Proposed Seniors Living Development Preliminary Geotechnical Assessment

Lot 2 DP 1145348,
107 Haussman Drive,
Thornton

NEW17P-0074-AA
29 June 2017

LABORATORY (NSW) PTY LTD

GEOTECHNICAL I LABORATORY I EARTHWORKS I QUARRY I CONSTRUCTION MATERIAL TESTING

29 June 2017

McCloy Group,
Suite 1, Level 3, 426 King St,
Newcastle West NSW 2302

Attention: Mr Shane Boslem

Dear Shane,

RE: PROPOSED SENIORS LIVING DEVELOPMENT
LOT 2 DP 1145348 (NO. 107) HAUSSMAN DRIVE, THORNTON
PRELIMINARY GEOTECHNICAL ASSESSMENT

Please find enclosed our Preliminary Geotechnical Assessment report for the proposed seniors living development, to be located at 107 Haussman Drive, Thornton.

The report includes preliminary geotechnical recommendations for urban development including earthworks procedures, batter slopes, and preliminary site classification in accordance with AS2870-2011, "*Residential Slabs and Footings*".

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

Jason Lee
Principal Geotechnical Engineer

Table of Contents:

Attachments:

1.0 Introduction

Qualtest Laboratory NSW Pty Ltd (Qualtest) is pleased to present this report on behalf of McCloy Group Pty Ltd (McCloy), for the proposed seniors living development located at Lot 2 DP 1145348, No. 107 Haussman Drive, Thornton.

Based on the brief and lot layout plans provided in an email from McCloy dated 2 May 2017, the project is understood to comprise cutting and filling within the limits of the former quarry site, to allow for the construction of an unspecified number of senior's living residential units, associated pavements, amenities, recreational areas and park reserves.

The scope of work for the geotechnical investigation included providing discussion and recommendations on the following:

- Site capability assessment - Assessing the suitability of the site for proposed development from a geotechnical perspective, including geotechnical constraints for development;
- Preliminary site classification to AS2870-2011, "*Residential Slabs and Footings*";
- Recommendations for earthworks including site preparation, excavation conditions, batters and benching, the suitability of the site soils for use as fill, and fill construction procedures.

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

2.0 Field Work

Field work investigations were carried out on 17 May, 2017 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 14 test pits (TP01 to TP14) using a 14 tonne rubber tracked excavator equipped with a 1100mm wide bucket to depths of between 0.90m and 3.30m. Dynamic Cone Penetrometer tests (DCP's) were undertaken adjacent to the test pit locations TP01 to TP04;
- Undisturbed samples (U50 tubes) and bulk disturbed samples were taken for subsequent laboratory testing;
- 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 AA1. 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.

Approximate reduced levels of the test pits have been interpolated from the survey plan provided by the client, (Drawing Ref: Project No. 15327, Drawing No. 1, Revision 1, dated 09/05/2017, prepared by Delfs Lascelles Consulting Surveys), on which Figure AA1 is based.

3.0 Site Description

3.1 Surface Conditions

The site is located at Lot 2 DP1145348, No. 107 Haussman Drive, Thornton, which is an irregular shaped allotment with a total plan area of about 39ha, which is the location of a disused clay quarry. The lot is bounded to the northwest by Raymond Terrace Road, to the east by undeveloped bushlands, to the south by residential lots, and to the west by an electricity sub-station and Haussman Drive.

The proposed area of development is understood to be generally limited to the zone containing most previous disturbance and vegetation clearing shown as the unshaded area visible on Figure AA. This area and is generally bounded by an unsealed access track on most sides, and by the crest of the quarry pit to the south and southeast.

The site is situated within an area of gently to moderately undulating topography, occupying the upper catchment of a local ephemeral creek which drains to the east from the eastern boundary of the site.

Based upon the survey plan provided by the client, ground levels are understood to range from about RL18m within the creek on the eastern boundary, up to about RL40 (AHD) near the western boundary in the vicinity of Haussman Drive.

The topography of the site has been modified during previous site use as a clay quarry. The main area of extraction was from the south-western side of the quarry pit, leaving batters along the southern to north-western edges of the pit, with a maximum height of about 12m along the western edge.

These batters generally drain towards a lower area of the quarry pit which has previously been levelled by filling, positioned near the centre of the site in the vicinity of TP01 to TP04. Based upon fill depth observed in these test pits, the fill is judged to mostly be of depths in the order of 1.5m or shallower.

A drainage channel is connected to the northern edge of the levelled fill area, draining through a cutting into bedrock towards the east-southeast into a detention basin (dam). A culvert is located beneath the access road on the eastern side of the dam, draining into the natural gully / creek near the eastern boundary of the site.

The northern area of the quarry pit generally slopes to the south towards the drainage channel and dam.

Existing development at the site includes the unsealed access roads mapped on the survey plan. Swale drains are present in several areas outside the quarry pit. No significant structures were observed at the site.

The site of proposed development is generally vegetated by established grass cover and a sparse to moderate cover of bushes and established trees. The coverage of bushes and established trees was denser on the outer perimeter of the site, while the fill at the approximate centre of the site was covered by short grass.

Photographs of the site taken on the day of the site investigations are shown below.

Photograph 1: From access road on southern area of site to the south of the filled area, facing west.

Photograph 2: From access road on southern area of site to the south of the filled area, facing north.

Photograph 3: From access road on western side of filled area, facing north.

Photograph 4: From access road on western side of filled area, facing southeast.

Photograph 5: Possible topsoil /fill mound at location of TP07, facing south.

Photograph 6: Drainage channel connecting to northern side of filled area, facing east. Rock outcropping visible in sides.

Photograph 7: Dam on eastern side of site, facing west.

Photograph 8: Facing southeast towards culvert outlet from dam into gully / creek on eastern boundary.

Photograph 9: View from access road south of dam, facing south.

Photograph 10: View of cleared area north of dam, facing north-west towards TP09 location.

Photograph 11: From access road along northwest edge of site, facing east.

Photograph 12: From access road along northwest edge of site, facing southeast.

3.2 Subsurface Conditions

Reference to the 1:100,000 Newcastle Regional Geology Series Sheet 9232 indicates the site to be underlain by the Tomago Coal Measures, comprising shale, mudstone, sandstone, coal, tuff and clay.

The typical soil types encountered at test pit locations during the field investigation have been divided into geotechnical units as summarised in Table 1.

TABLE 1 – SUMMARY OF GEOTECHNICAL UNITS AND SOIL TYPES

Unit	Soil Type	Description
1A	FILL – Topsoil / Root Affected	Sandy CLAY, Silty Sandy CLAY, CLAY – low plasticity to medium plasticity, dark brown / dark grey, fine to medium grained sand, root affected, some gravel in places.
1B	FILL - Other	Variable soil materials including: Sandy CLAY – variable plasticity, variable colours often including shades of grey and brown, fine to medium grained sand, trace / some fine to medium grained sub-angular to sub-rounded gravel. SAND – fine to medium grained, brown, some fines of low plasticity. CLAY – high plasticity, dark grey, with pockets and lenses of Gravelly Silty SAND. Gravelly Clayey SAND.
2	TOPSOIL	Sandy CLAY – low plasticity, dark grey-brown, fine to medium grained sand, some fine to medium grained sub-angular to sub-rounded gravel in places, root affected. Silty SAND – fine to medium grained, dark brown, fines of low plasticity, some fine to medium grained sub-angular to sub-rounded gravel in places, root affected.
3	RESIDUAL SOIL	Sandy CLAY – medium plasticity to high plasticity, grey to pale grey with some orange / dark grey to black / pale grey to white with some orange, fine to medium grained sand, some fine to medium grained angular to sub-rounded gravel in places. CLAY – medium plasticity to high plasticity, dark grey to black / pale grey to grey, some orange, some fine to medium grained sand. Silty CLAY – medium to high plasticity, pale orange-grey. Silty SAND – fine to coarse grained, black, fines of medium plasticity (ORIGIN: COAL). Clayey SAND, Gravelly CLAY, Clayey Gravelly SAND with cobble sized rock fragments. With relict rock structure, extremely weathered pockets in places.
4	EXTREMELY WEATHERED (EW) ROCK with soil properties	Extremely weathered SANDSTONE with soil properties, breaks down into Sandy CLAY – medium to high plasticity, grey to pale grey with orange.
5	HIGHLY WEATHERED (HW) ROCK	SHALE, SILTSONE, COAL - estimated very low to low strength. SANDSTONE - estimated low to medium strength. Extremely to highly weathered in places.

