Proposed Mixed Use Development Geotechnical Assessment

795 Medowie Road, Medowie

NEW19P-0074-AA
7 June 2019

Qualtest
LABORATORY (NSW) PTY LTD

GEOTECHNICAL I LABORATORY I EARTHWORKS I QUARRY I CONSTRUCTION MATERIAL TESTING

7 June 2019

Medowie Retail Unit Trust
C/- Mavid Group
PO Box 93
LORN NSW 2320

Attention: Mr Lee Bateman

Dear Lee,

RE: PROPOSED MIXED USE DEVELOPMENT
795 MEDOWIE ROAD, MEDOWIE
GEOTECHNICAL ASSESSMENT

Please find enclosed our Geotechnical Assessment report for the proposed mixed use development to be located at 795 Medowie Road, Medowie.

The purpose of the Preliminary Geotechnical Assessment is to support a Development Application (DA) submission to Port Stephens City Council.

The report includes description of site surface and sub-surface conditions, assessment of the risk of slope instability and associated geotechnical constraints, site classification in accordance with AS2870-2011 *'Residential Slabs and Footings',* and earthworks recommendations.

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

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

Jason Lee
Principal Geotechnical Engineer

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Attachments:

1.0 Introduction

Qualtest Laboratory NSW Pty Ltd (Qualtest) is pleased to present this geotechnical report on behalf of Medowie Retail Unit Trust (MRUT), care of Mavid Group Pty Ltd (Mavid) for the proposed mixed use development to be located at 795 Medowie Road, Medowie.

Based on the Brief and Ground Floor Plan provided in an email dated 26 September 2018, it is understood that it is proposed to develop the site as a mixed used development, including 94 place childcare centre, service station and food outlets, McDonalds, KFC, and a series of specialty retail/local shops.

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

- General description of site surface and subsurface conditions;
- Site classification to AS2870-2011, "Residential Slabs and Footings", including foundation design parameters for shallow footings;
- Slope stability assessment;
- Earthworks recommendations, excavation conditions and 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

The field work investigations were carried out on 6 May 2019 and comprised of:

- DBYD search and visual check of proposed test locations for the presence of underground services;
- Site walkover to make observations of surface features at the property and in the immediate surrounding area;
- Excavation of 14 test pits (TP01 to TP14) using a 2.7 tonne rubber tracked excavator with a 0.45m wide toothed bucket, to depths of approximately 2.00m within the proposed development area;
- 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 tracks and bucket.

Investigations were carried out by an experienced Geotechnical Engineer from Qualtest who located the test pits, carried out the sampling and testing, and produced field logs of the test pits. 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 using handheld GPS and relative to site features including trees, boundaries, and surrounding structures.

3.0 Site Description

3.1 Surface Conditions

The site comprises part of Lot 1, DP 1215257, No. 795 Medowie Road, Medowie, and has a total plan area of about 1.40ha. It is bounded by Peppertree Road to the west, by Muir Street to the north, Medowie Road to the east, and by existing commercial development to the south.

The site is located within a region of gently sloping topography, on the west facing lower slopes of a broad hill formation. Based on NSW Spatial Information Exchange (SIX Maps) survey data, the elevation of the site is judged to vary between approximately RL 10m and RL 20m (AHD). The site slopes towards the east at an overall slope angle of about 3° to 5°, with localised slopes of up to about 10° to 15° along the drainage trench, and in the order of 30° battered down to Peppertree Road.

The site was undeveloped at the time of site inspection, with the exception of a V-drain cut parallel to Peppertree Road along most of the western boundary. The low point of the V-drain contained a concrete stormwater drain.

There was no visible evidence of displacement observed on the site, and the existing retaining wall appeared to be in good condition, with no signs of significant displacement, and no sliding failure or overturning observed.

Nearby fences and poles supporting overhead wiring were also standing upright at the time of the investigation with no obvious evidence of significant movement or damage attributable to ground movement.

On the day of the investigation, the site was judged to be well drained primarily by way of the V-drain and downhill surface runoff towards the west. The site is vegetated by established grass cover.

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

Photograph 1: From south-eastern corner near Medowie Road, facing west.

Photograph 2: From north-eastern corner near Medowie Road, facing west.

Photograph 3: From near TP05, facing north.

Photograph 4: From near TP05, facing east.

Photograph 5: From south-eastern corner of proposed Childcare lot, facing west.

Photograph 6: From south-eastern corner of proposed Childcare lot, facing west.

Photograph 7: From near TP07, facing north.

Photograph 8: From near TP07, facing northeast.

Photograph 9: From near TP08, facing north.

Photograph 10: From near TP08, facing northeast.

Photograph 11: From near TP10, facing south.

Photograph 12: From near TP10, facing southwest.

3.2 Subsurface Conditions

Reference to the 1:100,000 Newcastle Coalfield Regional Geology Sheet indicates the site to be underlain by the Quaternary Aged Alluviual Soil deposits, comprising Gravel, Sand, Silt, and Clay soil types, underlain by the Tomago Coal Measures, which is characterised by Siltstone, Sandstone, Coal, Tuff, and Claystone rock types.

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

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

TABLE 1 – SUMMARY OF GEOTECHNICAL UNITS AND SOIL TYPES

Unit	Soil Type	Description
1	FILL – Uncontrolled	Sandy CLAY – low plasticity, dark grey-brown, fine grained sand, root affected, with some broken glass and plastic bags in places. Gravelly Sandy CLAY – low to medium plasticity, dark brown, fine to coarse grained (mostly fine grained) sand, fine to coarse grained (mostly fine to medium grained) angular to sub-angular gravel, trace concrete cobbles, root affected. Gravelly CLAY – medium to high plasticity, pale red-brown and pale grey to white, fine to coarse grained angular to sub-angular gravel.
2	TOPSOIL	Sandy CLAY – low plasticity, dark grey-brown, fine grained sand, root affected.
3	SLOPEWASH	Sandy CLAY – low plasticity, grey-brown to pale grey-brown, fine grained sand.
4	COLLUVIUM / RESIDUAL SOIL	Sandy CLAY / CLAY – medium plasticity, pale orange-brown to pale brown, with some fine to coarse grained (mostly fine grained) sand. Gravelly CLAY / CLAY – medium to high plasticity, red-brown and pale grey to white, with some fine to coarse grained (fine grained sand), with some fine to medium grained (mostly fine grained) angular to sub-angular gravel.
5	EXTREMELY WEATHERED (XW) ROCK with soil properties	Siltstone; breaks down into CLAY / Gravelly CLAY / Clayey GRAVEL – medium to high plasticity, red-brown and pale grey to white, fine to medium grained sub-angular gravel, with some fine to coarse grained sand. Increasing Gravel content with depth.
6	HIGHLY WEATHERED (HW) ROCK	Not Encountered.

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

Location	Unit 1 Fill - Uncontrolled	Unit 2 Topsoil	Unit 3 Slopewash	Unit 4 Colluvium / Residual Soil	Unit 5 XW Rock	Unit 6 HW Rock
	Depth in metres (m)					
TP01	-	0.00 – 0.30	0.30 – 0.40	0.40 – 1.30	1.30 – 2.00	-
TP02	-	0.00 – 0.30	0.30 – 0.40	0.40 – 1.30	1.30 – 2.00	-
TP03	0.00 – 0.25	-	0.25 – 0.30	0.30 – 1.20	1.20 – 2.00	-
TP04	-	0.00 – 0.30	0.30 – 0.40	0.40 – 1.30	1.30 – 2.00	-
TP05	-	0.00 – 0.15	0.15 – 0.20	0.20 – 0.95	0.95 – 2.00	-
TP06	0.00 – 0.80	-	-	0.80 – 1.30	1.30 – 2.00	-
TP07	-	0.00 – 0.30	0.30 – 0.40	0.40 – 1.20	1.20 – 2.00	-
TP08	0.00 – 0.70	0.70 – 1.00	-	1.00 – 2.00	-	-
TP09	-	0.00 – 0.20	0.20 – 0.30	0.30 – 1.15	1.15 – 2.00	-
TP10	-	0.00 – 0.30	0.30 – 0.40	0.40 – 2.00	-	-
TP11	-	0.00 – 0.20	0.20 – 0.30	0.30 – 0.90	0.90 – 2.00	-
TP12	-	0.00 – 0.30	0.30 – 0.40	0.40 – 2.00	-	-
TP13	-	0.00 – 0.25	0.25 – 0.30	0.30 – 1.35	1.35 – 2.00	-
TP14	-	0.00 – 0.20	0.20 – 0.30	0.30 – 1.40	1.40 – 2.00	-

Slow groundwater inflow (less than 1 litre per minute) was encountered at TP01, TP04, TP10, and TP14 at depths in the order of 1.95m to 2.00m. No groundwater levels or water inflows were encountered in the other 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 current field investigations were returned to our NATA accredited Warabrook Laboratory for testing which comprised of:

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

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

TABLE 3 – SUMMARY OF SHRINK / SWELL TESTING RESULTS

Location	Depth (m)	Material Description	I_{ss} (%)
TP01	0.60 - 0.80	(CH) CLAY	1.1
TP02	0.40 - 0.75	(CI) CLAY	1.8
TP05	0.75 - 0.90	(CI) Gravelly CLAY	1.5
TP06	0.80 - 1.05	(CI) CLAY	1.3
TP08	1.00 - 1.25	(CI) CLAY	2.4
TP10	1.50 - 1.80	(CH) CLAY	2.3
TP11	0.50 - 0.65	(CI) Sandy CLAY	1.8
TP13	0.50 - 0.65	(CI) Sandy CLAY	1.3
TP14	0.70 - 1.00	(CH) CLAY	2.0

TABLE 4 – SUMMARY OF ATTERBERG LIMITS TESTING RESULTS

Location	Depth (m)	Material Description	Liquid Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)
TP07	0.50 - 0.75	(CI) Sandy CLAY	47	29	14.5

5.0 Slope Stability Assessment

5.1 Basis of Assessment

The risk of slope instability has been assessed from the observed site conditions using methods consistent with those presented in the Australian Geomechanics Society (AGS) publication "*Practice Note Guidelines for Landslide Risk Management, 2007*". Based on those methods, the risks to property associated with slope instability on the subject area have been assessed using the terms presented in AGS 2007, *Landslide Risk Assessment Qualitative Terminology for Use in Assessing Risk to Property*, extracts of which are attached in Appendix C.

The report provides an assessment of the risk of slope instability on the proposed development area. The report also recommends some geotechnical constraints for the site development in light of the slope instability assessment. The assessed risk to the proposed development is based on the geotechnical constraints and recommendations provided in this report being implemented. The onus is on the owner, potential owner, or interested party to decide whether the assessed level of risk is acceptable taking into account the likely consequences of the risk and the recommended geotechnical constraints.

5.2 Principal Site Features and Evidence of Instability

The assessment of the risk of slope instability for the site has been based on the site observations recorded in Section 3 and the principal site features summarised below:

- The site is located within a region of gently undulating topography, on the west facing lower slopes of a broad hill formation;
- The site slopes have been modified slightly by shallow cut and filling (typically filling near to the retaining wall on the southern boundary, and minor earthworks associated with the easement trench). A retaining wall is present on the southern boundary of height up to about 3.5m;
- Site slopes are typically in the range of 3° to 5° sloping towards the west, with some localised steeper slopes of up to about 10° to 15° in the trench, and in the order of about 30° to the west adjacent to Peppertree Road;
- Soil depths assessed to be in the order of about 2m;
- The site appeared to be reasonably well drained by surface runoff to the west;
- Minor inflows were observed in the bottom of some of the test pits;
- No evidence of deep soil erosion was observed at the site at the time of the field work; and,
- No obvious evidence of overall slope instability or significant damage attributable to ground movement was observed on or in the vicinity of the site during the field work.

5.3 Hazard Identification

Elements at risk for the identified hazards are the proposed subdivision developments, which may include proposed buildings, driveways, carparks and / or other site infrastructure. Hazards that could potentially impact on this site are assessed to be as follows:

H1. Potential broad deep seated instability;

H2. Potential shallow instability such as overloading of slopes by excessive loads, unsuitable batters/support or unsuitable founding depths, or failure of fill not placed in a proper manner or subject to erosion by concentrated surface flows.

H3. Potential shallow ground 'creep' movements or slumping.

5.4 Risk Evaluation for the Proposed Development

The matrix below evaluates the hazards outlined above and their assessed consequence and likelihood of occurring, based on the proposed development of the site, and the site features described above.

