DM & RD DOSSOR

PROPOSED RESIDENTIAL SUBDIVISION

1 Survey Street, Lennox Head, NSW

SLOPE STABILITY ASSESSMENT

NR1059/3-AD

31 August 2006

NR1059/3-AD
31 August 2006

SAKE Development
Suite 11, 340 Darling Street
BALMAIN NSW 2041

Attention: Sarah Kelly

Dear Madam,

RE: PROPOSED RESIDENTIAL SUBDIVISION – 1 SURVEY STREET, LENNOX HEAD
SLOPE STABILITY ASSESSMENT

Coffey Geosciences Pty Ltd is pleased to present our report on the slope stability assessment carried out at the above site. The assessment comprised collation of information obtained during previous studies at the site, and presentation of a slope stability hazard assessment based on the assessment methodology presented by the Australian Geomechanics Society Landslide Risk Management Concepts and Guidelines 2000.

We draw your attention to the attached sheet entitled "Important Information About Your Coffey Report" which should be read in conjunction with this report.

We trust that this report meets with your requirements. If you require further information please contact the undersigned in our Coffs Harbour office.

For and on behalf of

COFFEY GEOSCIENCES PTY LTD

DAVID BARKER
Senior Geotechnical Engineer

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1. INTRODUCTION

Coffey Geosciences Pty Ltd (Coffey) has carried out a Slope Stability Assessment (SSA) for a proposed residential subdivision at 1 Survey Street, Lennox Head. The current assessment was commissioned by DM & RD Dossor for the preparation of a Project Application and Environmental Assessment under Part 3A of the Environmental Planning and Assessment Act 1979.

Based on the brief for the work, we understand that the aim of the SSA was to satisfy the requirements of the Director General of the Department of Planning with respect to slope stability. Documentation provided to Coffey indicates that the requirement for the SSA is as follows:

> *"A detailed geotechnical assessment is required to establish certainty regarding the site stability and suitability for the proposal. This should consider the Australian Geomechanics Society landslide Risk Management Guidelines 2000."*

This report collates the available information from the previous investigations and presents a SSA using an updated assessment methodology developed and presented in the Australian Geomechanics Society Sub-Committee (March 2000) Landslide Risk Management publication titled "Landslide Risk Management Concepts and Guidelines" (AGS 2000). Coffey conducted the work in general accordance with proposal NR1059/3-AA dated 2 June 2006.

2. PREVIOUS WORK

Coffey has previously conducted investigation and assessment work which included or was specific to the site of the proposed subdivision in 1986, 1999 and 2002. In addition, Coffey provided expert witness and geotechnical consultancy services in 2001 and 2002. The results of the previous work are discussed below.

2.1 1986 Coffey Report

The site was included in a geotechnical zoning survey carried out by Coffey in 1986 for Ballina Shire Council, the results of which were presented in report S7761/1-AA dated March 1986. This survey was primarily based on aerial photography interpretation, with some ground truthing.

Drawing S7761/1-3 in the report indicated that the site of the proposed subdivision is located within Zones IIA and III defined as Medium and Low to Very Low risk of instability respectively.

2.2 1999 Coffey Report

In September and October 1999, Coffey carried out a geotechnical and site stability assessment at the site, the results of which were presented along with comments and recommendations in report NR1059/1-C dated 11 October 1999.

Field work for the geotechnical and site stability assessment consisted of the excavation of 18 test pits (TP1 to TP18) to depths of between1.5m and 3m, and a site walkover and stability assessment by a Coffey Senior Engineering Geologist. The engineering logs of the test pits are presented in Appendix A. Reference should be made to the original report for explanation sheets defining the term and symbols used in the preparation of these logs. Laboratory testing comprised California Bearing Ratio (CBR) and shrink/swell tests for pavement thickness design and lot classification purposes respectively. The report presented the results of the investigation and laboratory testing, summarised the site conditions, and provided comments and recommendations on slope stability, lot classification, pavement thickness design, detention pond construction and site preparation.

With respect to slope stability, it was assessed that the site could be divided into three zones. The zones can be summarised as comprising a low risk zone (areas of flatter ground along the base of the valley and on the lower slopes of the ridges), a low to medium risk zone (areas of steeper slopes above the valley floor forming the middle slopes of the ridgelines) and a medium risk zone (areas of steeper slopes on the upper areas of the eastern ridge). General recommendations for development within the different risk zones were provided in the report.

2.3 Expert Witness Work and 2002 Coffey Report

Following the issue of the above report, we understand that the development application was rejected by Ballina Shire Council, and an appeal was heard before the Land and Environment Court (Dossor v Ballina Shire Council [2001] NSWLEC 173). During the appeal, Coffey provided expert evidence for Dossor regarding the geotechnical and slope stability issues for the development. For Ballina Shire Council, Robert Carr & Associates Pty Ltd (RCA) were engaged to provide expert evidence.

RCA raised several issues upon review of the Coffey reports, and considered that further investigations were required to investigate the interface between the basalt and underlying agglomerate geological units at the site and the presence of any weak layers, and to refine the understanding of groundwater flows. Both RCA and Coffey agreed that even if weak layers were present along with adverse groundwater conditions, technical solutions could be designed to allow residential development to proceed.

On 1 August 2001 the NSW LEC dismissed the appeal against Ballina Shire Council's refusal of the subdivision development application. With regard to geotechnical issues, the following conclusions were stated:

172(7) the site stability issues should be fully addressed before consent is given for any residential development of the subject land.

172(10) the subsurface drainage proposals which directly affect residential development on individual lots of the subject land should be fully designed and evaluated before consent is granted.

Discussions between Coffey and RCA continued following the judgement, and from these discussions it was agreed that additional investigations consisting of the drilling of four boreholes and installation of standpipe piezometers would resolve the geotechnical issues in relation to stability and drainage. On this basis, four boreholes (BH1 to BH4) were drilled in February 2002 to depths of between 6.2m and 19.58m at locations nominated by RCA during the discussions. One borehole was located within north western area of the site, with the remaining three boreholes located within the south eastern area of the site. The results of the drilling were presented in report CH1059/2-K dated 11 March 2002. The engineering logs of the boreholes are presented in Appendix B. Reference should be made to the original report for explanation sheets defining the term and symbols used in the preparation of these logs. Based on the drilling results, Coffey concluded that no significant clay layers that could adversely impact on the stability of the site were evident in the boreholes. Groundwater levels were measured in BH2 and BH4, and no groundwater was encountered in BH1. A blockage in BH3 prevented measurement of water levels.

2.4 Current Work

The current geotechnical work comprised the following:

- Review of available geotechnical data from previous work carried out by Coffey, and provision of an updated geotechnical report (including a plan of the currently proposed subdivision layout) which addresses the requirements of the Director General of the Department of Planning with respect to slope stability;
- A site walkover assessment carried out by a Coffey Senior Engineering Geologist on 10 August 2006. The purpose of the walkover was to observe the current site conditions with respect to slope

stability, and to map areas where groundwater seepage was evident.

The locations of the previous investigations and observations from the current site walkover assessment are shown on the current proposed subdivision layout on Figure 1. Figure 1 is based on a plan provided by Sarah Kelly of SAKE Developments.

Coffey is currently in the process of carrying out an Environmental Site Assessment at the site, the results of which will be presented in a separate report.

3. SITE CONDITIONS

3.1 General

The surface and subsurface conditions information presented in this report is based on Coffey reports NR1059/1-C and NR1059/2-K and the site walkover assessment carried out on 10 August 2006.

3.2 Surface Conditions

The information presented in this section is based on that presented in Coffey report NR1059/1-C dated 11 October 1999 and a site walkover carried out by a Coffey Senior Engineering Geologist on 10 August 2006.

The site of the proposed subdivision covers an area of around 9.9ha and lies on the eastern side of Survey Street and Amber Drive, Lennox Head. The site is bordered by existing residential subdivisions on the western and northern sides. The site is currently used as a pasture and is predominantly open paddock. A small area of woodland is present on the southern end of the site.

Topographically, the site lies in a broad, north-south trending valley, open to the south and bounded on the east, west and north sides by low ridges. Hills slopes on the ridges are generally moderate, varying from around 18° to 20° on the upper slopes to 12° to 15° on the lower slopes. The base of the valley is occupied by a broad, gently sloping area with slope angles of typically around 3° to 5°. A small creek runs along the base of the valley, draining to the south.

Localised areas of rock outcrop were noted along the bed of the creek and scattered basalt cobbles were noted on the upper slopes of the ridges.

During the previous work, the gently sloping area between the base of the lower slopes and the creek were noted to be wet and boggy, with widespread surface water and groundwater seepage. These wet and boggy soils were again evident during the recent site walkover. Groundwater seepage was inferred where surface water, wet/boggy surface soils and variations in vegetation were observed on the mid-slopes of the hills near proposed lots 27 to 32 on the eastern side of the creek. Areas of wet/boggy surface soils and inferred groundwater seepage observed during the recent site walkover are shown on Figure 1.

Localised soil erosion/scour was evident near the outlet of a stormwater drain on the western side of the site near proposed lots 1 and 2, and near a pump station/stormwater drain outlet near the northern end of the site. The approximate locations of the erosion/scour are shown on Figure 1.

3.3 Subsurface Conditions

The information presented in this section is based on that presented in Coffey reports NR1059/1-C dated 11 October 1999 and NR1059/2-K dated 11 March 2002.

The 1:250,000 scale, “Murwillumbah”, geology map of the area indicates the site is underlain by weathered volcanic rocks of the Tertiary Lismore Basalt, described as bedded basalt flows with layers of volcanic ash, agglomerate and sedimentary rocks.

Site observations indicated that the underlying geology on the site consists of three different subsurface units described as follows:

- On the crest and upper slopes of the ridge to the east of the site, the underlying rock appears to comprise highly weathered, low to medium strength, highly fractured basalt, overlain by gravelly clays with basalt cobbles and boulders;
- On the middle and lower slopes, the thickness of residual soils is considerably greater than on the upper slopes, and the underlying basalt appears to be more deeply weathered, possibly indicating a different composition or structural geology;
- On the bed of the creek in the southern and central area of the site, the rock exposed consists of rounded to sub-angular basalt gravel, cobbles and small boulders in a fine-grained matrix. This rock is considered to be volcanic agglomerate or possibly an alluvial deposit of basalt cobbles and boulders in a matrix of volcanic ash. This material appears to be less weathered and more resistant to erosion than the overlying basalt and was observed to be massive with very few joints or fractures.

The generalised subsurface conditions as indicated by the test pitting are shown in Table 1.

TABLE 1: SUMMARY OF SUBSURFACE CONDITIONS OBSERVED IN TEST PITS

UNIT	OBSERVED THICKNESS (m)	DESCRIPTION
Topsoil	0.1 to 0.4	Generally comprising Gravelly Silt Clay, high plasticity, red-brown and grey, typical unit thickness observed was 0.2m.
Residual Soil	0.7 to >3	Gravelly CLAY, high plasticity, fine to coarse grained gravel, orange-brown and grey, extent of gravel depends on the topographic location on site, refer to geological descriptions above.
Bedrock	-	BASALT, highly weathered, low to medium strength, highly to slightly fractured, fine to cobble size particles in matrix, red- brown and grey-brown, refer descriptions above.

The subsurface conditions encountered in each of the four boreholes drilled on site are summarised in Table 2.

TABLE 2: SUMMARY OF SUBSURFACE CONDITIONS OBSERVED IN BOREHOLES

BOREHOLE NO.	1	2	3	4
MATERIAL TYPE	DEPTH (m)			
Colluvial Soil	0.0-0.8	--	--	--
Residual Clay Soil	0.8-6.2	0.0-2.8	0.0-4.1	0.0-3.2
XW Basalt	--	2.8-5.7	4.1-6.6	3.2-4.8
HW to MW Basalt	--	--	6.6-7.8	4.8-5.4, 8.5-12.2
MW to SW Basalt	--	5.7-6.65	7.8-13.5	5.4-8.5, 12.2-13.4, 18.8-19.6
SW to Fr Basalt				13.4-18.8

The subsurface conditions interpreted from the boreholes are further discussed below.

Western Hillside

BH1 was drilled on moderately sloping ground on the lower part of the western hillside near the creek. BH1 encountered a surface layer of 0.8m of very stiff silty clay (possible colluvium) with basalt gravel, cobbles and boulders. This was underlain by hard, residual sandy and silty clay with occasional basalt cobbles continuing to borehole termination depth at 6.2m.

Eastern Hillside

BH2 was drilled on the lower part of the eastern hillside at approximately RL21.1m. BH2 encountered a 0.3m thick surface layer of soft, water affected clay underlain by stiff to very stiff residual clay to a depth of 2.8m. This was underlain by hard, residual clay (extremely weathered basalt) to a depth of 5.7m. Diamond coring commenced at 5.7m and encountered moderately and slightly weathered basalt to borehole termination depth at 6.65m. Significant clay seams were not observed.

