17 September 2019

Kristian Moon
31 Pine Avenue,
East Ballina NSW 2478
k@kristianmoon.com

Our ref: 12512758-89665
Your ref: Consultancy Agreement

Dear Kristian

Lot 3 DP525783 Compton Drive, Ballina

Geotechnical Assessment for residential use.

1 Introduction

This letter has been prepared for Kristian Moon for the purposes of informing the potential rezoning of the land at Lot 1 DP781542 and Lot 3 DP525783, located at 23 Compton Drive, East Ballina. The work has been commissioned in accordance with GHD's proposal 220105108 dated 4 July 2019, under GHD's standard consultancy agreement.

The site is located at the base of a steep slope near the southern frontage of the lots. In 2013 concern about possible slope instability constraints led to a geotechnical report being prepared by Coffey Geotechnics for the previous owner. Kristian Moon, now the current owner, has been provided a copy of that report and has requested the author of the report (Tom Nicholson, now employed by GHD) to prepare a follow up geotechnical advice on the lots for the potential rezoning to permit residential land use.

This report forms GHD's deliverable.

2 Scope of work

GHD's scope of work presented in this letter was to:

- Conduct a brief site walkover to observe the site for obvious changes in the conditions since the 2013 assessment
- Prepare a review report that presents:
  - A summary of the observations from the site walkover
  - A review of the 2013 geotechnical report
  - Comment on the suitability of the site for the proposed use as residential land
  - Comment on what further work will be required prior to construction of the proposed dwelling should the residential rezoning be successful.

3 Site walkover observations

A site walkover was undertaken by Tom Nicholson of GHD on 9 July 2019. Tom Nicholson is a Technical Director - Engineering Geology based in GHD’s Coffs Harbour Office.

Observations

1. On the day of the walkover the weather was fine. Weather on the days preceding the walkover included some rainfall.
2. The restaurant structure appears more dilapidated, but the dilapidation appears to result from a lack of use and maintenance as opposed to some form of slope movement.
3. The slope above the old restaurant remains largely as it was observed in 2013. Vegetation is slightly more dense (no pre walkover clearing was conducted in 2019) and the landslide scarps observed in 2013 remain visible, if slightly more subdued by soil creep and erosion. The headscarp is traceable slightly further west (into lot 11) than indicated in the figure in the Coffey report. This is not considered new movement but likely an area that was not observed due to dense vegetation in 2013.
4. The retaining wall behind the restaurant remains dilapidated. At the eastern end of the site there were indications that some of the concrete blocks had moved relative to each other. This movement was slightly more advanced than that observed in 2013.
5. West of the old restaurant building, the timber retaining wall is visible. This wall is in relatively good conditions for its age and appears slightly wetter and mossier, but apparently structurally unchanged since the authors visit in 2013.
6. No new indications of slope movement were observed in the area around the structures or within the slopes above the structures.
7. East of the site on the adjoining lot, the slope has recently been modified. The modifications include excavation of around 1.5 m of earth at the base of the slope and construction of a post and panel retaining wall. A small shed has been built in the newly levelled area. The slopes above the wall appear to be sandy in nature. The post and panel wall appears slightly bowed outwards downslope. Vegetation has been planted on the slopes above the wall but the vegetation is still low and not well established.
8. Groundwater seepage was observed west of the old restaurant within the stairs that descend from Pine Avenue. This seepage was also observed in 2013 and we understand is a consistent feature at this location.
9. Seepage continues to flow from the base of the slope west of lot 1 near the public toilet block, and from roadside drains into the street gutter. The seepage has led to the development of swampy vegetation in the road reserve west of the stairs. This area appears similar to that observed in 2013.
10. The pavement area in front of both lot 1 and lot 3 appears to be in good condition. Slight erosion of the concrete gutter appears to have developed. This erosion pattern indicates it could be related to acidic groundwater seepage from the organic and sand soils in the slopes above.

4 Review of 2013 report

4.1 Background

The 2013 geotechnical report was prepared to assess the geotechnical hazards to redevelopment of the site. The report (GEOTALST03550AA-AB) was released as a Draft on 5 September 2013.

The report was commissioned by Mr Ricky Lau, the property owner at the time who wished to redevelop the restaurant. The aim of the report was to assess the slope hazards at the site and advise the project teams structural engineers on possible schemes to manage the hazards should a redevelopment be more thoroughly considered. We are not aware of how far the development planning process went, but presume that the redevelopment process stalled shortly afterwards as the geotechnical report was never finalised to include review of the final mitigation arrangements the developer was to propose.

The geotechnical report included subsurface investigations (5 boreholes drilled by hand auger with 8 dynamic cone penetrometer (DCP) tests) and developed a geotechnical cross section. The location of the investigations is shown in Figure 4-1. The geotechnical model interpreted from the conditions observed in the 2013 report is shown in Figure 4-2.

In summary, the geotechnical model comprises a weathered basalt basement material, mantled by loose and very loose sand. The sand comprises an older dune system and at its angle of repose. The sand slope dips down to the south east at 30° to 40° towards the current development and shows signs of slope instability in the form of a small landslide headscarp and soil creep. The sand slope is retained at the base by a retaining wall of two or more different types.

The 2013 Coffey report offers preliminary parameters for proportioning of foundations and retention structures as well as advice on progressing the project (in its 2013 form).

A slope hazard assessment provides advice on the type and nature of slope instability hazards and offered mitigation methods for the observed hazards.

Figure 4-1 Site plan from 2013 report

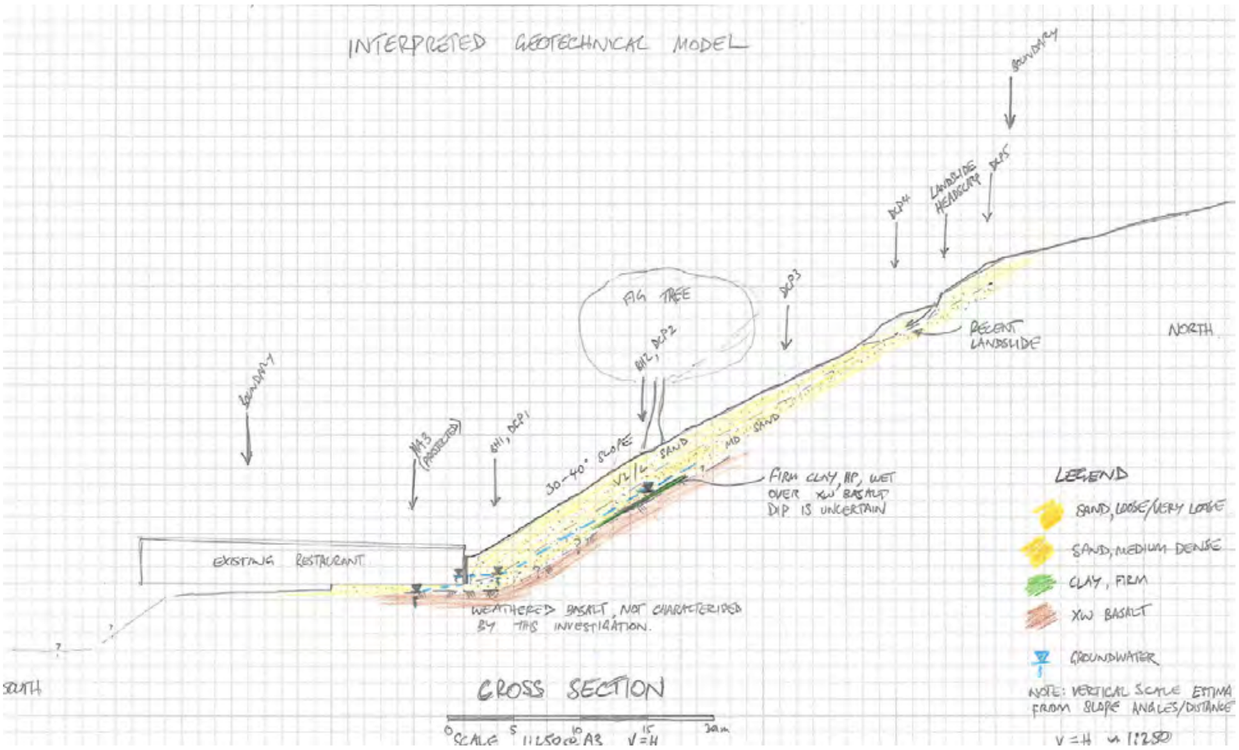


Figure 4-2 Geotechnical model from 2013 report

4.2 Have conditions changed and should the 2013 report conclusions change?

The site walkover indicates that the conditions observed in July 2019 are largely similar to those observed in 2013. No new slope movement appears to have been initiated and the hazards assessed in the 2013 report remain appropriate. A recent contour and detail survey of the site is attached to this letter.

We note that significant rain events have occurred in the intervening years and the lack of new slope movement corroborates the judgments of likelihood made in the 2013 report.

No changes were observed on site that would warrant a change to the intent or conclusions presented in the 2013 report. The mitigation options presented remain appropriate.

5 Suitability of the site for residential development

Part of our scope of work is to provide a geotechnical opinion as to whether the site is suitable for residential development.

The review of the slope conditions and the 2013 report identifies slope instability hazards. These are not insurmountable and are defined in size, scale and location, providing the inputs needed for engineering controls. The report also provides methods for mitigation of those hazards. This process indicates that given suitable geotechnical advice and structural engineering solutions, the site can safely be developed as a residential site. The residual risks can me managed to ‘Low’ which is in line with community expectations for residential land.

In summary, informed development in line with modern engineering standards and community expectations is possible within the bounds of commonly used engineering principles.

6 Further geotechnical work required should rezoning be successful

The steps for management of geotechnical constraints on this site appear to be:

1) Once the proposed building layout has been outlined and the final use defined (residential or commercial, number of levels, positioning of bedrooms identified etc) the structural engineering team should define how they will control the hazards identified in the 2013 report. These designs should be taken to concept level to allow confirmation of economic feasibility.

2) On completion of the feasibility level structural design a suitably qualified and experienced geotechnical professional should undertake a slope risk assessment assessing the risk to property and life following the guidelines developed by the Australian Geomechanics Society, as described in AGS2007c. (The 2013 report assesses landslide hazard in accordance with AGS2007b). For more information on the guidelines see: https://landsliderisk.org/resources/guidelines/).

The risk assessment would consider the suitability of the proposed structural controls to geotechnical hazards and provide feedback on whether the residual risk is tolerable or more engineering work is needed to meet the standards accepted by the community (AGS describes what these are generally accepted to be).

The risk assessment will need to include deeper drilling with recovery of rock core to:

- confirm the judgments made in the 2013 report,
- provide inputs into the slope risk assessment around possible global instability hazard levels,
- confirm design parameters for retention and foundations of the proposed development; and,
- provide more detailed planning information to inform structure specific geotechnical advice.

Following this level of work Council would then be well informed as to the risks and controls at the site, and should be able to make an informed decision as to whether the proposed development controls are adequate or need more engineering.

We recommend that at the conclusion of this process, when reports on slope hazard and risk are formally submitted to Council with a Development Application, the developer and the consultant preparing the reports provide authority to Council to share these reports with future land owners such that future land owners are adequately informed around the specific site features and controls.

7 Limitations

This report: has been prepared by GHD for Kristian Moon and may only be used and relied on by Kristian Moon for the purpose agreed between GHD and the Kristian Moon as set out in section 1 of this report.

GHD otherwise disclaims responsibility to any person other than Kristian Moon arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

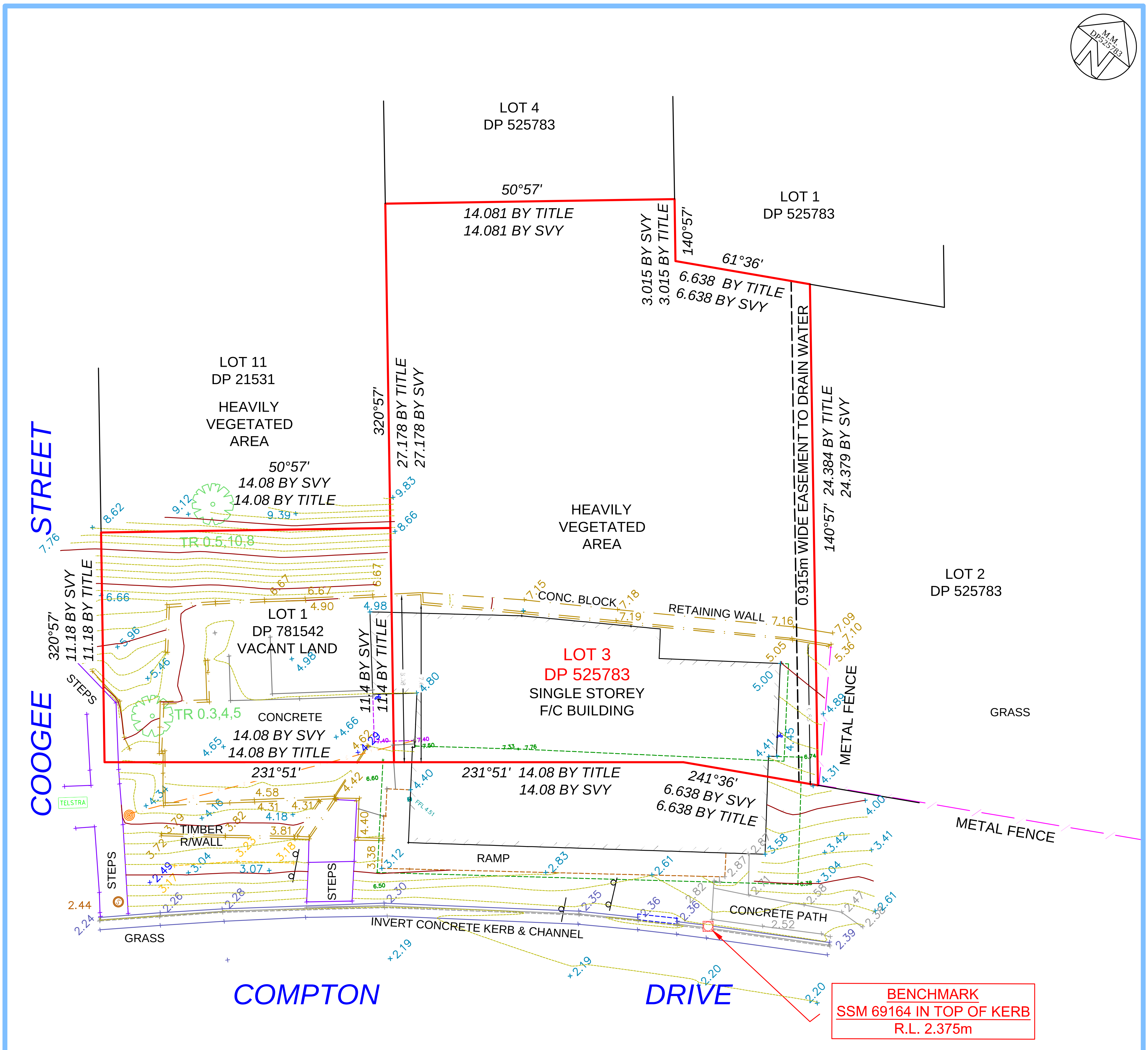
Sincerely
GHD

Tom Nicholson
Technical Director – Engineering Geology
0450 361 790

Attachment:

Recent contour and detail survey

2013 Report (43 pages)



BENCHMARK
SSM 69164 IN TOP OF KERB
R.L. 2.375m

N. Hele

Neil A. Kennedy
Registered Surveyor

NOTES

1. THE DEPICTION OF *CADASTRAL BOUNDARY* INFORMATION (WHETHER GRAPHICAL OR ANALYTICAL) CONSTITUTES A LAND SURVEY UNDER THE *SURVEYING AND SPATIAL INFORMATION ACT 2002* AND CAN ONLY BE UNDERTAKEN AND PRESENTED BY A REGISTERED SURVEYOR REGISTERED UNDER THE ACT.
   THE SIGNATURE ENDORSEMENT OF THIS PLAN BY THE *REGISTERED SURVEYOR* IS THE GUARANTEE THAT THIS *LAND SURVEY* HAS BEEN CONDUCTED IN ACCORDANCE WITH THE PROVISIONS OF THE *SURVEYING AND SPATIAL INFORMATION ACT (2002) & REGULATION (2017).*

2. FOR THIS PARTICULAR *LAND SURVEY*, THE *CADASTRAL BOUNDARY* POSITION HAS BEEN DETERMINED BY THE *REGISTERED SURVEYOR* TO AN APPROXIMATE ACCURACY OF +/- 0.50.
   CRITICAL FEATURES ON THIS PLAN MUST BE VERIFIED BY THE USER AS TO THE ACCURACY REQUIRED FOR THE INTENDED PURPOSE.

