PROPOSED SALAMANDER SHORES HOTEL REDEVELOPMENT

Sake Development Pty Ltd

GEOTWARA20848AA-AB
24 March 2009

Coffey Geotechnics Pty Ltd ABN 93 056 929 483
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coffey geotechnics
SPECIALISTS MANAGING THE EARTH

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

Mark Delaney

Mark Delaney

Principle Engineering Geologist

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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^2. 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.

TABLE 1 – SUMMARY OF TYPICAL SUBSURFACE PROFILE ENCOUNTERED

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 2 - SUMMARY OF SOIL UNITS ENCOUNTERED AT EACH BOREHOLE LOCATION

TEST ID	DEPTH OF INFERRED GEOTECHNICAL UNIT BELOW SURFACE LEVEL (m)				
	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	-

TEST ID	**DEPTH OF INFERRED GEOTECHNICAL UNIT BELOW SURFACE LEVEL (m)**				
	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.

TABLE 3 – SUMMARY OF GROUNDWATER

TEST LOCATION	WATER TABLE (m)	HYDRAULIC CONDUCTIVITY (m/sec)
BH1	1.05	$1.3x10^{-8}$
BH2	2.63	$8.7x10^{-7}$

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 x 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).

TABLE 4 – SUMMARY OF UCS TESTING

BOREHOLE	SAMPLE DEPTH (m)	MATERIAL DESCRIPTION	WET DENSITY (t/m^3)	UCS (MPa)
BH2	2.83 – 2.98	SLIGHTLY WEATHERED RHYODACITE (UNIT 2B)	2.6	223 (extremely high strength)

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 engineer-designed retaining wall and or a contiguous bored-pile wall. Typical retaining wall parameters for site soils are presented in Table 5

TABLE 5 – SUMMARY OF RETAINING WALL DESIGN PARAMETERS

GEOTECHNICAL UNIT	**PARAMETER**				
	UNIT WEIGHT (kN/m^3)	**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

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 potential ASS. When the soils are exposed, the oxidation of pyrite occurs and sulphuric acids are generated, and the soils are said to be actual 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;
- pH values of soil in 30% H_2O_2 were between 4.70 to 5.10. A pH of <3 in this test can indicate the presence of potential ASS;
- A maximum pH change of 2.54 after oxidation with H_2O_2 was recorded. Significant pH changes (>2) after oxidation with H_2O_2 can indicate potential ASS;
- No effervescence was observed in any of the samples tested. Vigorous effervescent reactions with oxidation in 30% H_2O_2 can indicate potential ASS;
- No odour was released upon oxidation with H_2O_2 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.

TABLE 6 – ACID SULFATE SOILS (ASS) TEST RESULTS

SAMPLE LOCATION	**DEPTH (metres)**	**SCREENING TEST**		**S_{POS} (%)**	**TAA (mol/tonne)**
		pH_F	**pH_{FOX}**		
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

Mark Delaney

Mark Delaney

Principle Engineering Geologist

Foundation Maintenance and Footing Performance: A Homeowner's Guide

CSIRO

BTF 18 replaces Information Sheet 10/91

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

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

Soil Types

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

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

Causes of Movement

Settlement due to construction

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

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

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

Erosion

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

Saturation

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

Seasonal swelling and shrinkage of soil

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

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

Shear failure

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

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

GENERAL DEFINITIONS OF SITE CLASSES

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

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

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

Unevenness of Movement

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

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

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

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

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

Effects of Uneven Soil Movement on Structures

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

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

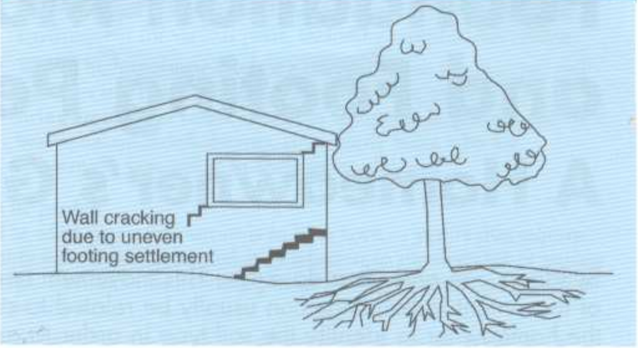
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

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

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

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

Trees can cause shrinkage and damage



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

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

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

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

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

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

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

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

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

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

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

Effects on framed structures

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

Effects on brick veneer structures

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

Water Service and Drainage

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

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.

Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

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

Seriousness of Cracking

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

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

Prevention/Cure

Plumbing

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

Ground drainage

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

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

Protection of the building perimeter

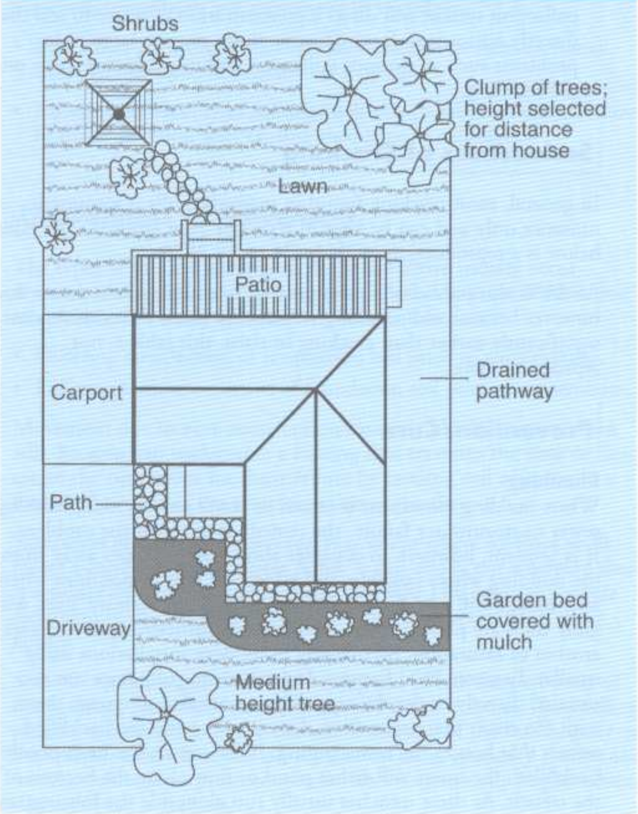
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

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

Gardens for a reactive site



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

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

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

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

Condensation

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

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

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

The garden

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

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

Existing trees

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

Information on trees, plants and shrubs

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

Excavation

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

Remediation

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

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

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

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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 INSTABILITY	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.

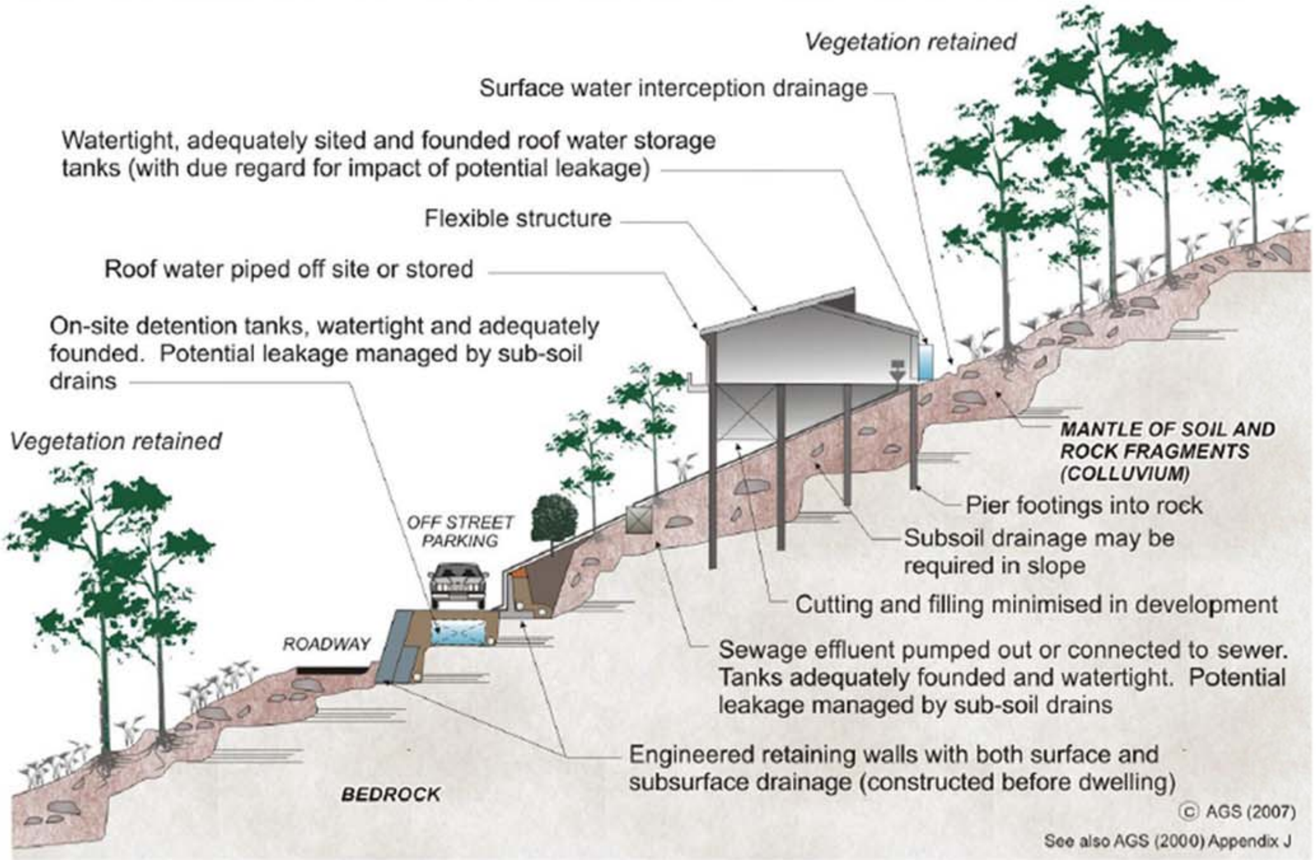
Attachment 2: Some Guidelines for Hillside Construction