BH3 was drilled in the lower to middle slopes of the eastern hillside. BH3 encountered stiff to very stiff residual clay soils to a depth of 1.7m underlain by hard residual clay to 4.15m. Diamond coring commenced at 4.15m depth. Extremely and extremely to highly weathered, very low strength basalt was encountered to a depth of 6.5m, becoming stronger towards base of this layer. Highly weathered, medium strength basalt was encountered to 7.9m and moderately weathered, medium to high strength basalt to a depth of 9.3m. From 9.3m to borehole termination depth at 13.5m, BH3 encountered inter-layered moderately weathered, moderately to slightly weathered basalt, varying in strength from medium to high to very high strength. The basalt in BH3 was observed to be locally vesicular/amygdaloidal with clay and zeolite-filled vesicles. A number of clay and fragmented rock seams were noted at various depths. These zones were typically 20mm to 50mm thick.

BH4 was drilled on the middle slopes of the hillside at approximately RL34.9m. BH4 encountered very stiff to hard residual clay soils to a depth of 4.8m, grading to extremely weathered basalt below approximately 4m depth. Diamond coring commenced at 4.8m depth. Highly weathered basalt (with a thin layer of extremely weathered basalt) was encountered from 4.8m to 5.4m, underlain by inter-layered moderately weathered, medium to high strength basalt and slightly weathered, high to very high strength basalt continuing to a depth of 8.5m. This was underlain by highly to moderately weathered, medium to high strength basalt to 12.2m, moderately to slight weathered, high strength basalt to 13.4m, slightly weathered to fresh, high to very high strength basalt to 18.8m and moderately weathered, medium to high strength basalt to borehole termination depth at 19.58m. No significant clay seams were observed in the drill core from BH4.

In general, the subsurface conditions encountered in boreholes BH2 and BH4 consist of a surface layer of around 3m to 4m of residual clay soils underlain by 1.5m to 3m of extremely weathered and highly weathered basalt grading to slightly weathered basalt continuing to depth. Significant clay seams (defined for the purposes of this report are typically 100mm or greater in thickness of predominately clay with less than 50% gravel or crushed rock) were not observed in any of the core sampled from the boreholes. Borehole BH3 encountered a small number of thinner clay seams, however these were not present in borehole BH2 or BH4.

3.4 Groundwater

Groundwater inflows were observed in all pits located in the lower sections of the site, namely TP6, TP7, TP8, and TP17. These pits appear to correspond to groundwater flows in top of the interface of volcanic agglomerate observed in the base of the creek. It is noted that the test pitting fieldwork carried out in September 1999 followed a protracted period of wet weather.

The standing groundwater table was measured on 26 February 2002 at a depth of 0.98m in borehole BH2 and 10.4m in borehole BH4. A blockage in BH3 prevented measurement of water levels. Groundwater was not observed in borehole BH1.

4. SLOPE STABILITY

4.1 General

With reference to AGS 2000, the assessment of risk should consider two factors, namely the likelihood of an event occurring and the consequences should it occur. The risk can be assessed for any number of identified hazards at the site (e.g. small slumps, large scale rotational failures or debris flows, global failure of retaining walls).

Previously, Coffey carried out an assessment (report NR1059/1-C) which divided the site into three “risk” zones based on the conditions evident at the site. The report indicated that it is not technically feasible to assess stability in absolute terms such as “stable” or “unstable”, and therefore its intent was to consider the “risk” of slope movement, where “risk” classes were defined in terms of the likelihood of slope instability (e.g. low risk was defined as “slope stability is very unlikely”). On this basis, though the previous Coffey report refers to “risk”, the assessment could be considered to be referring to the “likelihood” of slope instability with reference to AGS 2000.

In terms of slope stability risk, the likelihood and consequences of instability would depend on the nature, location and type of the development at the site. Without details of the proposed developments (e.g. specific locations and types of residential developments and details of site earthworks such as the location and depth of excavations, filling), the assessment of slope stability would be limited to consideration of hazards for the site in its undeveloped state, and an assessment of the relative likelihood of occurrence of these hazards. This was the intent of Coffey report NR1059/1-C, though with likelihood referred to as risk.

It is considered that the division of the site into zones of differing slope stability characteristics is appropriate for the site based on the site conditions. The delineated boundaries between the zones are shown on Figure 2, which also shows the current proposed subdivision layout. The zones are referred to as Zone 1, Zone 2 and Zone 3 as shown, and are discussed in section 4.2. Recommendations for development both in general and specifically related to each of these zones are presented in section 5 of this report.

In terms of the SSA for each of the site zones, it is considered that slope stability risk can be assessed with reference to AGS 2000 based on consideration of the likely type of development at the site and the likelihood and consequences of the identified hazards. The assessment of risk assumes that developments are designed and constructed in accordance with the recommendations for development in this report. The risk assessment is presented below.

4.2 Site Zones

The consideration of likelihood of slope instability is based on a number of factors including slope angle, subsurface conditions, groundwater levels and the existence of indicators of past instability. Based on the assessment, the site is divided into three zones. The three zones are shown on Figure 2 and are described below.

- Zone 1: Areas of flatter ground along the base of the valley and on the lower slopes of the ridges. Slope angles in this area are generally less than about 10^{o} to 12^{o}. Subsurface conditions in this zone generally comprise stiff to very stiff residual Gravelly Clay soils, with water inflows observed in several test pits at various depths. It is noted that previous reports indicated wet boggy surface soils in some portions of this zone at times of field work. No evidence of slope instability was observed in this zone during previous investigations.
- Zone 2: Areas of steeper slopes above the valley floor forming the middle slopes of the ridge lines on the eastern and western sides of the valley. Slope angles in this zone are typically in the range of

15° to 18°. Subsurface conditions in this zone generally comprise very stiff to hard residual Gravelly Clay soils overlying weathered basalt at depth. In general, the water inflows were not observed in the test pits excavated in this zone except for TP17, in which groundwater inflows were observed at a depth of between 1m and 1.5m. Groundwater seepages were evident in parts of this zone as shown on Figure 1 (near proposed lots 27 to 32). The ground surface in this zone shows some signs of soil creep. No evidence of significant past instability was observed in this zone.

- Zone 3: Areas of steep slopes on the upper areas of the eastern ridge. Slope angles in this zone are typically in the range of 18° to 22°. Subsurface conditions in this zone generally comprise very stiff to hard residual Gravelly Clay soils overlying weathered basalt at varying depths. In general, no water inflows observed in the test pits at the time of field work. The ground surface in this area shows some more widespread signs of soil creep. No evidence of significant past instability was observed in these areas.

4.3 Identification of Hazards

The hazards considered in the risk assessment for the site are shown below:

- Hazard 1: Shallow seated instability of the natural and altered slopes in the vicinity of the proposed developments. This failure might take the form of relatively minor slips and/or slumping of site soils;
- Hazard 2: Deep seated instability of the natural and altered slopes in the vicinity of the proposed developments. This failure might take the form of a significant slip/slump, with a relatively large amount of soil and/or rock material displaced;
- Hazard 3: Instability of appropriately battered and treated slopes or failure of engineer designed retaining walls.

4.4 Assessed Risk

For the purposes of this assessment, the terms and descriptions provided in Appendix G of AGS 2000 have been used. The terms and descriptions are summarised in Appendix C.

For the hazards indicated above, the assessed likelihood and consequences of each hazard and the associated risk is presented in Table 6.

TABLE 6: ASSESSED RISK FOR SLOPE INSTABILITY HAZARDS

ZONE	HAZARD	ASSESSED LIKELIHOOD	ASSESSED CONSEQUENCES	ASSESSED RISK
Zone 1	Hazard 1	Rare	Minor	Very Low
	Hazard 2	Not credible	Major	Very Low
	Hazard 3	Rare	Medium to major	Low
Zone 2	Hazard 1	Unlikely	Minor	Very Low to Low
	Hazard 2	Not credible to rare	Major	Low
	Hazard 3	Rare	Medium to major	Low
Zone 3	Hazard 1	Possible	Minor	Low to Moderate
	Hazard 2	Rare	Major	Low to Moderate
	Hazard 3	Rare	Medium to major	Low

A discussion of the assessed likelihood and consequences used to assess the risk of slope instability is presented in Appendix C.

Based on the above, the highest assessed risk for each of the zones is shown below:

- Zone 1 Very low to low risk of slope instability.
- Zone 2 Low risk of slope instability.
- Zone 3 Low to moderate risk of instability.

The above assessed risks are based on the developments being designed and constructed in accordance with the recommendations outlined in section 5 of this report.

AGS 2000 provides example implications for very low, low and moderate risk levels as follows:

- Very Low Risk: Acceptable. Manage by normal slope maintenance procedures.
- Low Risk: Usually accepted. Treatment requirements and responsibility to be defined to maintain or reduce risk.
- Moderate Risk: Tolerable provided treatment plan is implemented to maintain or reduce risks. May be accepted. May require investigation and planning of treatment options.

Recommended treatment options, slope maintenance procedures and limitations on development are provided in section 5 to achieve the assessed risks.

5. RECOMMENDATIONS FOR DEVELOPMENT

5.1 Limitations and Intent

This report provides an assessment of the risk associated with slope instability at the site. It must be accepted that the potential risks associated with hillside construction are greater than construction on level ground in the same geological environment, and inappropriate construction techniques can increase the potential for ground movement. Recommendations for development are provided below.

<u>All</u> developments should be designed and constructed in accordance with the recommendations presented in sections 5.2 and 5.3. In addition, developments should be designed and constructed in accordance with the recommendations in sections 5.4, 5.5 or 5.6 as appropriate for their location on the site with respect to the site stability zones.

This report should not be regarded as a site investigation report for the specific design of developments, though general comments regarding geotechnical issues have been made so far as these affect slope stability. Coffey has carried out an assessment of site contamination resulting from past uses of the land which has been issued under separate cover.

Site conditions exposed during site earthworks should be observed by a suitably experienced engineer to confirm conditions which have been inferred in this assessment.

5.2 General Guidelines for Construction

The following guidelines are recommended for <u>all</u> developments at the site (regardless of their location):

Design and Construction

- The design and construction of all developments should be carried out in accordance with good hillside practice as shown on Figure 3 and Figure 4, and the relevant recommendations for development presented in this report.

- All developments should be designed by an engineer with appropriate experience and knowledge of the site conditions, using sound engineering principles and in accordance with the relevant Australian Standard or appropriate industry standard.
- Foundations for residential structures should be designed and constructed in accordance with the recommendations and advice of AS2870-1996, 'Residential Slabs and Footings'. Footings should be founded outside or below the zone of influence of any existing or excavations (e.g. batter slopes, services trenches or retaining walls etc) where the structure loads have not been incorporated into the design of the excavation.

Earthworks

- Earthworks should be carried out in accordance with the guidelines presented in AS3798-1996 "Guidelines on Earthworks for Commercial and Residential Developments".
- The removal of vegetation has the potential to increase the risk of instability. It is recommended that existing vegetation be maintained where practicable and that stripped areas be revegetated as soon as possible. Where a hole is created from the removal of tree root balls, the hole should be backfilled in a controlled manner using fill materials which are similar in nature to the surrounding natural soils. The areas should then be revegetated as soon as possible. At the subdivision development stage, existing vegetation within the crown land road reserve near the eastern site boundary will be removed. Provided that the above recommendations are adopted, it is considered that the removal of this vegetation would not affect the slope stability risk assessment outcomes presented above.
- Prior to the placement of any fill, the proposed areas should be stripped to remove all existing uncontrolled fill, vegetation, topsoil, root affected or other potentially deleterious material. Following stripping, the exposed materials 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. Fill should be compacted in layers to appropriate engineering specifications.
- Where fill is placed on slopes in excess of 1V:8H (7°), horizontal benches should be cut into the natural slope prior to placement of the fill.
- Where fill is placed across an existing watercourse, a culvert of adequate size to accommodate design flows should be installed. A subsoil drain along low point of the filled area will also be required.
- Excavations and batter slopes should be designed for surcharge loading from slopes, retaining walls, structures and other improvements in the vicinity of the excavation.
- Temporary slopes in soil strength materials up to 3m in height should be formed at no steeper than 1H:1V. Further geotechnical advice should be sought where cuts greater than 3m in height are proposed. Adequate drainage should be provided for all batter slopes. During rainfall periods, temporary slopes should have surface water on the high and low side diverted away from the batter face. The face may also need to be protected by the placement of plastic sheeting.
- Unsupported permanent batter slopes in soil strength materials should be battered at no greater than 2H:1V. All batter slopes should be protected against erosion by appropriate plantings or fabric.

Retaining Walls

- Retaining walls should be designed by a suitably qualified engineer who is familiar with the site conditions.
- Design of the walls must take into account any surcharge from sloping ground or other loadings behind the wall. The design should incorporate an allowance for water pressures.

- Adequate drainage should be provided for all retaining walls. Flushing points should be incorporated into the design of the perimeter drain to allow for maintenance.