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

TABLE 2 – SUMMARY OF GEOTECHNICAL UNITS ENCOUNTERED AT EACH TEST LOCATION

Location	UNIT 1A FILL-Topsoil	UNIT 1B FILL - Other	UNIT 2 Topsoil	UNIT 3 Residual Soil	UNIT 4 EW Rock	UNIT 5 HW Rock
	Depth (metres)					
TP01	0.00 - 0.10	0.10 - 0.30	-	0.30 - 1.00 2.20 - 2.30	-	1.00 - 2.20 2.30 - 3.30
TP02	0.00 - 0.20	0.20 - 0.50	-	0.50 - 0.60	0.60 - 0.80	0.80 - 0.90*
TP03	0.00 - 0.50	0.50 - 1.50	-	1.50 - 1.70	-	1.70 - 2.20
TP04	0.00 - 0.10	0.10 - 1.50	-	1.50 - 2.00	-	2.00 - 2.20
TP05	0.00 - 0.10	0.10 - 0.30	-	0.30 - 1.60	-	1.60 - 2.30
TP06	0.00 - 0.40	0.40 - 1.80	-	1.80 - 2.20	-	-
TP07	0.00 - 0.60	-	-	0.60 - 1.20	-	1.20 - 3.00
TP08	-	-	0.00 - 0.30	0.30 - 0.70	-	0.70 - 0.95*
TP09	-	0.00 - 0.60	-	0.60 - 1.50	-	1.50 - 1.60*
TP10	-	-	0.00 - 0.30	0.30 - 2.00	-	2.00 - 2.40
TP11	0.00 - 0.50	-	0.50 - 0.70	0.70 - 1.70	-	1.70 - 2.10
TP12	-	-	0.00 - 0.30	0.30 - 0.90	-	0.90 - 0.95*
TP13	0.00 - 0.30	0.30 - 0.80	-	-	-	0.80 - 1.70*
TP14	-	-	0.00 - 0.20	0.20 - 0.50	-	0.50 - 1.60*
NOTES: * denotes practical refusal of 14 tonne excavator bucket.						

No groundwater levels or 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.

4.0 Laboratory Testing

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

- (7 no.) Atterberg tests;
- (1 no.) Four day soaked California Bearing Ratio (CBR) test and Standard Compaction.

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

Proposed Shrink/Swell tests were replaced with Atterberg Limits tests due to the typically friable nature of the site soils.

TABLE 3 – SUMMARY OF ATTERBERG LIMITS TESTING RESULTS

Location	Depth (m)	Material Description	Liquid Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)
TP05	0.7 – 0.9	(CH) CLAY	43	24	7.0
TP06	0.9 – 1.1	FILL (CI) Sandy CLAY	38	19	7.0
TP07	0.7 – 0.8	(CH) CLAY	55	33	10.5
TP08	0.4 – 0.7	(CH) CLAY	57	39	11.0
TP09	0.7 – 0.9	(CH) Sandy CLAY	71	40	14.5
TP10	0.5 – 0.9	(CH) CLAY	47	31	10.0
TP12	0.3 – 0.4	(CH) Sandy CLAY	71	47	7.5

TABLE 4 – SUMMARY OF CBR TESTING RESULTS

Location	Sample Depth (m)	Field Moisture Content (%)	Optimum Moisture Content (%)	Relationship of Field MC to OMC (%)	CBR (%)
TP13	0.9 – 1.2	13.2	17.2	4.0 dry	25

5.0 Discussion and Recommendations

5.1 General Suitability of the Site for the Proposed Development

The main geotechnical issues affecting urban capability identified at the site include:

- The presence of relatively steep slopes (in the order of 12° to 22°) in some areas of the site, including at the southern and western edges of the existing quarry pit. The likelihood of slope instability events may be higher in these areas than flatter areas if sound engineering and good hillside practice is not undertaken. This is likely to include stripping of existing uncontrolled fill, and flattening of batters where appropriate for the proposed development.
- The presence or inferred presence of uncontrolled fill affecting the majority of the existing quarry footprint. The existing fill has been assessed to be uncontrolled fill for the purposes of assessing preliminary site classifications, and footing should not be founded on the uncontrolled fill in its current state.

Based on the results of field investigations the site is considered suitable for the proposed development from a geotechnical viewpoint provided that development is carried out in accordance with sound engineering principles and good hillside practice, and with respect to the constraints and recommendations of this report, including geotechnical input during the design and construction phase.

Further geotechnical investigation and advice should be carried out during detailed design phase for earthworks/retention design, site classification to AS2870-2011 and pavement design as required.

In areas of previous filling, detailed geotechnical investigation at future stages of the development is recommended to delineate the extent, depth and properties of the fill.

Preliminary investigation of the roughly level filled area in the base of the pit, (as shown in Figure AA), indicates filling to be in the order of up to 1.5m depth. Based on anecdotal evidence, it is understood that the fill may have been placed as engineered fill l in the order of 15 to 20 years ago. Despite the generally compact appearance of the material, at the time of this assessment Qualtest has not been provided with records of the placement or compaction of this material; therefore, it has been assessed to be uncontrolled fill for the purposes of this assessment.

Based upon results of hand penetrometer and DCP testing at discrete locations, it is judged that a significant proportion of the filled area in the base of the pit may be of inadequate bearing capacity for support of residential footings. This may have been caused or contributed to by slower drainage in this lower lying position of the site, and resulting high moisture content of some of the fill materials.

Based upon the available information, it is recommended that allowance be made to remove and replace the existing fill materials as controlled fill. Subject to moisture conditioning (drying back), the majority of existing fill is anticipated to be suitable for re-use as general fill for engineering purposes; however, near surface topsoil and root affected material is likely to be suitable for landscaping purposes only.

In areas where proposed depth of controlled filling exceeds 2m (above existing site levels), and site preparation results in a suitable subgrade foundation for placement of controlled fill, the option of leaving existing fill materials in place may be considered. This may involve site preparation including stripping of topsoil, reworking and compaction of the upper fill surface, and proof roll assessment to identify any soft or deflecting areas requiring removal and replacement with approved controlled fill.

The option of leaving the fill in place (in its current condition) may carry a larger risk than would normally be accepted for low risk residential construction that settlements may exceed normal limits. It is recommended that further engineering assessment and advice is sought if this option is proposed in terms of remediation requirements for the filled areas.

Alternatively settlement sensitive structures may be supported on piers founded in bedrock beneath all uncontrolled fill, designed in accordance with sound engineering principles.

5.2 Preliminary Site Classification to AS2870-2011

Based on the results of the field work and laboratory testing, the site of the proposed seniors living development located at Lot 2 DP1145348, No. 107 Haussman Drive, Thornton, as shown on Figure AA1, is preliminary classified in its current condition in accordance with AS2870-2011 '*Residential Slabs and Footings*', as **Class 'P'**.

The site is classified as **Class 'P'** due to the presence or inferred presence of fill to depths of greater than 0.4m in many locations. The fill includes variable depths and types of soil materials understood to remain from previous quarry activities at the site. As there are no records of placement or compaction of the fill available, the existing fill has been assessed to be uncontrolled fill for the purposes of assessing preliminary site classifications.

The underlying natural soil profiles are anticipated to be classified as **Class 'M'** or potentially **Class 'H1'**, dependent on depth and reactivity of residual clay overlying weathered rock.

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.

Based upon discussions with the client, it is understood that significant earthworks are proposed at the site including reshaping batters and filling deeper areas of the quarry pit, likely to depths of several metres.

As a preliminary guide, if cutting is carried out to remove all uncontrolled fill, exposing residual soil or weathered rock, or if the site is filled with site won residual soil, weathered rock or similar material, carried out to 'Level 1' criteria as defined in Clause 8.2 – Section 8, of AS3798-2007, lots are likely to be classified as **Class 'M'** or **Class 'H1'**.

With engineering input and measures such as providing a sufficiently thick (about 0.2m to 0.3m depth) topsoil layer of very low to non-reactive soil, and using fill with Iss of about 2.0% or less, it is envisaged that site classification of **Class 'M'** could be achievable in most cases. However, this would need to be confirmed at the time of bulk earthworks once the type of fill and level of filling is confirmed. For higher reactivity fill material (of Iss greater than about 2.0%), filled areas may potentially be classified **Class 'H1' to Class 'E'**, depending upon the source and Iss of the fill.

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

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

The classification presented above assumes that:

- All footings are founded in controlled fill (if applicable) or in the residual clayey soils or rock below all non-controlled fill, topsoil material and root zones, and fill under slab panels meets the requirements of AS2870-2011, in particular, the root zone must be removed prior to the placement of fill materials beneath slabs;
- The performance expectations set out in Appendix B of AS2870-2011 are acceptable, and that site foundation maintenance is undertaken to avoid extremes of wetting and drying;
- Footings are to be founded outside of or below all zones of influence resulting from existing or future service trenches;
- The constructional and architectural requirements for reactive clay sites set out in AS2870-2011 are followed;
- Adherence to the detailing requirement outlined in Section 5 of AS2870-2011 '*Residential Slabs and Footings*' is essential, in particular Section 5.6, '*Additional requirements for Classes M, H1, H2 and E sites*' including architectural restrictions, plumbing and drainage requirements;
- Site maintenance complies with the provisions of CSIRO Sheet BTF 18, "*Foundation Maintenance and Footing Performance: A Homeowner's Guide*", a copy of which is attached in Appendix C.

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

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

The classification provided is preliminary based on broadly spaced investigations and limited surface observations, and should be confirmed prior to design of foundations. It is recommended that targeted investigations be carried out once a concept design including proposed cut/fill earthworks is developed, and that the extent of existing fill is further investigated prior to or during earthworks construction.

5.3 Excavation Conditions and Depth to Rock

The depths of fill, topsoil, colluvium, residual soils and weathered rock, together with depths of practical refusal of the 14 tonne excavator where encountered are summarised in Table 2.

In terms of excavation conditions, site materials can generally be divided into:

- Clayey and Granular Soils (Units 1, 2 & 3). It is anticipated that these materials could be excavated by a conventional excavator or backhoe bucket;
- Weathered Rock (Unit 4 & 5). Rippability is dependent on rock strength, depth, degree of weathering and number of defects within the rock mass which can vary significantly.

It is anticipated that the Weathered Rock (Unit 4 & 5) material encountered could be excavated by conventional 14 tonne excavator or equivalent at least to the depths indicated on the appended test pit logs.

