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Integrated Practical Solutions

Report on
Geotechnical Investigation

Lot Classification (Lots 601 – 607)
Stage 6 McCauleys Beach Estate, Bulli

Prepared for
Stockland Developments Pty Ltd

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Douglas Partners
Geotechnics / Environment / Groundwater

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		7/12/11
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Report on Geotechnical Investigation
Lot Classification (Lots 601 – 607)
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1. Introduction

This report presents the results of a geotechnical investigation carried out for Lots 601 – 607 in Stage 6 of the McCauleys Beach Estate at Bulli. The work was commissioned by Cardno (NSW/ACT) Pty Ltd, consulting engineers and project managers acting on behalf of the project developers, Stockland Developments Pty Ltd.

The Stage 6 development comprises the creation of six residential building lots (Lots 601 to 606), one super lot (Lot 607) and the construction of associated roadways. The purpose of the investigation described within this report was to broadly assess the subsurface conditions underlying Stage 6 and to provide a classification of each lot in accordance with Australian Standard AS 2870 – 2011 *'Residential Slabs and Footings'* (Ref 1).

The investigation comprised a review of earthworks results associated with lot filling and the excavation of test pits followed by laboratory testing of selected samples, engineering analysis and reporting. Details of the work undertaken and the results obtained are given within this report, together with comments relating to design and construction practice.

Site plans showing road alignments and the subdivision layout were provided by the client for the investigation.

2. Site Description

Stage 6 of the McCauleys Beach Estate comprises an irregular shaped area of some 1.5 ha with maximum north-south and east-west dimensions of 105 m and 230 m respectively. It is bounded to the north by grassed sporting fields, to the south by Hewitts Creek, to the east by existing low density residential development, and to the west by the existing Stage 1A development. Following completion of bulk filling, site levels fall in the southerly direction (ie towards Hewitts Creek) at grades of 1 in 3 to 1 in 70 (but generally 1 in 20 to 1 in 70) with an overall difference in level estimated to be about 6 m from the highest to the lowest parts of the site. Immediately to the south of the site, gradients steepen to 1 in 3 to 1 in 5 at a batter leading to Hewitts Creek, the invert of which is some 5 m to 8 m lower than the adjoining allotments (Lots 606 and 607).

At the time of the investigation, removal, culling and recompaction of the previous uncontrolled filling (where geotechnically feasible) had been completed together with the placement and compaction of additional filling to achieve design levels. Due to the depth of existing filling and the need to provide support to the northern and eastern boundaries during construction, complete removal was not feasible (refer Drawing 1). Road construction and service installation was still in progress at the time of reporting.

3. Regional Geology

Reference to the 1:50 000 Wollongong Geological Series Sheet (Ref 2) indicates that the site is close to a boundary between Quarternary alluvium (sand, silt and clay) and rocks belonging to the Illawarra Coal Measures of Permian age. This formation typically comprises sandstone, siltstone, shale, laminite and coal which weather to form clays of high plasticity.

The results of the field investigation were consistent with the geological mapping with weathered sandstone encountered in the four test pits that penetrated the filling.

4. Field Work

4.1 Methods

The field work comprised the excavation of the sixteen test pits (Pits 1 – 16) to depths of 2.2 – 2.7 m with a Komatsu PC228 USLC excavator fitted with a 500 mm wide bucket. The pits were logged on site by a geotechnical engineer who collected disturbed and 'undisturbed' samples (in 50 mm diameter thin-walled tubes) to assist in strata identification and for possible laboratory testing. Dynamic cone penetrometer tests (DCP, AS1289 6.3.2) were carried out adjacent to all test pit locations to assess the consistency of the upper 1.2 m of the subsurface profile.

The approximate locations of the test pits, which were marked onsite by Menai Civil Contractors Pty Ltd (MC), are shown on Drawing 1 (Appendix B). The surface levels (to Australian Height Datum, AHD) and MGA coordinates were also provided by MC.

4.2 Results

The test pit logs are included in Appendix C, which should be read in conjunction with the accompanying notes defining classification method and descriptive terms.

Relatively uniform conditions were encountered underlying most of the site with controlled filling comprising clay, sandy clay, clayey gravel and gravelly clay to the termination depth of 2.5 – 2.7 m in Pit 1, Pits 3 – 8, Pit 11 and Pits 14 – 16.

Slightly different conditions were encountered in Pit 9 where controlled filling was underlain by very stiff to hard silty clay, then extremely low to very low strength sandstone was intersected at 0.7 m depth and continued to the termination depth of 2.5 m. In Pits 10, 12 and 13, the controlled filling was directly underlain by weathered sandstone at depths of 0.3 – 1.7 m and continued to the termination depths of 2.5 m. Pit 12 was terminated at refusal of the excavator bucket on low to medium strength sandstone at a depth of 2.2 m.

Different conditions were also encountered in Pit 2 comprising uncontrolled filling that was left in place to provide support to the northern boundary to the termination depth of 2.5 m. It is noted that the controlled filling encountered in Pit 2 is also underlain by remnant uncontrolled filling that formed a batter to provide support to the northern boundary during subdivision construction.

It is noted that all test pits were excavated prior to the placement of topsoil.

No free groundwater was observed in the pits during excavation for the short time they were left open. It is noted however, that the pits were immediately backfilled following excavation, which precluded long term monitoring of groundwater levels.

5. Laboratory Testing

Selected samples from the test pits were tested in the laboratory for measurement of the field moisture content and Shrink–swell Index (I_{ss}). The detailed laboratory test report sheets are given in Appendix D, with the results summarised in Table 1.

Table 1: Results of Laboratory Testing

Pit No.	Depth (m)	W_F (%)	Iss (%/ΔpF)	Material
1	0.4 – 0.8	21.6	2.5	Filling
5	0.5 – 0.7	35.5	2.1	Filling
12	0.5 – 0.8	25.3	2.0	Filling
14	0.5 – 0.8	12.6	1.6	Filling

Where W_F = Field moisture content I_{ss} = Shrink-swell Index

The results indicate that the soils tested are of variable plasticity and would be expected to be susceptible to shrinkage and swelling movements with changes in soil and moisture content.

6. Comments

6.1 General

The following comments are based on the surface and subsurface profiles encountered at the time of the investigation, the results of laboratory testing of selected samples from within the proposed development area and a review of the filling compaction and survey results. It is possible however, that topsoil may be placed subsequent to the investigation and as such variations to the conditions given in the test pits logs must be anticipated.

6.2 Subsurface Conditions

The test pits have indicated that subsurface conditions comprise controlled filling to in excess of 2.5 – 2.7 m in Pits 1, Pits 3 – 8, Pit 11 and Pits 14 – 16. Controlled filling was encountered to depths of 0.3 – 1.9 m in Pits 9, 10, 12 and 13 overlying residual clay (where present) and weathered sandstone bedrock. Pit 2 intersected uncontrolled filling associated with a batter that was left in place to provide support to the northern boundary during subdivision construction. The controlled filling in Pit 11 would also be underlain by remnant uncontrolled filling (refer Drawing 1).

It is noted that the field work was undertaken prior to the placement of topsoil. It is also understood that topsoil depths could be of the order of 200 mm at the completion of subdivision construction.

6.3 Filling Placed on Allotments

Based on the field observations made by a geotechnical engineer during the test pit excavations and the soil technicians during fill placement, the controlled filling profile comprises compacted clay, silty clay, sandy clay and gravelly clay (with some crushed brick pieces) to depths of up to 8.5 m. The controlled filling was placed under Level 1 conditions as defined in AS 3798 – 2007 (Ref 3) with the inspection and testing services provided by Douglas Partners Pty Ltd.

The density test results indicate ratios of at least 98% relative to the standard compaction with placement moisture contents within 2% of standard optimum. Test result summary sheets and test location plans are given in Appendix E.

It is noted that due to the depth of existing uncontrolled filling and the requirement to provide support to the northern and eastern boundaries during construction, complete removal of the filling was not feasible. As such, remnant uncontrolled filling is present within parts of the lots (refer Drawing 1 in Appendix B). Additional filling required to achieve design levels was placed under controlled conditions as discussed above.

Based on the survey information provided by C Robson and Associates Pty Ltd (CRA) and the results of the field investigation, the approximate depth of controlled filling placed on the lots is summarised in Table 2. Reference should be made to the work-as-executed plans prepared by CRA for the surveyed extent and depth of filling placed on the lots.

Table 2: Approximate Depth of Controlled Filling[(1)]

Lot No.	Depth of Controlled Filling (m)	Lot No.	Depth of Controlled Filling (m)
601	1.5 – 2.5	605	2.0 – 5.0
602	1.0 – 2.0	606	3.0 – 4.0
603	0.5 – 1.5	607	0.5 – 8.5
604	1.0 – 2.0		

Note[(1)]: Does not include depths of remnant uncontrolled filling left in place to provide boundary support following bulk excavation.

6.4 Lot Classification

6.4.1 Class M and H Lots

Earthworks undertaken during subdivision construction comprised removal of all uncontrolled filling (where feasible) that was present on the site prior to the commencement of construction, culling of oversize and other deleterious fractions and re-compaction of approved soils under geotechnical control. All earthworks on the lots were undertaken in the full-time presence of the geotechnical consultant.

On the understanding that up to 200 mm of topsoil will be placed on the lots and based on the results of the field investigation and laboratory testing, characteristic surface movements (y_s) of up to 50 mm are predicted for Lots 601 – 605 and Lot 607. Accordingly, lot classifications in accordance with AS2870-2011 Residential Slabs and Footings (Ref 1) are as follows:

Class M* (moderately reactive / filled lots):	Lots 602, 603
Class H1* (highly reactive / filled lots):	Lots 601, 604, 605 and 607

It is noted that the above classifications are based on the site conditions at the time of the investigation and are independent of site preparation works that may be undertaken as part of dwelling construction. Furthermore, the classification given above is only applicable to areas underlain by controlled filling in Lot 601 – 605 and 607 (refer Drawing 1 in Appendix B).

Due to the size of Lot 607 and the likelihood that structures outside the scope of AS2870 will be proposed, the classification for Lot 607 must be considered as being preliminary only. Project-specific geotechnical investigations (possibly including borehole drilling and coring of the underlying rock) will need to be undertaken once site development details become known.

6.4.2 Class P Lot

Due to presence of deep uncontrolled filling (ie greater than 0.4 m depth) overlying soft to firm clays and the topographical location, Lot 606 is classified as Class P in accordance with the requirements of AS2870-2011 Residential Slabs and Footings (Ref 1).

The principal requirements for a Class P Lot is for structural design to be undertaken by a suitably qualified engineer using engineering principals that take into account the subsurface conditions following completion of project specific geotechnical investigation. Notwithstanding the P classification, reactivity movements are expected to be in the Class H1 (highly reactive) range.

6.5 Site Preparation

Subject to site-specific design requirements, site preparation for the construction of residential structures will most likely include the removal of all vegetation, organic topsoils and other deleterious materials from the building area. Particular note is made of the likelihood that topsoils may have been spread subsequent to the excavation of the test pits.

Where a level building platform is to be constructed on Lots 601 – 605 and Lot 607 by cut and fill methods, filling should be placed under controlled conditions with reference made to AS 3798 – 2007 (Ref 3). Filling should be placed in near horizontal layers of maximum 250 mm loose thickness and compacted to at least 98% dry density ratio relative to standard compaction. Placement moisture contents should be within 2% standard optimum values. Filling should not contain vegetation or other organic matter.

The principal feature in regards to earthworks on Lot 606 is the presence of deep uncontrolled filling overlying soft clays, and the topographical location of the site at the crest of an 8 m high batter slope. In this regard, excavation within the near-level section of the lot should be limited to less than 1 m with excess spoil removed from site. No excavation is to be undertaken within the existing fill batter. No additional filling is to be placed on Lot 606. Furthermore, dwelling design will need to incorporate suspended slab or pier-and-beam construction to transfer loads below the zone of influence of the batter, uncontrolled filling and underlying weak clays.

6.6 Footings

It is suggested that footing systems be designed and constructed in accordance with AS 2870 – 2011 (Ref 1) for the appropriate classification (refer Section 6.4) and the additional requirements given in this report.

Where footing systems are proposed adjacent to services or located through areas of uncontrolled fill (for example, following construction of a level building platform placed without engineering control or within the zone of existing uncontrolled filling shown in Drawing 1), local deepening of the footings or alternatively the inclusion of piers will most likely be required. Founding levels are to be within the underlying controlled filling, stiff clays or weathered rock, and below the zone of influence of service trenches and any retaining walls. The zone of influence is defined as a line extending from the base of the trench or retaining wall to the ground surface inclined at 45^{o} (ie: 1 horizontal: 1 vertical).

Where partial rock foundations result following construction of cut to fill platforms (which could occur on Lots 601 – 604 and south eastern section of Lot 607), reference must be made to AS 2870 – 2011 (Ref 1) regarding the provision of articulation within the structure and the construction of a foundation system that provides uniform (weathered rock) bearing. The main advantage of a footing-to-rock system would be that settlements would be negligible. As a guide, footings foundation on low strength rock could be proportioned for a maximum allowable base bearing pressure of 500 kPa. Raft stiffness should be designed in accordance with the designated lot classification.

Footings for residential structures proposed for Lot 606 will need to allow for uniform bearing in the underlying stiff clays. Suitable footing systems could comprise pre-formed steel screw piles or driven timber piles (provided vibration effects to neighbouring structures are addressed by the piling contractor. In addition, a grillage of deep edge beams and internal stiffening beams should be included to provide overall stiffness to the piled foundation. Articulation will also need to be included within the structural details, with slab design commensurate with the minimum requirements of a Class H1 detail with respect to reactivity.

6.7 Site Maintenance and Drainage

The developed lots should be maintained in accordance with the CSIRO publication *"Foundation Maintenance and Footing Performance: A Homeowners guide',* a copy of which is included in Appendix F. Whilst it must be accepted that some minor cracking in most structures is inevitable on reactive clay sites, the guide described suggested site maintenance practices aimed at minimising foundation movements and at keeping cracking within acceptable limits.

Surface drainage should be installed and maintained at the site. All collected stormwater, groundwater and rood runoff should be discharged into the stormwater disposal system.

7. References

1. Australian Standard AS 2870 – 2011 *Residential Slabs and Footings.*
2. Geology of Wollongong 1:50 000 Geological Series Sheet No 9029 – 11, Dept of Mines, (1977).
3. Australian Standard AS 3798 – 2007 *Guidelines on Earthworks for Commercial and Residential Developments.*

8. Limitations

Douglas Partners (DP) has prepared this report for a project at Stage 6 McCauleys Beach Bulli in accordance with DP's proposal 4 May 2010 and direction to proceed from Mr Kelly MacDonald of Cardno (NSW/ACT) Pty Ltd during a project meeting on 21 September 2011. The report is provided for the exclusive use of Stockland Developments Pty Ltd for this project only and for the purpose(s) described in the report. It should not be used for any other projects or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/ or their agents.

The results provided in the report are indicative of the sub-surface conditions only at the specific sampling or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological conditions and also as a result of anthropogenic influences. Such changed may occur after DP's field testing has been completed.

DP's advice is based on the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be limited by undetected variations in ground conditions between sampling locations. The advice may also be limited by budget constraints imposed by other or by site accessibility.

This report must be read in conjunction with all of the attached notes and should be kept in it's entirety without separation of individual paged or sections. DP cannot be held responsible for interpretations or conclusion made by others.

This report, or section from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

Douglas Partners Pty Ltd

Appendix A

About this Report

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Soil Descriptions

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Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

Rock Strength

Rock strength is defined by the Point Load Strength Index ($Is_{(50)}$) and refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects. The test procedure is described by Australian Standard 4133.4.1 - 1993. The terms used to describe rock strength are as follows:

Term	Abbreviation	Point Load Index $Is_{(50)}$ MPa	Approx Unconfined Compressive Strength MPa*
Extremely low	EL	<0.03	<0.6
Very low	VL	0.03 - 0.1	0.6 - 2
Low	L	0.1 - 0.3	2 - 6
Medium	M	0.3 - 1.0	6 - 20
High	H	1 - 3	20 - 60
Very high	VH	3 - 10	60 - 200
Extremely high	EH	>10	>200

* Assumes a ratio of 20:1 for UCS to $Is_{(50)}$

Degree of Weathering

The degree of weathering of rock is classified as follows:

Term	Abbreviation	Description
Extremely weathered	EW	Rock substance has soil properties, i.e. it can be remoulded and classified as a soil but the texture of the original rock is still evident.
Highly weathered	HW	Limonite staining or bleaching affects whole of rock substance and other signs of decomposition are evident. Porosity and strength may be altered as a result of iron leaching or deposition. Colour and strength of original fresh rock is not recognisable
Moderately weathered	MW	Staining and discolouration of rock substance has taken place
Slightly weathered	SW	Rock substance is slightly discoloured but shows little or no change of strength from fresh rock
Fresh stained	Fs	Rock substance unaffected by weathering but staining visible along defects
Fresh	Fr	No signs of decomposition or staining

Degree of Fracturing

The following classification applies to the spacing of natural fractures in diamond drill cores. It includes bedding plane partings, joints and other defects, but excludes drilling breaks.