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

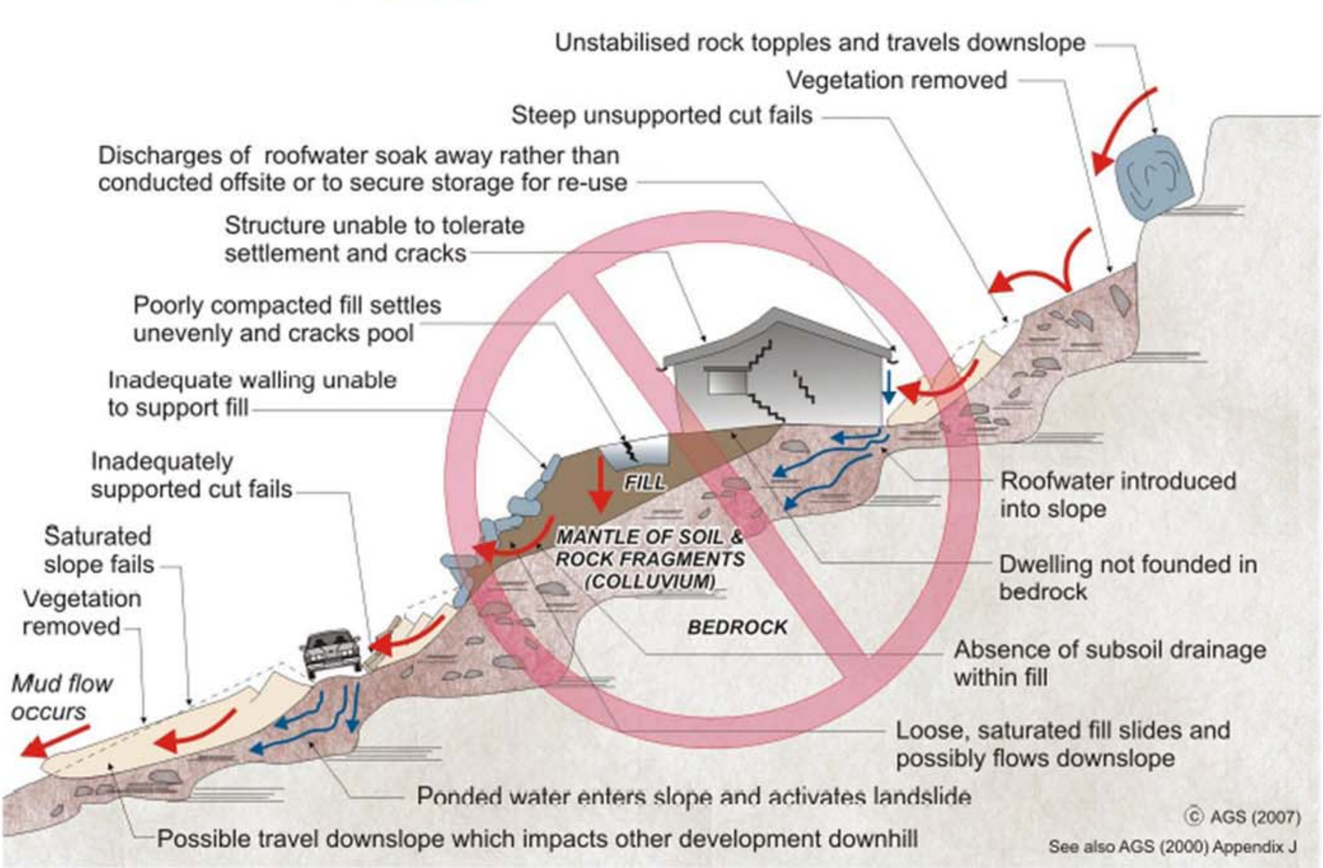
This table is an extract from Australian Geomechanics Journal and News of the Australian Geomechanics Society Volume 42 No1 March 2007.

Attachment 3: Illustrations of Good and Poor Hillside Practise

EXAMPLES OF **GOOD** HILLSIDE CONSTRUCTION PRACTICE



EXAMPLES OF **POOR** HILLSIDE CONSTRUCTION PRACTICE



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

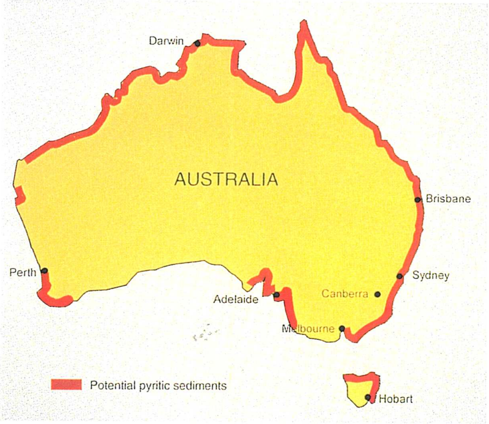
ACID SULFATE SOILS – BACKGROUND INFORMATION

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.

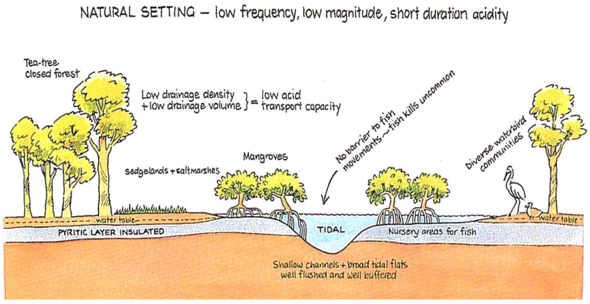
ASS soils occur across about 40,000km^2 of low lying coastal lands in every state of Australia (Sammut 2000), and mostly formed in the Holocene period (10,000 years ago to present day) predominantly in the 7,000 years since the last rise in sea level. It is generally considered that pyritic soils which 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.



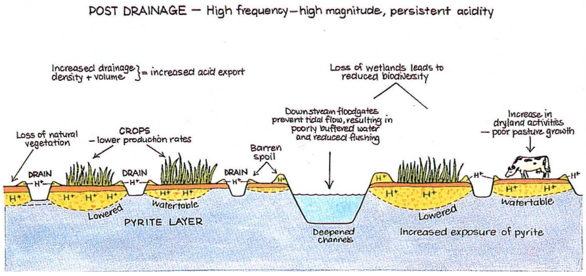
Photography: Ian White

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.



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.



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

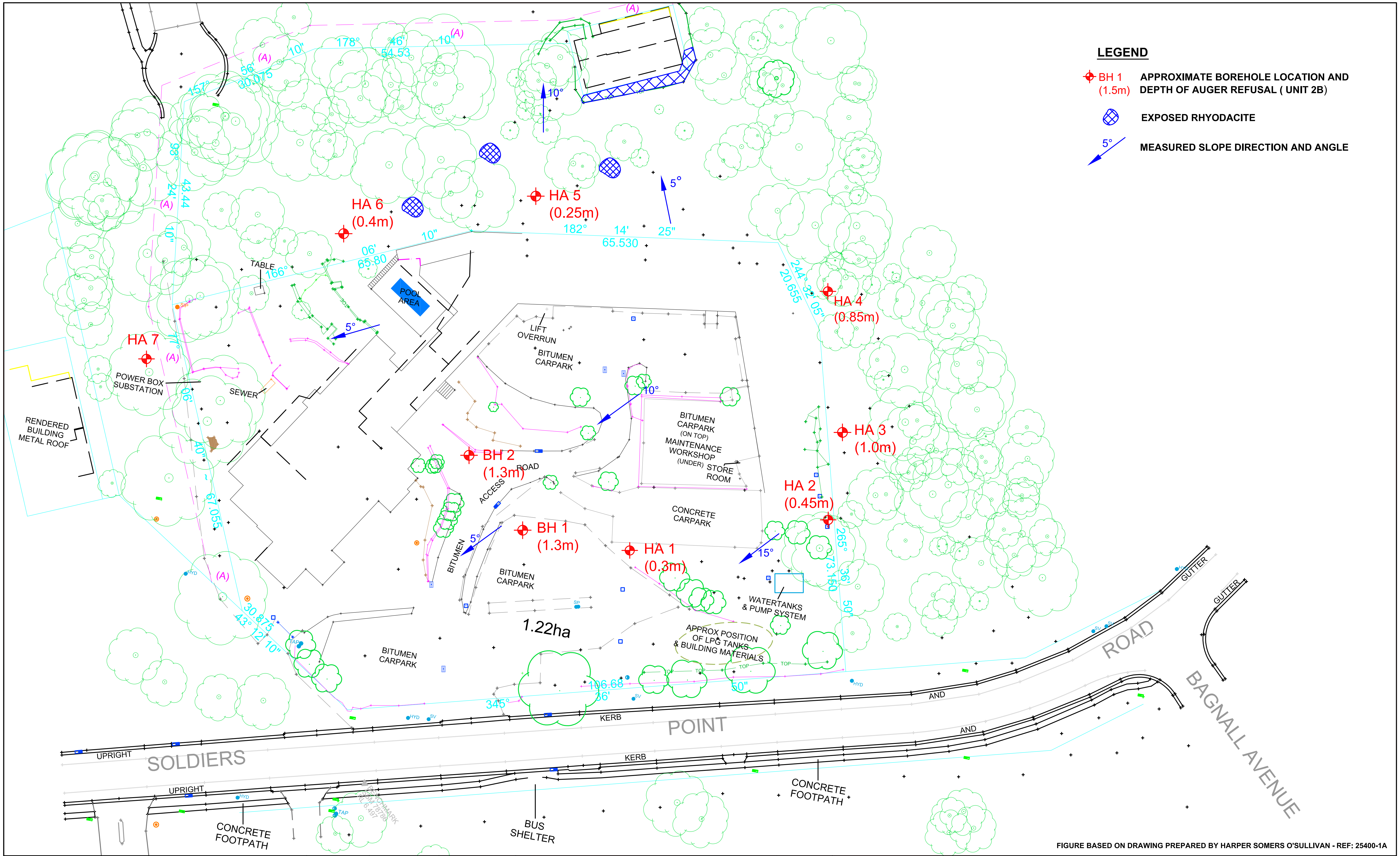
Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As 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