It is expected that material below the depth of 14 tonne excavator bucket refusal will be excavatable by ripping to some greater depth, although this has not been assessed as part of the current investigation.

It is recommended that targeted investigations (e.g. cored boreholes) are carried out if significant excavations are proposed where bedrock depth or excavatability is important to design or construction.

Care should be taken not to disturb or destabilise existing underground services or structures.

Slow water inflow is likely from the topsoil if earthworks are carried out following wet weather. It is also possible that groundwater could exist at localised areas of the site such as from water perched above the residual clay / bedrock profile, or in areas of existing depressions / dams.

5.4 Batter Slope Recommendations

Site materials should be supported by properly designed and constructed retaining walls or else battered in accordance with the recommended batter slopes summarised in Table 5, and protected against erosion.

Selection of batter slopes should consider future maintenance activities, such as operation of mowing equipment where necessary, requiring batters of about 1V:4H or flatter.

Temporary excavations to depths of up to 1.2m in competent compact material with sufficient cohesion, such as clay of stiff consistency or better may be battered vertically, subject to inspection during excavation by the geotechnical authority. Deeper excavations may be supported by means of temporary shoring.

Temporary earthworks in any wet or granular soils are likely to require shallow batters or shoring to prevent slumping and/or collapse.

Visual assessment for signs of instability should be made prior to carrying out any work in the excavation. If any deflection or excavation instability is observed, the excavation should be backfilled and further geotechnical advice sought.

The safe working procedures of Work Cover NSW *Excavation work code of practice*, dated July 2014 should be followed.

Recommended batter slopes for each inferred geotechnical unit are summarised in Table 5.

TABLE 5 - RECOMMENDED BATTER SLOPES

GEOTECHNICAL UNIT	**MATERIAL TYPE**	**MAXIMUM SLOPE OF EXCAVATED UNSUPPORTED BATTER**	
		Temporary Excavations *	Permanent Excavations
UNIT 1 & 2	Existing Fill & Topsoil	1V:1.5H	1V:3H
UNIT 3	Residual Soil (& Controlled Fill)	1V:1H	1V:2H
UNIT 4	Extremely Weathered Rock	1V:0.5H	1V:1.5H
UNIT 5	Highly Weathered Rock	1V:0.5H	1V:1H

NOTE: * Subject to inspection during excavation to check for water inflow, lack of soil cohesion, adversely orientated defects or other conditions that could affect stability of the slope.

Areas which may be subject to inundation should have flattened batters (approximately 1V:3.5H or flatter depending upon specific assessment).

Excavations should be designed for surcharge loading from slopes, retaining walls, structures and other improvements in the vicinity of the excavation.

Surcharge loads such as stockpiles of excavated soils and vehicle traffic should not be applied within a 1V:1.5H projection from the toe of any excavations or embankments, or within a 1m offset from the crest of the excavation or embankments, unless specific assessment is undertaken.

Drainage measures should be implemented above and behind all temporary and permanent batter slopes to avoid concentrated water flows on the face or infiltration into the soil/rock profile behind the face. Surface water flows from upslope areas should be diverted away from the face.

5.5 Design Subgrade CBR for Pavement Design

Based on the results of the field work, laboratory testing, and previous experience in the surrounding area, indicative California Bearing Ratio (CBR) values are provided below for preliminary purposes:

- CBR ≤ 3.0% Possible localised sections or poor / wet subgrade;
- CBR = 3% to 5% Unit 3 – Residual Soils and Controlled Fill (cohesive materials);
- CBR = 8% to 10% Unit 4 & 5 – Extremely to Highly Weathered Rock.

Earthworks including a large amount of filling are expected to occur prior to pavement construction. Therefore values of design subgrade CBR will be largely dependent upon the materials used for filling. It is expected that most areas of poor / wet subgrade will be remediated during the bulk earthworks phase.

The design CBR values for pavement thickness design should be assessed by laboratory testing when pavement layout and subgrade levels / conditions are known.

Subgrade should be prepared in accordance with the site preparation requirements presented in below.

5.6 Site Preparation

Site preparation and earthworks suitable for pavement support should consist of:

- Following any bulk excavation to proposed subgrade level, all areas of proposed pavement construction or site re-grading should be stripped to remove all existing uncontrolled fill, vegetation, topsoil, root affected or other potentially deleterious materials.
- Stripping depths are expected to be variable due to variable depths of existing fill.
- Following stripping, the exposed subgrade should be proof rolled (minimum 10 tonne static roller), to identify any wet or excessively deflecting material. Any such areas should be over excavated and backfilled with an approved select material.
- The moisture content of the subgrade materials and therefore the need for moisture conditioning or over-excavation and replacement, will be largely dependent on pre-existing and prevailing weather conditions at the time of construction;
- Protect the area after subgrade preparation to maintain moisture content as far as practicable. The placement of subbase gravel would normally provide adequate protection.
- Site preparation should include provision of drainage and erosion control as required as well as sedimentation control measures.

It should be anticipated that some moisture conditioning of the subgrade may be necessary prior to compaction and placement of fill materials.

The required time period to prepare the subgrade is likely to be dependent on the prevailing weather conditions at the time of construction.

If over wet subgrades exist at the time of construction or deleterious fill materials are encountered at subgrade level, these materials should be over-excavated and be replaced with a minimum depth of 250mm of well graded granular select material with CBR of 15% or greater. The requirement for, and extent of subgrade replacement / select filling, should be confirmed by the geotechnical authority at the time of construction.

Site preparation should include stripping of any over-wet or deleterious materials from any dams / detention basins and backfilling in accordance with the procedures in Section 5.7.

5.7 Fill Construction Procedures

Earthworks for pavement construction or support of foundations should consist of the following measures:

- Approved fill beneath pavements should be compacted in layers not exceeding 300mm loose thickness to a minimum density ratio of 95% Standard Compaction within ±2% of OMC in cohesive soils;

- The top 300mm of natural subgrade below pavements or the final 300mm of road subgrade fill should be compacted to a minimum density ratio of 98% Standard Compaction within the moisture range of 60% to 90% of Optimum Moisture Content (OMC).
- Site fill beneath structures should be compacted to a minimum density ratio of 98% Standard Compaction within ±2% of OMC in cohesive soils;
- All fill should be supported by properly designed and constructed retaining walls or else battered at 1V:2H or flatter and protected against erosion;
- Where fill is to be placed on slopes in excess of 1V:8H (7°), a prepared surface should be benched or stepped into the natural slope;
- Earthworks should be carried out in accordance with the recommendations outlined in AS3798-2007 'Guidelines for Earthworks for Commercial and Residential Developments'.

5.8 Suitability of Site Materials for Re-Use as Fill

The following comments are made with respect to suitability of site materials for re-use as fill:

- Units 1A & 2 – Topsoil-Fill & Topsoil materials are generally expected to be suitable for re-use for landscaping purposes only;
- Unit 1B – Fill materials may be variable. If fill material is not affected by roots, vegetation or other deleterious material, it may be suitable for re-use as general fill for engineering purposes. These materials will likely require some moisture conditioning, with materials excavated from lower lying areas more likely to require drying back. Suitability for re-use should be confirmed prior to, or at the time of construction;
- Unit 3 – Residual Soils are generally expected to be suitable for re-use as general fill for engineering purposes. These materials will likely require some moisture conditioning;
- Unit 4 & 5 – Extremely to Highly Weathered Rock materials are generally expected to be suitable for re-use as general fill, and possibly select fill in places. These materials may require some moisture conditioning.

Final selection of fill materials should consider properties such as reactivity which is typically moderate for site won Unit 3 Residual Soils, and likely to be lower for site won Unit 4 & 5 weathered rock.

The suitability of material for re-use should be assessed and confirmed by the geotechnical authority at the time of construction.

5.9 Management of Soil Erosion

The need for erosion protection of the site should be addressed during design. Depending upon the detailed design including expected flow rates, measures of protection may include constructing and maintaining appropriate batter slopes, established vegetation using suitably compacted soils, implementing storm water drainage measures to prevent concentrated flows on the slope, rip-rap, geosynthetic and nails, gabion / terramesh walls or concrete lining.

Levels of soil erosion should be able to be maintained within normally acceptable levels by adopting good soil erosion and sedimentation control practices, including:

- Minimise the area and duration of soil exposure by staged development and controlled clearing;
- Stockpile stripped soil for reuse and protect from erosion;

- Control storm water run-off by diverting clean run-off from denuded areas, minimising slope gradient, length and run-off velocities;
- Trap soil and water pollutants using silt traps, sediment basins, perimeter banks, silt fences and nutrient traps as appropriate;
- Re-vegetate as soon as is practicable.

5.10 Drainage

Adequate surface and storm water drainage should be installed and maintained on the building site in accordance with local government requirements.

All collected storm water run-off should be piped into the street drainage system or discharged into existing storm water drain or watercourses in a controlled manner that limits erosion. Surface and sub-soil drains may be required to improve drainage. Septic wastes should be connected to the reticulated disposal system.

If backfilling depressions within the lower lying areas of the existing quarry pit, it is likely to be necessary to divert drainage flows and/or provide dedicated sump and pump areas to prevent water ponding in areas of proposed fill placement.

6.0 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.