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with some fragments
Fractured	Core lengths of 40-200 mm with some shorter and longer sections
Slightly Fractured	Core lengths of 200-1000 mm with some shorter and loner sections
Unbroken	Core lengths mostly > 1000 mm

Rock Descriptions

Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$\text{RQD \%} = \frac{\text{cumulative length of 'sound' core sections} \geq \text{100 mm long}}{\text{total drilled length of section being assessed}}$$

where 'sound' rock is assessed to be rock of low strength or better. The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e. drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

Stratification Spacing

For sedimentary rocks the following terms may be used to describe the spacing of bedding partings:

Term	Separation of Stratification Planes
Thinly laminated	< 6 mm
Laminated	6 mm to 20 mm
Very thinly bedded	20 mm to 60 mm
Thinly bedded	60 mm to 0.2 m
Medium bedded	0.2 m to 0.6 m
Thickly bedded	0.6 m to 2 m
Very thickly bedded	> 2 m

Symbols & Abbreviations

Douglas Partners

Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core Drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General


Asphalt


Road base


Concrete


Filling

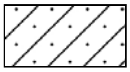
Soils


Topsoil

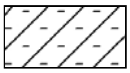

Peat


Clay

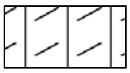

Silty clay

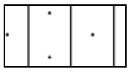

Sandy clay

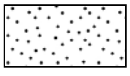

Gravelly clay

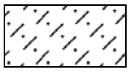

Shaly clay

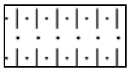

Silt


Clayey silt


Sandy silt

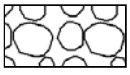

Sand

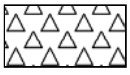

Clayey sand


Silty sand


Gravel


Sandy gravel


Cobbles, boulders

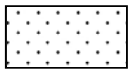

Talus

Sedimentary Rocks

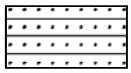

Boulder conglomerate

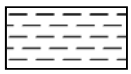

Conglomerate


Conglomeratic sandstone

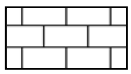

Sandstone


Siltstone


Laminite

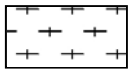

Mudstone, claystone, shale

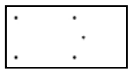

Coal


Limestone

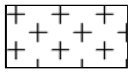
Metamorphic Rocks

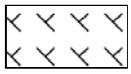

Slate, phyllite, schist

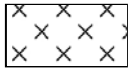

Gneiss

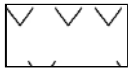

Quartzite

Igneous Rocks


Granite


Dolerite, basalt, andesite

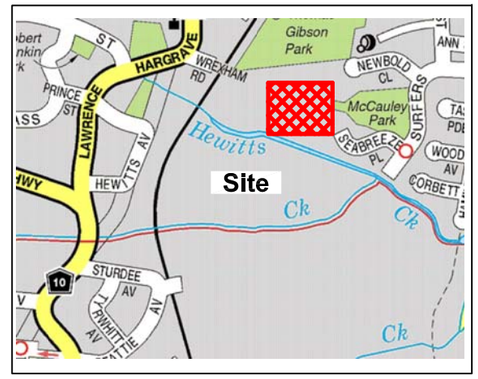

Dacite, epidote


Tuff, breccia


Porphyry

Appendix B

Drawing 1



Locality Plan

NOTE: Base drawing from Cardno (NSW/ACT) Pty Ltd (Drawing 9702, dated 13 July 2010)

0 10 20 30 40 50 75 100m

1:1000 @ A3

LEGEND

- Test Pit Location
- Stage 6 boundary
- Approximate extent of remnant uncontrolled filling
- Approximate extent of controlled filling

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Stockland Developments Pty Ltd		TITLE: **Location of Field Tests**	PROJECT No: 48694.26
OFFICE: Wollongong	DRAWN BY: PSCH	**Lot Classification**	DRAWING No: 1
SCALE: As shown	DATE: 29.11.2011	**Stage 6 McCauleys Beach Estate, BULLI**	REVISION: A

Appendix C

Test Pit Logs (Pits 1 – 16)

TEST PIT LOG

CLIENT: Stockland Developments Pty Ltd
PROJECT: Lot Classification
LOCATION: Stage 6 McCauleys Beach Estate, Bulli

SURFACE LEVEL: 14.2 AHD
EASTING: 308443.1
NORTHING: 6200340.5
DIP/AZIMUTH: 90°/--

PIT No: 1
PROJECT No: 48694.26
DATE: 23/9/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
14		FILLING (controlled) - grey brown, gravelly (brick pieces, coalwash, siltstone) clay with some silt and sand, humid to damp			0.4				
	0.5	FILLING (controlled) - dark grey, silty sandy gravel, (coalwash, siltstone, brick pieces) with trace cobbles (bricks) and clay in pockets, humid		U	0.75		PP = 380->600		
	1								1
13				D	1.1				
					1.2				
		- with some cobble to boulder sized pockets of brown clay below 1.5m							
				D	1.6		PP = 480-580		
					1.7				
	2								2
12		- becoming slightly clayey silty gravel below 2.0m		D	2.0				
					2.1				
		- becoming damp below 2.4m		D	2.4				
	2.5	Pit discontinued at 2.5m Limit of Investigation			2.5				

RIG: Komatsu PC228 USLC - 500mm bucket

LOGGED: RLG

SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Stockland Developments Pty Ltd
PROJECT: Lot Classification
LOCATION: Stage 6 McCauleys Beach Estate, Bulli

SURFACE LEVEL: 13.4 AHD
EASTING: 308488.8
NORTHING: 5200332.3
DIP/AZIMUTH: 90°/--

PIT No: 2
PROJECT No: 48694.26
DATE: 23/9/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
13		FILLING (uncontrolled) - grey brown, slightly sandy clay with some gravel (bricks pieces, sandstone, siltstone), silt, and trace cobbles (brick, sandstone), humid to damp		D	0.5		PP = 200-350		
					0.6				
	0.8	FILLING (uncontrolled) - red brown mottled orange brown, clay with some gravel (sandstone, siltstone, brick pieces), silt, trace sand and cobbles (brick, sandstone), humid to damp		D	1.0		PP = 340-410		
	1				1.1				1
	1.3	FILLING (uncontrolled) - grey mottled grey brown silty gravel (sandstone, siltstone, coalwash, brick pieces) with some sand, clay and cobbles (sandstone, brick) humid to damp		D	1.4				
12					1.5				
	2	- becoming slightly clayey silty gravel below 2.0m		D	2.0				2
					2.1				
11		- becoming silty clay with some gravel below 2.4m		D	2.4		PP = 200-300		
	2.5	Pit discontinued at 2.5m Limit of Investigation			2.5				

RIG: Komatsu PC228 USLC - 500mm bucket
LOGGED: RLG
SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Uncontrolled filling left in place to provide boundary support during subdivision construction

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Stockland Developments Pty Ltd
PROJECT: Lot Classification
LOCATION: Stage 6 McCauleys Beach Estate, Bulli

SURFACE LEVEL: 13.4 AHD
EASTING: 308488.8
NORTHING: 6200333.3
DIP/AZIMUTH: 90°/--

PIT No: 3
PROJECT No: 48694.26
DATE: 23/9/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
13	0.2	FILLING (controlled) - grey brown slightly gravelly (siltstone, sandstone) clay, with some silt and sand, humid to damp							
		FILLING (controlled) - red brown, clay with trace silt, sand and gravel, humid to damp		D	0.6		PP = 300-340		
	0.7	FILLING (controlled) - grey brown, slightly gravelly (siltstone, sandstone) clay with some silt, sand and trace cobbles (sandstone, siltstone, brick), humid to damp			0.7				
	1			D	1.0		PP = 300-380		1
					1.1				
12		- with some grey silty clay in pockets below 1.5m		D	1.5		PP = 170-250		
					1.6				
	2			D	2.0		PP = 200-230		2
					2.1				
	2.3	FILLING (controlled) - grey brown clay with some gravel (sandstone, siltstone, brick pieces, coalwash), sand and silt, damp		D	2.4		PP = 160-190		
11	2.5	Pit discontinued at 2.5m Limit of Investigation			2.5				

RIG: Komatsu PC228 USLC - 500mm bucket

LOGGED: RLG

SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Stockland Developments Pty Ltd
PROJECT: Lot Classification
LOCATION: Stage 6 McCauleys Beach Estate, Bulli

SURFACE LEVEL: 13.3 AHD
EASTING: 308523.8
NORTHING: 62003158
DIP/AZIMUTH: 90°/--

PIT No: 4
PROJECT No: 48694.26
DATE: 23/9/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
13	0	FILLING (controlled) - orange brown and red brown, slightly sandy clay with some silt, gravel (sandstone, siltstone, brick pieces, coalwash), trace cobbles and boulders (sandstone, brick), humid to damp		D	0.6		PP = 200-270		
					0.7				
12	1	- becoming grey brown with some grey below 1.0m		D	1.0		PP = 140-230		1
					1.1				
				D	1.5		PP = 420- 520		
					1.6				
11	2	- becoming grey brown, orange brown with some grey in pockets below 2.0m		D	2.0		PP = 230-410		2
					2.1				
		- becoming grey brown below 2.4m		D	2.4		PP = 300-350		
	2.5	Pit discontinued at 2.5m Limit of Investigation			2.5				

RIG: Komatsu PC228 USLC - 500mm bucket
LOGGED: RLG
SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Stockland Developments Pty Ltd
PROJECT: Lot Classification
LOCATION: Stage 6 McCauleys Beach Estate, Bulli

SURFACE LEVEL: 12.4 AHD
EASTING: 308536.5
NORTHING: 6200294.6
DIP/AZIMUTH: 90°/--

PIT No: 5
PROJECT No: 48694.26
DATE: 23/9/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
12	0.5	FILLING (controlled) - brown mottled red brown, clay with some silt, sand, gravel (sandstone, brick, pieces, siltstone), humid to damp							
		FILLING (controlled) - dark grey, silty gravelly (coalwash, brick pieces, sandstone, siltstone) clay with some sand		U	0.5 0.65		PP = 250-310		
11	1.0	FILLING (controlled) - grey brown with some light grey mottled red brown in pockets, clay with some silt, sand, gravel (sandstone, siltstone, coalwash, brick pieces), trace cobbles (sandstone, brick, concrete pieces) humid to damp		D	1.0 1.1		PP = 300-490		1
		- with a layer of grey mottled orange and red brown slightly gravelly (siltstone, sandstone) slightly silty clay between 1.5 to 1.8m		D	1.5 1.6		PP = 350-550		
10	2.0	- becoming slightly sandy clay below 2.0m		D	2.0 2.1		PP = 340-520		2
				D	2.4		PP = 250-480		
	2.5	Pit discontinued at 2.5m Limit of Investigation			2.5				

RIG: Komatsu PC228 USLC - 500mm bucket

LOGGED: RLG

SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Stockland Developments Pty Ltd
PROJECT: Lot Classification
LOCATION: Stage 6 McCauleys Beach Estate, Bulli

SURFACE LEVEL: 12.7 AHD
EASTING: 308571.8
NORTHING: 6206293.5
DIP/AZIMUTH: 90°/--

PIT No: 6
PROJECT No: 48694.26
DATE: 23/9/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
12		FILLING (controlled) - grey brown, slightly silty gravelly (coalwash, siltstone, sandstone, brick pieces) clay with some sand and trace cobbles (siltstone, sandstone, brick) humid to damp							
				D	0.5		PP = 200- 340		
					0.6				
	1	- becoming slightly silty, slightly sandy clay with some gravel below 1.0m		D	1.0		PP = 230-290		1
					1.1				
11		- becoming silty sandy clay with some gravel below 1.5m		D	1.5		PP = 410-490		
					1.6				
	2	- with some pockets of orange brown grey and grey brown, gravelly silty clay below 2.0m		D	2.0		PP = 270-300		2
					2.1				
		- becoming grey brown slightly sandy clay with some silt, gravel and trace cobbles, damp below 2.4m		D	2.4		PP = 230-260		
	2.5	Pit discontinued at 2.5m Limit of Investigation			2.5				
10									

RIG: Komatsu PC228 USLC - 500mm bucket

LOGGED: RLG

SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Stockland Developments Pty Ltd
PROJECT: Lot Classification
LOCATION: Stage 6 McCauleys Beach Estate, Bulli

SURFACE LEVEL: 12.4 AHD
EASTING: 308571.9
NORTHING: 6200278.7
DIP/AZIMUTH: 90°/--

PIT No: 7
PROJECT No: 48694.26
DATE: 23/9/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
12	0.0	FILLING (controlled) - light grey mottled red brown and grey brown sandy clay with some silt and gravel (sandstone) humid		D	0.5		PP = 420-590		
	0.6	FILLING (controlled) - dark grey brown, clay with some gravel (sandstone, brick pieces, coalwash, siltstone) silt and trace cobbles (brick, sandstone), damp		D	0.6				
	1			D	1.0		PP = 140-420		1
11				D	1.1				
		- becoming grey brown with some cream pockets, slightly gravelly clay, humid to damp below 1.5m		D	1.5		PP = 280-300		
				D	1.6				
	2			D	2.0		PP = 300-520		2
				D	2.1				
10				D	2.4		PP = 380-580		
	2.5	Pit discontinued at 2.5m Limit of Investigation			2.5				

RIG: Komatsu PC228 USLC - 500mm bucket
LOGGED: RLG
SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Stockland Developments Pty Ltd
PROJECT: Lot Classification
LOCATION: Stage 6 McCauleys Beach Estate, Bulli

SURFACE LEVEL: 14.6 AHD
EASTING: 308571.8
NORTHING: 6200304.5
DIP/AZIMUTH: 90°/--

PIT No: 8
PROJECT No: 48694.26
DATE: 23/9/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
14	0	FILLING (controlled) - dark grey brown, clay with some silt, sand, gravel (sandstone, siltstone, coalwash, brick pieces), trace cobbles (brick, sandstone), humid to damp							
				U	0.5				
					0.6		PP = 300-400		
	1			D	1.0		PP = 150-290		1
					1.1				
13		- becoming slightly gravelly below 1.5m		D	1.5		PP = 230-300		
					1.6				
	2			D	2.0		PP = 260-400		2
					2.1				
				D	2.4		PP = 170-280		
12	2.5	Pit discontinued at 2.5m Limit of Investigation			2.5				

RIG: Komatsu PC228 USLC - 500mm bucket
LOGGED: RLG
SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Stockland Developments Pty Ltd
PROJECT: Lot Classification
LOCATION: Stage 6 McCauleys Beach Estate, Bulli

SURFACE LEVEL: 12.3 AHD
EASTING: 308601.1
NORTHING: 6200256
DIP/AZIMUTH: 90°/--

PIT No: 9
PROJECT No: 48694.26
DATE: 23/9/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
12	0.3	FILLING (controlled) - grey brown slightly silty, slightly sandy clay with some gravel, humid							
		SILTY CLAY - very stiff to hard, orange brown, red brown mottled grey, silty clay with some gravel (sandstone), humid		D	0.5		PP = >600		
				D	0.6				
	0.9	SANDSTONE - extremely low to very low strength, extremely weathered to highly weathered, grey and red brown sandstone							
11	1	- becoming grey mottled red brown below 1.0m		D	1.0				1
				D	1.1				
		- extremerly low to low, extremely weathered to highly weathered below 1.5m		D	1.5		PP = >600		
				D	1.6				
	2			D	2.0				2
				D	2.1				
10				D	2.4				
	2.5	Pit discontinued at 2.5m Limit of Investigation			2.5				

RIG: Komatsu PC228 USLC - 500mm bucket

LOGGED: RLG

SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Stockland Developments Pty Ltd
PROJECT: Lot Classification
LOCATION: Stage 6 McCauleys Beach Estate, Bulli

SURFACE LEVEL: 12.8 AHD
EASTING: 308607.7
NORTHING: 6200256
DIP/AZIMUTH: 90°/--

PIT No: 10
PROJECT No: 48694.26
DATE: 23/9/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
12	0	FILLING (controlled) - grey brown, slightly silty, slightly sandy clay with some gravel, humid							
	0.3	SANDSTONE - extremely low to low strength, extremely to highly weathered, light grey and red brown sandstone							
				D	0.5		PP = >600		
					0.6				
11	1			D	1.0				1
					1.1				
		- becoming extremely low to medium strength, extremely to highly weathered below 1.5m		D	1.5				
					1.6				
		- becoming light grey brown below 1.7m							
	2			D	2.0		PP = >600		2
					2.1				
				D	2.4				
10	2.5	Pit discontinued at 2.5m Limit of Investigation			2.5				

RIG: Komatsu PC228 USLC - 500mm bucket

LOGGED: RLG

SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Stockland Developments Pty Ltd
PROJECT: Lot Classification
LOCATION: Stage 6 McCauleys Beach Estate, Bulli

SURFACE LEVEL: 16.3 AHD
EASTING: 308497.8
NORTHING: 6200314.5
DIP/AZIMUTH: 90°/--

PIT No: 11
PROJECT No: 48694.26
DATE: 23/9/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
16	0	FILLING (controlled) - grey brown slightly sandy clay with some silt and gravel (coalwash, siltstone, sandstone) humid to damp		D	0.5		PP = 200-430		
					0.6				
	1			D	1.0		PP = 170-460		1
15					1.1				
		- becoming slightly sandy slightly gravelly clay below 1.5m		D	1.5		PP = 400-450		
					1.6				
	2			D	2.0		PP = 250-370		2
					2.1				
14	2.3	FILLING (controlled) - red brown mottled cream and orange brown gravelly (sandstone, brick pieces, siltstone) clay with some silt, humid to damp		D	2.4		PP = 320-430		
	2.5	Pit discontinued at 2.5m Limit of Investigation			2.5				

RIG: Komatsu PC228 USLC - 500mm bucket

LOGGED: RLG

SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Controlled filling is underlain by remnant uncontrolled filling left in place to provide boundary support during subdivision construction

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Stockland Developments Pty Ltd
PROJECT: Lot Classification
LOCATION: Stage 6 McCauleys Beach Estate, Bulli

SURFACE LEVEL: 15.1 AHD
EASTING: 308633.8
NORTHING: 6200289.5
DIP/AZIMUTH: 90°/--

PIT No: 12
PROJECT No: 48694.26
DATE: 23/9/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
15		FILLING (controlled) - grey brown, red brown, slightly sandy, slightly gravelly (sandstone, siltstone, brick pieces) clay with some silt and trace cobbles (sandstone), humid							
		- becoming humid to damp below 0.15m		U	0.5				
					0.8		PP = 450-500		
14	1			D	1.0		PP = 230-500		1
					1.1				
				D	1.5		PP = 400-480		
					1.6				
	1.9	SANDSTONE - extremely low to low strength, extremely to highly weathered, red brown and light grey fine grained, sandstone							
13	2	- becoming low to medium strength, highly to moderately weathered below 2.0m		D	2.1				2
	2.2	Pit discontinued at 2.2m Refusal on low to medium strength sandstone			2.2				

Dynamic Penetrometer Test (blows per 150mm): 5 10 15 20

RIG: Komatsu PC228 USLC - 500mm bucket

LOGGED: RLG

SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Stockland Developments Pty Ltd
PROJECT: Lot Classification
LOCATION: Stage 6 McCauleys Beach Estate, Bulli

SURFACE LEVEL: 13.5 AHD
EASTING: 308644.7
NORTHING: 6200259.3
DIP/AZIMUTH: 90°/--

PIT No: 13
PROJECT No: 48694.26
DATE: 23/9/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
13	0.5	FILLING (controlled) - grey brown, silty sandy clay with some gravel (sandstone, siltstone) and trace cobbles (sandstone), humid		D	0.5		PP = 450 - >600		
	0.6				0.6				
	0.75	SANDSTONE - extremely low to low strength, extremely to highly weathered, grey and red brown, fine grained sandstone with trace rootlets							
1	1.0			D	1.0		PP = >600		1
	1.1				1.1				
12	1.5			D	1.5		PP = >600		
	1.6				1.6				
2	2.0			D	2.0		PP = >600		2
	2.1				2.1				
	2.4			D	2.4		PP = >600		
11	2.5	Pit discontinued at 2.5m Limit of Investigation			2.5				

RIG: Komatsu PC228 USLC - 500mm bucket

LOGGED: RLG

SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Stockland Developments Pty Ltd
PROJECT: Lot Classification
LOCATION: Stage 6 McCauleys Beach Estate, Bulli

SURFACE LEVEL: 12.3 AHD
EASTING: 308636.7
NORTHING: 6200229.3
DIP/AZIMUTH: 90°/--

PIT No: 14
PROJECT No: 48694.26
DATE: 23/9/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
12	0	FILLING (controlled) - grey brown slightly gravelly (siltstone, sandstone, brick pieces) clay with some silt and sand, humid to damp							
		- layer of light grey silty gravelly (siltstone) clay between 0.4 and 0.8m		U	0.5				
					0.75		PP = 270-340		
	1	- becoming clay with some gravel, silt, sand and trace cobbles (brick, sandstone) below 1.0m							1
				D	1.2		PP = 200-240		
11					1.3				
		- becoming grey brown, orange brown and cream, slightly sandy, slightly gravelly clay with some silt below 1.6m		D	1.6		PP = 200-520		
					1.7				
	2								2
		- becoming slightly sandy clay with some gravel and sand below 2.1m		D	2.1		PP = 320-370		
10					2.2				
				D	2.6		PP = 550-580		
	2.7	Pit discontinued at 2.7m Limit of Investigation			2.7				