3. TITLE DENOTES DISTANCE AS SHOWN ON TITLE PLAN.
   SVY DENOTES DISTANCE DETERMINED BY SURVEY.

4. ONLY VISIBLE SERVICES HAVE BEEN LOCATED. UNDERGROUND SERVICES HAVE NOT BEEN INVESTIGATED. A "DIAL BEFORE YOU DIG" SERVICES LOCATION SEARCH SHOULD BE CONDUCTED PRIOR TO ANY EXCAVATION WORKS.

5. SPOT LEVELS & CONTOURS INDICATE GENERAL TOPOGRAPHY. DO NOT SCALE OR INFER ACCURATE LEVELS. CONTOUR INTERVAL:
   MAJOR 1.0m
   MINOR 0.2m

6. LEGEND
   - SUBJECT LOT BOUNDARY
   - APPROX. ADJOIN. LOT BOUNDARY
   - RAMP
   - RETAINING WALL
   - BUILD GUTTER
   - BUILD WALL
   - EASEMENT
   - FENCE
   - KERB LIP
   - KERB BACK
   - KERB INVERT
   - KERB TOP
   - CONCRETE
   - STEPS
   - BUILD RIDGE
   - OVERHEAD ELECTRICITY
   - ROAD SIGN
   - WATER TAP
   - SEWER PIT
   - +1.23 - SPOT LEVEL ON NATURAL SURFACE
   - POWER POLE
   - TELSTRA - TELSTRA PIT

SURVEY CODE
FFL FINISH FLOOR LEVEL

7. THIS PLAN HAS BEEN PREPARED FOR KRISTIAN MOON.

8. THIS PLAN REPRESENTS A COPY OF INFORMATION SUPPLIED IN .DWG/.DXF FORMAT. THIS INFORMATION SHOULD BE VERIFIED AGAINST THIS PLAN. DIGITAL DATA ASSOCIATED WITH THIS PLAN IS SUBJECT TO CONDITIONS CONTAINED IN THESE NOTES.

9. THESE NOTES FORM AN INTEGRAL PART OF THIS PLAN AND AS SUCH MUST REMAIN WITH THE PLAN IN REPRODUCTION.

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SCALE: 1:150
ORIG: A3
0 1 2 5

REV	DATE	DESCRIPTION
1	22.05.2019	ORIGINAL ISSUE
2	24.05.2019	AMEND BOUNDARY
3	12.07.2019	ADDITIONAL SURVEY

HORIZONTAL DATUM: M.M.
ORIGIN: DP525783
VERTICAL DATUM: A.H.D.
ORIGIN: SSM 69164
REDUCED LEVEL: 2.370m
SCIMS DATE: 02.05.2019

JOB No: 19036
SURVEYED BY: AC
FIELD BOOK: IN FILE
DATE OF SURVEY: 03.05.2019
DRAWN: PDJ
PASSED: LF

TITLE: **SKETCH SHOWING CONTOURS AND DETAIL**

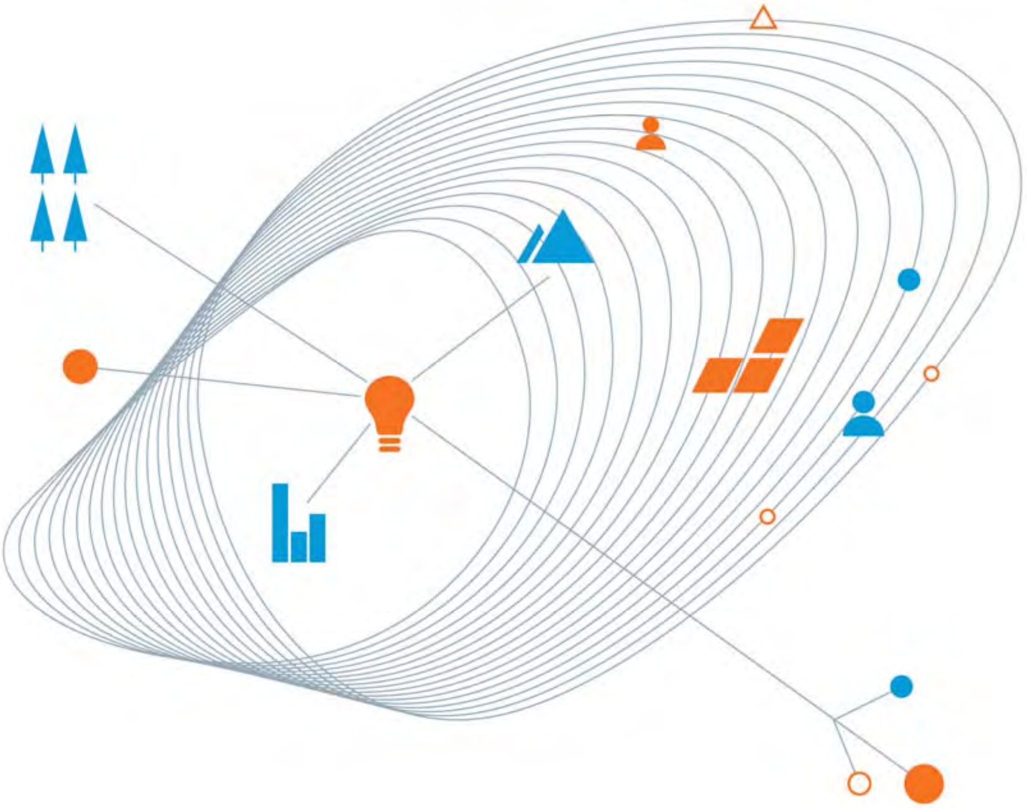
SITE: **LOT 3 IN DP 525783**
No. 23 COMPTON DRIVE
EAST BALLINA. 2478.

CLIENT: **KRISTIAN MOON**
DWG No: **19036A.DWG**
SHEET 1 of 1 REV 3

Mr Ricky Lau

Slope Hazard Assessment
23 Compton Drive, Ballina

5 September 2013



Innovation is
finding answers
to questions
no one has
asked

5 September 2013

Mr Ricky Lau
PO Box 280
Lennox Head, NSW 2478

Attention: Mr Ricky Lau

Dear Sir

RE: Slope Hazard Assessment: 23 Compton Drive, Ballina

Coffey Geotechnics Pty Ltd is pleased to present our slope hazard assessment on the slope at 23 Compton Dive, Ballina, NSW.

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

We hope 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 Geotechnics Pty Ltd

DRAFT

Tom Nicholson

Associate

CONTENTS

1 INTRODUCTION 1

2 SITE DESCRIPTION & PROPOSED DEVELOPMENT 1

- 2.1 Site Description 1
- 2.2 Fieldwork 1

3 SUB-SURFACE CONDITIONS 2

- 3.1 Stratigraphy 2
- 3.2 Groundwater 2

4 CONSIDERATIONS FOR DESIGN & CONSTRUCTION 3

- 4.1 Slope Instability and Hazards 3
- 4.2 Preliminary Retaining Wall Design Parameters 1

5 RECOMMENDED FURTHER GEOTECHNICAL WORK 2

6 LIMITATIONS 3

7 REFERENCES 3

Important Information About Your Coffey Report

Tables

Table 1: Slope hazard assessment for the slope above the restaurant

Figures

Figure 1: Site Plan

Figure 2: Geotechnical Model Cross Section

Figure 3: Landslide Hazards

Appendices

Appendix A: Engineering Borehole Logs and Explanation Sheets

Appendix B: DCP test results

Appendix C: Landslide Risk Management Guidelines Description of Terms (Appendix C from AGS2007)

1 INTRODUCTION

Coffey Geotechnics Pty Ltd (Coffey) was engaged by Mr Ricky Lau to undertake a Slope hazard Assessment of the slope behind the disused restaurant building at 23 Compton Drive, Ballina.

The aim of this Slope hazard assessment was to assess the magnitude of the instability problem and assess retaining wall design parameters to allow the projects structural engineer to design structural improvements to the retaining system behind the restaurant.

Coffey conducted the work presented in this report largely in accordance with proposal GEOTALST03550AA-AA, dated 5 August 2013 under Coffey Geotechnics Consultancy Agreement (Australia) V15 January 2012.

2 SITE DESCRIPTION & PROPOSED DEVELOPMENT

2.1 Site Description

Regionally, the site is within east Ballina in Northern NSW. The site is located on the lower slopes of a south east facing hillside. The restaurant site is situated at the base of the hill slope, above Compton Drive, which is located around two metres above the coastal Shaw’s Bay Lagoon. The site occupies the turning point between the low angle slopes of the coastal plain, and the relatively steep slopes of the aeolian dune system that has been deposited over the weathered basalt basement rocks which form the hillside above.

The site is currently occupied by a single storey timber and cladding structure which appears to be founded on shallow footings. At the rear of the structure, which once operated as a restaurant, excavation of the toe of the hillside has occurred and a retaining wall installed. The retaining wall is comprised of various materials. In part the wall is comprised of timber post and beam, concrete block and mortared stone wall.

The slope above the retaining wall is relatively steep, rising up to the north west at around 35 degrees for some fifteen to twenty meters vertical extent. This slope is well vegetated by large trees and dense undergrowth. Above the steep slope the land flattens out to around 14 degrees, and has been formed into gardens of the properties above.

Within the steep slope above the retaining wall, near the crest of the slope, a small arcuate landslide headscarp was observed. The headscarp of the landslide is around 10m in lateral extent and has formed a step of around 0.7m in vertical extent. Above and around this headscarp the garden waste and fill (including some bottles) was observed. This fill is of uncertain depth.

The general arrangement of the site, and the slope observed are indicated on Figure 1.

2.2 Fieldwork

Fieldwork was conducted during August 2013, and comprised the drilling of four boreholes and undertaking of five DCP tests, coupled by a walkover of the site by an associate engineering geologist and a geotechnical engineer from Coffey. The approximate location of the boreholes and DCP tests are shown on Figure 1.

Fieldwork was conducted in the full time presence of a geotechnical professional from Coffey who logged the materials observed, took samples and recorded results of in-situ testing.

Engineering Logs are presented in Appendix A, along with explanation sheets defining the terms and symbols used in their preparation.

3 SUB-SURFACE CONDITIONS

3.1 Stratigraphy

The Tweed Heads 1:250,000 geological map shows that the site is underlain by the Lismore Basalt Formation.

Our boreholes drilled on the site intersected fill and aeolian dune sand overlying weathered basaltic rock. In one borehole a firm clay of apparent alluvial/marine origin was observed overlying the weathered basalt. This clay could also be a weathered interflow layer from within the basaltic rocks that underlie the site.

The general stratigraphy of the site is presented in a cross section geotechnical model presented in Figure 2.

Further details of the materials intersected by the boreholes are provided in the Engineering Logs presented in Appendix A.

3.2 Groundwater

Groundwater was observed in BH1 and BH2. Groundwater seepage was also observed seeping from the slope and the retaining wall (in the lower metre of the wall) behind the restaurant. The seepage from the retaining wall is apparently long term in that the seepage areas are stained and include moss and algae growth. Further to these observations, residents commented to Coffey during our fieldwork that the slopes are always wet and rarely dry even in sustained dry weather periods.

It is likely that the groundwater seepage is emanating near the level of the the top of the weathered basalt or clay layers at the site.

No long term groundwater monitoring was undertaken and the groundwater levels may fluctuate after rain or due to seasonal variations.

4 CONSIDERATIONS FOR DESIGN & CONSTRUCTION

4.1 Slope Instability and Hazards

The slope above the restaurant is comprised of sand, which is generally very loose near the ground surface, increasing in density around 2m below ground to medium dense.

The slope angle of the ground surface are generally in excess of 35 degrees, and assuming a friction angle for loose sand of some 25 degrees, the slopes are significantly steeper than would normally be considered ‘stable’. Initial assessment indicates that the slope has a calculated Factor of Safety (FoS) close to 1, and instability of the sand slope is expected.

Further to this, a relatively small, though significant, landslide headscarp was observed within the slope above the restaurant. This headscarp is evidence that the theoretical assessment above is likely to be correct. We postulate that soil suction forces and vegetative root support is the reason that the slope remains largely in place.

The retention structure at the base of the slope is not likely to be providing significant support and appears to be under-designed and constructed in an irregular fashion.

Further to the above initial comments on slope instability, the presence of persistent groundwater seepage from the slope indicates that groundwater is exerting load on the current retention structures and could rise. Elevated groundwater levels will significantly reduce the stability of the slope. Based on our preliminary assessment it appears unlikely that the retaining wall is designed to withstand loads from a groundwater.

Table 1 below presents our assessment of the slope hazards at the site. The hazard assessment describes each hazard considered credible, the assessed likelihood of the event occurring, and the probable consequences of the event.

The aim of the hazard assessment is to provided a tool to the designer, to allow structured and appropriate decision making with respect to slope risk management, in line with Ballina Shire Councils Development Application consent conditions. The terms for likelihood used in the assessment are those used in the guidelines of the Australian Geomechanics Society Practice note on Landslide Risk Management (AGS2007) slope stability assessments, which are defined in Appendix C.