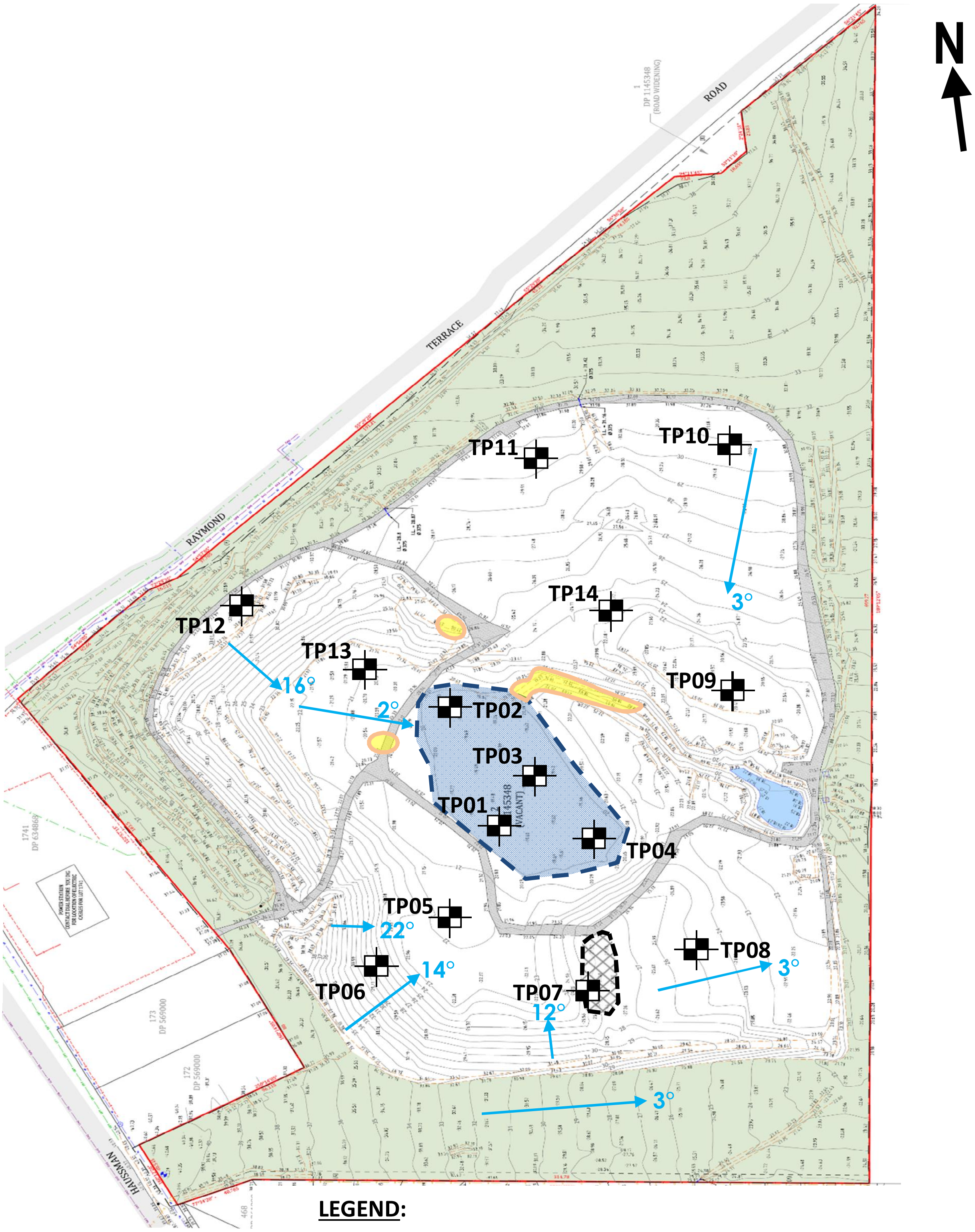
For and on behalf of Qualtest Laboratory (NSW) Pty Ltd.

Jason Lee

Jason Lee
Principal Geotechnical Engineer

FIGURE AA1:

Site Layout and Approximate Test Pit Locations



LEGEND:

⊞ Approximate test pit location.

▨ Approximate extent of filled area in base of pit.

▨ Approximate extent of potential topsoil fill mound.

● Approximate location of observed rock outcrop.

5° ↙ Approximate slope angle and direction.

Based upon contour plan prepared by Delfs Lascelles (Proj. No. 15327, Dwg No. 1, Rev. 1, dated 09/05/2017).

Qualtest
LABORATORY (NSW) PTY LTD

Client:	McCLOY GROUP	Drawing No:	FIGURE AA1
Project:	PROPOSED SENIORS LIVING DEVELOPMENT	Project No:	NEW17P-0074
Location:	107 HAUSSMAN DRIVE, THORNTON	Scale:	N.T.S.
Title:	SITE LAYOUT AND APPROXIMATE TEST PIT LOCATIONS	Date:	28/06/2017

APPENDIX A:

Results of Field Investigations

Qualtest
LABORATORY (NSW) PTY LTD

ENGINEERING LOG - TEST PIT

CLIENT: McCLOY GROUP
PROJECT: PROPOSED RESIDENTIAL SUBDIVISION
LOCATION: 107 HAUSSMAN DRIVE, THORNTON

TEST PIT NO: **TP01**
PAGE: 1 OF 2
JOB NO: NEW17P-0074
LOGGED BY: BB
DATE: 17/5/17

EQUIPMENT TYPE: 14 TONNE EXCAVATOR
TEST PIT LENGTH: 3.0 m **WIDTH:** 1.1 m
SURFACE RL: 19.5 m
DATUM: AHD

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: CLAY - low plasticity, dark brown, some fine to medium grained sand, root affected with trace organic matter (plant debris).	$M > W_P$				FILL - TOPSOIL
					▩	CI	0.10m FILL: Sandy CLAY - medium plasticity, pale grey, fine to medium grained sand, some fine to medium grained sub-angular to sub-rounded gravel.	$M \sim W_P$	St / VSt	HP	200 - 300	FILL
			19.0	0.5	▨	CH	0.30m CLAY - medium to high plasticity, dark grey to black.	$M < W_P$ - $M < W_P$	H	HP HP HP HP HP	500 550 520 500 >600	RESIDUAL SOIL
			18.5	1.0	┅		1.00m SHALE - dark grey to black with brown leaf fossils, estimated very low to low strength.	D				EXTREMELY TO HIGHLY WEATHERED ROCK
			18.0 17.5	1.5 2.0	▮		1.40m COAL - black, highly fractured, some CLAY between joints, estimated very low to low strength.					HIGHLY WEATHERED ROCK
					▨	CH	2.20m Silty CLAY - medium to high plasticity, pale orange-grey.	$M < W_P$	St - VSt			RESIDUAL SOIL
			17.0	2.5	▮		2.30m COAL - black, highly fractured, some CLAY between joints, estimated very low to low strength.	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	

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%

Qualtest
LABORATORY (NSW) PTY LTD

ENGINEERING LOG - TEST PIT

CLIENT: McCLOY GROUP
PROJECT: PROPOSED RESIDENTIAL SUBDIVISION
LOCATION: 107 HAUSSMAN DRIVE, THORNTON

TEST PIT NO: **TP01**
PAGE: 2 OF 2
JOB NO: NEW17P-0074
LOGGED BY: BB
DATE: 17/5/17

EQUIPMENT TYPE: 14 TONNE EXCAVATOR
TEST PIT LENGTH: 3.0 m **WIDTH:** 1.1 m
SURFACE RL: 19.5 m
DATUM: AHD

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					▥		COAL - black, highly fractured, some CLAY between joints, estimated very low to low strength. *(continued)* 3.30m	D				HIGHLY WEATHERED ROCK
							Hole Terminated at 3.30 m					
			16.0	3.5								
			15.5	4.0								
			15.0	4.5								
			14.5	5.0								
			14.0	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	

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%

Qualtest
LABORATORY (NSW) PTY LTD

ENGINEERING LOG - TEST PIT

CLIENT: McCLOY GROUP
PROJECT: PROPOSED RESIDENTIAL SUBDIVISION
LOCATION: 107 HAUSSMAN DRIVE, THORNTON

TEST PIT NO: TP02
PAGE: 1 OF 1
JOB NO: NEW17P-0074
LOGGED BY: BB
DATE: 17/5/17

EQUIPMENT TYPE: 14 TONNE EXCAVATOR
TEST PIT LENGTH: 3.0 m **WIDTH:** 1.1 m
SURFACE RL: 19.5 m
DATUM: AHD

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	E 0.10m			▩	CI	0.20m	FILL-TOPSOIL: Sandy CLAY - medium plasticity, dark grey, fine to medium grained sand, some fine to medium grained sub-angular to sub-rounded gravel, root affected.	M > w_P		HP	550	FILL - TOPSOIL
					▩	CI	0.40m	FILL: Sandy CLAY - medium plasticity, grey to pale grey, fine to medium grained sand, trace fine to medium grained sub-angular to sub-rounded gravel.		St / VSt	HP	220	FILL
			19.0	0.5	▩	SP	0.50m	FILL: SAND - fine to medium grained, brown, some fines of low plasticity.	M	MD			
					▨	CH	0.60m	Sandy CLAY - medium to high plasticity, grey to pale grey with some orange, fine to medium grained sand.	M ~ w_P	H / VD	HP	300	RESIDUAL SOIL
					▨	CH	0.80m	Extremely Weathered SANDSTONE with soil properties; breaks down into Sandy CLAY - medium to high plasticity, grey to pale grey with some orange, fine to medium grained sand. Sand content increasing with depth.			HP	>600	EXTREMELY WEATHERED ROCK
					⁘		0.90m	SANDSTONE - fine to medium grained, orange to dark orange-red (ironstained), estimated low to medium strength.					HIGHLY WEATHERED ROCK
			18.5	1.0				Hole Terminated at 0.90 m Refusal					
			18.0	1.5									
			17.5	2.0									
			17.0	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