Stormwater and Sewerage

- All collected stormwater run-off or stormwater discharging on to the site should be piped into the street drainage system or the existing watercourse in a controlled manner. Septic wastes should be connected to a reticulated disposal system.

5.3 Surface and Subsurface Drainage and Areas of Groundwater Seepage

5.3.1 General

The failure to provide adequate drainage is often a predominant cause of slope instability. Adequate surface and subsurface drainage should be provided for all site developments regardless of their location on the site. Surface and subsurface drainage should be considered at the subdivision development stage (e.g. prior to the sale and development of individual allotments) and during the individual allotment development stage.

During both stages of development, careful attention should be paid to the treatment of water emanating from springs and the like, as these have the potential to significantly increase the likelihood of instability if they are not appropriately treated. The need for treatment of springs and the appropriate treatment method should be assessed on a case by case basis as encountered during any site earthworks. Assessment and design of treatment systems should be carried out by an experienced consultant. In general, methods for treatment of water emanating from springs may take the form of trench drains or drainage blankets, with flows piped to the street stormwater system.

Specific comments and recommendations for subsurface drainage are provided below.

5.3.2 Subdivision Development Stage

It is recommended that subsurface drainage as recommended below be installed as soon as practicable during site earthworks. Having subsurface drainage in-place will reduce the likelihood of slope instability, and potentially reduce the likelihood of construction problems associated with groundwater such as heaving of subgrade soils and trafficability.

With respect to roads, it is recommended that subsurface drainage be provided along the high side of all roads (or road sections) aligned across site slopes, and along both sides of all roads (or road sections) aligned down site slopes. Subsurface drains should extend to at least 0.3m below the top of the natural undisturbed site soils, though this depth may need to be increased depending on site conditions exposed during site earthworks. Particular attention should be paid to subsurface drainage design in the area where groundwater seepage was evident (i.e. near lots 27 to 32) and near the southern end of the site.

Significant groundwater seepage was evident where surface water, wet/boggy surface soils and variations in vegetation were observed on the mid-slopes of the hills near proposed lots 27 to 32 on the eastern side of the creek. Previously, groundwater seepages were observed near proposed lots 24 to 32, and groundwater inflows were evident in TP17 which was located near the boundary between lots 24 and 25. These seepages could have an effect on residential developments on these allotments and on the road and other associated developments downslope of these allotments.

Based on the site conditions evident at the time of the current and previous field work, it is recommended that trench drains be constructed as follows:

- Trench drains should be constructed along the full length of the common boundaries of adjacent allotments inclusive of lots 24 to 33 (i.e. the southern boundaries of allotments 24 to 32).

- The trench drains should be of the order of 1.5m deep below the existing ground surface level and 0.5m wide.
- Perforated drainage pipe (min. 0.1m to 0.15m diameter, though a larger diameter may be required depending on flows encountered during construction) should be placed in the base of the trench and connected to the street stormwater drainage system.
- The trenches should be backfilled with an appropriate free draining granular material. The upper 0.7m of the trench should be backfilled with a clayey material to act as a capping layer for the trench and to allow the installation of fence post footings along the boundary. The clay material should be compacted to a target density ratio of 95% Standard compaction.

It is recommended that an experienced consultant be engaged to assess groundwater conditions during the construction of drainage trenches and to provide additional advice on subsurface drainage. It is noted that the recommendations provided above are based on the conditions evident at the time of field work. Additional subsurface drainage may be required depending on the conditions encountered during construction.

5.4 Specific Guidelines for Construction in Zone 1

It is considered that no geotechnical restrictions on dwelling type or design other than good engineering and construction practice are applicable in this zone. The recommendations provided in sections 5.2 and 5.3 should be adopted for design and construction in Zone 1.

5.5 Specific Guidelines for Construction in Zone 2

It is considered that the recommendations provided in sections 5.2, 5.3 and as shown below be adopted for design and construction in Zone 2.

- More flexible structures of timber or steel framed clad, brick veneer or similar construction should be adopted.
- Footings for developments should be founded within the natural undisturbed residual soils beneath all topsoil, uncontrolled fill or other deleterious materials.
- Cut and fill should be limited to 2.5m in depth/height unless subject to a site/development specific geotechnical assessment. Appropriate batters and/or retaining walls designed by an engineer who is familiar with the site conditions should be provided. The expertise of the contractor, the nature of the fill material and the degree of monitoring and testing of the filling will control the footing design required for any structures placed on the fill.

5.6 Specific Guidelines for Construction in Zone 3

It is considered that the recommendations provided in sections 5.2, 5.3 and as shown below should be adopted for design and construction in Zone 3.

- Flexible structures of timber or steel framed clad, brick veneer or similar construction should be adopted. Split level and suspended design should be considered to limit slope modification.
- Foundations should be designed and constructed in accordance with AS2870-1996, with footings for developments founded at least 0.6m into the natural undisturbed residual soils or weathered rock beneath all topsoil, uncontrolled fill or other materials.
- Cut and fill should be limited to 1.5m in depth/height unless subject to a site/development specific geotechnical assessment. Appropriate batters and/or retaining walls designed by an engineer who is familiar with the site conditions should be provided. The expertise of the contractor, the nature of the fill material and the degree of monitoring and testing of the filling will control the footing design required for any structures placed on the fill.

6. CONCLUSIONS

This report presents the results of a slope stability assessment carried out for a proposed residential subdivision development at 1 Survey Street, Lennox Head. The assessment comprised collation of information obtained during previous studies at the site, and presentation of a slope stability risk assessment based on the assessment methodology presented in AGS 2000.

Based on the work carried out, we consider that the site is appropriate for residential subdivision development, subject to the adoption of recommendations contained in this report. The decision as to the level of risk to be accepted or tolerated needs to be considered by both the owner and consent authorities involved. 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.

Development should be carried out in accordance with good hillside practice and the specific geotechnical recommendations defined in this report.

7. CONSTRUCTION RISK

The extent of testing associated with the current and previous assessments is limited and variations in ground conditions may occur between the test locations. If conditions other than those described in this report are encountered during construction further advice should be sought without delay. It is expected that geotechnical consultations will be required throughout the development of the site.

We draw your attention to the attached sheet entitled “Important Information About Your Coffey Report” which should be read in conjunction with this report.

For and on behalf of

COFFEY GEOSCIENCES PTY LTD

DAVID BARKER

Senior Geotechnical Engineer

Information

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 the 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.

Coffey

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 have incorporated 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.

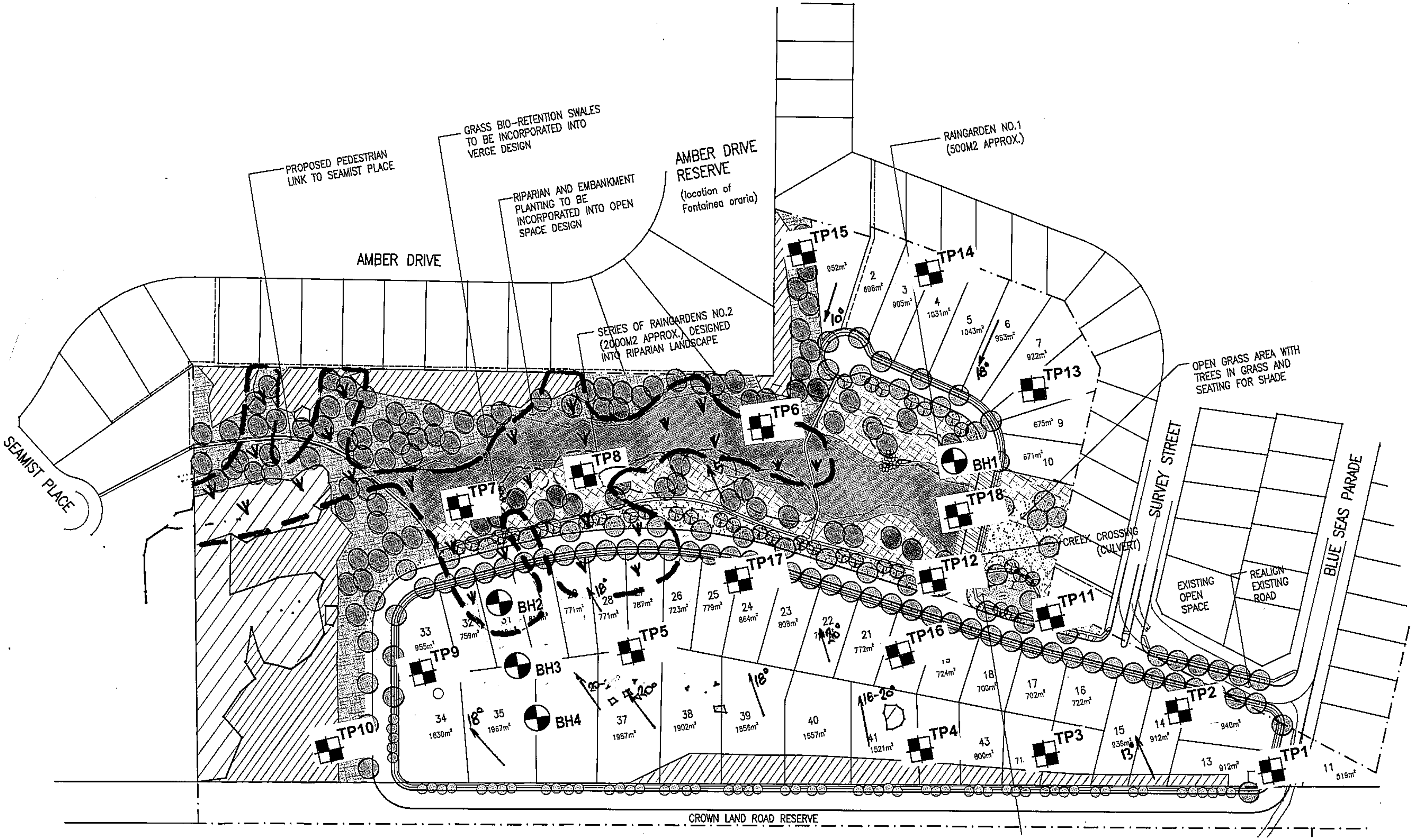
Rely on Coffey for additional assistance

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 toward 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.*



LEGEND

Borehole location & number BH1

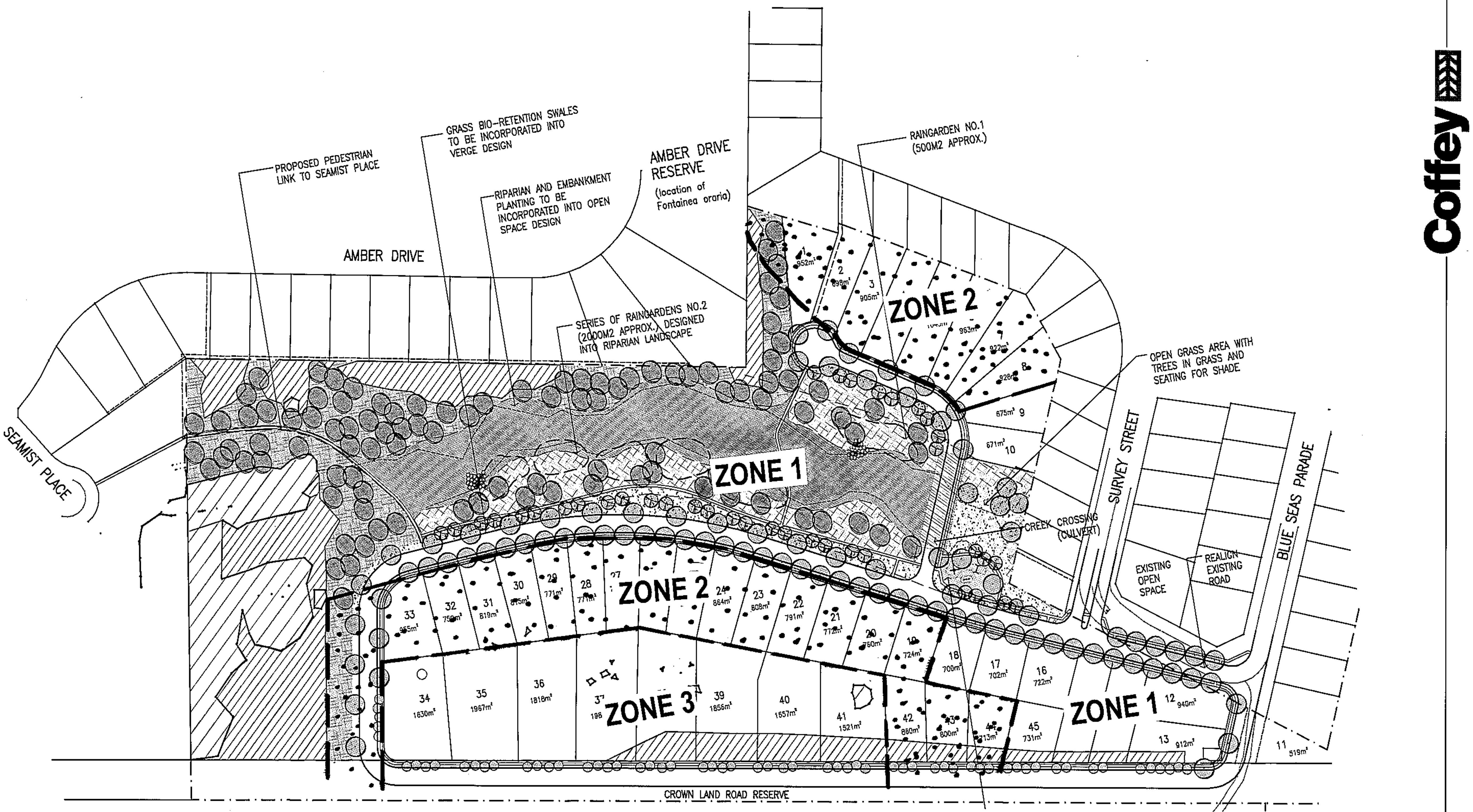
Test pit location & number TP1

Slope angle & down direction 10°

Wet/boggy soils & groundwater seepage

Coffey

Coffey Geosciences Pty Ltd ACN 056 335 516		Geotechnical I **Resources** I Environmental I **Technical** I Project Management	
Drawn	DJB	SAKE DEVELOPMENTS PROPOSED RESIDENTIAL SUBDIVISION 1 SURVEY STREET, LENNOX HEAD	Drawing no: **FIGURE 1**
Approved	[signature]		
Date	17/8/06		
Scale	1:200 (A3)	SITE PLAN	Job no: NR1059/3-AD