RIG: Komatsu PC228 USLC - 500mm bucket

LOGGED: RLG

SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Stockland Developments Pty Ltd
PROJECT: Lot Classification
LOCATION: Stage 6 McCauleys Beach Estate, Bulli

SURFACE LEVEL: 13.3 AHD
EASTING: 308464.3
NORTHING: 6200319.4
DIP/AZIMUTH: 90°/--

PIT No: 15
PROJECT No: 48694.26
DATE: 14/10/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
13		FILLING (controlled) - brown mottled orange brown, slightly sandy, fine gravelly (siltstone, sandstone, brick pieces) clay with some silt, humid to damp							
	0.4	FILLING (controlled) - grey, fine grained sand, humid							
	0.45	FILLING (controlled) - red brown, clay with trace sand and gravel (siltstone, sandstone) humid to damp		D	0.5		pp = 370 - 400		
					0.6				
	1	- becoming red brown mottled grey below 1.0m		D	1.0		pp > 600		1
					1.1				
	1.2	FILLING (controlled) - grey brown, slightly gravelly (siltstone, sandstone, brick pieces), sandy clay with some silt and trace cobbles (sandstone), humid to damp							
12	1.3	FILLING (controlled) - red brown mottled grey brown and grey, clay with some silt, sand, gravel (sandstone siltstone, crushed brick) and trace cobbles (brick, sandstone), humid to damp		D	1.6		pp = 570 - >600		
					1.7				
	2			D	2.0		pp = 400 - 580		2
					2.1				
11				D	2.6		pp = 130 - 550		
	2.7	- with some pockets of grey brown, silty gravelly, (siltstone, sandstone, brick pieces) clay with trace cobbles (brick), damp below 2.6m			2.7				
		Pit discontinued at 2.7m Limit of Investigation							

RIG: Komatsu PC228 USLC - 500mm bucket
LOGGED: RLG
SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Stockland Developments Pty Ltd
PROJECT: Lot Classification
LOCATION: Stage 6 McCauleys Beach Estate, Bulli

SURFACE LEVEL: 13.8 AHD
EASTING: 308443.9
NORTHING: 6200307
DIP/AZIMUTH: 90°/--

PIT No: 16
PROJECT No: 48694.26
DATE: 14/10/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		FILLING (controlled) - grey brown mottled pink brown, slightly sandy, slightly gravelly clay with some gravel (sandstone, siltstone, brick pieces) and trace cobbles (siltstone, sandstone, brick) humid to damp							
		- becoming gravelly sandy clay below 0.5m		D	0.5		pp = 340 - 400		
					0.6				
13									
	1	- becoming pink brown mottled grey brown below 1.0m		D	1.0		pp = 160 - 180		1
	1.1	FILLING (controlled) - dark grey brown sandy gravelly (siltstone, sandstone, coalwash, brick pieces) clay with silt and trace cobbles, humid to damp			1.1				
				D	1.5		pp = 330 - 350		
					1.6				
12									
	2								2
				D	2.1		pp > 600		
					2.2				
				D	2.5		pp = 230 - 320		
	2.6	Pit discontinued at 2.6m Limit of Investigation			2.6				
11									

RIG: Komatsu PC228 USLC - 500mm bucket

LOGGED: RLG

SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Appendix D

Laboratory Test Report Sheets (4 Sheets)

Douglas Partners
Geotechnics / Environment / Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
Unit 1, 1 Luso Drive
PO Box 486
Unanderra NSW 2526
Phone (02) 4271 1836
Fax (02) 4271 1897

Result of Shrink-Swell Index Determination

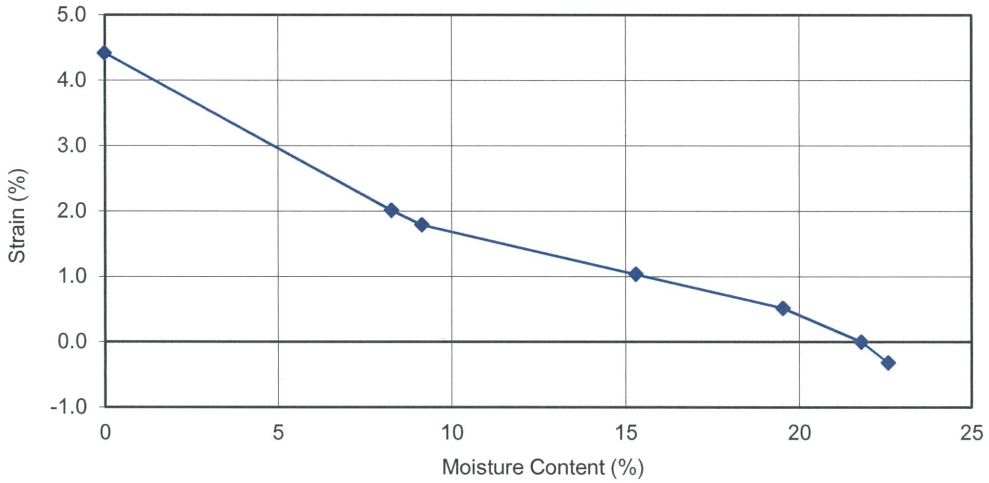
Client :	Stocklands Development Pty Ltd	**Project No. :**	48694.26
		Report No. :	UL11-180A
Project :	Lot Classification	**Report Date :**	5/10/2011
		Date Sampled :	23/09/2011
Location :	Stage 6 McCauleys Beach Estate, Bulli	**Date of Test:**	26/09/2011
Test Location :	TP1		
Depth / Layer :	0.40 - 0.75m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	2.0 %
Shrinkage - oven dried	4.4 %
Significant inert inclusions	3.0 %
Extent of cracking	MC
Extent of soil crumbling	0.0 %
Moisture content of core	21.8 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	450 kPa
Pocket penetrometer reading at final moisture content	370 kPa
Initial Moisture Content	21.6 %
Final Moisture Content	22.6 %
Swell under 25kPa	0.3 %



SHRINK-SWELL INDEX Iss 2.5% per Δ pF

Description: Black brown gravelly silty clay (Filling)

Test Method(s): AS 1289.7.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by Wollongong Engineering Department

Extent of Cracking:
UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks: -

Note that NATA accreditation does not cover the performance of pocket penetrometer readings

NATA Accredited Laboratory Number: 828

This Document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025

Tested:	AM, KK
Checked:	DE

Dave Evans
Laboratory Manager

Douglas Partners
Geotechnics / Environment / Groundwater

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PO Box 486
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Phone (02) 4271 1836
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Result of Shrink-Swell Index Determination

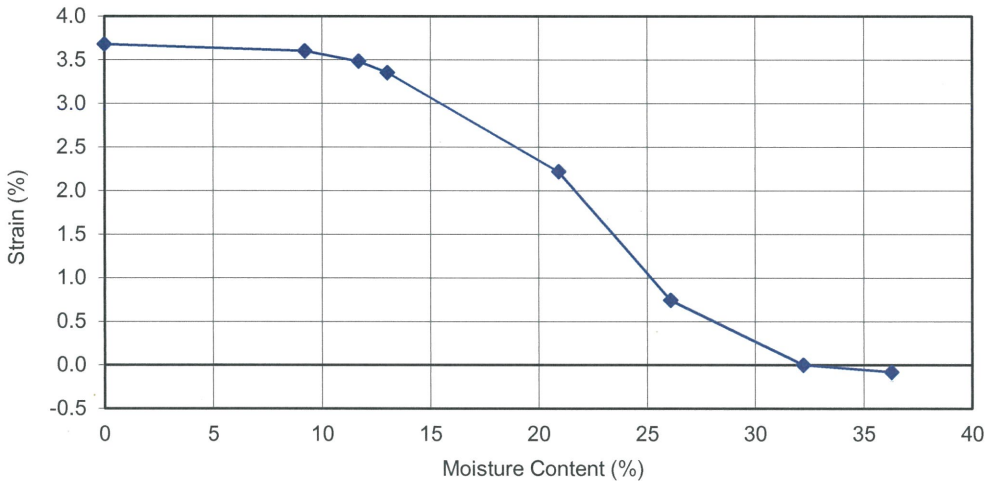
Client :	Stocklands Development Pty Ltd	**Project No. :**	48694.26
		Report No. :	UL11-180B
Project :	Lot Classification	**Report Date :**	5/10/2011
		Date Sampled :	23/09/2011
Location :	Stage 6 McCauleys Beach Estate, Bulli	**Date of Test:**	26/09/2011
Test Location :	TP5		
Depth / Layer :	0.50 - 0.65m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	3.6 %
Shrinkage - oven dried	3.7 %
Significant inert inclusions	3.0 %
Extent of cracking	MC
Extent of soil crumbling	0.0 %
Moisture content of core	32.2 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	180 kPa
Pocket penetrometer reading at final moisture content	130 kPa
Initial Moisture Content	35.5 %
Final Moisture Content	36.3 %
Swell under 25kPa	0.1 %



SHRINK-SWELL INDEX Iss 2.1% per Δ pF

Description: Brown gravelly silty clay (Filling)

Test Method(s): AS 1289.7.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by Wollongong Engineering Department

Extent of Cracking:
UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks: -

Note that NATA accreditation does not cover the performance of pocket penetrometer readings

NATA Accredited Laboratory Number: 828

ACCREDITED FOR

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Accredited for compliance with ISO/IEC 17025

Tested:	AM, KK
Checked:	DE

Dave Evans
Laboratory Manager

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Result of Shrink-Swell Index Determination

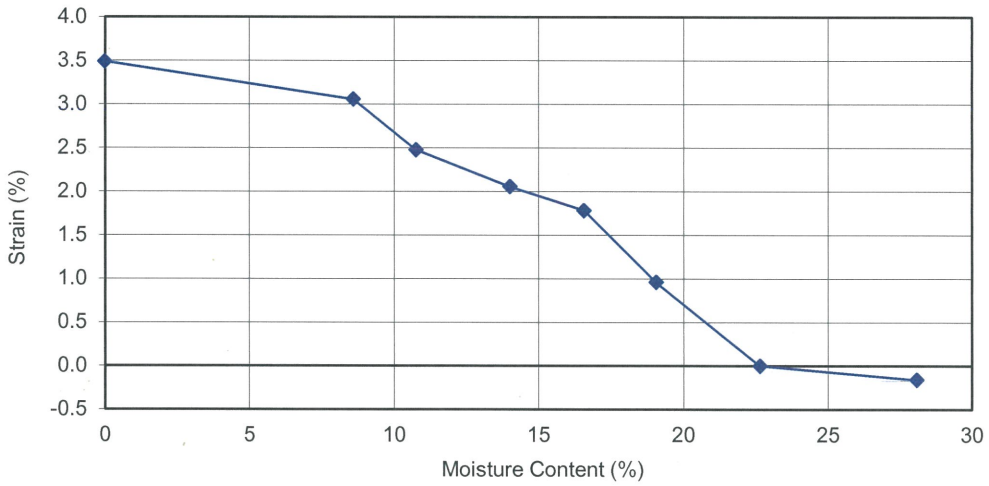
Client :	Stocklands Development Pty Ltd	**Project No. :**	48694.26
		Report No. :	UL11-180C
Project :	Lot Classification	**Report Date :**	5/10/2011
		Date Sampled :	23/09/2011
Location :	Stage 6 McCauleys Beach Estate, Bulli	**Date of Test:**	26/09/2011
Test Location :	TP12		
Depth / Layer :	0.5 - 0.8m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	3.1 %
Shrinkage - oven dried	3.5 %
Significant inert inclusions	3.0 %
Extent of cracking	SC
Extent of soil crumbling	0.0 %
Moisture content of core	22.6 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	600+ kPa
Pocket penetrometer reading at final moisture content	390 kPa
Initial Moisture Content	25.3 %
Final Moisture Content	28.1 %
Swell under 25kPa	0.2 %



SHRINK-SWELL INDEX Iss 2.0% per Δ pF

Description: Brown red silty gravelly clay (Filling)

Test Method(s): AS 1289.7.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by Wollongong Engineering Department

Extent of Cracking:
UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks: -

Note that NATA accreditation does not cover the performance of pocket penetrometer readings

NATA Accredited Laboratory Number: 828

ACCREDITED FOR

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Accredited for compliance with ISO/IEC 17025

Tested:	AM, KK
Checked:	DE

Dave Evans
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Result of Shrink-Swell Index Determination

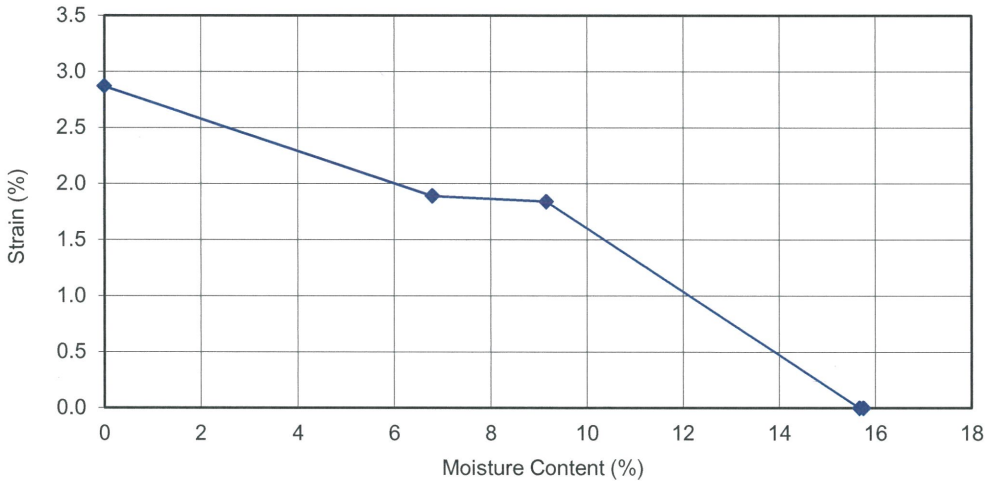
Client :	Stocklands Development Pty Ltd	**Project No. :**	48694.26
		Report No. :	UL11-180D
Project :	Lot Classification	**Report Date :**	5/10/2011
		Date Sampled :	23/09/2011
Location :	Stage 6 McCauleys Beach Estate, Bulli	**Date of Test:**	26/09/2011
Test Location :	TP14		
Depth / Layer :	0.50 - 0.75m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	1.9 %
Shrinkage - oven dried	2.9 %
Significant inert inclusions	3.0 %
Extent of cracking	SC
Extent of soil crumbling	0.0 %
Moisture content of core	15.7 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	250 kPa
Pocket penetrometer reading at final moisture content	240 kPa
Initial Moisture Content	12.6 %
Final Moisture Content	15.7 %
Swell under 25kPa	0.0 %



SHRINK-SWELL INDEX Iss 1.6% per Δ pF

Description: Black brown gravelly clay (Filling)

Test Method(s): AS 1289.7.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by Wollongong Engineering Department

Extent of Cracking:
UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks: -

Note that NATA accreditation does not cover the performance of pocket penetrometer readings

NATA Accredited Laboratory Number: 828
This Document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025

Tested:	AM, KK
Checked:	DE

Dave Evans
Laboratory Manager

Appendix E

Controlled Filling Summary Sheets (51 sheets)
Density Test Location Plans (1 sheet)

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 1 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments etc
			DENSITY RATIO %	MOISTURE VARIATION		
24/09/10	1	9.54	99.0	0.0	PASS	
24/09/10	2	9.76	100.0	0.5 Dry	PASS	
24/09/10	3	10.17	99.0	0.5 Dry	PASS	
24/09/10	4	10.44	99.5	0.0	PASS	
24/09/10	5	10.86	98.0	0.5 Dry	PASS	
24/09/10	6	11.48	99.5	0.0	PASS	
25/09/10	7	8.90	98.0	0.5 Dry	PASS	
25/09/10	8	9.27	99.5	0.5 Wet	PASS	
27/09/10	9	11.14	99.0	1.5 Wet	PASS	
27/09/10	10	11.47	98.5	1.5 Wet	PASS	
27/09/10	11	11.91	98.0	1.0 Wet	PASS	
27/09/10	12	10.07	99.0	0.5 Wet	PASS	
27/09/10	13	11.35	99.0	0.5 Wet	PASS	
27/09/10	14	12.02	100.0	0.0	PASS	
28/09/10	15	12.32	98.5	1.5 Wet	PASS	
28/09/10	16	11.46	98.0	2.0 Wet	PASS	
28/09/10	17	11.95	98.0	2.0 Wet	PASS	
28/09/10	18	12.54	101.0	2.0 Wet	PASS	
28/09/10	19	21.00	102.0	0.5 Dry	PASS	Temp Acid Pond
28/09/10	20	11.94	98.5	0.5 Wet	PASS	
28/09/10	21	12.73	100.0	0.5 Wet	PASS	
29/09/10	22	13.39	98.5	2.0 Dry	PASS	
29/09/10	23	12.81	98.5	2.0 Dry	PASS	
29/09/10	24	13.12	98.5	1.5 Dry	PASS	
29/09/10	25	13.75	101.0	1.0 Dry	PASS	

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 2 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments etc
			DENSITY RATIO %	MOISTURE VARIATION		
30/09/10	26	13.33	99.0	0.5 Wet	PASS	
30/09/10	27	12.95	101.0	0.5 Wet	PASS	
1/10/10	28	13.88	99.5	1.0 Wet	PASS	
1/10/10	29	13.33	100.5	0.5 Dry	PASS	
11/10/10	30	9.94	99.5	0.0	PASS	
11/10/10	31	10.31	101.0	0.5 Wet	PASS	
11/10/10	32	10.68	99.5	1.5 Wet	PASS	
11/10/10	33	11.00	99.0	0.5 Dry	PASS	
11/10/10	34	11.39	100.5	1.0 Wet	PASS	
11/10/10	35	11.77	98.0	0.5 Dry	PASS	
11/10/10	36	12.16	98.0	0.5 Wet	PASS	
11/10/10	37	12.58	99.5	0.5 Wet	PASS	
12/10/10	38	12.31	87.5	3.0 Wet	FAIL	Retest required
12/10/10	39	12.36	99.0	1.0 Wet	PASS	Retest of Test No 38
12/10/10	40	12.95	98.5	2.0 Wet	PASS	
13/10/10	41	13.25	90.0	5.0 Wet	FAIL	Retest required
14/10/10	42	10.71	98.5	1.0 Wet	PASS	
14/10/10	43	10.10	98.0	1.0 Wet	PASS	
14/10/10	44	10.94	99.0	0.5 Wet	PASS	
14/10/10	45	10.34	99.0	1.0 Wet	PASS	
15/10/10	46	11.22	98.5	0.5 Dry	PASS	
15/10/10	47	10.61	98.5	0.5 Wet	PASS	
18/10/10	48	11.00	99.0	0.0	PASS	
18/10/10	49	11.55	99.5	0.5 Dry	PASS	
18/10/10	50	11.18	99.0	0.0	PASS	