CLIENT:	McCLOY GROUP
PROJECT:	PROPOSED RESIDENTIAL SUBDIVISION
LOCATION:	107 HAUSSMAN DRIVE, THORNTON
TEST PIT NO:	**TP03**
PAGE:	1 OF 1
JOB NO:	NEW17P-0074
LOGGED BY:	BB
DATE:	17/5/17

EQUIPMENT TYPE: 14 TONNE EXCAVATOR
TEST PIT LENGTH: 3.0 m **WIDTH:** 1.1 m
SURFACE RL: 19.4 m
DATUM: AHD

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 E 0.40m	19.0	0.50m		CI	FILL-TOPSOIL: Sandy CLAY - low to medium plasticity, pale brown, fine to medium grained sand, some fine to medium grained sub-angular to sub-rounded gravel, root affected.	M > W$_P$				FILL - ROOT AFFECTED
			18.5	0.5 1.0 1.30m		CH	FILL: CLAY - high plasticity, dark grey, with pockets and lenses of Gravelly Silty SAND - grey to brown.		F S - F	HP HP HP	70 - 110 50 - 90 30 - 60	FILL
			18.0	1.50m		CI	FILL: Sandy CLAY - medium plasticity, grey to brown, fine to medium sand, some fine to medium sub-angular to sub-rounded gravel.		St / VSt	HP	220	
				1.5 1.60m		SM	Silty SAND - fine to coarse grained, black, fines of medium plasticity. Residual Soil from COAL.	M	MD	HP	250	RESIDUAL SOIL
				1.70m		CH	Sandy CLAY - high plasticity, pale grey, fine to medium grained sand.	M < W$_P$	H	HP	>600	
			17.5	2.0 2.20m			SHALE - pale grey-green, very low to low strength.			HP	>600	EXTREMELY TO HIGHLY WEATHERED ROCK
			17.0 16.5	2.5			Hole Terminated at 2.20 m					

LEGEND:

Water

▼	Water Level (Date and time shown)
►—	Water Inflow
—◄	Water Outflow

Strata Changes

— —	Gradational or transitional strata
——	Definitive or distict strata change

Notes, Samples and Tests

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

Field Tests

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

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

Moisture Condition	
D	Dry
M	Moist
W	Wet
W$_p$	Plastic Limit
W$_L$	Liquid Limit

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

ENGINEERING LOG - TEST PIT

CLIENT: McCLOY GROUP
PROJECT: PROPOSED RESIDENTIAL SUBDIVISION
LOCATION: 107 HAUSSMAN DRIVE, THORNTON

TEST PIT NO: **TP04**
PAGE: 1 OF 1
JOB NO: NEW17P-0074
LOGGED BY: BB
DATE: 17/5/17

EQUIPMENT TYPE: 14 TONNE EXCAVATOR
TEST PIT LENGTH: 3.0 m **WIDTH:** 1.1 m
SURFACE RL: 19.7 m
DATUM: AHD

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	
E	Not Encountered			0.10m		CL	FILL-TOPSOIL: Sandy CLAY - low plasticity, dark grey, fine to medium sand, root affected.	M > W$_P$				FILL - TOPSOIL
		0.70m E 0.80m	19.5 19.0 18.5	0.5 1.0 1.30m		CI	FILL: Sandy CLAY - low to medium plasticity, pale orange-brown, fine to medium grained sand, some fine to medium grained sub-angular to sub-rounded gravel. With pockets and lenses of Silty SAND - fine to medium grained, brown, fines of low plasticity.		St F	HP HP HP	170 150 90	FILL
				1.50m		CH	FILL: Sandy CLAY - medium to high plasticity, dark grey to black, fine to medium grained sand, some fine to medium grained angular to sub-angular gravel.					
			18.0	1.5 2.00m		CH	Sandy CLAY - medium to high plasticity, dark grey to black, fine to medium grained sand, some fine to medium grained angular gravel.	M ~ W$_P$	VSt	HP	320	RESIDUAL SOIL
			17.5	2.0 2.20m			SILTSTONE - pale grey to grey banded, estimated very low to low strength.	D				EXTREMELY TO HIGHLY WEATHERED ROCK
			17.0	2.5			Hole Terminated at 2.20 m					

LEGEND:

Water
- Water Level (Date and time shown)
- ▶— Water Inflow
- —◀ Water Outflow

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

Notes, Samples and Tests

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

Field Tests

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

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

Moisture Condition	
D	Dry
M	Moist
W	Wet
W$_p$	Plastic Limit
W$_L$	Liquid Limit

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

Qualtest
LABORATORY (NSW) PTY LTD

ENGINEERING LOG - TEST PIT

CLIENT:	McCLOY GROUP	**TEST PIT NO:**	**TP05**
PROJECT:	PROPOSED RESIDENTIAL SUBDIVISION	**PAGE:**	1 OF 1
LOCATION:	107 HAUSSMAN DRIVE, THORNTON	**JOB NO:**	NEW17P-0074
		LOGGED BY:	BB
		DATE:	17/5/17

EQUIPMENT TYPE:	14 TONNE EXCAVATOR	**SURFACE RL:**	21.5 m
TEST PIT LENGTH:	3.0 m **WIDTH:** 1.1 m	**DATUM:**	AHD

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			0.10m	▩	CL	FILL: Sandy CLAY - low plasticity, dark grey-brown, fine to medium grained sand, some fine to medium grained sub-angular to sub-rounded gravel, root affected.	M < W_P				FILL - ROOT AFFECTED
				0.30m	▩	CI	FILL: Sandy CLAY / Gravelly Clayey SAND - medium plasticity, grey with some orange, fine to medium grained sand, fine to medium grained sub-angular to angular gravel.		St - VSt	HP	250	FILL
			21.0	0.5 0.70m	▧	SC	Clayey SAND - fine to medium grained, pale grey with some orange, fines of medium to high plasticity.	M	D			RESIDUAL SOIL
		0.70m B 0.90m	20.5 20.0	1.0 1.5 1.60m	▨	CH	CLAY - high plasticity, grey with dark grey banding, some orange.	M < W_P	H	HP	>600	RESIDUAL SOIL WITH RELICT ROCK STRUCTURE
			19.5	2.0 2.30m	┄		SILTSTONE - grey and pale grey banded, estimated very low to low strength.	D				EXTREMELY TO HIGHLY WEATHERED ROCK
			19.0	2.5			Hole Terminated at 2.30 m					

LEGEND:

Water

- Water Level (Date and time shown)
- ▶— Water Inflow
- —◀ Water Outflow

Strata Changes

- — — Gradational or transitional strata
- —— Definitive or distict strata change

Notes, Samples and Tests

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

Field Tests

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

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

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

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

ENGINEERING LOG - TEST PIT

CLIENT:	McCLOY GROUP	**TEST PIT NO:**	**TP06**
PROJECT:	PROPOSED RESIDENTIAL SUBDIVISION	**PAGE:**	1 OF 1
LOCATION:	107 HAUSSMAN DRIVE, THORNTON	**JOB NO:**	NEW17P-0074
		LOGGED BY:	BB
		DATE:	17/5/17

EQUIPMENT TYPE:	14 TONNE EXCAVATOR	**SURFACE RL:**	26.5 m
TEST PIT LENGTH:	3.0 m **WIDTH:** 1.1 m	**DATUM:**	AHD

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					SM	FILL-TOPSOIL: Silty SAND - fine to medium grained, dark brown, fines of low plasticity, some fine to medium grained sub-angular to sub-rounded gravel, root affected.	D				FILL - TOPSOIL
			26.0	0.40m 0.5		CI	FILL: Sandy CLAY - medium plasticity, pale grey to grey, fine to medium grained sand, some fine to medium grained sub-angular to sub-rounded gravel, some roots.	M ~ W_P	St			FILL
		0.90m B 1.10m	25.5	0.90m 1.0		CI	FILL: Sandy CLAY - medium plasticity, pale grey to grey, fine to medium grained sand, some fine to medium grained sub-angular to sub-rounded gravel.		VSt / Fb	HP HP	320 360	FILL possibly RESIDUAL SOIL
			25.0	1.50m 1.5		CI	FILL: Sandy CLAY - medium plasticity, grey with some orange, fine to medium grained sand, some fine to medium grained sub-angular to angular gravel.			HP	350	
			24.5	1.80m 2.0		CH	Gravelly CLAY - high plasticity, pale grey to white some orange, fine rounded to sub-rounded gravel, some fine to medium grained sand.		VSt - H	HP HP	350 - 420 >600	RESIDUAL SOIL / EXTREMELY WEATHERED ROCK
			24.0	2.20m 2.5			Hole Terminated at 2.20 m					

LEGEND:

Water

- ▼ Water Level (Date and time shown)
- ▶— Water Inflow
- —◀ Water Outflow

Strata Changes

- — — Gradational or transitional strata
- —— Definitive or distict strata change

Notes, Samples and Tests

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

Field Tests

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

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

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

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

ENGINEERING LOG - TEST PIT

CLIENT:	McCLOY GROUP
PROJECT:	PROPOSED RESIDENTIAL SUBDIVISION
LOCATION:	107 HAUSSMAN DRIVE, THORNTON
TEST PIT NO:	**TP07**
PAGE:	1 OF 1
JOB NO:	NEW17P-0074
LOGGED BY:	BB
DATE:	17/5/17