Coffey

LEGEND

Boundary of Slope Stability Zone

Z

0 10 20 30

SCALE (m)

Coffey Geosciences Pty Ltd ACN 056 335 516		Geotechnical I **Resources** I Environmental I **Technical** I Project Management	
Drawn	DJB	SAKE DEVELOPMENTS PROPOSED RESIDENTIAL SUBDIVISION 1 SURVEY STREET, LENNOX HEAD	Drawing no: FIGURE 2
Approved			
Date	17/8/06		
Scale	1:200 (A3)	ASSESSED SLOPE STABILITY ZONING PLAN	Job no: NR1059/3-AD

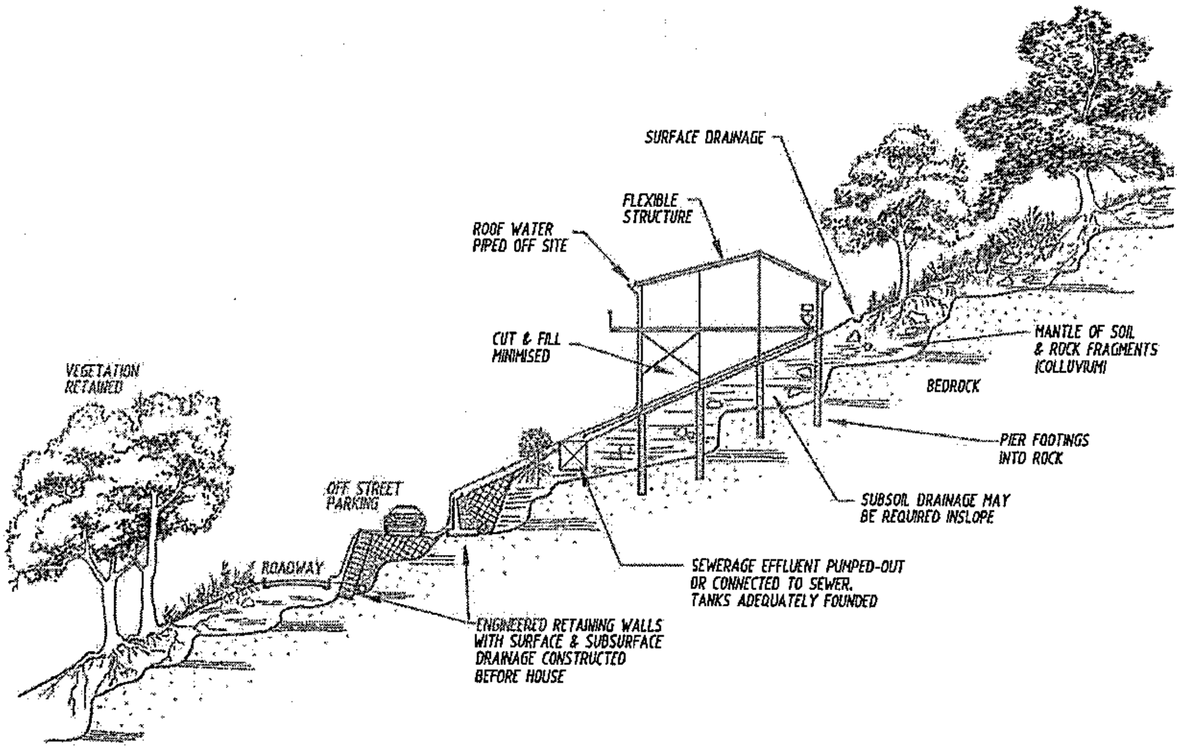
SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical consultant 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.	Indiscriminant 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.	

FIGURE 3: SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

This figure is an extract from LANDSLIDE RISK MANAGEMENT CONCEPTS AND GUIDELINES as presented in Australian Geomechanics, Vol 35, No. 1, 2000 which discusses the matter more fully.

EXAMPLES OF GOOD HILLSIDE PRACTICE



EXAMPLES OF POOR HILLSIDE PRACTICE

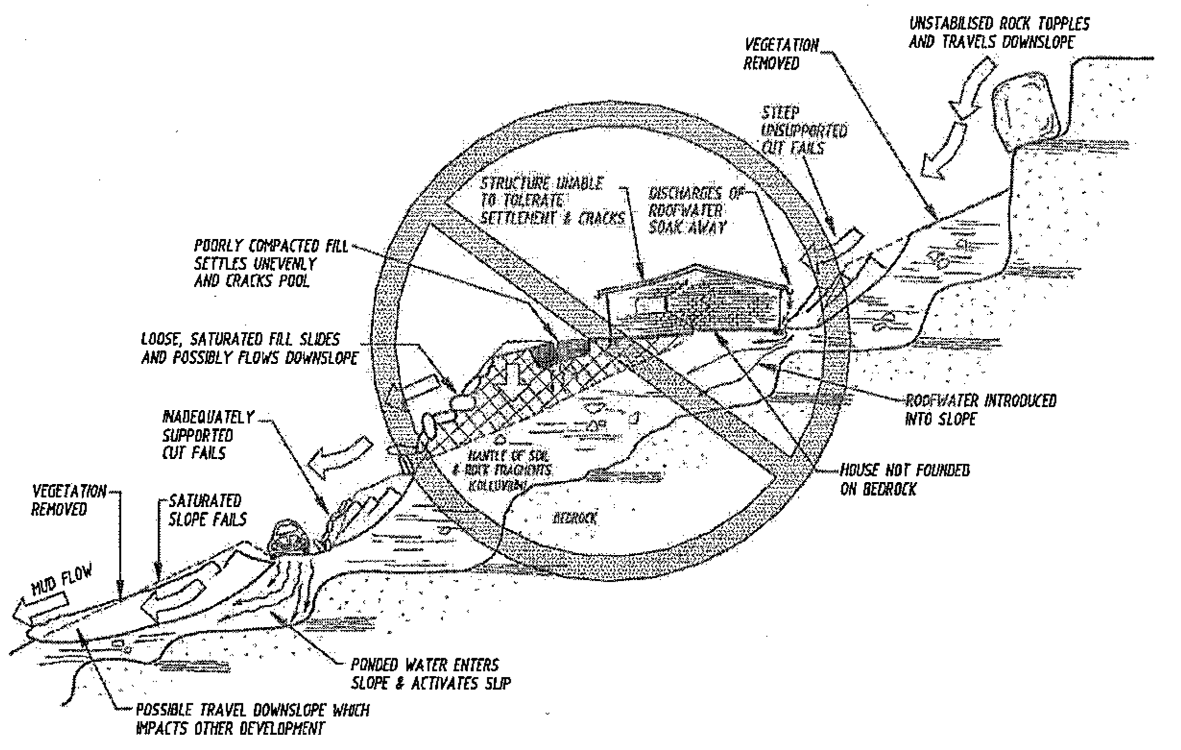


FIGURE 4: ILLUSTRATIONS OF GOOD AND POOR HILLSIDE PRACTICE

This figure is an extract form LANDSLIDE RISK MANAGEMENT CONCEPTS AND GUIDELINES as presented in *Australian Geomechanics*, Vol 35, No 1, 2000 which discusses the matter more fully.

APPENDIX A

ENGINEERING LOGS (TP1 TO TP18)

Coffey Geosciences Pty. Ltd.
ACN 056 335 516

engineering log - excavation

COFFEY

pit no: TP1
sheet 1 of 1

office job no: NR1059/1

client:	GeoLINK GROUP PTY LTD	pit commenced:	17-9-99
principal:		pit completed:	17-9-99
project:	DOSSER SUBDIVISION, LENNOX HEAD	logged by:	CMc
pit location:	REFER FIGURE 1	checked by:	[signature]

equipment type and model:	JCB-BACKHOE	R.L.Surface:	NOT MEASURED
excavation dimensions:	2.0 m long 0.6 m wide orientation: -90.	datum:	EXIST SURFACE

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
BH		NIL	D					CH	TOPSOIL: GRAVELLY CLAY: high plasticity, red-brown-brown, fine to coarse size gravel.	M	St / VSt		TOPSOIL, GRASS ROOTS
								CH	GRAVELLY CLAY: high plasticity, red-brown to brown, fine to coarse size gravel, becoming red-brown at 0.5m.				RESIDUAL
												X	pp in wall 450-500kPa
				U50 D							H		
						1						X	pp >600kPa
						2							
									Pit TP1 Terminated at 2.50 m				
						3							
						4							

METHOD
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R bulldozer ripper
E excavator
HA hand auger
HT hand tools

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
D none observed
X not measured
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
VS vane shear
DP dynamic penetrometer
FD field density
WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl 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

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Coffey Geosciences Pty. Ltd.
ACN 056 335 516

engineering log - excavation

COFFEY

pit no TP2
sheet 1 of 1

office job no: NR1059/1

client:	GeoLINK GROUP PTY LTD	pit commenced:	17-9-99
principal:		pit completed:	17-9-99
project:	DOSSER SUBDIVISION, LENNOX HEAD	logged by:	CMc
pit location:	REFER FIGURE 1	checked by:	[signature]

equipment type and model:	JCB-BACKHOE	R.L.Surface:	NOT MEASURED
excavation dimensions:	2.0 m long 0.6 m wide orientation: -90.	datum:	EXIST SURFACE

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
BH		NIL	D	D				CH	TOPSOIL: GRAVELLY CLAY: high plasticity, red-brown, fine to coarse size gravel.	M	St		TOPSOIL
				D				CH	GRAVELLY CLAY: high plasticity, red-brown, fine to coarse size gravel, becoming orange-brown with depth.		VSt	×	Residual pp 200kPa
												×	pp 400kPa
											H	×	pp in side wall 500-600kPa
						1						×	pp 500-600kPa
						2						×	pp 500-600kPa
						3			Pit TP2 Terminated at 3.00 m				
						4							

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT hand tools

SUPPORT
- SH shoring SC shotcrete
- Nil no support
- RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
- D none observed
- * not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl 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 Geosciences Pty. Ltd.
ACN 056 335 516

engineering log - excavation

COFFEY

pit no TP3
sheet 1 of 1

office job no: NR1059/1

client:	GeoLINK GROUP PTY LTD	pit commenced:	17-9-99
principal:		pit completed:	17-9-99
project:	DOSSER SUBDIVISION, LENNOX HEAD	logged by:	CMc
pit location:	REFER FIGURE 1	checked by:	[signature]

equipment type and model:	JCB-BACKHOE			R.L.Surface:	NOT MEASURED
excavation dimensions:	2.0 m long	0.6 m wide	orientation: -90.	datum:	EXIST SURFACE

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH		NIL	0					CH	TOPSOIL: GRAVELLY CLAY: high plasticity, brown-red-brown, fine to coarse size gravel, with basalt cobbles.	M	St	X	TOPSOIL pp in side wall 100-200kPa
				D									
				D				CH	CLAY: high plasticity, orange, brown.	-	H	X	RESIDUAL pp 600kPa
						1						X	pp 600kPa
												X	pp 600kPa
						2							
						3			Pit TP3 Terminated at 3.00 m				
						4							

B4. VERSION COFEXCA 12 /10 /99 11 :10 :6 B09

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT hand tools

SUPPORT
- SH shoring SC shotcrete
- Nil no support
- RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
- 0 none observed
- X not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl 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