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 3 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments etc
			DENSITY RATIO %	MOISTURE VARIATION		
18/10/10	51	11.93	100.5	0.0	PASS	
18/10/10	52	12.44	100.0	0.5 Dry	PASS	
18/10/10	53	12.45	102.0	0.5 Dry	PASS	
18/10/10	54	12.79	100.5	0.0	PASS	
18/10/10	55	12.96	100.5	0.0	PASS	
19/10/10	56	12.70	101.5	0.5 Wet	PASS	
19/10/10	57	13.24	98.5	0.5 Dry	PASS	Retest of Test No 41
19/10/10	58	13.05	101.0	0.0	PASS	
19/10/10	59	13.49	102.0	0.0	PASS	
21/10/10	60	10.49	99.5	1.0 Wet	PASS	
21/10/10	61	10.07	100.0	1.0 Dry	PASS	
21/10/10	62	10.41	99.5	0.5 Dry	PASS	
21/10/10	63	10.51	98.5	0.0	PASS	
22/10/10	64	10.91	99.5	0.5 Wet	PASS	
22/10/10	65	10.68	100.0	1.0 Dry	PASS	
23/10/10	66	11.00	99.0	1.0 Wet	PASS	
23/10/10	67	11.20	100.0	1.5 Wet	PASS	
8/11/10	68	11.36	99.0	0.5 Wet	PASS	
8/11/10	69	11.04	98.0	0.5 Wet	PASS	
8/11/10	70	12.15	99.0	0.5 Wet	PASS	
8/11/10	71	11.84	100.0	0.5 Dry	PASS	
25/11/10	72	4.36	100.0	0.5 Wet	PASS	
25/11/10	73	4.71	99.0	1.0 Wet	PASS	
25/11/10	74	5.22	99.0	1.0 Dry	PASS	
25/11/10	75	5.76	98.5	0.5 Dry	PASS	

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 4 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments etc
			DENSITY RATIO %	MOISTURE VARIATION		
26/11/10	76	6.31	99.0	1.0 Dry	PASS	
26/11/10	77	6.89	98.0	0.0	PASS	
26/11/10	78	7.35	100.0	1.0 Dry	PASS	
26/11/10	79	7.90	101.5	0.5 Wet	PASS	
14/12/10	80	8.34	99.0	0.5 Wet	PASS	
14/12/10	81	8.69	99.0	0.5 Dry	PASS	
14/12/10	82	9.17	101.0	1.0 Dry	PASS	
15/12/10	83	9.49	98.5	1.0 Dry	PASS	
15/12/10	84	9.37	99.0	0.5 Wet	PASS	
15/12/10	85	10.01	99.5	0.0	PASS	
15/12/10	86	9.82	98.5	0.5 Dry	PASS	
15/12/10	87	10.34	99.5	1.0 Dry	PASS	
15/12/10	88	10.20	99.0	1.0 Dry	PASS	
15/12/10	89	8.25	101.5	1.0 Wet	PASS	
15/12/10	90	8.88	99.0	1.0 Wet	PASS	
16/12/10	91	10.83	99.0	1.0 Wet	PASS	
16/12/10	92	9.89	100.0	1.0 Wet	PASS	
16/12/10	93	11.15	98.5	0.5 Wet	PASS	
16/12/10	94	10.14	98.0	2.0 Wet	PASS	
17/12/10	95	11.47	101.0	0.5 Dry	PASS	
17/12/10	96	10.57	99.0	0.5 Wet	PASS	
17/12/10	97	11.78	99.5	0.5 Dry	PASS	
17/12/10	98	10.42	101.5	1.0 Wet	PASS	
18/12/10	99	11.85	99.5	0.5 Wet	PASS	
18/12/10	100	11.20	100.5	1.0 Wet	PASS	

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 5 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments etc
			DENSITY RATIO %	MOISTURE VARIATION		
20/12/10	101	12.09	98.0	1.0 Wet	PASS	
20/12/10	102	12.00	100.0	0.5 Wet	PASS	
20/12/10	103	12.45	100.0	1.0 Wet	PASS	
20/12/10	104	12.39	99.0	1.0 Wet	PASS	
20/12/10	105	8.77	98.0	1.0 Dry	PASS	
20/12/10	106	9.25	100.5	1.0 Dry	PASS	
21/12/10	107	9.41	98.0	0.5 Dry	PASS	
21/12/10	108	9.95	98.5	0.5 Wet	PASS	
21/12/10	109	10.11	99.0	1.0 Wet	PASS	
21/12/10	110	10.65	99.5	2.0 Wet	PASS	
21/12/10	111	10.95	99.5	2.0 Wet	PASS	
21/12/10	112	12.92	101.0	2.0 Wet	PASS	
21/12/10	113	11.51	99.5	1.5 Wet	PASS	
22/12/10	114	11.91	98.5	0.5 Dry	PASS	
22/12/10	115	12.31	99.0	2.0 Dry	PASS	
22/12/10	116	11.80	100.5	1.0 Dry	PASS	
22/12/10	117	12.55	98.5	0.5 Wet	PASS	
23/12/10	118	12.22	101.0	0.5 Wet	PASS	
23/12/10	119	12.95	98.5	0.5 Wet	PASS	
23/12/10	120	12.61	99.5	0.5 Wet	PASS	
4/1/11	121	13.28	98.5	0.5 Wet	PASS	
4/1/11	122	13.05	98.0	1.0 Dry	PASS	
4/1/11	123	13.14	101.0	0.5 Wet	PASS	
4/1/11	124	12.51	98.5	1.5 Dry	PASS	
4/1/11	125	13.29	99.0	0.5 Wet	PASS	

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 6 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments etc
			DENSITY RATIO %	MOISTURE VARIATION		
4/1/11	126	13.00	101.0	0.5 Dry	PASS	
5/1/11	127	13.37	100.0	0.5 Wet	PASS	
5/1/11	128	13.41	100.0	0.5 Wet	PASS	
5/1/11	129	12.99	100.0	0.5 Dry	PASS	
5/1/11	130	13.53	99.0	0.5 Dry	PASS	
5/1/11	131	13.41	99.0	0.5 Dry	PASS	
5/1/11	132	13.75	98.5	0.5 Wet	PASS	
5/1/11	133	13.88	101.5	0.5 Wet	PASS	
7/1/11	134	14.23	98.0	0.5 Wet	PASS	
7/1/11	135	14.20	98.5	0.0 Dry	PASS	
7/1/11	136	6.98	100.5	0.5 Wet	PASS	
7/1/11	137	6.26	99.0	1.0 Wet	PASS	
7/1/11	138	6.97	98.5	0.5 Wet	PASS	
7/1/11	139	6.88	100.5	0.5 Dry	PASS	
8/1/11	140	9.46	99.5	0.5 Wet	PASS	
8/1/11	141	9.94	101.0	1.0 Wet	PASS	
17/1/11	142	10.61	98.5	1.0 Wet	PASS	
17/1/11	143	9.94	98.0	1.0 Wet	PASS	
17/1/11	144	10.98	99.5	0.5 Wet	PASS	
17/1/11	145	10.39	98.0	0.5 Wet	PASS	
17/1/11	146	11.22	101.0	1.0 Wet	PASS	
17/1/11	147	10.81	99.0	1.0 Wet	PASS	
17/1/11	148	11.29	100.0	0.5 Wet	PASS	
18/1/11	149	11.45	98.0	0.5 Wet	PASS	
18/1/11	150	11.62	100.5	0.5 Wet	PASS	

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 7 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments etc
			DENSITY RATIO %	MOISTURE VARIATION		
18/1/11	151	11.71	99.5	0.5 Wet	PASS	
18/1/11	152	11.91	100.5	0.5 Wet	PASS	
18/1/11	153	12.29	99.5	0.5 Wet	PASS	
18/1/11	154	12.37	98.5	0.5 Wet	PASS	
19/1/11	155	12.55	98.5	0.5 Wet	PASS	
19/1/11	156	12.67	101.0	0.5 Dry	PASS	
19/1/11	157	12.91	98.5	0.5 Wet	PASS	
19/1/11	158	12.96	98.0	0.5 Dry	PASS	
19/1/11	159	13.83	98.5	1.0 Wet	PASS	
19/1/11	160	13.20	98.5	2.0 Wet	PASS	
20/1/11	161	13.54	99.5	0.5 Wet	PASS	
20/1/11	162	13.66	100.5	0.5 Dry	PASS	
20/1/11	163	13.75	100.5	1.0 Wet	PASS	
20/1/11	164	13.81	99.5	0.5 Dry	PASS	
21/1/11	165	14.11	101.5	0.5 Wet	PASS	
21/1/11	166	14.14	100.5	0.5 Dry	PASS	
21/1/11	167	14.43	101.5	0.0	PASS	
21/1/11	168	14.50	100.5	0.0	PASS	
24/1/11	169	7.36	99.0	0.0	PASS	
24/1/11	170	7.21	100.5	0.5 Wet	PASS	
24/1/11	171	8.71	98.5	0.5 Dry	PASS	
24/1/11	172	10.43	99.0	0.0	PASS	
24/1/11	173	9.11	99.5	0.5 Wet	PASS	
24/1/11	174	9.49	100.0	0.0	PASS	
24/1/11	175	10.70	101.0	0.5 Wet	PASS	

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 8 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments etc
			DENSITY RATIO %	MOISTURE VARIATION		
25/1/11	176	7.80	99.0	0.5 Dry	PASS	
25/1/11	177	7.62	99.5	0.0	PASS	
25/1/11	178	11.11	100.5	0.5 Wet	PASS	
25/1/11	179	9.71	101.0	0.5 Dry	PASS	
25/1/11	180	7.94	99.0	0.5 Dry	PASS	
25/1/11	181	8.19	98.5	0.0	PASS	
25/1/11	182	11.46	99.0	0.5 Wet	PASS	
25/1/11	183	10.17	100.0	0.5 Dry	PASS	
27/1/11	184	8.51	98.0	0.5 Dry	PASS	
27/1/11	185	8.71	100.0	1.0 Dry	PASS	
27/1/11	186	9.12	98.0	1.0 Dry	PASS	
27/1/11	187	10.94	100.0	0.0	PASS	
27/1/11	188	10.21	99.5	0.0	PASS	
27/1/11	189	11.42	98.5	0.5 Wet	PASS	
31/1/11	190	10.81	100.5	1.0 Dry	PASS	
31/1/11	191	11.20	100.0	0.5 Dry	PASS	
31/1/11	192	9.20	98.0	0.5 Wet	PASS	
31/1/11	193	11.54	100.5	1.0 Dry	PASS	
31/1/11	194	11.35	101.0	0.0	PASS	
31/1/11	195	9.31	99.0	1.0 Wet	PASS	
31/1/11	196	11.69	101.0	0.5 Wet	PASS	
31/1/11	197	11.71	101.0	0.0	PASS	
31/1/11	198	9.43	101.5	0.5 Wet	PASS	
1/2/11	199	11.91	100.5	0.5 Wet	PASS	
1/2/11	200	11.97	102.0	0.0	PASS	

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 9 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments etc
			DENSITY RATIO %	MOISTURE VARIATION		
1/2/11	201	9.57	100.0	0.0	PASS	
1/2/11	202	12.22	99.5	0.5 Dry	PASS	
1/2/11	203	12.39	100.0	0.0	PASS	
1/2/11	204	10.11	101.0	1.0 Dry	PASS	
1/2/11	205	10.44	101.0	1.0 Dry	PASS	
2/2/11	206	12.47	95.5	3.0 Wet	FAIL	Retest required
2/2/11	207	12.85	101.0	2.0 Wet	PASS	
2/2/11	208	12.88	100.0	0.5 Wet	PASS	
2/2/11	209	12.45	100.0	0.5 Wet	PASS	Retest of 206
2/2/11	210	10.92	98.5	0.5 Dry	PASS	
2/2/11	211	13.11	98.5	1.0 Dry	PASS	
4/2/11	212	12.96	99.0	0.0	PASS	
4/2/11	213	13.19	99.0	1.5 Wet	PASS	
4/2/11	214	13.87	99.0	0.5 Wet	PASS	
4/2/11	215	13.76	101.0	0.5 Dry	PASS	
5/2/11	216	11.47	99.5	0.5 Wet	PASS	
5/2/11	217	11.84	99.5	1.0 Wet	PASS	
7/2/11	218	14.10	99.5	0.5 Dry	PASS	
7/2/11	219	14.15	101.5	0.5 Wet	PASS	
7/2/11	220	12.22	98.5	1.0 Dry	PASS	
7/2/11	221	12.59	99.5	0.5 Dry	PASS	
8/2/11	222	14.47	99.0	0.5 Dry	PASS	
8/2/11	223	14.59	101.5	1.0 Dry	PASS	
8/2/11	224	13.10	100.5	1.0 Dry	PASS	
8/2/11	225	13.56	98.5	0.0	PASS	

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 10 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments etc
			DENSITY RATIO %	MOISTURE VARIATION		
9/2/11	226	14.72	98.0	1.0 Dry	PASS	
9/2/11	227	14.75	99.0	0.0	PASS	
9/2/11	228	8.91	100.5	0.0	PASS	
9/2/11	229	9.29	100.5	0.5 Dry	PASS	
9/2/11	230	9.77	98.5	0.5 Dry	PASS	
9/2/11	231	15.02	101.0	0.5 Dry	PASS	
9/2/11	232	10.21	98.0	1.0 Wet	PASS	
9/2/11	233	10.66	99.5	0.5 Dry	PASS	
10/2/11	234	13.47	100.5	1.0 Dry	PASS	
10/2/11	235	13.88	102.0	1.0 Dry	PASS	
10/2/11	236	11.11	98.0	1.0 Wet	PASS	
10/2/11	237	11.56	98.0	0.5 Wet	PASS	
10/2/11	238	1201	99.0	1.0 Dry	PASS	
10/2/11	239	12.62	99.0	1.0 Wet	PASS	
11/2/11	240	13.07	98.5	2.0 Dry	PASS	
11/2/11	241	13.42	98.5	1.5 Dry	PASS	
11/2/11	242	13.99	101.5	2.0 Dry	PASS	
11/2/11	243	14.37	99.5	1.0 Dry	PASS	
11/2/11	244	15.21	99.5	1.0 Dry	PASS	
11/2/11	245	14.85	98.0	1.0 Wet	PASS	
14/2/11	246	7.04	98.0	1.0 Wet	PASS	
14/2/11	247	7.47	99.5	0.0	PASS	
14/2/11	248	7.99	101.5	0.5 Wet	PASS	
14/2/11	249	8.52	98.5	0.5 Wet	PASS	
14/2/11	250	8.92	98.5	0.5 Dry	PASS	

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 11 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments etc
			DENSITY RATIO %	MOISTURE VARIATION		
14/2/11	251	9.47	98.5	0.5 Dry	PASS	
14/2/11	252	9.81	100.0	0.5 Dry	PASS	
14/2/11	253	10.17	100.5	1.0 Wet	PASS	
15/2/11	254	10.51	98.0	1.5 Wet	PASS	
15/2/11	255	10.71	99.5	0.5 Wet	PASS	
15/2/11	256	11.22	98.5	0.0	PASS	
15/2/11	257	11.37	98.5	0.5 Wet	PASS	
15/2/11	258	11.91	101.5	1.0 Wet	PASS	
15/2/11	259	12.56	101.0	0.0	PASS	
16/2/11	260	12.94	99.5	1.0 Wet	PASS	
16/2/11	261	13.33	101.5	1.0 Dry	PASS	
16/2/11	262	13.41	98.5	0.0	PASS	
16/2/11	263	13.92	100.5	1.0 Wet	PASS	
17/2/11	264	13.86	99.0	1.0 Dry	PASS	
17/2/11	265	14.32	100.0	0.5 Wet	PASS	
17/2/11	266	14.68	99.0	1.0 Wet	PASS	
17/2/11	267	15.01	100.0	1.0 Wet	PASS	
17/2/11	268	14.21	100.5	1.0 Wet	PASS	
17/2/11	269	15.36	98.0	0.5 Dry	PASS	
17/2/11	270	14.81	98.5	1.0 Dry	PASS	
17/2/11	271	15.22	100.5	1.0 Dry	PASS	
18/2/11	272	6.47	100.0	1.0 Wet	PASS	
18/2/11	273	6.92	100.5	0.5 Wet	PASS	
18/2/11	274	7.32	100.5	0.0	PASS	
18/2/11	275	7.80	100.0	0.5 Wet	PASS	

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 12 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments etc
			DENSITY RATIO %	MOISTURE VARIATION		
18/2/11	276	1m BFL	99.0	2.0 Dry	PASS	Roadway
18/2/11	277	8.17	100.0	1.0 Wet	PASS	
18/2/11	278	8.51	99.5	1.0 Wet	PASS	
19/2/11	279	8.85	101.0	0.5 Wet	PASS	
19/2/11	280	9.11	99.5	0.0	PASS	
19/2/11	281	9.36	100.0	1.0 Wet	PASS	
19/2/11	282	0.5m BFL	101.0	1.0 Dry	PASS	Roadway
19/2/11	283	9.75	101.0	0.5 Wet	PASS	
21/2/11	284	10.16	101.5	0.0	PASS	
21/2/11	285	10.53	98.5	0.5 Wet	PASS	
21/2/11	286	10.86	101.0	0.5 Dry	PASS	
21/2/11	287	11.29	99.5	0.5 Dry	PASS	
21/2/11	288	11.60	99.0	0.5 Dry	PASS	
21/2/11	289	12.04	98.5	0.5 Dry	PASS	
21/2/11	290	12.42	100.5	1.0 Dry	PASS	
22/2/11	291	12.73	98.5	0.0	PASS	
22/2/11	292	13.21	99.0	0.5 Wet	PASS	
22/2/11	293	13.65	98.5	1.0 Wet	PASS	
22/2/11	294	14.14	99.0	0.5 Wet	PASS	
22/2/11	295	14.46	101.0	0.0	PASS	
22/2/11	296	14.65	99.0	1.0 Dry	PASS	
23/2/11	297	14.93	101.0	0.5 Wet	PASS	
23/2/11	298	15.19	99.0	1.0 Dry	PASS	
23/2/11	299	15.50	101.5	0.5 Wet	PASS	
23/2/11	300	15.47	99.0	0.5 Dry	PASS	

LEGEND – BFL = Below Finished Level

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 13 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments etc
			DENSITY RATIO %	MOISTURE VARIATION		
23/2/11	301	9.11	98.0	0.5 Dry	PASS	
23/2/11	302	9.20	98.5	0.0	PASS	
23/2/11	303	9.16	98.0	0.5 Wet	PASS	
23/2/11	304	9.38	98.0	0.5 Wet	PASS	
24/2/11	305	9.45	98.5	0.0	PASS	
24/2/11	306	9.54	101.5	1.0 Dry	PASS	
24/2/11	307	9.79	99.0	0.5 Wet	PASS	
24/2/11	308	9.93	101.0	0.5 Dry	PASS	
24/2/11	309	8.36	100.5	0.0	PASS	
24/2/11	310	8.78	98.5	0.5 Dry	PASS	
24/2/11	311	9.16	101.0	0.0	PASS	
24/2/11	312	9.50	99.5	0.0	PASS	
24/2/11	313	9.97	99.5	0.5 Dry	PASS	
24/2/11	314	10.12	99.0	0.5 Wet	PASS	
24/2/11	315	10.15	99.0	0.5 Dry	PASS	
25/2/11	316	11.46	99.0	1.0 Dry	PASS	
25/2/11	317	10.97	98.0	1.5 Dry	PASS	
25/2/11	318	10.41	100.5	0.5 Wet	PASS	
25/2/11	319	8.15	101.5	0.0	PASS	
25/2/11	320	11.82	101.0	0.5 Dry	PASS	
25/2/11	321	11.30	99.0	1.5 Dry	PASS	
25/2/11	322	12.18	98.0	2.0 Dry	PASS	
25/2/11	323	11.63	100.5	0.5 Dry	PASS	
25/2/11	324	11.54	100.0	2.0 Dry	PASS	
25/2/11	325	8.58	98.5	0.5 Wet	PASS	