EQUIPMENT TYPE: 14 TONNE EXCAVATOR
TEST PIT LENGTH: 3.0 m **WIDTH:** 1.1 m
SURFACE RL: 27.8 m
DATUM: AHD

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		27.5	0.5	▨	SM	FILL-TOPSOIL: Silty SAND - fine to medium grained, dark brown, fines of low plasticity, some fine to medium grained sub-angular to sub-rounded gravel, root affected.	D M				FILL - MOUND CONTAINING TOPSOIL
		0.70m B 0.80m	27.0	0.60m	▨	CH	CLAY - high plasticity, pale grey to grey, some fine to medium grained sand.	M > W_P	VSt	HP HP	200 220	RESIDUAL SOIL
				0.90m 1.0	▨	CH	Sandy CLAY - high plasticity, pale grey to white some orange, fine to medium grained sand, some fine angular to sub-angular gravel.	M ~ W_P	VSt - H	HP HP	350 >600	
			26.5 26.0 25.5 25.0	1.20m 1.5 2.0 2.5 3.00m	▨		SILTSTONE - pale grey to grey, estimated very low to low strength. becoming dark grey-brown	D				EXTREMELY TO HIGHLY WEATHERED ROCK

Hole Terminated at 3.00 m

LEGEND:

Water

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

Strata Changes

- - - Gradational or transitional strata
—— Definitive or distict strata change

Notes, Samples and Tests

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

Field Tests

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

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

Moisture Condition

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

Density

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

Qualtest
LABORATORY (NSW) PTY LTD

ENGINEERING LOG - TEST PIT

CLIENT: McCLOY GROUP
PROJECT: PROPOSED RESIDENTIAL SUBDIVISION
LOCATION: 107 HAUSSMAN DRIVE, THORNTON

TEST PIT NO: TP08
PAGE: 1 OF 1
JOB NO: NEW17P-0074
LOGGED BY: BB
DATE: 17/5/17

EQUIPMENT TYPE: 14 TONNE EXCAVATOR
TEST PIT LENGTH: 3.0 m **WIDTH:** 1.1 m
SURFACE RL: 24.0 m
DATUM: AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	CLASSIFICATION SYMBOL		MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
E	Not Encountered				CL		TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine to medium grained sand, root affected.	$M < W_P$				TOPSOIL
		0.40m B 0.70m	23.5	0.5	CH	0.30m	CLAY - high plasticity, pale grey to grey, some fine to medium grained sand, some fine grained sub-rounded to rounded gravel.	$M > W_P$	VSt	HP HP	250 320	RESIDUAL SOIL
						0.70m	SILTSTONE - grey, estimated very low to low strength.	D		HP	>600	EXTREMELY TO HIGHLY WEATHERED ROCK
						0.90m	SANDSTONE - fine to medium grained, pale grey to orange, estimated very low to medium strength.					HIGHLY WEATHERED ROCK
			23.0	1.0		0.95m	Hole Terminated at 0.95 m Refusal					
			22.5	1.5								
			22.0	2.0								
			21.5	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

CLIENT:	McCLOY GROUP	**TEST PIT NO:**	**TP09**
PROJECT:	PROPOSED RESIDENTIAL SUBDIVISION	**PAGE:**	1 OF 1
LOCATION:	107 HAUSSMAN DRIVE, THORNTON	**JOB NO:**	NEW17P-0074
		LOGGED BY:	BB
		DATE:	17/5/17

EQUIPMENT TYPE:	14 TONNE EXCAVATOR			**SURFACE RL:**	20.5 m
TEST PIT LENGTH:	3.0 m	**WIDTH:**	1.1 m	**DATUM:**	AHD

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		20.0	0.5		SC	FILL: Gravelly Clayey SAND - fine to medium grained, grey-brown, fine to medium grained sub-angular to sub-rounded gravel, fines of low to medium plasticity.	M / M > W_P				FILL
		0.70m B 0.90m	19.5 19.0	1.0 1.5		CH	0.60m Sandy CLAY - high plasticity, pale grey to white some orange, fine to medium grained sand, some fine to medium grained rounded to sub-rounded gravel.	M > W_P	H	HP HP	>600 >600	RESIDUAL SOIL
							1.50m SHALE - pale grey-green, estimated very low to low strength. 1.60m	D				HIGHLY TO MODERATELY WEATHERED ROCK
			18.5 18.0	2.0 2.5			Hole Terminated at 1.60 m 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	

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%

Qualtest
LABORATORY (NSW) PTY LTD

ENGINEERING LOG - TEST PIT

CLIENT: McCLOY GROUP
PROJECT: PROPOSED RESIDENTIAL SUBDIVISION
LOCATION: 107 HAUSSMAN DRIVE, THORNTON

TEST PIT NO: TP10
PAGE: 1 OF 1
JOB NO: NEW17P-0074
LOGGED BY: BB
DATE: 17/5/17

EQUIPMENT TYPE: 14 TONNE EXCAVATOR
TEST PIT LENGTH: 3.0 m **WIDTH:** 1.1 m
SURFACE RL: 30.6 m
DATUM: AHD

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		30.5			CL	TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine to medium grained sand, some fine to medium grained sub-angular to sub-rounded gravel, root affected.	M < W_P				TOPSOIL
				0.30m								
		0.50m U50 0.90m	30.0	0.5		CH	CLAY - high plasticity, dark grey with some pale orange, some fine to medium grained sand, trace fine to medium grained sub-angular to angular gravel (content increasing with depth).	M > W_P	St - VSt	HP HP HP	180 200 190	RESIDUAL SOIL possibly COLLUVIUM
				0.90m								
			29.5 29.0	1.0 1.5		CH	Sandy CLAY - high plasticity, pale grey to white some orange, fine to medium grained sand, some fine grained sub-angular to sub-rounded gravel.	M < W_P	VSt H	HP HP HP	350 480 520	RESIDUAL SOIL
				2.00m								
			28.5	2.0			SHALE - pale grey-green, estimated very low to low strength.	D				EXTREMELY TO HIGHLY WEATHERED ROCK
				2.40m								
			28.0	2.5			Hole Terminated at 2.40 m					

LEGEND:

Water

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

Strata Changes

- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

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

Field Tests

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

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

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

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

Qualtest
LABORATORY (NSW) PTY LTD

ENGINEERING LOG - TEST PIT

CLIENT: McCLOY GROUP
PROJECT: PROPOSED RESIDENTIAL SUBDIVISION
LOCATION: 107 HAUSSMAN DRIVE, THORNTON

TEST PIT NO: **TP11**
PAGE: 1 OF 1
JOB NO: NEW17P-0074
LOGGED BY: BB
DATE: 17/5/17

EQUIPMENT TYPE: 14 TONNE EXCAVATOR
TEST PIT LENGTH: 3.0 m **WIDTH:** 1.1 m
SURFACE RL: 30.3 m
DATUM: AHD

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		30.0	0.5		CH	FILL-TOPSOIL: CLAY - medium to high plasticity, dark grey-brown, some fine to medium grained sand, some fine to medium grained sub-rounded to sub-angular gravel, trace brick and plant debris, root affected.	$M > W_P$		HP HP	280 220	FILL - TOPSOIL
		0.70m		0.50m		SM	TOPSOIL (BURIED): Silty SAND - fine to medium grained, dark brown, fines of low plasticity, root affected.	M		HP	500	BURIED TOPSOIL
		U50 1.10m	29.5	0.70m 1.0		CH	CLAY - high plasticity, pale grey to grey, some fine to medium grained sand.	$M > W_P$	VSt	HP HP HP	350 220 290	RESIDUAL SOIL
			29.0	1.10m 1.5		CH	Sandy CLAY - high plasticity, pale grey to white some orange, fine to medium grained sand, some fine grained rounded to sub-rounded gravel.	$M \sim W_P$	H	HP HP	450 550	
			28.5	1.70m 2.0			SANDSTONE - fine to medium grained, pale grey to orange, estimated very low to medium strength.	D		HP	>600	EXTREMELY TO HIGHLY WEATHERED ROCK
			28.0 27.5	2.10m 2.5			Hole Terminated at 2.10 m					

LEGEND:

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

Strata Changes
Gradational or transitional strata
Definitive or distict strata change

Notes, Samples and Tests

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

Field Tests

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

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

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

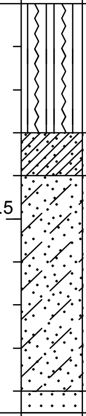
Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Qualtest
LABORATORY (NSW) PTY LTD

ENGINEERING LOG - TEST PIT

CLIENT:	McCLOY GROUP	**TEST PIT NO:**	**TP12**
PROJECT:	PROPOSED RESIDENTIAL SUBDIVISION	**PAGE:**	1 OF 1
LOCATION:	107 HAUSSMAN DRIVE, THORNTON	**JOB NO:**	NEW17P-0074
		LOGGED BY:	BB
		DATE:	17/5/17