LEGEND

- ⌖ BH 1 (1.5m) APPROXIMATE BOREHOLE LOCATION AND DEPTH OF AUGER REFUSAL (UNIT 2B)
- ▨ EXPOSED RHYODACITE
- ↙ 5° MEASURED SLOPE DIRECTION AND ANGLE

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

revision	description	drawn	approved	date

0 7.5 15 30 45

Horizontal Scale (metres)

drawn	ALR
approved	AMT
date	19/03/2009
scale	1:750
original size	A3

coffey geotechnics

SPECIALISTS MANAGING THE EARTH

client: SAKE DEVELOPMENT PTY LTD

project: PROPOSED HOTEL REDEVELOPMENT
SALAMANDER SHORES
147 SOLDIERS POINT ROAD, SOLDIERS POINT

title: 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

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_u (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	DENSITY INDEX (%)
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.

TRANSPORTED 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.

Soil Description Explanation Sheet (2 of 2)

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)							**USC**	**PRIMARY NAME**
COARSE GRAINED SOILS More than 50% of materials less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.0 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.			GW	GRAVEL
				Predominantly one size or a range of sizes with more intermediate sizes missing.			GP	GRAVEL
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)			GM	SILTY GRAVEL
				Plastic fines (for identification procedures see CL below)			GC	CLAYEY GRAVEL
		SANDS More than half of coarse fraction is smaller than 2.0 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes			SW	SAND
				Predominantly one size or a range of sizes with some intermediate sizes missing.			SP	SAND
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).			SM	SILTY SAND
				Plastic fines (for identification procedures see CL below).			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm				IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm.				
				DRY STRENGTH	**DILATANCY**	**TOUGHNESS**		
		SILTS & CLAYS Liquid limit less than 50		None to Low	Quick to slow	None	ML	SILT
				Medium to High	None	Medium	CL	CLAY
				Low to medium	Slow to very slow	Low	OL	ORGANIC SILT
		SILTS & CLAYS Liquid limit greater than 50		Low to medium	Slow to very slow	Low to medium	MH	SILT
				High	None	High	CH	CLAY
				Medium to High	None	Low to medium	OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS				Readily identified by colour, odour, spongy feel and frequently by fibrous texture.			Pt	PEAT

- Low plasticity – Liquid Limit W_L less than 35%.
- Medium plasticity – W_L between 35% and 50%.

COMMON DEFECTS IN SOIL

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.	
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.	
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.	
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.	

TERM	**DEFINITION**	**DIAGRAM**
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
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	
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.	
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.	

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.
Mass	Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

SUBSTANCE DESCRIPTIVE TERMS:

ROCK NAME	Simple rock names are used rather than precise geological classification.
PARTICLE SIZE	Grain size terms for sandstone are:
Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm (just visible) to 0.2mm
FABRIC	Terms for layering of penetrative fabric (eg. bedding, cleavage etc.) are:
Massive	No layering or penetrative fabric.
Indistinct	Layering or fabric just visible. Little effect on properties.
Distinct	Layering or fabric is easily visible. Rock breaks more easily parallel to layering of fabric.

CLASSIFICATION OF WEATHERING PRODUCTS

Term	**Abbreviation**	**Definition**
Residual Soil	**RS**	Soil derived from the weathering of rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Material	**XW**	Material is weathered to such an extent that it has soil properties, ie, it either disintegrates or can be remoulded in water. Original rock fabric still visible.
Highly Weathered Rock	**HW**	Rock strength is changed by weathering. The whole of the rock substance is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by leaching or may be decreased due to the deposition of minerals in pores.
Moderately Weathered Rock	**MW**	The whole of the rock substance is discoloured, usually by iron staining or bleaching , to the extent that the colour of the fresh rock is no longer recognisable.
Slightly Weathered Rock	**SW**	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance (usually by limonite) has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Fresh Rock	**FR**	Rock substance unaffected by weathering.

Notes on Weathering:

1. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is judged that there is no advantage in making such a distinction. DW may be used with the definition given in AS1726.
2. Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term "altered" may be substituted for "weathering" to give the abbreviations XA, HA, MA, SA and DA.

ROCK SUBSTANCE STRENGTH TERMS

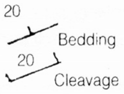
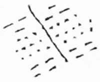
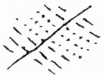
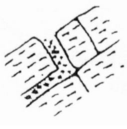
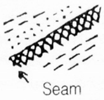
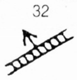
Term	**Abbrev-iation**	**Point Load Index, I_S50 (MPa)**	**Field Guide**
Very Low	**VL**	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	**L**	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm bows of a pick point; has a dull sound under hammer. Pieces of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	**M**	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	**H**	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	**VH**	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	**EH**	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

Notes on Rock Substance Strength:

1. In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy.
2. 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 makes it clear that materials in that strength range are soils in engineering terms.
3. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index (Is50). The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

Rock Description Explanation Sheet (2 of 2)

COMMON DEFECTS IN ROCK MASSES

Term	Definition	Diagram	Map Symbol	Graphic Log (Note 1)
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub parallel to layering (eg bedding) or a planar anisotropy in the rock substance (eg, cleavage). May be open or closed.			
Joint	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.			
Sheared Zone (Note 3)	Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.			
Sheared Surface (Note 3)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.			
Crushed Seam (Note 3)	Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties.			
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.			
Extremely Weathered Seam	Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.			

DEFECT SHAPE TERMS

Planar	The defect does not vary in orientation
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps
Irregular	The defect has many sharp changes of orientation

Note: The assessment of defect shape is partly influenced by the scale of the observation.

ROUGHNESS TERMS

Slickensided	Grooved or striated surface, usually polished
Polished	Shiny smooth surface
Smooth	Smooth to touch. Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

COATING TERMS

Clean	No visible coating
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
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.

BLOCK SHAPE TERMS

Blocky	Approximately equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greate than cross section

Notes on Defects:

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.
2. Partings and joints are not usually shown on the graphic log unless considered significant.
3. Sheared zones, sheared surfaces and crushed seams are faults in geological terms.

coffey geotechnics

Engineering Log - Borehole

Client:	*SAKE DEVELOPMENT PTY LTD*	Borehole No.	***BH 1***
Principal:		Sheet	1 of 3
Project:	*PROPOSED HOTEL REDEVELOPMENT*	Project No:	***GEOTWARA20848AA***
Borehole Location:	*REFER TO FIGURE 1*	Date started:	***23.2.2009***
		Date completed:	***23.2.2009***
		Logged by:	***GDT***
		Checked by:	

drill model and mounting:	Land Cruiser	Easting:		slope:	-90°	R.L. Surface:	10
hole diameter:	51 mm	Northing		bearing:		datum:	AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADT		N							FILL: ASHPALT				
								GC	FILL: Clayey GRAVEL, fine to medium grained, sub rounded to sub angular, brown mottled red and dark brown, medium plasticity clay, with some fine to coarse grained sand.	M	D		PAVEMENT GRAVEL
								CL	**Sandy CLAY:** medium plasticity, brown mottled yellow and white, fine to coarse grained sand.	M/W	H		EXTREMELY WEATHERED RHYODACITE
					9.5	0.5							
					9.0	1.0							
							× ×		**RHYODACITE:** fine grained with phenocrysts of quartz and black feldspar, pink, mottled black and white.		VD		HIGHLY WEATHERED RHYODACITE
					8.5	1.5			Borehole BH 1 continued as cored hole				
			None Observed		8.0	2.0							
					7.5	2.5							
					7.0	3.0							
					6.5	3.5							
					6.0	4.0							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support

M mud N nil
C casing

penetration

1 2 3 4 – no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown
►— water inflow
—◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Cored Borehole

Borehole No. **BH 1**
Sheet 2 of 3
Project No: **GEOTWARA20848AA**

Client: *SAKE DEVELOPMENT PTY LTD*
Principal:
Project: *PROPOSED HOTEL REDEVELOPMENT*
Borehole Location: *REFER TO FIGURE 1*