Table 1: Slope hazard assessment for the slope above the restaurant

Hazard	**Likelihood**	**Possible Consequences**	**Potential Mitigation Options**
H1) Shallow landslide of the loose to very loose sand (above the existing retaining wall). The landslide may be in the order of say 10m wide, 2 to 3m deep and say 10 to 15m long. When it slides down the slope we would expect it could overtop the existing wall, or topple it in part, and leave a debris pile that extends say 5m to 10m into the restaurant area.	The presence of an existing landslide of this type, coupled with deep loose sand and elevated groundwater indicates that this type of hazard is **likely** to occur. The trigger for the event could be minor rainfall or small changes to the slope vegetation and drainage.	If this hazard occurred, moderate volumes of soil could slide down the slope above the retaining wall, and spill over into the rear half of the restaurant. The debris could move faster than running pace with little or no warning. The consequences of the hazard are likely to be **moderate** to **major** with extensive damage to much of the existing structure possible, if no restraint of catch structure is built.	Retain the hazard in place or construct a catch structure above the development to provide protection H1+H2-a) Soil nailed retention systems, H1+H2-b) Piled retention systems installed within the slope above the existing retaining wall, stepped up the slope. H1+H2-c) A large retaining wall founded at the base of the slope with additional height to act as a catch structure or to provide a wall to backfill against to resist landslide forces. The wall could be an anchored piled wall or a gravity wall. H1+H2-d) Accept the hazard and develop such that the hazard does not affect the proposed structure. Such a strategy could rely on a specifically reinforced structure designed to withstand the forces should soil slide into the building, or design the structure such the landslide could travel below the proposed structure without unreasonably endangering life.
H2) Landslide of the soil above weathered rock (above the existing retaining wall) The landslide may be in the order of say 10m wide, 3 to 4 m deep and say 10 to 15m long. When it slides down the slope we would expect it could topple or slide through the existing wall, and leave a debris pile that extends say 5 to 15m into the restaurant area. If the debris was very wet greater travel distances could be expected.	The presence of a moist to wet clay layer at depth (HA2), which potentially dips downslope, indicates that a moderate sized landslide that would encompass a large amount of the slope, is considered **possible**. The trigger for the event could be moderate rainfall or changes in the slope loading or support. (Such as developing the slope without taking this into account).	The event could occur rapidly with debris moving downslope faster than running pace, or slowly with movements occurring over a number of years. The consequence of such a landslide is considered to be **catastrophic** for the current restaurant, with debris extending out from the base of the slope in the order of some 5m to 15m. In some circumstances, debris could reach the roadway.	
H3) Large scale landslide through weathered rock mass above the site, where he slide plane is located within weathered rock below the depth of the boreholes.	Data to indicate that a large scale landslide encompassing all of the slope is was not observed during the investigation (due to techniques used). Further, large scale instability such as this is not known to have occurred (by Coffey) in similar geological conditions within the Ballina coastal strip. The event is considered **unlikely** to **barely credible**. For such an event to be unlikely, a discontinuity or weakness within the rock mass within the slope would be required.	If such an event occurred, large scale destruction of the development would result. The consequences would be **catastrophic**	H3-a) It is unlikely that mitigation of this hazard is warranted. Deeper drilling data below the proposed development would be required to rule this hazard out.

Figure 3 presents a visual interpretation of Hazards 1 and 2.

Terms in **Bold** are defined in Appendix C

4.2 Preliminary Retaining Wall Design Parameters

Preliminary retaining wall design parameters for concept design purposes are provided in Table 2. Gravity and simple anchored retaining walls may be designed on the basis of a triangular stress distribution where up to one row of lateral anchors are considered.

Design of the walls should take into account surcharges from sloping ground, groundwater or other loadings behind the wall which will increase the earth pressure loads from the horizontal ground case. Global failure of the structure should also be checked for acceptable factors of safety.

Adequate drainage should be provided for all retaining walls.

For conventional construction, a drainage zone behind the wall should be incorporated for all retaining structures. This drainage zone should be hydraulically connected to porous drains, wrapped in geofabric, on the rear surface of the wall which should be linked to a geofabric wrapped perimeter drain provided at the toe of the final excavation. The perimeter drain should discharge to the site stormwater system to provide long term drainage behind excavation walls. Flushing points should be incorporated into the design of the perimeter drain and periodic maintenance should be incorporated into the management plan of the proposed development.

Drainage measures as described above, if properly maintained, should reduce the risk of elevated pore pressures at the back of the wall. However, pore pressures may still be generated at other points behind the wall due to drain failure or lack of maintenance over long periods of time. The design should incorporate an allowance for such pressures. A typical allowance of potential water pressure build-up equivalent to 1/3 of the wall height is considered to be reasonable with such drainage measures installed and maintained over the life of the structure.

Stability analyses of proposed designs should allow for global failure of the retained slope and for any surcharges at the top of the wall (e.g. sloping ground, traffic, structures, etc.). Under no circumstances should walls be founded on topsoil, colluvium, uncontrolled fill or other potentially deleterious materials.

Retaining wall design should incorporate checks on the following modes of failure:

- Global slope failure
- Overturning of the wall
- Sliding of the wall
- Internal component rupture (e.g. sliding of the blocks which form the wall)
- Bearing failure due to self-weight and overturning moments.

Retaining walls should be designed by a qualified engineer according to the provisions of AS4678-2002: *Earth-retaining Structures*. Retaining wall footings should allow for potential movement due to seasonal moisture variations.

Table 2: Preliminary Retaining Wall Design Parameters

Material	Bulk Density kN/m^3	Effective Friction Angle ϕ'	Effective Cohesion c' (kPa)	Allowable Bearing Capacity (kPa)
Very Loose / Loose Sand	16	25	0	-
Medium Dense Sand (or better)	18	30	0	100(1)
Marine Clay (firm clay or better)	19	20	5	25
Extremely Weathered Material (hard clay or better)	20	28	10	250

(1) Confirm the nature of strata below the sand before founding within this unit.

4.2.1 Foundations for retaining structures

The medium dense sand and extremely weathered material observed in BH3 may be considered for foundation support using high level pad or strip footings, or cantilevered piles. However confirmatory investigations should be undertaken to confirm that no low strength layers exist below foundation level.

The investigation data recovered for the foundation area was not able to assess the nature of the extremely weathered material to the full depth of the likely zone of influence of the probable wall foundation. As such the preliminary parameters are based on our expectations rather than confirmatory data. For preliminary design, the allowable bearing pressure for the extremely weathered hard clay material may be taken as 250 kPa with a Young's Modulus of 30 MPa.

It is likely that weathered rock is present below the site, and exploratory drilling could provide higher foundation design parameters if rock is found.

5 RECOMMENDED FURTHER GEOTECHNICAL WORK

Further geotechnical work may assist the planning process to progress the development of infrastructure on the site. We expect that Coffey can assist workshopping retention solutions and then furthering their design with your team.

Depending on the options chosen further geotechnical investigations may be required. Our Stage 2 report, which will discuss options for remediation, will discuss this in further detail if required.

We note that informed geotechnical assessment of conditions prior to construction stage can save considerable costs during development. Further to this rapid feedback during construction can assist in managing actual ground conditions and limit the magnitude of variations to budgets. Coffey would be pleased to assist with the above tasks.

6 LIMITATIONS

The assessment presented in this report is based on a limited number of investigation locations and observations. Engineering judgement has been made to assess potential conditions between investigation sites, but variability should be expected in the nature and depth of the soil units within natural geological environments. This report presents a preliminary assessment of the site conditions at the time of the site investigation. These conditions may change in the future.

This report presents a risk assessment of slope hazard for the site. Preliminary design parameters for structures are also presented. This information is intended to be used for concept design and is not appropriate for all design conditions that may be constructed. Given this, further investigation of site conditions will be required once the design of the structures is known to assess **structure specific** parameters.

Consideration should be given to these factors when following recommendations in this report.

We draw your attention to the factsheet entitled “Important information about your Coffey report” attached to this document.

For and on behalf of Coffey Geotechnics Pty Ltd

DRAFT

Tom Nicholson

Associate

7 REFERENCES

AGS 2007	Australian Geomechanics Society (AGS) A National Landslide Risk Management Framework for Australia”; Volume 42 March 2007.

Important information about your **Coffey** Report

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

Your report is based on project specific criteria

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

Subsurface conditions can change

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

Interpretation of factual data

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

Your report will only give preliminary recommendations

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

Your report is prepared for specific purposes and persons

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

Important information about your **Coffey** Report

Interpretation by other design professionals

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

Data should not be separated from the report*

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

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

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment.
Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

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

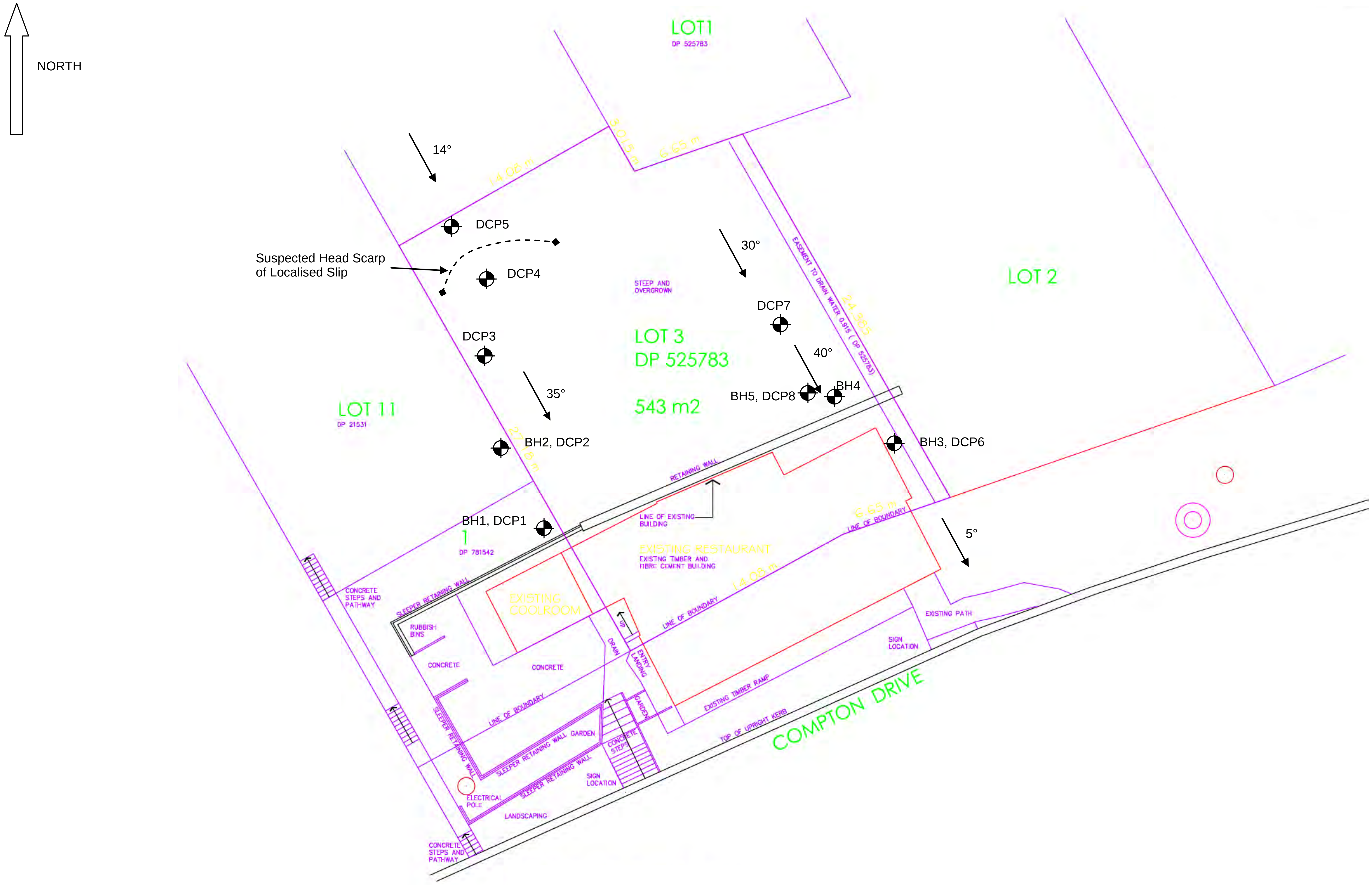
Responsibility

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

---

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

Figures



revision	description	drawn	approved	date

BASED ON ORIGINAL PREPARED BY
LOGAN ARCHITECTURE

0 5 10 20 30

Horizontal Scale (metres)

drawn	**RV**
approved	
date	**23/8/13**
scale	**TBC**
original size	**A3**

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client: **RICKY LAU**

project: **SLOPE HAZARD ASSESSMENT**
RESTAURANT ON SHAWS BAY
23 COMPTON DRIVE, EAST BALLINA

title: **SITE PLAN WITH INVESTIGATION LOCATIONS**

project no: **GEOTALST03550AA-AB**

figure no: **FIGURE 1**

FIGURE 2

coffey

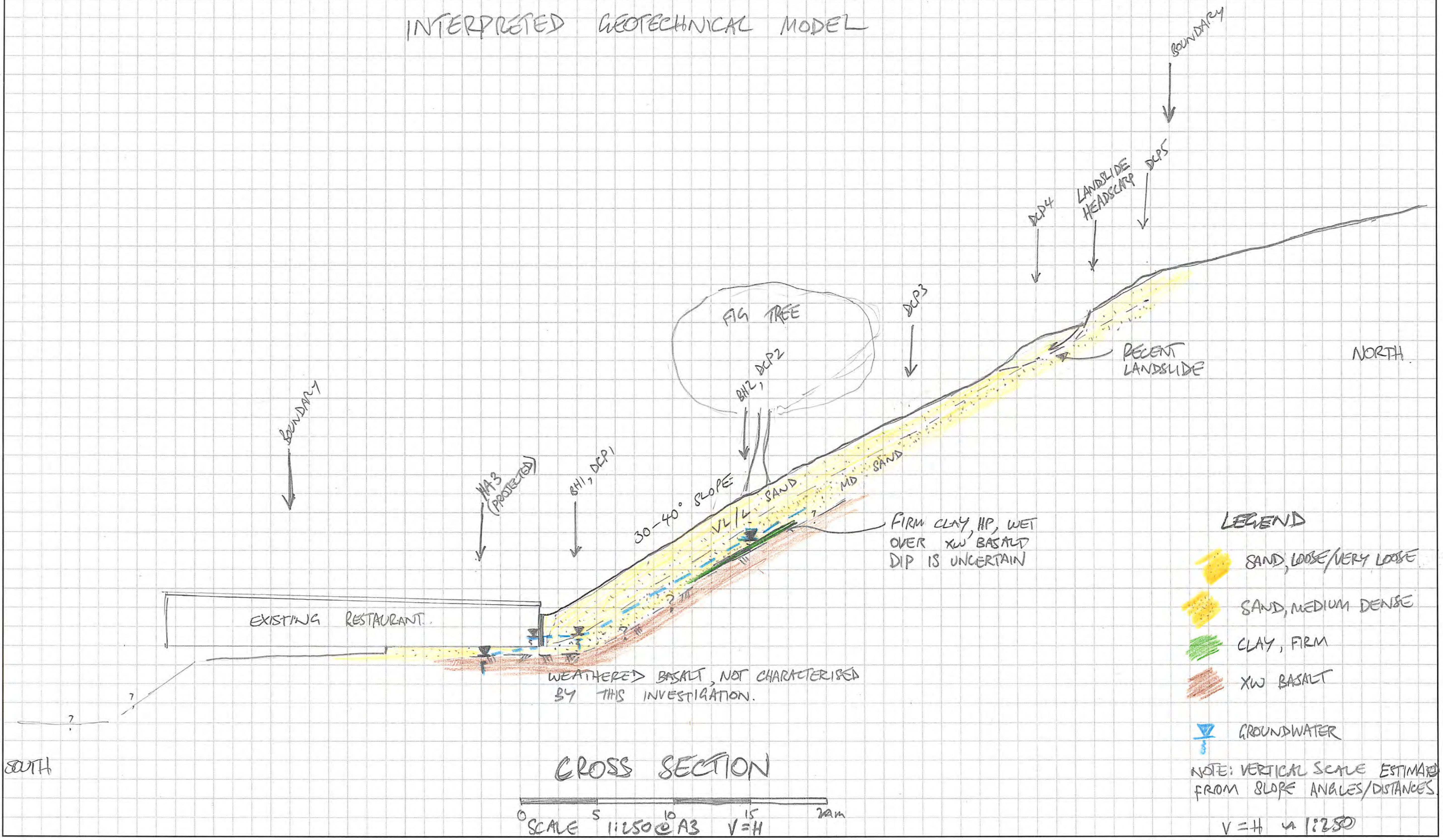
Computations

project no: GEOTALST03550AA
sheet of

client: RICKY LAU
principal:
project: SLOPE HAZARD ASSESSMENT
location: 23 COMPTON DRIVE, EAST BALLINA

office: ALST
date: 4/9/13
by: TGN
checked:

INTERPRETED GEOTECHNICAL MODEL



CROSS SECTION

SCALE 1:250@A3 V=H

NOTE: VERTICAL SCALE ESTIMATED FROM SLOPE ANGLES/DISTANCES.

