date Submitted:** | 31/10/2018 |
| **Specification:** | No Specification | | |
| **Project Location:** | Teralba, NSW | | |
| **Sample Location:** | TP1105 - (0.4 - 0.65m) | | |
| **Borehole Number:** | TP1105 | | |
| **Borehole Depth (m):** | 0.4 - 0.65 | | |

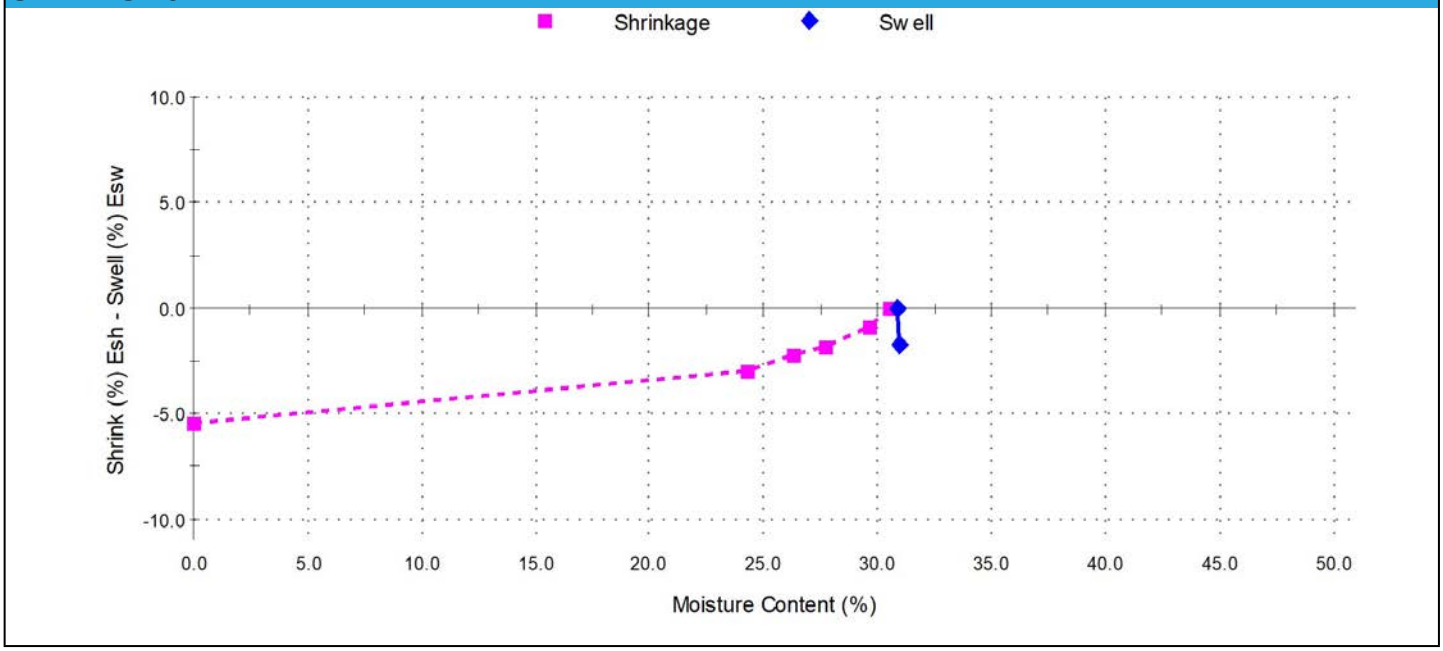
## Swell Test — AS 1289.7.1.1

| | |
|---|---|
| **Swell on Saturation (%):** | -1.7 |
| **Moisture Content before (%):** | 30.8 |
| **Moisture Content after (%):** | 30.9 |
| **Est. Unc. Comp. Strength before (kPa):** | 290 |
| **Est. Unc. Comp. Strength after (kPa):** | 260 |

## Shrink Test — AS 1289.7.1.1

| | |
|---|---|
| **Shrink on drying (%):** | 5.5 |
| **Shrinkage Moisture Content (%):** | 30.5 |
| **Est. inert material (%):** | 1.0 |
| **Crumbling during shrinkage:** | Nil |
| **Cracking during shrinkage:** | Nil |