EQUIPMENT TYPE:	14 TONNE EXCAVATOR	**SURFACE RL:**	32.8 m
TEST PIT LENGTH:	3.0 m **WIDTH:** 1.1 m	**DATUM:**	AHD

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	TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine to medium grained sand, some fine to medium grained sub-angular to sub-rounded gravel, root affected.	M < W_P				TOPSOIL
		0.30m B 0.40m	32.5			0.30m CH	Sandy CLAY - medium to high plasticity, red-brown, fine to medium grained sand.		H	HP	>600	RESIDUAL SOIL
			32.0	0.5		0.40m SC	Clayey SAND - fine to medium grained, pale grey with some orange, fines of medium to high plasticity. Becoming extremely weathered sandstone.	M	VD			
						0.90m	SANDSTONE - fine to medium grained, pale grey to orange, estimated medium strength.	D				HIGHLY WEATHERED ROCK
				1.0		0.95m	Hole Terminated at 0.95 m Refusal					
			31.5									
				1.5								
			31.0									
				2.0								
			30.5									
				2.5								
			30.0									

LEGEND:

Water

▼	Water Level (Date and time shown)
▶—	Water Inflow
—◀	Water Outflow

Strata Changes

— — —	Gradational or transitional strata
———	Definitive or distict strata change

Notes, Samples and Tests

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

Field Tests

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

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

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

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

Qualtest
LABORATORY (NSW) PTY LTD

ENGINEERING LOG - TEST PIT

CLIENT:	McCLOY GROUP	**TEST PIT NO:**	**TP13**
PROJECT:	PROPOSED RESIDENTIAL SUBDIVISION	**PAGE:**	1 OF 1
LOCATION:	107 HAUSSMAN DRIVE, THORNTON	**JOB NO:**	NEW17P-0074
		LOGGED BY:	BB
		DATE:	17/5/17

EQUIPMENT TYPE:	14 TONNE EXCAVATOR	**SURFACE RL:**	21.3 m
TEST PIT LENGTH:	3.0 m **WIDTH:** 1.1 m	**DATUM:**	AHD

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		21.0	0.30m		CL	FILL-TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine to medium grained sand, some fine to medium grained sub-angular to sub-rounded gravel, root affected.	M ~ w_P				FILL - TOPSOIL
				0.5 0.50m		CH	FILL: Sandy CLAY - high plasticity, grey, fine to medium grained sand, some fine grained rounded to sub-rounded gravel.	M > w_P	St - VSt	HP	150 - 250	FILL
			20.5	0.80m		SC	FILL: Clayey SAND - fine to medium grained, orange, fines of medium plasticity.	M	D	HP	>600	FILL possibly RESIDUAL SOIL
		0.90m CBR 1.20m	20.0	1.0 1.5 1.70m			SANDSTONE - fine to medium grained, pale grey, estimated very low to medium strength.	M - D				HIGHLY WEATHERED ROCK
			19.5 19.0 18.5	2.0 2.5			Hole Terminated at 1.70 m 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	

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

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

ENGINEERING LOG - TEST PIT

Qualtest
LABORATORY (NSW) PTY LTD

CLIENT:	McCLOY GROUP	**TEST PIT NO:**	**TP14**
PROJECT:	PROPOSED RESIDENTIAL SUBDIVISION	**PAGE:**	1 OF 1
LOCATION:	107 HAUSSMAN DRIVE, THORNTON	**JOB NO:**	NEW17P-0074
		LOGGED BY:	BB
		DATE:	17/5/17

EQUIPMENT TYPE:	14 TONNE EXCAVATOR	**SURFACE RL:**	23.4 m
TEST PIT LENGTH:	3.0 m **WIDTH:** 1.1 m	**DATUM:**	AHD

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			0.20m		SM	TOPSOIL: Silty SAND - fine to medium grained, dark brown, fines of low plasticity, some fine to medium grained sub-angular to sub-rounded gravel, root affected.	D - M				TOPSOIL possibly FILL
			23.0	0.5 0.50m		SC	Clayey Gravelly SAND - fine to medium grained, red, white and orange, fine to coarse garined angular to sub angular gravel, with cobble and boulder sized rock fragments up to ~400mm dia.	M	D			RESIDUAL SOIL possibly FILL
			22.5	1.0 1.10m			SANDSTONE - fine to medium grained, orange red and white, fractured with some Clayey SAND in the joints, estimated very low to low strength.	D	D			EXTREMELY TO HIGHLY WEATHERED ROCK
			22.0	1.5 1.60m			SILTSTONE - dark grey-brown, estimated low to medium strength.					HIGHLY WEATHERED ROCK
			21.5 21.0 20.5	2.0 2.5			Hole Terminated at 1.60 m 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	

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%

Qualtest
LABORATORY (NSW) PTY LTD

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

DYNAMIC CONE PENETROMETER - TEST REPORT

Client: MCCLOY GROUP
Principal:
Project: PROPOSED SENIORS LIVING DEVELOPMENT
Location: 107 HAUSSMAN DR, THORNTON

Project Number: *NEW17P-0074*
Sheet No: *1 of 1*
Test Date: 15/05/2017
Tested By: BB

Test Method: AS1289 6.3.2 ☑ Cone Tip
Drop Height: 510 ± 5mm ☐ Blunt Tip

Depth Below Surface (mm)	Test Number								Test Location / Comments
	TP01	TP02	TP03	TP04					
150	3	2	4	4					DCP locations are as shown on Figure AA1.
300	2	3	4	5					
450	7	5	4	4					R = Refusal, hammer bouncing.
600	24	7	5	3					
750		13	4	3					
900		R	2	2					
1050			2	3					
1200			4	2					
1350			8	6					
1500			9	11					
1650			R	6					
1800				10					
1950				13					
2100				R					
2250									
2400									
2550									
2700									
2850									
3000									
3150									
3300									
3450									
3600									
3750									
3900									
4050									
4200									
4350									
4500									

Comments: Readings recorded in blows per 150mm increments.

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

Material Test Report

Report No: MAT:NEW17W-1887--S01
Issue No: 1

Client: McCLOY GROUP
Suite 1, Level 3, 426 King Street
Newcastle West NSW 2300

Principal:
Project No.: NEW17P-0074
Project Name: Proposed Seniors Living Development

Accredited for compliance with ISO/IEC 17025
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 7/06/2017

Sample Details

Sample ID: NEW17W-1887--S01
Sampling Method: AS1289.1.2.1 cl 6.5
Date Sampled: 17/05/2017
Source: On-Site
Material: Sandy Clay
Specification: No Specification
Project Location: Lot 2 DP 1145348 - Haussman Drive, Thornton
Sample Location: TP05 - (0.7 - 0.9m)

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	7.0	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	43	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	19	
Plasticity Index (%)	AS 1289.3.3.1	24	

Comments

N/A

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

Material Test Report

Report No: MAT:NEW17W-1887--S02
Issue No: 1

Client:	McCLOY GROUP Suite 1, Level 3, 426 King Street Newcastle West NSW 2300
Principal:	
Project No.:	NEW17P-0074
Project Name:	Proposed Seniors Living Development

Accredited for compliance with ISO/IEC 17025
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 7/06/2017

Sample Details

Sample ID:	NEW17W-1887--S02
Sampling Method:	AS1289.1.2.1 cl 6.5
Date Sampled:	17/05/2017
Source:	On-Site
Material:	Sandy Clay
Specification:	No Specification
Project Location:	Lot 2 DP 1145348 - Haussman Drive, Thornton
Sample Location:	TP06 - (0.9 - 1.1m)

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	7.0	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Cracking		No	
Liquid Limit (%)	AS 1289.3.1.1	38	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	19	
Plasticity Index (%)	AS 1289.3.3.1	19	

Comments

N/A

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

Report No: MAT:NEW17W-1887--S03
Issue No: 1

Material Test Report

Client: McCLOY GROUP
Suite 1, Level 3, 426 King Street
Newcastle West NSW 2300

Principal:
Project No.: NEW17P-0074
Project Name: Proposed Seniors Living Development

Accredited for compliance with ISO/IEC 17025
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 30/05/2017

Sample Details

Sample ID: NEW17W-1887--S03
Sampling Method: AS1289.1.2.1 cl 6.5
Date Sampled: 17/05/2017
Source: On-Site
Material: Sandy Clay
Specification: No Specification
Project Location: Lot 2 DP 1145348 - Haussman Drive, Thornton
Sample Location: TP07 - (0.7 - 0.8m)

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	10.5	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	55	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	22	
Plasticity Index (%)	AS 1289.3.3.1	33	

Comments

N/A

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

Report No: MAT:NEW17W-1887--S04
Issue No: 1

Material Test Report

Client: McCLOY GROUP
Suite 1, Level 3, 426 King Street
Newcastle West NSW 2300

Principal:
Project No.: NEW17P-0074
Project Name: Proposed Seniors Living Development

Accredited for compliance with ISO/IEC 17025
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 7/06/2017

Sample Details

Sample ID: NEW17W-1887--S04
Sampling Method: AS1289.1.2.1 cl 6.5
Date Sampled: 17/05/2017
Source: On-Site
Material: Sandy Clay
Specification: No Specification
Project Location: Lot 2 DP 1145348 - Haussman Drive, Thornton
Sample Location: TP08 - (0.4 - 0.7m)

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	11.0	
Mould Length (mm)		250	
Crumbling		No	
Curling		Yes	
Cracking		No	
Liquid Limit (%)	AS 1289.3.1.1	57	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	18	
Plasticity Index (%)	AS 1289.3.3.1	39	

Comments

N/A

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

Report No: MAT:NEW17W-1887--S05
Issue No: 1

Material Test Report

Client: McCLOY GROUP
Suite 1, Level 3, 426 King Street
Newcastle West NSW 2300

Principal:
Project No.: NEW17P-0074
Project Name: Proposed Seniors Living Development