Date started: **23.2.2009**
Date completed: **23.2.2009**
Logged by: *GDT*
Checked by:

drill model & mounting: Land Cruiser
Easting:
slope: -90°
R.L. Surface: 10
hole diameter: 51 mm
Drilling fluid: Water
Northing:
bearing:
datum: AHD

drilling information / material substance / rock mass defects

method	core-lift	water	RL	depth metres	material (rock type; grain characteristics, colour, structure, minor components)	weathering alteration	RQD %
			9.5	0.5			
			9.0	1.0			
			8.5	1.5	Continued from non-cored borehole		
NMLC		None Observed	8.5	1.5	**RHYODACITE:** fine grained with phenocrysts of quartz and black feldspar, pink, grey mottled black and white.	HW SW	66
			8.0	2.0			
			7.5	2.5	**RHYODACITE:** CLAY, laminated, yellow, grey mottled green.	HA	
					RHYODACITE: fine grained with phenocrysts, grey mottled pink.	FR	100
			7.0	3.0			
			6.5	3.5			
			6.0	4.0			

defect description (type, inclination, planarity, roughness, coating, thickness) — particular:

- JT, 45°, IR, RO, CO, clay
- JT, 50°, PL, RO, CO, grey, clay
- JT, 0°, PL, RO, CO, grey, clay
- JT, 30°, IR, RO, CN
- JT, 10°, IR, RO, CN
- JT, 40°, IR, RO, CN
- JT, 32°, PL, RO, VN, ironstained
- JT, 85°, (Hematite?), PL, RO, VN, black stained
- JT, 45°, IR, RO, CN

estimated strength: VL L M H VH EH
$Is_{(50)}$ MPa: D- diametral, A- axial
defect spacing mm: 30 100 300 1000 3000

method

DT	diatube
AS	auger screwing
AD	auger drilling
RR	roller/tricone
CB	claw or blade bit
NMLC	NMLC core
NQ, HQ, PQ	wireline core

core-lift

- casing used
- barrel withdrawn

graphic log/core recovery

- core recovered - graphic symbols indicate material
- no core recovered

water

- 10/1/98 water level on date shown
- water inflow
- partial drill fluid loss
- complete drill fluid loss
- 25 water pressure test result (lugeons) for depth interval shown

weathering

FR	fresh
SW	slightly weathered
MW	moderately weathered
HW	highly weathered
XW	extremely weathered
DW	distinctly weathered (covers MW and HW)

strength

VL	very low
L	low
M	medium
H	high
VH	very high
EH	extremely high

defect type

JT	joint
PT	parting
SM	seam
SZ	sheared zone
SS	sheared surface
CS	crushed seam

planarity

PL	planar
CU	curved
UN	undulating
ST	stepped
IR	irregular

roughness

VR	very rough
RO	rough
SO	smooth
SL	slickensided

coating

CN	clean
SN	stained
VN	veneer
CO	coating

coffey geotechnics

Engineering Log - Cored Borehole

Client:	*SAKE DEVELOPMENT PTY LTD*	Borehole No.	***BH 1***
Principal:		Sheet	3 of 3
Project:	*PROPOSED HOTEL REDEVELOPMENT*	Project No:	***GEOTWARA20848AA***
Borehole Location:	*REFER TO FIGURE 1*	Date started:	***23.2.2009***
		Date completed:	***23.2.2009***
		Logged by:	***GDT***
		Checked by:	

drill model & mounting:	Land Cruiser	Easting:		slope:	-90°	R.L. Surface:	10
hole diameter:	51 mm	Drilling fluid: Water	Northing:	bearing:		datum:	AHD

drilling information					**material substance**					**rock mass defects**			
method	core-lift	water	RL	depth metres	graphic log core recovery	**material** rock type; grain characteristics, colour, structure, minor components	weathering alteration	estimated strength VL L M H VH EH	Is(50) MPa D- diametral A- axial	RQD %	defect spacing mm 30 100 300 1000 3000	**defect description** type, inclination, planarity, roughness, coating, thickness particular	general
NMLC		None Observed			× ×	**RHYODACITE:** fine grained with phenocrysts, grey mottled pink. *(continued)*	FR			100		JT, 50°, IR, RO, CN	
					× ×							JT, 50°, PL, RO, CN	
			5.5	4.5	× ×							JT, 40°, PL, RO, CN	
					× ×							JT, 45°, PL, SO, VN, clay JT, 25°, PL, SO, CN JT, 0°, PL, RO, CN	
			5.0	5.0	× ×					98		JT, 60°, PL, RO, CN JT, 60°, PL, RO, CN JT, 45°, PL, RO, CN	
			4.5	5.5	× ×								
						BH 1 terminated at 5.61m						~~JT, 15°, IR, RO, CN~~	
			4.0	6.0									
			3.5	6.5									
			3.0	7.0									
			2.5	7.5									
			2.0	8.0									

method

DT	diatube
AS	auger screwing
AD	auger drilling
RR	roller/tricone
CB	claw or blade bit
NMLC	NMLC core
NQ, HQ, PQ	wireline core

core-lift

casing used

barrel withdrawn

graphic log/core recovery

core recovered - graphic symbols indicate material

no core recovered

water

10/1/98 water level on date shown

water inflow

partial drill fluid loss

complete drill fluid loss

25 water pressure test result (lugeons) for depth interval shown

weathering

FR	fresh
SW	slightly weathered
MW	moderately weathered
HW	highly weathered
XW	extremely weathered
DW	distinctly weathered (covers MW and HW)

strength

VL	very low
L	low
M	medium
H	high
VH	very high
EH	extremely high

defect type

JT	joint
PT	parting
SM	seam
SZ	sheared zone
SS	sheared surface
CS	crushed seam

planarity

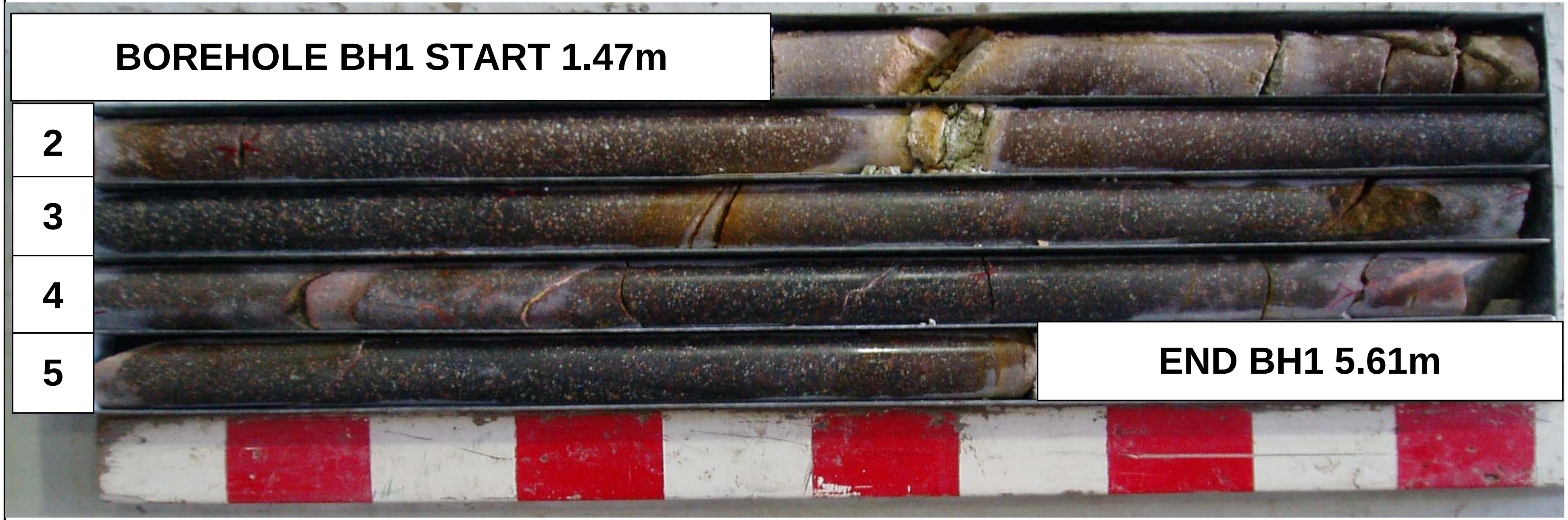
PL	planar
CU	curved
UN	undulating
ST	stepped
IR	irregular

roughness

VR	very rough
RO	rough
SO	smooth
SL	slickensided

coating

CN	clean
SN	stained
VN	veneer
CO	coating



1000mm

drawn	**AMT**	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	**SAKE DEVELOPMENT PTY LTD**
approved			project:	**SALAMANDER SHORES HOTTEL REDEVELOPMENT** **SOLDIERS POINT**
date	**23-Mar-09**		title:	**CORE PHOTO**
scale	**AS SHOWN**		project no:	**GEOTWARA20848AA-AB**
original size	A4			**BH 1**

coffey geotechnics

Engineering Log - Borehole

Borehole No.	*BH 2*
Sheet	1 of 3
Project No:	*GEOTWARA20848AA*
Client:	*SAKE DEVELOPMENT PTY LTD*
Principal:	
Project:	*PROPOSED HOTEL REDEVELOPMENT*
Borehole Location:	*REFER TO FIGURE 1*
Date started:	*23.2.2009*
Date completed:	*23.2.2009*
Logged by:	*GDT*
Checked by:	

drill model and mounting:	Land Cruiser	Easting:		slope:	-90°	R.L. Surface:	12
hole diameter:	51 mm	Northing		bearing:		datum:	AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADT		N							**Sandy GRAVEL:** fine to coarse grained, angular, brown pink, fine to coarse grained sand, trace of fines.	D	MD		ROAD BASE
								SP	**SAND:** fine to medium grained, pale brown, trace of fines.	M	MD		AEOLIAN
					11.5	0.5							
								CL	**Sandy CLAY:** medium plasticity, brown, fine to coarse grained sand with some fine sub angular to angular gravel.	M<Wp	H		EXTREMELY WEATHERED RHYODACITE
					11.0	1.0							
							× × ×		**RHYODACITE:** fine grained with phenocrysts of quartz and black feldspar pink, brown colour.				HIGHLY WEATHERED RHYODACITE
					10.5	1.5							
									Borehole BH 2 continued as cored hole				
			None Observed		10.0	2.0							
					9.5	2.5							
					9.0	3.0							
					8.5	3.5							
					8.0	4.0							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix	
e.g.	ADT

support

M mud N nil
C casing

penetration

1 2 3 4 no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown
► water inflow
◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