## Shrink Swell




**Shrink Swell Index - Iss (%):** 3.1

## Comments

**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

# Shrink Swell Index Report

**Report No: SSI:NEW18W-3526--S06**
**Issue No: 1**

**Client:** McCloy Development Management Pty Ltd
Suite 1 Level 3, 426 King Street
Newcastle West NSW 2300

**Principal:**
**Project No.:** NEW15P-0070B
**Project Name:** Billys Lookout - Stage 11



Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 29/11/2018

## Sample Details

| | | | |
|---|---|---|---|
| **Sample ID:** | NEW18W-3526--S06 | **Client Sample ID:** | - |
| **Test Request No.:** | - | **Sampling Method:** | AS1289.1.2.1 cl 6.5 |
| **Material:** | Sandy Clay | **Date Sampled:** | 30/10/2018 |
| **Source:** | On-Site | **Date Submitted:** | 31/10/2018 |
| **Specification:** | No Specification | | |
| **Project Location:** | Teralba, NSW | | |
| **Sample Location:** | TP1106 - (0.6 - 0.85m) | | |
| **Borehole Number:** | TP1106 | | |
| **Borehole Depth (m):** | 0.6 - 0.85 | | |

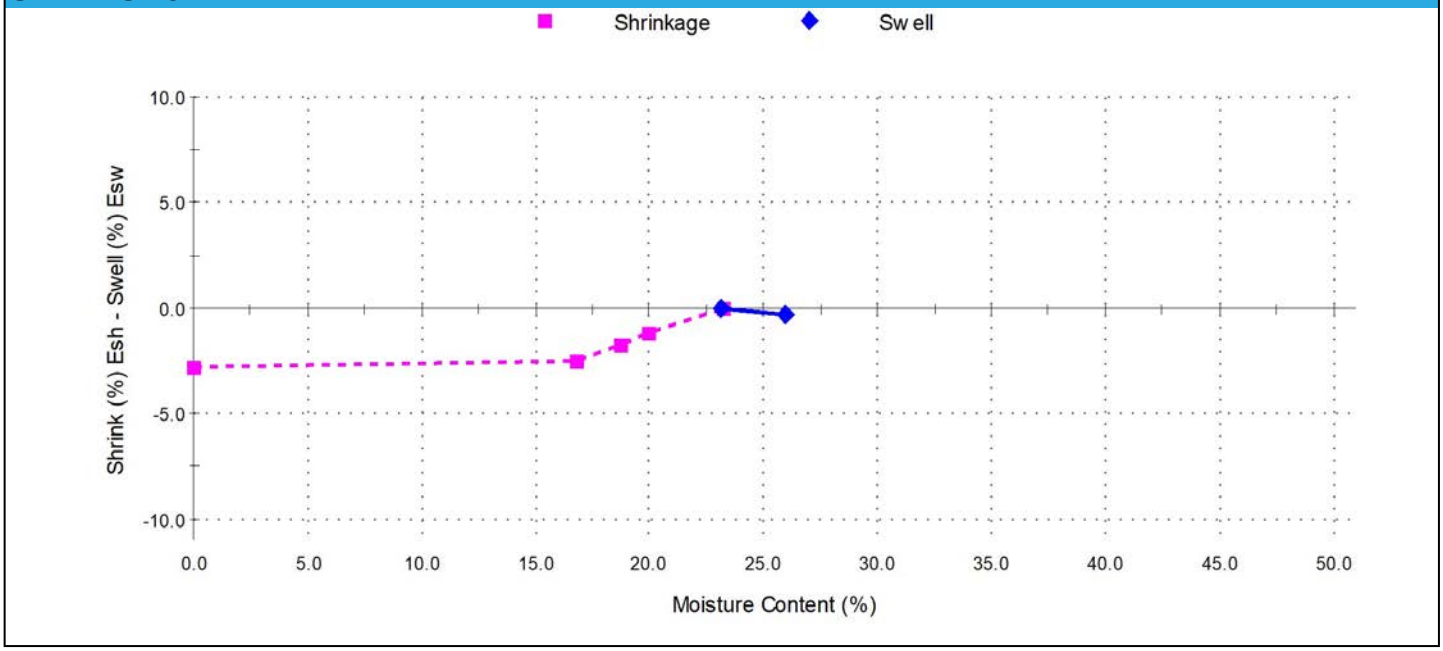
## Swell Test — AS 1289.7.1.1

| | |
|---|---|
| **Swell on Saturation (%):** | -0.3 |
| **Moisture Content before (%):** | 23.1 |
| **Moisture Content after (%):** | 25.9 |
| **Est. Unc. Comp. Strength before (kPa):** | 580 |
| **Est. Unc. Comp. Strength after (kPa):** | 250 |

## Shrink Test — AS 1289.7.1.1

| | |
|---|---|
| **Shrink on drying (%):** | 2.8 |
| **Shrinkage Moisture Content (%):** | 23.2 |
| **Est. inert material (%):** | 1.0 |
| **Crumbling during shrinkage:** | Nil |
| **Cracking during shrinkage:** | Nil |