TBB-239

Coffey Geosciences Pty. Ltd.
ACN 056 335 516

engineering log - excavation

COFFEY

pit no TP4

sheet 1 of 1

office job no: NR1059/1

client:	GeoLINK GROUP PTY LTD	pit commenced:	17-9-99
principal:		pit completed:	17-9-99
project:	DOSSER SUBDIVISION, LENNOX HEAD	logged by:	CMc
pit location:	REFER FIGURE 1	checked by:	[signature]

equipment type and model:	JCB-BACKHOE			R.L.Surface:	NOT MEASURED
excavation dimensions:	2.0 m long	0.6 m wide	orientation: -90.	datum:	EXIST SURFACE

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
BH		Nil	D					GC	TOPSOIL: CLAYEY GRAVEL: fine grained, red-brown, high plasticity, coarse, with basalt cobbles.	M	MD / D		TOPSOIL
								GC	CLAYEY GRAVEL: fine grained, red-brown, high plasticity, some basalt cobbles.				RESIDUAL
						1			BASALT: HW, fine cobble size, highly fractured, low to medium strength, red-brown and grey in colour.				WEATHERED ROCK basalt highly fractured
									Pit TP4 Terminated at 1.50 m				
						2							
						3							
						4							

COFEXCA VERSION B4. B09 12 /10 /99 10 :31 :56

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT hand tools

SUPPORT
- SH shoring SC shotcrete
- Nil no support
- RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
- D none observed
- * not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl 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

TBB-239

Coffey Geosciences Pty. Ltd.
ACN 056 335 516

COFFEY

pit no: TP5

sheet 1 of 1

engineering log - excavation

office job no: NR1059/1

client:	GeoLINK GROUP PTY LTD	pit commenced:	17-9-99
principal:		pit completed:	17-9-99
project:	DOSSER SUBDIVISION, LENNOX HEAD	logged by:	CMc
pit location:	REFER FIGURE 1	checked by:	[signature]

equipment type and model: JCB-BACKHOE | R.L. Surface: NOT MEASURED

excavation dimensions: 2.0 m long 0.6 m wide | orientation: -90. | datum: EXIST SURFACE

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material (soil type: plasticity or particle characteristics colour, secondary and minor components)	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH		NIL	D	D				CH	TOPSOIL: GRAVELLY CLAY: high plasticity, brown, fine to coarse size gravel, with basalt cobbles.	M	VSt		TOPSOIL, HW-MW
								CH	GRAVELLY CLAY: high plasticity, brown, fine to coarse size gravel, with basalt cobbles.			x	RESIDUAL pp 210-250kPa
				U50				CH	CLAY: high plasticity, orange-brown.		H	x	pp 550kPa
						1						x	pp 500-600KPa some basalt cobbles
									slight colour change to brown				
						2		CH	GRAVELLY CLAY: medium to high plasticity, fine to coarse size gravel, with grey lenses, trace of fine to medium grained sand, grading to extremely weathered basalt.				Increase in FMC FMC >Wp <WL
				D						M W			Some wet pockets
						3			Pit TP5 Terminated at 3.00 m				
						4							

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT hand tools

SUPPORT
- SH shoring SC shotcrete
- Nil no support
- RB rockbolts

PENETRATION
1 2 3 4 — little resistance ranging to very slow progress

WATER
- D none observed
- * not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl 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 Geosciences Pty. Ltd.
ACN 056 335 516

engineering log - excavation

COFFEY

pit no	TP6
sheet	1 of 1

office job no: NR1059/1

client:	GeoLINK GROUP	pit commenced:	17-9-99
principal:		pit completed:	17-9-99
project:	DOSSER SUBDIVISION, LENNOX HEAD	logged by:	CMc
pit location:	REFER FIGURE 1	checked by:	[signature]

equipment type and model:	JCB-BACKHOE	R.L.Surface:	NOT MEASURED
excavation dimensions:	2.0 m long 0.6 m wide orientation: -90.	datum:	EXIST SURFACE

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH		NIL		D				CH	GRAVELLY CLAY: high plasticity, grey-brown.	W / M	St / VSt		SURFACE COBBLES-BASALT
								CH	SILTY CLAY: high plasticity, brown, with orange-brown mottle.			X	RESIDUAL pp 150-200kPa
			water inflow	D				CH	GRAVELLY CLAY: high plasticity, orange-brown, with grey mottle, fine to coarse size gravel (HW).	W M		X	numerous water inflow through highly fissured clay pp 200-300kPa most clay
						1						X	pp 230kPa most clay
			water inflow										
			water inflow	D		2							
									Pit TP6 Terminated at 2.10 m				
						3							
						4							

METHOD
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R bulldozer ripper
E excavator
HA hand auger
HT hand tools

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 — little resistance ranging to very slow progress

WATER
O none observed
* not measured
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
VS vane shear
DP dynamic penetrometer
FD field density
WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl 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 Geosciences Pty. Ltd.
ACN 056 335 516

COFFEY

engineering log - excavation

pit no TP7
sheet 1 of 1

office job no: NR1059/1

client:	GeoLINK GROUP	pit commenced:	17-9-99
principal:		pit completed:	17-9-99
project:	DOSSER SUBDIVISION, LENNOX HEAD	logged by:	CMc
pit location:	REFER FIGURE 1	checked by:	[signature]

equipment type and model:	JCB-BACKHOE	R.L.Surface:	NOT MEASURED
excavation dimensions:	2.0 m long 0.6 m wide, orientation: -90.	datum:	EXIST SURFACE

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH		NIL						CH	SILTY CLAY: high plasticity, dark grey.	M	F / St	X	pp 90-120kPa RESIDUAL
			water inflow	D				GC	CLAYEY GRAVEL: fine to coarse grained, dark brown, with orange and grey mottle, some medium to high plasticity clay lenses.	W	MD / D		
				U50		1		CH	GRAVELLY CLAY: high plasticity, brown, with grey and orange-brown mottle, fine to coarse size gravel, trace of fine to medium grained sand, with basalt cobbles.	M	St	X	pp 100-150kPa cobbles are sub-rounded with exfoliated weathering patterns, HW-MW
				D								X	pp 110-140kPa
				D		2			becoming grey with orange mottle				
						3			Pit TP7 Terminated at 2.50 m				
						4							

COFEXCA VERSION B4. 12/10/99 10:35:31 B09

METHOD	PENETRATION	SAMPLES, TESTS, ETC	CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION	CONSISTENCY/DENSITY INDEX
N natural exposure X existing excavation BH backhoe bucket B bulldozer blade R bulldozer ripper E excavator HA hand auger HT hand tools SUPPORT SH shoring SC shotcrete Nil no support RB rockbolts	1 2 3 4 little resistance ranging to very slow progress WATER D none observed * not measured water level water outflow water inflow	U undisturbed sample (mm) D disturbed sample Bs bulk sample E environmental sample VS vane shear DP dynamic penetrometer FD field density WS water sample	based on unified classification system MOISTURE D dry M moist W wet Wp plastic limit Wl liquid limit	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 Geosciences Pty. Ltd.
ACN 056 335 516

engineering log - excavation

COFFEY

pit no TP8

sheet 1 of 1

office job no: NA1059/1

client:	GeoLINK GROUP	pit commenced:	17-9-99
principal:		pit completed:	17-9-99
project:	DOSSER SUBDIVISION, LENNOX HEAD	logged by:	CMc
pit location:	REFER FIGURE 1	checked by:	

equipment type and model:	JCB-BACKHOE			R.L.Surface:	NOT MEASURED
excavation dimensions:	2.0 m long	0.6 m wide	orientation: -90.	datum:	EXIST SURFACE

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH		NIL	*				CH	TOPSOIL: GRAVELLY CLAY: high plasticity, grey-brown, fine to coarse size gravel.	M	St		TOPSOIL
				D			CH	GRAVELLY CLAY: high plasticity, grey-brown, fine to coarse size gravel.	W		X	RESIDUAL; pp 100-130kPa
				D			GC	CLAYEY GRAVEL: fine to coarse grained, brown with orange mottle, high plasticity, trace of fine to coarse grained sand, trace of silt fines, with basalt cobbles.	M		X	pp in clay matrix 120-180kpa
						1					X	pp 180-220kPa
				D			CH	GRAVELLY CLAY: high plasticity, colour changing to red-orange, brown, fine to coarse size gravel, trace of silt fines, with basalt cobbles.		VSt	X	pp in clay matrix 300-400kPa
						2						
						3		Pit TP8 Terminated at 2.50 m				
						4						

METHOD	PENETRATION	SAMPLES, TESTS, ETC	CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION	CONSISTENCY/DENSITY INDEX
N natural exposure X existing excavation BH backhoe bucket B bulldozer blade R bulldozer ripper E excavator HA hand auger HT hand tools SUPPORT SH shoring SC shotcrete Nil no support RB rockbolts	1 2 3 4 little resistance ranging to very slow progress WATER D none observed * not measured water level water outflow water inflow	U undisturbed sample (mm) D disturbed sample Bs bulk sample E environmental sample VS vane shear DP dynamic penetrometer FD field density WS water sample	based on unified classification system MOISTURE D dry M moist W wet Wp plastic limit Wl liquid limit	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 Geosciences Pty. Ltd.
ACN 056 335 516

engineering log - excavation

COFFEY

pit no	TP9
sheet	1 of 1

office job no: NR1059/1

client:	GeoLINK GROUP	pit commenced:	17-9-99
principal:		pit completed:	17-9-99
project:	DOSSER SUBDIVISION, LENNOX HEAD	logged by:	CMc
pit location:	REFER FIGURE 1	checked by:	[signature]

equipment type and model:	JCB-BACKHOE	R.L.Surface:	NOT MEASURED
excavation dimensions:	2.0 m long 0.6 m wide orientation: -90.	datum:	EXIST SURFACE

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH		NIL	D				CH	TOPSOIL: SILTY CLAY: high plasticity, red-brown.	M			TOPSOIL
				D			CH	SILTY CLAY: high plasticity, red-brown.		St / VSt	x	RESIDUAL; pp 180-220kPa
											x	pp 190-250kPa
								trace of fine to coarse size gravel, some brown mottle		H	x	pp 500kPa
						1						
				D							x	pp >500kPa
						2	CH	GRAVELLY CLAY: high plasticity, brown, with grey mottle, fine to coarse size gravel, trace of fine to medium grained sand.				
						3		Pit TP9 Terminated at 3.00 m				
						4						

METHOD
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R bulldozer ripper
E excavator
HA hand auger
HT hand tools

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
D none observed
* not measured
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
VS vane shear
DP dynamic penetrometer
FD field density
WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl 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

COFEXCA VERSION B4. 12/10/99 10:36:43 B09

Coffey Geosciences Pty. Ltd.
ACN 056 335 516

engineering log - excavation

COFFEY

pit no TP10

sheet 1 of 1

office job no: NR1059/1

client:	GeoLINK GROUP	pit commenced:	17-9-99
principal:		pit completed:	17-9-99
project:	DOSSER SUBDIVISION, LENNOX HEAD	logged by:	CMc
pit location:	REFER FIGURE 1	checked by:	

equipment type and model:	JCB-BACKHOE			R.L.Surface:	NOT MEASURED
excavation dimensions:	2.0 m long	0.6 m wide	orientation: -90.	datum:	EXIST SURFACE

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH		NIL	D	D				CH	TOPSOIL: SILTY CLAY: high plasticity, brown.	M			TOPSOIL
								CH	SILTY CLAY: high plasticity, brown.		St		RESIDUAL
												X	pp 200kPa
									colour changing to red-brown, trace			X	pp 200kPa
				D					of fine to medium grained sand.		H	X	pp >500kPa
													gravel EW-HW
												X	pp 520kPa
						1							
				U50									
												X	pp 550kPa
												X	pp 500-560kPa
						2							
				D					as above, colour change to dark brown				
						3			Pit TP10 Terminated at 3.00 m				
						4							

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT hand tools

SUPPORT
- SH shoring SC shotcrete
- Nil no support
- RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
- O none observed
- X not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl 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

COFEXCA VERSION B4. 12/10/99 10:37:39 809

Coffey Geosciences Pty. Ltd.
ACN 056 335 516

engineering log - excavation

COFFEY

pit no: TP11
sheet 1 of 1

office job no: NR1059/1

client:	GEOLINK GROUP	pit commenced:	20-9-99
principal:		pit completed:	20-9-99
project:	DOSSER SUBDIVISION, LENNOX HEAD	logged by:	CMc
pit location:	REFER FIGURE 1	checked by:	[signature]

equipment type and model:	JCB-BACKHOE	R.L.Surface:	NOT MEASURED
excavation dimensions:	2.0 m long 0.6 m wide, orientation: -90.	datum:	EXIST SURFACE