LEGEND – BFL = Below Finished Level

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 14 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments etc
			DENSITY RATIO %	MOISTURE VARIATION		
25/2/11	326	10.53	99.5	1.0 Dry	PASS	
25/2/11	327	10.58	98.5	0.5 Wet	PASS	
26/2/11	328	12.64	101.5	2.0 Dry	PASS	
26/2/11	329	11.98	99.5	1.5 Dry	PASS	
26/2/11	330	10.95	98.0	0.5 Dry	PASS	
26/2/11	331	10.98	98.5	0.5 Dry	PASS	
26/2/11	332	13.01	98.0	1.0 Dry	PASS	
26/2/11	333	12.30	100.0	2.0 Dry	PASS	
26/2/11	334	11.33	98.5	0.5 Wet	PASS	
26/2/11	335	11.27	98.0	0.5 Wet	PASS	
28/2/11	336	13.39	99.0	0.5 Dry	PASS	
28/2/11	337	12.72	100.5	1.5 Dry	PASS	
28/2/11	338	12.60	100.5	2.0 Dry	PASS	
28/2/11	339	11.67	98.5	0.5 Wet	PASS	
28/2/11	340	11.72	100.0	0.5 Wet	PASS	
28/2/11	341	13.76	98.0	0.5 Wet	PASS	
28/2/11	342	13.03	98.0	0.5 Wet	PASS	
28/2/11	343	14.19	100.5	2.0 Dry	PASS	
28/2/11	344	13.47	98.0	2.0 Dry	PASS	
28/2/11	345	12.13	101.0	0.5 Dry	PASS	
28/2/11	346	12.06	98.5	0.5 Dry	PASS	
01/3/11	347	14.50	98.5	2.0 Dry	PASS	
01/3/11	348	14.01	99.0	1.0 Dry	PASS	
01/3/11	349	13.83	98.5	0.0	PASS	
01/3/11	350	7.91	99.0	2.0 Dry	PASS	

LEGEND – BFL = Below Finished Level

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 15 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments etc
			DENSITY RATIO %	MOISTURE VARIATION		
01/3/11	351	12.35	99.0	2.0 Dry	PASS	
01/3/11	352	12.44	99.0	2.0 Dry	PASS	
01/3/11	353	14.83	98.0	1.0 Dry	PASS	
01/3/11	354	14.18	98.5	0.5 Dry	PASS	
01/3/11	355	8.27	99.5	0.5 Wet	PASS	
01/3/11	356	12.77	98.5	0.5 Wet	PASS	
01/3/11	357	12.75	98.0	0.5 Dry	PASS	
02/3/11	358	13.08	99.0	0.5 Dry	PASS	
02/3/11	359	13.11	100.0	0.0	PASS	
02/3/11	360	14.44	101.5	2.0 Dry	PASS	
02/3/11	361	13.94	101.0	1.5 Dry	PASS	
02/3/11	362	13.40	98.5	0.5 Dry	PASS	
02/3/11	363	13.39	98.5	1.0 Dry	PASS	
02/3/11	364	8.25	101.5	0.0	PASS	
02/3/11	365	13.72	98.5	0.5 Wet	PASS	
02/3/11	366	13.68	101.0	1.0 Dry	PASS	
02/3/11	367	14.03	100.0	0.0	PASS	
02/3/11	368	14.01	98.5	0.5 Wet	PASS	
03/3/11	369	14.26	98.5	0.5 Dry	PASS	
03/3/11	370	14.26	101.0	1.5 Dry	PASS	
03/3/11	371	14.52	101.5	2.0 Dry	PASS	
03/3/11	372	14.48	99.0	1.5 Dry	PASS	
03/3/11	373	0.5 m BSG	102.0	0.5 Dry	PASS	Roadway
03/3/11	374	0.5 m BSG	100.5	1.0 Dry	PASS	Roadway
03/3/11	375	14.74	100.5	2.0 Dry	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 16 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments etc
			DENSITY RATIO %	MOISTURE VARIATION		
03/3/11	376	14.73	99.0	2.0 Dry	PASS	
04/3/11	377	15.01	101.5	1.5 Dry	PASS	
04/3/11	378	15.02	99.5	2.0 Dry	PASS	
04/3/11	379	15.29	99.0	0.5 Dry	PASS	
04/3/11	380	4.86	99.0	0.0	PASS	
04/3/11	381	4.93	99.5	0.0	PASS	
04/3/11	382	5.19	98.5	0.0	PASS	
04/3/11	383	5.55	99.5	0.0	PASS	
04/3/11	384	5.89	100.0	0.5 Dry	PASS	
04/3/11	385	5.96	99.5	0.5 Wet	PASS	
08/3/11	386	15.32	101.0	2.0 Dry	PASS	
08/3/11	387	6.32	99.0	0.0 Dry	PASS	
08/3/11	388	6.65	99.0	0.0 Dry	PASS	
08/3/11	389	7.04	99.5	0.5 Dry	PASS	
08/3/11	390	7.39	101.5	1.5 Dry	PASS	
08/3/11	391	7.77	100.5	2.0 Dry	PASS	
08/3/11	392	8.16	100.0	0.5 Dry	PASS	
08/3/11	393	8.51	98.5	2.0 Dry	PASS	
08/3/11	394	8.60	98.5	1.5 Dry	PASS	
09/3/11	395	FL	100.5	2.0 Dry	PASS	Roadway
09/3/11	396	8.94	102.0	0.5 Dry	PASS	
09/3/11	397	8.92	100.5	0.5 Dry	PASS	
09/3/11	398	9.31	100.5	0.0	PASS	
09/3/11	399	9.40	98.5	1.5 Dry	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade, FL = Finished Level