V=H ≈ 1:250

64210 / 07-06

FIGURE 3

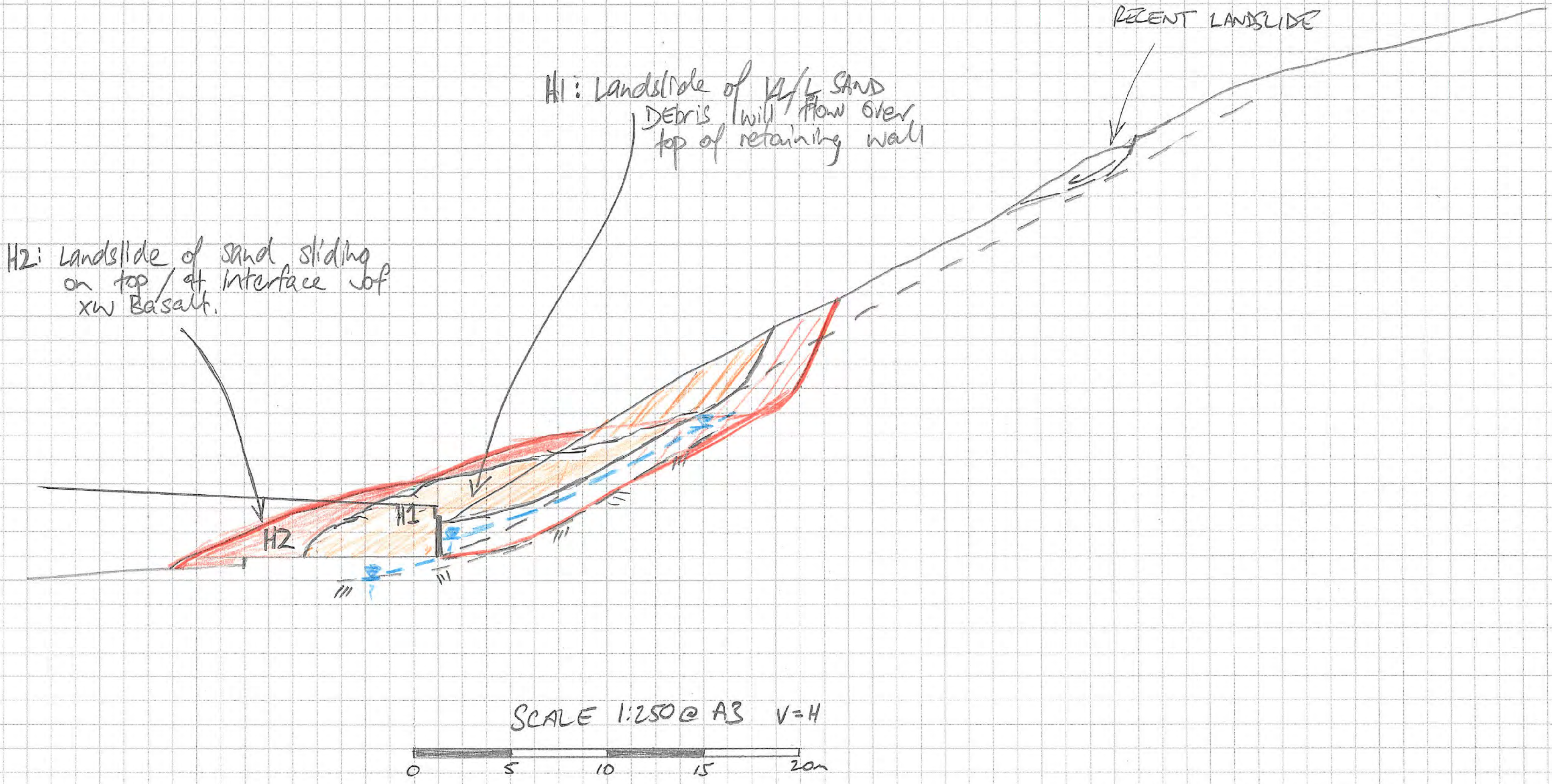
coffey
Computations

project no: GEOTALST03550AA
sheet of

client: RICKY LAU
principal:
project: SLOPE HAZARD ASSESSMENT
location: 23 COMPTON DRIVE BALLINA

office: ALST
date: 4/9/13
by: TCN
checked:

CREDIBLE HAZARDS



Appendix A

Engineering Borehole Logs and Explanation Sheets

coffey geotechnics

Engineering Log - Borehole

Borehole No.	***BH1***
Sheet	1 of 1
Project No:	***GEOTALST03550AA***
Client:	***RICKY LAU***
Date started:	***23.8.2013***
Principal:	
Date completed:	***23.8.2013***
Project:	***SHAWS BAY RESTAURANT - SLOPE HAZARD ASSESSMENT***
Logged by:	***RV***
Borehole Location:	***Refer Figure 1 of Report***
Checked by:	

drill model and mounting: Hand Auger	Easting:	slope: -90°	R.L. Surface: -0.6		
hole diameter: 75 mm	Northing	bearing:	datum: Eaves		

drilling information | **material substance**

method	penetration 1 2 3	support	water	**notes** samples, tests, etc	RL	depth metres	graphic log	classification symbol	**material** soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	**structure and additional observations**
HA		N						SP	**SAND:** fine to medium grained, pale brown	M	VL to L		AEOLIAN SAND
					-1.0	0.5							
					-1.5	1.0			becoming pale brown to white				
				D	-2.0	1.5			roots from 1.5 to 1.8m, diameter 2 to 5mm				
			►—						becoming dark brown	W			
					-2.5	2.0			Terminated due to hole collapse below groundwater table Borehole BH1 terminated at 2m				
					-3.0	2.5							
					-3.5	3.0							
					-4.0	3.5							
					-4.5	4.0							

method

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

support

M	mud	N	nil
C	casing		

penetration
1 2 3 4
no resistance ranging to refusal

water

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

notes, samples, tests

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

classification symbols and soil description
based on unified classification system

moisture

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

consistency/density index

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

coffey geotechnics

Engineering Log - Borehole

Borehole No.	*BH2*
Sheet	1 of 1
Project No:	*GEOTALST03550AA*
Client:	*RICKY LAU*
Date started:	*23.8.2013*
Principal:	
Date completed:	*23.8.2013*
Project:	*SHAWS BAY RESTAURANT - SLOPE HAZARD ASSESSMENT*
Logged by:	*TGN*
Borehole Location:	*Refer Figure 1 of Report*
Checked by:	

drill model and mounting:	Hand Auger	Easting:		slope:	-90°	R.L. Surface:	4
hole diameter:	75 mm	Northing		bearing:		datum:	Eaves

drilling information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	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
HA		N					SP	**SAND:** fine to medium grained, grey to pale brown	M	VL to L		AEOLIAN SAND
					3.5	0.5						
					3.0	1.0						
					2.5	1.5		becoming white				minor hole collapse
										L		
					2.0	2.0				MD		
					1.5	2.5				D		
					1.0	3.0			W			
			►				SM	**Silty SAND:** fine to medium grained, dark brown, trace of fine organics at 3.5m: 50mm thick interbed of Clayey SAND, mottled red-brown				Old Topsoil Surface, ALLUVIUM
					0.5	3.5						
							CH	**CLAY:** high plasticity, dark grey		F		MARINE CLAY
								Terminated due to limit of reach Borehole BH2 terminated at 3.8m				
					0.0	4.0						

method

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

*bit shown by suffix
e.g. ADT

support

M	mud	N	nil
C	casing		

penetration
1 2 3 4
no resistance ranging to refusal

water

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

notes, samples, tests

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

classification symbols and soil description
based on unified classification system

moisture

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

consistency/density index

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

coffey geotechnics

Engineering Log - Borehole

Borehole No.	*BH3*
Sheet	1 of 1
Project No:	*GEOTALST03550AA*
Client:	*RICKY LAU*
Principal:	
Project:	*SHAWS BAY RESTAURANT - SLOPE HAZARD ASSESSMENT*
Borehole Location:	*Refer Figure 1 of Report*
Date started:	*23.8.2013*
Date completed:	*23.8.2013*
Logged by:	*RV*
Checked by:	

drill model and mounting:	Hand Auger	Easting:		slope:	-90°	R.L. Surface:	-2.5
hole diameter:	75 mm	Northing		bearing:		datum:	Eaves

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
HA		N						SP	**FILL - SAND:** fine to medium grained, brown, trace gravel	M to W	MD		UNCONTROLLED FILL
					-3.0	0.5		SP	**SAND:** fine to medium grained, pale brown-grey some rootlets, single flaky subrounded pebble, 40 x 20mm		D		AEOLIAN SAND
			►		-3.5	1.0		SM	**Silty SAND:** fine to medium grained, dark brown, trace fine organics	W			ALLUVIUM
								GC	**Clayey GRAVEL:** fine to medium grained, angular, high particle strength, medium plasticity fines, gravel is pale grey (basaltic)		VD		RESIDUAL SOIL/ XW MATERIAL
									Terminated due to refusal Borehole BH3 terminated at 1.15m				
					-4.0	1.5							
					-4.5	2.0							
					-5.0	2.5							
					-5.5	3.0							
					-6.0	3.5							
					-6.5	4.0							

method

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

*bit shown by suffix
e.g. ADT

support

M mud N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water

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

notes, samples, tests

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

classification symbols and soil description
based on unified classification system

moisture

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

consistency/density index

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

coffey geotechnics

Engineering Log - Borehole

Borehole No.	***BH4***
Sheet	1 of 1
Project No:	***GEOTALST03550AA***
Client:	***RICKY LAU***
Principal:	
Project:	***SHAWS BAY RESTAURANT - SLOPE HAZARD ASSESSMENT***
Borehole Location:	***Refer Figure 1 of Report***
Date started:	***23.8.2013***
Date completed:	***23.8.2013***
Logged by:	***TGN***
Checked by:	

drill model and mounting:	Hand Auger	Easting:		slope:	-90°	R.L. Surface:	-0.2
hole diameter:	75 mm	Northing		bearing:		datum:	Eaves

drilling information							material substance						
method	penetration 1 2 3	support	water	**notes** samples, tests, etc	RL	depth metres	graphic log	classification symbol	**material** soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	**structure and additional observations**
HA		N	Not Observed				▨	SP	**FILL - SAND:** fine to medium grained, trace silt and fine organics	M	L to VL		UNCONTROLLED FILL
					-0.5	0.5	▨	SP	**FILL - Gravelly SAND:** fine to medium grained, brown, gravel is single sized (20mm) fresh angular basalt, high particle strength				
					-1.0	1.0			Terminated due to refusal on gravel Borehole BH4 terminated at 0.7m				
					-1.5	1.5							
					-2.0	2.0							
					-2.5	2.5							
					-3.0	3.0							
					-3.5	3.5							
					-4.0	4.0							

method

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

support

M	mud	N	nil
C	casing		

penetration

water

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

notes, samples, tests

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

classification symbols and soil description
based on unified classification system

moisture

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

consistency/density index

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

coffey geotechnics

Engineering Log - Borehole

		Borehole No.	**BH5**
		Sheet	1 of 1
		Project No:	**GEOTALST03550AA**
Client:	**RICKY LAU**	Date started:	**23.8.2013**
Principal:		Date completed:	**23.8.2013**
Project:	**SHAWS BAY RESTAURANT - SLOPE HAZARD ASSESSMENT**	Logged by:	**TGN**
Borehole Location:	**Refer Figure 1 of Report**	Checked by:	

drill model and mounting:	Hand Auger	Easting:		slope:	-90°	R.L. Surface:	+0.3
hole diameter:	75 mm	Northing		bearing:		datum:	Eaves

drilling information | **material substance**

method	penetration 1 2 3	support	water	**notes** samples, tests, etc	RL	depth metres	graphic log	classification symbol	**material** soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	**structure and additional observations**
HA		N						SP	**SAND:** fine to medium grained, brown, some organic silt	M	VL		UNCONTROLLED FILL
					0.0								
						0.5			rootlets, 0.5mm diameter				
					-0.5								
						1.0			trace angular medium grained gravel, basalt				
			Not Observed		-1.0								
						1.5		SP	**SAND:** fine to medium grained, pale brown to white,				AEOLIAN SAND
					-1.5					M to W			
						2.0							
			►							W	L		
					-2.0								
						2.5		SP	**SAND:** fine to medium grained, dark brown, many fine organics		MD		ALLUVIUM
								SC/CH	**Sandy CLAY/Clayey SAND:** medium to high plasticity fines, sand is fine to coarse grained, some fine gravel, mottled red-brown and pale grey		D		BASALTIC CLAY, Poosible Colluvial Fan?
					-2.5				Terminated due to refusal on gravel Borehole BH5 terminated at 2.7m				
						3.0							
					-3.0								
						3.5							
					-3.5								
						4.0							

method

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

support

M	mud	N	nil
C	casing		

penetration
1 2 3 4
no resistance ranging to refusal

water

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

notes, samples, tests

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

classification symbols and soil description
based on unified classification system

moisture

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

consistency/density index

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

Soil Description Explanation Sheet (1 of 2)

DEFINITION:

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

CLASSIFICATION SYMBOL & SOIL NAME

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

PARTICLE SIZE DESCRIPTIVE TERMS

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

MOISTURE CONDITION

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

CONSISTENCY OF COHESIVE SOILS

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

DENSITY OF GRANULAR SOILS

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

MINOR COMPONENTS

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

SOIL STRUCTURE

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

GEOLOGICAL ORIGIN

WEATHERED IN PLACE SOILS

Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TRANSPORTED SOILS

Aeolian soil	Deposited by wind.
Alluvial soil	Deposited by streams and rivers.
Colluvial soil	Deposited on slopes (transported downslope by gravity).
Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
Lacustrine soil	Deposited by lakes.
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.