## Shrink Swell




**Shrink Swell Index - Iss (%):** 1.5

## Comments

**QUALTEST Laboratory (NSW) Pty Ltd (20708)**
**8 Ironbark Close Warabrook NSW 2304**
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ABN: 98 153 268 896

# Shrink Swell Index Report

**Report No: SSI:NEW18W-3526--S07**
**Issue No: 1**

**Client:** McCloy Development Management Pty Ltd
Suite 1 Level 3, 426 King Street
Newcastle West NSW 2300

**Principal:**
**Project No.:** NEW15P-0070B
**Project Name:** Billys Lookout - Stage 11



Approved Signatory: Brent Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 22/11/2018

## Sample Details

| | | | |
|---|---|---|---|
| **Sample ID:** | NEW18W-3526--S07 | **Client Sample ID:** | - |
| **Test Request No.:** | - | **Sampling Method:** | AS1289.1.2.1 cl 6.5 |
| **Material:** | Sandy Clay | **Date Sampled:** | 30/10/2018 |
| **Source:** | On-Site | **Date Submitted:** | 31/10/2018 |
| **Specification:** | No Specification | | |
| **Project Location:** | Teralba, NSW | | |
| **Sample Location:** | TP1107 - (0.4 - 0.5m) | | |
| **Borehole Number:** | TP117 | | |
| **Borehole Depth (m):** | 0.4 - 0.5 | | |

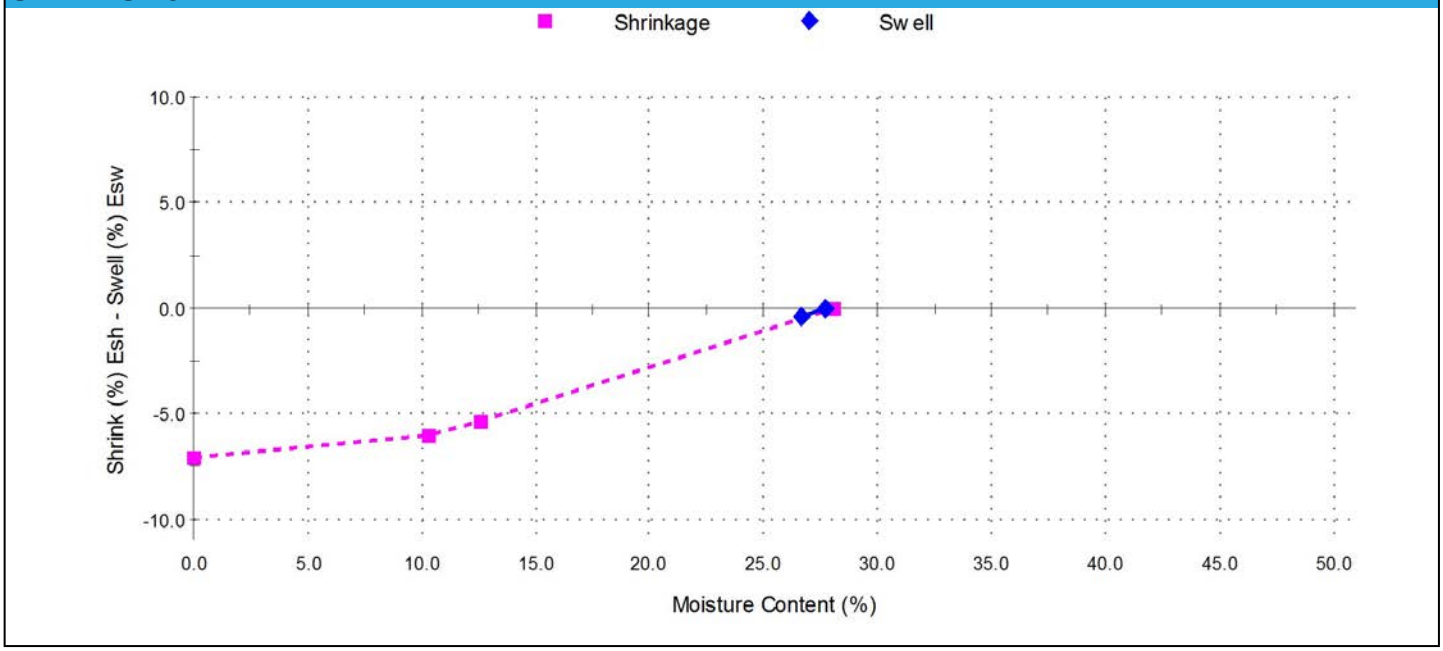
## Swell Test — AS 1289.7.1.1

| | |
|---|---|
| **Swell on Saturation (%):** | -0.4 |
| **Moisture Content before (%):** | 27.7 |
| **Moisture Content after (%):** | 26.6 |
| **Est. Unc. Comp. Strength before (kPa):** | 380 |
| **Est. Unc. Comp. Strength after (kPa):** | 210 |