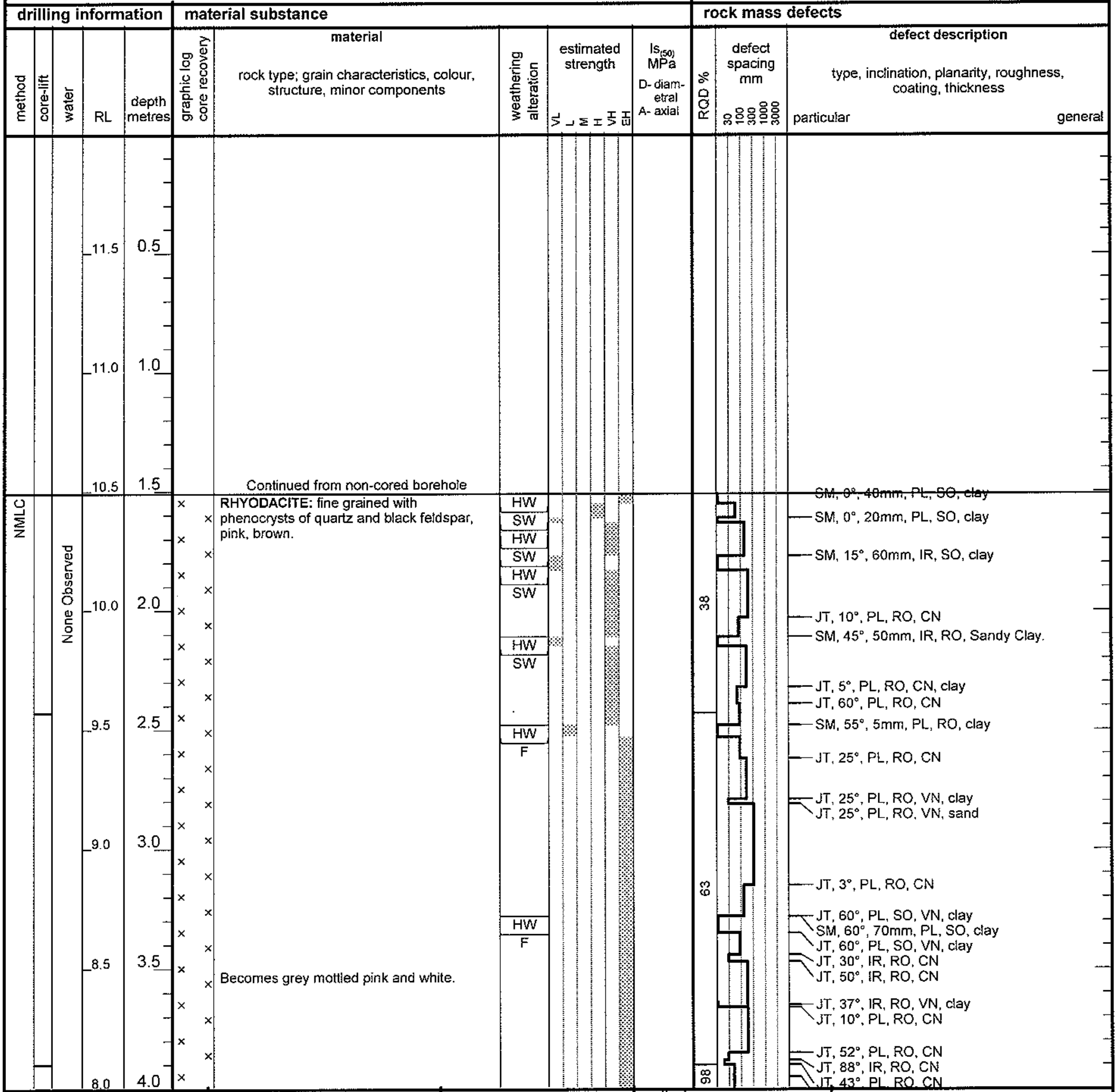
Engineering Log - Cored Borehole

Borehole No. ***BH 2***
Sheet 2 of 3
Project No: ***GEOTWARA20848AA***

Client: ***SAKE DEVELOPMENT PTY LTD***
Principal:
Project: ***PROPOSED HOTEL REDEVELOPMENT***
Borehole Location: ***REFER TO FIGURE 1***

Date started: ***23.2.2009***
Date completed: ***23.2.2009***
Logged by: ***GDT***
Checked by:

drill model & mounting: Land Cruiser
Easting:
slope: -90°
R.L. Surface: 12
hole diameter: 51 mm
Drilling fluid: Water
Northing:
bearing:
datum: AHD



material: rock type; grain characteristics, colour, structure, minor components

Continued from non-cored borehole

RHYODACITE: fine grained with phenocrysts of quartz and black feldspar, pink, brown.

Becomes grey mottled pink and white.

defect description: type, inclination, planarity, roughness, coating, thickness — particular / general

SM, 0°, 40mm, PL, SO, clay
SM, 0°, 20mm, PL, SO, clay
SM, 15°, 60mm, IR, SO, clay
JT, 10°, PL, RO, CN
SM, 45°, 50mm, IR, RO, Sandy Clay.
JT, 5°, PL, RO, CN, clay
JT, 60°, PL, RO, CN
SM, 55°, 5mm, PL, RO, clay
JT, 25°, PL, RO, CN
JT, 25°, PL, RO, VN, clay
JT, 25°, PL, RO, VN, sand
JT, 3°, PL, RO, CN
JT, 60°, PL, SO, VN, clay
SM, 60°, 70mm, PL, SO, clay
JT, 60°, PL, SO, VN, clay
JT, 30°, IR, RO, CN
JT, 50°, IR, RO, CN
JT, 37°, IR, RO, VN, clay
JT, 10°, PL, RO, CN
JT, 52°, PL, RO, CN
JT, 88°, IR, RO, CN
JT, 43°, PL, RO, CN

method

DT	diatube
AS	auger screwing
AD	auger drilling
RR	roller/tricone
CB	claw or blade bit
NMLC	NMLC core
NQ, HQ, PQ	wireline core

core-lift

casing used
barrel withdrawn

graphic log/core recovery

core recovered
- graphic symbols indicate material

no core recovered

water

10/1/98 water level on date shown
water inflow
partial drill fluid loss
complete drill fluid loss
25 water pressure test result (lugeons) for depth interval shown

weathering

FR	fresh
SW	slightly weathered
MW	moderately weathered
HW	highly weathered
XW	extremely weathered
DW	distinctly weathered (covers MW and HW)

strength

VL	very low
L	low
M	medium
H	high
VH	very high
EH	extremely high

defect type

JT	joint
PT	parting
SM	seam
SZ	sheared zone
SS	sheared surface
CS	crushed seam

roughness

VR	very rough
RO	rough
SO	smooth
SL	slickensided

planarity

PL	planar
CU	curved
UN	undulating
ST	stepped
IR	irregular

coating

CN	clean
SN	stained
VN	veneer
CO	coating

coffey geotechnics

Engineering Log - Cored Borehole

Borehole No.	*BH 2*
Sheet	3 of 3
Project No:	*GEOTWARA20848AA*
Client:	*SAKE DEVELOPMENT PTY LTD*
Date started:	*23.2.2009*
Principal:	
Date completed:	*23.2.2009*
Project:	*PROPOSED HOTEL REDEVELOPMENT*
Logged by:	*GDT*
Borehole Location:	*REFER TO FIGURE 1*
Checked by:	

drill model & mounting: Land Cruiser	Easting:	slope: -90°	R.L. Surface: 12
hole diameter: 51 mm Drilling fluid: Water	Northing:	bearing:	datum: AHD