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 17 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
09/3/11	400	9.66	99.0	2.0 Dry	PASS	
09/3/11	401	9.71	101.5	1.5 Dry	PASS	
09/3/11	402	10.05	100.0	1.5 Dry	PASS	
09/3/11	403	10.11	99.0	2.0 Dry	PASS	
10/3/11	404	10.43	101.0	1.5 Dry	PASS	
10/3/11	405	10.46	98.5	2.0 Dry	PASS	
10/3/11	406	10.87	99.0	1.5 Dry	PASS	
10/3/11	407	10.85	100.5	2.0 Dry	PASS	
10/3/11	408	11.71	98.0	2.0 Dry	PASS	
10/3/11	409	12.04	98.5	1.5 Dry	PASS	
10/3/11	410	12.42	102.0	2.0 Dry	PASS	
10/3/11	411	12.82	102.0	2.0 Dry	PASS	
10/3/11	412	11.25	100.5	1.5 Dry	PASS	
10/3/11	413	11.64	100.5	1.5 Dry	PASS	
11/3/11	414	12.05	101.0	1.5 Dry	PASS	
11/3/11	415	13.14	99.0	2.0 Dry	PASS	
11/3/11	416	13.37	100.0	2.0 Dry	PASS	
11/3/11	417	13.47	99.5	2.0 Dry	PASS	
11/3/11	418	13.60	100.5	1.5 Dry	PASS	
11/3/11	419	13.79	98.5	1.5 Dry	PASS	
11/3/11	420	8.68	99.5	1.5 Dry	PASS	
11/3/11	421	10.14	101.0	2.0 Dry	PASS	
11/3/11	422	9.08	100.0	1.5 Dry	PASS	
11/3/11	423	8.91	101.5	2.0 Dry	PASS	
11/3/11	424	9.30	100.0	2.0 Dry	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 18 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
12/3/11	425	9.71	99.5	1.5 Dry	PASS	
12/3/11	426	9.50	98.5	2.0 Dry	PASS	
12/3/11	427	9.88	101.0	2.0 Dry	PASS	
12/3/11	428	10.57	98.5	1.5 Dry	PASS	
12/3/11	429	10.24	99.5	1.5 Dry	PASS	
12/3/11	430	10.85	100.0	1.5 Dry	PASS	
14/3/11	431	10.10	99.0	0.0 Dry	PASS	
14/3/11	432	11.26	99.0	0.5 Dry	PASS	
14/3/11	433	10.68	99.0	0.5 Wet	PASS	
14/3/11	434	10.51	102.0	1.5 Dry	PASS	
14/3/11	435	11.64	100.5	1.5 Dry	PASS	
14/3/11	436	11.09	102.0	2.0 Dry	PASS	
14/3/11	437	11.46	101.5	2.0 Dry	PASS	
14/3/11	438	12.03	99.0	1.5 Dry	PASS	
14/3/11	439	10.93	99.0	1.5 Dry	PASS	
15/3/11	440	11.82	99.5	2.0 Dry	PASS	
15/3/11	441	11.28	101.0	1.5 Dry	PASS	
15/3/11	442	10.50	101.0	2.0 Dry	PASS	
15/3/11	443	10.41	100.0	1.5 Dry	PASS	
15/3/11	444	10.86	100.0	2.0 Dry	PASS	
15/3/11	445	10.73	99.5	2.0 Dry	PASS	
15/3/11	446	11.27	99.5	1.5 Dry	PASS	
15/3/11	447	11.13	101.5	1.5 Dry	PASS	
15/3/11	448	11.66	100.0	1.5 Dry	PASS	
15/3/11	449	11.50	99.5	1.5 Dry	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 19 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
16/3/11	450	11.91	100.5	2.0 Dry	PASS	
16/3/11	451	12.09	99.5	1.5 Dry	PASS	
16/3/11	452	10.90	99.0	1.5 Dry	PASS	
16/3/11	453	10.30	99.5	2.0 Dry	PASS	
16/3/11	454	11.28	98.5	1.5 Dry	PASS	
16/3/11	455	11.64	102.0	1.5 Dry	PASS	
16/3/11	456	12.07	98.5	1.5 Dry	PASS	
16/3/11	457	12.48	100.0	2.0 Dry	PASS	
16/3/11	458	12.35	98.5	1.5 Dry	PASS	
31/3/11	459	12.46	100.5	2.0 Dry	PASS	
31/3/11	460	13.47	99.5	2.0 Dry	PASS	
31/3/11	461	4.54	99.0	0.5 Wet	PASS	
31/3/11	462	12.90	101.5	1.5 Dry	PASS	
31/3/11	463	13.78	99.0	1.5 Dry	PASS	
31/3/11	464	4.91	99.5	0.5 Dry	PASS	
1/4/11	465	5.30	99.5	0.5 Wet	PASS	
1/4/11	466	5.65	99.5	0.0	PASS	
1/4/11	467	6.09	98.5	0.5 Dry	PASS	
4/4/11	468	6.42	99.0	0.5 Dry	PASS	
4/4/11	469	6.81	101.5	1.5 Dry	PASS	
4/4/11	470	7.13	99.5	2.0 Dry	PASS	
5/4/11	471	4.96	98.5	2.0 Dry	PASS	
5/4/11	472	5.32	98.5	2.0 Dry	PASS	
6/4/11	473	5.73	98.5	2.0 Dry	PASS	
6/4/11	474	6.05	100.5	0.5 Dry	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 20 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
6/4/11	475	6.54	99.0	0.0	PASS	
7/4/11	476	6.88	102.0	1.5 Dry	PASS	
7/4/11	477	7.25	98.5	2.0 Dry	PASS	
7/4/11	478	7.65	101.5	2.0 Dry	PASS	
7/4/11	479	8.09	98.5	1.5 Dry	PASS	
7/4/11	480	8.56	98.5	0.5 Dry	PASS	
7/4/11	481	8.94	99.0	0.5 Dry	PASS	
7/4/11	482	9.35	99.0	1.5 Dry	PASS	
7/4/11	483	9.71	100.5	2.0 Dry	PASS	
7/4/11	484	10.80	98.0	0.5 Dry	PASS	
7/4/11	485	11.33	100.5	1.0 Dry	PASS	
7/4/11	486	10.05	100.0	1.5 Dry	PASS	
8/4/11	487	4.83	101.0	2.0 Dry	PASS	
8/4/11	488	5.22	100.0	1.5 Dry	PASS	
8/4/11	489	11.81	98.0	1.0 Dry	PASS	
8/4/11	490	10.48	100.5	2.0 Dry	PASS	
8/4/11	491	10.92	99.5	1.0 Dry	PASS	
8/4/11	492	12.35	101.0	0.5 Dry	PASS	
8/4/11	493	5.59	102.0	1.5 Dry	PASS	
8/4/11	494	11.31	99.0	1.5 Dry	PASS	
8/4/11	495	5.95	99.5	1.5 Dry	PASS	
8/4/11	496	12.82	98.0	0.5 Dry	PASS	
9/4/11	497	6.30	98.5	0.5 Dry	PASS	
9/4/11	498	6.72	98.0	2.0 Dry	PASS	
9/4/11	499	11.72	99.0	1.5 Dry	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 21 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
9/4/11	500	7.16	98.0	1.5 Dry	PASS	
9/4/11	501	12.08	99.0	0.5 Dry	PASS	
9/4/11	502	7.50	101.0	1.0 Dry	PASS	
9/4/11	503	12.40	99.5	1.5 Dry	PASS	
9/4/11	504	12.76	100.5	1.5 Dry	PASS	
11/4/11	505	7.84	99.0	1.5 Dry	PASS	
11/4/11	506	8.17	99.0	2.0 Dry	PASS	
11/4/11	507	13.07	99.0	1.5 Dry	PASS	
11/4/11	508	8.51	98.5	2.0 Dry	PASS	
11/4/11	509	8.82	101.0	1.5 Dry	PASS	
11/4/11	510	9.16	99.0	1.0 Dry	PASS	
11/4/11	511	13.40	102.0	0.5 Dry	PASS	
11/4/11	512	13.76	100.5	1.0 Dry	PASS	
11/4/11	513	9.57	99.0	0.5 Wet	PASS	
12/4/11	514	9.92	99.0	1.5 Dry	PASS	
12/4/11	515	10.25	98.5	1.5 Dry	PASS	
12/4/11	516	10.62	98.5	1.0 Dry	PASS	
12/4/11	517	10.94	99.5	0.5 Wet	PASS	
12/4/11	518	11.29	98.0	1.5 Dry	PASS	
12/4/11	519	11.62	99.5	1.0 Dry	PASS	
12/4/11	520	13.28	98.5	0.0	PASS	
13/4/11	521	11.95	101.5	2.0 Dry	PASS	
13/4/11	522	12.32	100.0	1.5 Dry	PASS	
13/4/11	523	1m BSG	101.0	0.5 Dry	PASS	Road 01
13/4/11	524	12.61	99.0	1.5 Wet	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 22 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
13/4/11	525	12.93	99.0	2.0 Wet	PASS	
13/4/11	526	0.5m BSG	98.0	0.5 Dry	PASS	Road 01
13/4/11	527	4.70	100.5	2.0 Dry	PASS	
13/4/11	528	5.08	99.0	1.5 Dry	PASS	
13/4/11	529	5.41	101.5	1.0 Dry	PASS	
14/4/11	530	Subgrade	101.0	0.5 Dry	PASS	Road 01
14/4/11	531	Subgrade	101.5	1.0 Dry	PASS	Road 01
14/4/11	532	10.5	99.5	1.5 Dry	PASS	Base of GPT Pit
14/4/11	533	5.77	98.0	0.0	PASS	
14/4/11	534	6.18	99.5	2.0 Dry	PASS	
14/4/11	535	6.55	98.0	0.5 Dry	PASS	
14/4/11	536	6.89	102.0	1.5 Dry	PASS	
14/4/11	537	7.21	99.0	1.5 Dry	PASS	
14/4/11	538	7.54	100.0	1.5 Dry	PASS	
15/4/11	539	7.59	99.5	0.5 Wet	PASS	
15/4/11	540	7.85	99.0	0.5 Dry	PASS	
15/4/11	541	7.95	98.5	1.0 Dry	PASS	
15/4/11	542	8.21	101.5	0.5 Wet	PASS	
15/4/11	543	8.36	101.0	0.5 Wet	PASS	
15/4/11	544	8.65	101.0	1.5 Dry	PASS	
15/4/11	545	8.75	99.0	2.0 Dry	PASS	
15/4/11	546	9.07	101.5	1.5 Dry	PASS	
15/4/11	547	9.15	99.0	1.5 Dry	PASS	
15/4/11	548	9.43	99.0	2.0 Dry	PASS	
20/4/11	549	4.68	100.0	1.5 Dry	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 23 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
20/4/11	550	5.04	100.5	1.0 Dry	PASS	
20/4/11	551	5.43	98.5	0.0	PASS	
20/4/11	552	5.84	99.0	1.5 Dry	PASS	
20/4/11	553	6.19	102.5	1.0 Dry	PASS	
20/4/11	554	6.57	102.5	0.0	PASS	
20/4/11	555	7.01	99.0	1.5 Dry	PASS	
20/4/11	556	7.40	102.0	1.0 Dry	PASS	
21/4/11	557	7.73	102.5	2.0 Dry	PASS	
21/4/11	558	4.78	100.5	1.5 Dry	PASS	
21/4/11	559	5.19	99.5	1.5 Dry	PASS	
21/4/11	560	5.58	98.5	2.0 Dry	PASS	
21/4/11	561	5.94	99.0	1.0 Dry	PASS	
21/4/11	562	6.38	100.5	0.0	PASS	
21/4/11	563	6.79	98.5	0.5 Wet	PASS	
21/4/11	564	7.27	100.0	0.0	PASS	
3/5/11	565	6.27	99.5	0.5 Wet	PASS	
3/5/11	566	6.71	100.0	0.5 Wet	PASS	
3/5/11	567	7.05	100.0	0.5 Wet	PASS	
4/5/11	568	7.57	99.0	0.5 Wet	PASS	
4/5/11	569	7.87	101.5	1.0 Wet	PASS	
4/5/11	570	8.28	102.0	0.0	PASS	
4/5/11	571	8.67	101.0	0.0	PASS	
4/5/11	572	8.15	101.5	2.0 Wet	PASS	
4/5/11	573	8.53	99.5	1.5 Wet	PASS	
5/5/11	574	8.90	101.5	0.5 Dry	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 24 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
5/5/11	575	9.31	101.0	0.5 Wet	PASS	
5/5/11	576	9.21	101.0	2.0 Dry	PASS	
5/5/11	577	9.54	98.0	1.5 Dry	PASS	
5/5/11	578	9.70	98.5	0.5 Dry	PASS	
5/5/11	579	9.91	99.0	1.5 Dry	PASS	
5/5/11	580	9.61	100.0	2.0 Dry	PASS	
5/5/11	581	10.24	101.5	2.0 Wet	PASS	
5/5/11	582	9.99	99.5	1.5 Wet	PASS	
6/5/11	583	10.35	101.0	0.5 Dry	PASS	
6/5/11	584	10.74	102.0	0.5 Dry	PASS	
6/5/11	585	10.57	98.5	2.0 Wet	PASS	
6/5/11	586	10.40	99.0	1.5 Wet	PASS	
6/5/11	587	11.16	101.5	1.0 Dry	PASS	
6/5/11	588	11.52	100.0	0.0	PASS	
6/5/11	589	11.91	99.0	0.0	PASS	
6/5/11	590	12.27	98.5	0.5 Dry	PASS	
6/5/11	591	12.68	99.5	0.5 Dry	PASS	
7/5/11	592	9.08	98.0	0.5 Wet	PASS	
7/5/11	593	9.45	101.0	0.5 Wet	PASS	
7/5/11	594	10.90	101.5	1.5 Wet	PASS	
7/5/11	595	10.78	100.0	2.0 Wet	PASS	
7/5/11	596	9.84	102.0	0.5 Dry	PASS	
7/5/11	597	10.28	99.5	0.5 Dry	PASS	
9/5/11	598	11.06	100.0	0.0	PASS	
9/5/11	599	11.26	99.0	0.5 Wet	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 25 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
9/5/11	600	10.68	98.5	0.5 Dry	PASS	
9/5/11	601	11.05	100.0	1.5 Wet	PASS	
9/5/11	602	11.50	98.0	2.0 Wet	PASS	
9/5/11	603	11.89	99.5	0.0	PASS	
9/5/11	604	12.35	98.0	1.5 Wet	PASS	
10/5/11	605	12.74	98.5	1.0 Wet	PASS	
10/5/11	606	11.63	99.0	2.0 Wet	PASS	
10/5/11	607	11.38	101.0	2.0 Wet	PASS	
10/5/11	608	4.41	100.0	1.5 Wet	PASS	
10/5/11	609	12.04	98.5	2.0 Wet	PASS	
10/5/11	610	11.79	102.0	1.5 Wet	PASS	
10/5/11	611	4.77	101.0	0.5 Wet	PASS	
10/5/11	612	5.12	101.0	0.5 Dry	PASS	
10/5/11	613	5.53	99.5	0.0	PASS	
11/5/11	614	12.09	98.0	1.5 Wet	PASS	
11/5/11	615	12.41	99.0	1.5 Wet	PASS	
11/5/11	616	6.56	101.0	0.5 Wet	PASS	
11/5/11	617	4.72	101.5	0.5 Dry	PASS	
11/5/11	618	6.97	100.0	0.5 Wet	PASS	
11/5/11	619	7.33	98.0	0.0	PASS	
11/5/11	620	5.11	98.0	1.5 Wet	PASS	
11/5/11	621	5.45	99.5	1.5 Wet	PASS	
11/5/11	622	5.85	102.0	1.0 Wet	PASS	
12/5/11	623	7.74	101.0	0.5 Dry	PASS	
12/5/11	624	8.12	100.0	0.5 Wet	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 26 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
12/5/11	625	6.21	98.5	1.5 Wet	PASS	
12/5/11	626	8.48	98.5	2.0 Wet	PASS	
12/5/11	627	6.54	101.0	2.0 Wet	PASS	
12/5/11	628	8.87	99.0	1.0 Dry	PASS	
12/5/11	629	6.87	99.5	0.5 Wet	PASS	
12/5/11	630	9.18	102.0	1.5 Wet	PASS	
12/5/11	631	7.28	99.0	0.5 Wet	PASS	
13/5/11	632	9.58	98.5	2.0 Wet	PASS	
13/5/11	633	12.77	100.5	0.5 Dry	PASS	
13/5/11	634	12.37	102.0	2.0 Wet	PASS	
13/5/11	635	7.66	99.0	2.0 Dry	PASS	
13/5/11	636	9.95	98.0	0.5 Dry	PASS	
13/5/11	637	10.34	100.0	0.5 Dry	PASS	
13/5/11	638	10.69	98.0	1.5 Wet	PASS	
13/5/11	639	11.10	102.0	2.0 Wet	PASS	
13/5/11	640	11.48	98.0	0.0	PASS	
14/5/11	641	12.18	98.5	0.5 Dry	PASS	
14/5/11	642	11.89	101.0	1.5 Wet	PASS	
14/5/11	643	12.27	101.0	0.5 Wet	PASS	
14/5/11	644	12.53	100.0	0.5 Wet	PASS	
14/5/11	645	12.64	98.0	2.0 Dry	PASS	
14/5/11	646	12.98	100.0	0.0	PASS	
16/5/11	647	16.44	102.0	0.5 Dry	PASS	
16/5/11	648	16.31	101.5	0.5 Wet	PASS	
16/5/11	649	13.40	99.0	1.5 Wet	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 27 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
16/5/11	650	13.10	100.0	0.5 Wet	PASS	
16/5/11	651	13.79	102.0	0.5 Wet	PASS	
16/5/11	652	13.48	98.0	0.0	PASS	
16/5/11	653	14.12	99.0	1.5 Wet	PASS	
16/5/11	654	14.49	102.0	2.0 Wet	PASS	
16/5/11	655	14.81	100.5	0.5 Wet	PASS	
17/5/11	656	15.12	102.0	2.0 Wet	PASS	
17/5/11	657	16.87	99.0	0.5 Wet	PASS	
17/5/11	658	16.43	101.5	0.5 Wet	PASS	
17/5/11	659	16.74	99.5	0.5 Dry	PASS	
17/5/11	660	17.21	101.5	1.5 Dry	PASS	
18/5/11	661	15.39	101.5	1.0 Dry	PASS	
18/5/11	662	8.07	99.0	0.5 Wet	PASS	
18/5/11	663	8.41	98.0	1.0 Wet	PASS	
18/5/11	664	17.05	100.0	0.0	PASS	
18/5/11	665	17.50	99.5	0.5 Wet	PASS	
18/5/11	666	8.90	101.0	0.5 Wet	PASS	
18/5/11	667	9.34	98.0	0.5 Wet	PASS	
18/5/11	668	9.75	98.0	1.0 Wet	PASS	
19/5/11	669	10.16	101.0	1.0 Wet	PASS	
19/5/11	670	10.54	99.5	0.5 Wet	PASS	
19/5/11	671	16.35	101.5	2.0 Dry	PASS	
19/5/11	672	16.76	100.0	1.5 Dry	PASS	
19/5/11	673	11.01	101.0	0.5 Wet	PASS	
19/5/11	674	5.51	99.5	2.0 Wet	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 28 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
19/5/11	675	11.50	98.0	1.0 Dry	PASS	
19/5/11	676	17.15	102.0	0.0	PASS	
19/5/11	677	17.51	100.0	1.5 Dry	PASS	
20/5/11	678	10.21	98.5	1.5 Wet	PASS	
20/5/11	679	5.89	98.5	2.0 Wet	PASS	
20/5/11	680	17.91	101.0	0.5 Wet	PASS	
20/5/11	681	9.23	100.0	0.5 Dry	PASS	
20/5/11	682	9.64	101.0	1.0 Dry	PASS	
20/5/11	683	10.01	99.0	2.0 Dry	PASS	
20/5/11	684	12.90	98.5	2.0 Wet	PASS	
20/5/11	685	10.48	99.5	0.5 Wet	PASS	
20/5/11	686	10.89	99.5	0.0	PASS	
21/5/11	687	13.26	98.5	1.5 Wet	PASS	
21/5/11	688	16.88	101.0	0.5 Dry	PASS	
21/5/11	689	17.29	101.0	0.5 Wet	PASS	
21/5/11	690	18.29	99.0	1.5 Wet	PASS	
21/5/11	691	13.59	99.0	2.0 Wet	PASS	
21/5/11	692	6.29	98.0	0.5 Dry	PASS	
23/5/11	693	11.32	98.0	1.5 Dry	PASS	
23/5/11	694	11.68	98.5	1.5 Dry	PASS	
23/5/11	695	17.69	101.0	0.5 Wet	PASS	
23/5/11	696	12.04	99.5	0.5 Dry	PASS	
23/5/11	697	12.44	98.0	1.5 Dry	PASS	
23/5/11	698	18.04	102.0	0.5 Dry	PASS	
23/5/11	699	6.70	98.5	1.5 Wet	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 29 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
23/5/11	700	7.06	99.0	2.0 Wet	PASS	
23/5/11	701	18.43	101.0	1.5 Wet	PASS	
24/5/11	702	7.39	99.0	1.0 Wet	PASS	
24/5/11	703	7.09	98.5	2.0 Wet	PASS	
24/5/11	704	18.83	101.0	0.5 Dry	PASS	
24/5/11	705	19.19	100.0	0.5 Dry	PASS	
24/5/11	706	7.77	98.0	1.5 Wet	PASS	
24/5/11	707	7.52	98.5	1.5 Wet	PASS	
24/5/11	708	12.86	101.0	0.5 Dry	PASS	
24/5/11	709	19.60	101.0	1.0 Dry	PASS	
24/5/11	710	8.13	99.5	2.0 Wet	PASS	
25/5/11	711	20.04	101.5	0.5 Dry	PASS	
25/5/11	712	18.66	100.0	0.5 Dry	PASS	
25/5/11	713	22.38	98.5	1.0 Wet	PASS	
25/5/11	714	13.97	98.0	1.5 Wet	PASS	
25/5/11	715	7.85	100.5	1.5 Wet	PASS	
25/5/11	716	8.48	99.0	1.5 Wet	PASS	
25/5/11	717	20.35	100.0	0.5 Dry	PASS	
25/5/11	718	8.87	99.0	2.0 Wet	PASS	
26/5/11	719	8.21	98.5	0.5 Wet	PASS	
26/5/11	720	8.83	98.0	0.5 Wet	PASS	
26/5/11	721	9.20	99.5	1.5 Wet	PASS	
26/5/11	722	8.59	98.0	1.5 Wet	PASS	
26/5/11	723	10.50	98.0	1.5 Wet	PASS	
26/5/11	724	9.58	99.5	1.5 Wet	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 30 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
26/5/11	725	8.10	101.0	0.5 Dry	PASS	
26/5/11	726	12.55	98.5	0.5 Wet	PASS	
27/5/11	727	9.99	98.5	1.5 Wet	PASS	
27/5/11	728	9.02	98.0	2.0 Wet	PASS	
27/5/11	729	5.10	100.0	0.5 Dry	PASS	
27/5/11	730	5.46	98.5	0.5 Dry	PASS	
27/5/11	731	5.79	102.0	0.5 Wet	PASS	
27/5/11	732	6.15	100.5	0.5 Dry	PASS	
28/5/11	733	6.56	98.5	1.0 Wet	PASS	
28/5/11	734	6.95	98.5	0.5 Dry	PASS	
28/5/11	735	7.26	98.0	0.5 Dry	PASS	
8/6/11	736	9.45	99.5	1.5 Wet	PASS	
8/6/11	737	10.39	99.5	2.0 Wet	PASS	
8/6/11	738	7.71	101.0	0.5 Wet	PASS	
8/6/11	739	10.02	98.5	0.5 Dry	PASS	
9/6/11	740	10.38	101.0	1.0 Wet	PASS	
9/6/11	741	8.07	99.5	0.5 Wet	PASS	
9/6/11	742	9.78	98.5	0.5 Dry	PASS	
9/6/11	743	10.74	98.5	0.5 Dry	PASS	
9/6/11	744	8.41	98.0	2.0 Wet	PASS	
9/6/11	745	10.71	99.5	1.5 Wet	PASS	
9/6/11	746	11.13	100.0	1.5 Wet	PASS	
9/6/11	747	10.24	98.5	1.5 Wet	PASS	
10/6/11	748	11.15	99.0	0.5 Wet	PASS	
10/6/11	749	8.80	101.5	0.5 Dry	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 31 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
10/6/11	750	10.61	100.0	0.5 Dry	PASS	
10/6/11	751	11.49	100.5	0.5 Dry	PASS	
21/6/11	752	8.49	101.0	0.5 Dry	PASS	
21/6/11	753	11.41	100.0	0.5 Dry	PASS	
21/6/11	754	8.91	98.5	1.0 Wet	PASS	
21/6/11	755	11.69	98.0	0.0	PASS	
21/6/11	756	11.01	99.0	1.5 Wet	PASS	
21/6/11	757	11.87	98.5	1.5 Wet	PASS	
22/6/11	758	11.37	99.5	2.0 Wet	PASS	
22/6/11	759	12.26	99.0	1.5 Wet	PASS	
22/6/11	760	11.68	98.5	0.5 Dry	PASS	
22/6/11	761	12.54	98.5	0.5 Wet	PASS	
22/6/11	762	9.32	100.0	0.5 Wet	PASS	
22/6/11	763	12.00	102.0	0.5 Dry	PASS	
22/6/11	764	12.82	99.5	1.5 Wet	PASS	
22/6/11	765	12.03	98.0	2.0 Wet	PASS	
23/6/11	766	8.58	98.5	2.0 Wet	PASS	
23/6/11	767	12.61	99.0	1.5 Wet	PASS	
23/6/11	768	8.94	101.0	0.5 Dry	PASS	
23/6/11	769	9.31	99.0	0.5 Dry	PASS	
23/6/11	770	12.39	98.0	1.5 Wet	PASS	
23/6/11	771	13.10	99.5	1.5 Wet	PASS	
23/6/11	772	9.69	102.0	0.5 Wet	PASS	
24/6/11	773	9.76	100.0	0.5 Dry	PASS	
24/6/11	774	12.31	101.5	0.5 Dry	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 32 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
24/6/11	775	12.57	99.0	1.0 Wet	PASS	
24/6/11	776	10.15	99.0	0.5 Wet	PASS	
24/6/11	777	10.84	98.5	2.0 Wet	PASS	
24/6/11	778	11.20	99.5	1.5 Wet	PASS	
24/6/11	779	10.63	101.5	0.5 Dry	PASS	
24/6/11	780	12.96	101.0	0.5 Wet	PASS	
24/6/11	781	11.64	98.0	2.0 Wet	PASS	
24/6/11	782	11.03	98.5	0.5 Wet	PASS	
25/6/11	783	13.22	98.5	0.0	PASS	
25/6/11	784	11.42	101.0	1.0 Dry	PASS	
25/6/11	785	13.46	98.5	0.5 Dry	PASS	
25/6/11	786	11.83	100.0	0.5 Dry	PASS	
25/6/11	787	13.77	99.0	0.5 Dry	PASS	
25/6/11	788	12.22	102.0	0.5 Dry	PASS	
27/6/11	789	14.10	99.5	0.5 Wet	PASS	
27/6/11	790	12.58	99.5	0.5 Dry	PASS	
27/6/11	791	14.33	101.0	1.0 Wet	PASS	
27/6/11	792	12.89	100.0	0.5 Wet	PASS	
28/6/11	793	7.77	98.0	1.5 Wet	PASS	
28/6/11	794	8.13	99.5	1.5 Wet	PASS	
28/6/11	795	8.47	98.0	2.0 Wet	PASS	
28/6/11	796	8.86	98.0	1.5 Wet	PASS	
28/6/11	797	13.17	101.5	0.5 Dry	PASS	
28/6/11	798	10.10	98.5	2.0 Wet	PASS	
28/6/11	799	9.30	99.5	0.5 Wet	PASS	

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CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 33 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
29/6/11	800	9.66	99.5	0.5 Dry	PASS	
29/6/11	801	10.06	98.0	0.5 Dry	PASS	
29/6/11	802	12.12	98.5	1.5 Wet	PASS	
29/6/11	803	12.50	98.0	1.5 Wet	PASS	
30/6/11	804	12.88	99.5	1.5 Wet	PASS	
30/6/11	805	10.45	98.5	1.5 Wet	PASS	
30/6/11	806	10.76	99.0	2.0 Wet	PASS	
4/7/11	807	11.09	101.0	0.5 Dry	PASS	
4/7/11	808	11.37	101.5	0.5 Wet	PASS	
4/7/11	809	13.20	100.0	0.5 Dry	PASS	
5/7/11	810	6.94	99.0	1.5 Dry	PASS	
5/7/11	811	7.32	99.0	1.5 Dry	PASS	
5/7/11	812	7.73	99.5	2.0 Dry	PASS	
5/7/11	813	8.09	98.5	0.5 Wet	PASS	
5/7/11	814	8.37	99.0	1.5 Wet	PASS	
5/7/11	815	8.77	98.0	1.5 Wet	PASS	
6/7/11	816	9.00	98.5	0.5 Wet	PASS	
6/7/11	817	11.60	100.0	0.5 Wet	PASS	
6/7/11	818	13.53	98.0	0.5 Dry	PASS	
6/7/11	819	11.85	98.0	1.5 Wet	PASS	
6/7/11	820	13.84	98.5	1.5 Wet	PASS	
7/7/11	821	14.28	100.0	0.5 Wet	PASS	
7/7/11	822	12.16	100.5	0.5 Dry	PASS	
7/7/11	823	9.45	98.0	0.5 Wet	PASS	
7/7/11	824	12.34	98.5	1.5 Wet	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 34 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
7/7/11	825	12.80	98.0	2.0 Wet	PASS	
8/7/11	826	14.74	99.5	0.5 Wet	PASS	
8/7/11	827	6.63	101.0	1.5 Dry	PASS	
8/7/11	828	7.04	99.0	1.5 Dry	PASS	
8/7/11	829	7.42	99.5	2.0 Dry	PASS	
8/7/11	830	7.84	98.0	0.5 Wet	PASS	
8/7/11	831	8.30	98.0	0.5 Wet	PASS	
9/7/11	832	15.10	99.5	1.0 Wet	PASS	
9/7/11	833	12.55	100.0	0.5 Wet	PASS	
9/7/11	834	15.51	100.5	0.5 Wet	PASS	
9/7/11	835	12.94	98.5	0.5 Dry	PASS	
11/7/11	836	15.86	99.0	0.5 Dry	PASS	
11/7/11	837	13.35	98.5	1.5 Wet	PASS	
11/7/11	838	9.93	98.5	1.5 Wet	PASS	
11/7/11	839	13.68	99.5	0.5 Dry	PASS	
11/7/11	840	10.37	99.0	1.0 Dry	PASS	
12/7/11	841	14.08	100.5	0.5 Dry	PASS	
12/7/11	842	10.76	99.0	0.5 Dry	PASS	
12/7/11	843	14.49	98.5	0.0	PASS	
12/7/11	844	11.24	101.0	0.5 Dry	PASS	
12/7/11	845	11.72	99.5	0.5 Dry	PASS	
12/7/11	846	8.76	99.5	0.5 Dry	PASS	
13/7/11	847	9.09	99.0	1.0 Wet	PASS	
13/7/11	848	5.57	101.0	0.5 Dry	PASS	
13/7/11	849	5.95	101.0	0.5 Dry	PASS	