Soil Description Explanation Sheet (2 of 2)

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)						**USC**	**PRIMARY NAME**
COARSE GRAINED SOILS More than 50% of materials less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.36 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.		GW	GRAVEL
				Predominantly one size or a range of sizes with more intermediate sizes missing.		GP	GRAVEL
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)		GM	SILTY GRAVEL
				Plastic fines (for identification procedures see CL below)		GC	CLAYEY GRAVEL
		SANDS More than half of coarse fraction is smaller than 2.36 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes		SW	SAND
				Predominantly one size or a range of sizes with some intermediate sizes missing.		SP	SAND
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).		SM	SILTY SAND
				Plastic fines (for identification procedures see CL below).		SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm			IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm.				
			DRY STRENGTH	**DILATANCY**	**TOUGHNESS**		
		SILTS & CLAYS Liquid limit less than 50	None to Low	Quick to slow	None	ML	SILT
			Medium to High	None	Medium	CL	CLAY
			Low to medium	Slow to very slow	Low	OL	ORGANIC SILT
		SILTS & CLAYS Liquid limit greater than 50	Low to medium	Slow to very slow	Low to medium	MH	SILT
			High	None	High	CH	CLAY
			Medium to High	None	Low to medium	OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS			Readily identified by colour, odour, spongy feel and frequently by fibrous texture.			Pt	PEAT

- Low plasticity – Liquid Limit w_L less than 35%. • Medium plasticity – w_L between 35% and 50%. • High plasticity – w_L greater than 50%.

COMMON DEFECTS IN SOIL

TERM	**DEFINITION**	**DIAGRAM**
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
JOINT	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2 m in length.	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	**DEFINITION**	**DIAGRAM**
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

Rock Description Explanation Sheet (1 of 2)

The descriptive terms used by Coffey are given below. They are broadly consistent with Australian Standard AS1726-1993.

DEFINITIONS:

Rock substance, defect and mass are defined as follows:

Rock Substance	In engineering terms rock substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic.
Defect	Discontinuity or break in the continuity of a substance or substances.
Mass	Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

SUBSTANCE DESCRIPTIVE TERMS:

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

CLASSIFICATION OF WEATHERING PRODUCTS

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

Notes on Weathering:

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

ROCK SUBSTANCE STRENGTH TERMS

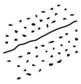
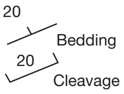
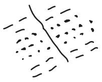
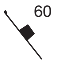
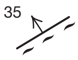
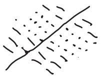
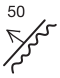
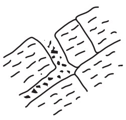
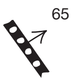
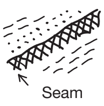
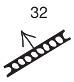
Term	Abbreviation	Point Load Index, $I_{s(50)}$ (MPa)	Field Guide
Very Low	**VL**	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	**L**	0.1 to 0.3	Easily scored with a knife; indentations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

Notes on Rock Substance Strength:

1. In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy.
2. The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range are soils in engineering terms.
3. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index $I_{s(50)}$. The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

Rock Description Explanation Sheet (2 of 2)

COMMON DEFECTS IN ROCK MASSES

Term	Definition	Diagram	Map Symbol	Graphic Log (Note 1)
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub parallel to layering (eg bedding) or a planar anisotropy in the rock substance (eg, cleavage). May be open or closed.			(Note 2)
Joint	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.			(Note 2)
Sheared Zone (Note 3)	Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.			
Sheared Surface (Note 3)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.			
Crushed Seam (Note 3)	Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties.			
Infilled Seam	Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.			
Extremely Weathered Seam	Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.			

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

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

ROUGHNESS TERMS

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

COATING TERMS

Clean	No visible coating
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

BLOCK SHAPE TERMS

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

Notes on Defects:

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

Appendix B

DCP test results

A.B.N: 93 056 929 483

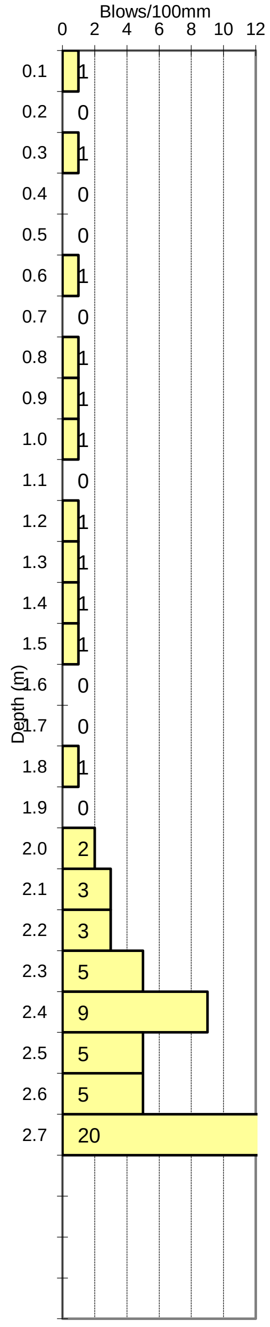
Job No **GEOTALST03550AA**

AS1289 6.3.2 - 1997 Dynamic Cone Penetrometer Test

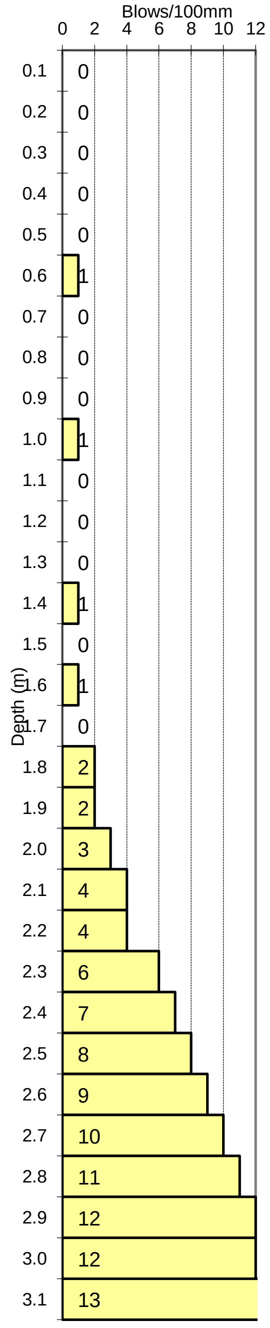
Sheet **1** of **11**

Client	***Ricky Lau***	Office	***ALST***
Principal		Date	***23/8/13***
Project	***Shaws Bay Restaurant - Slope Hazard Assessment***	By	***RV***
Location	***23 Compton Drive, East Ballina***	Checked	

Test No.	***DCP1***	**Test No.**	***DPC2***	**Test No.**	***DPC2***	**Test No.**	***DCP4***
Test Location:	BH1	Test Location:	BH2	Test Location:	BH2	Test Location:	Upslope BH2
RL:	-0.6	RL:	+4	RL:	+4	RL:	+9.5
Soil Classificatio	Sand	Soil Classificatio	Sand	Soil Classificatio	Sand	Soil Classificatio	Sand
Moisture Condition:	Wet from 1.8	Moisture Condition:	Wet from 3.0	Moisture Condition:	Wet from 3.0	Moisture Condition:	



0.1	1
0.2	0
0.3	1
0.4	0
0.5	0
0.6	1
0.7	0
0.8	1
0.9	1
1.0	1
1.1	0
1.2	1
1.3	1
1.4	1
1.5	1
1.6	0
1.7	0
1.8	1
1.9	0
2.0	2
2.1	3
2.2	3
2.3	5
2.4	9
2.5	5
2.6	5
2.7	20



0.1	0
0.2	0
0.3	0
0.4	0
0.5	0
0.6	1
0.7	0
0.8	0
0.9	0
1.0	1
1.1	0
1.2	0
1.3	0
1.4	1
1.5	0
1.6	1
1.7	0
1.8	2
1.9	2
2.0	3
2.1	4
2.2	4
2.3	6
2.4	7
2.5	8
2.6	9
2.7	10
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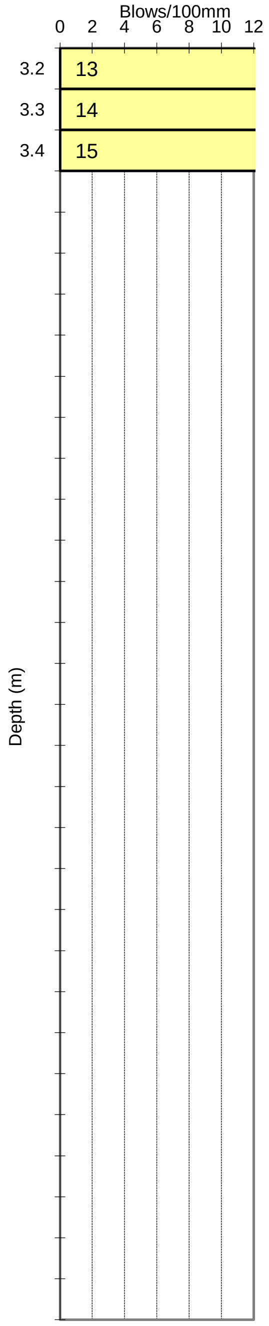
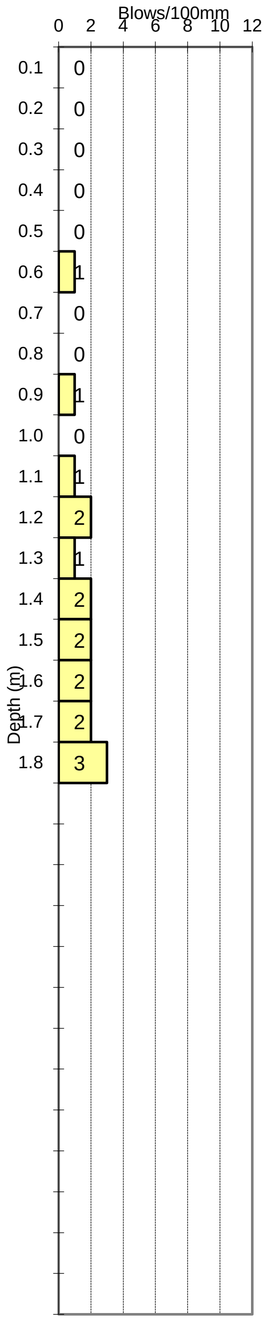
2.9	12
3.0	12
3.1	13



3.2	13
3.3	14
3.4	15



0.1	0
0.2	0
0.3	0
0.4	0
0.5	0
0.6	1
0.7	0
0.8	0
0.9	1
1.0	0
1.1	1
1.2	2
1.3	1
1.4	2
1.5	2
1.6	2
1.7	2
1.8	3

Job No ***GEOTALST03550AA***

AS1289 6.3.2 - 1997 Dynamic Cone Penetrometer Test

Sheet ***2*** of ***11***

Client ***Ricky Lau***

Office ***ALST***

Principal

Date ***23/8/13***

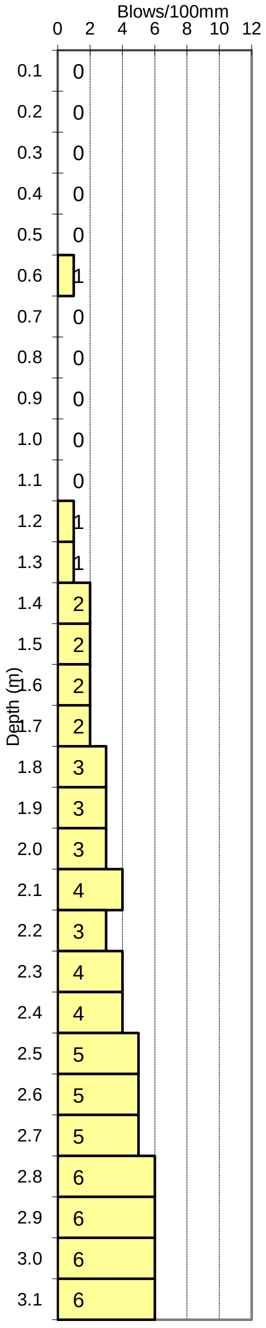
Project ***Shaws Bay Restaurant - Slope Hazard Assessment***

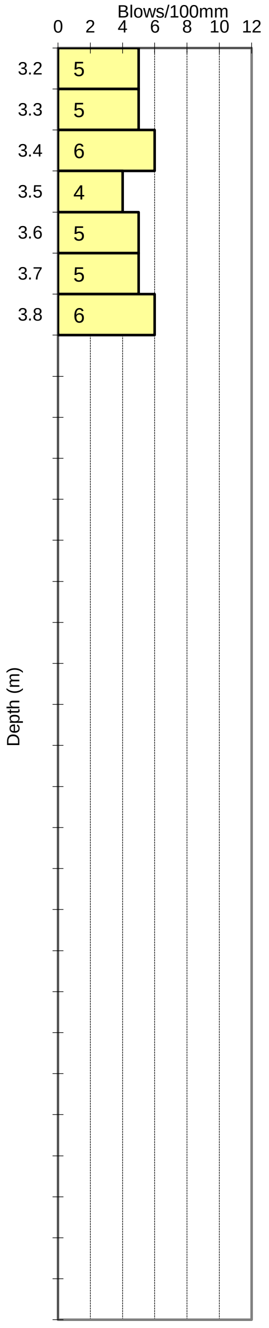
By ***RV***

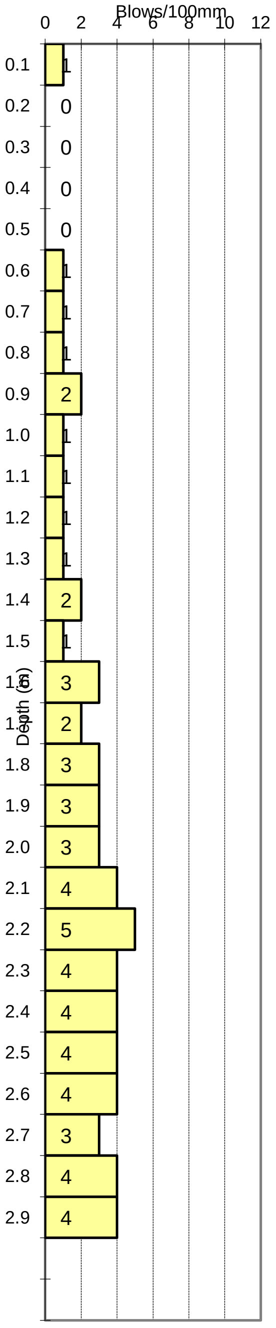
Location ***23 Compton Drive, East Ballina***

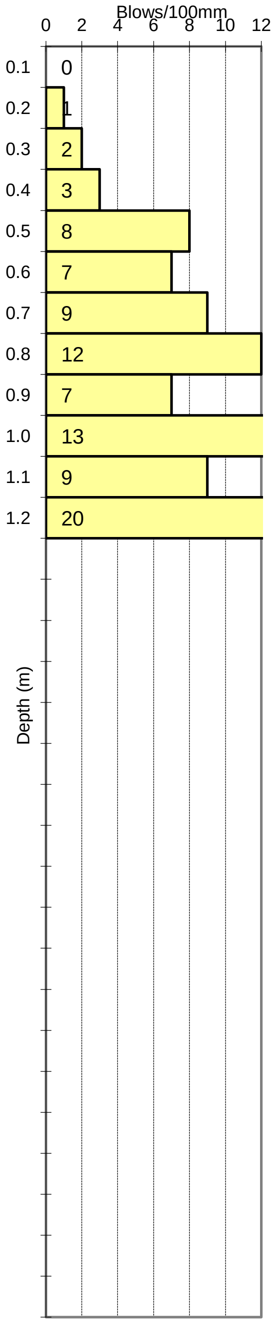
Checked

Test No. **DCP3**	**Test No.** **DCP3**	**Test No.** **DCP5**	**Test No.** **DCP6**
Test Location: Upslope BH2	Test Location: Upslope BH2	Test Location: Crest of slope	Test Location: BH3
RL: +7	RL: +7	RL: +11	RL: -2
Soil Classificatio Sand	Soil Classificatio Sand	Soil Classificatio Sand	Soil Classificatio Sand
Moisture Condition:	Moisture Condition:	Moisture Condition:	Moisture Condition: Wet at 0.8









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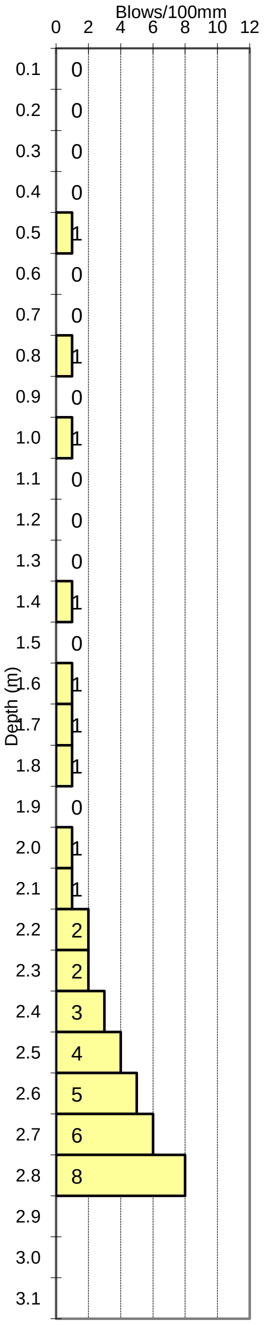
Job No *GEOTALST03550AA*

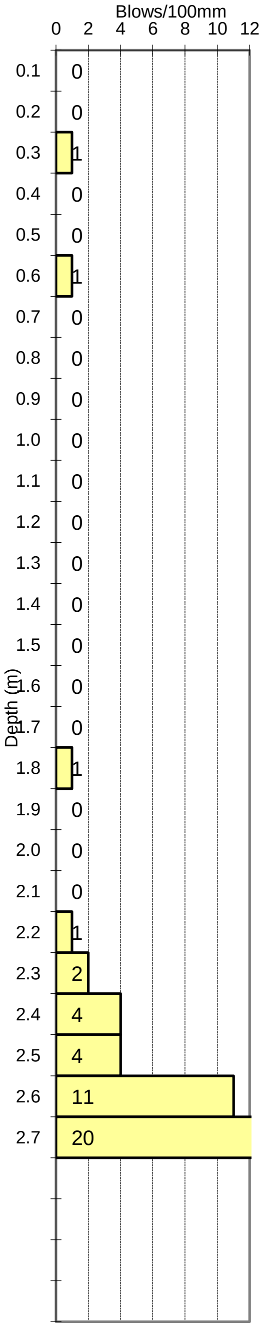
Sheet *3* of *11*

AS1289 6.3.2 - 1997 Dynamic Cone Penetrometer Test

Client	*Ricky Lau*	Office	*ALST*
Principal		Date	*23/8/13*
Project	*Shaws Bay Restaurant - Slope Hazard Assessment*	By	*RV*
Location	*23 Compton Drive, East Ballina*	Checked	

Test No.	***DCP7***	**Test No.**	***DCP8***	**Test No.**		**Test No.**	
Test Location:	Upslope BH5	Test Location:	BH5	Test Location:		Test Location:	
RL:	+4	RL:	+0.3	RL:		RL:	
Soil Classificatio	Sand	Soil Classificatio	Sand	Soil Classificatio		Soil Classificatio	
Moisture Condition:		Moisture Condition:	Wet from 2.2	Moisture Condition:		Moisture Condition:	





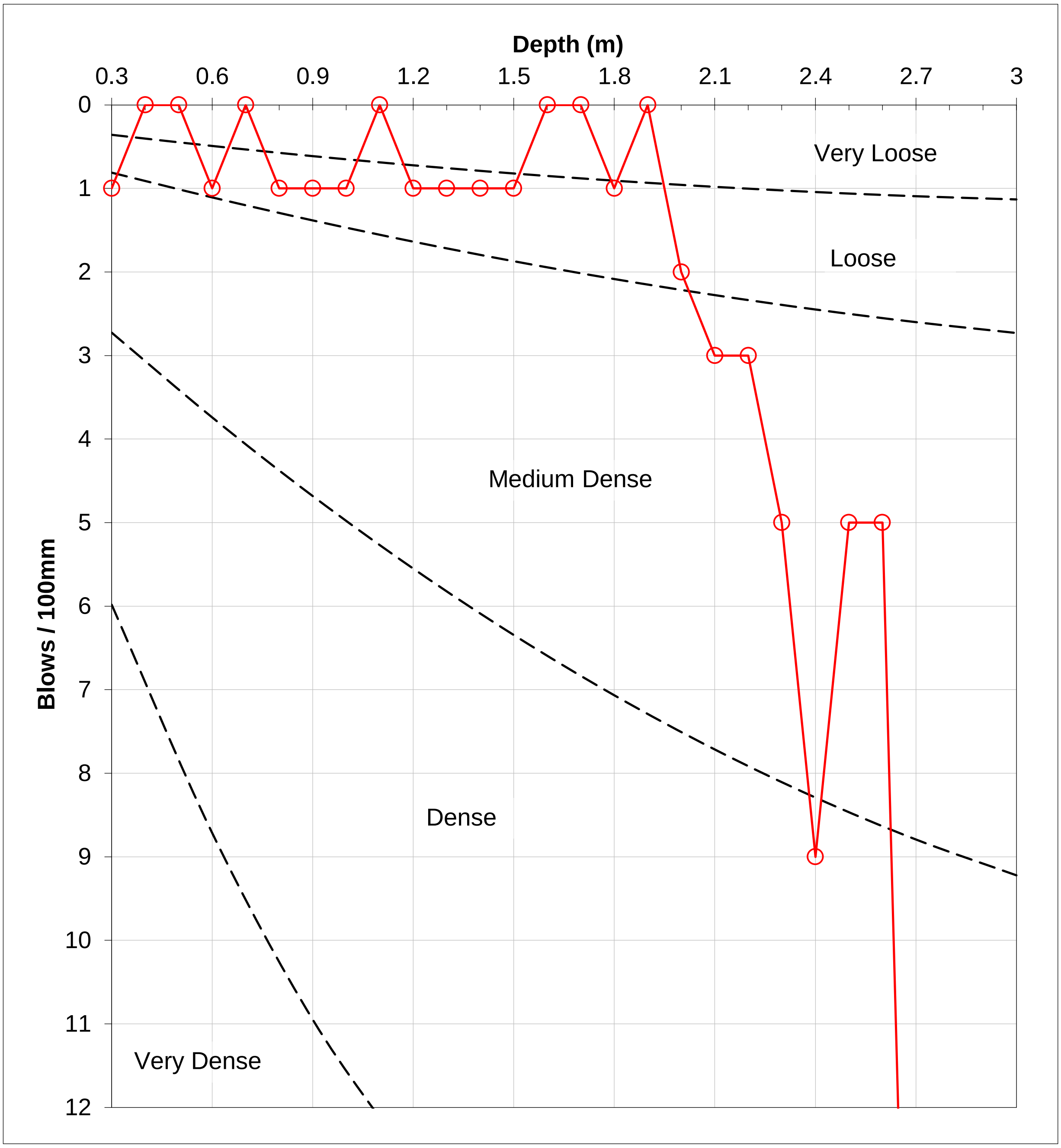
		Job No	***GEOTALST03550AA***
		Sheet	***4*** of ***11***

Density Index Correlation (Sands)

Client	***Ricky Lau***	Office	***ALST***
Principal		Date	***23/8/13***
Project	***Shaws Bay Restaurant - Slope Hazard Assessment***	By	***RV***
Location	***23 Compton Drive, East Ballina***	Checked	

Test No.	***DCP1***
Test Location:	BH1
RL:	-0.6
Soil Classificatio	Sand
Moisture Condition:	Wet from 1.8

Notes:



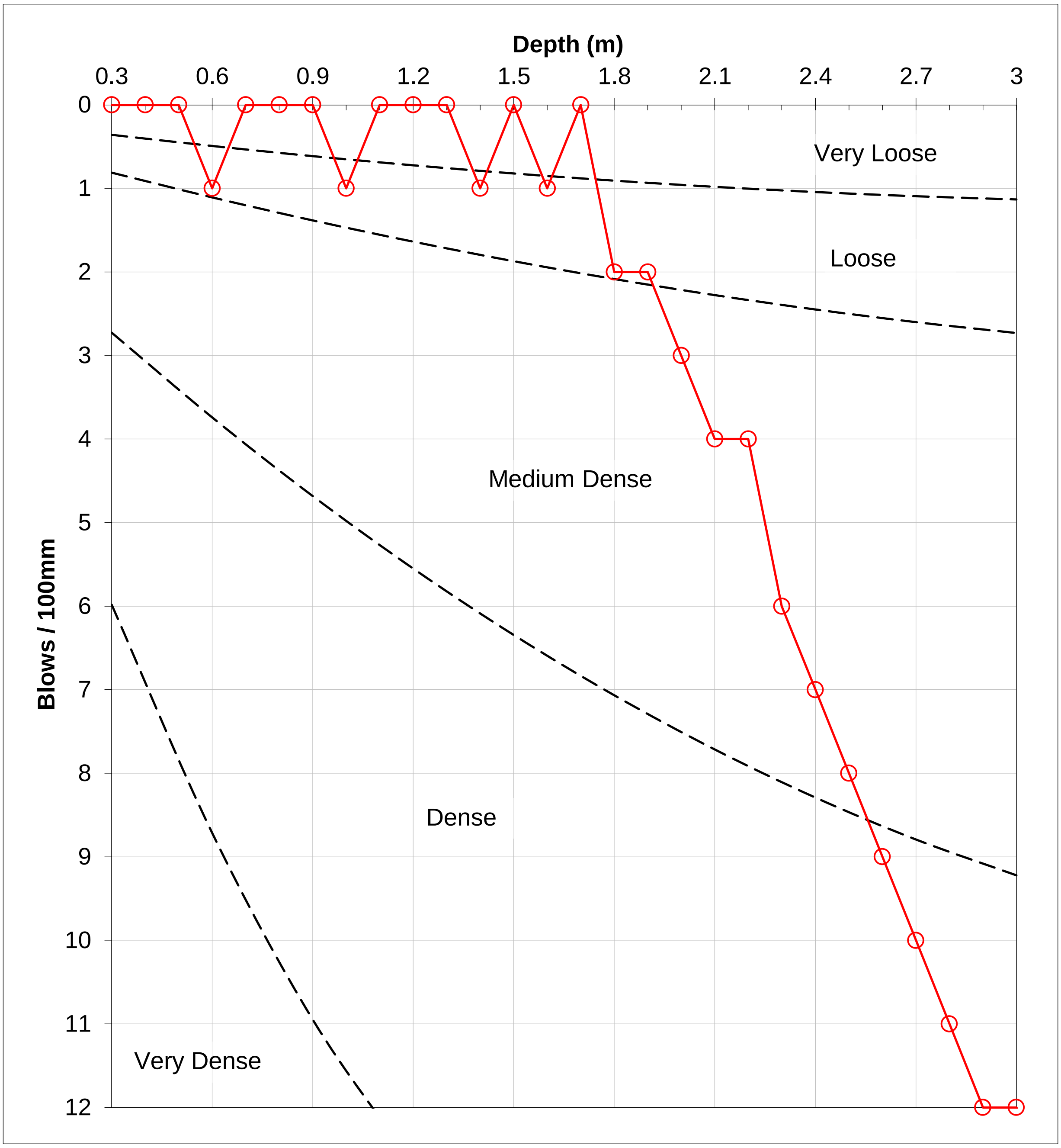
Job No	*GEOTALST03550AA*
Sheet	***5*** of ***11***

Density Index Correlation (Sands)

Client	***Ricky Lau***	Office	***ALST***
Principal		Date	***23/8/13***
Project	***Shaws Bay Restaurant - Slope Hazard Assessment***	By	***RV***
Location	***23 Compton Drive, East Ballina***	Checked	

Test No.	***DPC2***
Test Location:	BH2
RL:	+4
Soil Classificatio	Sand
Moisture Condition:	Wet from 3.0

Notes:



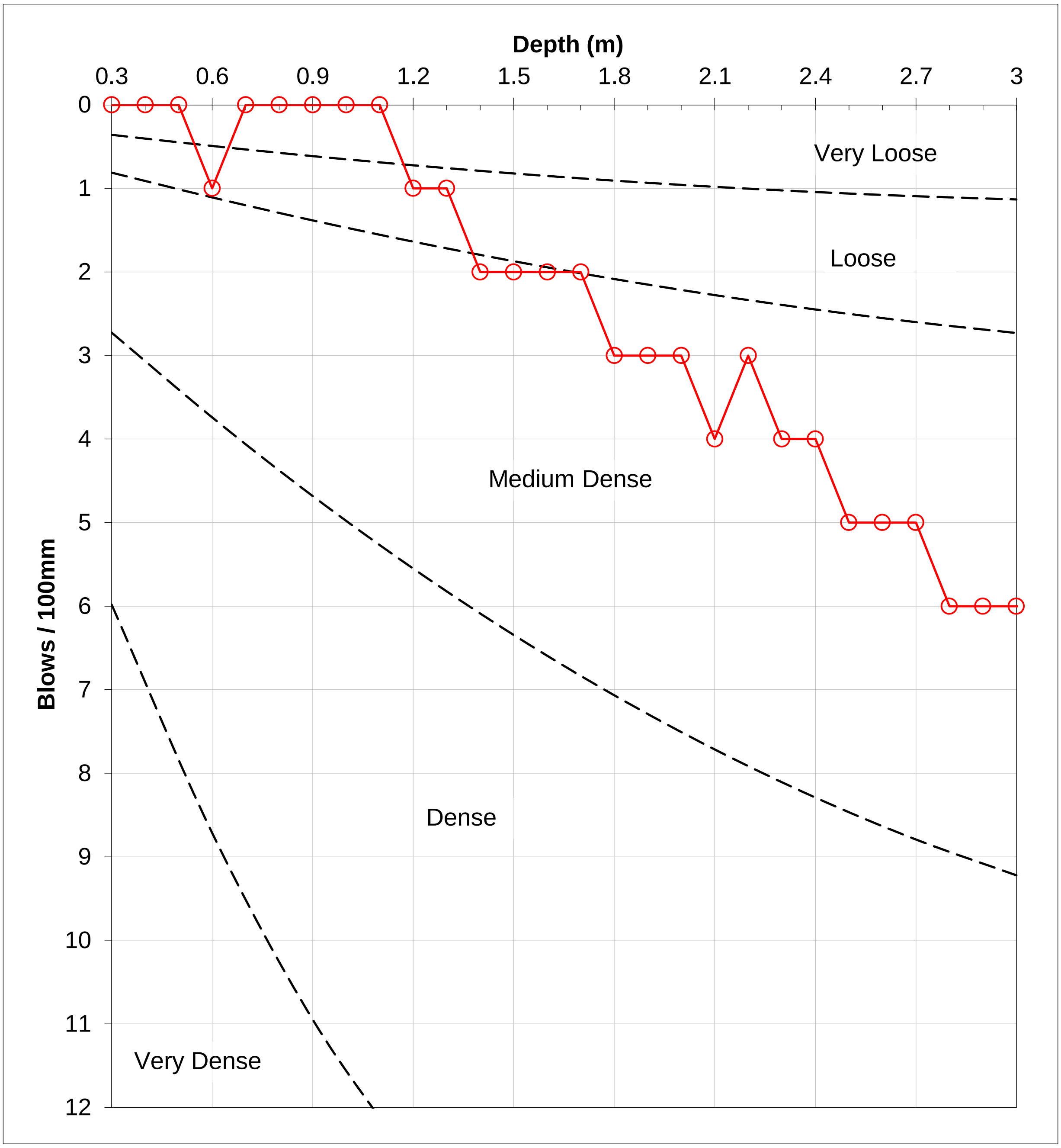
Job No	*GEOTALST03550AA*
Sheet	*6* of *11*

Density Index Correlation (Sands)

Client	*Ricky Lau*	Office	*ALST*
Principal		Date	*23/8/13*
Project	*Shaws Bay Restaurant - Slope Hazard Assessment*	By	*RV*
Location	*23 Compton Drive, East Ballina*	Checked	

Test No.	***DCP3***
Test Location:	Upslope BH2
RL:	+7
Soil Classificatio	Sand
Moisture Condition:	

Notes:



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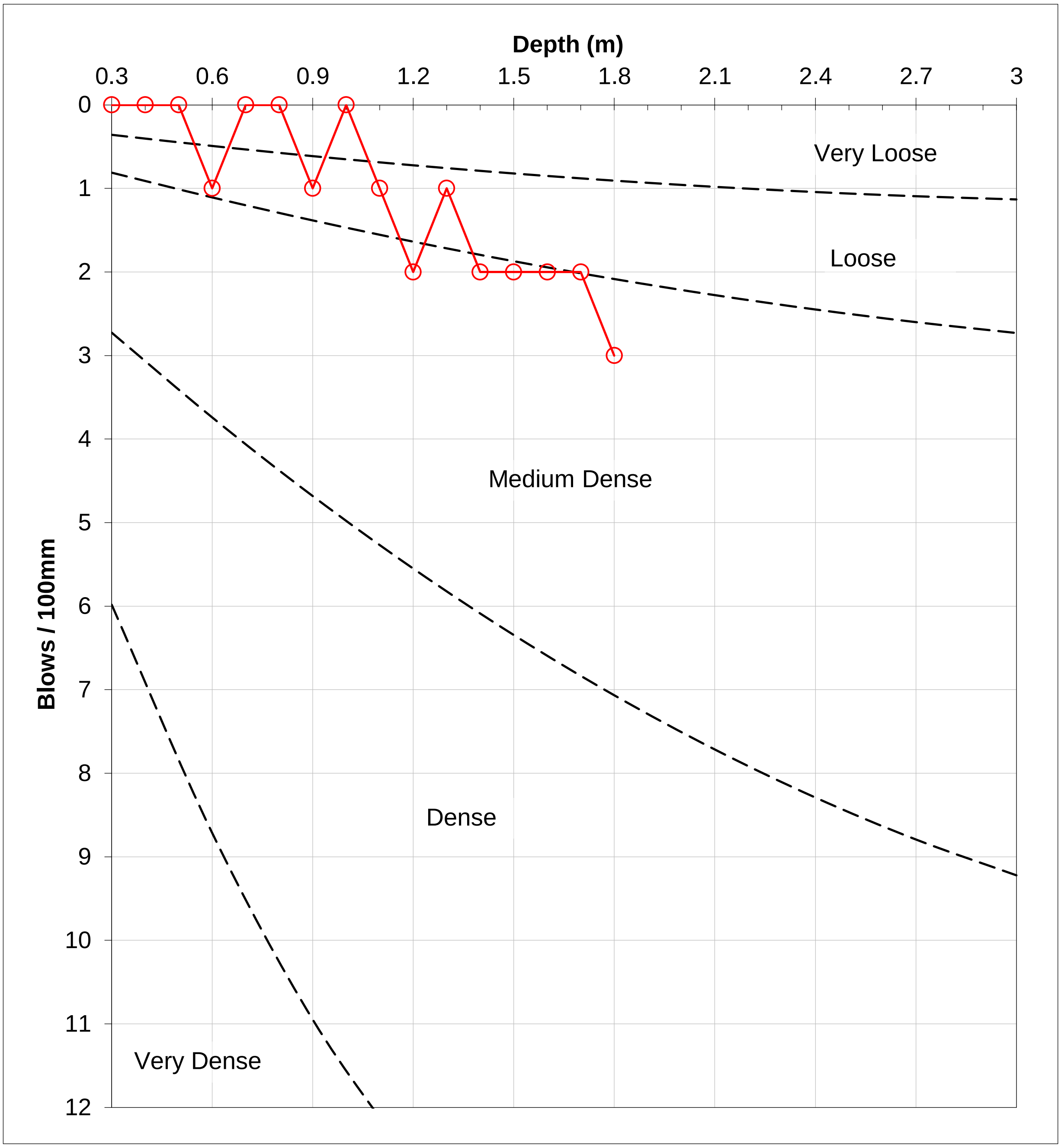
Density Index Correlation (Sands)

Client	*Ricky Lau*	Job No	*GEOTALST03550AA*
		Sheet	*7* of *11*
		Office	*ALST*
Principal		Date	*23/8/13*
Project	*Shaws Bay Restaurant - Slope Hazard Assessment*	By	*RV*
Location	*23 Compton Drive, East Ballina*	Checked	

Test No.	***DCP4***	Notes:
Test Location:	Upslope BH2	
RL:	+9.5	
Soil Classificatio	Sand	
Moisture Condition:		



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Job No *GEOTALST03550AA*

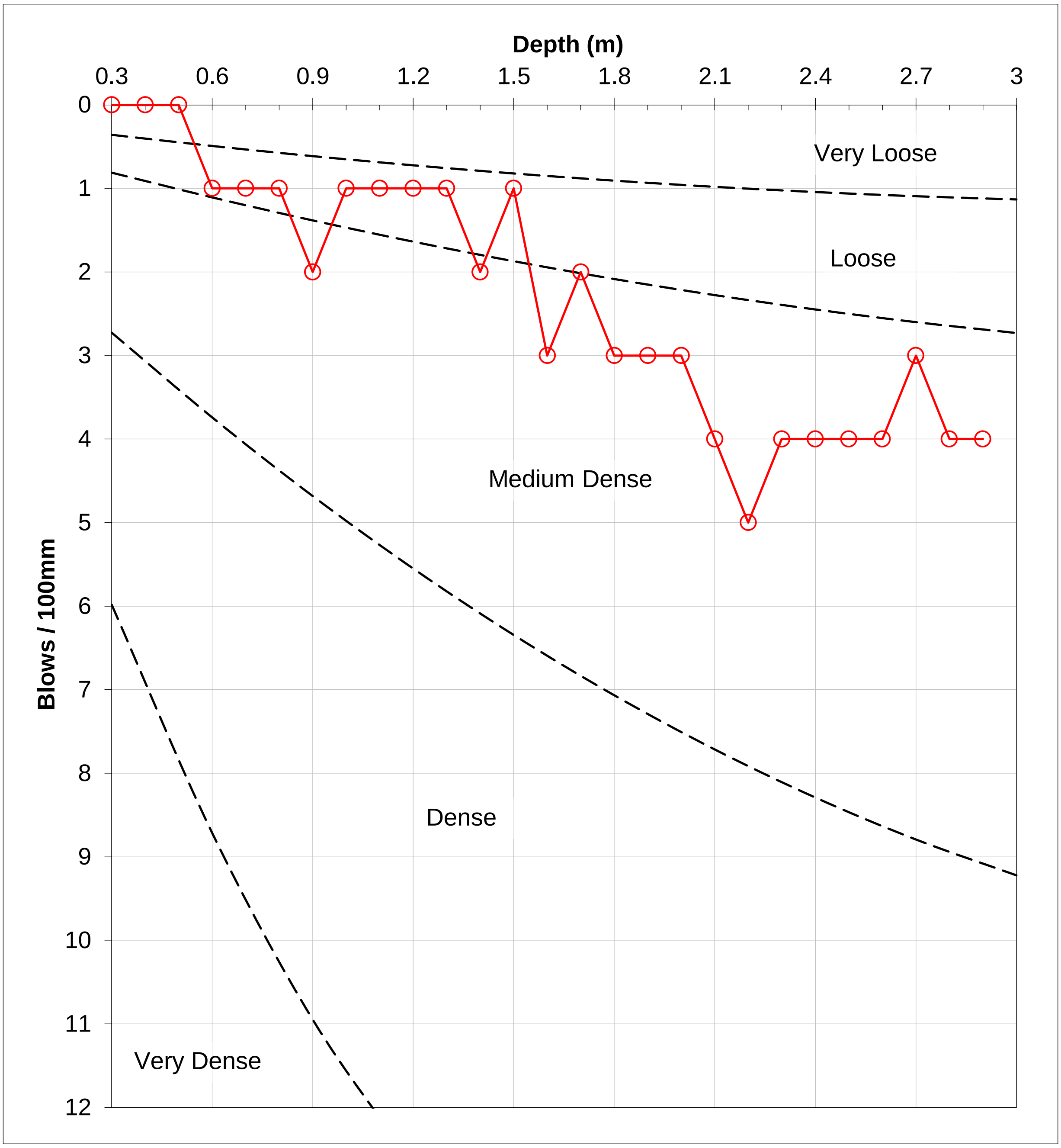
Sheet *8* of *11*

Density Index Correlation (Sands)

Client	*Ricky Lau*	Office	*ALST*
Principal		Date	*23/8/13*
Project	*Shaws Bay Restaurant - Slope Hazard Assessment*	By	*RV*
Location	*23 Compton Drive, East Ballina*	Checked	

Test No.	***DCP5***
Test Location:	Crest of slope
RL:	+11
Soil Classificatio	Sand
Moisture Condition:	0

Notes:



Job No *GEOTALST03550AA*

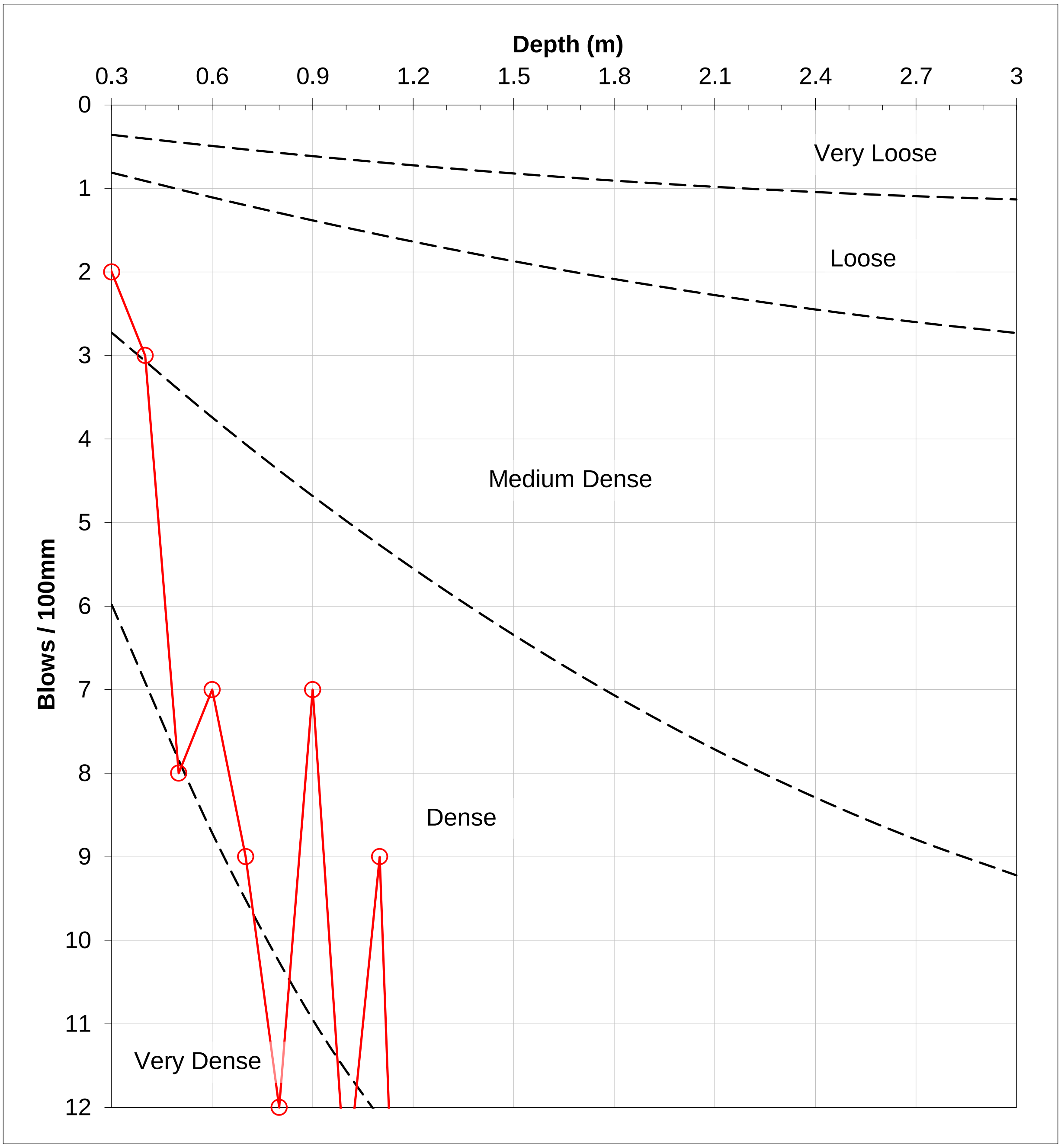
Sheet *9* of *11*

Density Index Correlation (Sands)

Client	*Ricky Lau*	Office	*ALST*
Principal		Date	*23/8/13*
Project	*Shaws Bay Restaurant - Slope Hazard Assessment*	By	*RV*
Location	*23 Compton Drive, East Ballina*	Checked	

Test No.	***DCP6***
Test Location:	BH3
RL:	-2
Soil Classificatio	Sand
Moisture Condition:	Wet at 0.8

Notes:



coffey geotechnics
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A.B.N: 93 056 929 483

Job No *GEOTALST03550AA*

Density Index Correlation (Sands)

Sheet ***10*** of ***11***

Client ***Ricky Lau***

Principal

Project ***Shaws Bay Restaurant - Slope Hazard Assessment***

Location ***23 Compton Drive, East Ballina***

Office ***ALST***

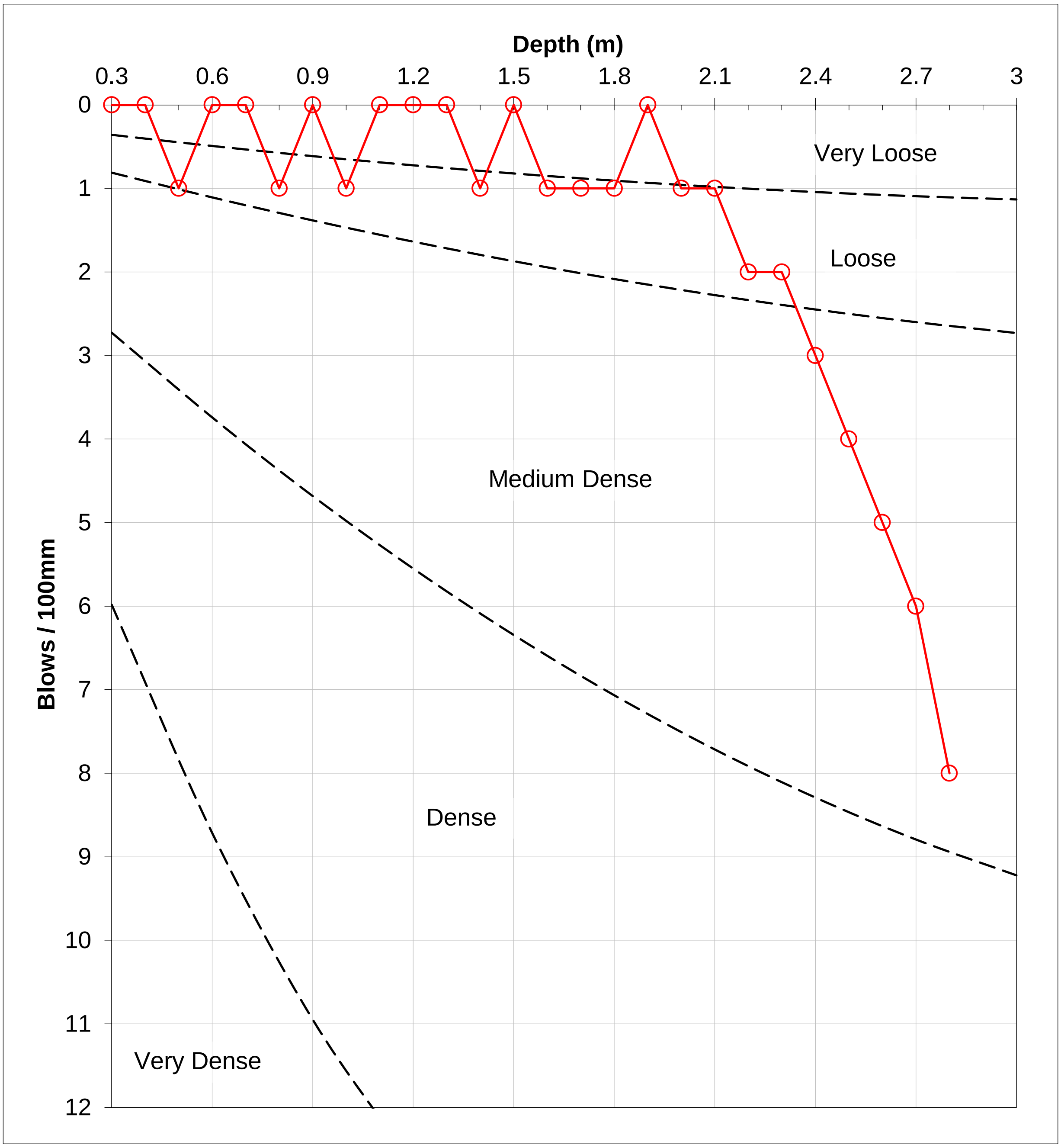
Date ***23/8/13***

By ***RV***

Checked

Test No.	***DCP7***
Test Location:	Upslope BH5
RL:	+4
Soil Classificatio	Sand
Moisture Condition:	

Notes:



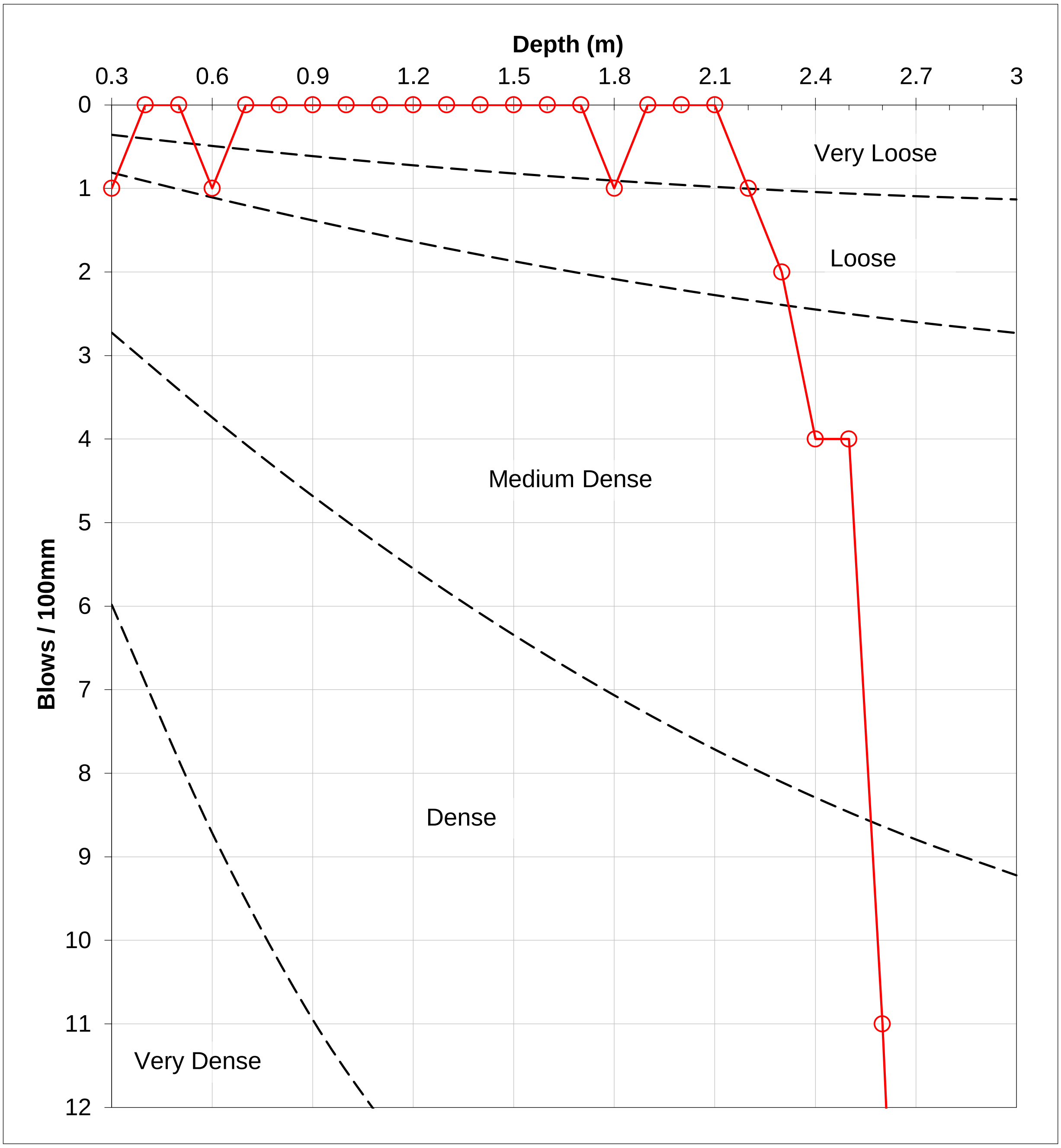
Job No	*GEOTALST03550AA*
Sheet	*11* of *11*

Density Index Correlation (Sands)

Client	***Ricky Lau***	Office	***ALST***
Principal		Date	***23/8/13***
Project	***Shaws Bay Restaurant - Slope Hazard Assessment***	By	***RV***
Location	***23 Compton Drive, East Ballina***	Checked	

Test No.	***DCP8***
Test Location:	BH5
RL:	+0.3
Soil Classificatio	Sand
Moisture Condition:	Wet from 2.2

Notes:



Appendix C

Landslide Risk Management Guidelines Description of Terms

(Appendix C from AGS2007)

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

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

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

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

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

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

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

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

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

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

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

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

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

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

RISK LEVEL IMPLICATIONS

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

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

Landslide Risk Management

Important Information about AGS 2007 Appendix C (1 of 2)

INTRODUCTION

This sheet provides important information on the following Appendix C which has been copied from “Practice note guidelines for landslide risk management 2007”. The “Practice Note” and accompanying “Commentary” (References 1 & 2, hereafter referred to as AGS2007) are part of a series of documents on landslide risk management prepared on behalf of, and endorsed by, the Australian Geomechanics Society. These documents were primarily prepared to apply to residential or similar development.

It should be noted that AGS2007 define landslides as “the movement of a mass of rock, debris or earth down a slope”. This definition includes falls, topples, slides, spreads and flows from both natural and artificial slopes.

LANDSLIDE LIKELIHOOD ASSESSMENT

The assessment of the likelihood of landsliding requires evidence-based judgements.

Judging how often and how much an existing landslide will move is difficult. Judging the likelihood of a new landslide occurring is even harder. Records of past landslides can provide some information on what has happened, but are invariably incomplete and often provide little or no guidance on less frequent events that may occur. Often judgements have to be made about the likelihood of infrequent events with serious consequences, with little or no help from historical records. Slope models, which reflect evidence-based knowledge of how a slope was formed, how it behaved in the past and how it might behave in the future, are used to support judgements about what might happen. Because of the difficulties in assessing landslide likelihood, different assessors may make different judgements when presented with the same information.

The likelihood terms in Appendix C can be taken to imply that it is possible to distinguish between low probability events (e.g. between events having a probability of 1 in 10,000 and 1 in 100,000). In many circumstances it will not be possible to develop defensibly realistic judgements to do so, and so joint terms need to be used (e.g. Likely or Possible). For further discussion on landslide likelihood and other matters see References 3, 4 and 5.

CONSEQUENCES OF LANDSLIDES

There can be direct (e.g. property damage, injury / loss of life) and indirect (e.g. litigation, loss of business confidence) consequences of a landslide. The assessment of the importance (seriousness) of the consequences is a value judgement best made by those most affected (e.g. client, owner, regulator, public). The main role of the expert is usually to understand and explain what and who might be affected, and what damage or injury might occur.

Appendix C implies that we can anticipate total cost (direct and indirect) of landslide damage to about half an order of magnitude (e.g. the difference between $30,000 and $100,000). This involves predicting the location, size, travel distance and speed of a landslide, the response of a building (often before it has been built), the nature and the extent of damage, repair costs as well as indirect consequences such as legal costs, accommodation etc. There can be other direct and indirect consequences of a landslide which can be difficult to anticipate, let alone quantify and cost. The situation is analogous to the cost of work place accidents where the hidden costs can range from less than one to more than 20 times the visible direct costs (Reference 5).

In many circumstances it will not be possible to develop defensibly realistic judgements to enable use of a single consequence descriptor from Appendix C, and so joint terms need to be used (e.g. Minor or Medium). In our experience, explicit descriptions of potential consequences (e.g. rocks up to 0.5m across may fall on a parked car) help those affected to make their own judgements about the seriousness of the consequences.

RISK MATRIX

The main purpose of a risk matrix is to help rank risks, set priorities and help the decision making process. The risk terms should be regarded only as a guide to the relative level of risk as they are the product of an evidence-based quantitative judgement of likelihood and a value judgement about consequences, both of which involve considerable uncertainty. Different assessors may arrive at different judgements on the risk level.

Using Appendix C, many existing houses on sloping land will be assessed to have a Moderate Risk.

Landslide Risk Management

Important Information about AGS 2007 Appendix C (2 of 2)

RISK LEVEL IMPLICATIONS

In general, it is the responsibility of the client and/or owner and/or regulatory authority and/or others who may be affected to decide whether to accept or treat the risk. The risk assessor and/or other advisers may assist by making risk comparisons, discussing treatment options, explaining the risk management process, advising how others have reacted to risk in similar situations, and making recommendations. Attitudes to risk vary widely and risk evaluation often involves considering more than just property damage (e.g. environmental effects, public reaction, political consequences, business confidence etc).

The risk level implications in Appendix C represent a very specific example and are unlikely to be generally applicable. In our experience the typical response of regulators to assessed risk is as follows:

Assessed risk	**Typical response of client/ owner/ regulator/ person affected**
Very High, High [1]	Treats seriously. Usually requires action to reduce risk. Will generally avoid development.
Moderate	May accept risk. Usually looks for ways to reduce risk if reasonably practicable.
Low, Very Low [1]	Usually regards risk as acceptable. May reduce risk if reasonably practicable.

1 The distinctions between Very High and High and between Low and Very Low risks are usually used to help set priorities.

REFERENCES

1. AGS (2007). “Practice note guidelines for landslide risk management 2007”. Australian Geomechanics, Vol. 42, No. 1, pp 63-114.
2. AGS (2007). “Commentary on practice note guidelines for landslide risk management 2007”. Australian Geomechanics, Vol. 42, No. 1, pp 115-158.
3. Baynes, F.J., Lee I.K. and Stewart, I.E., (2002). “A study of the accuracy and precision of some landslide risk analyses.” Australian Geomechanics, Vol. 37, No. 2, pp 149-156.
4. Baynes, et. al., (2007). “Concerns about the Practice Note Guidelines for Landslide Risk Management 2007.” Letter to the editor, Australian Geomechanics, Vol. 2, No. 4, pp 63-114.
5. Moon, A.T., and Wilson, R,A., (2004). “Will it happen? – Quantitative judgements of landslide likelihood”. Proceedings of the Australia New Zealand conference on Geomechnics, Centre of continuing education, University of Auckland, Vol. 2, pp 754-760.