Accredited for compliance with ISO/IEC 17025
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards

NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 7/06/2017

Sample Details

Sample ID: NEW17W-1887--S05
Sampling Method: AS1289.1.2.1 cl 6.5
Date Sampled: 17/05/2017
Source: On-Site
Material: Sandy Clay
Specification: No Specification
Project Location: Lot 2 DP 1145348 - Haussman Drive, Thornton
Sample Location: TP09 - (0.7 - 0.9m)

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	14.5	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	71	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	31	
Plasticity Index (%)	AS 1289.3.3.1	40	

Comments

N/A

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

Report No: MAT:NEW17W-1887--S06
Issue No: 1

Material Test Report

Client: McCLOY GROUP
Suite 1, Level 3, 426 King Street
Newcastle West NSW 2300

Principal:
Project No.: NEW17P-0074
Project Name: Proposed Seniors Living Development

Accredited for compliance with ISO/IEC 17025
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 7/06/2017

Sample Details

Sample ID: NEW17W-1887--S06
Sampling Method: AS1289.1.2.1 cl 6.5
Date Sampled: 17/05/2017
Source: On-Site
Material: Sandy Clay
Specification: No Specification
Project Location: Lot 2 DP 1145348 - Haussman Drive, Thornton
Sample Location: TP10 - (0.5 - 0.9m)

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	10.0	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.2	47	
Method		One Point	
Plastic Limit (%)	AS 1289.3.2.1	16	
Plasticity Index (%)	AS 1289.3.3.1	31	

Comments

N/A

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

Report No: MAT:NEW17W-1887--S08
Issue No: 1

Material Test Report

Client:	McCLOY GROUP Suite 1, Level 3, 426 King Street Newcastle West NSW 2300
Principal:	
Project No.:	NEW17P-0074
Project Name:	Proposed Seniors Living Development

Accredited for compliance with ISO/IEC 17025
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards

NATA
WORLD RECOGNISED ACCREDITATION

D. Cullen

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 30/05/2017

Sample Details

Sample ID:	NEW17W-1887--S08
Sampling Method:	AS1289.1.2.1 cl 6.5
Date Sampled:	17/05/2017
Source:	On-Site
Material:	Sandy Clay
Specification:	No Specification
Project Location:	Lot 2 DP 1145348 - Haussman Drive, Thornton
Sample Location:	TP12 - (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	7.5	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	71	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	24	
Plasticity Index (%)	AS 1289.3.3.1	47	

Comments

N/A

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

California Bearing Ratio Test Report

Report No: CBR:NEW17W-1887--S09
Issue No: 1

Client:	McCLOY GROUP Suite 1, Level 3, 426 King Street Newcastle West NSW 2300
Principal:	
Project No.:	NEW17P-0074
Project Name:	Proposed Seniors Living Development

WORLD RECOGNISED ACCREDITATION

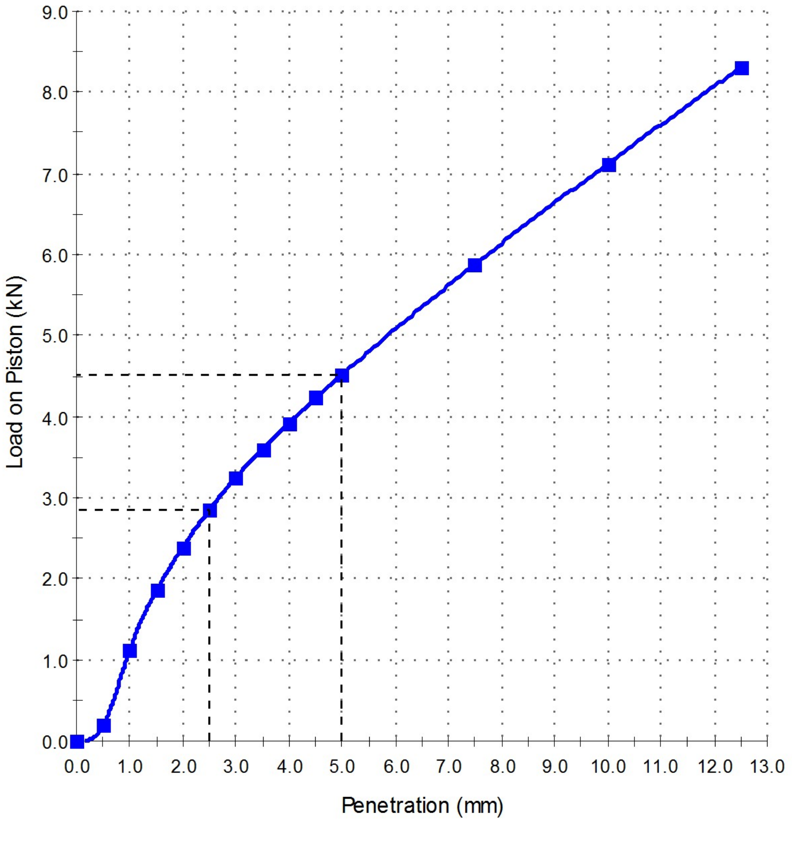
Accredited for compliance with ISO/IEC 17025
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 30/05/2017

Sample Details

Sample ID:	NEW17W-1887--S09	Date Sampled:	17/05/2017
Sampling Method:	AS1289.1.2.1 cl 6.5		
Specification:	No Specification	Source:	On-Site
Location:	TP13 - (0.9 - 1.2m)	Material:	Sandy Clay
Project Location:	Lot 2 DP 1145348 - Haussman Drive, Thornton		

Load vs Penetration



Test Results

AS 1289.6.1.1

CBR At 5.0mm (%):	25
Maximum Dry Density (t/m³):	1.73
Optimum Moisture Content (%):	17.2
Dry Density before Soaking (t/m³):	1.73
Density Ratio before Soaking (%):	100
Moisture Content before Soaking (%):	16.9
Moisture Ratio before Soaking (%):	98
Dry Density after Soaking (t/m³):	1.74
Density Ratio after Soaking (%):	100
Swell (%):	0.0
Moisture Content of Top 30mm (%):	20.4
Moisture Content of Remaining Depth (%):	17.5
Compactive Effort:	Standard
Surcharge Mass (kg):	9.00
Period of Soaking (Days):	4
Oversize Material (%):	0.0

Moisture Content

Field Moisture Content (%):	13.2

Comments

Moisture Content Method Performed as Per AS1289.2.1.1.
Laboratory Moisture Ratio (LMR): 98.0% Laboratory Density Ratio (LDR): 100.0%

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.

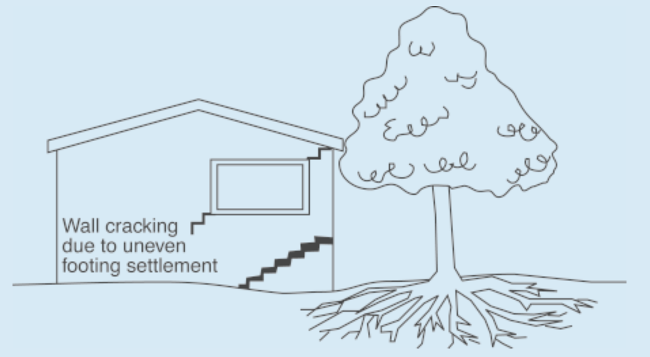
Seasonal swelling/shrinkage in clay

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.

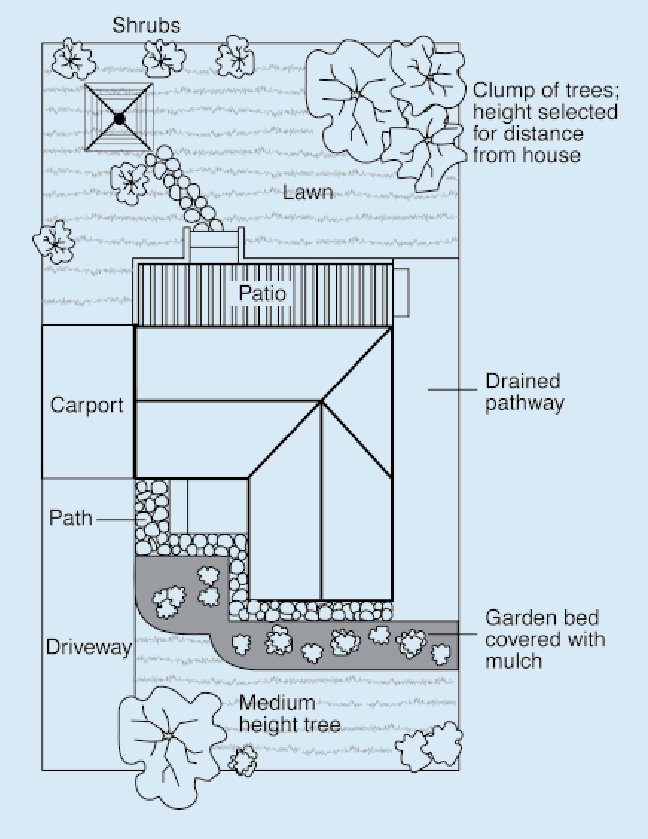
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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.

Distributed by

CSIRO PUBLISHING PO Box 1139, Collingwood 3066, Australia

Freecall 1800 645 051 Tel (03) 9662 7666 Fax (03) 9662 7555 www.publish.csiro.au

Email: publishing.sales@csiro.au