Hazard	Location	Consequence	Likelihood	Risk
H1	Overall Site	Major	Barely Credible	Very Low
H2	Overall Site	Medium	Unlikely	Low
H3	Overall Site	Minor	Rare	Very Low

Based on the above, the proposed development is assessed as having a **"Low"** risk of slope instability.

It would be normal practice in the Port Stephens City Council local government area for development to proceed on a site with a risk level classification of Low.

Development should be carried out in accordance with sound engineering principles and good hillside practice (as set out in Appendix C), and the geotechnical constraints outlined in this report.

If these recommendations are not followed, the likelihood of hazards occurring may increase and the level of risk may change. Further advice should be sought where necessary.

5.5 Recommended Geotechnical Constraints for Development

Type of Structure:

There are no particular geotechnical constraints on the type of structures provided they are founded on footings designed and constructed in general accordance with AS2870, '*Residential Slabs and Footings*' and/or sound engineering principles.

Area for Development:

All of the site is considered feasible for development from a slope stability viewpoint.

It is advised that any developments proposed to be constructed in the vicinity of the existing retaining walls at the southern boundary of the site should be supported on deep footings founded below the zone of influence of the existing footings for the retaining wall.

Care should be taken in the design of any developments in the vicinity of any existing excavations, fill platforms, embankments and retaining walls, particularly if they involve surcharge loads or excavations.

Development of the site should be undertaken in accordance with good hillside construction practice and sound engineering principles as presented in the attached excerpts from AGS 2007.

Foundation Type:

Strip / pad footings, pier and beam systems or raft slabs would be feasible from a slope stability viewpoint.

Footings should not be founded within any existing uncontrolled fill, including but not limited to the inferred fill along the retaining wall on the southern boundary. If fill is encountered, this will require footings to be founded beneath the fill, removal of the fill, or removal and replacement of the fill to engineering specification. Foundations should also be supported below the zone of influence of the existing footings of existing retaining walls.

Foundations should be designed and constructed in accordance with the recommendations and advice of AS2870-2011, '*Residential Slabs and Footings*' and/or sound engineering principles.

Foundations near the crest of excavations should be taken to rock or founded behind or below a 1V:2H projection from the toe of the excavation.

Footings are to be founded outside of or below all zones of influence resulting from existing or future service trenches.

Additional foundation recommendations including Site Classification to AS2870-2011 are provided in Section 6.2.

Site investigation and specific engineering foundation design should be carried out for any significant structures.

<u>Excavations:</u>

Excavations should be supported by properly designed and constructed retaining walls or else battered at 1V:2H or flatter and protected from erosion.

Excavations in competent bedrock (below the level of backhoe refusal) may be battered at 1V:1H.

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.

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 2015 should be followed.

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

Care should be taken not to disturb or destabilise existing underground services or structures. Excavations should remain outside a 1V:2H projection from the base of any structural footings.

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

<u>Filling:</u>

All fill should be supported by properly designed and constructed retaining walls or else battered at 1V:2H or flatter and protected against erosion.

The depth of unsupported fill on the site should preferably not exceed 1.5m. All fill greater than 1.5m deep should be supported by engineer designed retaining walls.

If fill is to be placed on slopes in excess of 1V:8H (7°), a prepared surface should be benched or stepped into the existing slope.

Potential effects of slope modifications on groundwater flowing from upslope should also be considered, with provision of subsurface drainage to intercept and redirect groundwater where assessed to be necessary.

It is recommended that existing fill on site in any areas of proposed settlement sensitive development be removed and replaced with approved clean materials. Alternatively, footings supporting such structures should be taken to underlying natural soils or bedrock.

Earthworks should be carried out in accordance with the recommendations outlined in AS3798-2007 '*Guidelines for Earthworks for Commercial and Residential Developments*'.

Geotechnical advice should be sought with regards to site preparation and fill construction procedures.

Retaining Walls:

All structural retaining walls and all landscaping walls in excess of 1.0m should be designed by an experienced engineer familiar with the site conditions.

All retaining walls should be designed for surcharge loading from slopes, structures and other existing/future improvements in the vicinity of the wall. Adequate subsurface and surface drainage should be provided behind all retaining walls.

Excavations for the construction of retaining walls result in a temporary reduction in the stability of the adjacent area particularly during wet weather until the wall is complete. This increased risk can be managed or reduced by appropriate construction planning, using temporary support, staged excavation and control of drainage.

If any significant developments such as settlement sensitive structures are proposed in the vicinity of the existing walls, then it is recommended that specific engineering assessment of the capacity of the existing wall and foundations are undertaken, or the loads supported by a new engineer designed retaining wall.

Drainage and Sewage Disposal:

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

All collected storm water run-off should be piped into the street / interallotment 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.

Potential effects of slope modifications on groundwater flowing from upslope should also be considered, with provision of subsurface drainage to intercept and redirect groundwater where assessed to be necessary.

Septic wastes should be connected to the reticulated disposal system.

Other:

Inspection should be carried out by a geotechnical authority during construction to confirm the conditions assumed in this report and in the design.

Additional recommendations are provided in following sections of this report.

Further recommendations may be provided during future stages of the project.

6.0 Discussions and Recommendations

6.1 General

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.

6.2 Preliminary Site Classification to AS2870-2011

Based on the results of the field work and laboratory testing, the site of the proposed mixed use development to be located at 795 Medowie Road, Medowie, as shown on Figure AA1, is preliminarily classified in its current condition in accordance with AS2870-2011 '*Residential Slabs and Footings*', as shown in Table 5.

TABLE 5 – SITE CLASSIFICATION TO AS2870-2011

Location	Site Classification
Locations affected by uncontrolled filling and/or topsoil/slopewash of depths of greater than 0.4m. Generally includes the inferred areas of fill in the south-western portion of the site, near the existing trench and retaining wall, plus any areas of past disturbance to depths of greater than 0.4m if encountered.	**P**
Majority of the site / Natural soil profile. Locations within the proposed development area not affected by uncontrolled fill and topsoil/slopewash of >0.4m depth, abnormal moisture conditions, or possible inadequate bearing capacity	**M**

Part of the site has been classified as **Class 'P'** in its existing condition due to the presence of uncontrolled fill to depths of greater than 0.4m, as encountered in TP06 and TP08. No records of the placement or compaction of the fill material are available, and the fill contains deleterious material, therefore, it has been assessed as uncontrolled fill.

The approximate extent of fill was inferred based on limited information including observation of surface features and test pits conducted. If the depth and extent of fill needs to be known more accurately for planning, design or other purposes, then it should be investigated further.

It is recommended that the extent of fill is investigated further during or prior to construction works, and that fill is removed or replaced as controlled fill to 'Level 1' criteria as defined in Clause 8.2 – Section 8, of AS3798-2007.

As a preliminary guide, areas stripped of uncontrolled fill (where applicable) and topsoil, then filled with site won Residual Soil or similar material, carried out to 'Level 1' criteria as defined in Clause 8.2 – Section 8, of AS3798-2007, with a non-reactive topsoil layer of thickness in the order of 0.2m to 0.3m, are likely to be re-classified as **Class 'M'** or **Class 'H1'**.

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

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

The effects of changes to the soil profile by additional cutting and filling and the effects of past and future trees should be considered in selection of the design value for differential movement. If site re-grading works involving cutting or filling are performed after the date of this assessment the classification may change and further advice should be sought.

Footings for the proposed development should be designed and constructed in accordance with the requirements of AS2870-2011 and/or sound engineering principles.

The classification presented above assumes that:

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

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 0.40m are encountered during construction, footings should be designed in accordance with engineering principles for Class 'P' sites.

6.3 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 2.7 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 & 4). It is anticipated that these materials could be excavated by a conventional excavator or backhoe bucket;
- Weathered Rock (Unit 5 & 6). 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 5 & 6) material encountered could be excavated by conventional 2.7 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 2.7 tonne excavator bucket refusal (or 2.0m limit of investigations), will be excavatable by ripping to some greater depth, although this has not been assessed as part of the current investigation.

The use of toothed buckets, ripping tines, and/or hydraulic rock hammers may be required if hard bands of weathered rock are encountered or for deep confined excavations such as for service trenches. Higher strength rock or randomly occurring hard bands within the rock mass if encountered, are likely to occur towards the base of deeper cuts.

It is recommended that targeted investigations are carried out if significant excavations are proposed where bedrock depth or excavatability is important to design or construction.

Groundwater may exist at localised areas of the site such as within the topsoil / colluvium profile, from water perched above the residual clay / bedrock profile, or in areas of former drainage channels. It is possible that slow water inflow may be encountered from such layers, particularly if earthworks are carried out during or following periods of wet weather. If encountered, in most cases shallow groundwater is generally expected to be manageable by de-watering by sump and pump methods.

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

6.4 Site Preparation

Site preparation and earthworks suitable for site regrading and 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, with stripping of fill, topsoil and slopewash generally expected to be in the range of about 0.20m to 0.40m based on the depths encountered within the test pits;
- 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.

6.5 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; and,
- Earthworks should be carried out in accordance with the recommendations outlined in AS3798-2007 'Guidelines for Earthworks for Commercial and Residential Developments'.

6.6 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:

- Unit 1 - Fill materials may be variable. Some fill material may be suitable for landscaping purposes only due to the presence of roots and organics.

  If fill material is not affected by roots or other deleterious material, it is generally expected to be suitable for re-use as general fill for engineering purposes. These materials may require some moisture conditioning sorting and/or blending. Suitability for re-use should be confirmed prior to, or at the time of construction;
- Unit 2 - Topsoil materials are expected to be suitable for landscaping purposes only;
- Unit 3 - Slopewash material may be variable and suitability for re-use should be confirmed at the time of construction;
- Unit 4 - Colluvium / Residual Soils are generally expected to be suitable for re-use as general fill for engineering purposes;
- Unit 5 - Extremely Weathered Rock is generally expected to be suitable for re-use as general fill for engineering purposes;
- Unit 6 - Highly Weathered Rock (not encountered in current investigations) is generally expected to be suitable for re-use as general fill for engineering purposes. These materials if encountered may require sorting or processing by crushing / screening depending upon excavation methods, source material characteristics and proposed uses.

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 4 Colluvium/Residual Soils.

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

6.7 Shallow Foundations

Shallow footings founded on stiff or better residual clay, dense or better sand, or approved controlled fill (placed under Level 1 supervision in accordance with AS3798-2007) may be proportioned for a maximum allowable bearing pressure of 100kPa, provided they are founded below any existing uncontrolled fill, topsoil, deleterious material, or very soft to firm material.

Shallow footings founded in Extremely Weathered Rock may be proportioned for a maximum allowable bearing pressure of 300kPa.

The recommended allowable bearing pressures assume that elastic settlements will be less than about 1% of least footing width; although, relevant ground movements related to reactive clay would also apply.

If these bearing pressures are insufficient, foundations can be supported by use of bored piers.

Foundation materials and design parameters should be confirmed by the geotechnical authority at the time of construction / bulk excavation.

The footing should be trimmed and cleaned prior to pouring concrete to remove any loosened or disturbed material.

7.0 Limitations

The findings presented in the report and used as the basis for recommendations presented herein were obtained using normal, industry accepted geotechnical design practices and standards. To our knowledge, they represent a reasonable interpretation of the general conditions of the site.