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CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 35 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
13/7/11	850	6.36	98.5	0.5 Dry	PASS	
13/7/11	851	6.78	98.0	0.5 Wet	PASS	
13/7/11	852	7.16	98.5	0.5 Dry	PASS	
14/7/11	853	7.62	98.0	1.5 Wet	PASS	
14/7/11	854	8.04	98.0	1.5 Wet	PASS	
14/7/11	855	8.43	99.5	0.5 Wet	PASS	
14/7/11	856	8.94	101.0	1.0 Dry	PASS	
14/7/11	857	9.32	99.0	0.5 Dry	PASS	
14/7/11	858	9.45	98.5	0.5 Dry	PASS	
15/7/11	859	9.71	101.0	1.5 Dry	PASS	
15/7/11	860	9.86	99.5	1.5 Dry	PASS	
15/7/11	861	10.09	100.0	0.5 Dry	PASS	
15/7/11	862	10.26	98.5	0.5 Dry	PASS	
15/7/11	863	12.16	99.0	0.5 Wet	PASS	
18/7/11	864	10.52	98.0	1.5 Wet	PASS	
18/7/11	865	10.65	99.0	2.0 Wet	PASS	
18/7/11	866	11.02	99.0	0.5 Wet	PASS	
18/7/11	867	10.85	98.5	0.5 Wet	PASS	
19/7/11	868	11.25	98.0	1.5 Wet	PASS	
19/7/11	869	11.11	99.5	1.5 Wet	PASS	
19/7/11	870	11.49	100.0	0.5 Dry	PASS	
19/7/11	871	11.42	101.0	0.5 Dry	PASS	
1/8/11	872	11.73	98.5	2.0 Wet	PASS	
1/8/11	873	12.00	98.0	2.0 Wet	PASS	
2/8/11	874	12.36	99.5	0.5 Dry	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 36 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
2/8/11	875	12.04	98.0	0.5 Wet	PASS	
3/8/11	876	12.42	98.0	1.5 Wet	PASS	
3/8/11	877	12.69	99.5	2.0 Wet	PASS	
4/8/11	878	12.90	101.0	1.5 Dry	PASS	
4/8/11	879	12.78	99.5	1.5 Dry	PASS	
5/8/11	880	14.97	101.0	1.5 Dry	PASS	
5/8/11	881	12.67	99.5	2.0 Dry	PASS	
6/8/11	882	9.77	99.5	0.5 Dry	PASS	
6/8/11	883	10.18	100.0	0.5 Wet	PASS	
6/8/11	884	13.41	98.0	1.5 Wet	PASS	
8/8/11	885	9.81	98.0	0.5 Wet	PASS	
8/8/11	886	10.07	98.5	0.5 Dry	PASS	
8/8/11	887	10.51	99.0	1.5 Dry	PASS	
8/8/11	888	10.20	98.0	1.5 Dry	PASS	
9/8/11	889	10.51	101.0	0.5 Dry	PASS	
9/8/11	890	10.87	99.5	1.0 Dry	PASS	
10/8/11	891	10.99	98.5	1.5 Wet	PASS	
10/8/11	892	11.32	98.0	2.0 Wet	PASS	
10/8/11	893	11.67	99.5	2.0 Dry	PASS	
10/8/11	894	11.99	101.0	1.5 Dry	PASS	
11/8/11	895	14.26	99.0	1.5 Wet	PASS	
11/8/11	896	14.89	98.0	1.5 Wet	PASS	
11/8/11	897	12.30	98.0	1.5 Wet	PASS	
24/8/11	898	12.20	92.5	6.5 Wet	FAIL	
24/8/11	899	12.25	97.5	3.5 Wet	FAIL	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 37 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
25/8/11	900	12.41	98.5	1.0 Wet	PASS	Retest of 899
26/8/11	901	13.22	99.0	1.5 Wet	PASS	
26/8/11	902	14.72	98.0	1.5 Wet	PASS	
26/8/11	903	15.31	98.0	2.0 Wet	PASS	
26/8/11	904	13.75	99.5	1.5 Wet	PASS	
29/8/11	905	12.38	99.0	1.0 Wet	PASS	Retest of 898
29/8/11	906	12.68	101.0	0.5 Wet	PASS	
31/8/11	907	8.80	98.0	1.5 Wet	PASS	
31/8/11	908	9.28	98.5	1.0 Wet	PASS	
31/8/11	909	9.81	98.0	2.0 Wet	PASS	
1/9/11	910	9.07	99.5	0.5 Wet	PASS	
1/9/11	911	9.51	100.0	0.5 Dry	PASS	
1/9/11	912	9.11	98.0	1.5 Dry	PASS	
1/9/11	913	10.07	98.0	2.0 Dry	PASS	
1/9/11	914	9.59	99.5	0.5 Dry	PASS	
1/9/11	915	10.08	98.5	0.5 Dry	PASS	
2/9/11	916	10.55	98.0	2.0 Wet	PASS	
2/9/11	917	8.95	99.5	0.5 Wet	PASS	
2/9/11	918	9.47	98.5	1.5 Wet	PASS	
2/9/11	919	9.88	98.0	1.5 Wet	PASS	
2/9/11	920	10.26	101.0	0.5 Dry	PASS	
5/9/11	921	6.01	101.0	1.5 Dry	PASS	
5/9/11	922	6.49	98.5	1.5 Wet	PASS	
5/9/11	923	6.91	99.0	1.5 Wet	PASS	
5/9/11	924	6.90	98.0	0.5 Wet	PASS	

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CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 38 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
5/9/11	925	7.35	99.5	0.5 Dry	PASS	
6/9/11	926	7.34	101.0	1.5 Dry	PASS	
6/9/11	927	7.71	99.5	1.5 Dry	PASS	
6/9/11	928	7.75	100.0	1.0 Dry	PASS	
6/9/11	929	8.02	98.5	0.5 Dry	PASS	
6/9/11	930	8.38	98.0	1.5 Wet	PASS	
6/9/11	931	8.21	99.0	2.0 Wet	PASS	
6/9/11	932	8.79	101.0	0.5 Dry	PASS	
6/9/11	933	8.67	100.5	0.5 Dry	PASS	
7/9/11	934	10.66	100.0	1.5 Dry	PASS	
7/9/11	935	10.67	98.5	1.5 Wet	PASS	
7/9/11	936	11.06	98.0	1.5 Wet	PASS	
7/9/11	937	11.49	99.0	1.5 Dry	PASS	
7/9/11	938	11.18	101.0	0.5 Dry	PASS	
7/9/11	939	11.90	98.5	1.0 Wet	PASS	
7/9/11	940	11.66	99.5	1.0 Dry	PASS	
8/9/11	941	12.21	99.0	1.0 Wet	PASS	
8/9/11	942	7.50	98.0	1.5 Wet	PASS	
8/9/11	943	7.10	99.0	1.0 Wet	PASS	
8/9/11	944	7.62	98.0	2.0 Wet	PASS	
8/9/11	945	8.06	99.5	1.0 Wet	PASS	
8/9/11	946	10.37	98.0	0.5 Wet	PASS	
8/9/11	947	10.85	101.0	1.0 Dry	PASS	
8/9/11	948	11.43	99.5	1.5 Dry	PASS	
9/9/11	949	9.12	98.0	1.0 Dry	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 39 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
9/9/11	950	9.48	98.0	0.5 Dry	PASS	
9/9/11	951	9.99	98.5	0.5 Dry	PASS	
12/9/11	952	10.40	98.0	1.0 Wet	PASS	
12/9/11	953	9.27	99.5	1.0 Wet	PASS	
12/9/11	954	9.66	100.0	0.0	PASS	
12/9/11	955	10.84	98.5	0.5 Dry	PASS	
12/9/11	956	10.03	98.0	1.5 Wet	PASS	
12/9/11	957	11.26	99.0	1.5 Wet	PASS	
12/9/11	958	11.62	99.0	1.5 Wet	PASS	
12/9/11	959	10.49	98.0	2.0 Wet	PASS	
13/9/11	960	12.06	98.0	1.5 Wet	PASS	
13/9/11	961	10.97	98.5	2.0 Wet	PASS	
13/9/11	962	8.64	99.0	0.5 Dry	PASS	
13/9/11	963	9.25	99.5	0.5 Wet	PASS	
13/9/11	964	9.83	98.0	1.0 Wet	PASS	
13/9/11	965	11.12	98.0	1.5 Wet	PASS	
13/9/11	966	11.71	98.0	1.5 Wet	PASS	
13/9/11	967	2.90	101.0	1.0 Dry	PASS	
14/9/11	968	3.31	99.5	1.5 Dry	PASS	
14/9/11	969	3.65	98.0	2.0 Dry	PASS	
14/9/11	970	4.12	98.5	1.5 Wet	PASS	
14/9/11	971	4.56	101.0	0.5 Dry	PASS	
14/9/11	972	4.94	99.5	0.5 Dry	PASS	
14/9/11	973	5.35	100.0	0.5 Dry	PASS	
14/9/11	974	5.75	98.0	1.0 Wet	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 40 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc
			DENSITY RATIO %	MOISTURE VARIATION		
14/9/11	975	6.21	98.0	2.0 Dry	PASS	
15/9/11	976	3.71	99.5	1.0 Dry	PASS	
15/9/11	977	4.09	98.0	1.5 Wet	PASS	
15/9/11	978	4.54	98.5	1.5 Wet	PASS	
15/9/11	979	4.93	98.0	2.0 Wet	PASS	
15/9/11	980	5.39	98.5	1.0 Dry	PASS	
15/9/11	981	5.85	99.5	1.5 Dry	PASS	
15/9/11	982	10.45	98.0	1.5 Dry	PASS	
15/9/11	983	11.02	99.0	0.5 Dry	PASS	
16/9/11	984	12.50	98.5	2.0 Wet	PASS	
16/9/11	985	11.43	98.5	1.5 Wet	PASS	
16/9/11	986	1.42	100.5	1.5 Dry	PASS	
16/9/11	987	1.93	99.0	1.5 Dry	PASS	
16/9/11	988	2.31	98.5	0.5 Wet	PASS	
16/9/11	989	2.73	98.5	1.5 Wet	PASS	
16/9/11	990	3.24	98.0	1.5 Dry	PASS	
16/9/11	991	3.61	99.5	0.5 Dry	PASS	
17/9/11	992	4.12	98.0	2.0 Wet	PASS	
17/9/11	993	4.58	98.0	2.0 Wet	PASS	
17/9/11	994	5.06	98.0	0.5 Wet	PASS	
17/9/11	995	5.38	100.0	0.5 Dry	PASS	
17/9/11	996	5.79	99.0	1.0 Wet	PASS	
17/9/11	997	6.23	98.5	1.5 Wet	PASS	
19/9/11	998	6.59	100.5	0.5 Dry	PASS	
19/9/11	999	6.75	98.0	1.0 Dry	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 41 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc.
			DENSITY RATIO %	MOISTURE VARIATION		
19/9/11	1000	7.00	99.0	1.5 Dry	PASS	
19/9/11	1001	7.21	99.5	2.0 Dry	PASS	
19/9/11	1002	7.36	98.0	2.0 Wet	PASS	
19/9/11	1003	7.60	98.0	1.5 Wet	PASS	
19/9/11	1004	7.77	99.0	1.5 Wet	PASS	
19/9/11	1005	8.04	98.5	1.5 Wet	PASS	
20/9/11	1006	8.28	98.0	2.0 Dry	PASS	
20/9/11	1007	11.57	98.5	2.0 Dry	PASS	
20/9/11	1008	14.13	101.0	1.0 Dry	PASS	
20/9/11	1009	10.75	98.0	2.0 Wet	PASS	
20/9/11	1010	8.23	98.0	2.0 Wet	PASS	
20/9/11	1011	8.55	99.0	2.0 Wet	PASS	
20/9/11	1012	8.70	98.5	1.5 Wet	PASS	
20/9/11	1013	8.96	98.0	2.0 Wet	PASS	
21/9/11	1014	9.48	101.0	1.0 Dry	PASS	
21/9/11	1015	9.06	99.0	0.5 Dry	PASS	
21/9/11	1016	9.99	98.5	2.0 Dry	PASS	
21/9/11	1017	9.40	98.0	1.5 Dry	PASS	
21/9/11	1018	8.56	100.0	0.5 Dry	PASS	
21/9/11	1019	10.67	100.5	1.0 Dry	PASS	
21/9/11	1020	9.15	98.0	2.0 Dry	PASS	
21/9/11	1021	8.94	98.0	2.0 Wet	PASS	
21/9/11	1022	11.11	98.0	2.0 Wet	PASS	
22/9/11	1023	11.57	100.5	1.0 Dry	PASS	
22/9/11	1024	9.30	101.0	0.5 Dry	PASS	

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CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 42 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc.
			DENSITY RATIO %	MOISTURE VARIATION		
22/9/11	1025	10.02	98.0	1.5 Wet	PASS	
22/9/11	1026	9.88	101.0	0.5 Dry	PASS	
22/9/11	1027	10.45	100.0	1.0 Dry	PASS	
22/9/11	1028	9.72	98.0	1.5 Dry	PASS	
22/9/11	1029	12.08	99.5	1.5 Dry	PASS	
22/9/11	1030	11.63	98.5	1.5 Dry	PASS	
23/9/11	1031	10.96	99.0	1.5 Wet	PASS	
23/9/11	1032	10.34	98.0	1.5 Wet	PASS	
23/9/11	1033	12.60	98.0	1.5 Wet	PASS	
23/9/11	1034	10.20	98.5	2.0 Wet	PASS	
23/9/11	1035	10.78	98.0	1.0 Dry	PASS	
23/9/11	1036	11.42	99.5	0.5 Dry	PASS	
24/9/11	1037	13.01	101.0	1.0 Dry	PASS	
24/9/11	1038	10.48	99.0	0.5 Dry	PASS	
24/9/11	1039	10.74	98.5	0.5 Wet	PASS	
24/9/11	1040	13.50	99.5	1.0 Wet	PASS	
27/9/11	1041	11.17	96.0	6.0 Wet	FAIL	
27/9/11	1042	10.51	94.5	7.5 Wet	FAIL	
28/9/11	1043	11.06	99.5	1.0 Wet	PASS	Retest of No 1041
28/9/11	1044	12.83	101.0	0.5 Dry	PASS	
28/9/11	1045	11.79	98.5	1.0 Dry	PASS	
28/9/11	1046	11.87	100.0	0.5 Dry	PASS	
28/9/11	1047	12.38	101.5	0.5 Dry	PASS	
30/9/11	1048	11.71	98.0	1.5 Wet	PASS	
30/9/11	1049	11.14	99.5	1.5 Wet	PASS	

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PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 43 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc.
			DENSITY RATIO %	MOISTURE VARIATION		
5/10/11	1050	11.47	98.0	1.0 Wet	PASS	
5/10/11	1051	11.98	98.5	1.5 Wet	PASS	
6/10/11	1052	12.27	101.0	0.5 Dry	PASS	
6/10/11	1053	11.82	98.0	1.0 Dry	PASS	
6/10/11	1054	12.28	98.0	2.0 Wet	PASS	
6/10/11	1055	12.60	98.5	1.5 Wet	PASS	
10/10/11	1056	11.11	100.0	1.0 Dry	PASS	
10/10/11	1057	11.26	98.5	0.5 Dry	PASS	
10/10/11	1058	12.95	100.0	1.0 Dry	PASS	
10/10/11	1059	12.73	99.0	0.5 Dry	PASS	
11/10/11	1060	11.57	101.0	1.0 Dry	PASS	
11/10/11	1061	11.41	102.0	1.0 Dry	PASS	
11/10/11	1062	10.37	98.0	1.0 Wet	PASS	Retest of No 1042
11/10/11	1063	11.85	100.0	0.5 Dry	PASS	
11/10/11	1064	11.73	99.5	0.5 Dry	PASS	
12/10/11	1065	6.26	98.0	1.5 Dry	PASS	
12/10/11	1066	9.53	99.0	2.0 Dry	PASS	
12/10/11	1067	9.89	99.5	2.0 Dry	PASS	
12/10/11	1068	6.68	98.0	2.0 Dry	PASS	
12/10/11	1069	7.11	100.0	1.0 Dry	PASS	
12/10/11	1070	9.91	98.0	1.5 Dry	PASS	
13/10/11	1071	10.37	98.0	0.5 Wet	PASS	
13/10/11	1072	7.52	99.5	1.0 Wet	PASS	
13/10/11	1073	7.90	101.0	1.5 Dry	PASS	
13/10/11	1074	10.69	99.5	1.5 Dry	PASS	

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PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 44 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc.
			DENSITY RATIO %	MOISTURE VARIATION		
13/10/11	1075	8.30	98.5	2.0 Dry	PASS	
13/10/11	1076	11.02	99.0	1.5 Dry	PASS	
13/10/11	1077	10.09	98.0	1.0 Dry	PASS	
13/10/11	1078	10.56	98.0	1.5 Dry	PASS	
14/10/11	1079	10.97	99.5	2.0 Dry	PASS	
14/10/11	1080	11.33	98.5	2.0 Dry	PASS	
14/10/11	1081	11.76	99.0	1.5 Dry	PASS	
14/10/11	1082	8.92	98.0	1.5 Wet	PASS	
14/10/11	1083	12.10	101.0	1.5 Dry	PASS	
14/10/11	1084	9.30	98.0	1.5 Wet	PASS	
17/10/11	1085	12.16	101.5	1.0 Dry	PASS	
17/10/11	1086	12.52	101.0	1.5 Dry	PASS	
17/10/11	1087	10.78	98.0	1.5 Wet	PASS	
17/10/11	1088	11.11	98.5	2.0 Wet	PASS	
17/10/11	1089	11.36	98.0	1.5 Wet	PASS	
17/10/11	1090	11.80	99.5	0.5 Dry	PASS	
18/10/11	1091	10.81	101.0	1.0 Dry	PASS	
18/10/11	1092	9.73	98.5	1.5 Dry	PASS	
18/10/11	1093	11.20	98.0	1.5 Wet	PASS	
18/10/11	1094	10.17	98.0	2.0 Wet	PASS	
18/10/11	1095	10.55	100.0	1.5 Dry	PASS	
18/10/11	1096	10.95	98.5	2.0 Dry	PASS	
18/10/11	1097	13.25	101.5	1.5 Dry	PASS	
19/10/11	1098	12.21	98.5	2.0 Wet	PASS	
19/10/11	1099	12.57	98.0	2.0 Wet	PASS	

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PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 45 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc.
			DENSITY RATIO %	MOISTURE VARIATION		
19/10/11	1100	11.44	100.5	1.0 Dry	PASS	
19/10/11	1101	13.92	98.5	0.5 Dry	PASS	
19/10/11	1102	13.03	99.0	1.5 Dry	PASS	
20/10/11	1103	14.26	100.0	1.0 Dry	PASS	
20/10/11	1104	11.70	98.5	1.5 Dry	PASS	
20/10/11	1105	12.28	98.0	2.0 Dry	PASS	
20/10/11	1106	12.61	99.5	1.0 Dry	PASS	
20/10/11	1107	13.02	98.0	2.0 Dry	PASS	
21/10/11	1108	13.34	100.5	1.5 Dry	PASS	
21/10/11	1109	13.70	98.0	1.5 Dry	PASS	
21/10/11	1110	14.04	101.0	1.5 Dry	PASS	
21/10/11	1111	11.43	98.5	2.0 Dry	PASS	
22/10/11	1112	22.45	100.5	1.0 Dry	PASS	
22/10/11	1113	22.78	99.5	2.0 Dry	PASS	
22/10/11	1114	23.08	98.0	2.0 Dry	PASS	
24/10/11	1115	11.74	101.0	1.0 Dry	PASS	
24/10/11	1116	11.56	102.0	0.5 Dry	PASS	
24/10/11	1117	12.15	99.0	0.5 Dry	PASS	
24/10/11	1118	11.94	98.5	0.5 Dry	PASS	
24/10/11	1119	11.39	99.0	1.5 Dry	PASS	
25/10/11	1120	11.70	98.0	2.0 Dry	PASS	
25/10/11	1121	12.41	99.5	1.5 Dry	PASS	
25/10/11	1122	12.30	98.5	1.0 Dry	PASS	
28/10/11	1123	8.83	98.0	2.0 Dry	PASS	
28/10/11	1124	9.56	98.5	2.0 Dry	PASS	