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
BH		NIL	O					CH	TOPSOIL: GRAVELLY CLAY: high plasticity, red-brown, fine to coarse gravel.	M	St		TOPSOIL
				D				CH	GRAVELLY CLAY: high plasticity, red-brown, fine to coarse size gravel.		H	X	RESIDUAL pp 400-480kPa
				U50								X	pp >600kPa
						1			slight colour change, red-brown with grey and pale brown mottle.			X	pp 500kPa
				D								X	pp 500-550kPa
						2			Pit TP11 Terminated at 2.00 m				
						3							
						4							

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT hand tools

SUPPORT
- SH shoring SC shotcrete
- Nil no support
- RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
- O none observed
- * not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl 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 Geosciences Pty. Ltd.
ACN 056 335 516

engineering log - excavation

COFFEY

pit no: TP12
sheet 1 of 1

office job no: NR1059/1

client:	GeoLINK GROUP	pit commenced:	20-9-99
principal:		pit completed:	20-9-99
project:	DOSSER SUBDIVISION LENNOX HEAD	logged by:	CMc
pit location:	REFER FIGURE 1	checked by:	[signature]

equipment type and model:	JCB-BACKHOE		R.L.Surface:	NOT MEASURED	
excavation dimensions:	0.2 m long	0.6 m wide	orientation: -90.	datum:	EXIST SURFACE

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH		NIL	D	D				CH	TOPSOIL: GRAVELLY CLAY: high plasticity, brown, fine to coarse size gravel.	M	St / VSt	x	TOPSOIL pp 250-300kPa
				D				CH	GRAVELLY CLAY: high plasticity, brown and orange-brown.		H	x	RESIDUAL pp 500-600kPa occasional cobbles pp 500-560kPa
						1							
				D				CH	SILTY CLAY: high plasticity, red-brown, trace of fine to coarse size gravel, grading to extremely weathered basalt.			x	pp >600kPa
						2							
									Pit TP12 Terminated at 2.50 m				
						3							
						4							

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT hand tools

SUPPORT
- SH shoring SC shotcrete
- Nil no support
- RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
- D none observed
- * not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl 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

COFEXCA VERSION B4. B09 12/10/99 10:39:14

T88-239

Coffey Geosciences Pty. Ltd.
ACN 056 335 516

engineering log - excavation

COFFEY

pit no	TP13
sheet	1 of 1

office job no: NR1059/1

client:	GeoLINK GROUP	pit commenced:	20-9-99
principal:		pit completed:	20-9-99
project:	DOSSER SUBDIVISION, LENNOX HEAD	logged by:	CMc
pit location:	REFER FIGURE 1	checked by:	[signature]
equipment type and model:	JCB-BACKHOE	R.L.Surface:	NOT MEASURED
excavation dimensions:	2.0 m long 0.6 m wide, orientation: -90.	datum:	EXIST SURFACE

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH		Nil	D	D				CH	TOPSOIL: GRAVELLY CLAY: high plasticity, brown, fine to coarse size gravel, with basalt cobbles.	M	St	X	TOPSOIL pp 200-250kPa
				D U50		1		CH	GRAVELLY CLAY: high plasticity, brown, fine to coarse size gravel, becoming pale brown, with orange-brown mottle with depth.		VSt H	X X	RESIDUAL p 300-400kPa occassional boulders pp in tube >600kPa occassional boulders
						2 3 4			Pit TP13 Terminated at 1.50 m Backhoe bucket refusal on boulders				

COFEXCA VERSION B4. B09 12/10/99 10:41:38

METHOD
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R bulldozer ripper
E excavator
HA hand auger
HT hand tools

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
D none observed
* not measured
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
VS vane shear
DP dynamic penetrometer
FD field density
WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl 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

T88-239

Coffey Geosciences Pty. Ltd.
ACN 056 335 516

engineering log - excavation

COFFEY

pit no: TP14
sheet 1 of 1

office job no: NR1059/1

client:	GeoLINK GROUP	pit commenced:	20-9-99
principal:		pit completed:	20-9-99
project:	DOSSER SUBDIVISION, LENNOX HEAD	logged by:	CMc
pit location:	REFER FIGURE 1	checked by:	[signature]

equipment type and model: JCB-BACKHOE — R.L.Surface: NOT MEASURED

excavation dimensions: 2.0 m long 0.6 m wide — orientation: -90. — datum: EXIST SURFACE

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH		NIL	D					CH	TOPSOIL: GRAVELLY CLAY: high plasticity, red-brown, fine to coarse size gravel, with basalt cobbles.	M	St / VSt		TOPSOIL
				D				CH	GRAVELLY CLAY: high plasticity, red, brown, fine to coarse size gravel, basalt cobbles.			x	RESIDUAL pp 200kPa
				U50				CH	SILTY CLAY: high plasticity, red-brown, trace of fine to coarse size gravel, with fragments of extremely weathered basalt.		H	x x x	pp 250kPa pp 400-450kPa pp 400kPa
				D								x	pp 500-600kPa
						1			trace of orange-grey mottle.			x	pp 500-600kPa
				D								x	pp 500-600kPa
						2							
									Pit TP14 Terminated at 2.50 m				
						3							
						4							

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT hand tools

SUPPORT
- SH shoring SC shotcrete
- Nil no support
- RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
- D none observed
- ¥ not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl 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 Geosciences Pty. Ltd.
ACN 056 335 516

engineering log - excavation

COFFEY

pit no TP15
sheet 1 of 1

office job no: NR1059/1

client:	GeoLINK GROUP	pit commenced:	20-9-99
principal:		pit completed:	20-9-99
project:	DOSSER SUBDIVISION, LENNOX HEAD	logged by:	CMc
pit location:	REFER FIGURE 1	checked by:	[signature]

equipment type and model:	JCB-BACKHOE			R.L.Surface:	NOT MEASURED
excavation dimensions:	2.0 m long	0.6 m wide	orientation: -90.	datum:	EXIST SURFACE

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH		NIL	D					CH	TOPSOIL: GRAVELLY CLAY: high plasticity, brown, fine to coarse size gravel.	M	St / VSt	X	TOPSOIL pp 200-250kPa
				D U50 D		1		CH	CLAY: high plasticity, red-brown, trace fine to medium size gravel, trace of silt fines. slight colour change red-brown, orange and grey mottle.		H	X	RESIDUAL pp 300-350kPa pp 480kPa pp 500-600kPa pp 500-600kPa
						2							
						3			Pit TP15 Terminated at 2.50 m				
						4							

B4. VERSION COFEXCA B09 10:48:17 12/10/99

METHOD
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R bulldozer ripper
E excavator
HA hand auger
HT hand tools

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
D none observed
* not measured
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
VS vane shear
DP dynamic penetrometer
FD field density
WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl 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 Geosciences Pty. Ltd.
ACN 056 335 516

engineering log - excavation

COFFEY

pit no	TP16
sheet	1 of 1

office job no: NR1059/1

client:	GeoLINK GROUP	pit commenced:	20-9-99
principal:		pit completed:	20-9-99
project:	DOSSER SUBDIVISION, LENNOX HEAD	logged by:	CMc
pit location:	REFER FIGURE 1	checked by:	[signature]

equipment type and model:	JCB-BACKHOE			R.L.Surface:	NOT MEASURED
excavation dimensions:	2.0 m long	0.6 m wide	orientation: -90.	datum:	EXIST SURFACE

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH		Nil	D	D				CH	TOPSOIL: GRAVELLY CLAY: high plasticity, dark brown, fine to coarse size gravel.	M	St		TOPSOIL
								CH	GRAVELLY CLAY: high plasticity, dark brown, fine to coarse size gravel.		VSt	X	RESIDUAL pp 250-300kPa occassional basalt boulders
												X	pp 300kPa
				D		1			becoming red-brown with orange lenses		H		
												X	pp 450-500kPa
												X	pp 480-550kPa
						2							
						3			Pit TP16 Terminated at 3.00 m				
						4							

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT hand tools

SUPPORT
- SH shoring SC shotcrete
- Nil no support
- RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
- D none observed
- X not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl 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 Geosciences Pty. Ltd.
ACN 056 335 516

engineering log - excavation

COFFEY

pit no TP17
sheet 1 of 1

office job no: NR1059/1

client:	GeoLINK GROUP	pit commenced:	20-9-99
principal:		pit completed:	20-9-99
project:	DOSSER SUBDIVISION, LENNOX HEAD	logged by:	CMc
pit location:	REFER FIGURE 1	checked by:	

equipment type and model: JCB-BACKHOE — R.L. Surface: NOT MEASURED
excavation dimensions: 2.0 m long 0.6 m wide — orientation: -90. — datum: EXIST SURFACE

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa	structure and additional observations
BH		NIL				0	CH	TOPSOIL: GRAVELLY CLAY: red-brown, high plasticity, fine to coarse size gravel.	W	F		TOPSOIL, BAND OF SILTY CLAY, GREY-100mm THICK
				D			CH	CLAY: high plasticity, red-brown, with orange, grey, mottle, trace fine to coarse size gravel.	M	VSt	X	RESIDUAL pp 300-350kPa pp 300-350kPa
			water inflow (x2)	D		1	CH	GRAVELLY CLAY: high plasticity, red-brown and orange, with grey mottle, fine to coarse size gravel.	M W		X	EW BASALT pockets of wet material numerous water inflows pp 200-220kPa
						2						

Pit TP17 Terminated at 2.50 m

NB: Surface conditions wet/boggy

3

4

METHOD
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R bulldozer ripper
E excavator
HA hand auger
HT hand tools

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
none observed
not measured
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
VS vane shear
DP dynamic penetrometer
FD field density
WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl 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 Geosciences Pty. Ltd.
ACN 056 335 516

engineering log - excavation

COFFEY

pit no TP18
sheet 1 of 1

office job no: NR1059/1

client:	GeoLINK GROUP	pit commenced:	20-9-99
principal:		pit completed:	20-9-99
project:	DOSSER SUBDIVISION, LENNOX HEAD	logged by:	CMc
pit location:	REFER FIGURE 1	checked by:	[signature]

equipment type and model:	JCB-BACKHOE	R.L.Surface:	NOT MEASURED
excavation dimensions:	2.0 m long 0.6 m wide orientation: -90.	datum:	EXIST SURFACE

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH		NIL		D		0 – 1.1		CH	FILL: GRAVELLY CLAY: high plasticity, brown, fine to coarse size gravel, with iron strapping and traces of charcoal and ash.	M	F / St		FILL, some 50mm bands of silty clay pp 150-180kPa pp 140-160kPa
			▷ (inflow)	D		1.1 – 3.0		CH	CLAY: high plasticity, orange, brown, trace of fine to coarse size gravel.	M / W	St / VSt		RESIDUAL, numerous water inflows pp 180-230kPa pockets of wet material

Pit TP18 Terminated at 3.00 m

Top 1.1m suggested to be
Fill in nature, possible
gully filled with farm debri

METHOD	PENETRATION	SAMPLES, TESTS, ETC	CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION	CONSISTENCY/DENSITY INDEX
N natural exposure X existing excavation BH backhoe bucket B bulldozer blade R bulldozer ripper E excavator HA hand auger HT hand tools	1 2 3 4 little resistance ranging to very slow progress	U undisturbed sample (mm) D disturbed sample Bs bulk sample E environmental sample VS vane shear DP dynamic penetrometer FD field density WS water sample	based on unified classification system	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
SUPPORT SH shoring SC shotcrete Nil no support RB rockbolts	WATER D none observed ¥ not measured water level water outflow water inflow		MOISTURE D dry M moist W wet Wp plastic limit Wl liquid limit	

COFEXCA VERSION B4. B09 12 /10 /99 10 :50 :30

APPENDIX B

ENGINEERING LOGS (BH1 TO BH4)

Coffey Geosciences Pty Ltd ACN 056 335 516

Coffey

Engineering Log - Borehole

Borehole No.	BH1
Sheet	1 of 1
Office Job No.:	NR1059/2
Date started:	13.2.2002
Date completed:	13.2.2002
Logged by:	RW / KU
Checked by:	PS

Client: **GEOLINK GROUP**

Principal: **DM & RD DOSSOR**

Project: **DOSSOR SUBDIVISION**

Borehole Location:

drill model and mounting: JACRO 350 100 — Easting: — slope: -90° — R.L. Surface: 29.2

hole diameter: mm — Northing — bearing: — datum:

drilling information / **material substance**

method	support	water	notes samples, tests, etc	depth metres	classification symbol	material (soil type: plasticity or particle characteristics, colour, secondary and minor components)	moisture condition	consistency/density index	structure and additional observations
ADT	C	NOT OBSERVED		0.0	CH	**SILTY CLAY:** high plasticity, red-brown, with some basalt, gravel, cobbles and boulders, trace of sand, friable.	M	VSt	pp 350kPa POSSIBLE COLLUVIUM
			U50	0.8	CH	**SANDY CLAY:** high plasticity, yellow-brown, fine grained sand, bands of clayey sand.		H	RESIDUAL SOIL pp >500kPa
			U50	2.5	SC	**SILTY CLAYEY SAND:** fine to coarse grained, brown, fine grained clay of low to medium plasticity. ...250mm diameter large cobble. ...cobble 120mm diameter.		D	
RR	N		D						pp >500kPa REFUSAL ON BASALT COBBLE (DIAMOND DRILLED)
			U50	4.4	CH	**CLAY:** high plasticity, red-brown, some fine grained sand. ...grey.		VSt-H	pp 175kPa
				6.2		Borehole BH1 terminated at 6.2m			