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

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

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

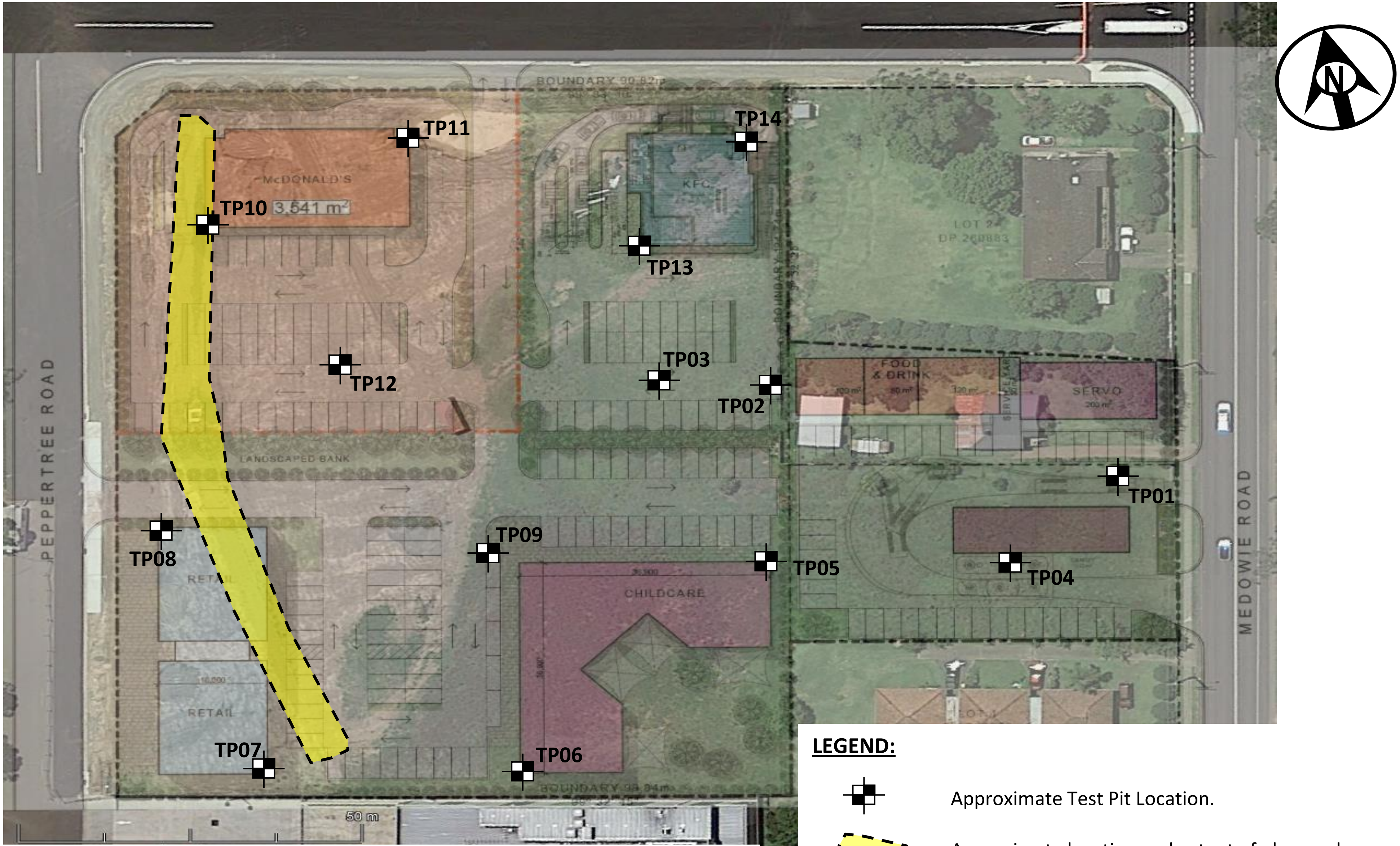
If you have any further questions regarding this report, please do not hesitate to contact Shannon Kelly or the undersigned.

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

Jason Lee
Principal Geotechnical Engineer

FIGURE AA1:

Site Plan and Approximate Test Locations



Based on Ground Floor Plan prepared by CKDS ARCHITECTURE (Project No. ----, Dwg No. SK-1101, Issue A, Dated 31/08/2018), overlaid on Google Earth image.

LEGEND:

Approximate Test Pit Location.

Approximate location and extent of observed drainage trench.

Qualtest
LABORATORY (NSW) PTY LTD

Client:	MAVID GROUP	Drawing No:	FIGURE AA1
Project:	PROPOSED MIXED USE SUBDIVISION	Project No:	NEW19P-0074
Location:	795 MEDOWIE ROAD, MEDOWIE	Scale:	AS SHOWN
Title:	SITE PLAN AND APPROXIMATE TEST LOCATIONS	Date:	7/5/2019

APPENDIX A:

Results of Field Investigations

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT:	MAVID GROUP	TEST PIT NO:	TP01
PROJECT:	PROPOSED MIXED USED SUBDIVISION	PAGE:	1 OF 1
LOCATION:	795 MEDOWIE ROAD, MEDOWIE	JOB NO:	NEW19P-0067
		LOGGED BY:	BB
		DATE:	6/5/19

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

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
E				0.00–0.30m		CL	TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine grained sand, root affected.	M ~ w_P				TOPSOIL
E				0.30–0.40m		CL	Sandy CLAY - low plasticity, grey-brown to pale grey-brown, fine grained sand.	M ~ w_P		HP	300	SLOPE WASH
E				0.40–0.60m (0.5)		CI	CLAY - medium plasticity, pale orange-brown to pale brown, with some fine to coarse grained (mostly fine grained) sand.	M > w_P	VSt	HP	320	COLLUVIUM / RESIDUAL SOIL
E		0.60m U50 0.80m		0.60–1.30m (1.0)		CH	CLAY - medium to high plasticity, red-brown and pale grey, with some fine to coarse grained (mostly fine grained) sand, with some fine to medium grained (mostly fine grained) sub-angular gravel.	M < w_P	H	HP HP HP HP HP HP	380 >600 >600 >600 >600 >600	RESIDUAL SOIL
E	Water inflow at 2.0 m, <1L/min			1.30–2.00m (1.5, 2.0)		CH	Extremely Weathered Siltstone with soil properties; breaks down into Gravelly CLAY - medium to high plasticity, red-brown and pale grey, fine to medium grained sub-angular gravel, with some fine to coarse grained sand. Becoming Clayey GRAVEL	M < w_P	H	HP HP HP	>600 >600 >600	EXTREMELY WEATHERED ROCK
				2.00m			Hole Terminated at 2.00 m					

LEGEND:

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

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

Notes, Samples and Tests

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

Field Tests

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

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

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

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

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT:	MAVID GROUP	TEST PIT NO:	TP02
PROJECT:	PROPOSED MIXED USED SUBDIVISION	PAGE:	1 OF 1
LOCATION:	795 MEDOWIE ROAD, MEDOWIE	JOB NO:	NEW19P-0067
		LOGGED BY:	BB
		DATE:	6/5/19

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

METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
E	Not Encountered			0.00–0.30m	CL	TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine grained sand, root affected.	M ~ w_P				TOPSOIL
				0.30–0.40m	CL	Sandy CLAY - low plasticity, grey-brown to pale grey-brown, fine grained sand.					SLOPE WASH
		0.40m U50 0.75m		0.40–1.10m	CI	CLAY - medium plasticity, pale orange-brown to pale brown, with some fine to medium grained (mostly fine grained) sand.	M > w_P	VSt	HP HP HP HP HP	330 350 300 320 490	COLLUVIUM / RESIDUAL SOIL
				1.10–1.30m	CH	CLAY - medium to high plasticity, red-brown and pale grey to white, with some fine to coarse grained (mostly fine grained) sand, with some fine to medium grained (mostly fine grained) angular to sub-angular gravel.		H	HP HP	580 >600	RESIDUAL SOIL
				1.30–2.00m	CH	Extremely Weathered Siltstone with soil properties; breaks down into Gravelly CLAY - medium to high plasticity, red-brown and pale grey, fine to medium grained sub-angular gravel, with some fine to coarse grained sand. Becoming Clayey GRAVEL	M < w_P	H	HP HP HP	>600 >600 >600	EXTREMELY WEATHERED ROCK
				2.00m		Hole Terminated at 2.00 m					

LEGEND:

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

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

Notes, Samples and Tests

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

Field Tests

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

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

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

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

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT: MAVID GROUP
PROJECT: PROPOSED MIXED USED SUBDIVISION
LOCATION: 795 MEDOWIE ROAD, MEDOWIE

TEST PIT NO: TP03
PAGE: 1 OF 1
JOB NO: NEW19P-0067
LOGGED BY: BB
DATE: 6/5/19

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

METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
E	Not Encountered			0.00–0.25m	CL	FILL-TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine grained sand, root affected, trace broken glass.					FILL - TOPSOIL
				0.25m	CL	Sandy CLAY - low plasticity, grey-brown to pale grey-brown, fine grained sand.	M > Wp		HP	300	SLOPE WASH
		0.50m CBR 0.70m		0.30m	CI	CLAY - medium plasticity, pale orange-brown to pale brown, with some fine grained sand.	M > Wp	VSt	HP HP HP	320 330 300	COLLUVIUM / RESIDUAL SOIL
				0.70m	CH	CLAY - medium to high plasticity, red-brown and pale grey and pale orange-brown, with some fine to coarse grained (mostly fine grained) sand, with some fine grained angular to sub-angular gravel.	M ~ Wp	H	HP HP HP HP	580 >600 >600 >600	RESIDUAL SOIL
				1.20m	CH	Extremely Weathered Siltstone with soil properties; breaks down into CLAY - medium to high plasticity, red-brown and pale grey, with some fine to medium grained sub-angular gravel. Becoming Gravelly CLAY.	M < Wp	H	HP HP HP HP	>600 >600 >600 >600	EXTREMELY WEATHERED ROCK
				2.00m		Hole Terminated at 2.00 m					

LEGEND:

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

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

Notes, Samples and Tests

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

Field Tests

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

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

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

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

QT LIB 1.1.GLB Log NON-CORED BOREHOLE - TEST PIT TEMPLATE LOGS SHEET.GPJ <<DrawingFile>> 21/05/2019 10:38 10.0.000 Datgel Lab and In Situ Tool

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT:	MAVID GROUP	TEST PIT NO:	TP04
PROJECT:	PROPOSED MIXED USED SUBDIVISION	PAGE:	1 OF 1
LOCATION:	795 MEDOWIE ROAD, MEDOWIE	JOB NO:	NEW19P-0067
		LOGGED BY:	BB
		DATE:	6/5/19

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

METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
				0.00–0.30m	CL	TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine grained sand, root affected.	M ~ W_P				TOPSOIL
				0.30–0.40m	CL	Sandy CLAY - low plasticity, grey-brown to pale grey-brown, fine grained sand.	M ~ W_P		HP	320	SLOPE WASH
		0.60m CBR & U50 0.75m		0.40–0.80m	CI	CLAY - medium plasticity, pale orange-brown to pale brown, with some fine to medium grained (mostly fine grained) sand.	M > W_P	VSt	HP HP HP HP	300 350 390 >600	COLLUVIUM / RESIDUAL SOIL
				0.80–1.30m	CH	Gravelly CLAY - medium to high plasticity, red-brown and pale orange-brown, with some fine to coarse grained (mostly fine grained) sand, with some fine grained angular to sub-angular gravel.	M < W_P	H	HP HP	>600 >600	RESIDUAL SOIL
	<1L/min (water inflow at 2.0 m)			1.30–2.00m	CH	Extremely Weathered Siltstone with soil properties; breaks down into Gravelly CLAY - medium to high plasticity, red-brown with some pale grey, fine to medium grained angular to sub-angular gravel. Becoming Clayey GRAVEL	M < W_P	H	HP HP HP	>600 >600 >600	EXTREMELY WEATHERED ROCK
				2.00m		Hole Terminated at 2.00 m					

LEGEND:

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

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

Notes, Samples and Tests

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

Field Tests

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

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

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

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

ENGINEERING LOG - TEST PIT

CLIENT:	MAVID GROUP	**TEST PIT NO:**	**TP05**
PROJECT:	PROPOSED MIXED USED SUBDIVISION	**PAGE:**	1 OF 1
LOCATION:	795 MEDOWIE ROAD, MEDOWIE	**JOB NO:**	NEW19P-0067
		LOGGED BY:	BB
		DATE:	6/5/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR **SURFACE RL:**

TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **DATUM:**

METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
E	Not Encountered			0.00–0.15m	CL	TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine grained sand, root affected.	$M \sim W_P$				TOPSOIL
				0.15–0.20m	CL	Sandy CLAY - low plasticity, grey-brown to pale grey-brown, fine grained sand.					SLOPE WASH
				0.20–0.70m	CI	CLAY - medium plasticity, pale orange-brown to pale brown, with some fine to medium grained (mostly fine grained) sand.	$M > W_P$	VSt - H	HP HP HP HP	320 380 420 >600	COLLUVIUM / RESIDUAL SOIL
		0.75m U50 0.90m		0.70–0.95m	CI	Gravelly CLAY - medium plasticity, red-brown and pale grey to white with some pale orange-brown, fine to medium grained angular to sub-angular gravel, with some relict rock structure.	$M < W_P$	H	HP	>600	RESIDUAL SOIL
				0.95–2.00m	CH	Extremely Weathered Siltstone with soil properties; breaks down into Gravelly CLAY - medium to high plasticity, red-brown and pale grey, fine to medium grained sub-angular gravel, with some fine to coarse grained sand. Becoming Clayey GRAVEL			HP HP HP HP	>600 >600 >600 >600	EXTREMELY WEATHERED ROCK
				2.00m		Hole Terminated at 2.00 m					