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CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 46 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc.
			DENSITY RATIO %	MOISTURE VARIATION		
28/10/11	1125	9.41	98.0	1.5 Wet	PASS	
28/10/11	1126	10.07	98.0	1.0 Dry	PASS	
28/10/11	1127	10.27	99.5	2.0 Dry	PASS	
28/10/11	1128	9.51	98.5	1.0 Dry	PASS	
29/10/11	1129	8.50	98.0	1.5 Dry	PASS	
29/10/11	1130	8.98	99.5	1.5 Dry	PASS	
29/10/11	1131	8.10	100.5	2.0 Dry	PASS	
29/10/11	1132	9.50	98.0	1.0 Dry	PASS	
29/10/11	1133	10.03	101.0	1.0 Dry	PASS	
31/10/11	1134	10.49	99.0	1.5 Wet	PASS	
31/10/11	1135	10.90	98.0	2.0 Dry	PASS	
31/10/11	1136	11.42	98.5	1.5 Dry	PASS	
31/10/11	1137	8.62	98.0	0.5 Wet	PASS	
31/10/11	1138	9.09	98.0	1.5 Wet	PASS	
31/10/11	1139	9.62	98.5	1.5 Dry	PASS	
31/10/11	1140	10.06	99.5	0.5 Wet	PASS	
31/10/11	1141	10.59	100.0	0.5 Dry	PASS	
1/11/11	1142	11.17	101.0	0.5 Dry	PASS	
1/11/11	1143	11.61	98.5	1.5 Dry	PASS	
1/11/11	1144	12.07	99.5	1.0 Dry	PASS	
1/11/11	1145	12.55	99.5	1.5 Dry	PASS	
1/11/11	1146	12.91	100.5	0.5 Dry	PASS	
1/11/11	1147	13.39	98.5	2.0 Dry	PASS	
1/11/11	1148	11.28	98.0	1.5 Wet	PASS	
1/11/11	1149	11.90	98.0	1.5 Wet	PASS	

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CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 47 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc.
			DENSITY RATIO %	MOISTURE VARIATION		
2/11/11	1150	12.36	98.0	1.5 Dry	PASS	
2/11/11	1151	12.85	98.5	2.0 Dry	PASS	
2/11/11	1152	12.76	98.0	1.0 Wet	PASS	
2/11/11	1153	12.92	99.0	0.5 Wet	PASS	
2/11/11	1154	12.18	98.0	0.5 Wet	PASS	
2/11/11	1155	10.02	98.0	1.5 Wet	PASS	
5/11/11	1156	11.87	99.5	1.5 Dry	PASS	
5/11/11	1157	12.36	98.0	1.5 Wet	PASS	
5/11/11	1158	10.53	98.5	1.0 Dry	PASS	
5/11/11	1159	12.98	100.5	0.5 Dry	PASS	
5/11/11	1160	13.46	98.0	1.5 Dry	PASS	
5/11/11	1161	14.04	98.5	1.0 Dry	PASS	
7/11/11	1162	7.60	99.0	1.0 Wet	PASS	
7/11/11	1163	8.11	99.5	0.5 Dry	PASS	
7/11/11	1164	8.44	98.0	2.0 Wet	PASS	
7/11/11	1165	9.02	98.5	0.5 Dry	PASS	
7/11/11	1166	12.66	101.5	0.5 Dry	PASS	
7/11/11	1167	13.20	99.5	0.5 Wet	PASS	
7/11/11	1168	9.63	98.0	2.0 Dry	PASS	
8/11/11	1169	23.02	99.5	1.0 Dry	PASS	
8/11/11	1170	23.42	98.0	1.5 Dry	PASS	
8/11/11	1171	23.93	99.0	0.5 Dry	PASS	
8/11/11	1172	24.09	100.5	0.5 Dry	PASS	
8/11/11	1173	24.48	98.0	1.5 Wet	PASS	
8/11/11	1174	24.66	99.0	1.5 Wet	PASS	

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PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 48 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc.
			DENSITY RATIO %	MOISTURE VARIATION		
8/11/11	1175	25.10	98.5	1.5 Dry	PASS	
8/11/11	1176	24.97	100.5	1.5 Dry	PASS	
8/11/11	1177	25.45	98.0	2.0 Wet	PASS	
9/11/11	1178	13.72	98.5	2.0 Wet	PASS	
9/11/11	1179	14.16	99.0	1.5 Wet	PASS	
9/11/11	1180	14.65	99.5	1.5 Dry	PASS	
9/11/11	1181	15.16	99.5	1.0 Dry	PASS	
9/11/11	1182	10.01	98.0	2.0 Dry	PASS	
9/11/11	1183	10.52	98.5	2.0 Dry	PASS	
9/11/11	1184	15.57	99.5	2.0 Dry	PASS	
9/11/11	1185	11.03	100.5	1.5 Dry	PASS	
10/11/11	1186	25.04	101.0	0.5 Dry	PASS	
10/11/11	1187	11.39	99.5	1.0 Dry	PASS	
10/11/11	1188	11.91	101.5	0.5 Dry	PASS	
10/11/11	1189	12.46	98.0	2.0 Dry	PASS	
10/11/11	1190	12.95	99.0	2.0 Dry	PASS	
11/11/11	1191	13.10	101.0	1.0 Dry	PASS	
11/11/11	1192	13.58	98.0	1.5 Dry	PASS	
11/11/11	1193	15.90	99.5	0.5 Dry	PASS	
11/11/11	1194	16.26	100.0	1.0 Dry	PASS	
11/11/11	1195	16.67	98.0	0.5 Wet	PASS	
11/11/11	1196	8.10	98.5	1.0 Wet	PASS	
11/11/11	1197	8.69	98.0	0.5 Dry	PASS	
11/11/11	1198	17.00	101.0	0.5 Dry	PASS	
12/11/11	1199	25.40	100.0	0.5 Dry	PASS	

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CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

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DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc.
			DENSITY RATIO %	MOISTURE VARIATION		
12/11/11	1200	23.46	98.5	0.5 Wet	PASS	
12/11/11	1201	23.80	101.5	0.5 Dry	PASS	
12/11/11	1202	25.61	99.5	1.5 Dry	PASS	
12/11/11	1203	25.96	98.0	2.0 Dry	PASS	
14/11/11	1204	9.32	98.5	1.0 Wet	PASS	
14/11/11	1205	9.90	99.5	1.5 Wet	PASS	
14/11/11	1206	10.58	99.5	1.5 Wet	PASS	
14/11/11	1207	12.96	100.5	0.5 Dry	PASS	
14/11/11	1208	10.14	99.0	1.0 Dry	PASS	
14/11/11	1209	11.29	98.0	1.5 Wet	PASS	
14/11/11	1210	13.37	98.0	1.5 Dry	PASS	
14/11/11	1211	10.62	98.0	1.5 Dry	PASS	
15/11/11	1212	11.08	100.0	0.5 Dry	PASS	
15/11/11	1213	13.68	98.5	1.0 Dry	PASS	
15/11/11	1214	11.90	98.0	0.5 Dry	PASS	
15/11/11	1215	12.57	99.5	1.0 Dry	PASS	
15/11/11	1216	14.01	101.0	0.5 Wet	PASS	
15/11/11	1217	11.53	99.5	0.5 Wet	PASS	
15/11/11	1218	13.15	98.0	1.5 Dry	PASS	
16/11/11	1219	14.39	99.5	0.5 Dry	PASS	
16/11/11	1220	12.00	100.5	1.0 Dry	PASS	
16/11/11	1221	13.76	98.0	1.5 Wet	PASS	
16/11/11	1222	14.44	98.0	0.5 Dry	PASS	
16/11/11	1223	12.44	101.5	0.5 Wet	PASS	
16/11/11	1224	14.70	99.0	0.5 Wet	PASS	

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PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 50 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc.
			DENSITY RATIO %	MOISTURE VARIATION		
16/11/11	1225	10.70	101.0	1.5 Dry	PASS	
16/11/11	1226	15.16	98.0	1.5 Dry	PASS	
17/11/11	1227	10.06	99.0	0.5 Dry	PASS	
17/11/11	1228	11.75	99.0	1.0 Dry	PASS	
17/11/11	1229	12.09	99.5	1.0 Wet	PASS	
17/11/11	1230	10.49	98.0	0.5 Wet	PASS	
17/11/11	1231	11.00	100.5	0.5 Dry	PASS	
17/11/11	1232	12.47	100.0	0.5 Wet	PASS	
17/11/11	1233	11.28	98.0	1.0 Dry	PASS	
17/11/11	1234	11.10	98.0	1.5 Dry	PASS	
17/11/11	1235	11.46	98.0	2.0 Dry	PASS	
18/11/11	1236	11.87	99.0	1.0 Dry	PASS	
18/11/11	1237	10.36	98.5	2.0 Dry	PASS	
18/11/11	1238	10.91	99.5	2. 0Dry	PASS	
18/11/11	1239	12.43	98.0	1.5 Dry	PASS	
18/11/11	1240	12.95	100.5	0.5 Dry	PASS	
18/11/11	1241	11.48	98.0	0.5 Wet	PASS	
18/11/11	1242	13.39	98.0	1.5 Wet	PASS	
18/11/11	1243	11.88	98.0	1.5 Wet	PASS	
19/11/11	1244	10.56	101.0	1.0 Dry	PASS	
19/11/11	1245	11.07	98.5	0.5 Dry	PASS	
19/11/11	1246	11.62	99.5	0.5 Dry	PASS	
19/11/11	1247	12.05	100.0	0.5 Wet	PASS	
19/11/11	1248	12.54	100.0	1.5 Wet	PASS	
19/11/11	1249	13.00	98.5	1.0 Dry	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade

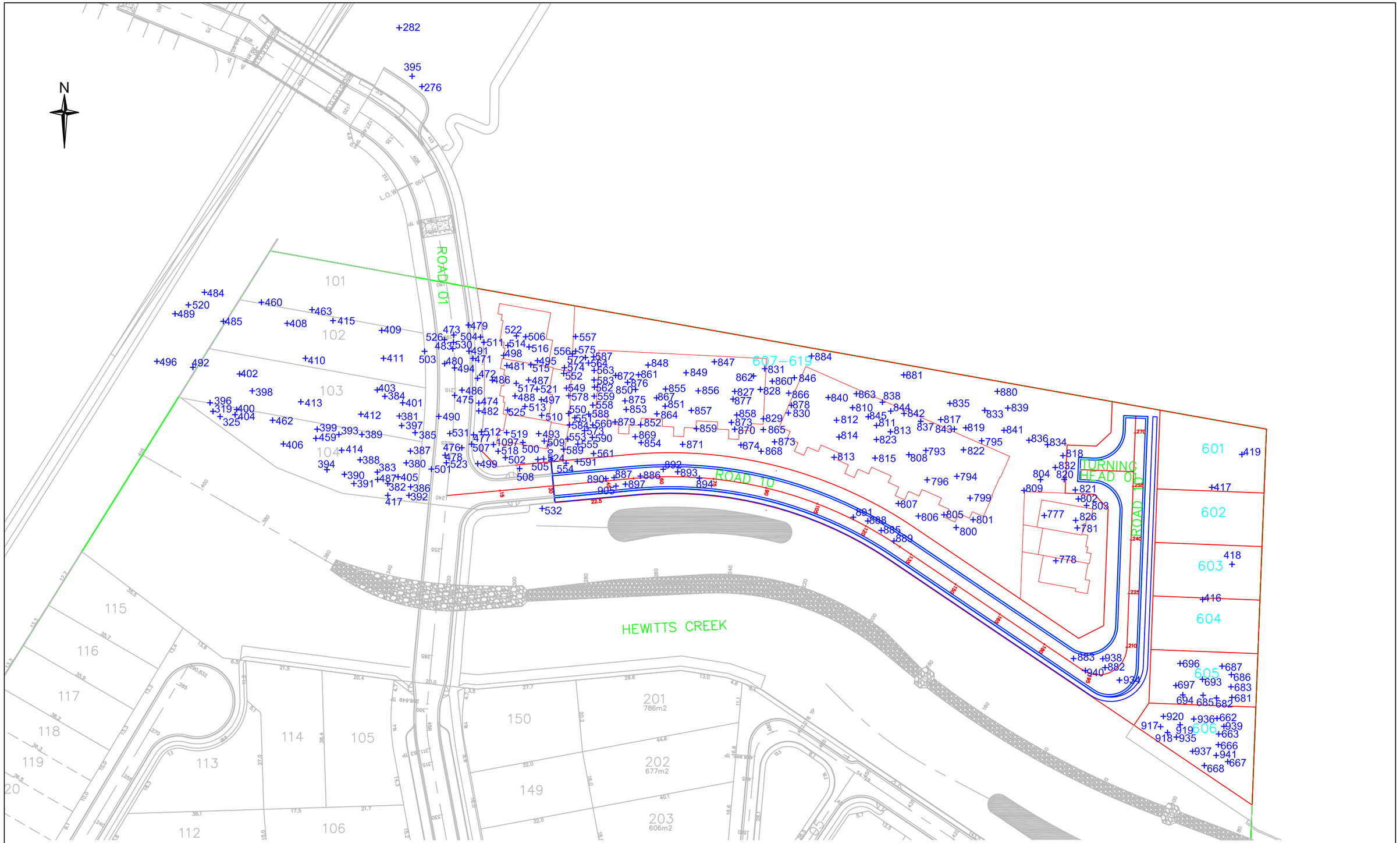
CLIENT: STOCKLAND DEVELOPMENTS PTY LTD C/- CARDNO PTY LTD

PROJECT: STAGES 1 – 4 & 6 McCAULEY'S BEACH ESTATE, BULLI PROJECT: 671056

LOCATION: SITE FILLING PAGE: 51 OF 51

DATE	DENSITY TEST NO.	RL	RESULTS		PASS / FAIL	COMMENT Retest/Comments Etc.
			DENSITY RATIO %	MOISTURE VARIATION		
21/11/11	1250	15.22	100.5	0.5 Dry	PASS	
21/11/11	1251	12.92	102.0	1.0 Dry	PASS	
21/11/11	1252	13.44	99.0	2.0 Wet	PASS	
21/11/11	1253	12.29	99.0	2.0 Wet	PASS	
21/11/11	1254	12.73	99.0	1.5 Wet	PASS	
21/11/11	1255	13.93	98.0	2.0 Wet	PASS	
21/11/11	1256	13.40	98.5	2.0 Dry	PASS	
21/11/11	1257	15.61	98.5	1.0 Dry	PASS	
22/11/11	1258	14.49	101.5	1.0 Dry	PASS	
22/11/11	1259	13.17	99.5	1.0 Wet	PASS	
22/11/11	1260	13.44	100.0	1.5 Wet	PASS	
22/11/11	1261	13.95	98.0	1.5 Wet	PASS	
22/11/11	1262	14.51	98.5	2.0 Dry	PASS	

LEGEND – BFL = Below Finished Level, BSG = Below Subgrade



Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Stockland Developments c/o Cardno Pty Ltd	TITLE: **Location of Density Tests** **Site Filling** **Stage 6, McCauley's Beach Estate, BULLI**	PROJECT No: 671056.00
	OFFICE: Wollongong DRAWN BY: BFR		DRAWING No: A
	SCALE: As shown DATE: 6.12.2011		REVISION: H

N MGA

Appendix F

CSIRO Publication

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

BTF 18 replaces Information Sheet 10/91

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

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

Soil Types

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

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

Causes of Movement

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

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

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

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

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

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

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

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

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

GENERAL DEFINITIONS OF SITE CLASSES

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

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

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

Unevenness of Movement

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

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

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

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

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

Effects of Uneven Soil Movement on Structures

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

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

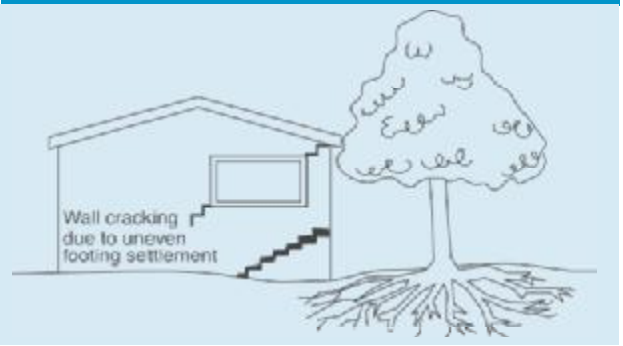
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

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

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

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

Trees can cause shrinkage and damage



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

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

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

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

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

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

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

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

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

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

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

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

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

Water Service and Drainage

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

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

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

Seriousness of Cracking

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

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

Prevention/Cure

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

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

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

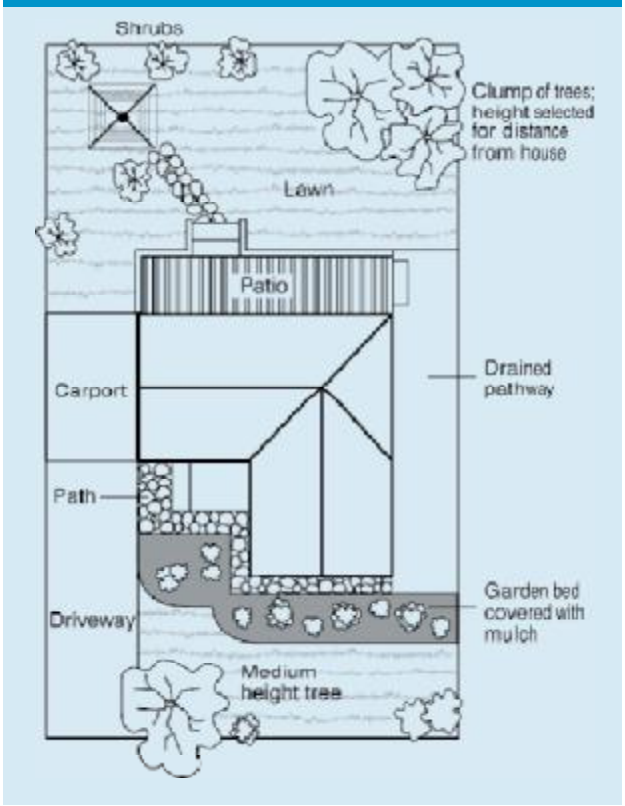
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

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

Gardens for a reactive site



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

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

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

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

Condensation

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

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

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

The garden

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

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

Existing trees

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

Information on trees, plants and shrubs

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

Excavation

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

Remediation

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

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

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

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