## Shrink Test — AS 1289.7.1.1

| | |
|---|---|
| **Shrink on drying (%):** | 7.1 |
| **Shrinkage Moisture Content (%):** | 28.1 |
| **Est. inert material (%):** | <1% |
| **Crumbling during shrinkage:** | Nil |
| **Cracking during shrinkage:** | Nil |

## Shrink Swell




**Shrink Swell Index - Iss (%):** 4.0

## Comments

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# Shrink Swell Index Report

**Report No: SSI:NEW18W-3526--S08**
**Issue No: 2**
*This report replaces all previous issues of report no 'SSI:NEW18W-3526--S08'.*

**Client:** McCloy Development Management Pty Ltd
Suite 1 Level 3, 426 King Street
Newcastle West NSW 2300

**Principal:**
**Project No.:** NEW15P-0070B
**Project Name:** Billys Lookout - Stage 11



Approved Signatory: Brent Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 28/11/2018

## Sample Details

| | | | |
|---|---|---|---|
| **Sample ID:** | NEW18W-3526--S08 | **Client Sample ID:** | - |
| **Test Request No.:** | - | **Sampling Method:** | AS1289.1.2.1 cl 6.5 |
| **Material:** | Sandy Clay | **Date Sampled:** | 30/10/2018 |
| **Source:** | On-Site | **Date Submitted:** | 31/10/2018 |
| **Specification:** | No Specification | | |
| **Project Location:** | Teralba, NSW | | |
| **Sample Location:** | TP1108 - (1.4 - 1.6m) | | |
| **Borehole Number:** | TP118 | | |
| **Borehole Depth (m):** | 1.4 - 1.6 | | |