RL scale: 29, 28, 27, 26, 25, 24, 23, 22. Depth scale: 1–8 m. Pocket penetrometer kPa: 100, 200, 300, 400.

method		support		notes, samples, tests		classification symbols and soil description	consistency/density index	
AS	auger screwing*	M mud	N nil	U50	undisturbed sample 50mm diameter	based on unified classification system	VS	very soft
AD	auger drilling*	C casing		U63	undisturbed sample 63mm diameter		S	soft
RR	roller/tricone	penetration 1 2 3 4 — no resistance ranging to refusal		D	disturbed sample		F	firm
W	washbore			N	standard penetration test (SPT)		St	stiff
CT	cable tool			N*	SPT - sample recovered	**moisture**	VSt	very stiff
HA	hand auger			Nc	SPT with solid cone	D dry	H	hard
DT	diatube	water		V	vane shear (kPa)	M moist	Fb	friable
B	blank bit	10/1/98 water level on date shown		P	pressuremeter	W wet	VL	very loose
V	V bit			Bs	bulk sample	Wp plastic limit	L	loose
T	TC bit	water inflow		E	environmental sample	W_L liquid limit	MD	medium dense
*bit shown by suffix		water outflow		R	refusal		D	dense
e.g.	ADT						VD	very dense

BOREHOLE BORELOGS.GPJ COFFEY.GDT 11.03.02

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Coffey Geosciences Pty Ltd ACN 056 335 516

Borehole No.	BH2
Sheet	1 of 2
Office Job No.:	NR1059/2
Date started:	15.2.2002
Date completed:	15.2.2002
Logged by:	RW/KU
Checked by:	PS

Engineering Log - Borehole

Client: GEOLINK GROUP

Principal: DM & RD DOSSOR

Project: DOSSOR SUBDIVISION

Borehole Location:

drill model and mounting:	JACRO 350 100	Easting:		slope:	-90°	R.L. Surface:	21.1
hole diameter:	mm	Northing		bearing:		datum:	

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 penetrometer kPa 100 200 300 400	structure and additional observations
ADT		N	15/2/02		21			CL	**SILTY CLAY:** medium plasticity, dark grey, some fine grained sand.	W	S		RESIDUAL SOIL; SURFACE WATER
								CH	**SILTY CLAY:** high plasticity, grey, yellow mottled, some fine grained gravel.	M	F-St		
				D									
					20	1							
											VSt		
				U_{50}								×	pp 250kPa
					19	2							
				D									
						3		CH	**SANDY SILTY CLAY:** high plasticity, grey to brown mottled, fine grained sand, with fine to medium grained gravel lenses.		H		EXTREMELY WEATHERED ROCK, FRIABLE
				U_{50}	18							×	pp >500kPa
													U50 REFUSAL ON GRAVEL BAND
					17	4							
				U_{50}								×	pp >500kPa
					16	5							U50 REFUSAL ON GRAVEL BAND
				D									
					15	6			Borehole BH2 continued as cored hole				
					14	7							
						8							

BOREHOLE BORELOGS.GPJ COFFEY.GDT 11.03.02

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

Form GEO 5.3 Issue 3 Rev.2

Coffey Geosciences Pty Ltd ACN 056 335 516

Coffey

Engineering Log - Cored borehole

Client:	GEOLINK GROUP	Borehole No.	BH2
Principal:	DM & RD DOSSOR	Sheet	2 of 2
Project:	DOSSOR SUBDIVISION	Office Job No.:	NR1059/2
Borehole Location:		Date started:	15.2.2002
		Date completed:	15.2.2002
		Logged by:	RW/KY
		Checked by:	PS

drill model & mounting: JACRO 350 100 | Easting: | slope: -90° | R.L. Surface: 21.1

hole diameter: mm | Drilling fluid: | Northing: | bearing: | datum:

method	core-lift	water	RL	depth metres	graphic log / core recovery	material: rock type; grain characteristics, colour, structure, minor components (Continued from non-cored borehole)	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			15	6		**BASALT:** dark grey, fine grained.	SW	VH		10		JT, 70°, PL, RO JT, 70°, IR, RO JT, 23°, PL, RO JT, 33°, PL, RO JT, 35°, PL - CU, RO 6.10m-6.16m: Crushed seam 6.25m - 6.35m: Fractured zone JT, 10°, IR, CU, RO JT, 32°, IR, RO
						BASALT: grey to grey-brown, fine grained, with clay filled vesicles.	MW	M				
						BASALT: dark grey, fine grained.	SW	VH				
						BH2 terminated at 6.65m						
			14	7								
			13	8								
			12	9								
			11	10								
			10	11								
			9	12								
			8	13								

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/alteration
FR fresh
SW slightly weathered
DW distinctly weathered
XW extremely weathered
SA slightly altered
DA distinctly altered
XA extremely altered

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

CORED BOREHOLE BORELOGS.GPJ COFFEY.GDT 06.03.02

Form GEO 5.5 Issue 3 Rev.2

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Borehole

Borehole No.	BH3
Sheet	1 of 3
Office Job No.:	NR1059/2
Date started:	7.2.2002
Date completed:	7.2.2002
Logged by:	RW / KY
Checked by:	PS

Client: GEOLINK GROUP

Principal: DM & RD DOSSOR

Project: DOSSOR SUBDIVISION

Borehole Location:

drill model and mounting: JACRO 350 100 | Easting: | slope: -90° | R.L. Surface: 27.95

hole diameter: mm | Northing | bearing: | datum:

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 penetrometer kPa (100 200 300 400)	structure and additional observations
ADT		N						CL	**SILTY CLAY:** medium plasticity, brown, some fine grained sand, some red mottling.	M	St		RESIDUAL SOIL
					27	1		CL	**SANDY SILTY CLAY:** medium plasticity, brown, fine grained sand, some ironstone nodules to 10mm.		VSt		INCREASE IN MOISTURE CONTENT
				U_{50}									
					26	2		CL	**SILTY CLAY:** medium plasticity, grey.		H	x	pp >500kPa DECREASE IN MOISTURE CONTENT
					25	3		CH	**SILTY CLAY:** high plasticity, dark red, some fine grained sand.				SMALL IRONSTONE NODULES
				U_{50}								x	pp >500kPa
			NOT OBSERVED		24	4							
									Borehole BH3 continued as cored hole				
					23	5							
					22	6							
					21	7							
					20	8							

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 BORELOGS.GPJ COFFEY.GDT 11.03.02

Form GEO 5.3 Issue 3 Rev.2

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Cored borehole

Client:	GEOLINK GROUP	Borehole No.	BH3
Principal:	DM & RD DOSSOR	Sheet	2 of 3
Project:	DOSSOR SUBDIVISION	Office Job No.:	NR1059/2
Borehole Location:		Date started:	7.2.2002
		Date completed:	7.2.2002
		Logged by:	RW / KY
		Checked by:	PS

drill model & mounting: JACRO 350 100 | Easting: | slope: -90° | R.L. Surface: 27.95

hole diameter: mm | Drilling fluid: | Northing: | bearing: | datum:

drilling information (method, core-lift, water, RL, depth metres) | **material substance** (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) | **rock mass defects** (RQD %; defect spacing mm 30 100 300 1000 3000; defect description: type, inclination, planarity, roughness, coating, thickness — particular, general)

Continued from non-cored borehole

Method: NMLC

RL	depth (m)	material	weathering/alteration
		BASALT: brown to yellow-brown and dark grey, fine grained, locally grading to hard clay (CH).	XW
23	5		
		NO CORE:	
		BASALT: brown to yellow-brown and dark grey, fine grained, locally grading to hard clay (CH).	XW
22	6	NO CORE:	
		BASALT: brown to red-brown, fine grained, with clay filled vesicles, occasional thin clay seams along joint planes, occasional zeolite amygdales.	XW/HW, HW
21	7		
20	8	BASALT: brown-grey to dark grey, fine grained, with clay filled vesicles.	MW
19	9		
		BASALT: dark grey, fine grained.	SW
18	10		
		BASALT: dark grey to brown-grey grading to red-grey, fine grained, locally vesicular.	MW, MW/SW, MW
17	11		
16	12		

RQD %: 0, 41, 0, 41, 58, 30, 22, 0, 0

Defect description:

- 4.15m-4.60m: Core highly fractured
- JT, 15°, PL, RO
- Core break
- Core break
- JT, 45°, PL, RO, CN
- JT, 5°, PL, RO,
- 2 x core breaks
- JT, 20°, PL, RO, clay smear
- JT, 40°, PL, RO, CN
- JT, 5°, PL, RO, CN
- JT, 5°, PL, RO, CN
- Core fracture, IR
- JT, 10°, PL, RO
- JT, 30°, PL - CU, RO, Fe, SN
- Core break
- JT, 28°, IR, RO, CN
- JT, 20°, PL - IR, RO, CN
- JT, 20°, PL, RO, CN
- JT, 5°, PL - IR, RO, 5mm clay seam
- PT, 10°, IR, RO, CN
- Core break
- 2 x JT, 30°, PL, RO, CN
- Large vesicles to 30mm
- JT, 60°, IR, RO, CN
- JT, 20°, PL, RO, Fe, SN
- JT, 30°, PL, RO, Fe, SN
- JT, 40°, PL - IR, RO, Fe, SN
- JT, 90°, PL, RO, Fe, SN
- JT, 15°, PL, RO, Fe, SN
- JT, 35°, PL - IR, RO, Fe, SN
- JT, 43°, PL, RO, Fe, SN
- JT, 35°, PL, RO, Fe, SN
- JT, 30°, PL, RO, Fe, SN
- 20mm clay and fragmented rock seam, dipping 10°
- JT, CU, 60° - 90°, RO
- JT, 20°, PL, RO
- JT, 70°, PL - CU, RO, Fe, SN
- JT, 20°, PL, 20°, Fe, SN
- JT, 38°, PL, RO, Fe, SN
- JT, 70° - 75°, PL - CU, RO, Fe, SN
- JT, 40°, PL, RO, Fe, SN
- JT, 15°, PL, RO, Fe, SN
- 10.60m - 10.80m: Fractured zone with clay in top 50mm
- JT, 55°, PL - IR, RO, Fe, SN
- JT, IR, RO, Fe, SN
- JT, 75°, PL, SO, SL
- 2 x JT, 5° - 10°, PL, RO, Fe, SN
- 3 x JT, 40°, 60°, 85°, PL, RO, Fe, SN
- JT, 20°, PL, RO, Fe, SN
- 30mm fragmented zone

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/alteration
FR fresh
SW slightly weathered
DW distinctly weathered
XW extremely weathered
SA slightly altered
DA distinctly altered
XA extremely altered

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

Form GEO 5.5 Issue 3 Rev.2 CORED BOREHOLE BORELOGS.GPJ COFFEY.GDT 11.03.02

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Cored borehole

Coffey

Client:	*GEOLINK GROUP*	Borehole No.	*BH3*
Principal:	*DM & RD DOSSOR*	Sheet	3 of 3
Project:	*DOSSOR SUBDIVISION*	Office Job No.:	*NR1059/2*
Borehole Location:		Date started:	*7.2.2002*
		Date completed:	*7.2.2002*
		Logged by:	RW / KY
		Checked by:	PS

drill model & mounting: JACRO 350 100 | Easting: | slope: -90° | R.L. Surface: 27.95

hole diameter: mm | Drilling fluid: | Northing: | bearing: | datum:

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						**BASALT:** dark grey to brown-grey grading to red-grey, fine grained, locally vesicular. *(continued)*	MW	H		0		JT, 70°, PL, RO, Fe, SN JT, 5°, PL, RO, Fe, SN JT, 87°, PL, RO, Fe, SN
						BASALT: dark grey, fine grained, slightly vesicular.	MW/SW	H-VH		18		50mm clay and fragmented rock zone 3 x JT, 40°, 45°, 75°, PL, RO, Fe, SN Core break JT, 45°, IR, RO, Fe, SN
			15	13						31		JT, 20°, PL, RO, Fe, SN JT, 20°, IR, RO, Fe, SN JT, 50°, PL - IR, RO, Fe, SN 2 x JT, 20°, 30°, PL, RO, Fe, SN 2 x JT, 10°, 40°, PL, SL, RO, Fe, SN
						BH3 terminated at 13.5m						JT, 55°, PL, RO, SS, Fe, SW, zeolite infill JT, CU, Fe, SN
			14	14								
			13	15								
			12	16								
			11	17								
			10	18								
			9	19								
			8	20								

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/alteration
- FR fresh
- SW slightly weathered
- DW distinctly weathered
- XW extremely weathered
- SA slightly altered
- DA distinctly altered
- XA extremely altered