LEGEND:

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

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

Notes, Samples and Tests

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

Field Tests

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

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

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

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

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT: MAVID GROUP
PROJECT: PROPOSED MIXED USED SUBDIVISION
LOCATION: 795 MEDOWIE ROAD, MEDOWIE

TEST PIT NO: TP06
PAGE: 1 OF 1
JOB NO: NEW19P-0067
LOGGED BY: BB
DATE: 6/5/19

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

METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
E	Not Encountered			0.00–0.35m		CL	FILL-TOPSOIL: Gravelly Sandy CLAY - low to medium plasticity, dark brown, fine to coarse grained (mostly fine grained) sand, fine to coarse grained (mostly fine to medium grained) angular to sub-angular gravel, trace concrete cobbles, root affected.	M ~ W_P				FILL - TOPSOIL SLOPING PROFILE: FILL SHALLOWER AT NORTHERN END OF PIT.
				0.35m–0.80m		CH	FILL: Gravelly CLAY - medium to high plasticity, pale red-brown and pale grey to white, fine to coarse grained angular to sub-angular gravel. Concrete rubble and disused drainage line from northern end of pit. Pocket of Gravelly Sandy CLAY - low to medium plasticity, dark brown, fine to coarse grained sand, fine to coarse grained angular gravel.	M > W_P M		HP	150 - 300	FILL
		0.80m U50 1.05m		0.80m–1.30m		CI	CLAY - medium plasticity, orange-brown and red-brown, with some fine to medium grained angular to sub-angular gravel.	M ~ W_P	H			RESIDUAL SOIL
				1.30m–2.00m		CI	Extremely Weathered Siltstone with soil properties; breaks down into Gravelly CLAY - medium plasticity, red-brown and pale grey to white, fine to medium grained angular to sub-angular gravel. Becoming Clayey GRAVEL.	M ~ W_P M	H			EXTREMELY WEATHERED ROCK
				2.00m			Hole Terminated at 2.00 m					

Depth scale: 0.5, 1.0, 1.5, 2.0

LEGEND:

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

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

Notes, Samples and Tests

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

Field Tests

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

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

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

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

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT:	MAVID GROUP	TEST PIT NO:	TP07
PROJECT:	PROPOSED MIXED USED SUBDIVISION	PAGE:	1 OF 1
LOCATION:	795 MEDOWIE ROAD, MEDOWIE	JOB NO:	NEW19P-0067
		LOGGED BY:	BB
		DATE:	6/5/19

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

METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics, colour, minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
E	Not Encountered			0.00–0.30m	CL	TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine grained sand, root affected.	M > Wp				TOPSOIL
				0.30–0.40m	CL	Sandy CLAY - low plasticity, grey-brown to pale grey-brown, fine grained sand.	M ~ Wp		HP	300	SLOPE WASH
		0.50m–0.75m U50		0.40–0.80m	CI	CLAY - medium plasticity, pale orange-brown to pale brown, with some fine to medium grained (mostly fine grained) sand.	M > Wp	VSt	HP HP HP	320 300 380	COLLUVIUM / RESIDUAL SOIL
				0.80–1.20m	CH	CLAY - medium to high plasticity, red-brown and orange-brown, with some fine to medium grained (mostly fine grained) sand, with some fine to medium grained (mostly fine grained) angular to sub-angular gravel. Red-brown and pale grey to white.	M ~ Wp	H	HP HP	>600 >600	RESIDUAL SOIL
				1.20–1.40m	CH	Extremely Weathered Siltstone with soil properties; breaks down into CLAY - medium to high plasticity, red-brown and pale grey, with some fine to medium grained sub-angular gravel, with some fine to coarse grained sand.			HP	>600	EXTREMELY WEATHERED ROCK
				1.40–2.00m	CH	Extremely Weathered Siltstone with soil properties; breaks down into CLAY - medium to high plasticity, red-brown and pale grey, with some fine to medium grained sub-angular gravel, with some fine to coarse grained sand. Becoming Clayey GRAVEL.			HP HP HP	>600 >600 >600	
				2.00m		Hole Terminated at 2.00 m					

LEGEND:

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

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

Notes, Samples and Tests

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

Field Tests

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

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

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

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

ENGINEERING LOG - TEST PIT

CLIENT: MAVID GROUP
PROJECT: PROPOSED MIXED USED SUBDIVISION
LOCATION: 795 MEDOWIE ROAD, MEDOWIE

TEST PIT NO: TP08
PAGE: 1 OF 1
JOB NO: NEW19P-0067
LOGGED BY: BB
DATE: 6/5/19

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

METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
E	Not Encountered			0.00–0.40m	CL	FILL-TOPSOIL: Sandy CLAY - low plasticity, grey-brown to dark grey-brown, fine grained sand, root affected.	M < W_P				FILL - TOPSOIL
				0.40m–0.70m	CH	FILL: CLAY - medium to high plasticity, red-brown and orange-brown, with some fine to medium grained sand, trace concrete cobbles.	M < W_P				FILL
				0.70m–1.00m	CL	TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine grained sand.	M ~ W_P				BURIED TOPSOIL
		U50 1.00m–1.25m		1.00m–1.40m	CI	CLAY - medium plasticity, pale orange-brown to pale brown, with some fine grained sand.	M > W_P	VSt	HP	350	COLLUVIUM / RESIDUAL SOIL
				1.40m–2.00m	CH	Sandy CLAY - medium to high plasticity, red-brown and pale orange-brown with some pale grey, fine to medium grained sand. With some relict rock structure.	M < W_P	H	HP	530	RESIDUAL SOIL
				2.00m		Hole Terminated at 2.00 m					

LEGEND:

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

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

Notes, Samples and Tests

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

Field Tests

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

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

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

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

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT: MAVID GROUP
PROJECT: PROPOSED MIXED USED SUBDIVISION
LOCATION: 795 MEDOWIE ROAD, MEDOWIE

TEST PIT NO: TP09
PAGE: 1 OF 1
JOB NO: NEW19P-0067
LOGGED BY: BB
DATE: 6/5/19

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

METHOD	WATER	SAMPLES	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 grained sand, root affected.	M ~ W_P				TOPSOIL
			0.20m	CL	Sandy CLAY - low plasticity, grey-brown to pale grey-brown, fine grained sand.	M ~ W_P				SLOPE WASH
		0.40m CBR 0.60m	0.30m	CI	CLAY - medium plasticity, pale orange-brown to pale brown, with some fine to medium grained (mostly fine grained) sand.	M > W_P	VSt	HP HP HP	300 280 350	COLLUVIUM / RESIDUAL SOIL
			0.60m	CH	CLAY - medium to high plasticity, red-brown and pale orange-brown, with some fine to coarse grained (mostly fine grained) sand, with some fine grained angular to sub-angular gravel.	M < W_P	H	HP HP HP HP HP	450 550 500 >600 >600	RESIDUAL SOIL
			1.15m	CH	Extremely Weathered Siltstone with soil properties; breaks down into Gravelly CLAY - medium to high plasticity, red-brown and pale grey to white, fine to coarse grained angular to sub-angular gravel. Becoming Clayey GRAVEL	M < W_P / M	H	HP HP HP HP	>600 >600 >600 >600	EXTREMELY WEATHERED ROCK
			2.00m		Hole Terminated at 2.00 m					

LEGEND:

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

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

Notes, Samples and Tests

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

Field Tests

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

Consistency / **UCS (kPa)**

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

Moisture Condition

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

Density

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

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT:	MAVID GROUP	TEST PIT NO:	TP10
PROJECT:	PROPOSED MIXED USED SUBDIVISION	PAGE:	1 OF 1
LOCATION:	795 MEDOWIE ROAD, MEDOWIE	JOB NO:	NEW19P-0067
		LOGGED BY:	BB
		DATE:	6/5/19

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

METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
E				0.00–0.30m	CL	TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine grained sand, root affected.	M ~ W_P				TOPSOIL
				0.30–0.40m	CL	Sandy CLAY - low plasticity, grey-brown to pale grey-brown, fine grained sand.	M < W_P		HP	200	SLOPE WASH
				0.40–1.40m	CI	CLAY - medium plasticity, pale orange-brown to pale brown, with some fine to medium grained (mostly fine grained) sand. Red-brown and pale orange-brown.	M > W_P	VSt	HP HP HP HP HP HP HP	300 250 320 370 300 230 350	COLLUVIUM / RESIDUAL SOIL
	<1L/min (inflow at 2.0m)	1.50m U50 1.80m		1.40–2.00m	CH	CLAY - high plasticity, dark red-brown and pale grey, with some fine to medium grained sand.			HP HP	310 260	RESIDUAL SOIL
				2.00m		Hole Terminated at 2.00 m					TEST PIT CARRIED OUT ON EASTERN FACE OF EXISTING TRENCH. PROFILE INDICATES TRENCH CUT INTO NATURAL PROFILE.

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: MAVID GROUP
PROJECT: PROPOSED MIXED USED SUBDIVISION
LOCATION: 795 MEDOWIE ROAD, MEDOWIE

TEST PIT NO: TP11
PAGE: 1 OF 1
JOB NO: NEW19P-0067
LOGGED BY: BB
DATE: 6/5/19

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

METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
	Not Encountered				CL	TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine grained sand, root affected.	M ~ W_P				TOPSOIL
				0.20m	CL	Sandy CLAY - low plasticity, grey-brown to pale grey-brown, fine grained sand.			HP	350	SLOPE WASH
		0.50m U50 0.65m		0.30m (0.5)	CI	Sandy CLAY - medium plasticity, pale orange-brown to pale brown, fine to medium grained sand.	M > W_P	VSt	HP / HP / HP	280 / 380 / 350	COLLUVIUM / RESIDUAL SOIL
				0.65m	CH	CLAY - medium to high plasticity, red-brown with some pale grey and pale orange-brown, with some fine to coarse grained (mostly fine grained) sand.	M ~ W_P		HP	350	RESIDUAL SOIL
				0.90m (1.0, 1.5)	CH	Extremely Weathered Siltstone with soil properties; breaks down into CLAY - medium to high plasticity, red-brown and pale grey, with some fine to medium grained sub-angular gravel. Red-brown and pale grey to white.	M < W_P	H	HP / HP / HP / HP	500 / >600 / >600 / >600	EXTREMELY WEATHERED ROCK
				2.00m (2.0)		Hole Terminated at 2.00 m					

LEGEND:

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

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

Notes, Samples and Tests

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

Field Tests

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

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

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

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

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT:	MAVID GROUP	**TEST PIT NO:**	**TP12**
PROJECT:	PROPOSED MIXED USED SUBDIVISION	**PAGE:**	1 OF 1
LOCATION:	795 MEDOWIE ROAD, MEDOWIE	**JOB NO:**	NEW19P-0067
		LOGGED BY:	BB
		DATE:	6/5/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR **SURFACE RL:**

TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **DATUM:**

METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
E	Not Encountered			0.00–0.30m	CL	TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine grained sand, root affected. Fill in places within top 0.10m, containing plastic bags and glass.	$M \sim W_P$				TOPSOIL
				0.30–0.40m	CL	Sandy CLAY - low plasticity, grey-brown to pale grey-brown, fine grained sand.	$M < W_P$				SLOPE WASH
		0.60m–0.80m CBR		0.40–0.85m	CI	CLAY - medium plasticity, pale orange-brown to pale brown, fine to medium grained sand.	$M > W_P$	VSt	HP HP HP HP	280 360 380 420	COLLUVIUM / RESIDUAL SOIL
				0.85–2.00m	CH	CLAY - medium to high plasticity, red-brown and pale grey to white, with some fine to coarse grained (mostly fine to medium grained) sand, with some fine grained angular to sub-angular gravel. Relict rock structure. With some pockets of Extremely Weathered Siltstone with soil properties.	$M < W_P$	H	HP HP HP HP HP	580 >600 >600 >600 >600	RESIDUAL SOIL
				2.00m		Hole Terminated at 2.00 m					

LEGEND:

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

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

Notes, Samples and Tests

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

Field Tests

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

Consistency

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

Moisture Condition

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

Density

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

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT:	MAVID GROUP	**TEST PIT NO:**	**TP13**
PROJECT:	PROPOSED MIXED USED SUBDIVISION	**PAGE:**	1 OF 1
LOCATION:	795 MEDOWIE ROAD, MEDOWIE	**JOB NO:**	NEW19P-0067
		LOGGED BY:	BB
		DATE:	6/5/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR **SURFACE RL:**

TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **DATUM:**

Drilling and Sampling					Material description and profile information					Field Test		Structure and additional observations
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics, colour, minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	
	Not Encountered			0.00–0.25m		CL	TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine grained sand, root affected.	M ~ W_P				TOPSOIL
				0.25–0.30m		CL	Sandy CLAY - low plasticity, grey-brown to pale grey-brown, fine grained sand.			HP	290	SLOPE WASH
		0.50m U50 0.65m		0.30–0.65m (0.5)		CI	Sandy CLAY - medium plasticity, pale orange-brown to pale brown, fine to medium grained (mostly fine grained) sand.	M > W_P	VSt	HP HP HP	250 390 360	COLLUVIUM / RESIDUAL SOIL
				0.65–1.35m (1.0)		CH	CLAY - medium to high plasticity, red-brown and pale grey, with some fine to coarse grained (mostly fine grained) sand, with some fine grained sub-rounded to sub-angular gravel.	M < W_P	H	HP HP HP HP	>600 >600 >600 >600	RESIDUAL SOIL
				1.35–1.75m (1.5)		CH	Extremely Weathered Siltstone with soil properties; breaks down into CLAY - medium to high plasticity, red-brown and pale grey to white, with some fine to medium grained sub-angular gravel, with some fine to coarse grained sand.			HP HP	>600 >600	EXTREMELY WEATHERED ROCK
				1.75–2.00m (2.0)		CH	Extremely Weathered Siltstone with soil properties; breaks down into Gravelly CLAY - medium to high plasticity, red-brown and pale grey, fine to medium grained sub-angular gravel, with some fine to coarse grained sand.			HP	>600	
							Hole Terminated at 2.00 m					

LEGEND:

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

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

Notes, Samples and Tests

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

Field Tests

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

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

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

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

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT: MAVID GROUP
PROJECT: PROPOSED MIXED USED SUBDIVISION
LOCATION: 795 MEDOWIE ROAD, MEDOWIE

TEST PIT NO: TP14
PAGE: 1 OF 1
JOB NO: NEW19P-0067
LOGGED BY: BB
DATE: 6/5/19

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

METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	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	CL	TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine grained sand, root affected.	$M > W_P$				TOPSOIL TRENCH FILL IN TOP 0.30M OF PIT AT EASTERN END.
				0.30m	CL	Sandy CLAY - low plasticity, grey-brown to pale grey-brown, fine grained sand.	$M \sim W_P$				SLOPE WASH
				0.5 0.65m	CI	CLAY - medium plasticity, pale orange-brown to pale brown, with some fine to coarse grained (mostly fine grained) sand.	$M > W_P$	VSt	HP HP HP HP	290 300 350 300	COLLUVIUM / RESIDUAL SOIL
		0.70m U50 1.00m		1.0 1.40m	CH	CLAY - medium to high plasticity, red-brown and pale grey, with some fine to coarse grained (mostly fine grained) sand, with some fine to medium grained (mostly fine grained) sub-angular gravel.	$M \sim W_P$	H	HP HP HP HP	480 >600 >600 550	RESIDUAL SOIL
				1.5 2.0 2.00m	CH	Extremely Weathered Siltstone with soil properties; breaks down into CLAY - medium to high plasticity, red-brown and pale grey, fine to medium grained sub-angular gravel, with some fine to coarse grained sand. Becoming Gravelly CLAY.	$M < W_P$		HP HP HP	>600 >600 >600	EXTREMELY WEATHERED ROCK
						Hole Terminated at 2.00 m					

LEGEND:

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

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

Notes, Samples and Tests

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

Field Tests

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

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

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

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

APPENDIX B:

Results of Laboratory Testing

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

Report No: SSI:NEW19W-1502--S01
Issue No: 1

Shrink Swell Index Report

Client: Mavid Group
81 Mustang Drive
Rutherford NSW 2320

Principal:
Project No.: NEW19P-0074
Project Name: Proposed Mixed Use Development

NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 16/05/2019

Sample Details

Sample ID:	NEW19W-1502--S01	**Client Sample ID:**	
Test Request No.:		**Sampling Method:**	Sampled by Engineering Department
Material:	Clay	**Date Sampled:**	6/05/2019
Source:	On Site	**Date Submitted:**	7/05/2019
Specification:	No Specification		
Project Location:	795 Medowie Road, Medowie		
Sample Location:	TP01 - (0.6 - 0.8m)		
Borehole Number:	TP01		
Borehole Depth (m):	0.6 - 0.8		

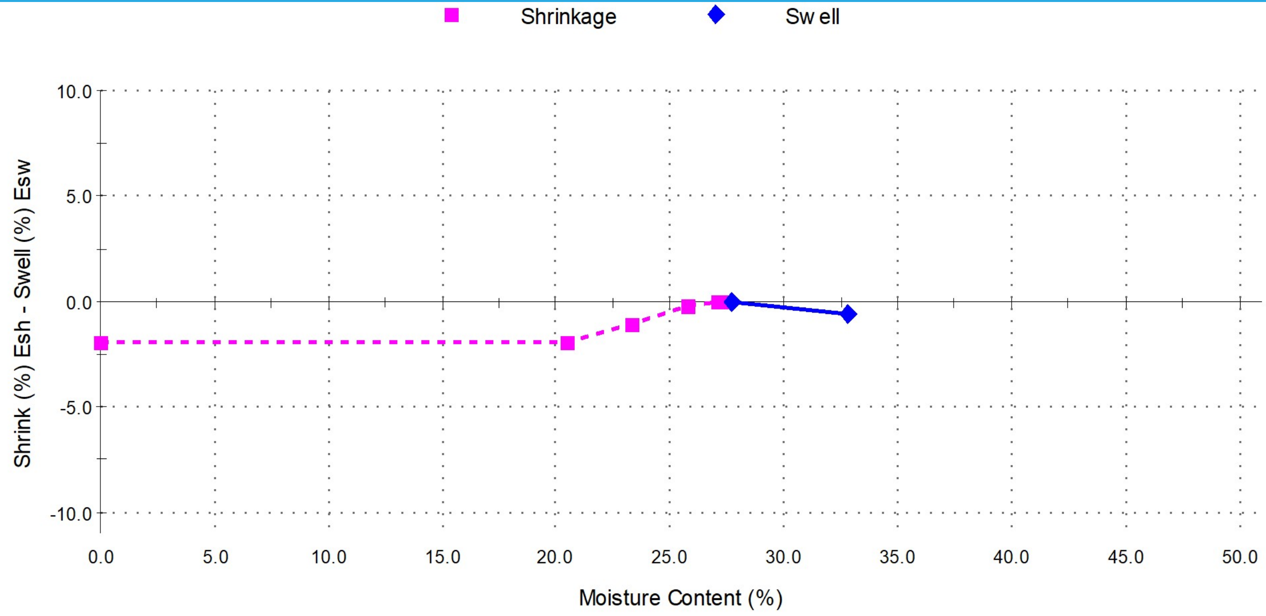
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.6
Moisture Content before (%):	27.7
Moisture Content after (%):	32.8
Est. Unc. Comp. Strength before (kPa):	300
Est. Unc. Comp. Strength after (kPa):	330

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	1.9
Shrinkage Moisture Content (%):	27.5
Est. inert material (%):	5%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Major

Shrink Swell



Shrink Swell Index - Iss (%): 1.1

Comments

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

Report No: SSI:NEW19W-1502--S02
Issue No: 1

Shrink Swell Index Report

Client: Mavid Group
81 Mustang Drive
Rutherford NSW 2320

Principal:
Project No.: NEW19P-0074
Project Name: Proposed Mixed Use Development

Accredited for compliance with ISO/IEC 17025-Testing.
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.
Results provided relate only to the items tested or sampled.
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NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 16/05/2019

Sample Details

Sample ID:	NEW19W-1502--S02	**Client Sample ID:**	
Test Request No.:		**Sampling Method:**	Sampled by Engineering Department
Material:	Clay	**Date Sampled:**	6/05/2019
Source:	On Site	**Date Submitted:**	7/05/2019
Specification:	No Specification		
Project Location:	795 Medowie Road, Medowie		
Sample Location:	TP02 - (0.4 - 0.75m)		
Borehole Number:	TP02		
Borehole Depth (m):	0.40 - 0.75		

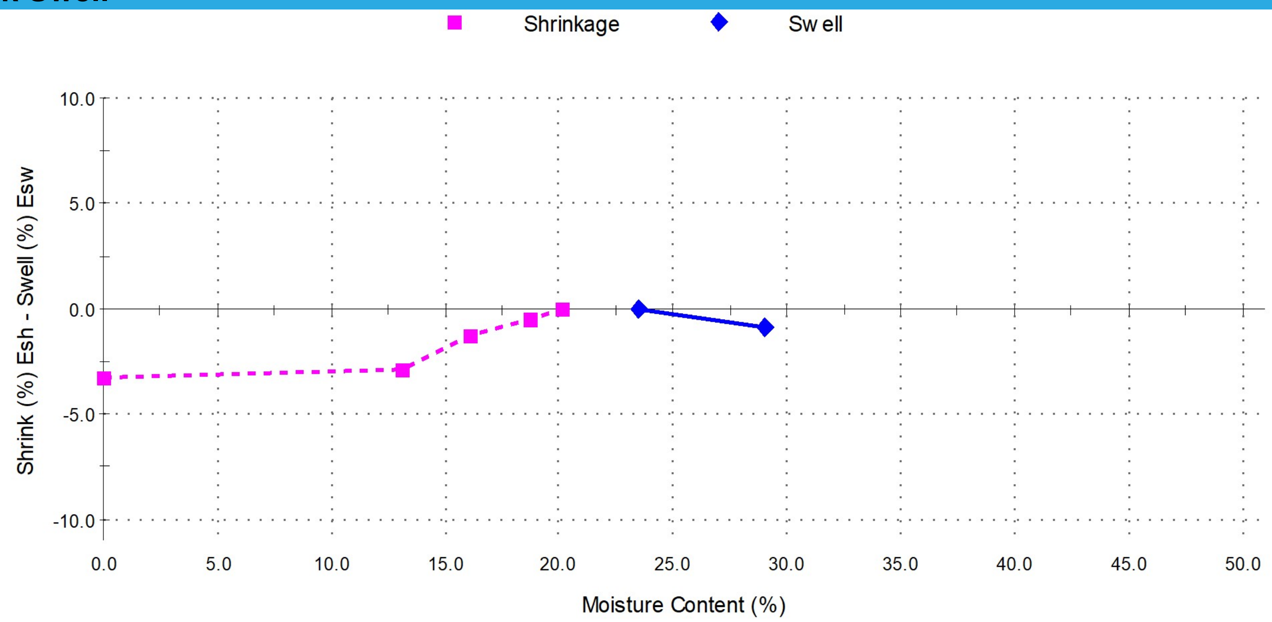
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.9
Moisture Content before (%):	23.5
Moisture Content after (%):	29.0
Est. Unc. Comp. Strength before (kPa):	190
Est. Unc. Comp. Strength after (kPa):	150

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	3.3
Shrinkage Moisture Content (%):	20.2
Est. inert material (%):	0%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 1.8

Comments

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Report No: SSI:NEW19W-1502--S04
Issue No: 1

Shrink Swell Index Report

Client: Mavid Group
81 Mustang Drive
Rutherford NSW 2320

Principal:
Project No.: NEW19P-0074
Project Name: Proposed Mixed Use Development

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NATA Accredited Laboratory Number: 18686
Date of Issue: 16/05/2019

Sample Details

Sample ID:	NEW19W-1502--S04	**Client Sample ID:**	
Test Request No.:		**Sampling Method:**	Sampled by Engineering Department
Material:	Gravelly Clay	**Date Sampled:**	6/05/2019
Source:	On Site	**Date Submitted:**	7/05/2019
Specification:	No Specification		
Project Location:	795 Medowie Road, Medowie		
Sample Location:	TP05 - (0.75 - 0.9m)		
Borehole Number:	TP05		
Borehole Depth (m):	0.75 - 0.90		

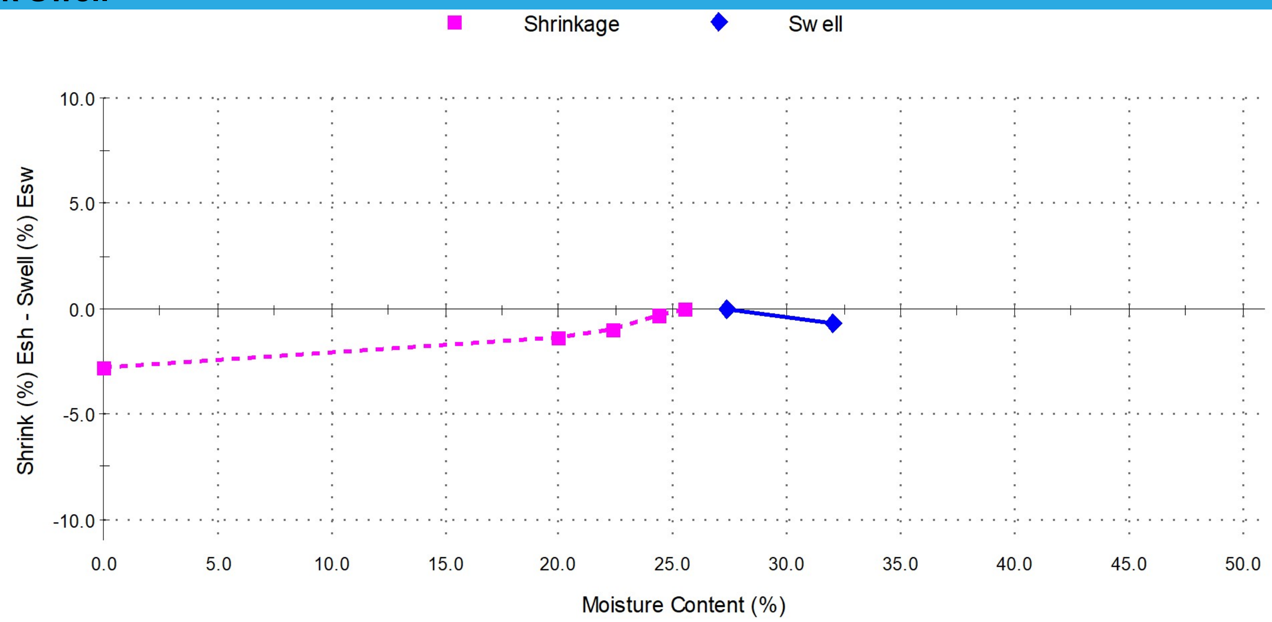
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.7
Moisture Content before (%):	27.4
Moisture Content after (%):	32.0
Est. Unc. Comp. Strength before (kPa):	580
Est. Unc. Comp. Strength after (kPa):	400

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	2.8
Shrinkage Moisture Content (%):	25.5
Est. inert material (%):	5%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Moderate

Shrink Swell



Shrink Swell Index - Iss (%): 1.5

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Report No: SSI:NEW19W-1502--S05
Issue No: 1

Shrink Swell Index Report

Client: Mavid Group
81 Mustang Drive
Rutherford NSW 2320

Principal:
Project No.: NEW19P-0074
Project Name: Proposed Mixed Use Development

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WORLD RECOGNISED ACCREDITATION

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 16/05/2019

Sample Details

Sample ID:	NEW19W-1502--S05	**Client Sample ID:**	
Test Request No.:		**Sampling Method:**	Sampled by Engineering Department
Material:	Clay	**Date Sampled:**	6/05/2019
Source:	On Site	**Date Submitted:**	7/05/2019
Specification:	No Specification		
Project Location:	795 Medowie Road, Medowie		
Sample Location:	TP06 - (0.8 - 1.05m)		
Borehole Number:	TP06		
Borehole Depth (m):	0.80 - 1.05		

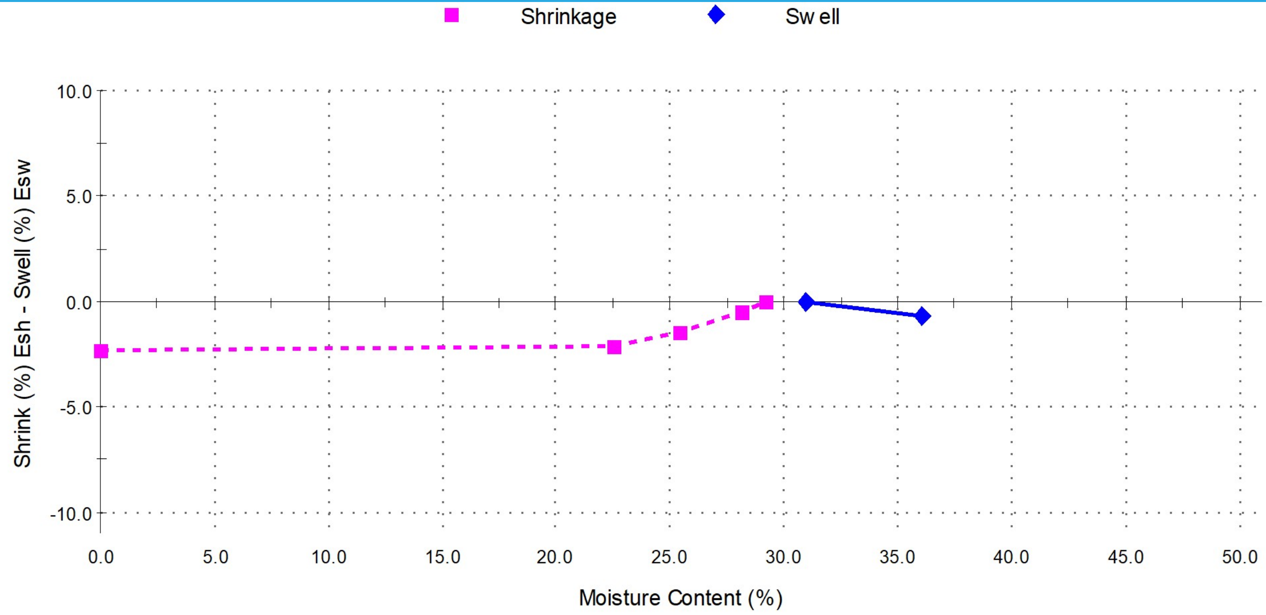
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.7
Moisture Content before (%):	31.0
Moisture Content after (%):	36.0
Est. Unc. Comp. Strength before (kPa):	400
Est. Unc. Comp. Strength after (kPa):	250

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	2.3
Shrinkage Moisture Content (%):	29.2
Est. inert material (%):	4%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Major

Shrink Swell



Shrink Swell Index - Iss (%): 1.3

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Report No: MAT:NEW19W-1502--S06
Issue No: 1

Material Test Report

Client: Mavid Group
81 Mustang Drive
Rutherford NSW 2320

Principal:
Project No.: NEW19P-0074
Project Name: Proposed Mixed Use Development

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WORLD RECOGNISED ACCREDITATION

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 20/05/2019

Sample Details

Sample ID: NEW19W-1502--S06
Sampling Method: Sampled by Engineering Department
Date Sampled: 06/05/2019
Source: On Site
Material: Sandy Clay
Specification: No Specification
Project Location: 795 Medowie Road, Medowie
Sample Location: TP07 - (0.5 - 0.75m)

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	47	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	18	
Plasticity Index (%)	AS 1289.3.3.1	29	

Comments

N/A

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Shrink Swell Index Report

Report No: SSI:NEW19W-1502--S07
Issue No: 1

Client:	Mavid Group 81 Mustang Drive Rutherford NSW 2320
Principal:	
Project No.:	NEW19P-0074
Project Name:	Proposed Mixed Use Development

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NATA Accredited Laboratory Number: 18686
Date of Issue: 16/05/2019

Sample Details

Sample ID:	NEW19W-1502--S07	**Client Sample ID:**	
Test Request No.:		**Sampling Method:**	Sampled by Engineering Department
Material:	Clay	**Date Sampled:**	6/05/2019
Source:	On Site	**Date Submitted:**	7/05/2019
Specification:	No Specification		
Project Location:	795 Medowie Road, Medowie		
Sample Location:	TP08 - (1.0 - 1.25m)		
Borehole Number:	TP08		
Borehole Depth (m):	1.00 - 1.25		

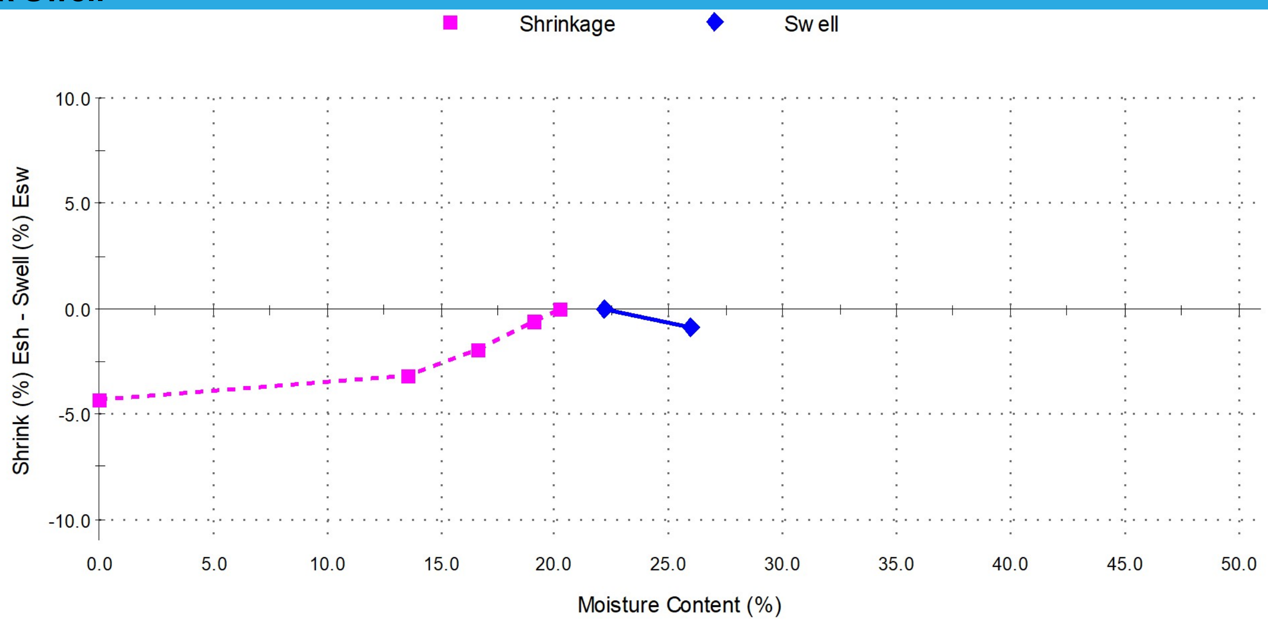
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.9
Moisture Content before (%):	22.1
Moisture Content after (%):	26.0
Est. Unc. Comp. Strength before (kPa):	190
Est. Unc. Comp. Strength after (kPa):	220

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	4.3
Shrinkage Moisture Content (%):	20.2
Est. inert material (%):	0%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Nil

Shrink Swell



Shrink Swell Index - Iss (%): 2.4

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Report No: SSI:NEW19W-1502--S08
Issue No: 1

Shrink Swell Index Report

Client: Mavid Group
81 Mustang Drive
Rutherford NSW 2320

Principal:
Project No.: NEW19P-0074
Project Name: Proposed Mixed Use Development

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NATA Accredited Laboratory Number: 18686
Date of Issue: 16/05/2019

Sample Details

Sample ID:	NEW19W-1502--S08	**Client Sample ID:**	
Test Request No.:		**Sampling Method:**	Sampled by Engineering Department
Material:	Clay	**Date Sampled:**	6/05/2019
Source:	On Site	**Date Submitted:**	7/05/2019
Specification:	No Specification		
Project Location:	795 Medowie Road, Medowie		
Sample Location:	TP10 - (1.5 - 1.8m)		
Borehole Number:	TP10		
Borehole Depth (m):	1.50 - 1.80		

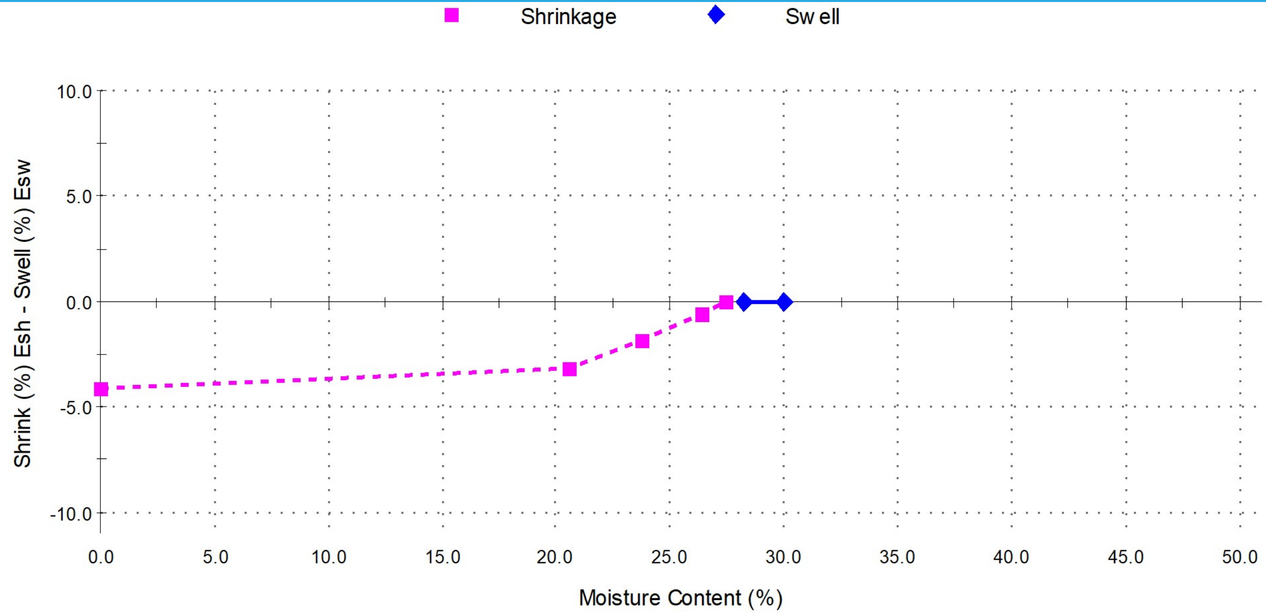
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	0.0
Moisture Content before (%):	28.2
Moisture Content after (%):	30.0
Est. Unc. Comp. Strength before (kPa):	400
Est. Unc. Comp. Strength after (kPa):	350

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	4.1
Shrinkage Moisture Content (%):	27.4
Est. inert material (%):	2%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Moderate

Shrink Swell



Shrink Swell Index - Iss (%): 2.3

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Report No: SSI:NEW19W-1502--S09
Issue No: 1

Shrink Swell Index Report

Client:	Mavid Group 81 Mustang Drive Rutherford NSW 2320
Principal:	
Project No.:	NEW19P-0074
Project Name:	Proposed Mixed Use Development

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Approved Signatory: Dane Cullen
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NATA Accredited Laboratory Number: 18686
Date of Issue: 16/05/2019

Sample Details

Sample ID:	NEW19W-1502--S09	**Client Sample ID:**	
Test Request No.:		**Sampling Method:**	Sampled by Engineering Department
Material:	Sandy Clay	**Date Sampled:**	6/05/2019
Source:	On Site	**Date Submitted:**	7/05/2019
Specification:	No Specification		
Project Location:	795 Medowie Road, Medowie		
Sample Location:	TP11 - (0.5 - 0.65m)		
Borehole Number:	TP11		
Borehole Depth (m):	0.50 - 0.65		

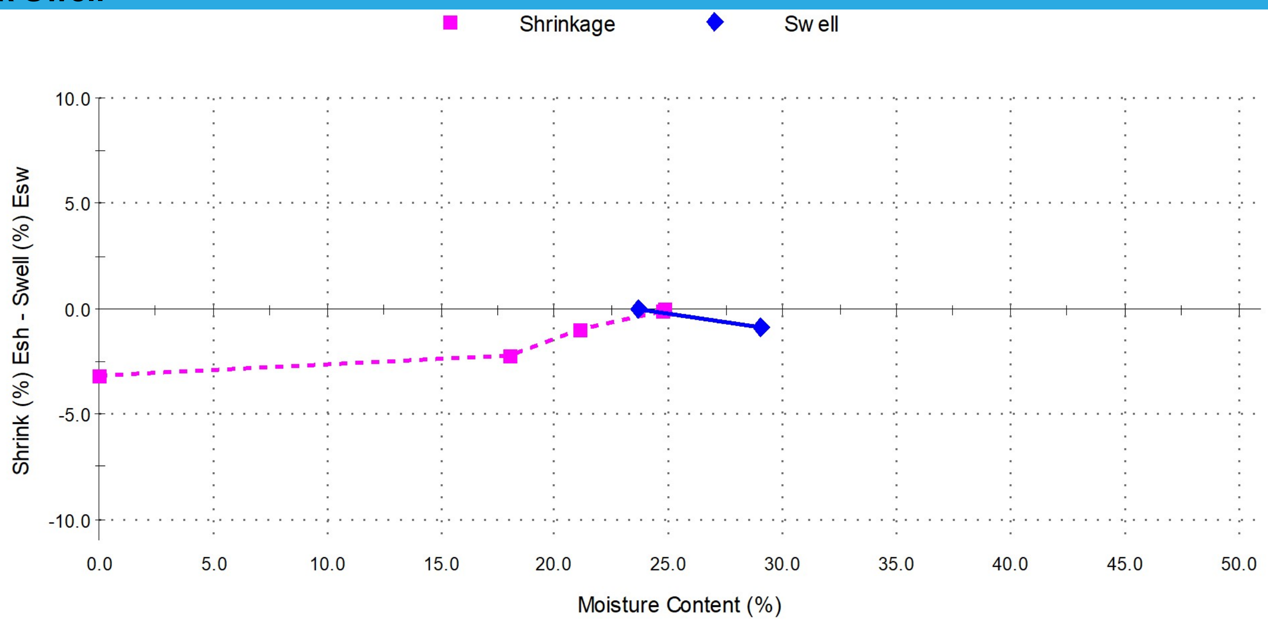
Swell Test — AS 1289.7.1.1

Swell on Saturation (%):	-0.8
Moisture Content before (%):	23.6
Moisture Content after (%):	29.0
Est. Unc. Comp. Strength before (kPa):	470
Est. Unc. Comp. Strength after (kPa):	420

Shrink Test — AS 1289.7.1.1

Shrink on drying (%):	3.2
Shrinkage Moisture Content (%):	24.8
Est. inert material (%):	3%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 1.8

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Report No: SSI:NEW19W-1502--S10
Issue No: 1

Shrink Swell Index Report

Client:	Mavid Group 81 Mustang Drive Rutherford NSW 2320
Principal:	
Project No.:	NEW19P-0074
Project Name:	Proposed Mixed Use Development

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Sample Details

Sample ID:	NEW19W-1502--S10	**Client Sample ID:**	
Test Request No.:		**Sampling Method:**	Sampled by Engineering Department
Material:	Sandy Clay	**Date Sampled:**	6/05/2019
Source:	On Site	**Date Submitted:**	7/05/2019
Specification:	No Specification		
Project Location:	795 Medowie Road, Medowie		
Sample Location:	TP13 - (0.5 - 0.65m)		
Borehole Number:	TP13		
Borehole Depth (m):	0.50 - 0.65		

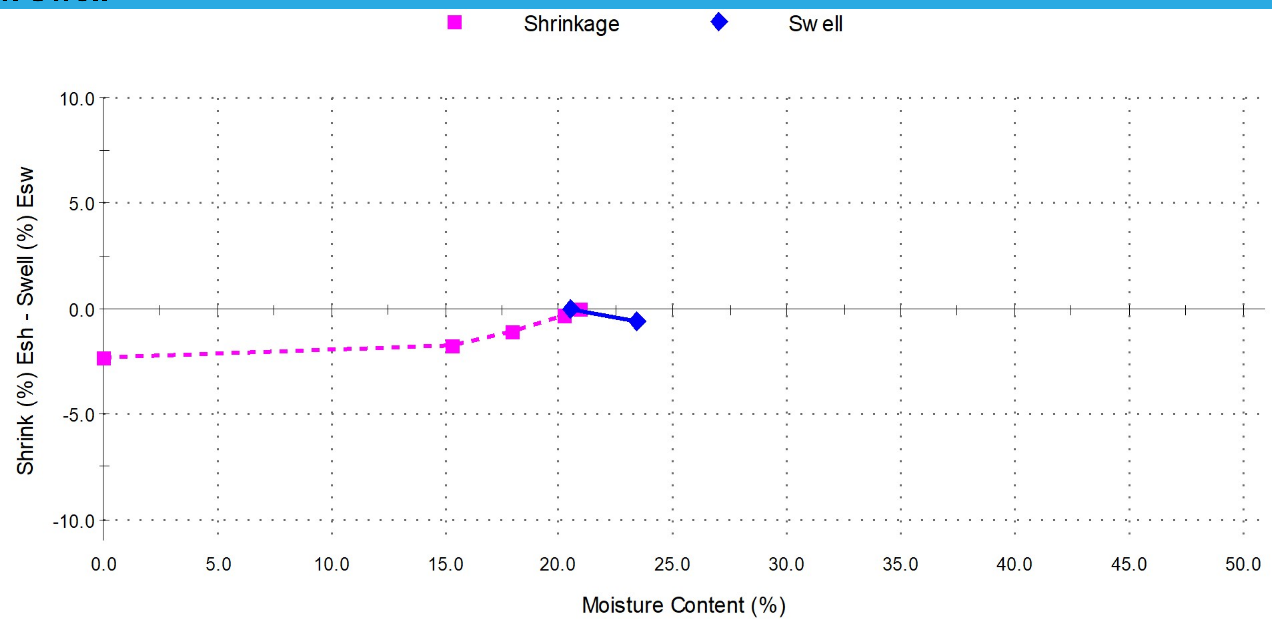
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.6
Moisture Content before (%):	20.5
Moisture Content after (%):	23.4
Est. Unc. Comp. Strength before (kPa):	>600
Est. Unc. Comp. Strength after (kPa):	>600

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	2.3
Shrinkage Moisture Content (%):	21.0
Est. inert material (%):	2%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Moderate

Shrink Swell



Shrink Swell Index - Iss (%): 1.3

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Report No: SSI:NEW19W-1502--S11
Issue No: 1

Shrink Swell Index Report

Client:	Mavid Group 81 Mustang Drive Rutherford NSW 2320
Principal:	
Project No.:	NEW19P-0074
Project Name:	Proposed Mixed Use Development

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NATA Accredited Laboratory Number: 18686
Date of Issue: 16/05/2019

Sample Details

Sample ID:	NEW19W-1502--S11	**Client Sample ID:**	
Test Request No.:		**Sampling Method:**	Sampled by Engineering Department
Material:	Clay	**Date Sampled:**	6/05/2019
Source:	On Site	**Date Submitted:**	7/05/2019
Specification:	No Specification		
Project Location:	795 Medowie Road, Medowie		
Sample Location:	TP14 - (0.7 - 1.0m)		
Borehole Number:	TP14		
Borehole Depth (m):	0.70 - 1.00		