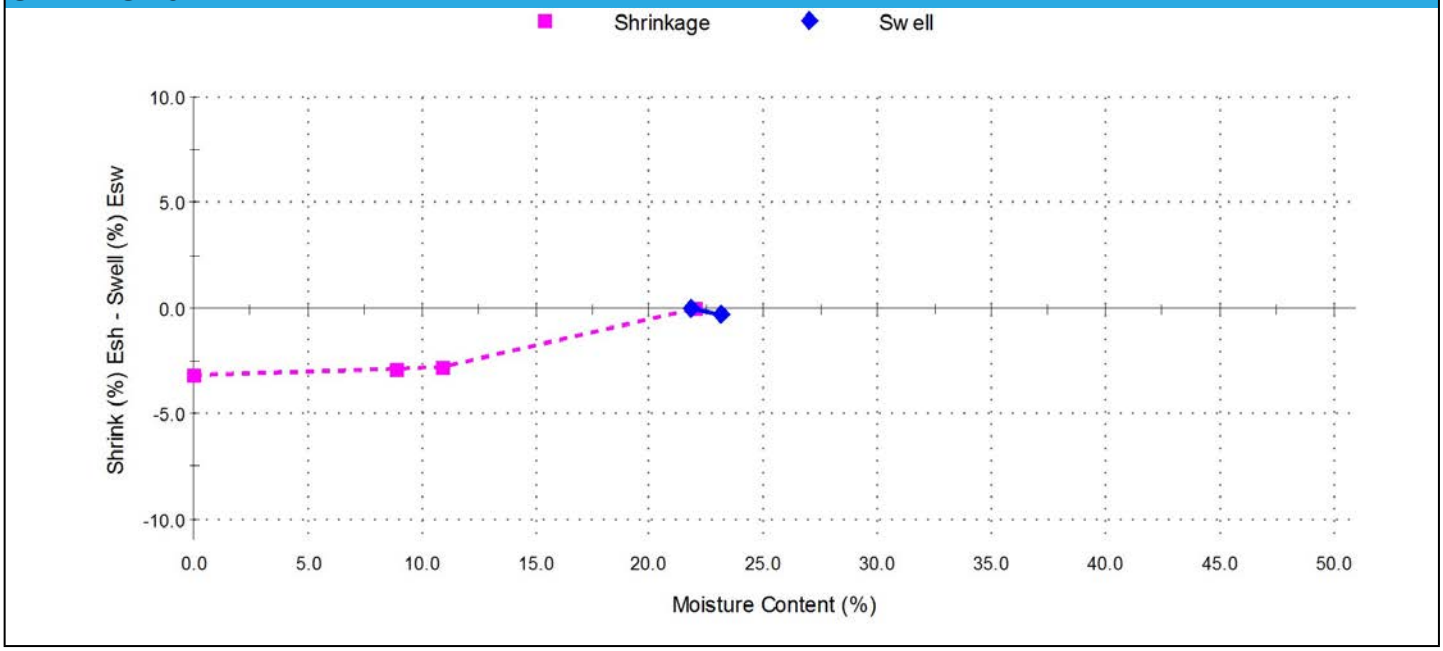
## Swell Test AS 1289.7.1.1

| | |
|---|---|
| **Swell on Saturation (%):** | -0.3 |
| **Moisture Content before (%):** | 21.8 |
| **Moisture Content after (%):** | 23.2 |
| **Est. Unc. Comp. Strength before (kPa):** | 440 |
| **Est. Unc. Comp. Strength after (kPa):** | 250 |

## Shrink Test AS 1289.7.1.1

| | |
|---|---|
| **Shrink on drying (%):** | 3.2 |
| **Shrinkage Moisture Content (%):** | 22.0 |
| **Est. inert material (%):** | <1% |
| **Crumbling during shrinkage:** | Nil |
| **Cracking during shrinkage:** | Minor |

## Shrink Swell




**Shrink Swell Index - Iss (%):** 1.8

## Comments

Report re-issued due to amendment of Sample depth

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**Report No: MAT:NEW18W-3526--S09**
**Issue No: 1**

# Material Test Report

**Client:** McCloy Development Management Pty Ltd
Suite 1 Level 3, 426 King Street
Newcastle West NSW 2300

**Principal:**
**Project No.:** NEW15P-0070B
**Project Name:** Billys Lookout - Stage 11



Approved Signatory: Brent Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 8/11/2018

## Sample Details

**Sample ID:** NEW18W-3526--S09
**Sampling Method:** AS1289.1.2.1 cl 6.5
**Date Sampled:** 30/10/2018
**Source:** On-Site
**Material:** Sandy Clay
**Specification:** No Specification
**Project Location:** Teralba, NSW
**Sample Location:** TP1109 - (0.3 - 0.4m)

## 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 | 6.5 | |
| Mould Length (mm) | | 250 | |
| Crumbling | | No | |
| Curling | | No | |
| Cracking | | Yes | |
| Liquid Limit (%) | AS 1289.3.1.1 | 36 | |
| Method | | Four Point | |
| Plastic Limit (%) | AS 1289.3.2.1 | 17 | |
| Plasticity Index (%) | AS 1289.3.3.1 | 19 | |

## Comments

N/A

# 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.

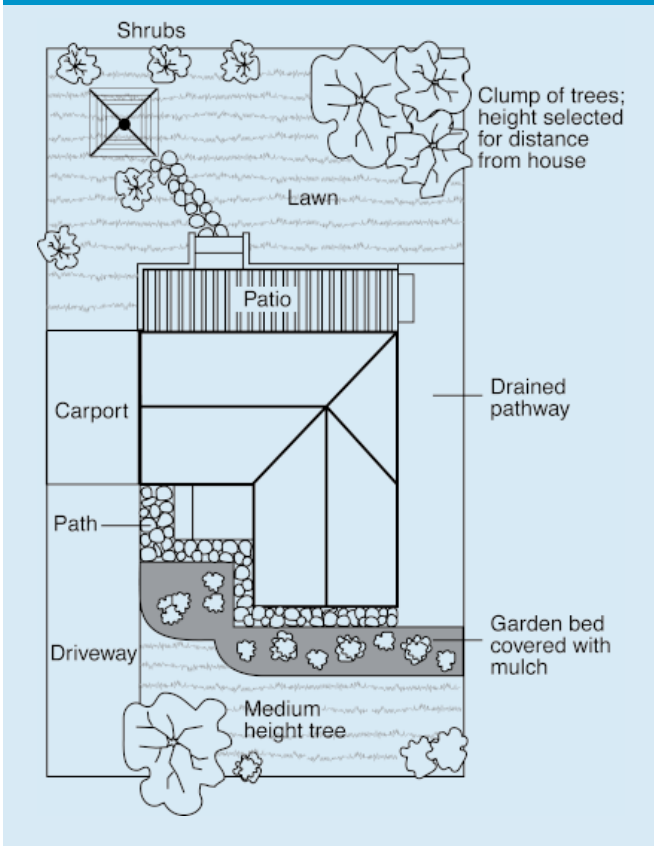
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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.**



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