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 Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Borehole

Client:	GEOLINK GROUP	Borehole No.	BH4
Principal:	DM & RD DOSSOR	Sheet	1 of 3
Project:	DOSSOR SUBDIVISION	Office Job No.:	NR1059/2
Borehole Location:		Date started:	11.2.2002
		Date completed:	11.2.2002
		Logged by:	RW/KY
		Checked by:	PS

drill model and mounting: JACRO 350 100 | Easting: | slope: -90° | R.L. Surface: 34.9

hole diameter: mm | Northing | bearing: | datum:

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 penetrometer kPa	structure and additional observations
ADT		N				0		CH	**SILTY CLAY:** high plasticity, brown, trace of fine grained sand. ...red-brown	M	H	>500	RESIDUAL SOIL pp >500kPa
					34	1					VSt		
				U_{50}				CH	**SILTY CLAY:** high plasticity, with some fine grained sand.			300	
					33	2			...decrease in sand content				pp 300kPa
				U_{50}	32	3					H		
			NOT OBSERVED					CH	**SILTY CLAY:** high plasticity, grey, with bands of sandy clay.			>500	pp >500kPa BANDS OF EXTREMELY WEATHERED BASALT
					31	4			...increase in frequency of banding grading to extremely weathered basalt.				INCREASE IN MOISTURE CONTENT
				U_{50}									U50 REFUSAL
					30	5			Borehole BH4 continued as cored hole				
					29	6							
					28	7							
					27	8							

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 BORELOGS.GPJ COFFEY.GDT 11.03.02

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Engineering Log - Cored borehole

Client:	GEOLINK GROUP	Borehole No.	BH4
Principal:	DM & RD DOSSOR	Sheet	2 of 3
Project:	DOSSOR SUBDIVISION	Office Job No.:	NR1059/2
Borehole Location:		Date started:	11.2.2002
		Date completed:	11.2.2002
		Logged by:	RW/KH
		Checked by:	PS

drill model & mounting: JACRO 350 100 | Easting: | slope: -90° | R.L. Surface: 34.9

hole diameter: mm | Drilling fluid: | Northing: | bearing: | datum:

Continued from non-cored borehole

Method: NMLC

RL	depth metres	material (rock type; grain characteristics, colour, structure, minor components)	weathering alteration	RQD %
30	5	BASALT: brown to grey-brown, medium grained.	HW	23
			XW	
		BASALT: brown-grey to grey, medium grained.	MW	
29	6	BASALT: grey to dark grey speckled, medium grained.	SW	50
28	7			56
		BASALT: grey-brown, fine to medium grained.	MW	
27	8	BASALT: grey to dark grey speckled, medium grained.	SW	53
		BASALT: grey to brown-grey, fine grained, vesicular.	MW	0
26	9	BASALT: grey-brown to red-brown, with clay filled vesicles.	HW/MW	39
25	10			14
24	11			37
23	12			
		BASALT: dark grey to red-grey, fine grained, with zeolite and clay filled vesicles.	MW/SW	68

Defect description (type, inclination, planarity, roughness, coating, thickness):

- JT, 10°, PL, RO, Fe, SN
- 5.00m - 5.40m: Fractured zone with extremely weathered basalt.
- JT, 10°, PL, RO, Fe, SN
- JT, 10°, PL, RO, Fe, SN
- JT, 40°, IR, RO, Fe, SN
- 2 x core fractures
- JT, 60°, PL, RO, Fe, SN
- JT, 45°, IR, CU, RO, Fe, SN
- 3 x JT, 10° - 25°, PL, RO, Fe, SN
- JT, 20°, PL, IR, RO, Fe, SN
- JT, 70°, PL, RO, Fe, SN
- JT, 20°, PL - IR, RO, Fe, SN
- JT, 30°, PL, RO, Fe, SN
- JT, 35°, PL, RO, Fe, SN
- JT, 85°, PL, RO, Fe, SN
- JT, 55°, PL, RO, Fe, SN
- 5 x JT, 60° and irregular fractures
- JT, 60°, PL, RO, Fe, SN
- 2 x JT, 10° and 25°, PL, RO, Fe, SN
- JT, 10°, PL, RO, Fe, SN
- JT, 30°, PL, RO, Fe, SN
- 2 x JT, 20°, 30°, PL, RO, Fe, SN
- JT, 10°, PL, RO, Fe, SN
- 8.40m - 8.65m: Fractured zone along 10° and 45° joints
- 8.75m - 8.82m: Fractured zone
- JT, 15°, PL, RO, Fe, SN
- Irregular fracture, 20° - 45°
- JT, 60°, PL, RO, Fe, SN
- Irregular fracture, 60°
- JT, 30°, IR, RO, Fe, SN
- JT, 85°, IR, RO, Fe, SN
- JT, 88°, PL, RO, Fe, SN
- JT, 45°, PL, RO, Fe, SN
- JT, 50°, IR, RO, Fe, SN
- 2 x JT, 20°, 55°, PL, RO, Fe, SN
- 10.50m - 10.90m: core fracture along joints at 10°, 20°, 55°
- JT, 20°, PL, RO, Fe, SN
- JT, 60°, PL, RO, Fe, SN
- JT, 55°, PL, RO, Fe, SN
- JT, 60°, PL, IR, RO, Fe, SN
- 11.40m - 11.85m: 6 x irregular core fractures
- 2 x core breaks
- 2 x core breaks
- Core fracture, 30° - 40°
- 12.50m - 12.60m: 4 x core fractures at 5°, 20°, 55°

Legend

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

weathering/alteration: FR fresh; SW slightly weathered; DW distinctly weathered; XW extremely weathered; SA slightly altered; DA distinctly altered; XA extremely altered

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 Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Cored borehole

Client:	GEOLINK GROUP	Borehole No.	BH4
Principal:	DM & RD DOSSOR	Sheet	3 of 3
Project:	DOSSOR SUBDIVISION	Office Job No.:	NR1059/2
Borehole Location:		Date started:	11.2.2002
		Date completed:	11.2.2002
		Logged by:	RW / KU
		Checked by:	PS

Coffey

drill model & mounting: JACRO 350 100 Easting: slope: -90° R.L. Surface: 34.9

hole diameter: mm Drilling fluid: Northing: bearing: datum:

drilling information / material substance / rock mass defects

method	RL	depth metres	material (rock type; grain characteristics, colour, structure, minor components)	weathering alteration	RQD %
NMLC	22	13	**BASALT:** dark grey to red-grey, fine grained, with zeolite and clay filled vesicles. *(continued)*	MW/SW	68
	21	14	**BASALT:** dark grey to grey speckled, fine to medium grained.	SW/Fr	80
	20	15	**BASALT:** dark grey, fine grained,		76
	19	16			
	18	17	**BASALT:** dark grey, fine grained, with zeolite and filled vesicles.		76
	17	18			72
				SW	
	16	19	**BASALT:** dark grey to brown-grey, fine grained, with large pale green zeolite vesicles, dipping 85° - 90°.	MW	43
	15	20	BH4 terminated at 19.58m		

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

- JT, 15°, Fe, SN, RO
- Subhorizontal core break
- Core break
- ? JT, 10°, PL, RO
- JT, 20°, PL, RO
- JT, 30°, PL, RO
- Core break
- Core fracture, 18°
- JT, 20°, PL, RO
- Core fracture, 35°
- JT, 35°, PL - IR, RO
- JT, 45°, PL, RO, SL
- JT, 10°, PL, RO
- JT, 35°, PL, RO, Fe, SN
- JT, 30°, PL, RO
- JT, 60°, PL - IR, RO
- JT, 35°, PL, RO
- JT, 15°, PL - IR, RO
- JT. 45°, PL, RO
- Core fracture
- JT, 30°, PL, RO
- JT, 50°, PL - IR, RO, SL
- JT, 50°, PL - IR, RO, SL
- JT, 70°, PL, RO, SL
- Core fractures
- JT, 25°, PL, RO
- JT, 60° - 70°, IR, RO
- JT, 5°, PL, RO, SL
- JT, 5° - 7°, PL, RO
- JT, 20°, PL, RO
- JT, 60° - 70°, CU, RO
- JT, 3 x JT, 5°, 45°, 75°, PL, RO, calcite
- 18.44m - 18.64m: Fractured zone
- JT, 85°, PL, RO
- Large, sub-vertical, zeolite vein
- JT, 15°, PL, RO
- JT, 22°, PL, RO
- Core fracture
- JT, 18°, PL, RO
- JT, 60°, PL, RO
- JT, 40°, PL, RO, Fe, SN
- JT, 30°, PL, RO, Fe, SN

CORED BOREHOLE BORELOGS.GPJ COFFEY.GDT 05.03.02

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
water pressure test result (lugeons) for depth interval shown

weathering/alteration
FR fresh
SW slightly weathered
DW distinctly weathered
XW extremely weathered
SA slightly altered
DA distinctly altered
XA extremely altered

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

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APPENDIX C

RISK ASSESSMENT TERMS, DESCRIPTIONS AND DISCUSSION

For the purposes of the risk assessment presented in this report, the terms and descriptions provided in Appendix G of AGS 2000 have been used and are summarised below.

TABLE 3: QUALITATIVE MEASURES OF LIKELIHOOD

Level	Descriptor	Description	Indicative Annual Probability
A	Almost Certain	The event is expected to occur	$>\sim 10^{-1}$
B	Likely	The event will probably occur under adverse conditions	$\sim 10^{-2}$
C	Possible	The event could occur under adverse conditions	$\sim 10^{-3}$
D	Unlikely	The event might occur under very adverse circumstances	$\sim 10^{-4}$
E	Rare	The event is conceivable but only under exceptional circumstances	$\sim 10^{-5}$
F	Not credible	The event is inconceivable or fanciful	$<\sim 10^{-6}$

TABLE 4: QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Level	Descriptor	Description
1	Catastrophic	Structure completely destroyed or large scale damage requiring major engineering works for stabilisation
2	Major	Extensive damage to most of the structure, or extending beyond site boundaries requiring significant stabilisation works
3	Medium	Moderate damage to some of the structure, or significant part of the site requiring large stabilisation works
4	Minor	Limited damage to part of the structure, or part of the site requiring some reinstatement/stabilisation works
5	Insignificant	Little damage

TABLE 5: QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

Likelihood	Consequences to Property				
	1	2	3	4	5
A	VH	VH	H	H	M
B	VH	H	H	M	L-M
C	H	H	M	L-M	VL-L
D	M-H	M	L-M	VL-L	VL
E	M-L	L-M	VL-L	VL	VL
F	VL	VL	VL	VL	VL

Notes: Risk levels - VH = Very High, H = High, M = Moderate, L = Low, VL = Very Low.

A discussion of the assessed likelihood and consequences used to assess the risk of slope instability at the site is shown below:

- Hazard 1: Shallow seated instability of the natural and altered slopes in the vicinity of the proposed developments.
    - The consequences of shallow seated instability were assessed to be minor for all zones. Shallow seated instability would likely cause limited damage to part of residential dwellings and other residential structures, or part of the site may require some reinstatement/stabilisation works.
    - The likelihood of shallow seated instability will increase with increasing slope angle. Signs of soil creep were evident in Zones 2 and 3, indicating that very slow down slope movement of soils has taken place on the upper site slopes. Development of the site in accordance with the above recommendations for development may actually decrease the likelihood of shallow seated failures.
- Hazard 2: Deep seated instability of the natural and altered slopes in the vicinity of the proposed developments.
    - The consequences of deep seated instability were assessed to be major for all zones. Deep seated instability would likely cause extensive damage to residential dwellings and other residential structures. In addition, the instability may extend beyond allotment and/or the site boundaries, and will likely require significant stabilisation works
    - The likelihood of deep seated instability will in part be driven by slope angle, though site earthworks such as cut and fill, groundwater and the subsurface conditions play a much more significant role than for shallow seated instability. No signs of existing deep seated instability were observed at the site. General geotechnical conditions at the site comprise stiff to hard residual soils overlying weathered rock. No weak layers or zones which could trigger instability were observed in boreholes cored through the rock. As part of the recommendations for development, cut and fill has been limited in Zones 2 and 3, and recommendations for filling are provided in this report and on the attached hillside construction information documents. Groundwater seepages were observed in zone 2, however recommendations for the treatment of groundwater in this area and where encountered elsewhere on the site have been provided. On this basis, the likelihood of deep seated instability has been assessed as between Not Credible and Rare for the

three zones.

- Hazard 3: Instability of appropriately battered and treated slopes or failure of engineer designed retaining walls.
  - ➢ The consequences of instability of engineered slopes and retaining walls were assessed to be medium to major for all zones. This could require reconstruction of some or all of the retaining wall and large to significant site stabilisation works. As retaining walls are often located near allotment boundaries, instability may extend beyond allotment boundaries.
  - ➢ The likelihood of instability of engineered slopes and retaining walls is assessed to be rare, in that the engineering design should have an adequate factor of safety in all but exceptional circumstances.