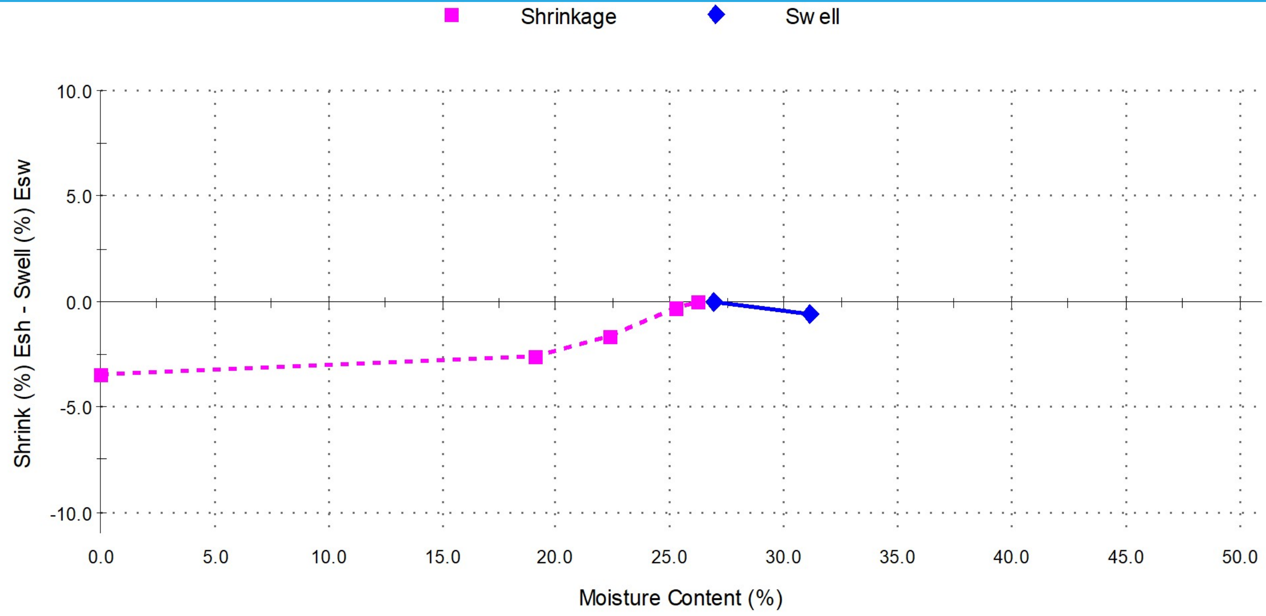
Swell Test — AS 1289.7.1.1

Swell on Saturation (%):	-0.6
Moisture Content before (%):	26.9
Moisture Content after (%):	31.2
Est. Unc. Comp. Strength before (kPa):	>600
Est. Unc. Comp. Strength after (kPa):	500

Shrink Test — AS 1289.7.1.1

Shrink on drying (%):	3.5
Shrinkage Moisture Content (%):	26.2
Est. inert material (%):	2%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Major

Shrink Swell



Shrink Swell Index - Iss (%): 2.0

Comments

APPENDIX C:

Selected Excerpts from AGS 2007 - Practice Note Guidelines for Landslide Risk Management

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	**Notional Boundary**					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	$5x10^{-3}$	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-4}$	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-5}$	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-6}$	100,000 years	200,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	**Notional Boundary**			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	**1: CATASTROPHIC 200%**	**2: MAJOR 60%**	**3: MEDIUM 20%**	**4: MINOR 5%**	**5: INSIGNIFICANT 0.5%**
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or **L** (5)
B - LIKELY	10^{-2}	VH	VH	H	M	**L**
C - POSSIBLE	10^{-3}	VH	H	M	M	**VL**
D - UNLIKELY	10^{-4}	H	M	**L**	**L**	**VL**
E - RARE	10^{-5}	M	**L**	**L**	**VL**	**VL**
F - BARELY CREDIBLE	10^{-6}	**L**	**VL**	**VL**	**VL**	**VL**

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.

(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

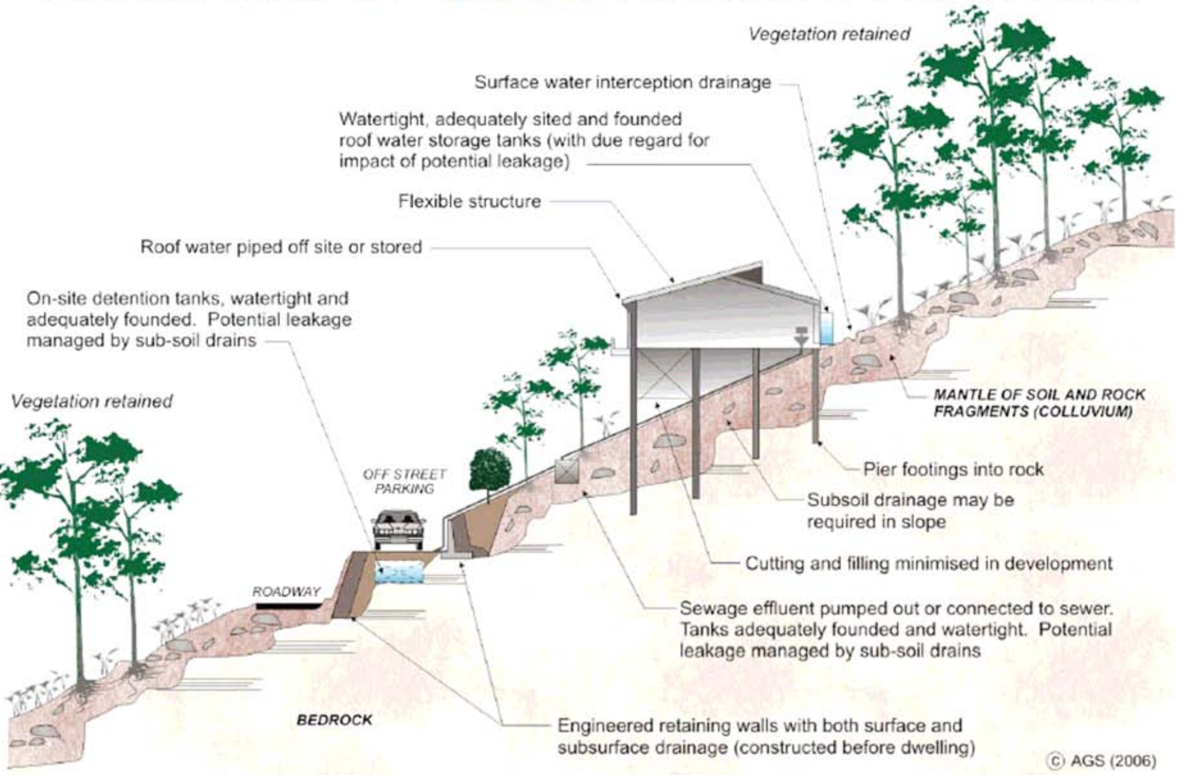
Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

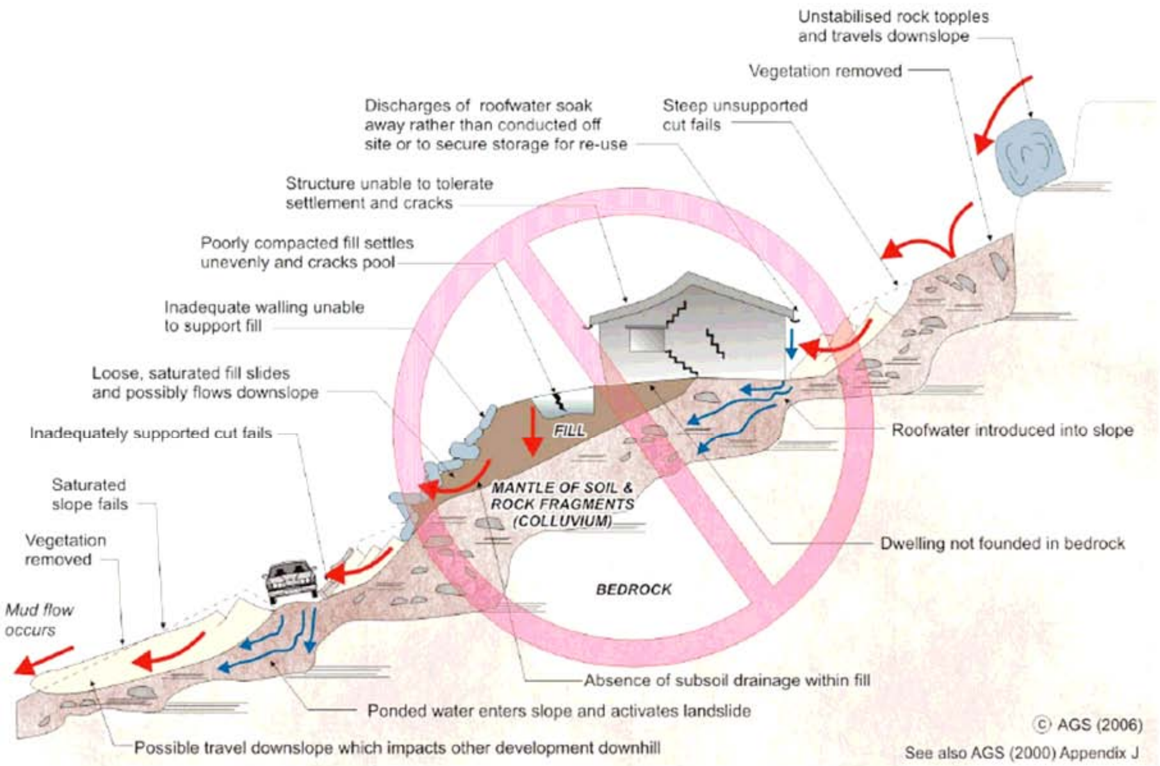
APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
DESIGN AND CONSTRUCTION		
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminatory bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto property below. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill.
ROCK OUTCROPS & BOULDERS	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within rock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE		
SURFACE	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide general falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge roof runoff into absorption trenches.
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.
DRAWINGS AND SITE VISITS DURING CONSTRUCTION		
DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	
INSPECTION AND MAINTENANCE BY OWNER		
OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	

EXAMPLES OF GOOD HILLSIDE PRACTICE



EXAMPLES OF POOR HILLSIDE PRACTICE



APPENDIX D:

CSIRO Sheet BTF 18

Foundation Maintenance and Footing Performance: A Homeowner's Guide

Foundation Maintenance and Footing Performance: A Homeowner's Guide

BTF 18 replaces Information Sheet 10/91

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

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

Soil Types

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

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

Causes of Movement

Settlement due to construction

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

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

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

Erosion

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

Saturation

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

Seasonal swelling and shrinkage of soil

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

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

Shear failure

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

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

GENERAL DEFINITIONS OF SITE CLASSES

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

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

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

Unevenness of Movement

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

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

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

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

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

Effects of Uneven Soil Movement on Structures

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

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

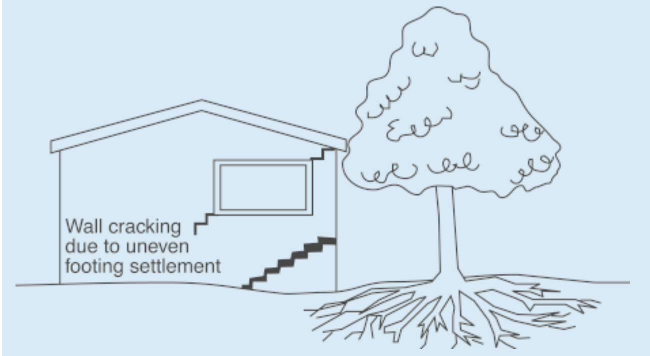
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

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

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

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

Trees can cause shrinkage and damage



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

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

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

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

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

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

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

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

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

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

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

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

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

Water Service and Drainage

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

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

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

Seriousness of Cracking

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

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

Prevention/Cure

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

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

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

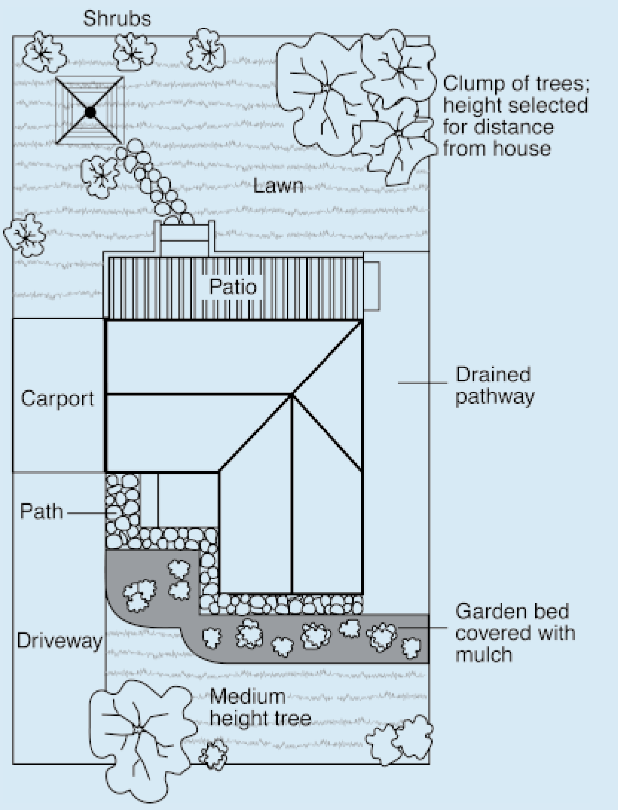
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

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

Gardens for a reactive site



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

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

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

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

Condensation

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

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

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

The garden

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

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

Existing trees

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

Information on trees, plants and shrubs

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

Excavation

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

Remediation

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

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

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

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