method	core-lift	water	RL	depth metres	graphic log / core recovery	material: rock type; grain characteristics, colour, structure, minor components	weathering alteration	RQD %	defect description (type, inclination, planarity, roughness, coating, thickness) particular / general
NMLC		None Observed			×	**RHYODACITE:** fine grained with phenocrysts of quartz and black feldspar, pink, brown. *(continued)*	F		JT, 0°, IR, RO, CO, sand JT, 0°, IR, RO, CN
					×				JT, 30°, PL, SO, CN JT, 10°, PL, SO, CO, clay
			7.5	4.5	×			98	
			7.0	5.0	×				JT, 3°, IR, RO, CN
					×				JT, 5°, PL, RO, CN
			6.5	5.5	×				
			6.0	6.0	×			100	JT, 71°, PL, RO, VN
			5.5	6.5	×				SM, 0°, 50mm, IR, RO, Sandy Clay and fine gravel.
						Core Loss		97	JT, 37°, PL, RO, CN
			5.0	7.0		BH 2 terminated at 7m			
			4.5	7.5					
			4.0	8.0					

estimated strength: VL L M H VH EH

Is(50) MPa: D- diametral, A- axial

defect spacing mm: 30 100 300 1000 3000

method

DT	diatube
AS	auger screwing
AD	auger drilling
RR	roller/tricone
CB	claw or blade bit
NMLC	NMLC core
NQ, HQ, PQ	wireline core

core-lift

- casing used
- barrel withdrawn

graphic log/core recovery

- core recovered - graphic symbols indicate material
- no core recovered

water

- 10/1/98 water level on date shown
- water inflow
- partial drill fluid loss
- complete drill fluid loss
- 25 water pressure test result (lugeons) for depth interval shown

weathering

FR	fresh
SW	slightly weathered
MW	moderately weathered
HW	highly weathered
XW	extremely weathered
DW	distinctly weathered (covers MW and HW)

strength

VL	very low
L	low
M	medium
H	high
VH	very high
EH	extremely high

defect type

JT	joint
PT	parting
SM	seam
SZ	sheared zone
SS	sheared surface
CS	crushed seam

roughness

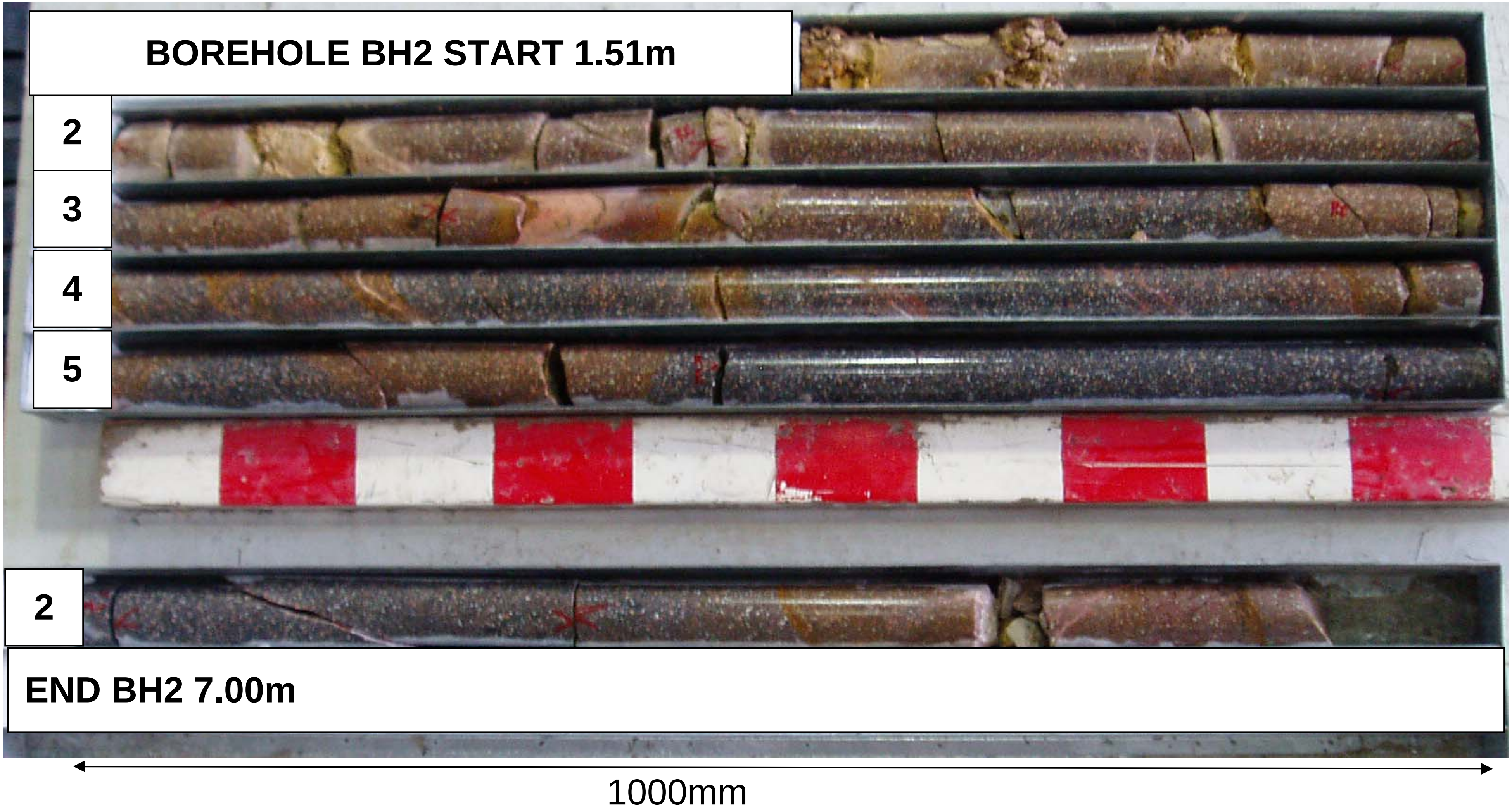
VR	very rough
RO	rough
SO	smooth
SL	slickensided

planarity

PL	planar
CU	curved
UN	undulating
ST	stepped
IR	irregular

coating

CN	clean
SN	stained
VN	veneer
CO	coating



drawn	**AMT**	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	**SAKE DEVELOPMENT PTY LTD**	
approved			project:	**SALAMANDER SHORES HOTTEL REDEVELOPMENT** **SOLDIERS POINT**	
date	**23-Mar-09**				
scale	**AS SHOWN**		title:	**CORE PHOTO**	
original size	A4		project no:	**GEOTWARA20848AA-AB**	**BH 2**

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

coffey geotechnics

Engineering Log - Borehole

Borehole No.	*HA 1*
Sheet	1 of 1
Project No:	*GEOTWARA20848AA*
Client:	*SAKE DEVELOPMENT PTY LTD*
Date started:	*9.12.2008*
Principal:	
Date completed:	*9.12.2008*
Project:	*PROPOSED HOTEL REDEVELOPMENT*
Logged by:	GDT
Borehole Location:	*REFER TO FIGURE 1*
Checked by:	

drill model and mounting:	Hand Auger	Easting:		slope:	-90°	R.L. Surface:	13
hole diameter:	62 mm	Northing		bearing:		datum:	AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
HA		N						SC	**TOPSOIL:** Clayey SAND, fine to medium grained, dark brown, medium plasticity fines, some sub angular gravel, trace of rootlets.	M			TOPSOIL
								GP	**Sandy GRAVEL:** fine grained, angular, pale grey to white with fine to coarse grained sand.				EXTREMELY WEATHERED RHYODACITE
									Terminated at refusal on Highly Weathered Rhyodacite. Borehole HA 1 terminated at 0.31m				
					12.5	0.5							
					12.0	1.0							
					11.5	1.5							
					11.0	2.0							
					10.5	2.5							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix	
e.g.	ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No.	*HA 2*
Sheet	1 of 1
Project No:	*GEOTWARA20848AA*
Client:	*SAKE DEVELOPMENT PTY LTD*
Principal:	
Project:	*PROPOSED HOTEL REDEVELOPMENT*
Borehole Location:	*REFER TO FIGURE 1*
Date started:	*9.12.2008*
Date completed:	*9.12.2008*
Logged by:	GDT
Checked by:	

drill model and mounting:	Hand Auger	Easting:		slope:	-90°	R.L. Surface:	18
hole diameter:	62 mm	Northing		bearing:		datum:	AHD

drilling information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
HA		N						SW	**TOPSOIL:** SAND, fine to medium grained, brownish grey speckled white, some organics and rootlets.	D			TOPSOIL
								SC	**Gravelly Clayey SAND:** fine to coarse grained, brown mottled yellow, medium plasticity fines, some sub angular gravel.	M	MD		EXTREMELY WEATHERED RHYODACITE
				D									
					17.5	0.5			Borehole HA 2 terminated at 0.45m				
					17.0	1.0							
					16.5	1.5							
					16.0	2.0							
					15.5	2.5							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support

M mud N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water
10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE HA1 - HA7.GPJ COFFEY.GDT 3.24.09

Form GEO 5.3 Issue 3 Rev.2

coffey geotechnics

Engineering Log - Borehole

Borehole No. **HA 3**
Sheet 1 of 1
Project No: **GEOTWARA20848AA**

Client: *SAKE DEVELOPMENT PTY LTD*
Principal:
Project: *PROPOSED HOTEL REDEVELOPMENT*
Borehole Location: *REFER TO FIGURE 1*

Date started: **9.12.2008**
Date completed: **9.12.2008**
Logged by: GDT
Checked by:

drill model and mounting: Hand Auger
Easting:
slope: -90°
R.L. Surface: 21
hole diameter: 62 mm
Northing
bearing:
datum: AHD

drilling information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
HA		N						SP	**TOPSOIL:** SAND, fine to medium grained, brownish grey with some rootlets and traces of organics.	D			TOPSOIL
								SC	**Clayey SAND:** fine to coarse grained, brown with low to medium plasticity clay and minor cobbles at top, trace of cobbles less than 100mm in dimension.	M			RESIDUAL
					20.5	0.5							
				D				SP	**Gravelly SAND:** fine to coarse grained, yellow / brown with fine to coarse grained sub angular to angular gravel.		MD		EXTREMELY WEATHERED RHYODACITE
					20.0	1.0			Borehole HA 3 terminated at 1m				
					19.5	1.5							
					19.0	2.0							
					18.5	2.5							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix	
e.g.	ADT

support

M mud N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water
10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No.	*HA 4*
Sheet	1 of 1
Project No:	*GEOTWARA20848AA*
Date started:	*9.12.2008*
Date completed:	*9.12.2008*
Logged by:	*GDT*
Checked by:	GWT

Client:	*SAKE DEVELOPMENT PTY LTD*
Principal:	
Project:	*PROPOSED HOTEL REDEVELOPMENT*
Borehole Location:	*REFER TO FIGURE 1*

drill model and mounting:	Hand Auger	Easting:		slope:	-90°	R.L. Surface:	19
hole diameter:	62 mm	Northing		bearing:		datum:	AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
HA		N							**TOPSOIL:** fine to coarse grained, black with rootlets.	M			TOPSOIL
								SW	**Gravelly SAND:** fine to coarse grained, pale brown with minor sub angular to angular gravel, trace of cobbles <100mm in dimension, trace of organics.				RESIDUAL
					18.5	0.5		CL	**Sandy CLAY:** medium plasticity, pale brown, mottled yellow and grey, fine grained sand.	<Wp	H		EXTREMELY WEATHERED RHYODACITE
								SC	**Clayey SAND:** fine to coarse grained, pale pink, mottled red and white, medium plasticity fines.	M			
									Borehole HA 4 terminated at 0.85m				
					18.0	1.0							
					17.5	1.5							
					17.0	2.0							
					16.5	2.5							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support

M	mud	N	nil
C	casing		

penetration
1 2 3 4
no resistance ranging to refusal

water
10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Client:	*SAKE DEVELOPMENT PTY LTD*	Borehole No.	***HA 5***
Principal:		Sheet	1 of 1
Project:	*PROPOSED HOTEL REDEVELOPMENT*	Project No:	***GEOTWARA20848AA***
Borehole Location:	*REFER TO FIGURE 1*	Date started:	***9.12.2008***
		Date completed:	***9.12.2008***
		Logged by:	***GDT***
		Checked by:	

drill model and mounting: Hand Auger	Easting:	slope: -90°	R.L. Surface: 17
hole diameter: 62 mm	Northing	bearing:	datum: AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	**material** soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	**structure and additional observations**
HA	▒	N					⁘	SP	**SAND:** fine to coarse grained, pale brown with grass at top and rootlets.	M			AEOLIAN
	▒			D			⁘	SC	**Clayey SAND:** fine to medium grained, dark brown with medium plasticity clay.	W	MD		EXTREMELY WEATHERED RHYODACITE
									Terminated at refusal on Highly Weathered Rhyodacite. Borehole HA 5 terminated at 0.25m				
					16.5	0.5							
					16.0	1.0							
					15.5	1.5							
					15.0	2.0							
					14.5	2.5							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix	
e.g.	ADT

support

M mud N nil

C casing

penetration

1 2 3 4 ▒ no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No.	*HA 6*
Sheet	1 of 1
Project No:	*GEOTWARA20848AA*
Client:	*SAKE DEVELOPMENT PTY LTD*
Principal:	
Project:	*PROPOSED HOTEL REDEVELOPMENT*
Borehole Location:	*REFER TO FIGURE 1*
Date started:	*9.12.2008*
Date completed:	*9.12.2008*
Logged by:	*GDT*
Checked by:	

drill model and mounting:	Hand Auger	Easting:		slope:	-90°	R.L. Surface:	14
hole diameter:	62 mm	Northing		bearing:		datum:	AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	**material** soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	**structure and additional observations**
HA		N						SP	**TOPSOIL:** SAND, fine to coarse grained, with organics and rootlets.	M	VL		TOPSOIL
								SC	**Clayey SAND:** fine to medium grained, dark brown to brown with medium plasticity clay, trace of angular gravel <10mm.	W			RESIDUAL
								CL	**Sandy CLAY:** medium plasticity, brown mottled yellow and red, trace of fine to coarse grained sand and fine grained gravel, sub angular to angular.	<Wp	VSt		EXTREMELY WEATHERED RHYODACITE
								CL	**Gravelly CLAY:** medium plasticity, pale brown, mottled yellow with fine grained gravel.	M			
									Terminated at refusal on Highly Weathered Rhyodacite. Borehole HA 6 terminated at 0.4m				
					13.5	0.5							
					13.0	1.0							
					12.5	1.5							
					12.0	2.0							
					11.5	2.5							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support

M mud N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE HA1 - HA7.GPJ COFFEY.GDT 3.24.09

coffey geotechnics

Engineering Log - Borehole

Borehole No.	*HA 7*
Sheet	1 of 1
Project No:	*GEOTWARA20848AA*
Date started:	*9.12.2008*
Date completed:	*9.12.2008*
Logged by:	*GDT*
Checked by:	

Client: *SAKE DEVELOPMENT PTY LTD*

Principal:

Project: *PROPOSED HOTEL REDEVELOPMENT*

Borehole Location: *REFER TO FIGURE 1*

drill model and mounting:	Hand Auger	Easting:		slope:	-90°	R.L. Surface:	7
hole diameter:	62 mm	Northing		bearing:		datum:	AHD

drilling information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
HA		N						SP	**TOPSOIL:** SAND, fine to medium grained, grey with rootlets.	M	VL		TOPSOIL
								SP	**SAND:** fine to coarse grained, mottled brown, white and pale grey, angular gravel (<10mm), trace of fine to medium grained.	M			AEOLIAN
				D									
					6.5	0.5							
				D									
					6.0	1.0							
					5.5	1.5							
					5.0	2.0							
									Borehole HA 7 terminated at 2m				
					4.5	2.5							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix	
e.g.	ADT

support

M mud N nil

C casing

penetration

1 2 3 4

no resistance ranging to refusal

water

10/1/98 water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
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

coffey information
SPECIALISTS IN SCIENTIFIC TESTING SOLUTIONS

Unit 2, 4 Kellogg Road Glendenning NSW 2761
ph: (+61) (2) 9421 3800 Fax: (+61) (2) 9421 3899
ABN: 92 114 364 046

uniaxial compressive strength

client: *COFFEY GEOTECHNICS - WARABROOK*
principal: *SAKE DEVELOPMENT PTY LTD*
project: *GEOTWARA 20848AA - PROPOSED HOTEL UPGRADE*
location: *SALAMANDER SHORES HOTEL, SOLDIERS POINT*
job no: ***INFOGLEN 00131AA***
laboratory: *Glendenning*
report date: *4 March 2009*
borehole: ***BH 2***

test procedure: *AS 4133.1.1.1 and 4133.4.2.1*
test apparatus: *Avery 1800 kN compression machine S/N E65321*
date received: *26 February 2009*
page: 1 of 1

The sample was received by our laboratory on February 26th, 2009 from a courier. It had been wrapped in bubble-wrap and placed inside split poly pipe which was sealed with tape.
The sample was tested in an "as received" condition.

QESTLAB work order ID depth QESTLab sample ID	date tested test duration	height average diameter height/dia ratio	uniaxial compressive strength **MPa**	wet density moisture content	sample description bedding/foliation	comments failure mechanism
GLEN09W-00146 ***BH 2 2.83 to 2.98 m*** *GLEN09S-00515*	*2 Mar 09* *8.60 min*	*148 mm* *51.8 mm* *2.85:1*	***223***	***2.6 t/m^3*** ***0.9 %***	*rhyodacite*	*disintegrated*

Before

After

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

NATA Accredited Laboratory
No. 431
Authorised Signature:
Alan Cocks
Associate Geotechnician

Date: *4 Mar 2009*

Environmental Analysis Laboratory

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 (note 7)	Moisture Content (% moisture)	Extractable Sulphate Sulphur $\%S_{kcl}$	Extractable Calcium $\%Ca_{kcl}$	Extractable Magnesium $\%Mg_{kcl}$	Oxidisable Sulphur $\%S_{pos}$ (as $\%S_p - \%S_{kcl}$)	Oxidisable Sulphur S_{pos} mole H^+/tonne	Oxidisable Calcium $\%Ca_A$ (%Cap - %Cakcl)	Oxidisable Magnesium $\%Mg_A$ (%Mgp - %Mgkcl)	TAA pH_{kcl}	Titratable Actual Acidity (TAA) mole H^+/tonne (to pH 6.5)
Method No.					*23C*	*23V*	*23S*	*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)

checked: ....

TPA pH_{ox}	TPA pH_{TPA}	Titratable Potential Acidity (TPA) mole H^+/tonne (to pH 6.5)	NET ACIDITY SPOCAS Suite mole H^+/tonne (based on %Spos)	NET ACIDITY TPA Only mole H^+/tonne (based on TPA)	LIME CALCULATION SPOCAS Suite kg $CaCO_3$/tonne DW	LIME CALCULATION TPA Only kg $CaCO_3$/tonne DW
					(includes 1.5 safety Factor)	
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

checked: ....

coffey information
SPECIALISTS IN SCIENTIFIC TESTING SOLUTIONS

job no: ***INFOWAR00187AA***

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

acid sulfate soil screening test

office: Newcastle

client: ***COFFEY GEOTECHNICS***
date: ***12 December 2008***
principal: ***SALAMANDER SHORES HOTEL PTY LTD***
test location: ***LABORATORY***
project: ***GEOTWARA20848AA – Hotel Development***
tested by: ***GREG E***
location: ***SOLDIERS POINT***
checked by:

date samples recovered: ***9/12/08***
pH meter used/serial no: HORIBA D-24
date of calibration: ***12/12/08***
hydrogen peroxide pH prior to use: ***4.9***
hydrogen peroxide temperature prior to use: ***22.7°C***

sample location	**depth (m)**	**RL (mAHD)**	**soil description**	**$_pH_F$ pH in 1:5 distilled water**	**$_pH_{FOX}$ (oxidation in 30% hydrogen peroxide)**							
					time (mins)	**pH $_{FOX}$**	**temp (°C)**	**Effervescence (see note below)**	**Odour**	**Colour change during reaction**	**$_pH$ Change (ie $_pH_F$-$_pH_{FOX}$)**	**Additional comments**
HA 2	*0.4-0.45*		*CLAY*	*7.37*	*20*	*5.10*	23.4	Nil	Nil	Nil	2.27	
HA 3	*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: **1. Observed Reaction:** a. No visible effervescence b. Slight to moderate effervescence c. Vigorous effervescent reaction
2. Strong Odour:

Appendix C

Hydraulic Conductivity Calculations

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

HYDRAULIC CONDUCTIVITY -
CONFINED BELOW WATER TABLE - CASED - OPEN
Variable Head

Borehole Number
BH1

office : Newcastle

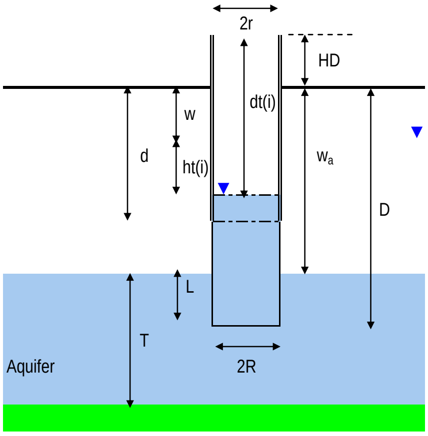
Client :	Sake Development Pty Ltd	Job Number :	GEOTWARA20848A
Principal :	All Seasons Salamander Shores Hotel Pty Ltd	Test Date :	5/03/2009
Project :	Proposed Hotel Redevelopment	Tested By :	AGB
Test Location :	147 Soldiers point Road, Soldiers Point	Checked By :	

Test Method : NAVFAC 1986; case F

Test Fluid : Ground Water

Height to Datum, HD :	0.00	m
Hole Radius, R :	0.037	m
Hole Depth, D :	4.83	m
Borehole Area, A :	0.0043	m^2
Casing Radius, r :	0.025	m
Casing Depth, d :	1.50	m
Aquifer Thickness, T :	10.00	m
Depth to Aquifer, w_a :	1.50	m
Test Length, L :	3.33	m
Depth to Water Table, w :	1.05	m
- date & time :	5-Mar-09 9:15 AM	
L / T :	0.33	
L / R :	89.86	
Shape Factor, F :	4.64	m

Sketch of site conditions (not to scale)

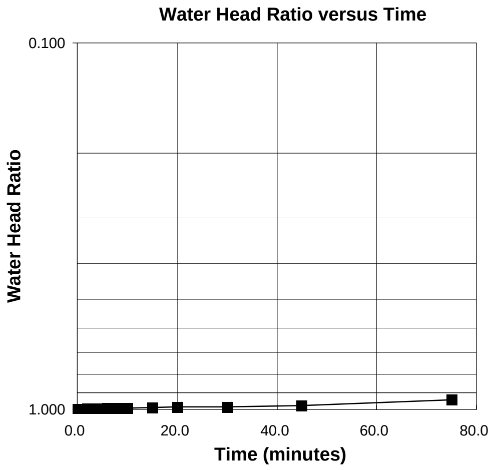


If L/T < 0.2 then F = C_sR and Cs = 6 + L/R + 6 log (L/R)

If 0.2< L/T < 0.85 then F = $\frac{2 \pi L}{\ln (L / R)}$

If L/ T > 0.85 then F = $\frac{2 \pi L}{\ln (R_0/R)}$ and Ro/R = 200

Reading No.	Elapsed Time t (mins)	Depth to Water dt(i) (m)	Water Head ht(i) (m)	Water Head Ratio ht(i)/ht(0)
0	0.0	4.674	3.63	1.000
1	1.0	4.669	3.62	0.999
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
7	10.0	4.641	3.59	0.991
8	15.0	4.631	3.58	0.988
9	20.0	4.623	3.58	0.986
10	30.0	4.609	3.56	0.982
11	45.0	4.591	3.54	0.977
12	75.0	4.459	3.41	0.941
13				
14				
15				
16				
17				
18				
19				
20				



($r.no., t_1, y_1$)	=	0	0.0	3.63
($r.no., t_2, y_2$)	=	12	75.0	3.41

Hydraulic Conductivity, K = $\frac{A \ln (h_1 / h_2)}{F (t_2 - t_1)}$

= 1.3E-08 m/sec

= 0.00 m/day

Notes:

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

HYDRAULIC CONDUCTIVITY - CONFINED BELOW WATER TABLE - CASED - OPEN

Rising Head

Borehole Number
BH2

office : Newcastle

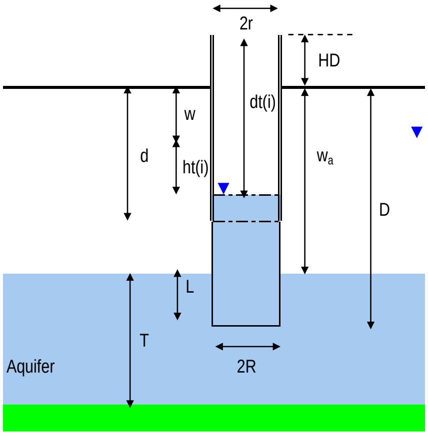
Client :	Sake Development Pty Ltd	Job Number :	GEOTWARA20848A
Principal :	All Seasons Salamander Shores Hotel Pty Ltd	Test Date :	5/03/2009
Project :	Proposed Hotel Redevelopment	Tested By :	AGB
Test Location :	147 Soldiers Point Road, Soldiers Point	Checked By :	

Test Method : NAVFAC 1986; case F

Test Fluid : Ground Water

Height to Datum, HD :	0.00	m
Hole Radius, R :	0.037	m
Hole Depth, D :	6.73	m
Borehole Area, A :	0.0043	m^2
Casing Radius, r :	0.025	m
Casing Depth, d :	1.50	m
Aquifer Thickness, T :	10.00	m
Depth to Aquifer, w_a :	1.50	m
Test Length, L :	5.23	m
Depth to Water Table, w :	2.63	m
- date & time :	5-Mar-09	9:20 AM
L / T :	0.52	
L / R :	141.35	
Shape Factor, F :	6.64	m

Sketch of site conditions (not to scale)

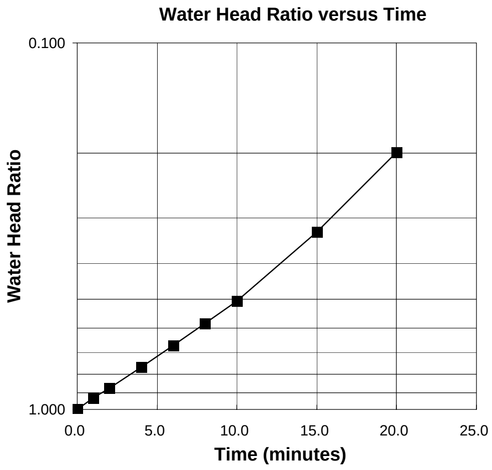


If L/T < 0.2 then $F = C_sR$ and $Cs = 6 + L/R + 6 \log(L/R)$

If 0.2< L/T < 0.85 ther $F = \frac{2\pi L}{\ln(L/R)}$

If L/ T > 0.85 then $F = \frac{2\pi L}{\ln(R_0/R)}$ and Ro/R = 200

Reading No.	Elapsed Time t (mins)	Depth to Water dt(i) (m)	Water Head ht(i) (m)	Water Head Ratio ht(i)/ht(0)
0	0.0	6.005	3.37	1.000
1	1.0	5.765	3.13	0.929
2	2.0	5.590	2.96	0.877
3	4.0	5.215	2.58	0.766
4	6.0	4.890	2.26	0.669
5	8.0	4.600	1.97	0.583
6	10.0	4.340	1.71	0.506
7	15.0	3.740	1.11	0.328
8	20.0	3.305	0.67	0.199
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				



$(r.no., t_1, y_1)$	=	0	0.0	3.37
$(r.no., t_2, y_2)$	=	8	20.0	0.67

Hydraulic Conductivity, K $= \frac{A \ln(h_1 / h_2)}{F(t_2 - t_1)}$

= 8.7E-07 m/sec

= 0.08 m/day

Notes: