

## PROPOSED SALAMANDER SHORES HOTEL REDEVELOPMENT

Sake Development Pty Ltd

GEOTWARA20848AA-AB 24 March 2009

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24 March 2009

Sake Development Pty Ltd Suite 11, 340 Darling Street BALMAIN NSW 2041

Attention: Sarah Kelly

Dear Sarah

## RE: PROPOSED SALAMANDER SHORES HOTEL REDEVELOPMENT SOLDIERS POINT ROAD, SOLDIERS POINT GEOTECHNICAL ASSESSMENT

Please find enclosed our report on the above project.

If you have any questions regarding this matter please contact Andrew Tait or the undersigned.

For and on behalf of Coffey Geotechnics Pty Ltd

More Deleme

Mark Delaney
Principle Engineering Geologist

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CSIRO Sheet BTF 18, 'Foundation Maintenance and Footing Performance: A Home Owner's Guide"

Attachment 1, 2 and 3

Acid Sulfate Soils Information Sheet

Important Information About Your Coffey Report

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## Appendices

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- Appendix C: Hydraulic Conductivity Calculations

## 1 INTRODUCTION

This report presents the results of a geotechnical assessment carried out by Coffey Geotechnics Pty Ltd (Coffey) for the proposed redevelopment of the All Seasons Salamander Shores Hotel located on Soldiers Point Road, Soldiers Point.

The work was commissioned by Chris Herbert of Salamander Shores Hotel Pty Ltd in a letter dated 28 November 2008.

Conceptual plans provided to Coffey show the construction of a four storey hotel with 180 rooms with underground (basement parking) and four five level apartment blocks housing 20 apartments each. It is understood that this concept may vary significantly prior to final Development Application (DA) lodgement.

This report provides a geotechnical assessment for conceptual design and development approval purposes to identify the key geotechnical constraints at the site and provide preliminary design parameters. The scope of work provides preliminary recommendations on:

- Acid Sulphate soils;
- Slope stability;
- Site classification to AS2870-1996;
- Site Preparation and earthworks;
- Excavation conditions, support and preliminary retaining wall design parameters;
- Alternative footing types, founding depths and allowable bearing pressures.

Conceptual architectural plans, elevations and sections of the proposed development were provided by the client.

## 2 FIELD WORK

Field work was carried out in two stages, Stage 1 on 9 December 2008 and Stage 2 on, 23 February and 24 February 2009. Groundwater monitoring and testing was conducted on 5 March 2009. Site fieldwork activities were limited by site access and the existing hotel activities.

Stage 1 comprised:

- Drilling seven boreholes (HA1 HA7) using hand auger methods to refusal on highly weathered rock, with depths ranging from 0.25m to 1.0m. Each borehole was advanced to refusal except for HA7 which was terminated at 2.0m within aeolian (wind blown) sands;
- Site observations and mapping of existing site features.

Stage 2 comprised:

- Drilling two boreholes (BH1 and BH2) using NMLC diamond bit coring methods to 5.6m and 7.0m respectively;
- Installation of PVC standpipes for groundwater level monitoring and testing.

All field work was carried out in the full time presence of an Engineering Geologist from Coffey who located the boreholes and produced field logs of the boreholes. Engineering logs of the boreholes are presented in Appendix A, together with explanation sheets defining the terms and symbols used in its preparation.

Borehole test locations were located by tape measurements relative to site boundaries. Reduced levels (mAHD) were interpreted from contours reproduced on drawings provided by the client and should only be considered approximate.

The approximate locations of boreholes and site features are presented in Figure AB1.

## 3 SITE CONDITIONS

## 3.1 Surface Conditions

The site is located on the eastern side of Soldiers Point Road, Soldiers Point. Site dimensions are approximately 100m wide by 130m long and occupy an approximate area of 12300m<sup>2</sup>. The site is bounded by Port Stephens Sailing and Aquatic Club to the east, maintained reserve and parklands to the north and undeveloped bushland to the south. The foreshore of Port Stephens is situated approximately 50m to the east of the site boundary.

Regional topography in the vicinity of the site is typified by an elongated peninsular (Soldiers Point) extending into Port Stephens approximately 600m wide and 3km long with a transition of residual slightly undulating terrain situated to the west of the area and near shore low lying aeolian dunes and estuarine tidal flats toward the east.

The site is positioned on the northern side a prominent low rounded residual knoll/hill with surface relief ranging from approximately RL20m to RL6m (AHD). The site predominately slopes toward the north west with slope angles in the order of 15° to 10° toward the upper slopes of the hill flatting to 5° toward Soldiers Point Road. The site slopes toward east / north east along the eastern boundary at 5° increasing to 10° to 15° toward the mid and lower slopes of the hill where it flattens at the foreshore of Port Stephens. A near vertical rock cutting is situated to the east of the site, approximately 8m high, with Port Stephens Sailing and Aquatic club clubhouse positioned within this area.

The site is currently occupied by a brick construction multilevel hotel fronting Solider Point Road, with associated car parks and garden beds. No evidence of brickwork distress was noted from external observation.

Numerous small rock outcrops, comprising very high strength rhyodacite (volcanic rock), were observed along the eastern site boundary and in the adjacent council reserve. Slightly weathered rhyodacite was also observed in the rock cutting adjacent to the Sailing and Aquatic Club

Drainage at the site is assessed to occur predominantly by infiltration into the sand subsoil with some minor overland flow over paved surfaces directed to dedicated storm water drainage structures over the site. Vegetation across the site comprises maintained lawns and gardens, with some stands of trees up to 10m height.

## 3.2 Subsurface Conditions

Reference to the 1:250,000 scale Newcastle Geological Series Sheet S1 56-1 indicates the site is underlain by the Nerong Volcanics comprising toscanite, dacite, andesite, ignimbrite, agglomerate, conglomerate, sandstone and siltstone.

The typical subsurface profile encountered at the site has been divided into geological units and is summarised in Table 1.

GEOTECHNICAL UNIT	SOIL TYPE	DESCRIPTION
UNIT 1	AEOLIAN SAND	SAND, fine to medium grained, brown / dark brown and yellow / light brown, medium dense.
UNIT 2A	RESIDUAL SOIL/ EXTREMELY WEATHERED ROCK	Sandy CLAY/Clayey SAND, medium plasticity brown to yellow, fine to coarse sand. Moisture content generally less than plastic limits with a very stiff consistency.
UNIT 2B	HIGHLY WEATHERED RHYODACITE (Volcanic Rock)	Coarse grained crystal structure, light pink and blue grey, highly to moderately weathered, very high to extremely high strength
UNIT 2C	MODERATELY WEATHERED TO FRESH RHYODACITE (Volcanic Rock)	Coarse grained crystal structure, light pink and blue grey, slightly weathered to fresh, extremely high strength.

TABLE 1 – SUMMARY OF TYPICAL SUBSURFACE PROFILE ENCOUNTERED

## TABLE 2 - SUMMARY OF SOIL UNITS ENCOUNTERED AT EACH BOREHOLE LOCATION

	DEPTH OF INFERRED GEOTECHNICAL UNIT BELOW SURFACE LEVEL (m)					
TEST ID	Unit 1A (Topsoil)	Unit 1B (Aeolian Sand)	Unit 2A (Extremely Weathered Rhyodacite)	Unit 2B (Highly to Moderately Weathered Rhyodacite)	Unit 2C (Slightly Weathered to Fresh Rhyodacite)	
HA1	0.00 - 0.30	-	0.30 – 0.31	>0.31	-	
HA2	0.00 - 0.20	-	0.20 – 0.45	>0.45	-	
HA3	0.00 - 0.20	-	0.20 – 1.00	>1.00	-	
HA4	0.00 - 0.05	-	0.05 – 0.85	>0.85 -	-	
HA5	-	0.00 - 0.15	0.15 – 0.25	>0.25	-	

	DEPTH OF INFERRED GEOTECHNICAL UNIT BELOW SURFACE LEVEL (m)				
TEST ID	Unit 1A (Topsoil)	Unit 1B (Aeolian Sand)	Unit 2A (Extremely Weathered Rhyodacite)	Unit 2B (Highly to Moderately Weathered Rhyodacite)	Unit 2C (Slightly Weathered to Fresh Rhyodacite)
HA6	0.00 - 0.10	0.10 – 0.20	0.20 - 0.40	>0.40	-
HA7	0.00 - 0.10	0.10 - >2.0	-	-	-
BH1	-	-	0.3 – 1.30	1.30 – 1.60	1.60 - >5.61
BH2	-	0.20 - 0.60	0.60 – 1.30	1.30 – 1.80	1.80 ->7.00

Existing pavement gravel fill was encountered within bores BH1 and BH2 to a maximum depth of 0.3m.

The rhyodacite is a volcanic extrusive rock (lava) with a crystal structure predominately comprised phenocrysts (large crystals 1mm to 5mm) of quartz and K (potassium) feldspar within a fine grained pyroxene (iron) matrix. The rock is characterised by a very high to extremely high strength.

Defects throughout the rock mass comprise mainly of moderately dipping joints with clean or slightly ironstained joint faces. Some weathered clay seams occur throughout the rockmass representing weathering zones of secondary hydrothermal mineralisation and alteration. Defect spacing within the rock mass generally increases with depth, with the general defect spacing in Unit 2B in the order of 100m to 300m increasing in Unit 2C to 300mm to 1000mm. Local outcropping and previous experience with rhyodacite materials in the area suggest the defects within the rock mass form a predominately columnar jointing structure. Areas of localised intense random jointing may be apparent along previous cooling margins and hydrothermal intrusion within the rock mass.

A photograph of the rock cutting behind the Sailing and Aquatic Club, located to the east of the site shows the typical jointing structure of the exposed rhyodacite.



**Photograph 1** – Cutting behind the Sailing and Aquatic Club to the east of the site, red dashed line annotates the predominant columnar structure of the rhyodacite rock.

## 3.3 Groundwater

PVC standpipe wells were installed in each of the cored boreholes (BH1 and BH2) to assess the groundwater conditions in the rock. Installation of these wells included a bentonite seal within the overlying soils to prevent interference from perched groundwater in the soils.

Standing groundwater level was measured on 5 March 2009 at 1.1m below existing surface level in BH1 (RL8.9m AHD) and 2.6m below existing surface level in BH2 (RL9.4m AHD).

It is assessed that a perched water table would exist at the interface of the Unit 1 aeolian sand and Unit 2 weathered rock during or immediately after intense periods of rainfall.

Development of each well was undertaken on 5 March and consisted of bailing each of the wells until well was effectively dry. Rising head permeability testing was conducted in each of the boreholes comprising initial water measurements before bailing and during the recovery period for each well at nominal time intervals, results are summarised in Table 3 and attached in Appendix C.

TEST LOCATION	WATER TABLE (m)	HYDRAULIC CONDUCTIVITY (m/sec)
BH1	1.05	1.3x10 <sup>-8</sup>
BH2	2.63	8.7x10 <sup>-7</sup>

## TABLE 3 – SUMMARY OF GROUNDWATER

Results of the permeability testing suggest that a permeability value of the underling Unit 2 rhyodacite unit to be in the order of  $8.5 \times 10^{-4}$ m / day. Groundwater behaviour within the rock mass is controlled by the type and amount of defects within the rock mass which allows infiltration and migration of groundwater from potential rainfall recharge from the overlying aeolian sandy soils. It is assessed from the permeability testing, that any groundwater inflows into proposed excavations over the site within Unit 2 rhyodacite could be adequately handled using a sump and pump system.

## 4 LABORATORY TESTING

Samples obtained during the field investigations were returned to Coffey's NATA registered Newcastle Laboratory for testing. The testing comprised of one Uniaxial Compressive Strength (UCS) test within the Unit 2C rock and acid sulfate testing of soil samples. Results of laboratory testing are presented in Appendix B and summarised in Table 4 and Section 6 (acid sulfate soils).

BOREHOLE	SAMPLE	MATERIAL	WET DENSITY	UCS
	DEPTH (m)	DESCRIPTION	(t/m³)	(MPa)
BH2	2.83 – 2.98	SLIGHTLY WEATHERED RHYODACITE (UNIT 2B)	2.6	223 (extremely high strength)

## TABLE 4 – SUMMARY OF UCS TESTING

## 5 DISCUSSION AND RECOMMENDATIONS

## 5.1 General

At the time of writing this report conceptual architectural drawings were made available showing the proposed layout of development. It is understood that this preliminary design will change during ongoing planning. Currently no specific design including expected loading of the structures is available. General recommendations have been provided regarding the proposed development based on the conditions encountered at the site and previous experience. If required, further geotechnical investigation or discussion can be provided when the location and nature of proposed structures is finalised.

## 5.2 Risk of Slope Instability

The risk of slope instability has been assessed from the observed site conditions in accordance with the classification system formulated by the Australian Geomechanics Society and published in '*Australian Geomechanics News, Number 10, 1985*' (see Attachment 1: Classification of Risk of Slope Instability, for explanation of risk categories and implications for development).

This report provides an assessment of the risk of slope instability over the investigation site and immediate surrounding area. The report also recommends some geotechnical constraints for the site development in light of the assessed risk of slope instability. The onus is on the owner, potential owner or interested party to decide whether the assessed level of risk is acceptable taking into account likely economic consequences of the risk and the recommended geotechnical constraints

The risk of slope instability for the site has been based on the site observations recorded in Section 3.0. The principal site features used in the assessment are:

- Position of the site on a northerly to north westerly facing slope within sightly undulating terrain;
- Regional slope angles on the site in the order of 5° to 15°;
- An aeolian sand soil profile over lying rock of up to 1.3m or greater;
- High strength rhyodacite outcrop noted over the site;
- No evidence of seepage within the natural soils over the investigation area;
- A measured groundwater table within the Rhyodacite at approximately RL 9m;
- · Good surface drainage directed into dedicated stormwater structures, and infiltration into sand ;
- No evidence of instability or significant erosion.

On the basis of these site features the site is assessed to have an overall low risk of slope instability in accordance with the classification system presented in Attachment 1. The risk of slope instability associated with cuts and fills undertaken as part of the project can be managed by adopting the recommendations of this report.

It would be normal practice in the Port Stephens area for development to proceed on a site with this risk level classification. Development should be carried out in accordance with good hillside practice (as set out in Attachment 2 and 3) and the specific geotechnical constraints defined in Section 4.2.

## 5.3 Recommended General Geotechnical Constraints for Development

### Type of Structure:

There are no particular geotechnical constraints on the type of structures provided they are founded in natural ground on footings designed and constructed in accordance with the engineering principals outlined in AS2870, '*Residential Slabs and Footings*' which provides a sound basis for design to accommodate reactive soil movements.

### Area for Development:

Development of the lot should be undertaken in accordance with good hillside construction practice and sound engineering principles as presented in Attachment 2.

### Foundation Type:

Strip, stiffened raft or pad footings would be feasible from a slope stability viewpoint provided the resulting slope modifications comply with the geotechnical constraints set out below.

Footings should not be founded within any uncontrolled fill if encountered onsite. This will require the removal of the fill if encountered and replacement under geotechnical supervision carried out in accordance with the recommendations outlined in Australian Standard AS3798-1996, '*Guidelines on Earthworks for Commercial and Residential Development*' or alternatively all structures fully supported on foundations founded uniformly below all fill soils within the natural residual profile. Addition information regarding foundation conditions is presented in Section 5.6.

### **Excavation:**

Excavation conditions within the weathered rock substrata are expected to be very difficult, Section 5.4 provides additional comment and recommendations with respect to excavatability.

Excavations in soil materials should be supported by properly designed and constructed retaining walls, rock bolting, shotcrete or else battered at 1V: 2H or flatter and protected against erosion. Excavations in rock should be subject to specific geotechnical assessment in relation to long term stable batters gradients and this will depend on treatment solutions such as rock bolting, shotcrete, meshing etc being adopted. Additional comment on excavation retention is presented in Section 5.5.

Permanent/temporary excavations greater than 1.5m deep will require further detailed geotechnical assessment once the location and extent of such excavations are known. This assessment may involve:

- Excavation of boreholes / test pits to below the depth of cut to assess material properties;
- Assessment of slope / retaining wall design parameters;
- Assessment of need to provide temporary retention or special precautions during construction;
- Viewing of the excavation by a geotechnical engineer during bulk excavation;
- Assessment of staged construction requirements.

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

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

### **Retaining Walls:**

Retaining walls should be designed for surcharge loading from slopes, other retaining walls, structures and other existing/future improvements in the vicinity of the proposed structures.

Adequate subsurface and surface drainage should be provided behind all retaining walls. Retaining walls should be designed by an experienced engineer familiar with the site conditions and founded below the fill and topsoil soils.

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

Further comment is provided for retaining walls and support of excavations in Section 5.5 of this report.

## Filling:

Reference should be made to Section 5.8 of this report for further comment on site filling.

### Drainage:

All collected stormwater run-off should be discharged into the existing stormwater drainage system. A lined catch drain should be constructed toward the crest of the slope directing water into the dedicated storm water drainage system to avoid erosion over the site.

## 5.4 Excavation Conditions

It is assessed that excavation conditions at the site pose the most significant geotechnical constraint to the project. Laboratory testing and field observations of the Unit 2 rhyodacite indicate an extremely high strength rock with defect spacing in the order of 300mm to 1000mm.

Bulk excavations within the underlying very high to extremely high strength rhyodacite (Unit 2B and 2C) are unlikely to be achievable using heavy construction plant (ie: Caterpillar D10 or 30 tonne excavator) equipped with ripping tynes. The rhyodacite rock is also likely to cause significant excavation resistance to hydraulic rock hammering, with very slow excavation rates likely and possible vibratory dilapidation concerns for surrounding structures. Conventional hardened steel ripping tooths and bits are expected to experience significant wear and disintegration during excavation within the rhyodacite materials.

Possible alternatives for excavation include;

- Drilling presplit bores to aid hydraulic hammer- this would involve using a dedicated drilling rig equipped with air percussion drilling techniques to drill a pattern closely spaced bores (say 300mm to 500mm centres) within the proposed excavation area to aid the purchase of hydraulic hammers fitted to excavators and to effectively increase the defect spacing (ie jointing) and therefore weakening, of the rock mass. This technique has been previously used on civil projects in the Nelson Bay area to facilitate rock excavation;
- Rock sawing or milling with excavators diamond bit, large diameter rock saws or milling heads attached to excavators could be used to progressively cut then rip the rhyodacite rock. Advantages of this method are good control of excavation edges and dimension during excavation and limited use of vibratory hydraulic hammers. It is noted that this type of equipment is normally used on sandstone type rock and excessive wear associated with the volcanic rock may preclude this option;
- **Blasting** the use of slow release expansive rock blasting techniques such as cone penetration fracture (RockTek) or similar that limit fly rock could be used to fracture the rock mass facilitating easier excavation.

Each of the recommended alternatives to excavation provided require specialist equipment to be sourced to conduct the work and each have individual health and safety concerns, adding cost to any potential mass excavation task. It is recommended where possible, that bulk excavations are limited to Unit 1 sands and 2A extremely weathered rock. It is assessed that excavations within Unit 1 sands and Unit 2A extremely weathered rock would be achievable using conventional excavation equipment which would rapidly refuse once Unit 2B was encountered.

## 5.5 Support of Excavations

Temporary excavations in sand (Unit 1) should be supported by a suitable shoring system such as sheet piles or contiguous or secant pile walls installed using continuous flight auger (CFA) grout injected piles or alternatively battered at no steeper than 1V : 2H. Temporary excavations in residual soil or weathered rock should be battered at no steeper than 1V:1H or retained by a suitable shoring system such as a contiguous or secant pile wall.

Temporary excavations in Unit 2B and 2C rhyodacite should be battered at 1V:0.25H or near vertical however retention of loose bocks or highly fractured zones may be required using scaling (removal), rock bolts, shotcrete or a combination of all three. All excavations within Unit 2B and 2C rhyodacite should be inspected by a suitably qualified geotechnical professional on site during the excavation to advise on retention measures.

It is recommended that permanent excavations within Unit 2B and 2C be supported by reinforced shotcrete with selective or pattern rock bolting as required. Any rock bolting or shotcrete works proposed for the development should be designed by a suitably qualified geotechnical professional and conducted by qualified contractors familiar with shotcrete application and products.

Permanent excavations for excavations within Unit 1 and 2A should be supported by an engineerdesigned retaining wall and or a contiguous bored-pile wall. Typical retaining wall parameters for site soils are presented in Table 5

	PARAMETER					
GEOTECHNICAL UNIT	UNIT WEIGHT (kN/m <sup>3</sup> )	EFFECTIVE FRICTION ANGLE	ACTIVE EARTH PRESSURE COEFFICIENT	PASSIVE EARTH PRESSURE COEFFICIENT	AT REST EARTH PRESSURE COEFFICIENT	
Unit 1 (sand)	18	30	0.33	3.00	0.5	
Unit 2A (residual/ XW)	20	30	0.33	3.00	0.5	

TABLE 5 - SUMMARY OF RETAINING WALL DESIGN PARAMETERS

If retaining systems are to be eventually propped by the new building structure, the at-rest earth pressure coefficients indicated above should be used in design.

The above parameters make no allowance for lateral pressures induced by surcharge loading from existing or proposed structures near the crest of the excavation, or for hydrostatic pressure due to groundwater build-up. Based on the results of subsurface investigations, it is recommended that non free draining retaining structures (ie: secant or sheet pile walls) be designed for a full hydrostatic head.

It should be noted that some lateral deformation may still occur with the use of retaining walls. The amount of movement is dependent on the rigidity of the retaining walls, and on the excavation and anchoring procedure. Observed lateral movements of documented walls are typically of the order of 0.5% of wall height.

Coffey can estimate deflections for the preferred retention system, if required. Alternatively, the excavation face could be set back a sufficient distance from site boundaries so as not to have an influence on neighbouring surface facilities. On this site, it is considered that a zone of influence defined by a line drawn upwards at 1.5H:1V from the toe of the proposed excavation within Unit 1 and 2A materials would be appropriate for estimation of set back distance.

During construction, a perimeter drain could be constructed within the basement excavation, draining toward a temporary sump and pump to collect groundwater inflows. A drainage layer on the underside of the of the basement slab that directs water to a dedicated dewatering system could be incorporated into the proposed building design. The use of a free draining gravel sub-base or no fines concrete could be incorporated into the rigid basement pavement design (ie: sub-base) to be used as a drainage layer.

## 5.6 Foundations

Due to the final design for the redevelopment not being completed, it is unknown what the design loads or foundation levels will be. However, it is anticipated that the foundation level of structures are likely to be situated within Unit 2B and 2C rhyodacite.

Shallow footings comprising strip and pad footings may be proportioned for an allowable bearing pressure of;

- 200kPa in Unit 2A residual soil and extremely weathered rhyodacite;
- 5MPa in Unit 2B and 2C high to extremely high strength rhyodacite rock.

Higher loads may be applicable but would require specific investigation to confirm.

Excavations for foundations are expected to be very difficult as outlined in Section 5.4. Provision may be required in design for incorporating predrilled grouted dowels inserted into the rock and structurally incorporated (tied) into reinforcement to provide lateral shear resistance.

Due to the very high to extremely high rock strength and loose nature of the overlying sands, bored pier footings are not considered a viable option at the site due to possible excavation collapse and difficulty drilling a suitable socket depth.

For footings to carry design loads it is assumed that the footing excavations are cleaned of debris. Footings should be inspected by a suitably experienced geotechnical engineer to confirm the above parameters are appropriate.

## 5.7 Site Classification

Due to the presence of predominantly aeolian sand overlying a less than 1m residual soil and extremely weathered rock occurring as Clayey SAND and Sandy CLAY, the site is classified as Class S, as defined in AS2870-1996. Where site regrading works involving cutting or filling are performed after the date of this assessment the classification may change and further advice should be sought. A characteristic free surface movement within natural Unit 2A soils of 10mm to 20mm is estimated for the site in its existing condition. The effects of changes to the soil profile by additional cutting and filling and the effects of past and future trees should be considered in selection of the design value for differential movement.

## 5.8 Pavement Design

## 5.8.1 Preliminary Design Parameters

Based on the results of the field investigation and previous laboratory testing within the area, a design CBR value of 10% has been adopted for Unit 1 sand subgrades and Unit 2 weathered rock that are likely to be encountered over the site, however localised zones of sandy CLAY subgrade (residual soil) are likely to be encountered with a CBR value in the order of 5%.

Where rhyodacite subgrades are encountered, the rock should be ripped and re-compacted to a minimum depth of 300mm to break-up preferential drainage paths and provide a dense homogenous surface on which to construct the pavement. Specific advice should be sought where high strength rock subgrade is encountered to assess treatment options.

Pavement design should be undertaken in accordance with Port Stephens Council guidelines on the basis of traffic loading. Preliminary conceptual access road and car park pavement thickness is likely to be in the order of 300mm and will need to be confirmed by specific investigation and testing at the appropriate stage of development.

If over wet subgrades exist at the time of construction or if deleterious fill materials are encountered at subgrade level, these materials may be over-excavated and replaced with a minimum depth of 300mm of well graded granular select material of CBR >10%.

It is recommended that each construction length be boxed out to the minimum subgrade level required by the pavement thickness design. Prior to construction, the exposed subgrade should be assessed by the geotechnical authority who can confirm the pavement thickness requirements for that section.

The provision of adequate surface and subsurface drainage of the pavement and adjacent areas will contribute significantly to ongoing performance and longevity of proposed pavements. It is recommended that as a minimum adequate grade is designed to direct runoff to stormwater structures and subsoil drains be installed:

- Along the high side of roads aligned across site slopes;
- Internally within larger car park areas;
- Along both sides of roads aligned down slope, or within areas of cut.

## 5.9 Site Preparation

Site preparation and earthworks suitable for structure support and pavements should consist of:

- Proposed earthwork areas should be stripped to remove all vegetation, topsoil, root affected or other potentially deleterious materials. Stripping is generally expected to be required to depths of between 0.1m to 0.2m;
- Following stripping, the exposed subgrade should be proof rolled to identify any wet or excessively deflecting material. Any such areas should be over excavated and backfilled with an approved select material;
- Approved fill beneath pavements should be benched into the slope profile if slopes are greater than 1V:8H (7°) and placed in layers not exceeding 300mm loose thickness and compacted to a minimum density ratio of 95% Standard Compaction in accordance with AS1289.5.1.1 or equivalent. Clay subgrade fill should be placed and maintained at 60% to 90% of Optimum Moisture Content (OMC);
- The top 300mm of natural subgrade below pavements or the final 300mm of road subgrade replaced should be compacted to minimum density ratio of 100% Standard Compaction or 80% density index if in Sands within the above stated moisture range;
- Approved fill beneath structures should be compacted in layers not exceeding 300mm loose thickness to a minimum density ratio of 98% Standard Compaction in accordance with AS1289 5.1.1 or equivalent within +/- 2% of Optimum Moisture Content (OMC). If clean Unit 1 or imported Sand is used for site filling the sand should be free of deleterious material and compacted in layers not exceeding 500mm loose thickness to 75% density index;
- All fill should be supported by properly designed and constructed retaining walls or else battered at 1V:2H or flatter and protected against erosion;
- Earthworks should be carried out in accordance with the recommendations outlined in AS3798-2007 'Guidelines for Earthworks for Commercial and Residential Developments'.

## 6 ACID SULPHATE SOILS

## 6.1 Background Information

Acid Sulphate Soils (ASS) are soils containing significant concentrations of pyrite, which, when exposed to oxygen in the presence of sufficient moisture, oxidises, resulting in the generation of sulphuric acid. Unoxidised pyritic soils are referred to as <u>potential</u> ASS. When the soils are exposed, the oxidation of pyrite occurs and sulphuric acids are generated, and the soils are said to be <u>actual</u> ASS.

Pyritic soils typically form in waterlogged, saline sediments rich in iron and sulphate. Typical environments for the formation of these soils include tidal flats, salt marshes and mangrove swamps below about RL 5m AHD. They can also form as bottom sediments in coastal rivers and creeks.

Pyritic soils of concern on low lying NSW and coastal lands have mostly formed in the Holocene period (10,000 years ago to present day) predominantly in the 7,000 years since the last rise in sea level. It is generally considered that pyritic soils which formed prior to the Holocene period (greater than 10,000 years ago) would already have oxidised and leached during periods of low sea level which occurred during ice ages, exposing pyritic coastal sediments to oxygen.

## 6.2 Significance of ASS

Disturbance or poorly managed development and use of acid sulphate soils can generate significant amounts of sulphuric acid, which can lower soil and water pH to extreme levels (generally less than 4) and produce acid salts, resulting in high salinity.

The low pH, high salinity soils can reduce or altogether preclude vegetation growth and can produce aggressive soil conditions which may be detrimental to concrete and steel components of structures, foundations, pipelines and other engineering works.

Generation of the acid conditions often releases aluminium, iron and other naturally occurring elements from the otherwise stable soil matrices. High concentrations of some such elements, coupled with low pH and alterations to salinity can be detrimental to aquatic life. In severe cases, affected waters flowing off-site into aquatic ecosystems can have a detrimental effect on these ecosystems.

## 6.3 Acid Sulphate Soils Risk Map

Reference to the Acid Sulphate Soils (ASS) Risk Map for Port Stephens indicates the site is located in an area where there is no know occurrence of acid sulphate soil materials. The map also indicates that the landform is dominated by bedrock slopes, elevated Pleistocene and Holocene dunes and elevated alluvial plains.

## 6.4 Screening Tests

Samples obtained during the field investigation were screened for the presence of actual and potential acid sulfate soils using methods 21Af and 21Bf of the 1998 ASSMAC Guidelines. The results of screening tests are attached to this report and are summarised below:

- pH values in 1:5 soil to distilled water mix ranged from 6.90 to 7.48. A pH of <4 in this test can
  indicate the presence of actual ASS;</li>
- pH values of soil in 30% H<sub>2</sub>O<sub>2</sub> were between 4.70 to 5.10. A pH of <3 in this test can indicate the presence of potential ASS;</li>
- A maximum pH change of 2.54 after oxidation with H<sub>2</sub>O<sub>2</sub> was recorded. Significant pH changes (>2) after oxidation with H<sub>2</sub>O<sub>2</sub> can indicate potential ASS;
- No effervescence was observed in any of the samples tested. Vigorous effervescent reactions with oxidation in 30% H<sub>2</sub>O<sub>2</sub> can indicate potential ASS;
- No odour was released upon oxidation with H<sub>2</sub>O<sub>2</sub> in any of the samples tested. A sulphurous odour is often associated with oxidising potential ASS;

## 6.5 Laboratory Testing

One sample of sand HA7 (0.65m to 0.70m) was selected to be sent to EAL at Southern Cross University Lismore, for SPOCAS testing. This sample ware selected based on site characteristics and screening testing conducted as described above. Laboratory test results are summarised in Table 6.

SAMPLE LOCATION	DEPTH	SCREENING TEST		S (%)	ТАА
	(metres) pH <sub>F</sub>	рН <sub>F</sub>	рН <sub>FOX</sub>	0000 (70)	(mol/tonne)
HA7	0.65 – 0.70	7.48	5.05	0.00	2
ASSMAC Action Criteria*	-	-	-	0.06	36
Levels of Concern for Screening Test	-	<4	<3	-	-

## NOTE:

\* Action Criteria from the Acid Sulfate Soil Manual (1998) shown are those for coarse textured soils (ie medium sands) and management of excavations involving disturbance of less than 1000 tonnes of soil.

## 6.6 Acid Sulphate Soils

Results of the laboratory testing conducted of recovered samples are well below the ASSMAC action criteria and indicate all samples tested are **not** actual or potential ASS. This combined with the residual nature of the site and minimum elevation over the site of RL6m suggests that it is highly unlikely for acid sulphate soils to be present and an ASS Management Plan would not be required for this project.

## 7 FURTHER INVESTIGATION

This report provides a level of geotechnical investigation, constraints identification and preliminary recommendations suitable for conceptual design and development application purposes. More detailed geotechnical investigation and design will be required at the appropriate stage of development notably for foundation, excavation support and pavement design.

## 8 LIMITATIONS

The findings contained in this report are the result of discrete/specific methodologies used in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points. Should any site conditions be encountered during construction that vary significantly from those discussed in this report, Coffey should be advised and appropriate action taken.

For and on behalf of Coffey Geotechnics Pty Ltd

Make Delemey

Mark Delaney Principle Engineering Geologist

# Foundation Maintenance and Footing Performance: A Homeowner's Guide



BTF 18 replaces Information Sheet 10/91

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

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

### Soil Types

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

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

#### **Causes of Movement**

#### Settlement due to construction

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

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

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

#### Erosion

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

#### Saturation

This is particularly a problem in clay soils. Saturation creates a boglike 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				
М	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes				
Н	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				
Р	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.



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

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



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

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

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

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

#### Condensation

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

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

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

#### The garden

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

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

#### Existing trees

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

#### Information on trees, plants and shrubs

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

#### Excavation

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

#### Remediation

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

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

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

The information in this and other issues in the series was derived from various sources and was believed to be correct when published.
The information is advisory. It is provided in good faith and not claimed to be an exhaustive treatment of the relevant subject.
Further professional advice needs to be obtained before taking any action based on the information provided.
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## Attachment 1: Classification of Risk of Slope Instability

## ASSESSMENT OF RISK

Natural hill slopes are formed by processes which reflect the site geology, environment and climate. These processes include downslope movement of the near surface soil and rocks, in geological time all slopes are unstable. The area of influence of these downslope movements may range from local to regional and are rarely related to property boundaries. The natural processes may be affected by human intervention in the form of construction and related activities.

A landslip (or landslide) is a downslope movement of a soil or rock mass as a result of shear failure at the boundaries of the moving mass. Soil creep, which is extremely slow and occurs without a well defined surface, is not included as a landslip.

It is not technically feasible to assess the stability of a particular site in absolute terms such as stable or unstable. However, the degree of risk of slope movement can be assessed by the recognition of surface features supplemented by limited information on the regional and local subsurface profile and with the benefit of experience gained in similar geological environments. The degree of risk is categorised below:

RISK OF	EXPLANATION	IMPLICATIONS FOR DEVELOPMENT			
VERY HIGH	Evidence of active or past landslips or rockface failure, extensive or rockface failure, extensive instability may occur.	Unsuitable for development unless major geotechnical work can satisfactorily improve the stability. Extensive geotechnical investigation necessary. Risk after development may be higher than usually accepted.			
HIGH	Evidence of active soil creep or minor slips or rockface instability, significant instability may occur during and after extreme climatic conditions.	Development restrictions and/or geotechnical works required. Geotechnical investigation necessary. Risk after development may be higher than usually accepted.			
MEDIUM	Evidence of possible soil creep or a steep soil covered slope, significant instability can be expected if the development does not have due regard for the site conditions.	Development restrictions may be required. Engineering practices suitable to hillside construction necessary. Geotechnical investigation may be needed. Risk after development generally no higher than usually accepted.			
LOW	No evidence of instability observed, instability not expected.	Good engineering practices suitable for hillside construction required. Risk after development normally acceptable.			
VERY LOW	Typically shallow soil cover with flat to gently sloping topography.	Good engineering practices should be followed.			

Ref 1: GEOTECHNICAL RISKS ASSOCIATED WITH HILLSIDE DEVELOPMENT Australian Geomechanics News, Number 10, December, 1985.

## **Attachment 2: Some Guidelines for Hillside Construction**

#### GOOD ENGINEERING PRACTICE

### POOR ENGINEERING PRACTICE

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

This table is an extract from Australian Geomechanics Journal and News of the Australian Geomechanics Society Volume 42 No1 March 2007.

## **Attachment 3: Illustrations of Good and Poor Hillside Practise**

## EXAMPLES OF GOOD HILLSIDE CONSTRUCTION PRACTICE



This figure is an extract from Australian Geomechanics Journal and News of the Australian Geomechanics Society Volume 42 No1 March 2007.



## ACID SULFATE SOILS – BACKGROUND INFORMATION

#### Background

Acid Sulfate Soils (ASS) are soils containing significant concentrations of pyrite, which when exposed to oxygen in the presence of sufficient moisture, oxidise resulting in the generation of sulfuric acid. Unoxidised pyritic soils are referred to as <u>potential</u> ASS (PASS). When the soils are exposed, the oxidation of pyrite occurs and sulfuric acids are generated, and the soils are said to be <u>actual</u> ASS (AASS).

Pyritic soils typically form in waterlogged, saline sediments rich in iron and sulfate. Typical environments for the formation of these soils include tidal flats, salt marshes and mangrove swamps below about RL 5m AHD. They can also form as bottom sediments in coastal rivers and creeks.

ASS soils occur across about 40,000km<sup>2</sup> of low lying coastal lands in every state of Australia (Sammut 2000), and mostly formed in the Holocene period (10,000 years ago to present day) predominantly in the 7,000 years since the last rise in sea level. It is generally considered that pyritic soils which formed prior to the Holocene period (greater than 10,000 years ago) would already have oxidised and leached during periods of low sea level which occurred during ice ages, exposing pyritic coastal sediments to oxygen.



### Significance of ASS

In their natural setting, ASS soils are buried beneath the water table and have a healthy vegetation cover. Any localised areas of acid generation are typically diluted by water runoff or neutralised by tidal flows of alkaline seawater.

NATURAL SETTING - low frequency, low magnitude, short duration acidity



Disturbance or poorly managed development and use of acid sulfate soils can generate significant amounts of sulfuric acid, which can lower soil and water pH to extreme levels (generally less than 4) and produce acid salts, resulting in high salinity. The low pH, high salinity soils can reduce or altogether preclude vegetation growth and can produce aggressive soil conditions which may be detrimental to concrete and steel components of structures, foundations, pipelines and other engineering works.

POST DRAINAGE - High frequency-high magnitude, persistent acidity



Generation of the acid conditions often releases aluminium, iron and other naturally occurring elements from the otherwise stable soil matrices. High concentrations of some such elements, coupled with low pH and alterations to salinity can be detrimental to aquatic life. In severe cases, affected waters flowing off-site into aquatic ecosystems can have a detrimental effect on these ecosystems.

This background information sheet was compiled by the Coffey, Acid Sulfate Soil - Centre of Specialist Knowledge.

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## Important information about your Coffey Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

### Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

### Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

### Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

### Your report will only give

### preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

# Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.



## Important information about your Coffey Report

### Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

## Data should not be separated from the report\*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

## Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment.

Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

## Rely on Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

## Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

\* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Figures



(1.5m) DEPTH OF AUGER REFUSAL (UNIT 2B)



FIGURE BASED ON DRAWING PREPARED BY HARPER SOMERS O'SULLIVAN - REF: 25400-1A

client:	SAKE DEVELOPMEN	T PTY LTD	
project:	PROPOSED HOTEL RED SALAMANDER SI 147 SOLDIERS POINT ROAD	EVELOPME IORES SOLDIERS	
itle:	APPROXIMATE BOREHOLE	LOCATION	PLAN
project no:	GEOTWARA20848AA	figure no:	FIGURE AB1

# Appendix A

**Results of Field Investigations** 



## Soil Description Explanation Sheet (1 of 2)

#### **DEFINITION:**

In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

#### **CLASSIFICATION SYMBOL & SOIL NAME**

Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on Sheet 2.

#### PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 μm to 2.36 mm
	medium	200 μm to 600 μm
	fine	75 μm to 200 μm
1		

#### **MOISTURE CONDITION**

- Dry Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.
- **Moist** Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
- Wet As for moist but with free water forming on hands when handled.

#### CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH S <sub>U</sub> (kPa)	FIELD GUIDE
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12 - 25	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	_	Crumbles or powders when scraped by thumbnail.

#### DENSITY OF GRANULAR SOILS

TERM	<b>DENSITY INDEX (%)</b>	
Very loose	Less than 15	
Loose	15 - 35	
Medium Dense	35 - 65	
Dense	65 - 85	
Very Dense	Greater than 85	

#### MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:		
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%		
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%		

#### SOIL STRUCTURE

	ZONING	CEMENTING			
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.		
Lenses	Discontinuous layers of lenticular shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.		
Pockets	Irregular inclusions of different material.				

GEOLOGICAL ORIGIN WEATHERED IN PLACE SOILS							
Extremely weathered material	Structure and fabric of parent rock visible.						
Residual soil	Structure and fabric of parent rock not visible.						
TRANSPORTE	D SOILS						
Aeolian soil	Deposited by wind.						
Alluvial soil Deposited by streams and rivers.							
Colluvial soil	Deposited on slopes (transported downslope by gravity).						
Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.						
Lacustrine soil	Deposited by lakes.						
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.						

# coffey **>**

## Soil Description Explanation Sheet (2 of 2)

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)					USC PRIMARY NAME			
		arse 2.0 mm	EAN /ELS ttle no es)	Wide amou	Wide range in grain size and substantial amounts of all intermediate particle sizes.		GW	GRAVEL
3 mm is		/ELS If of co r than 2	CLE GRANE (Lit	Predo with r	ominantly one size or more intermediate siz	a range of sizes es missing.	GP	GRAVEL
SOILS than 60	eye)	GRAV than ha is large	/ELS FINES ciable unt nes)	Non- proce	plastic fines (for ident	tification )	GM	SILTY GRAVEL
AlINED ials less 0.075 m	e naked	More	GRAN WITH I (Appre amo of fir	Plasti see C	c fines (for identificat L below)	ion procedures	GC	CLAYEY GRAVEL
ARSE GF of mater jer than	ble to th	trse 0.0 mm	AN DS S) S)	Wide amou	range in grain sizes a ints of all intermediat	and substantial e sizes	SW	SAND
COA an 50% larç	ticle visi	IDS If of coa er than 2	CLEA SANG (Little	Predo with s	ominantly one size or some intermediate siz	a range of sizes zes missing.	SP	SAND
More the	llest par	SAN More than ha fraction is smalle	SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).		SM	SILTY SAND	
	the sma			Plastic fines (for identification procedures see CL below).		SC	CLAYEY SAND	
	out		IDENTIFICAT	ION PI	ROCEDURES ON FR	OCEDURES ON FRACTIONS <0.2 mm.		
uan nan	s ab		DRY STREN	GTH	DILATANCY	TOUGHNESS		
01LS less th 075 mr	rticle i	TS & CLAYS Liquid limit ess than 50	None to Low	1	Quick to slow	None	ML	SILT
ED SC aterial an 0.0	nm pa		Medium to H	ligh	None	Medium	CL	CLAY
BRAIN of m aller th	.075 r	10 1 9	Low to medi	um Slow to very slow		Low	OL	ORGANIC SILT
FINE O n 50% is sma	(A O	LAYS nit tin 50	Low to medium		Slow to very slow	Low to medium	MH	SILT
re tha 3 mm		S & Cl quid lir ter the	High		None	High	СН	CLAY
Mc 66		SILT Lic grea	Medium to H	ligh	None	Low to medium	ОН	ORGANIC CLAY
HIGHLY ORGANIC Readily identified by colour, odour, spongy feel and frequently by fibrous texture.			Pt	PEAT				
• Low plasticity – Liquid Limit WL less than 35%. • Medium plasticity – WL between 35% and 50%.								

### SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM	TERM	DEFINITION	DIAGRAM
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.		SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	AND DESCRIPTION OF THE OWNER OF T
JOINT	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2 m in length.		TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.		TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.		INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

72810-03/02/2009



## Rock Description Explanation Sheet (1 of 2)

The descriptive terms used by Coffey are given below. They are broadly consistent with Australian Standard AS1726-1993. DEFINITIONS: Rock substance, defect and mass are defined as follows: Rock Substance In engineering terms roch substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic. Defect Discontinuity or break in the continuity of a substance or substances. Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or Mass more substances with one or more defects. SUBSTANCE DESCRIPTIVE TERMS: **ROCK SUBSTANCE STRENGTH TERMS ROCK NAME** Simple rock names are used rather than precise Abbrev- Point Load Field Guide Term Index, I<sub>S</sub>50 (MPa) geological classification. iation PARTICLE SIZE Grain size terms for sandstone are: Coarse grained Mainly 0.6mm to 2mm Mainly 0.2mm to 0.6mm Very Low VL Less than 0.1 Material crumbles under firm Medium grained blows with sharp end of pick; Mainly 0.06mm (just visible) to 0.2mm Fine grained can be peeled with a knife: pieces up to 30mm thick can FABRIC Terms for layering of penetrative fabric (eg. bedding, be broken by finger pressure. cleavage etc.) are: Massive No layering or penetrative fabric. 0.1 to 0.3 Easily scored with a knife: Low L Indistinct Lavering or fabric just visible. Little effect on properties. indentations 1mm to 3mm show with firm bows of a Layering or fabric is easily visible. Rock breaks more Distinct pick point; has a dull sound easily parallel to layering of fabric. under hammer. Pieces of core 150mm long by 50mm CLASSIFICATION OF WEATHERING PRODUCTS diameter may be broken by Term Abbreviation Definition hand. Sharp edges of core may be friable and break RS Soil derived from the weathering of rock; the during handling. Residual Soil mass structure and substance fabric are no longer evident; there is a large change in 0.3 to 1.0 volume but the soil has not been significantly Medium Μ Readily scored with a knife; a piece of core 150mm long by transported. , 50mm diameter can be broken by hand with difficulty. xw Extremely Material is weathered to such an extent that it has soil properties, ie, it either disintegrates or Weathered can be remoulded in water. Original rock fabric Material Hiah н 1 to 3 A piece of core 150mm long still visible. by 50mm can not be broken by hand but can be broken нw Rock strength is changed by weathering. The Highly by a pick with a single firm whole of the rock substance is discoloured, Weathered blow; rock rings under usually by iron staining or bleaching to the Rock extent that the colour of the original rock is not hammer. recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by Very High VH 3 to 10 Hand specimen breaks after leaching or may be decreased due to the more than one blow of a deposition of minerals in pores pick: rock rings under Moderately MW The whole of the rock substance is discoloured, hammer. usually by iron staining or bleaching , to the Weathered extent that the colour of the fresh rock is no Rock Extremely EH More than 10 Specimen requires many longer recognisable. blows with geological pick to High Rock substance affected by weathering to the break; rock rings under Slightly SW extent that partial staining or partial hammer Weathered discolouration of the rock substance (usually by Rock limonite) has taken place. The colour and texture of the fresh rock is recognisable: strength properties are essentially those of the Notes on Rock Substance Strength: fresh rock substance. 1. In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may Fresh Rock FR Rock substance unaffected by weathering. break readily parallel to the planar anisotropy. The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein Notes on Weathering: 1. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of makes it clear that materials in that strength range are soils in substance weathering conditions between XW and SW. For projects where it is engineering terms. not practical to delineate between HW and MW or it is judged that there is no 3. The unconfined compressive strength for isotropic rocks (and advantage in making such a distinction. DW may be used with the definition anisotropic rocks which fall across the planar anisotropy) is typically given in AS1726. 10 to 25 times the point load index (Is50). The ratio may vary for 2. Where physical and chemical changes were caused by hot gasses and liquids different rock types. Lower strength rocks often have lower ratios associated with igneous rocks, the term "altered" may be substituted for than higher strength rocks. "weathering" to give the abbreviations XA, HA, MA, SA and DA.



## Rock Description Explanation Sheet (2 of 2)

COMMON DEFECTS IN ROCK MASSES Term Definition		Diagram	Map Symbol	Graphic Log (Note 1)	DEFECT SHAPE Planar	<b>TERMS</b> The defect does not vary in orientation
Parting	A surface or crack across which the rock has little or no tensile strength.		20		Curved	The defect has a gradual change in orientation
	(eg bedding) or a planar anisotropy	· · · ·	20 Clean		Undulating	The defect has a wavy surface
	In the fock substance (eg, cleavage). May be open or closed.		Gleav	(Note 2)	Stepped	The defect has one or more well defined steps
Joint	A surface or crack across which the rock has little or no tensile strength.	1.55			Irregular	The defect has many sharp changes of orientation
	but which is not parallel of sub parallel to layering or planar anisotropy in the rock substance.		<b>1</b> 60	(Note 2)	Note: The assess influenced	ment of defect shape is partly by the scale of the observation.
					ROUGHNESS Slickensided	FERMS Grooved or striated surface, usually polished
Sheared Zone	Zone of rock substance with roughly parallel near planar, curved or				Polished	Shiny smooth surface
(NOLE 3)	undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of		35		Smooth	Smooth to touch. Few or no surface irregularities
the defects are usually curved intersect to divide the mass int lenticular or wedge shaped blc		. /		[*-]	Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Sheared Surface (Note 3)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.		40		Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.
Crushed Seam	Seam with roughly parallel almost				COATING TER	MS No visible coating
(Note 3)	disoriented, usually angular fragments of the host rock substance which may be more		50 50 50		Stained	No visible coating but surfaces are discoloured
	weathered than the host rock. The seam has soil properties.				Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Infilled Seam	Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.		ALL ALL	65 	Coating	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.
Extremely	Seam of soil substance. often with				BLOCK SHAPE Blocky	<b>TERMS</b> Approximately equidimensional
Weathered Seam	gradational boundaries. Formad by weathering of the rock substance in place.	8000 NO.		IL DI	Tabular	Thickness much less than length or width
		Seam		1	Columnar	Height much greate than cross section
Notes on D	efects:					

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.

<sup>2.</sup> Partings and joints are not usually shown on the graphic log unless considered significant.

<sup>3.</sup> Sheared zones, sheared surfaces and crushed seams are faults in geological terms.



## Engineering Log - Borehole

Client:

## SAKE DEVELOPMENT PTY LTD

Principal: Project:

### PROPOSED HOTEL REDEVELOPMENT

Borehole Location: REFER TO FIGURE 1

[	drili	mode	el a	10 r	nour	nting: [	and (	Cruiser			Easting:	slope:	-90°				R.L	Surface: 10	)
	hole	: dian	nete	er:		ŧ	51 mn	n			Northing	bearing:	:				dat	ium: Al	HD
[	dr	illinç	j in	for	mat	tion			mate	rial s	ubstance								
	method	t benetration	3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	mate soil type: plasticity or pa colour, secondary and	rial article characteris minor compone	stics, nts.	moisture condition	consistency/ density index	200 A pocket	300 by Perleu 0- 400 meter	struc additiona	cture and I observations
ľ	ADT			N						GC	FILL: ASHPALT FILL: Clayey GRAVEL, fine rounded to sub angular, brow brown, medium plasticity cla	to medium graine wn mottled red au y, with some fine	ed, sub nd dark to	М	D			PAVEMENT GR	
							_9.5	0.5		CL	coarse grained sand. Sandy CLAY: medium plasti yellow and white, fine to coar	city, brown mottle 'se grained sand	ed I.	M/W	Н			EXTREMELY V RHYODACITE	VEATHERED
							_9.0	1. <u>0</u>			RHYODACITE: fine orgined	with phenocrysts	of		VD			THIGHLY WEAT	
								1 6	×		quartz and black feldspar, pi	nk, mottled black	k and					RHYODACITE	
ſ			Π				28.5	<u></u>			Borehole BH 1 continued as	cored hole	/						
					None Observed		_8.0 _7.5 _7.0	2.0 2.5 3.0 3.5											
-orm GEO 5.3 Issue 3 Rev.2	metil AS AD RR W CT HA DT B V T T tbit s e.g.	lod	by	aug aug rolk was cab har diat blar blar V b TC Suffi AD	er so jer dr sr/tric shbor Je too id au tube nk bit it bit x T	:rewing* illing* :one :e ol ger :		pport mud casing netration 2 3 4 r r tter 30/1/9/ on date water i	N no resistar anging to refusal 8 water I e shown nflow putflow	nil nce evel	notes, samples, tests           U <sub>50</sub> undisturbed sample to disturbed to	i0mm diameter i3mm diameter test (SPT) red	classific soil dese based or system D dr M m W w Wp pl W_ liq	ation syn cription 1 unified ( 2 y oist et astic limit uid limit	nbols an	d ion		consistency/ VS F St VSt H Fb VL L MD D VD	density Index very soft soft firm stiff very stiff hard friable very loose loose medium dense dense very dense

Borehole No.

Project No:

Date started:

Logged by:

Checked by:

Date completed:

Sheet

BH 1 1 of 3

23.2.2009 23.2.2009

VΝ

GDT

GEOTWARA20848AA

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C		U		e	Y	• geolecini	103						Bo	orehole No.	BH 1	
Ε	n	gi	ne	eri	ng	Log - Cored E	Bore	ho	le				Sh Pr	ieet oiect No:	2 of 3 <b>GEO7</b>	WARA20848AA
Cli	ent	:		5	SAKI	E DEVELOPMENT PTY L	TD						Da	ate started:	23.2.2	2009
Pri	ncij	pal:											Da	ate complete	d: <b>23.2.2</b>	2009
Pro	ojec	st:		F	PROI	POSED HOTEL REDEVE	LOPM	IENT					Lo	gged by:	GDT	
Bo	reh	ole	Locat	ion: <b>F</b>	REFE	ER TO FIGURE 1							Cł	necked by:	<del>(</del>	+
drill	mo	del 8	k mour	nting: La	nd Cru	iser	Eastin	g:			slope:		-90°	R.L	Surface:	10
hole dr	e dia illia	amet na is	er: n <b>form</b>	51 ation	mm mat	Drilling fluid: Water erial substance	Northi	ng:			bearin	g: re	ock mass	dat defects	um:	AHÐ
					ery -	material		a	esti	mated	1s(50)		defect		defect desc	cription
ethod	ore-lift	ater		depth	aphic log	rock type; grain characteristics, c structure, minor components	otour, s	eathering teration	stre	ength	MPa D-diam- etral	QD %	spacing mm	type, ir	coating, thi	arity, roughness, ckness
Ē	8	W	RL	metres	58			5 č	∶יר≽	≥≖∃∄	A- axiai	č	S5858	particular		general
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				-												-
						Continued from non-cored hore	hole									_
ALC			_ <del>_0.5</del>	1.6	××	RHYODACITE: fine grained with phenocrysts of guartz and black feld	lspar,	HW		88		Γ		JT, 45°, I	R, RO, CO, cla	
Z		q			××	pink, grey mottled black and white.		300						17 500 1	1 BO CO a	-
		serve			××									JT, 0°, PI	L, RO, CO, gre ., RO, CO, gre R, RO, CN	ey, clay
		ne Ob	_8.0	2.0	××									JT, 10°, I	R, RO, CN	
		٥N			× ×							66				-
				-	× ×											-
			_7.5	2.5	××											
				-	×××	RHYODACITE: CLAY, laminated, ye arey mottled areen	ellow,	HA						—— JT, 40°, I	R, RO, CN	-
	H			-	×	RHYODACITE: fine grained with		FR				┢				-
			_7.0	3.0	×	phenocrysis, grey motiled pink.										-
				-	×											
					× Ĵ					20030202						-
			<u> </u>	2 -	×							100		IT 32° I	PL.RO. VN. im	unstained
			_6.5	<u>3.9</u>   _	×									01,02,1		
					×									JT, 85°, ( black sta	Hematite?), P ined	L, RO, VN,
				-	××									JT, 45°, I	R, RO, CN	-
me	 tho	d	6.0	4.0	l×_	core-lift	water				weatherin	ng		defec	t type	roughness
DT AS			diati aug	ube er screwi er dallige	ng	casing used	10/ on	1/98 wat date sho	er leve wn	e)	≻R fr SW s MW α	iesh lightl node	y weathered rately weath	JT PT ered SM	joint parting seam	VR very rough RO rough SO smooth
RR			aug rolle clav	er unining ir/tricone / or blade	bit	barrel withdrawn	► wa → par	ter inflow tial drill f	, luid los	s	HW h XW e DW d	ighly xtrer listing	weathered nely weather otly weathere	red SS ad CS	sheared zone sheared surface crushed seam	SL slickensided
NN NC	ilc , Ho	2, PQ	NMI wire	_C core line core		graphic log/core recovery	cor	nplete di	ill fluid	loss	(d strength	cove	rs MW and H	HW) plana	rity	coating CN_clean
						- graphic symbols indicate material	T wa	ter press	ure tes	st result	L k	ery k ow nediu	uu Wo		curved undulating	SN stained VN veneer
						no core recovered	۲۵۲ (ku) inte	geons) fo erval sho	or depti wn	h	H h VH v EH e	igh ery f xtre	iigh nely high	IR IR	stepped irregular	CC coating

CORED BOREHOLE BH1- BH2.GPJ COFFEY.GDT 3.17.09

Form GEO 5.5 Issue 3 Rev. 3

_	•	~	£		, 6		obnice												
L	ار	U		e	Y	geoie	CHINCS							Bor	rehole I	No.	BH 1		
E	n	gi	ine	eri	ng	Log - Cor	ed Bore	eho	le					She Pro	eet oject No		3 of 3 <b>GEOT</b>	WARA20	848AA
Cli	ent	:		S	SAKE	E DEVELOPMEN	T PTY LTD							Dat	te starte	ed:	23.2.2	2009	
Pri	nci	pal:												Dat	te comp	eted:	23.2.2	2009	
Pro	ojeo	ct:		F	PROI	POSED HOTEL F	REDEVELOPN	<b>IENT</b>						Log	gged by	r:	GDT	1	
Во	reh	ole	Locat	tion: <b>F</b>	REFE	R TO FIGURE 1								Che	ecked k	oy:	Eth	+-	
drill	ma	del 8	& mour	nting: La	nd Crui	ser	Eastin	ıg:			slope:		~90°	)		R.L. S	urface:	10	
hok	e dia	amet	er:	51	mm	Drilling fluid: Water	Northi	ing:			bearin	g:	ok m	aré	defects	datum	:	AHD	
ur	BIN	ıy ı	nom	ation	mat ≥	materi	al		ootime	hod	le		dofa	a33		, (	defect desc	ription	
σ	L_	:			c iog ecove	rock type; grain chara	cteristics, colour,	ering tion	streng	gth	MPa	%	spac	ing n	ty	/pe, inclir	nation, plan	arity, roughnes	is,
metho	core-li	water	RL	depth metres	graphi core r	structure, minor	components	weath alterat	5 187	- <del>-</del> - <del>-</del>	D- diam- etral A- axial	RQD	838	0000	particul	ar	coating, this	ckness	general
ΓC					x	RHYODACITE: fine grain	ned with	FŔ											<u> </u>
ΜN					×	phenocrysis, grey moule	а ріпк. (солиново)					100			JT, :	50°, IR, F	RO, CN		-
	Η			-	××							$\left  - \right $			—→JT, :	50°, PL, i	RO, CN		-
			_5.5	4.5	××										JT, -	40°, PL, i	RO, CN		_
		erved		_	××										,	45°, PL, 4	SO, VN, cla	iγ	
		e Obs		-	×										JT,	25°, PL, 3	SO, CN		
		None		- -	××							80			, 	- 0, FL, A			-
			_5.0	0.0	××							Ű	Π		JT,	50°, PL, I 50°, PL, I	RO, CN RO, CN		
				-	×										JI, -	45°, PL, I	RO, CN		-
				_	Ŷ×														-
			_4.5	5.5	^ ×														_
					×	BH 1 terminated at 5.61r	ກ							<u> </u>	<del>- JΤ,</del>	1 <del>5°, IR, F</del>	<del>30, CN</del>		<del>-</del>
				-															-
			4.0	60															-
			_4.0																
				_															-
			_3.5	6. <u>5</u>															_
																			_
				_															-
			3.0	7.0															-
				_											ļ.				-
																			-
			_2.5	7. <u>5</u>															
				_															
				-															-
			2.0	8.0			i												
me DT	tho	1	diatu	.be		core-lift	water	/1/98 wat	er level		FR fro SW sl	ig esh jahtly	/ weathe	ered		defect typ JT joint PT part	be t lina	roughnes: VR very RO rough	s rough
AD RP			auge auge rolle	a acrewir ar drilling r/tricone	'a	barrel withdrawn	— on ▶— wa	ter inflow	17)1		MW m HW hi	ioder ighly	ately we weather	eather red	red	SM sea SZ she	m ared zone	SO smoo SL slicke	ith ensided
CB	ILC		claw NML	or blade	bit	graphic log/core recovery	< participation of the second secon	rtial drill fi mplete dr	uid loss ill fluid los	s	DW di (c	istinc over	itiy weat itiy weati is MW a	hered nd HV	Ň)	oo sne CS crus	areo surrace shed seam		
NG	, Ho	), PQ	wire	line core		core recovered					strength VL ve	ery lo	w			planarity PL plar	nar ved	coating CN clear	
						indicate material	wa ອຸເມ	iter pressi aeons'i fo	ure test re r depth	esult	L ko M m H hi	w iediu iah	m			UN und ST step	lulating oped	VN vene CO coati	er ng
							inte	erval sho	wp		VH ve EH ex	ery hi xtrem	igh nely high	n		IR irreg	gular		

CORED BOREHOLE BH1- BH2.GPJ COFFEY.GDT 3.17.09

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F:\GEOTECHNICS\JOB FILES\WARA 20800 - 20899\WARA20848AA\[GEOTWARA20848AA - AB BH1 CORE PHOTO.xls]A4 Landscape Figure



## **Engineering Log - Borehole**

Client: Principal:

Project:

## PROPOSED HOTEL REDEVELOPMENT

SAKE DEVELOPMENT PTY LTD

Borehole Location: REFER TO FIGURE 1

drill	model	and	mou	nting: l	and (	Cruiser			Easting:	slope:	-90°			F	R.L.	Surface: 12	
hok	e diame	eter:		٤	51 mm	1			Northing	bearing:				c	datu	im: AHE	>
dr	illing	info	rma	tion			mate	erial su	Ibstance								
method	5 penetration	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	mater soil type: plasticity or pa colour, secondary and	ial rticle characteristi minor component	ics, ts.	moisture condition	consistency/ density index	200 × pocket 200 × peretro-	400 meter	structi additional c	ure and bservations
ADT		N							Sandy GRAVEL: fine to coar brown pink, fine to coarse gra	se grained, angul ained sand, trace	ar, of fines.	D	MD			ROAD BASE	_
					_11.6	- 0. <u>5</u>		SP	SAND: fine to medium graine fines.	d, pale brown, tra	ace of	м	MD			AEOLIAN	
					_11.0			CL	Sandy CLAY: medium plastic coarse grained sand with sor angular gravel.	ity, brown, fine to ne fine sub angula	ar to	M <wp< td=""><td>Η</td><td></td><td></td><td>EXTREMELY WE RHYODACITE</td><td>ATHERED</td></wp<>	Η			EXTREMELY WE RHYODACITE	ATHERED
					10.5	- - 1. <u>5</u>	× ×		RHYODACITE: fine grained v quartz and black feldspar pin	vith phenocrysts ( k, brown colour.						HIGHLY WEATH RHYODACITE	- 
		1				_			Borehole BH 2 continued as	cored hole							
			None Observed		_10.0 _9.5	- 2.0 - - 2.5											
					_9.0	- 3. <u>0</u> - 3. <u>5</u> -											
ш GEO 5.3 Issue 3 Rev.2 щ т < 8 Q H Q & 2 W Q S m	shown t	au au ro ww cz ha di b! V V V V V V SVI	ger s ger d ller/tri- ashbo ble to ank bi bl to bl to ti ti ti ti ti	crewing* rilling* cone re ol uger t	8.0 Sul C pei 1 Wa Wa	4.0 aport mud casing netratio 2 3 4 ter 10/1/9 on dat water	N no resista anging to refusal 8 water I 8 water I e shown nflow	nil nce evel	notes, samples, tests       U <sub>so</sub> undisturbed sample 5       U <sub>so</sub> undisturbed sample 6       D     disturbed sample 7       N     standard penetration       N*     SPT - sample recover       Nc     SPT with solid cone       V     vane shear (kPa)       P     pressuremeter       Bs     bulk sample       E     environmental sample       R     refusal	0mm diameter іЗmm diameter test (SPT) — red e	classifica soil desc based or system moisture D dr M mo W we Wp pla W_ liq	ation syn ription a unified o y bist at astic limit uid limit	nbols ar	tion		consistency/de VS F t St St VSt H t Fb t VL L t MD t D	nsity index rery soft soft irm stiff nard riable rery loose oose nedium dense dense

 Sheet
 1 of 3

 Project No:
 GEOTWARA20848AA

 Date started:
 23.2.2009

BH 2

GDT

Date completed: 23.2.2009

Logged by:

Borehole No.

Checked by:

		_	£				viaa								
(	)(	O	T	e	y	geoleciii	ncs	i				Borehol	e No.	BH 2	
F	'n	ai	ine	eri	na	Log - Cored E	Bore	ho	le			Sheet	No	2 of 3	A D A 208 A 8 A A
	ient	ອ			SAKI		TD					Date sta	arted:	23.2.200	<u>47742004077</u> 9
Pr	inci	ipal:										Date co	mpleted:	23.2.200	9
Pr	oied	ct:		F	PRO	POSED HOTEL REDEVE	LOPM	IENT				Logged	by:	GDT ,	
Bc	oreh	nole	Locat	ion: 🖡	REFE	ER TO FIGURE 1						Checke	d by:	(Att)	<b></b> .
dril	l mo	odel 8	k mour	iting: La	nd Cru	iser	Eastin	g:		slope:	:	-90°	R.L. St	urface: 12	
hol	e di rilli	amet	er: nform	51 ation	mm mat	Drilling fluid: Water	Northi	ng:		bearin	ng:	ock mass defe	datum: c <b>ts</b>	AH	D
	Π	lig ii		acion		material		_	estimated	ISco		defect	d	lefect descript	ion
nethod	core-lift	vater	RI	depth metres	graphic log core recovi	rock type; grain characteristics, c structure, minor component	xolour, s	weathering alteration	strength	MPa D-diam- etral A-axial	RQD %	spacing mm	type, inclin	ation, planarity coating, thickne	, roughness, ss generat
Ē		~		116865					JISIS	Ū	┢		çuidi		generar
				_											-
				-											
			_11.5	0.5_											_
				-											-
				-											-
			_11.0	1.0											_
				_											
				-											-
			10.5	1. <u>5</u>		Continued from non-cored bore	hoie						M-0°-40m	n Pl. SO. clav	
MLC				_	××	RHYODACITE: fine grained with phenocrysts of quartz and black feto pick brown	ispar,	HW SW		8			5M, 0°, 20m	n, PL, SO, clay	-
Ĺ		pez		-	××			HW SW					SM, 15°, 60n	nm, IR, SO, cla	y _
		Obse	10.0	2.0	× . ×			SW			38				-
		None		_	Ĉ ×			HW					T, 10°, PL, I SM, 45°, 50n	RO, CN nm, IR, RO, Sa	ndy Clay. –
				-	^ ×			sw							-
	Ц			25	x ×								T, 60°, PL, R T, 60°, PL, I	C, CN, Clay RO, CN	
			_9.5	2. <u>0</u>	××			HW F					м, 55°, эли т. 25° Рі І	m, PL, RU, ciay RO, CN	
				-	× ×								T 25° DI 1	RO VN clav	-
				-	×								T, 25°, PL, I	RO, VN, sand	-
			_9.0	3.0	×										
				-	×						63		IT, 3°, PL, R		-
				-	×			HW F				$\Pi \square \Sigma$	SM, 60°, PL, 3 M, 60°, 70n IT, 60°, PL, 3	so, vn, clay nm, PL, SO, cla SO, VN, clay	ay _
			_8.5	3.5	××	Becomes grey mottled pink and whi	ite.						IT, 30°, IR, F IT, 50°, IR, F	RO, CN RO, CN	
				-	××	-				8			IT, 37°, IR, F IT, 10°, PL, I	RO, VN, clay RO, CN	-
				-	× _ ×								IT, 52°, PL,	RO, CN	-
m	etho	d	8,0	4.0	×	core-lift	water			weatheri	86 ing		11, 88°, IR, F IT, 43°, PL, defect tvn	KU, UN RO. CN 19	roughness
DT	5	-	diatu auge	ibe er screwi	ng	casing used	▲ 10/ on	/1/98 wat date sho	er level wn	FR fr SW s	resh slightly	y weathered	JT joint PT part	ing	VR very rough RO rough
AI Ri	2 7 7		auge rolle	er drilling r/tricone		barrel withdrawn		ter inflow	uid loss	HW h	nighly extren	weathered nely weathered	SZ she SS she	ared zone ared surface	SL slickensided
	э MLC Q, Hr	Q. PO	Claw NML wire	or blade .C core ine core	: SIL	graphic log/core recovery		mplete dr	I fluid loss	UW d (i strength	ustinc cover	ny weathered rs MW and HW)	CS crus	med seam	coating
						- graphic symbols indicate material	$ _{T_{wa}}$	ter press	ure test result		very lo ow nedio	w	PL plan CU cun UN und	tar Ved Tulating	CN clean SN stained VN veneer
						no core recovered	127 (lug inte	geons) fo erval sho	rdepth ⊮∩	H h VH v EH e	nigh very h extren	igh nely high	ST step IR irreg	oped gular	CO coating

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		-	<u>.</u>				hnioc	1									
(	)	U		e'	y	geoleci	mics	1				Bor	ehole N	0.	BH 2		
E	'n	ai	ine	eri	na	Loa - Corec	d Bore	eho	le			She	eet		3 of 3	ARA 2084	1800
Cli	ent	:			SAK		TYLTD					Dat	te starte	d:	23.2.200	)9	
Pri	nci	nal:										Dat	te compl	leted:	23.2.200	9	
Pri	nier	nt.		,	PRO	POSED HOTEL RED	EVELOPN	1ENT				Loc	iaed by:		GDT .		
Bo	reh	ole.	Local	ion: I	REFE	ER TO FIGURE 1						Ch	ecked by	v: i	Ant		
đril	mc	del 8	& mour	nting: La	nd Cru	iser	Eastin	ig:		slope;	:	-90°		R.L. Surf	iace: 12		
hol	e di	amet	ter:	51	mm	Drilling fluid: Water	Northi	ng:		bearir	ig:			datum:	AH	ID	
di		ng i	ntorm	ation	mat ≥	erial substance material		1		Ι.	r	ock mass	defects	dei	fect descrip	tion	
7	<b>_</b>				c log	rock type; grain characteris	stics, colour,	ering ion	strength	Is <sub>(50)</sub> MPa	%	defect spacing	tyr	pe, inclinat	tion, planarity	y, roughness,	
hetho	ore-lif	/ater		depth	raphi ore re	structure, minor comp	onents	/eathe		D-diam- etral A-axial	g	0088		, co	ating, thickn	ess	
	0	3	RL	metres	x	RHYODACITE: fine grained wi	ith	s ⊲ F	╡₋≥ェ≶ҵ		<u> </u>	85858	particula <u> <u> </u> <u> </u> </u>	r דור, דס,	CO, sano	ge	eneral
NML				-	××	phenocrysts of quartz and bla pink, brown. (continued)	ck feldspar,						0 ,TLי	°, IR, RO,	CN		1
				_	×								— ЈТ, З	0°, PL, SC	), CN		4
			7.5	4.5	×								—— JT, 1	0°, PL, SC	), CO, clay		
					×												_
				-	×						98						-
					×								IT 3	• 18 80	CN		
			_7.0	5.0	Ŷ×								51,0	,,,	OI1		_
		75		-	Û ×												_
		servec		-	Ĉ×								IT 5		CN		-
	Η	e Ob	_6.5	5.5	ĺ ×						$\vdash$		— JI, 5	, PL, KO,	, CN		_
		Non		-	××												-
				-	××												1
			6.0	60	××												-
			_0.0		××						100						
				_	××								—— JT, 7	1°, PL, R(	D, VN		-
				-	××												1
			_5.5	6. <u>5</u>	××												_
	Η			-	××						⊢		SM, (	0°, 50mm, ine gravel	, IR, RO, Sar	ndy Clay	
				-	××						97						
			5.0	7.0	×	Core Loss		-		<u>.</u>			— JT, З	7°, PL, R(	D, CN		
				-		BH 2 terminated at 7m											-
				-													
																	4
			_4.5	7. <u>5</u> _													-
				_													-
				-													
	1	4	4.0	8.0	L	corp.lift	wator			weatheri	na		 			6	
DT	ano		diatu augo	ibe er screwi	na	casing used		/1/98 wat date sho	er level wn	FR fi SW s	resh ilighti	y weathered	a J P	ietect type T joint T parting	)	VR very rou RO rough	igh
AC RF	1		augi rolle	er drilling r/tricone		barrel withdrawn	► wa	ter inflow	,	MW n HW h XW e	node lighly extrem	rately weather weathered nely weathere	red S d S	SM seam SZ sheard	ed zone	SO smooth SL slickens	ided
CE NA	i ILC		claw NML	or blade .C core	bit	graphic log/core recovery	pai cor	rtial drill f mplete di	luid loss ill fluid loss	DW c	listing	tly weathered	m C	S crushe	ed seam		
NC	ι, Ho	Q, PQ	wire	line core		core recovered				strength VL v L <sup>v</sup>	i iery k owi	w		nananty 2L planar 2U curveo	J	coating CN clean SN stained	
						indicate material no core recovered	wa 52 (lu	ter press geons) fo	ure test result or depth	M n H h	nediu 1igh	im iete	U S	JN undula T steppe	ating ed lar	VN veneer CO coating	
							inte	erval sho	wn	EH e	ery h	iign nely high	<b> </b> "	. negu			

CORED BOREHOLE BH1- BH2.GPJ COFFEY.GDT 3.17.09

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F:\GEOTECHNICS\UOB FILES\WARA 20800 - 20899\WARA20848AA\\GEOTWARA20848AA - AB BH2 CORE PHOTO.xls]A4 Landscape Figure

Borahole No.     HA 1       Ingeneering Log - Borehole     Sheet i of 1     of 1       SAKE DEVELOPMENT PTY LTD     Date started:     9.12.2008       ipplice     PROPOSED HOTEL REDEVELOPMENT     Date started:     9.12.2008       cc:     PROPOSED HOTEL REDEVELOPMENT     Date started:     9.12.2008       ipplice     10 monopole     Ouged by:     Ouged by:     Ouged by:       ipplice     10 monopole     0 monopole     0 monopole     0 monopole       ipplice     10 monopole     0 monopole     0 monopole     0 monopole     0 monopole       ipplice     10 monopole     0 monopole     0 monopole     0 monopole     0 monopole       ipplice     10 monopole     0 monopole     0 monopole     0 monopole     0 monopole       ipplice     10 monopole     0 monopole     0 monopole     0 monopole     0 monopole       ipplice     10 monopole     0 monopole     0 monopole     0 monopole     0 monopole       ipplice     10 monopole     0 monopole     0 monopole     0 monopole     0 monopole       ipplice     10 monopole     0 monopole     0 monopole     0 monopole     0 monopole       ipplice     10 monopole     0 monopole     0 monopole     0 monopole     0 monopole       <	CO	٦f	ff		V	Ż	<u>ه</u> (	ae	ot	echnics		_					
Sheet     1 of 1 GEOTWARA208 (GEOTWARA208)       tri     SAKE DEVELOPMENT PTY LTD     Date stanted:     9.12.2008       cpat:     Date completed:     9.12.2008       etc:     PROPOSED HOTEL REDEVELOPMENT     Logged by: GEOTWARA208       will and monitoring information:     Refer TO FIGURE 1     Concertainty       fig information:     Refer TO FIGURE 1     Concertainty     GEOTWARA208       ing information:     Refer TO FIGURE 1     Concertainty     Refer To FIGURE 1       ing information:     Refer To FIGURE 1     Concertainty     Refer To FIGURE 1       ing information:     Refer To FIGURE 1     Concertainty     Refer To FIGURE 1       ing information:     Refer To FIGURE 1     Concertainty     Refer To FIGURE 1       ing information:     Refer To FIGURE 1     Concertainty     Refer To FIGURE 1       ing information:     Refer To FIGURE 1     Stantation:     Refer To FIGURE 1       ing information:     Refer To FIGURE 1     Stantation:     Refer To FIGURE 1       ing information:     Refer To FIGURE 1     Stantation:     Refer To FIGURE 1       ing information:     Refer To FIGURE 1     Stantation:     Refer To FIGURE 1       ing information:     Refer To FIGURE 1     Stantation:     Refer To FIGURE 1       ing information:     Refer To FIGURE 1     S	50	<b>7</b> 1			y		<u> </u>	<b>,</b> "					Boreho	ole No.		HA 1	
Bit is an example of the second state of the seco	Enai	nin	ne	eri	inc	ı L	oa	-	Bo	rehole			Sheet				40 /
Description	lient:	2			SAK		FVE	LO					Project Date st	t No:		9.12.2008	18/
er: PROPOSED HOTEL REDEVILOPMENT biole Location: REFER TO FIGURE 1  REFER T	rincipal:	al:			0, 1,			_0,				:	Date o	omplet	ed:	9.12.2008	
the Location: REFER TO FIGURE 1         Concerned by          Checked by:	roiect:				PRC	PO	SED	но	TEL	REDEVELOPMENT		1		i bv:		GÐI v	
Indefinition     Hand Auger     Easing:     stop:     -00"     R.L. Surface:     13       Istemeter:     62 mm     Northing     bearing:     datum:     AtD       Istemeter:     62 mm     material substance     material     geneticity	orehole I	le Lo	ocat	ion:	REF	ER	 TO F	IGL	IRE <sup>·</sup>				Checki	ed by:		Emt	
Item etc         10 motion         material substance         datum         AtD           Imp formation         material substance         material substance         material substance         structure and construction         structure and co	ill model a	el and	id mo	ounting	: 1	Hand	Auger			Easting:	slope: -90	۰		R	L. Si	urface: 13	
Image monometer     Image material is substance       Image monometer     Image monometer       Image monometer     Image monometer </td <td>le diamete</td> <td>neter:</td> <td>r:</td> <td></td> <td></td> <td>62 mn</td> <td>n</td> <td></td> <td></td> <td>Northing</td> <td>bearing:</td> <td></td> <td></td> <td>d</td> <td>atum</td> <td>: AHD</td> <td></td>	le diamete	neter:	r:			62 mn	n			Northing	bearing:			d	atum	: AHD	
Sign bit	rilling in	g info	torm	ation		1		ma	terial	substance			_ ×	ہ ا		· · · ·	
12.3     Image: Solution of the second	benetrati	support	support water	san test	npies, s, etc	RL	depth	graphic log	classificatio	material soil type: plasticity or particle cl colour, secondary and minor d	aracteristics,	moisture condition	consistency density inde	kPa kPa		structure and additional observations	i
A super norward auger norward buset	123	3 N	V				meaco	BIL	} sc	TOPSOIL: Clayey SAND, fine to me	dium grained,	M		= N.B.	₹   T(	OPSOIL	
A Support							-			dark brown, medium plasticity lines, angular gravel, trace of rootlets.	some sup						
d     ager arraying*     Consistency/density index by our cash       d     ager arraying*     Support M mod     N nil       d     ager arraying*     Consistency/density index So on the same is s		~~	+							Sandy GRAVEL: fine grained, angu	ar, pale grey to	1					
d     auger acrowing <sup>2</sup> Support     N     noles, samples, tests     classification symbols and boil description     consistency/density index VS										Terminated at refusal on Highly Wei Rhyodacite.	thered	1					
d suger screwing auger screwing auger screwing d suger screwing						12.5	0.5			Borehole HA 1 terminated at 0.31m							
d       auger screwing*       N nit       U_u       roles, samples, tests       classification symbols and sold description         d       auger screwing*       M mud       N nit       U_u       undisturbed sample 50mm diameter based on united classification       consistency/density index vs ort							-										
d       support       N nil       Use       consistency/density index undisturbed sample 60mm diameter undisturbed sample 60mm diameter support Ming*       consistency/density index VS       very soft S							-					-					
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roller/income I construction ID disturbed sample System IF firm	2	au au	auger auger roller#	screwin drilling* ricone	ŋ.	C C	muð casing	_	n All	U <sub>50</sub> undisturbed sample 50mm dia U <sub>60</sub> undisturbed sample 63mm dia	meter soil des meter based (	scription on unified	classifica	lion		va very solt S soft F firm	
washbore 1234 no resistance N* SPT - sample recovered molsture VSt very stiff		W8 SW	vashb cable i	iore tool		per 12		no resis	tance	N standard penetration test (SP     N* SPT - sample recovered	) molstu	re			-	St stiff VSt verv stiff	
hand auger information in the strateging to the		ha dia	hand a diatub	auger		wat	ter	anging efusal	ĩŌ	Nc SPT with solid cone V vane shear (kPa)	D c M r	try noist				H hard Fb friable	
blank bit V bit         V 10/1/98 water level         P         pressuremeter         W         wet         VL         very loose           V bit		bla V I	olank I √bit	bit		<u> </u>	10/1/98 on date	3 wate e show	r level n	P pressuremeter Bs bulk sample	W v Wp r	vet plastic limi	t			VL very loose L loose	
TC bit E environmental sample W iliquid limit MD medium dense own by suffix R refusal D dense	t shown by s	TC by suff	TC bit uffix				water in	nflow		E environmental sample R refusai	W <sub>L</sub> I	iquid limit				MD medium dense D dense	

BOREHOLE HA1 - HA7.GPJ COFFEY.GDT 3.24.09

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Boreł	nole	Loc	atio	n: <b>REF</b>	ER	TO F	IGU	RE 1				(	Checke	ed by:		CHM-	
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	tion			notes			mac	5					y/ ex	ੂੰ ਦ	5		
method	o penetra	support	water	samples, tests, etc	RL	depth	graphic log	classificatio symbol	n soil type: plasticity o colour, secondary	naterial or particle character and minor compon	istics, ents.	moisture condition	consistenc density ind	Pere Book Book	00 mete	structure and additional observations	
AH		N				-		sw	TOPSOIL: SAND, fine to grey speckled white, sor	medium grained, to me organics and roo	prownish otlets.	D				TOPSOIL	
						-	}  }  ////	SC	Gravelly Clavey SAND.	fine to coarse grain	ed.	M	MD				
						_		00	brown mottled yellow, m sub angular gravel.	edium plasticity fine	is, some				F	RHYODACITE	
-	3			D	17 9	0.5	////		Borehole HA 2 terminate	ed at 0.45m							
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ethor S	t	au	ger so ner de	rewing* illino*	su M	pport mud casico	N	nil	notes, samples, tests U <sub>50</sub> undisturbed sam	uple 50mm diameter	classific soil desi based or	ation sy cription n unified	m <b>DOIS ar</b> classifice	10 Ition		Consistency/density index VS very soft S soft	
R		rol wa	er/tric shbor	ione ie	ре 1	netration	n.		D disturbed sampl N standard penetr	e ation test (SPT)	system					F firm St stiff	
r A		ca ha	ole too nd au	ol ger		j	to resista anging to efusal	ince	N* SPT - sample re No SPT with solid o	covered one	moistur D dr	e Ny				VSt very stiff H hard	
ŕ		dia bla	itube ink bit		wa ▼	ter 10/1/9	3 water	level	V vane shear (kPa P pressuremeter	i)	M m W w	ioist et				Fb friable VL very loose	
it cho	יא טעט	vt TC #usu#	яс bit ix			on date water i	e showr nflow	I	E environmental s	ample	Wp pi W <sub>L</sub> lic	asuc imi quid limit	L			MD medium dense	
a, srid g.	an oʻ	, sun AC	Ť		-	water o	outflow									VD very dense	

BOREHOLE HA1 - HA7.GPJ COFFEY.GDT 3.24.09

coffee de cont	ochnice		
coney geou		Borehole No.	НА З
Engineering Log - Bo	rehole	Sheet Project No:	1 of 1 GEOTWARA20848AA
Client: SAKE DEVELOPME	NT PTY LTD	Date started:	9.12.2008
Principal		Date completed	9.12.2008
Project: PROPOSED HOTEL	REDEVELOPMENT	Logged by:	GDF 1
Borehole Location: <b>REFER TO FIGURE</b>	1	Checked by:	ZOMT
drill model and mounting: Hand Auger	Easting: slope: -90°	R.L.	Surface: 21
hole diameter: 62 mm	Northing bearing:	datu	m: AHD
drilling information material	substance		
notes protes protection protecti	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	consistency/ density indey density indey 200 d penetra 400 meter	structure and additional observations
⊈ NSF	TOPSOIL: SAND, fine to medium grained, brownish grey with some rootlets and traces of organics.		TOPSOIL _
	to medium plasticity clay and minor cobbles at top, trace of cobbles less than 100mm in dimension		RESIDUAL
20.5 0.5			
			_
			-
	Gravely SAND: fine to coarse grained, yellow /	MD	EXTREMELY WEATHERED
	angular gravel.		-
20.d 1.0 ····	Borehole HA 3 terminated at 1m		
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			-
18.5 2.5	notes, samples, tests classification	symbols and	consistency/density index
AS auger screwing* M mud N nil AD auger drilling* C casing	U <sub>so</sub> undisturbed sample 50mm diameter based on unifie U <sub>sa</sub> undisturbed sample 63mm diameter based on unifie	n d classification	VS very soft S soft
RR roller/tricone penetration W washbore 1234	D disturbed sample system N standard penetration test (SPT)		F firm St stiff
CT cable tool no residence HA hand auger	N*         SPT - sample recovered         moisture           Nc         SPT with solid cone         D         dry           V         vertextraction of the set of the s		VSt very stiff H hard
B blank bit 1/1/98 water level	v varie snear (kPa) M moist P pressuremeter W wet Bs bulk sample W/a close in	nit	ro madie VL very loose
T TC bit *bit shown by suffix e.g. ADT water outflow	E environmental sample W <sub>L</sub> liquid lim R refusal	it	MD medium dense D dense VD verv dense

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BOREHOLE HA1 - HA7.GPJ COFFEY.GDT 3.24.09

Form GEO 5.3 issue 3 Rev.2

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drill	mod	del a	and	mour	nting:	Hand	Auger			Easting:	slope:	~90°		onconc		-,. R.	.L. Su	Inface:	19	
hole	e dia	met	er:			62 mr	n	•••••		Northing	bearin	g:				da	atum:		AHD	
dr	illin S	ig i S	nfo	rmat	tion		1	mat	erial s	ubstance				_ X		6				
method	1 totooo	c perienan	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classificatior symbol	n soil type: plasticity colour, secondary	naterial or particle character and minor compon	ristics, ents.	moisture condition	consistency, density inde	100 - pocket	300 B penetr	400	str additior	ructure and nal observatio	ns
НA	8		N					גווג	SIN	TOPSOIL: fine to coarse	grained, black with	1 rootlets.	м			Π	TC	PSOIL		
									SW	Gravely SAND: tine to with minor sub angular t cobbles <100mm in dim	coarse grained, pair o angular gravel, tra ension, trace of org	anics.						SIDUAL		
						_18.9	0. <u>5</u>		CL	Sandy CLAY: medium p yellow and grey, fine gra	Ilasticity, pale brown ined sand.	1, mottled	<wp< td=""><td>H</td><td></td><td></td><td>R</td><td>(TREMELY IYODACIT</td><td>WEATHEREI E</td><td>0</td></wp<>	H			R	(TREMELY IYODACIT	WEATHEREI E	0
									SC	Clavev SAND: fine to co	arse grained, pale	pink.	M							
								/.		mottled red and white, n Borehole HA 4 terminate	redium plasticity find	25.								
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							25													
mett AS AD RR V CT HA DT B V toit s	show	n by	au au roll wa cal ha dia bla V t TC suff	ger so ger dr er/tric shbor ble too hd au tube nk bit bit bit	rrewing* illing* one e ger	16.5 su M C pei 1 wa wa	2.3 pport mud casing netration 2.3.4 ter 10/1/90 on date water i	N n no resista anging to anging to a	nil nce evel	notes, samples, tests       Use     undisturbed sam       D     disturbed samples       N     standard penetr       N*     SPT - sample re       Nc     SPT with solid c       V     vane shear (kPZ)       P     pressuremeter       Bs     bulk sample       E     environmental s       R     refusal	nple 50mm diameter nple 63mm diameter e ation test (SPT) covered one a) ample	classific soll des based or system D dr M m W w Wp pl W <sub>L</sub> lit	I ration syn cription n unified e ry ry ry ry ry ry ry ry ry ry ry ry ry	l mbols an classifica	11 10 11 11 10 10			consistenc VS F St VSt H Fb VL L MD D VD	//density index very soft soft firm stiff very stiff hard friable very loose loose medium den dense	se

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Engineering	Log -	Borehole

Bornhole No.       HA 5         Ingineering Log - Borehole       Sheet       1 of 1         triplet No.       GEOTWARAZ084!         triplet No.       Sheet       1 of 1         triplet No.       PROPOSED HOTEL REDEVELOPMENT       Date stance:       9.12.2008         triplet No.       REFER TO FIGURE 1       Logged by:       Status:       1         triplet No.       REFER TO FIGURE 1       Logged by:       Status:       1         triplet No.       REFER TO FIGURE 1       Logged by:       Status:       1         triplet No.       REFER TO FIGURE 1       Easting:       Use:       -0*       R.1. Surface:       1         triplet No.       REFER TO FIGURE 1       Status:       Additional Status:       Hole:       -       Hole:       -         triplet No.       Temper Additional Status:       Status:       -       Hole:       -       Hole:       -	$\sim$	ſ		f,		Ĵ		ne	ote	chnics								
Binden     Office     Office     Office     Office       ist     SAKE DEVELOPMENT PTV LTD     Date stanted:     9.12.2008       ispan="2">Ispan="2"     Ispan="2"     Ispan="2"     Ispan="2"       ispan="2">Ispan="2"     Ispa="2"     Ispa="2"     Ispa="2"       ispa="2">Ispa="2"     Ispa="2"     Ispa="2"     Ispa="2"       ispa="2">Ispa= Ispa="2"     Ispa= Ispa="2"     Ispa="2"	U		/		Cy			<i>,</i> –					ī	Boreho	le No	).	HA 5	
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beneficial in the local to Main Handler in the local to Beneficial Control of the second	lier	<u> </u>			SAK		EVE	LOP	MEN					Project Date st	N0: arted		9.12.2008	10/
PROPOSED HOTEL REDEVELOPMENT     September 2     Septembe	Princ	inal	I-		07.17	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		_0,						Date or	nmole	sted:	9 12 2008	
Barbon     Description     REFER TO FIGURE 1     Checked by       Index or moving     Head Auge     Easting:     stop:     -07     R L Surface     17       Index or moving     Stop     Stop     Nothing     Learing:     data     AHD       Index or moving     Stop     Stop     Nothing     Learing:     data     AHD       Index or moving     Stop     Stop     Material substance     Index or moving     Index or moving     AHD       Index or moving     Nothing     Learing:     Index or moving     Index or moving     AHD     Index or moving     AHD       Index or moving     Nothing     Index or moving       Index or moving     Nothing     Stop     Stop     Stop     Stop     Stop     Index or moving	nnie	npa nct	••		PRC	DPO	SFD	нот	FI F						l hv		GDT )	
add and mounting:     Hend Auger     Easting:     slope:     40°     R.L.Surface:     1       istrated:     12 mm     Northing     bearing:     datum:     AHD       istrated:     12 mm     material substance     istrates:	lore	hole	e Lo	catio	on: <b>REF</b>	ER	TO F	IGU	· RE 1					Checke	• ~ , ed bv		CMT	
Barry Normanian         Monthing         Destring         datum         Audio           Ing information         material allocana         material allocana         grad barry allocana	rill m	odel	and	mou	nting;	Hand	Auger			Easting:	slope:	-90°		51100/10		R.L. S	Surface: 17	
Ing information       material substance         get all status       score         score       score	ole c	liam	eter:			62 mr	n			Northing	bearin	g:				datur	n: AHD	
Bit Strate         Str	drill	ing 5	into	prma	tion	1	1	mat	erial s	ubstance				. ×	- ¢			
N     SANO: file to coarse grained, pale brown with grass     M     AGOLIAN       SC     Clayey SAND: file to coarse grained, pale brown     W     MD       SC     Clayey SAND: file to medium grained, dark brown     W     MD       To     SC     Clayey SAND: file to coarse grained, and brown     W     MD       To     SC     Clayey SAND: file to coarse grained, and brown     W     MD       To     SC     Clayey SAND: file to coarse grained, and brown     W     MD       To     SC     Clayey SAND: file to coarse grained, and brown     W     MD       To     SC     Clayey SAND: file to coarse grained, and brown     W     MD       To     SC     Clayer SAND: file to coarse grained, based     Boehold to LSE     Extremely SAND: file to coarse grained, based       To     -16.5     0.5     -16.5     0.5     -16.5     0.5       To     -16.5     0.5     -16.5     0.5     -16.5       To     -16.5 </td <td>וופתוסם</td> <td>benetrati</td> <td>support</td> <td>water</td> <td>notes samples, tests, etc</td> <td>RL</td> <td>depth</td> <td>graphic log</td> <td>classificatio symbol</td> <td>ma soil type: plasticity or colour, secondary ar</td> <td>erial particle character d minor compon</td> <td>ristics, ents.</td> <td>moisture condition</td> <td>consistency density inde</td> <td>100 200 Appocke</td> <td>400 meter</td> <td>structure and additional observations</td> <td></td>	וופתוסם	benetrati	support	water	notes samples, tests, etc	RL	depth	graphic log	classificatio symbol	ma soil type: plasticity or colour, secondary ar	erial particle character d minor compon	ristics, ents.	moisture condition	consistency density inde	100 200 Appocke	400 meter	structure and additional observations	
Image: second constrained and second constrained cons	5		N						SP	SAND: fine to coarse grain at top and rootlets.	ied, pale brown w	with grass	м			1	AEOLIAN	
Bit I I I I I I I I I I I I I I I I I I I						-				Clauge SAND: Grada and	ium graisad d	cheorem	147	MO				
Image: some of the set of t		\$	8_		D		-			with medium plasticity clay	un yaneo, dan	NUT	~~				RHYODACITE	
suger screening suger screening subtroop wathood task augur subtroop subtroop marking super string super							-			I erminated at refusal on H Rhyodacite. Borehole HA 5 terminated	ignly Weathered							
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Image: screwing*       auger screwing*       motes, samples, tests       consistency/density index         auger screwing*       mud       N mid       N       N         auger screwing*       mud       N       nil       Use       undisturbed sample 50mm diameter       classification symbols and       consistency/density index         valuer drilling*       no resistance       undisturbed sample 50mm diameter       soil description       based on unified classification       S       soft         ron resistance       no resistance       no resistance       N       standard penetration test (SPT)       based on unified classification       S       soft         N       SPT with solid cone       N       SPT with solid cone       M       moist       Fb       friable         VSt       very stiff       H       nard       Fb       friable       W       water       N       motes there if (Pa)       W       W       W       W       W       W       M       M       M       Fb       friable																		
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Image: support auger screwing* auger screwing* auger drilling* notes, samples, tests undisturbed sample 50mm diameter washbore cable tool hand auger disturbed sample       notes, samples, tests undisturbed sample 50mm diameter Uses undisturbed sample 63mm diameter C casing Uses undisturbed sample 63mm diameter auger drilling to resistance refusal       classification symbols and soil description based on unified classification system       consistency/density index soil description based on unified classification system         Image: Washbore cable tool hand auger dilutube       1 2 3 4 more sistance refusal       N standard penetration test (SPT) N* SPT - sample recovered Nc SPT with solid cone       Image: Washbore St SPT - sample recovered Nc SPT with solid cone       N moist       VSt very stiff         Mail tube       water       V vane shear (KPa)       M moist       Fb friable																		
1       14,5       2.5         auger screwing* auger drilling* roller/tricone washbore cable tool hand auger dilatube       M mud N mil Vs       notes, samples, tests Use undisturbed sample 50mm diameter Use undisturbed sample 63mm diameter D       classification symbols and soil description D       consistency/density index very soft         N       mud Standard penetration hand auger       N       notes, samples, tests Use undisturbed sample 63mm diameter D       soil description based on unified classification system       VS       very soft         N       standard penetration test (SPT) Nc       N       standard penetration test (SPT) Nc       ST       soil description based on unified classification system       St       soft st         M       SPT - sample recovered diatube       N       SPT - sample recovered Nc       SPT with solid cone       D       dry M       H       hard hard         M       moist       Fb       Fiable       Fb       Fiable       V/       V/       V/       V/       V/																		
auger screwing*       support       notes, samples, tests       classification symbols and soil description       consistency/density index         auger screwing*       M mud       N nil       Use       undisturbed sample 50mm diameter       classification symbols and soil description       VS       very soft         notes, samples, tests       undisturbed sample 63mm diameter       classification symbols and soil description       VS       very soft         notes, samples, tests       undisturbed sample 63mm diameter       based on unified classification       S       soft         roller/tricone       penetration       D       disturbed sample ecovered       N       standard penetration test (SPT)       St       stiff         N       spect ranging to refusal       NC       SPT with solid cone       D       dry       H       hard         diatube       water       V       vanes shear (KPa)       M       moist       Fb       Fifable																		
auger screwing*       support       notes, samples, tests       consistency/density index         auger screwing*       M mud       N nil       Use       undisturbed sample 50mm diameter         noter/tricone       D       disturbed sample       soil description       VS       very soft         washbore       1.2.3.4       D       disturbed sample       soil description       VS       very soft         cable tool       1.2.3.4       no resistance       N       standard penetration test (SPT)       moisture       VSt       very stiff         N       Standard penetration test (SPT)       N'       SPT - sample recovered       moisture       VSt       very stiff         Idatube       water       V       vare shear (KPa)       M       moist       Fb       friable         Name       D       Consistence       N       Recent (KPa)       M       moist       Fb       friable							-	1										
Image: support       notes, samples, tests       classification symbols and soil description       consistency/density index         auger screwing*       M mud       N nil       Use       undisturbed sample 50mm diameter       soil description       VS       very soft         auger drilling*       C casing       Use       undisturbed sample 63mm diameter       based on unified classification       S       soft         roller/tricone       penetration       D       disturbed sample       ST       system       F       firm         soil description       12.3.4       N       standard penetration test (SPT)       N*       SPT - sample recovered       moisture       VSt       very stiff         hand auger       water       V       vane shear (kPa)       M       moist       Fb       Finable         blabbit       Tot 04/02 watersland       Penetrestromation       Penetrestromation       W       W       W       W							-											
auger screwing:     M. mud     N. nil     Uso     undisturbed sample 30mm diameter     soil description     VS     very soft       auger drilling*     C casing     Uso     undisturbed sample 30mm diameter     soil description     S     soft       roller/tricone     penetration     D     disturbed sample 63mm diameter     based on unified classification     S     soft       washbore     1.2.3.4     N     standard penetration test (SPT)     N     SpT - sample recovered     moisture     VSt     very stiff       hand auger     water     V     vane shear (KPa)     M     moist     Fb     friable       blait/bit     moist     Procesurements     Procesurements     W     W     W     W	i   tho	4 	ļ			14.5 su	2.5			notes, samples, tests		classific	ation sy	nbols an	d	╧╁	consistency/density index	
Newshore     1 2 3 4 ranging to hand auger     N     standard penetration test (SPT)     system     F     IIIm       washbore     1 2 3 4 ranging to hand auger     N     standard penetration test (SPT)     St     stiff       washbore     V     VSt     very stiff       hand auger     V     SPT - sample recovered     moisture     VSt     very stiff       diatube     water     V     vane shear (kPa)     M     moist     Fb     friable       blank bit     Transferred     P     pressurements     W     water     V     vane shear (kPa)     M     moist     Fb     friable	; ) ?		au au	iger si iger d	crewing* rilling*:	M C	mud casing	N	nil	U <sub>so</sub> undisturbed sample U <sub>so</sub> undisturbed sample	2 50mm diameter 2 63mm diameter	soil dese based or	cription n unified (	classificat	tion		VS very soft S soft	
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hlank hit 40% /00 water lovel P proset/complex			ha dia	ind au atube	ger	wa wa	ter	enging to efusal	,	Nc SPT with solid cone V vane shear (kPa)	•	D dr M m	y oist				H hard Fb friable	
V bit     V     vic     vic     vic     vic     vic     vic       V bit     V     on date shown     Bs     bulk sample     Wp     plastic limit     L     loose			bi V	ank bi bit	t	⊻	10/1/98 on date	8 water I e shown	evel	P pressuremeter Bs bulk sample		W wi Wp pl	et astic limit				VL very loose L loose	
TC bit         E         environmental sample         W_ liquid limit         MD         medium dense           wn by suffix         Model water inflow         R         refusal         D         dense	t sho	wn b	T( y suf	C bit fix			water îr	nflow		E environmental sam R refusal	ple	W, liq	juid limit				MD medium dense D dense	

BOREHOLE HA1 - HA7.GPJ COFFEY.GDT 3.24,09

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			Ν						SP	TOPSOIL: SAND, fine to organics and rootlets.	coarse grained, w	ith	M	VL			TOPSOIL		
						1			SC	Clayey SAND: fine to me to brown with medium pla	dium grained, darl isticity clay, trace (	c brown of angular	W				RESIDUAL		
									CL	Sandy CLAY: medium pl yellow and red, trace of fi and fine grained gravel, s	asticity, brown mol ne to coarse grain ub angular to ang	ttled ed sand ular.	<wp< td=""><td>VSt</td><td></td><td></td><td>EXTREMELY RHYODACITE</td><td>WEATHERED</td><td></td></wp<>	VSt			EXTREMELY RHYODACITE	WEATHERED	
			_	_				[]]]]	CL	Gravelly CLAY: medium mottled yellow with fine g	plasticity, pale bro rained gravel.	wn, /	M		-				
						_13.5	0. <u>5</u>			Terminated at refusal on Rhyodacite.	Highly Weathered								
										Borenole HA 6 terminate	1 at U.4m								
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l A			cat har	id aug	y ger			anging to efusal		N° SPT - sample rec No SPT with solid co	overed	D dr	e y oist				VSt H Eb	very stiff hard frichlo	
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it i	show	n by	TC SUff	bit x			water in	nflow		E environmental sa	mple	W <sub>L</sub> liq	uid limit				MD D	medium dense dense	
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BOREHOLE HA1 - HA7.GPJ COFFEY.GDT 3.24.09

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arlining i		notos	1	1	mate	eriai si ⊊				۲. Xe	τġ.				
ethod penetrat	ipport ater	samples, tests, etc		depth	aphic log	assificatio	material soil type: plasticity or particle characte	ristics,	oisture	onsistency ensity ind	kPa	additional observations	;		
E 123 조제	S S N		RL.	metres	5   )   )	ວິດີ SP	colour, secondary and minor compon	ents. arev with	£ ठ М	ម័ VL	<u>8</u> 88				
				-	<u> }  }</u>	SP	rootlets. SAND: fine to coarse grained motified brow	n, white	M						
			-	_		Ű,	and pale grey, angular gravel (<10mm), trai to medium grained.	ce of fine							
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method			4.5 su	2.5			notes, samples, tests	classifica	ation sy	mbols an		consistency/density index			
AS AD RR	auger s auger o	screwing* Irilling* icone	C M	mud casing	N	nil	U <sub>50</sub> undisturbed sample 50mm diameter U <sub>50</sub> undisturbed sample 63mm diameter D disturbed sample	based on	ription unified (	classifica	tion	VS very soft S soft F firm			
W	washbo cable to	ore pol	pe 1	netratio	n no resista	nce	N standard penetration test (SPT) N* SPT - sample recovered	moisture				St stiff VSt verv stiff			
HA DT	hand a diatube	uger	wa	iter	anging to refusal	,	Nc SPT with solid cone V vane shear (kPa)	D dry M mo	/ bist			H hard Fb friable			
B V	blank b V bit	it	⊻	10/1/9 оп dat	8 water I e shown	evel	P pressuremeter Bs bulk sample	W we Wp pla	et astic limit			VL very loose L loose			
*bit shown b e.g.	y suffix ADT			water i water o	nflow outflow		R refusal	ara mini			D dense VD very dense				

BOREHOLE HA1 - HA7.GPJ COFFEY.GDT 3.24.09

Form GEO 5.3 Issue 3 Rev.2

# Appendix B

Laboratory Results



## uniaxial compressive strength

client: C	COFFEY GEOTECHNICS - WARABROOK job no: INFOGLEN 00131AA										
principal: S	SAKE DEVEL	OPMENT PT	Glend	enning							
project: C	GEOTWARA	20848AA - PF	4 March 2009								
location: S	SALAMANDE	BH 2									
test procedure: AS 4133.1.1.1 and 4133.4.2.1 date received: 26 February 2009											
tes	st apparatus:	Avery 180	0 kN compre	ession mac	hine S/N E	E65321	page: 1	of 1			
The sample wa poly pipe which The sample wa	he sample was received by our laboratory on February 26th, 2009 from a courier. It had been wrapped in bubble-wrap and placed inside split oly pipe which was sealed with tape. The sample was tested in an "as received" condition.										
QESTLAB wo	ork order ID		height	uniaxial	wet density						
dept	th	date tested	average diameter	compressive strength	moisture	sample descripti	on	comments			
QESTLab s	QESTLab sample ID test duration height/dia ratio MPa content bedding/foliation failure mechanism										
GLEN09W	GLEN09W-00146 148 mm 2.6 t/m <sup>3</sup>										
BH 2 2.83 t	BH 2 2.83 to 2.98 m 2 Mar 09 51.8 mm 223 0.0 % rhyodacite										
GLEN09S	-00515	8.60 min	2.85:1		0.3 /0			usintegrated			



Before



After

#### F:\2. Laboratory\1-INFOGLEN Jobs\INFOGLEN 00131AA - WARA\[UCS.xls]Report



This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025 The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/national standards. NATA Accredited Laboratory No. 431 Authorised Signature: *Alan Cocks Associate Geotechnician* 

4 Mar 2009 Date

### PAGE 1 OF 2

## **RESULTS OF ACID SULPHATE SOIL ANALYSIS**

1 sample supplied by Coffey- Warabrook on the 9th January, 2009 - Lab. Job No. A1641 Analysis requested by Andrew Tait. - Your Project: GEOTWARA20848AA

Sample Site	Depth (m)	EAL lab code	Texture	Moisture Content (% moisture)	Extractable Sulphate Sulphur %S <sub>kcl</sub>	Extractable Calcium %Ca <sub>kci</sub>	Extractable Magnesium %Mg <sub>kcl</sub>	Oxidisable Sulphur %S <sub>pos</sub> (as %S <sub>p</sub> - %S <sub>kcl</sub> )	Oxidisable Sulphur S <sub>pos</sub>	Oxidisable Calcium %Ca <sub>A</sub>	Oxidisable Magnesium %Mg <sub>A</sub>	TAA pH <sub>kci</sub>	Titratable Actual Acidity (TAA) mole H <sup>*</sup> /tonne
			(note 7)						mole H <sup>+</sup> /tonne	(%Cap - %Cakcl)	(%Mgp - %Mgkcl)		(to pH 6.5)
Method No.					23C	23V	235	23E	a-23E	23X	23U	23A	23F
HA7	0.65 - 0.70	A1641/1	Coarse	6.8	0.00	0.04	0.00	0.00	1	0.00	0.00	6.33	2

#### NOTE:

1 - All analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground)

2 - Samples analysed by SPOCAS method 23 (ie Suspension Peroxide Oxidation Combined Acidity & sulfate) and 'Chromium Reducible Sulfur' technique (Scr - Method 22B)

3 - Methods from Ahern, CR, McElnea AE , Sullivan LA (2004). Acid Sulfate Soils Laboratory Methods Guidelines. QLD DNRME.

4 - Bulk Density is required for liming rate calculations per soil volume. Lab. Bulk Density is no longer applicable - field bulk density rings can be used and dried/ weighed in the laboratory.

5 - ABA Equation: Net Acidity = Potential Sulfidic Acidity (ie. Scrs or Sox) + Actual Acidity + Retained Acidity - measured ANC/FF (with FF currently defaulted to 1.5)

6 - The neutralising requirement, lime calculation, includes a 1.5 safety margin for acid neutralisation (an increased safety factor may be required in some cases)

7 - For Texture: coarse = sands to loamy sands; medium = sandy loams to light clays; fine = medium to heavy clays and silty clays

8 - .. denotes not requested or required

9 - SCREENING, CRS, TAA and ANC are NATA certified but other SPOCAS segments are currently not NATA certification

10- Results at or below detection limits are replaced with '0' for calculation purposes.

11 - Projects that disturb >1000 tonnes of soil, the ≥0.03% S classification guideline would apply (refer to acid sulfate management guidelines).

(Classification of potential acid sulfate material if: coarse Scr≥0.03%S or 19mole H+/t; medium Scr≥0.06%S or 37mole H+/t; fine Scr≥0.1%S or 62mole H+/t)

TPA pH <sub>ox</sub>	ТРА рН <sub>тра</sub>	Titratable Potential Acidity (TPA) mole H <sup>+</sup> /tonne (to pH 6.5)	NET ACIDITY SPOCAS Suite mole H <sup>+</sup> /tonne (based on %Spos)	NET ACIDITY TPA Only mole H <sup>*</sup> /tonne (based on TPA)	LIME CALCULATION SPOCAS Suite kg CaCO <sub>3</sub> /tonne DW	LIME CALCULATION TPA Only kg CaCO <sub>3</sub> /tonne DW
23B		23G	note 5	note 5	note 5	note 5
5.75	6.79	0	3 Refer Note 6 & 7	0 Refer Note 6 & 7	0.2	0

Environmental Analysis Laboratory

checked:

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- 1 -

job no: **INFOWAR00187AA** 

sheet **1** of **1** 

<u>acid</u>	sulfa	ate s	oil scre	ening	g tes	st		office:	Newcastle				
client:		COFF	EY GEOTECHI	NICS				date:	12 E	December 20	008		
principal		SALA	MANDER SHO	RES HO	TEL P	TY LT	D	test location:	LAE	BORATORY			
project:	project: GEOTWARA20848AA – Hotel Development tested by: GREG E												
location:	location: SOLDIERS POINT checked by:												
date sam	date samples recovered: 9/12/08 pH meter used/serial no: HORIBA D-24 date of calibration: 12/12/08												
hydroger	hydrogen peroxide pH prior to use: <b>4.9</b> hydrogen peroxide temperature prior to use: <b>22.7°C</b>												
				₽H₽					(oxidatior	PH <sub>Fox</sub> n in 30% hydrog	gen peroxide)		
sample location	depth (m)	RL (mAHD)	soil description	pH in 1:5 distilled water	time (mins)	<b>рН</b> ғох	temp (°C)	Effervescence (see note below)	Odour	Colour change during reaction	PH Change (ie PHF-PHFox)	Additional comments	
HA 2	0.4-0.45		CLAY	7.37	20	5.10	23.4	Nil	Nil	Nil	2.27		
НА З	0.85-0.9		CLAY	6.90	20	4.87	22.7	Nil	Nil	Nil	2.03		
HA 5	0.15-0.2		SAMD	7.20	20	4.70	23.1	Nil	Nil	Nil	2.50		
HA 7	0.2-0.25		SAND	7.27	20	4.73	23.0	Nil	Nil	Nil	2.54		
HA 7	0.65-0.7		SAND	7.48	20	5.05	22.9	Nil	Nil	Nil	2.43		
NOTES:	<u>1.</u> 2.	Observe Strong (	ed Reaction: a Ddour:	. No visible	efferves	cence	b. SI	ight to moderate effe	ervescence	e c. Vigor	ous effervescen	t reaction	

# Appendix C

Hydraulic Conductivity Calculations

#### coffey > geotechnics HYDRAULIC CONDUCTIVITY -ECIALISTS MANAGING THE EARTH CONFINED BELOW WATER TABLE - CASED - OPEN Borehole Number BH1 Variable Head office : Newcastle GEOTWARA20848A Client : Sake Development Pty Ltd Job Number : Principal : All Seasons Salamander Shores Hotel Pty Ltd Test Date : 5/03/2009 Proposed Hotel Redevelopment Tested By : AGB Project : 147 Soldiers point Road, Soldiers Point Test Location : Checked By : Sketch of site conditions (not to scale) Test Method : NAVFAC 1986; case F Test Fluid : Ground Water 2r - - -HD Height to Datum, HD : 0.00 m dt(i) W Hole Radius, R : 0.037 m • Hole Depth, D : 4.83 m d Wa ht( Borehole Area, A : 0.0043 m Casing Radius, r : 0.025 m D Casing Depth, d : 1.50 m Aquifer Thickness, T : 10.00 m Depth to Aquifer, w<sub>a</sub> 1.50 m L Test Length, L : 3.33 m Т Aquifer Depth to Water Table, w : 1.05 2R m - date & time : 5-Mar-09 9:15 AM L/T: 0.33 If L/T < 0.2 then $F = C_s R$ and $Cs = 6 + L/R + 6 \log (L/R)$ L/R: 89.86 If 0.2< L/T < 0.85 ther F = $2 \pi L$ Shape Factor, F : 4.64 m In (L / R) If L/ T > 0.85 then F = $2\pi L$ and Ro/R = 200 In (R<sub>o</sub>/R) Reading Depth to Water Water Head Flapsed Water Head Ratio versus Time Water Ratio No. Time Head 0.100 dt(i) ht(i) ht(i)/ht(0) t (mins) (m) (m) 4.674 1.000 0 0.0 3.63 Water Head Ratio 4.669 0.999 1 1.0 3.62 2 2.0 4.665 3.62 0.998 3 3.0 4.660 3.61 0.996 4 4.0 4.656 3.61 0.995 5 6.0 4.649 3.60 0.993 6 8.0 4.645 3.60 0.992 3.59 0.991 7 10.0 4.641 1.000 8 3.58 \_ 15.0 4.631 0.988 0.0 20.0 40.0 60.0 80.0 9 20.0 4.623 3.58 0.986 Time (minutes) 10 30.0 4.609 0.982 3.56 4.591 3.54 0.977 11 45.0 75.0 4.459 3.41 0.941 0.0 12 (r.no., t<sub>1</sub>, y<sub>1</sub>) = 0 3.63 13 12 75.0 3.41 $(r.no., t_2, y_2) =$ 14 Hydraulic 15 $A \ln (h_1 / h_2)$ = Conductivity, K 16 F (t<sub>2</sub> - t<sub>1</sub>) 17 1.3E-08 m/sec 18 = 19 0.00 m/day = 20

Notes:

