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AUSTRALIAN SOIL & CONCRETE TESTING PTY LTD

GEOTECHNICAL STABILITY ASSESSMENT
8 COOMBURRA CRESCENT
OCEAN SHORES, NSW

181147/1-B
17 May 2018

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181147/1-B ps:PS
17 May 2018

Australian Soil & Concrete Testing Pty Ltd

PO Box 5120

BALLINA MAIL CENTRE NSW 2478

Attention: Mr Darran Kennedy

RE: GEOTECHNICAL STABILITY ASSESSMENT – 8 COOMBURRA CRESCENT, OCEAN SHORES, NSW

Please find attached our report on a geotechnical stability assessment for the proposed residential subdivision at 8 Coomburra Crescent, Ocean Shores.

The report presents the results of field investigations and slope stability studies and provides geotechnical guidelines for residential development of the site.

If you have any questions or wish to discuss or clarify any of the issues raised in this report, please contact Philip Shaw at our Brisbane office.

For and on behalf of

SHAW URQUHART PTY LTD

PHILIP SHAW

Principal Geotechnical Engineer

Distribution: Original held by Shaw Urquhart Pty Ltd

1 electronic copy Australian Soil & Concrete Testing Pty Ltd

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1. INTRODUCTION

This report presents the results of a slope stability assessment carried out by Shaw Urquhart Pty Ltd for Australian Soil & Concrete Testing Pty Ltd (ASCT) at 8 Coomburra Crescent, Ocean Shores, New South Wales.

The proposed development is to subdivide the existing single allotment into four new allotments accessed from a common driveway along the southern boundary.

The proposed allotment layout is shown on the following drawings by Ardill Payne & Partners Pty Ltd:

- Drawing DA01, Issue A, "Existing Site Layout Plan".
- Drawing DA02, Issue C, "Proposed Development Layout Plan".
- Drawing DA03, Issue C, "Proposed Development Driveway Plan and Sections."
- Drawing DA04, Issue B, "Swept Paths Layout Plan".

Copies of the drawings are presented in Appendix D for reference.

It is understood that Byron Shire Council has requested a slope stability study in accordance with the "Practice Note Guidelines for Landslide Risk Management", Australian Geomechanics Society, 2007.

2. FIELD WORK

The field work consisted of the following:

- A site visit by a Geotechnical Engineer on the morning of 19 April 2018. A walk-over assessment was carried out to view surface conditions and make observations of local geology and geomorphology relevant to the stability of the natural slopes on the site.
- Six (6) test pits were excavated on 15 May 2018 at the approximate locations shown on Figure 1. The excavations were carried out using a CAT 305E excavator. The test pits were backfilled with the excavated spoil using the backhoe bucket for compaction. The test pits were carried out in the full-time presence of an experienced Geotechnician from Australian Soil & Concrete Testing Pty Ltd who was responsible for locating the test pits, nominating and directing sampling and testing and preparing field logs of the soil and weathered rock profiles encountered.
- Dynamic Cone Penetrometer (DCP) tests were carried out adjacent to each of the test pits.

Engineering logs of the test pits are presented in Appendix A along with the DCP test results and explanation sheets describing the terms and symbols used.

3. SITE CONDITIONS

3.1 Surface Conditions

Site site observations and surface features are shown on Figure 1.

The site is located in a well established residential area and is surrounded on all sides by existing houses. The site, which is identified as 8 Coomburra Crescent, is accessed by a panhandle from Coomburra Crescent located between numbers 6 and 10.

Slope angle measurements taken at the time of the site visit using a hand-held clinometer are shown on Figure 1.

Slope angles along the panhandle access range between about 10° and 12° increasing to about 14° where the panhandle enters the main site.

The allotment is located topographically below the existing allotments on Coomburra Crescent on the lower flanks of a north-west facing hill.

The land slopes downwards from a high point in the south-east corner towards the north-west, becoming flatter in the north-west corner as shown by the contour plan which forms the base-plan to Figure 1.

Slope angles in the south-eastern part of the site vary between about 13° and 18°. There is a locally steeper area about midway along the southern boundary where slope angles increase to about 23° before reducing to about 10° to 12° in the south-western part of the site. Slope angles on the natural slopes in the north-western part of the site vary between about 6° and 7°.

A small fill platform has been constructed in north-western part of the site with slope angles of about 4°across the platform and batter slopes in the order of 22° to 26° on the down-slope side of the platform. There was also evidence of filling in the south-west corner of the site to the west of the panhandle entrance to the main site.

Mounds of soil and dirt were observed around the base of some of the trees suggesting that soil may have been stripped from the land adjacent to the trees.

Widespread surface water and boggy conditions were observed on the day of the site visit extending over the area shown on Figure 1. It is considered that some of the surface water was due to runoff from the allotments up-slope, but the boggy areas on the steeper slopes were likely to be due to groundwater seepage.

A surface drainage channel discharged onto the site in the south-east corner. Surface water flowed across the site and along the northern site boundary to an existing stormwater inlet located in the north-west part of the site as shown on Figure 1.

3.2 Subsurface Conditions

According to the published geology map of the area (1:250,000 scale “Tweed Heads” sheet), the site is underlain by weathered rocks of the Neranleigh Fernvale Group.

Uncontrolled fill was observed in test pits TP1 and TP3 to 1.0m and 0.7m depth respectively. A thin surface layer of fill (0.1m) was also observed in test pit TP2.

Elsewhere the site was underlain by stiff to hard, residual, clayey soil with gravel, cobbles and boulders. The fill was underlain by similar soils.

With the exception of test pit TP6, no topsoil was encountered at the locations investigated.

The subsurface materials encountered in each test pit are summarised in Table 1.

TABLE 1: SUMMARY OF SUBSURFACE CONDITIONS

Location	Depth (m)			
	Fill	Topsoil	Residual clayey soil, stiff	Residual, clayey soil, very stiff to hard.
TP1	0.0 - 1.0	N/E	1.0 - 3.1	N/E
TP2	0.0 - 0.1	N/E	0.1 - 1.6*	N/E
TP3	0.0 - 0.7	N/E	N/E	0.7 - 2.5
TP4	N/E	N/E	0.0 - 2.2*	N/E
TP5	N/E	N/E	0.0 - 2.0*	N/E
TP6	N/E	0.0 - 0.1	0.2 - 1.4*	N/E

N/E = Not Encountered

* Excavator refusal on gravel, cobbles and boulders

3.3 Groundwater

Groundwater seepage was observed at 1.1m depth in test pit TP4 at the time of the investigations.

On the basis of site observations at the time of the site visit on 19 April 2018, it is considered likely that groundwater seepage occurs across a significant portion of the site.

Widespread surface water and boggy conditions were observed on the day of the site visit as shown on Figure 1. It is considered that some of the surface water was due to runoff from the allotments up-slope, but the boggy areas on the steeper slopes were likely to be due to groundwater seepage.

4. SLOPE STABILITY & LANDSLIDE RISK ASSESSMENT

4.1 Discussion

Natural slopes are formed by processes which reflect the site geology, climate and environment. These processes result in ongoing down slope movements of materials within the slope. The area of influence of these down slope movements may range from local to regional. The natural process may be influenced by human intervention in the form of construction and related activities. It must be accepted that the hazards associated with construction on or immediately adjacent to steep slopes are greater than construction on level ground in the same geological environment. The impact of construction may be adverse and poor construction practice and techniques may increase the potential likelihood of ground movement.

It is not technically feasible to assess the stability of the natural slopes on a particular site in absolute terms such as “stable” or “unstable”. However, a degree of likelihood of slope movement can be assessed by the recognition of surface features supplemented by limited information on the regional and local subsurface conditions and with the benefit of experience gained in similar geological and engineering environments.

4.2 Definitions of Terms Used

The following brief definitions of terms used in this report are taken from the Australian Geomechanics Society “Guideline for Landslide Susceptibility, Hazard and Risk Zoning for Land Use Planning”, Australian Geomechanics Volume 42, No. 1 March 2007.

Landslide - The movement of a mass of rock, debris, or earth (soil) down a slope.

Landslide inventory – An inventory of the location, classification, volume, activity and date of occurrence of individual landslides in an area.

Hazard – A condition with the potential for causing an undesirable consequence. Landslide hazard includes landslides which have their source in the area or may have their source outside the area but may travel to or regress into the area.

Risk – a measure of the probability and severity of an adverse effect to health, property or the environment. Risk is often estimated by the product of probability and consequences. However, a more general interpretation involves a comparison of the probability and consequences in a non-product form.

Zoning – The division of land into homogeneous areas or domains and their ranking according to degrees of actual or potential landslide susceptibility, hazard or risk.

The general approach of the Australian Geomechanics Society publications is to define and assess “risk” as a function of the likelihood or probability of an event occurring (such as a landslide) and the potential consequences of such an event (eg. damage to property, loss of life).

4.3 Landslide Inventory

Shaw Urquhart Pty Ltd is not aware of any documented record of historical slope instability on or in the vicinity of the site. The periodic history and therefore frequency of slope instability on the site is not known.

4.4 Identification of Potential Hazards

On this site, the main potential landslide and related hazards are identified as follows:-

- Uncontrolled fill on the lower north-western part of the site with steep batter slopes.
- Natural steep slopes (generally steeper than 18˚) in the upper central part of the site and in the north-western corner.
- Groundwater seepage at about mid-slope in the central part of the site.

The hazards have been identified from a site walk-over assessment and observations by a Geotechnical Engineer as described in Sections 2 and 3.

4.5 Hazard Zoning

4.5.1 General

The main causes of landslides are well documented in the literature and include the following factors:

- Slope angle.
- Underlying geology and soil types.
- Vegetation cover.
- Variable and transient factors such as rainfall intensity, overland water flows, groundwater flows, piezometric pressure and seismic vibrations.
- Presence of soil masses in a potentially unstable condition.
- Man-made factors such as excavations, construction activity, removal of vegetation and changes to the surface and subsurface drainage.

In a given area, some of the above factors can be identified, while other possible contributing factors can be considered. From a study of existing landslides and an assessment of the likely mechanisms and influences on these events, it is possible to develop an understanding of the processes involved which in turn allows an assessment to be made of the potential, relative likelihood of similar conditions arising in other adjacent areas.

Landslides within the study area may also be induced by man-made factors. Known causes of landslides in other areas include but are not limited to:

- Construction of loose, uncompacted fill slopes.
- Undercutting of steep slopes.
- Relocation of water courses adjacent to the toes of slopes.

- Concentrated stormwater run-off from roads or building platforms causing fill failures.
- Poor design and/or construction of retaining structures.
- Ground saturation of land below septic waste disposal absorption fields.

4.5.2 Qualitative Measures of Likelihood

The qualitative measures of Likelihood presented in Table 2 have been adopted for this study consistent with the terminology of Appendix C of the Australian Geomechanics Society "Practice Note Guidelines for Landslide Risk Management", Australian Geomechanics Vol 42 No 1 March 2007. A copy is presented in Appendix B of this report.

TABLE 2: QUALITATIVE MEASURES OF LIKELIHOOD OF INSTABILITY

Approximate Annual Probability	Description	Descriptor
10^{-2}	The event will probably occur under adverse conditions over the design life	Likely
10^{-3}	The event could occur under adverse conditions over the design life	Possible
10^{-4}	The event might occur under very adverse circumstances over the design life	Unlikely
10^{-5}	The event is conceivable but only under exceptional circumstances over the design life	Rare
10^{-6}	The event is inconceivable or fanciful over the design life	Barely Credible

4.5.3 Zones of Likelihood of Instability

Taking into account the measures described above, zones of likelihood of instability have been assigned on the basis of slope angle as follows:-

- **Barely Credible:** Gently sloping to flat-lying areas with slope angles of less than 7°. This does not include the potential for localised instability on drainage ditches, fill stockpiles or other man-made features.
- **Rare:** - Gently sloping areas and the crests and upper slopes of ridges and spurs with slope angles of greater than 7˚ to 12˚.
- **Unlikely: -** Areas with slope angles of greater than 12˚ to 18˚.
- **Possible:** - Areas with slope angles of greater than 18˚ to 25˚.

- **Likely:** Very steep slopes in residual soils with slope angles generally steeper than 25˚. Slopes steeper than 25˚ were not observed on the natural slopes on this site.

It should be appreciated that the likelihood of slope instability is not defined by slope angle alone and hazard zoning needs to also take into account many other parameters including drainage, observations on site and site geology as understood from subsurface investigations.

The interpreted zones of different likelihood of instability are presented on Figure 2. These zones are as interpreted from measured slope angles, site observations and subsurface investigations and may not strictly follow the simplified slope angle categories described previously.

4.6 Quantitative Assessment

4.6.1 Cross Sections

The survey contours on the Ardill Payne & Partners Pty Ltd Drawing No. DA01 Issue A were used as the basis for developing topographical cross sections across the site.

Two cross sections (A and B) were selected at the locations shown on Figure 1 and a subsurface geotechnical design profile was formulated from the engineering logs of the nearest test pits.

For the purpose of the quantitative stability analyses, the following assumptions have been made:

- The depth to weathered rock has been assumed to coincide with excavator refusal depth.
- Stability analyses have been carried out using the computer program SLOPE/W for dry conditions and for extreme conditions were the soils above the weathered rock are assumed to be fully saturated. These groundwater conditions are also considered to be extreme given the limited catchment above the building area.
- The analyses have been carried out for the existing undeveloped slopes.

4.6.2 Results of Stability Analyses

The results of the stability analyses are presented in Table 3 and selected computer stability plots are presented in Appendix C. Geotechnical strength parameters have been assumed based on our experience with similar materials and are shown on the stability plots in Appendix C.

TABLE 3: SUMMARY OF FACTORS OF SAFETY AGAINST INSTABILITY

Condition Analysed	Estimated Factor of Safety	
	Section A	Section B
Existing undeveloped slopes – dry	2.16	2.44
Existing undeveloped slopes – residual soil saturated	1.32	1.49

Generally a factor of safety of 1.5 is considered to be acceptable under normal operating conditions with a reduced factor of safety of 1.3 considered to be acceptable under extreme conditions.

The stability analyses show that the stability of the steeper parts of the undeveloped slopes are only marginally acceptable under extreme conditions. Development on these steeper slopes will need to be carried out in such a way as to not contribute to further loading the slopes and reducing the factor of safety.

4.7 Geotechnical Constraints to Residential Development

The development constraints outlined in Table 4 may be considered typical for a site of this type and may be considered for preliminary concept planning purposes.

TABLE 4: PROPOSED DEVELOPMENT CONSTRAINTS – RESIDENTIAL STRUCTURES

Barely Credible (Less than 7°)	• No specific constraints other than good engineering and construction practice. • May be settlement issues if areas of uncontrolled fill are present.
Rare (7°-12°)	• Minimise earthworks. Maximum unsupported cut depths and fill thicknesses of 2.0m battered no steeper than 1V:2H are recommended unless subject to site-specific engineering investigations and design. Steeper and deeper unsupported cuts and fills should be supported with engineered retaining walls. • Pre-strip the vegetation and topsoil prior to placement of any filling, and bench engineered fill into the natural slope and compact to the requirements of AS3798, "Guidelines on earthworks for commercial and residential developments". • Provide appropriate surface and subsurface drainage, and direct water collected by these drainage systems, together with run-off from gutters, down-pipes, driveways and paved areas, into the stormwater reticulation system or discharge in a controlled manner into existing natural drainage features on the site. • Pay particular attention to drainage and erosion control measures during site development. Areas where surface groundwater seepage currently exists or becomes apparent during or immediately after periods of heavy rainfall may require sub-soil drains.
Unlikely (12°-18°)	For residential buildings constructed on the natural slopes and founded in residual soils, it is recommended that the type of building generally be restricted to lightweight slope-sensitive structures of timber or similar construction to limit surcharge loadings on the slopes. Depending on the results of an appropriate, site-specific geotechnical assessment, the constraints on development are expected to typically include: • Avoid development near locally over-steepened areas or gullies. • Pre-strip the vegetation/topsoil prior to placement of any filling, bench engineered fill into the natural slope and compact to the requirements of AS3798, "Guidelines on earthworks for commercial and residential developments".

	• Minimise bulk earthworks. Maximum unsupported cut depths and fill thicknesses of 1.0m, and batters no steeper than 1V:2H are recommended unless subject to site-specific engineering investigations and design. Steeper and deeper cuts/fills should be supported with engineered retaining walls. • Locate footings on weathered rock where practical. • Found engineered retaining walls in rock where practicable, and design the walls to resist applied soil and water forces, allowing for the sloping ground and any surcharge loadings. • Provide appropriate surface and subsurface drainage, and direct water collected by these drainage systems, together with run-off from gutters, down-pipes, driveways and paved areas, into the stormwater reticulation system or discharge in a controlled manner into existing natural drainage features on the site. • Pay particular attention to drainage and erosion control measures during site development. Areas where surface groundwater seepage currently exists or becomes apparent during or immediately after periods of heavy rainfall may require sub-soil drains.
Possible **(18°-25°)**	On this site, it is recommended that residential development should not extend into areas of Possible instability unless sufficient, appropriate geotechnical studies are carried out to enable the area to be re-zoned as Unlikely or better. This may result in modification of the natural ground surface to achieve the same outcome. The feasibility of developing in these areas will depend on the nature of the proposed development and proposed changes to the ground topography. Further discussion is presented in Section 5.0

In general it is recommended that all development on hillside areas should follow good hillside construction practice in accordance with the information sheets presented in Appendix B. These are taken from the Australian Geomechanics Society "Practice Note Guidelines for Landslide Risk Management", Australian Geomechanics Vol 42, No 1, March 2007.

4.8 Specific Comments on the Proposed Development

4.8.1 Proposed Driveway

The proposed bulk earthworks associated with the driveway as shown on Ardill Payne & Partners Drawing Nos. DA2 & DA3 are considered to be acceptable.

The driveway passes through an area of Possible Likelihood of instability but is entirely in cut in this area.

There is potential for instability on the steeper slopes on Proposed Lot 3 to extend up-slope to beneath the driveway but it is expected that development improvements on Lot 3, as discussed in Section 4.8.3, will reduce the potential for this to occur.

4.8.2 Uncontrolled Fill

Uncontrolled fill is present on the lower slopes of Proposed Lots 1, 2 and 3 and, whilst not a slope stability issue, will need to be addressed at the time of site classification and footing design.

4.8.3 Proposed Lot 3

The natural slopes on part of Proposed Lot 3 are considered to have a Possible likelihood of instability and in their present condition are considered to be unsuitable for residential development.

It is recommended that measures be taken to address the seepage encountered in test pit TP4 and to modify the topography such that the allotment can be re-zoned as Unlikely or better.

It may be possible to do this in conjunction with the proposed driveway bulk earthworks.

Alternatively, if the allotment is approved in its current condition, future residential development will need to take into consideration the potential for instability of the natural slopes and either modify the slopes or design any structures on the slopes to withstand the likely ground movement associated with the potential instability.

5. FUTURE DESIGN LEVEL INVESTIGATIONS

It is recommended that at, the time of construction, a site-specific geotechnical investigation and risk assessment be carried out for each proposed residential allotment and/or building envelope which is located in a zone of Unlikely instability (areas with slopes of 12˚ or steeper).

For and on behalf of

SHAW URQUHART PTY LTD

UNDERSTAND THE LIMITATIONS OF YOUR GEOTECHNICAL REPORT

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This report has been based on project details as provided to us at the time of the commission. It therefore applies only to the site investigated and to a specific set of project requirements as understood by Shaw:Urquhart.

If there are changes to the project, you need to advise us in order that the effect of the changes on the report recommendations can be adequately assessed. Shaw:Urquhart cannot take responsibility for problems that may occur due to project changes if they are not consulted.

It is important to remember that the subsurface conditions described in the report represent the state of the site at the time of investigation. Natural processes and the activities of man can result in changes to site conditions. For example, ground water levels can change or fill can be placed on a site after the investigation is completed. If there is a possibility that conditions may have changed with time, Shaw:Urquhart should be consulted to assess the impact on the recommendations of the report.

The site investigation only identifies the actual subsurface conditions at the location and time when the samples were taken. Geologists and engineers then extrapolate between the investigation points to provide an assumed three-dimensional picture of the site conditions. The report is based on the assumption that the site conditions as identified at the investigation locations are representative of the actual conditions throughout an area. This may not be the case and actual conditions may differ from those inferred to exist. This will not be known until construction has commenced. Your geotechnical report and the recommendations contained within it can therefore only be regarded as preliminary.

In the event that conditions encountered during construction are different to those described in the report, Shaw:Urquhart should be consulted immediately. 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, the services of Shaw:Urquhart should be retained through the development stage of a project.

Problems can occur when other design professionals misinterpret a report. To help avoid this, Shaw:Urquhart should be retained to work with other design professionals to explain the implications of the report.

This report should be retained as a complete document and should not be copied in part, divided or altered in any way.

It is recommended that Shaw:Urquhart is retained during the construction phase to confirm that conditions encountered are consistent with design assumptions. For example, this may involve assessment of bearing capacity for footings, stability of natural slopes or excavations or advice on temporary construction conditions.

This document has been produced to help all parties involved recognise their individual responsibilities.

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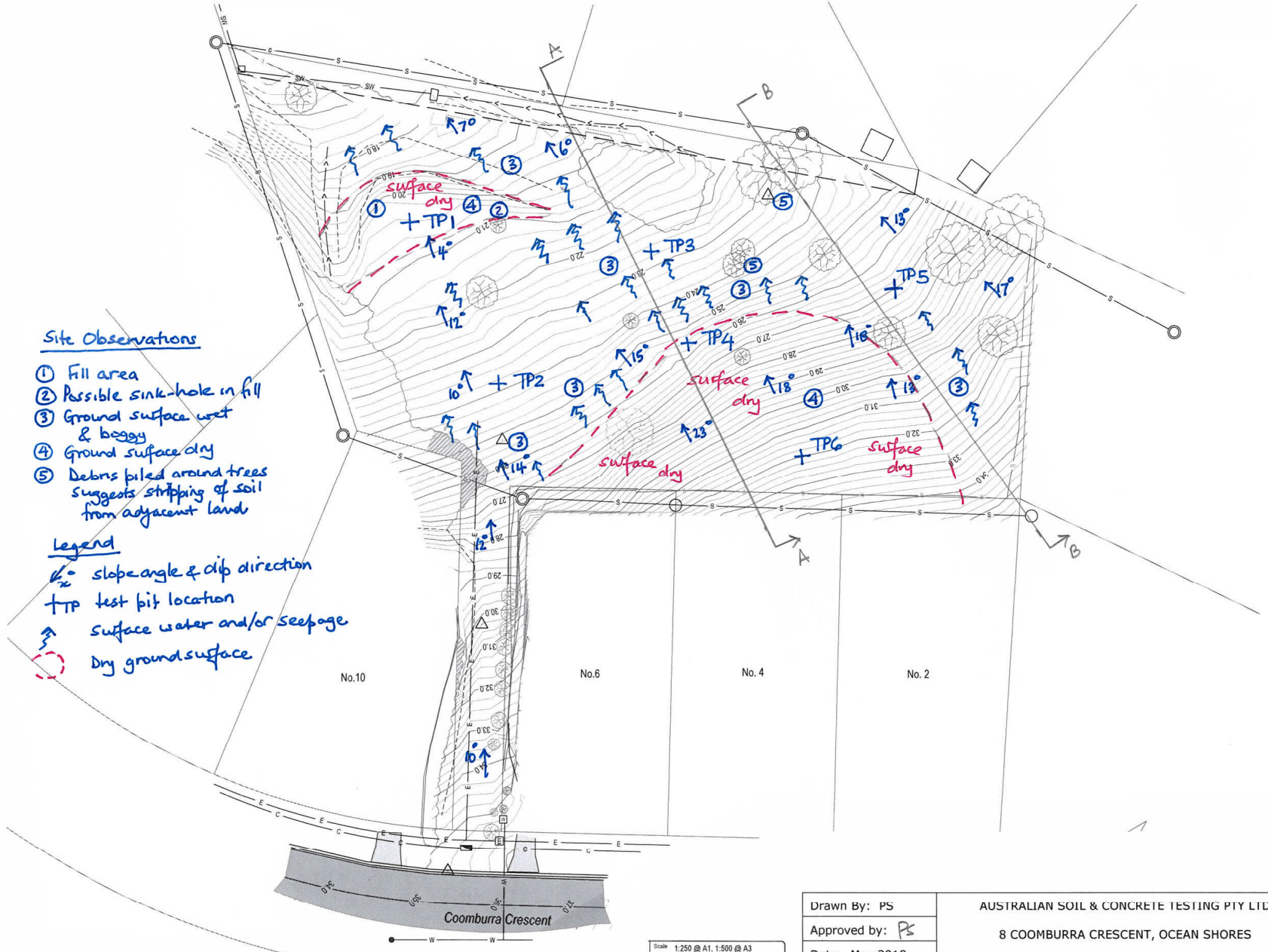

Baseplan by Ardill Payne & Pts

Drawn By: PS	AUSTRALIAN SOIL & CONCRETE TESTING PTY LTD	Figure 1
Approved by: PS	8 COOMBURRA CRESCENT, OCEAN SHORES	
Date: May 2018	**SITE OBSERVATIONS AND APPROXIMATE TEST PIT LOCATIONS**	Job No.: 181147/1
Scale: as shown		

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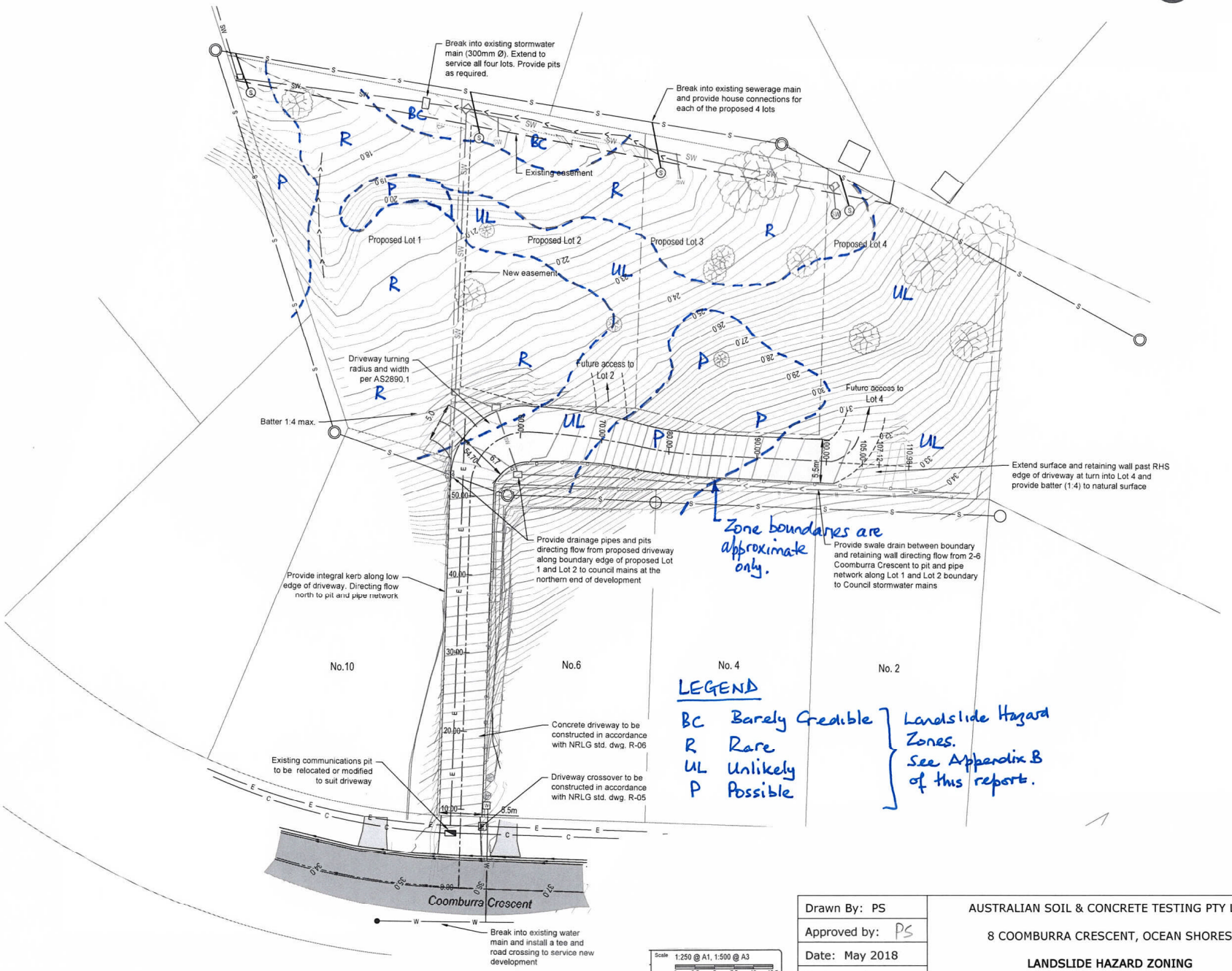

Baseplan by Ardill Payne & Partners

Drawn By: PS	AUSTRALIAN SOIL & CONCRETE TESTING PTY LTD	Figure 2
Approved by: PS	8 COOMBURRA CRESCENT, OCEAN SHORES	
Date: May 2018	**LANDSLIDE HAZARD ZONING**	
Scale: as shown		Job No.: 181147/1

APPENDIX A

ENGINEERING LOGS OF TEST PITS & DCP TEST RESULTS

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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% Fined 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		CEMENTED	
Layers	Continuous across exposure of 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.

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Explanation Sheet (2 of 2) – Soil Description

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

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

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
CRACK	A surface or discontinuity 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.	
PARTING	A surface or discontinuity across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
SHEARED ZONE	Zone of deformation in clayey soil which may contain roughly parallel, near planar, curved or undulating boundaries containing one or more closely spaced, smooth or slickensided, surfaces. The soil within the shear zone is likely to have been significantly remoulded.	
FISSURE	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 and lower strength 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.	

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Engineering Log - Test Pit

Test pit No.	**TP1**
Sheet	1 of 1
Job No.:	**181147/1**
Client:	**AUSTRALIAN SOIL AND CONCRETE TESTING PTY LTD**
Project:	**8 COOMBURRA CRESCENT, OCEAN SHORES**
Test pit location:	**REFER FIGURE 1**
Coordinates:	
Date started:	**11.5.2018**
Date completed:	**11.5.2018**
Logged by:	**DK**
Checked by:	

Equipment Type And Model: CAT 305E | Pit Orientation: | R.L. Surface:

Excavation Dimensions: m long m wide | Datum:

excavation information						material substance					
method	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	structure and additional observations
E							CL	Silty CLAY: medium plasticity, dark brown.	W	S	TOP SOIL
							CL	Gravelly, Silty CLAY: medium plasticity, brown orange, fine to coarse grained gravel and large boulders.	M	F	FILL
					0.5		CL	Gravelly, Silty CLAY: medium plasticity, dark brown, fine to coarse grained gravel and large boulders.			
					1.0		CH	Gravelly, Silty CLAY: high plasticity, dark brown, grey, fine to coarse grained gravel and large boulders.		St	RESIDUAL PP=150kPa
					1.5		CH	Silty CLAY: high plasticity, grey, orange, with some large boulders and some fine to medium grained gravel.			PP=200kPa
					2.0						
					2.5			Silty CLAY: high plasticity, grey, brown, red, with some fine to medium grained gravel.		St/VSt	PP=200kPa
					3.0			Test pit TP1 terminated at 3.1m			
					3.5						
					4.0						

TEST PIT WO SKETCH TEST PIT LOGS.GPJ SHAW URQUHART.GDT 16/5/18

Method

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

Support

T timbering
N nil

Water

water level on date shown
water inflow
water outflow

Notes, Samples, Tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
R	refusal
E	environmental sample

Classification Symbols And Soil Description
based on unified classification system

Moisture

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

Consistency/Density Index

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

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Engineering Log - Test Pit

Test pit No.	**TP2**
Sheet	1 of 1
Job No.:	**181147/1**
Client:	**AUSTRALIAN SOIL AND CONCRETE TESTING PTY LTD**
Project:	**8 COOMBURRA CRESCENT, OCEAN SHORES**
Test pit location:	**REFER FIGURE 1**
Coordinates:	
Date started:	**11.5.2018**
Date completed:	**11.5.2018**
Logged by:	**DK**
Checked by:	

Equipment Type And Model: CAT 305E | Pit Orientation: | R.L. Surface:

Excavation Dimensions: m long m wide | Datum:

excavation information						material substance					
method	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	structure and additional observations
E							CL	Gravelly, Silty CLAY: medium plasticity, yellow, brown, orange, fine to coarse grained gravel, and some boulders.	M/W	St	FILL
							CH	Gravelly, Silty CLAY: high plasticity, grey, brown, fine to coarse grained gravel, and some boulders.	M		RESIDUAL PP=150kPa
					0.5						
					1.0						
					1.5						
								Excavator refusal on large boulders. Test pit TP2 terminated at 1.6m			
					2.0						
					2.5						
					3.0						
					3.5						
					4.0						

Method

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

Support

T	timbering
N	nil

Water

- water level on date shown
- water inflow
- water outflow

Notes, Samples, Tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
R	refusal
E	environmental sample

Classification Symbols And Soil Description

based on unified classification system

Moisture

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

Consistency/Density Index

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

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Engineering Log - Test Pit

Test pit No.	**TP3**
Sheet	1 of 1
Job No.:	**181147/1**
Client:	**AUSTRALIAN SOIL AND CONCRETE TESTING PTY LTD**
Project:	**8 COOMBURRA CRESCENT, OCEAN SHORES**
Test pit location:	**REFER FIGURE 1**
Coordinates:	
Date started:	**11.5.2018**
Date completed:	**11.5.2018**
Logged by:	**DK**
Checked by:	

Equipment Type And Model: CAT 305E | Pit Orientation: | R.L. Surface:

Excavation Dimensions: m long m wide | Datum:

excavation information						material substance					
method	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	structure and additional observations
E					0.0		CL	Gravelly, Silty CLAY: medium plasticity, yellow, brown, fine to coarse grained gravel and large boulders.	W	St	FILL
							CH	Silty CLAY: high plasticity, grey, orange, with some fine to coarse grained gravel and some large boulders.	M		PP=150kPa
							CH	Gravelly, Silty CLAY: high plasticity, grey, orange, fine to coarse grained gravel and boulders.			
					0.5						
							CL	Gravelly, Silty CLAY: medium plasticity, brown, orange, yellow, fine to coarse grained gravel, some sand and boulders.		H	RESIDUAL
					1.0						PP=500kPa
					1.5		CL	Sandy, Silty CLAY: medium plasticity, pale white and orange.	D/M	VSt/H	PP=400kPa
					2.0						
					2.5			Test pit TP3 terminated at 2.5m			
					3.0						
					3.5						
					4.0						

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

Support
- T timbering
- N nil

Water
- water level on date shown
- water inflow
- water outflow

Notes, Samples, Tests
- U_{50} undisturbed sample 50mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- R refusal
- E environmental sample

Classification Symbols And Soil Description
based on unified classification system

Moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

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

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Engineering Log - Test Pit

Test pit No.	**TP4**
Sheet	1 of 1
Job No.:	**181147/1**
Client:	**AUSTRALIAN SOIL AND CONCRETE TESTING PTY LTD**
Project:	**8 COOMBURRA CRESCENT, OCEAN SHORES**
Test pit location:	**REFER FIGURE 1**
Coordinates:	
Date started:	**11.5.2018**
Date completed:	**11.5.2018**
Logged by:	**DK**
Checked by:	

Equipment Type And Model: CAT 305E | Pit Orientation: | R.L. Surface:

Excavation Dimensions: m long m wide | Datum:

excavation information						material substance					
method	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	structure and additional observations
E					0.5		CL	Gravelly, Silty CLAY: medium plasticity, brown, fine to coarse grained gravel, with some boulders and roots.	M	St	RESIDUAL
		►			1.0		CH	Gravelly, Silty CLAY: high plasticity, grey, brown, red, fine to coarse grained gravel and some boulders.			PP=100kPa
					1.5						
					2.0			Excavator refusal on cobbles and boulders. Test pit TP4 terminated at 2.2m			
					2.5						
					3.0						
					3.5						
					4.0						

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

Support
- T timbering
- N nil

Water
- ▼ water level on date shown
- ► water inflow
- ◄ water outflow

Notes, Samples, Tests
- U_{50} undisturbed sample 50mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- R refusal
- E environmental sample

Classification Symbols And Soil Description
based on unified classification system

Moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

Consistency/Density Index

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

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Engineering Log - Test Pit

Test pit No.	**TP5**
Sheet	1 of 1
Job No.:	**181147/1**
Client:	**AUSTRALIAN SOIL AND CONCRETE TESTING PTY LTD**
Project:	**8 COOMBURRA CRESCENT, OCEAN SHORES**
Test pit location:	**REFER FIGURE 1**
Coordinates:	
Date started:	**11.5.2018**
Date completed:	**11.5.2018**
Logged by:	**DK**
Checked by:	

Equipment Type And Model: CAT 305E | Pit Orientation: | R.L. Surface:

Excavation Dimensions: m long m wide | Datum:

excavation information						material substance					
method	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	structure and additional observations
E							CL	Silty CLAY: medium plasticity, dark brown, with some boulders and roots.	M	St	RESIDUAL
					0.5		CH	Gravelly, Silty CLAY: high plasticity, grey, brown, orange and some boulders.	M/W		
					1.0						PP=150kPa
					1.5						PP=150kPa
					2.0			Excavator refusal on cobbles and boulders. Test pit TP5 terminated at 2m			
					2.5						
					3.0						
					3.5						
					4.0						

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

Support
- T timbering
- N nil

Water
- water level on date shown
- water inflow
- water outflow

Notes, Samples, Tests
- U_{50} undisturbed sample 50mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- R refusal
- E environmental sample

Classification Symbols And Soil Description
based on unified classification system

Moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

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

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Engineering Log - Test Pit

Test pit No.	**TP6**
Sheet	1 of 1
Job No.:	**181147/1**
Client:	**AUSTRALIAN SOIL AND CONCRETE TESTING PTY LTD**
Project:	**8 COOMBURRA CRESCENT, OCEAN SHORES**
Test pit location:	**REFER FIGURE 1**
Coordinates:	
Date started:	**11.5.2018**
Date completed:	**11.5.2018**
Logged by:	**DK**
Checked by:	

Equipment Type And Model: CAT 305E | Pit Orientation: | R.L. Surface:

Excavation Dimensions: m long m wide | Datum:

excavation information						material substance					
method	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	structure and additional observations
E							CL	Silty CLAY: medium plasticity, dark brown.	M	St	TOP SOIL
							CL	Gravelly, Silty CLAY: medium plasticity, brown, fine to coarse grained gravel and some boulders.			RESIDUAL
					0.5		CH	Gravelly, Silty CLAY: high plasticity, grey, brown, orange, fine to coarse grained gravel and some boulders.			
					1.0						PP=200kPa
											PP=150kPa
					1.5			Excavator refusal on cobbles and boulders. Test pit TP6 terminated at 1.4m			
					2.0						
					2.5						
					3.0						
					3.5						
					4.0						

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

Support
- T timbering
- N nil

Water
- water level on date shown
- water inflow
- water outflow

Notes, Samples, Tests
- U_{50} undisturbed sample 50mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- R refusal
- E environmental sample

Classification Symbols And Soil Description
based on unified classification system

Moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

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

TEST PIT WO SKETCH TEST PIT LOGS.GPJ SHAW URQUHART.GDT 16/5/18

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Dynamic Cone Penetrometer

Client	**Australian Soil & Concrete Testing**	Hammer mass: 9kg
Project	**8 Coomburra Crescent, Ocean Shores**	Hammer drop: 0.510m
Location	**Refer Figure 1**	Cone: 20mm diameter (cone angle 30°)

Depth (m)	LOCATION								
	TP1	TP2	TP3	TP4	TP5	TP6			
0.0 - 0.1	3	11	4	2	5	2			
0.1 - 0.2	3	10	2	4	4	4			
0.2 - 0.3	3	R	3	4	6	4			
0.3 - 0.4	2		6	6	9	6			
0.4 - 0.5	R		7	R	12	7			
0.5 - 0.6			R		R	R			
0.6 - 0.7									
0.7 - 0.8									
0.8 - 0.9									
0.9 - 1.0									
1.0 - 1.1									
1.1 - 1.2									
1.2 - 1.3									
1.3 - 1.4									
1.4 - 1.5									
1.5 - 1.6									
1.6 - 1.7									
1.7 - 1.8									
1.8 - 1.9									
1.9 - 2.0									
2.0 - 2.1									
2.1 - 2.2									
2.2 - 2.3									
2.3 -2.4									
2.4 - 2.5									
2.5 - 2.6									
2.6 - 2.7									
2.7 - 2.8									
2.8 - 2.9									
2.9 - 3.0									

Observations:
R = DCP refusal, generally on cobbles or boulders

181147/1-B
17 May 2018

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APPENDIX B

GUIDELINES FOR HILLSIDE CONSTRUCTION
&
APPENDIX C OF AGS "PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK ASSESSMENT"

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

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.

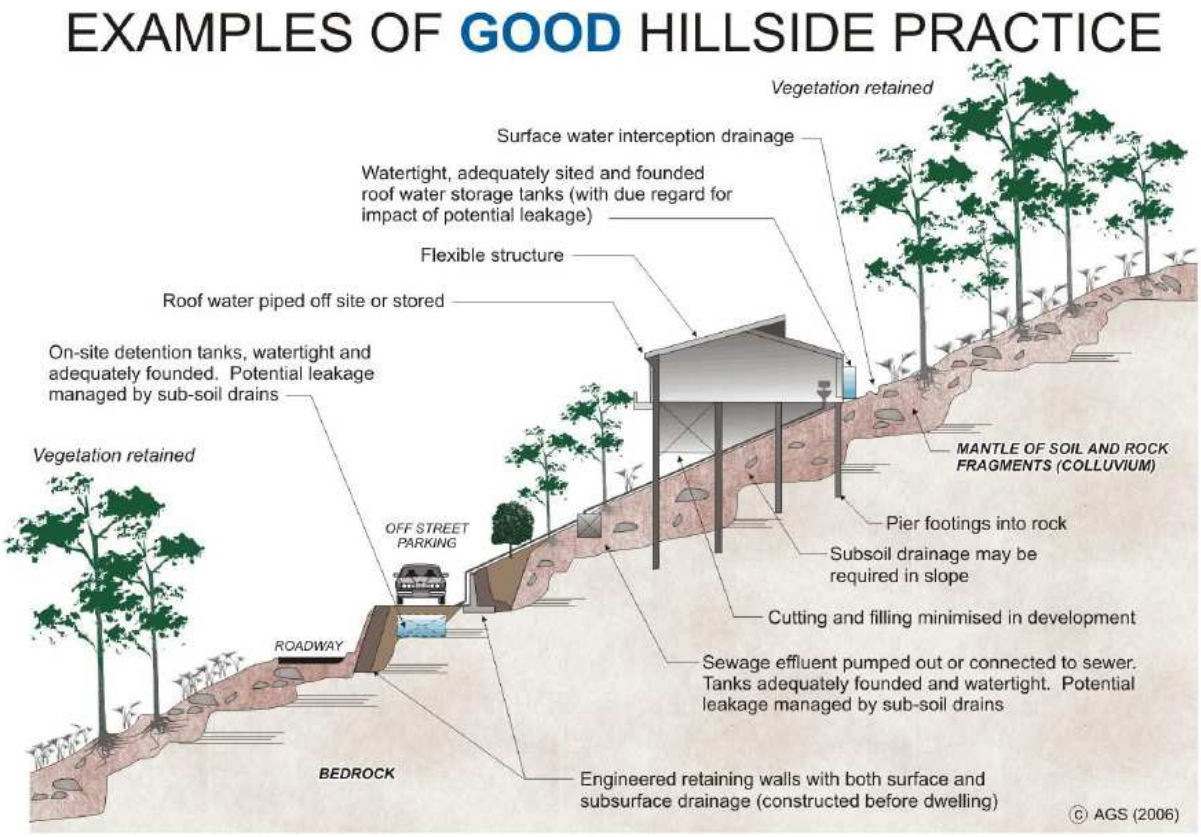
RISK LEVEL IMPLICATIONS

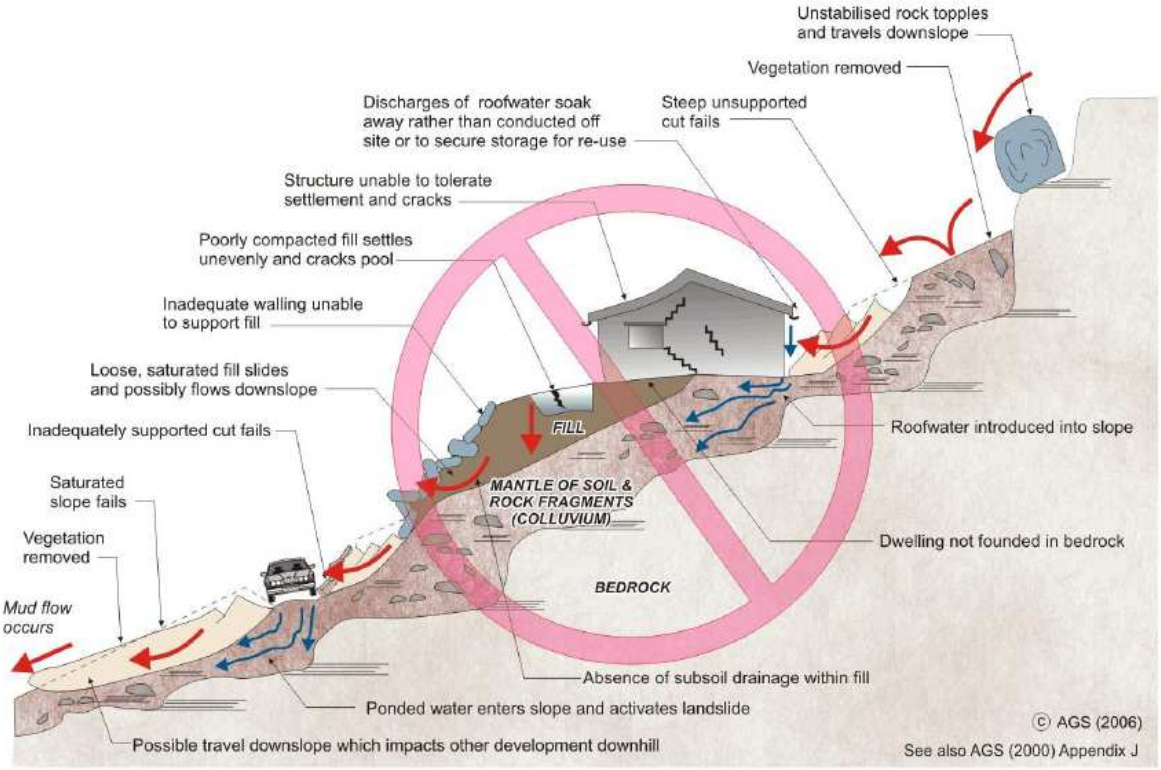
Risk Level		**Example Implications** (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the 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.

APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

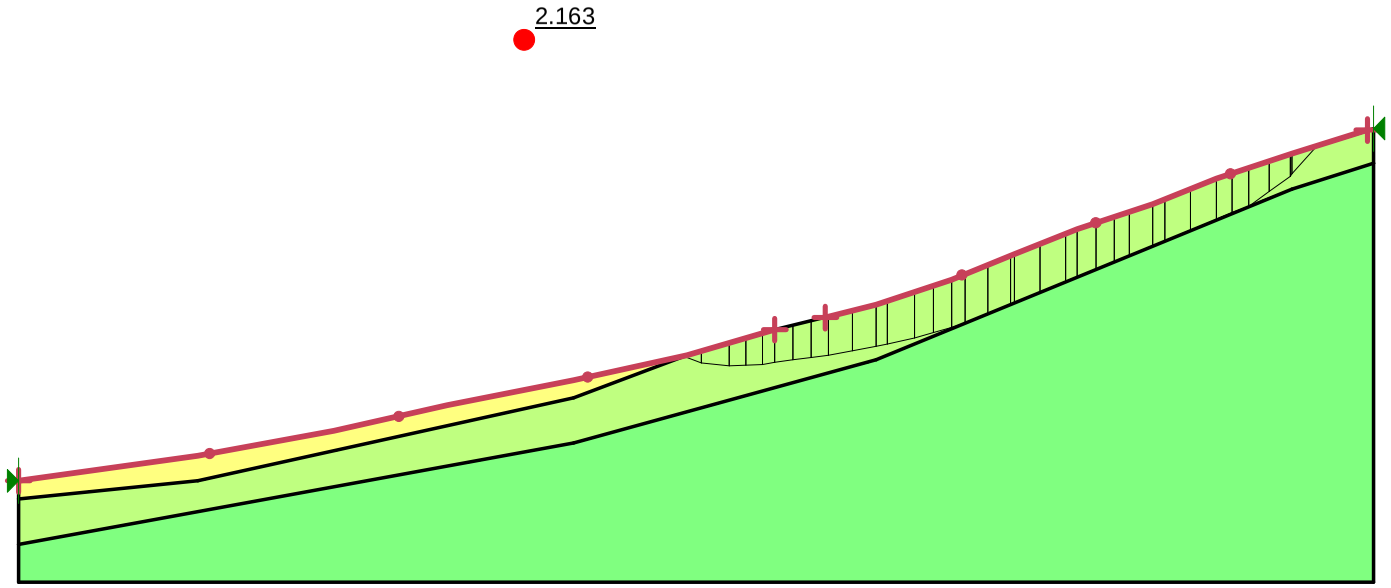
	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING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


EXAMPLES OF GOOD HILLSIDE PRACTICE
Vegetation retained
Surface water interception drainage
Watertight, adequately sited and founded roof water storage tanks (with due regard for impact of potential leakage)
Flexible structure
Roof water piped off site or stored
On-site detention tanks, watertight and adequately founded. Potential leakage managed by sub-soil drains
Vegetation retained
MANTLE OF SOIL AND ROCK FRAGMENTS (COLLUVIUM)
OFF STREET PARKING
Pier footings into rock
Subsoil drainage may be required in slope
Cutting and filling minimised in development
ROADWAY
Sewage effluent pumped out or connected to sewer. Tanks adequately founded and watertight. Potential leakage managed by sub-soil drains
BEDROCK
Engineered retaining walls with both surface and subsurface drainage (constructed before dwelling)
© AGS (2006)


EXAMPLES OF POOR HILLSIDE PRACTICE
Unstabilised rock topples and travels downslope
Vegetation removed
Discharges of roofwater soak away rather than conducted off site or to secure storage for re-use
Steep unsupported cut fails
Structure unable to tolerate settlement and cracks
Poorly compacted fill settles unevenly and cracks pool
Inadequate walling unable to support fill
Loose, saturated fill slides and possibly flows downslope
Inadequately supported cut fails
FILL
Roofwater introduced into slope
Saturated slope fails
MANTLE OF SOIL & ROCK FRAGMENTS (COLLUVIUM)
Vegetation removed
Dwelling not founded in bedrock
BEDROCK
Mud flow occurs
Absence of subsoil drainage within fill
Ponded water enters slope and activates landslide
Possible travel downslope which impacts other development downhill
© AGS (2006)
See also AGS (2000) Appendix J

APPENDIX C

SELECTED COMPUTER STABILITY PLOTS

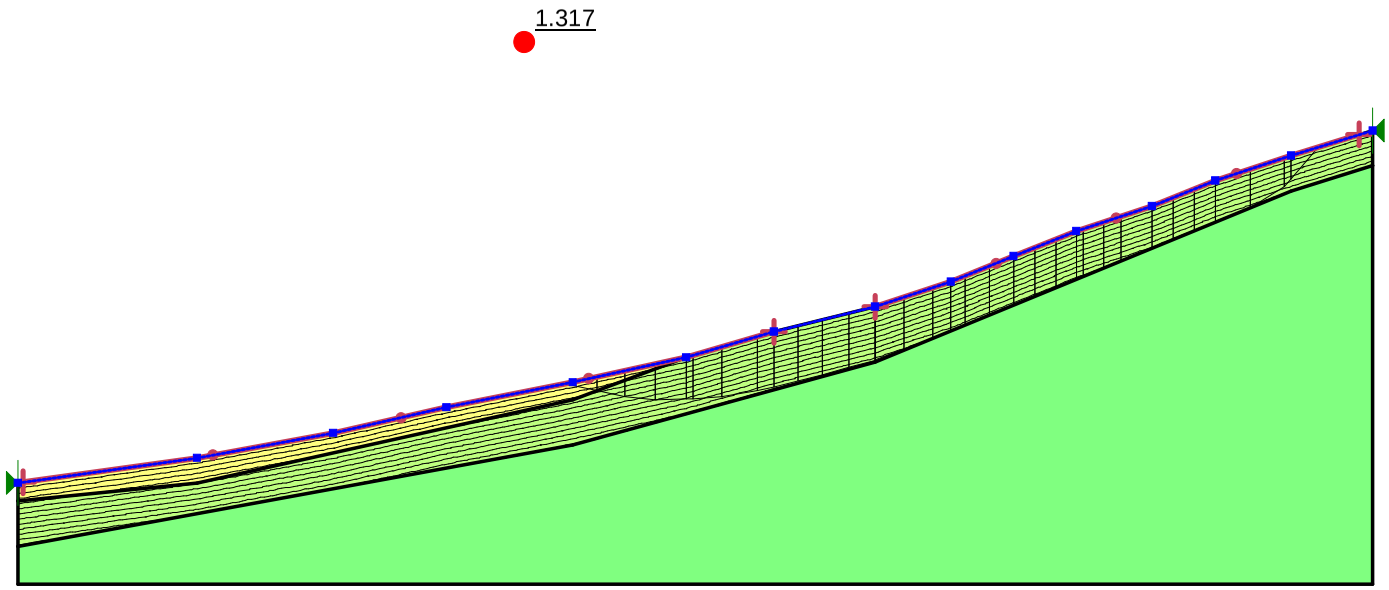


Name: Fill
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 0 kPa
Phi': 27 °
Phi-B: 0 °

Name: Residual
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 5 kPa
Phi': 27 °
Phi-B: 0 °

Name: Weathered Rock
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 15 kPa
Phi': 30 °
Phi-B: 0 °

SECTION A - DRY

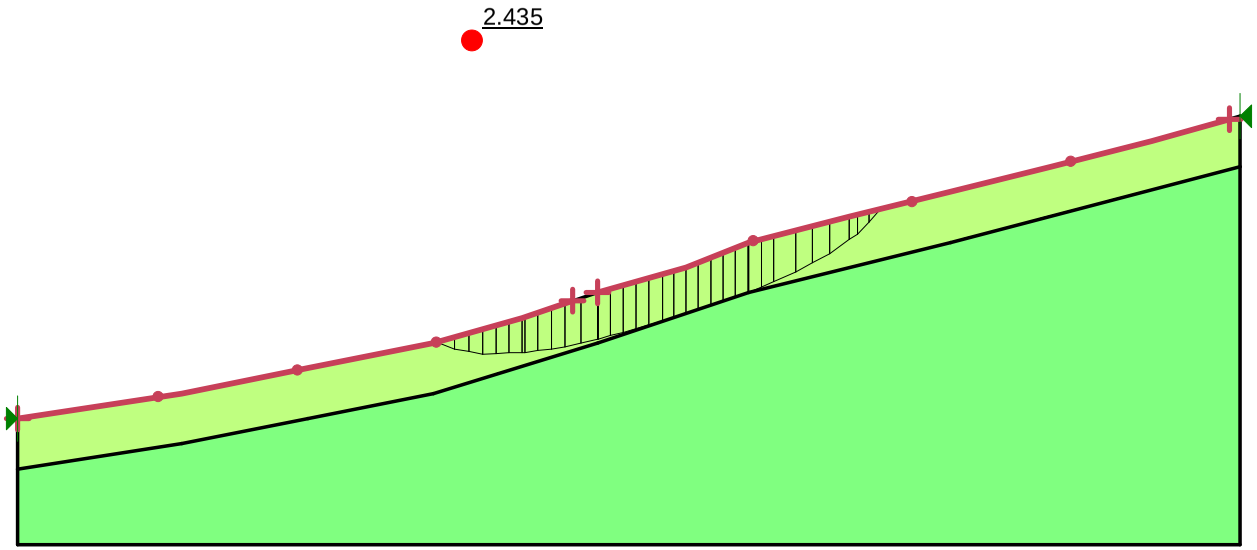


SECTION A - WET

Name: Fill
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 0 kPa
Phi': 27 °
Phi-B: 0 °
Piezometric Line: 1

Name: Residual
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 5 kPa
Phi': 27 °
Phi-B: 0 °
Piezometric Line: 1

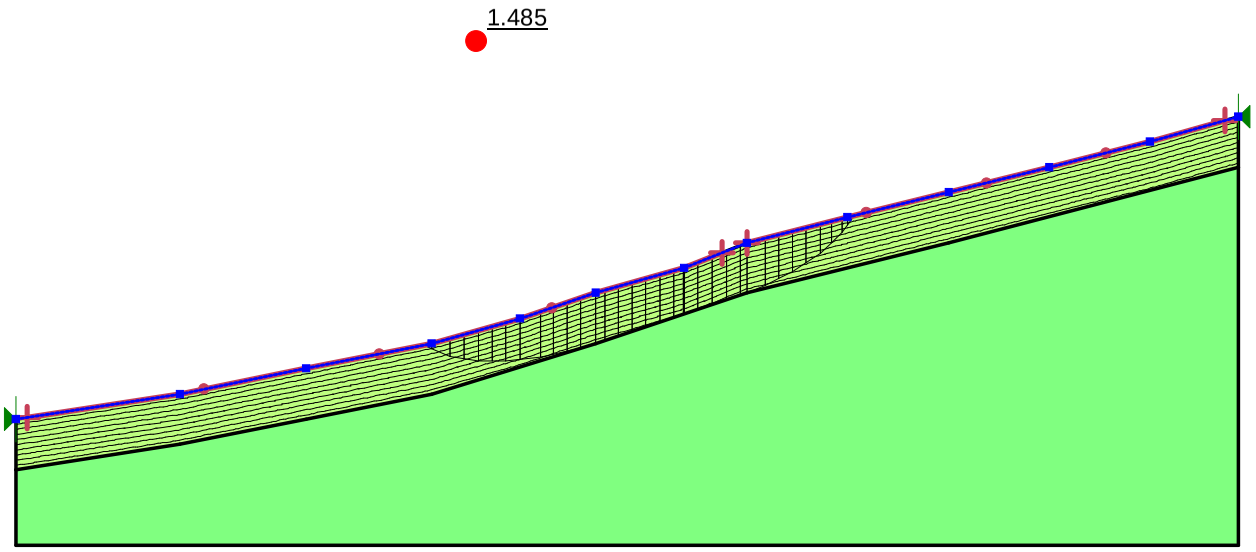
Name: Weathered Rock
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 15 kPa
Phi': 30 °
Phi-B: 0 °



Name: Residual
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 5 kPa
Phi': 27 °
Phi-B: 0 °

Name: Weathered Rock
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 15 kPa
Phi': 30 °
Phi-B: 0 °

SECTION B - DRY



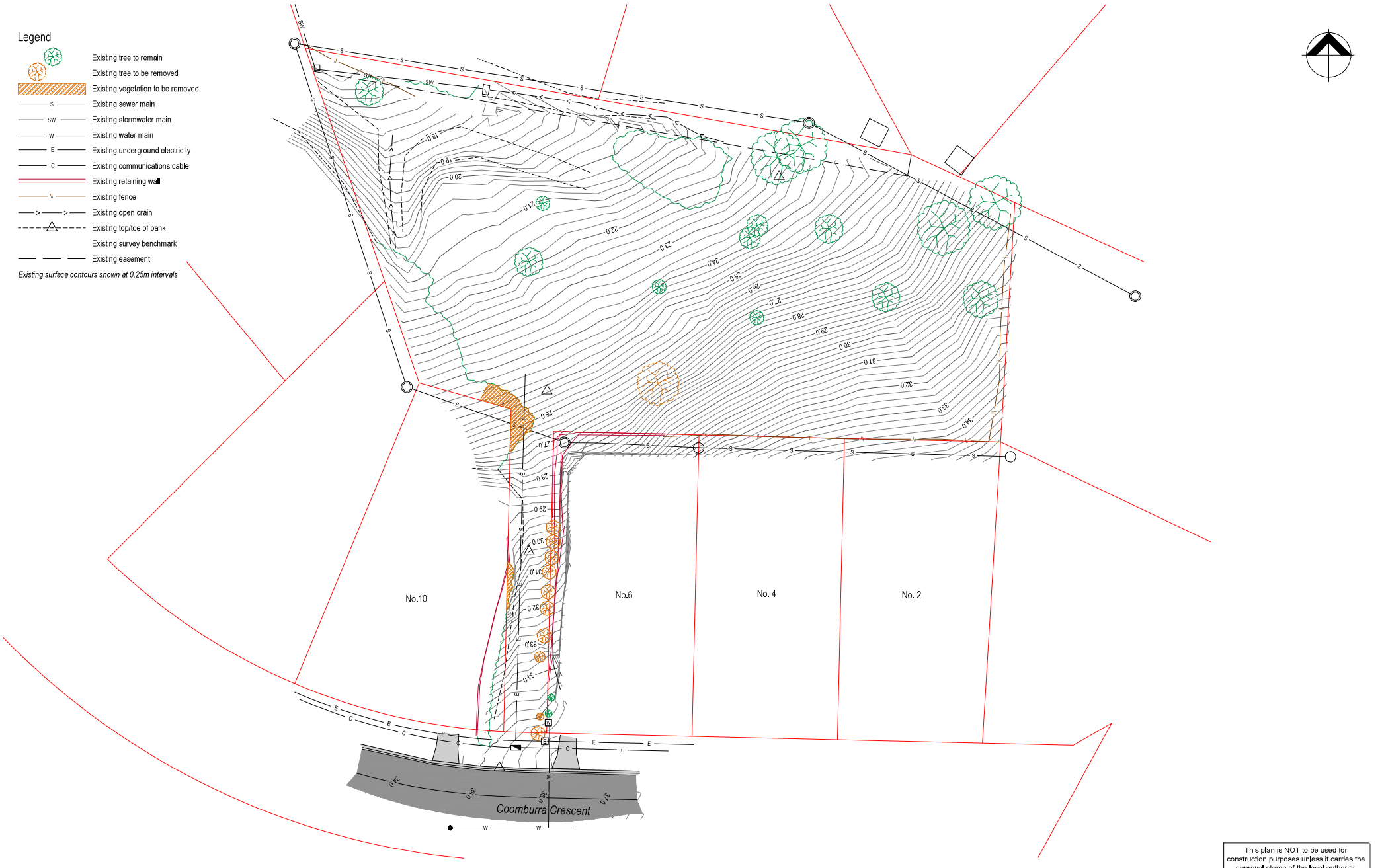
Name: Residual
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 5 kPa
Phi': 27 °
Phi-B: 0 °
Piezometric Line: 1

Name: Weathered Rock
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 15 kPa
Phi': 30 °
Phi-B: 0 °

SECTION B - WET

APPENDIX D

COPIES OF PLANS PROVIDED



This plan is NOT to be used for construction purposes unless it carries the approval stamp of the local authority.

Issue	Date	Description	App'd
B	27/02/2018	Amendments - Council RFI Dated 22/01/2018	TC
A	21/09/2017	Development Application Issue	PS

Client: Adam Mangleson

Project: 8 Coomburra Crescent, Ocean Shores, Lot 1577 DP 243995

Title: Existing Site Layout Plan

ARDILL PAYNE & Partners
ENGINEERS PLANNERS SURVEYORS
ENVIRONMENTAL PROJECT MANAGEMENT
BALLINA 45 River Street Ph. 02 6686 3280
SOUTH BRISBANE 89 Grey Street Ph. 07 3123 6675
GUNNEDAH 285 Conadilly Street Ph. 02 6742 9955
A.B.N. 51 808 558 977 e-mail: info@ardillpayne.com.au

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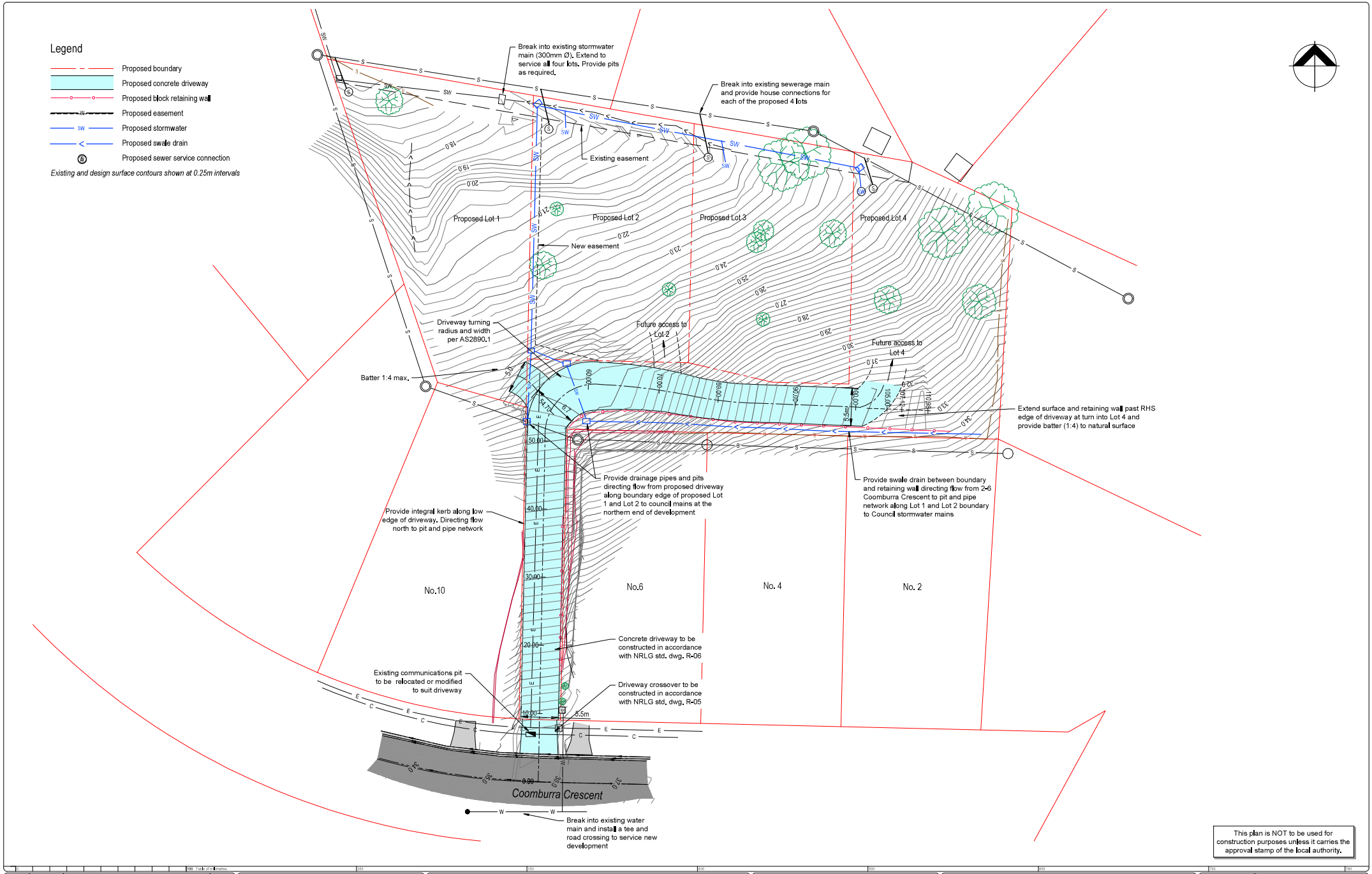

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B	27/02/2018	Amendments - Council RFI Dated 22-01-2018	TC
A	21/09/2017	Development Application Issue	PS

Client: Adam Mangleson

Project: 8 Coomburra Crescent, Ocean Shores, Lot 1577 DP 243995

Title: Proposed Development Layout Plan

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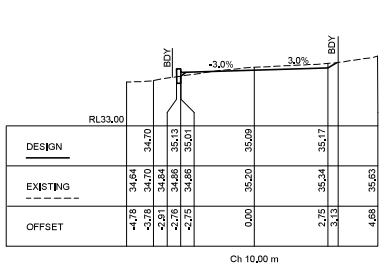

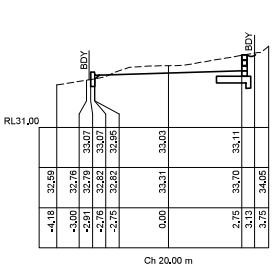

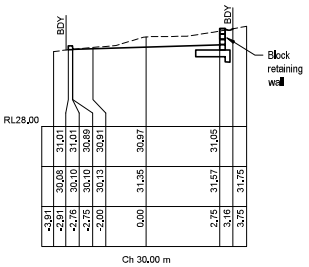

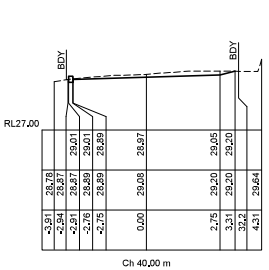

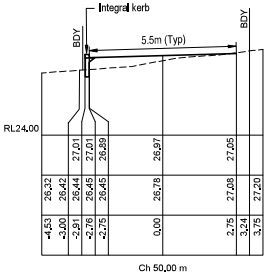

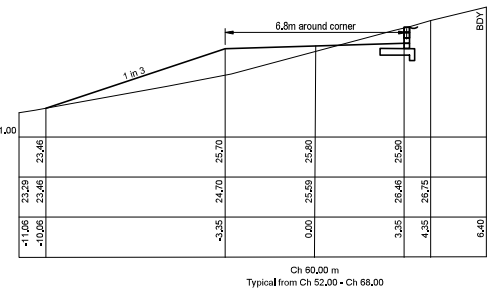

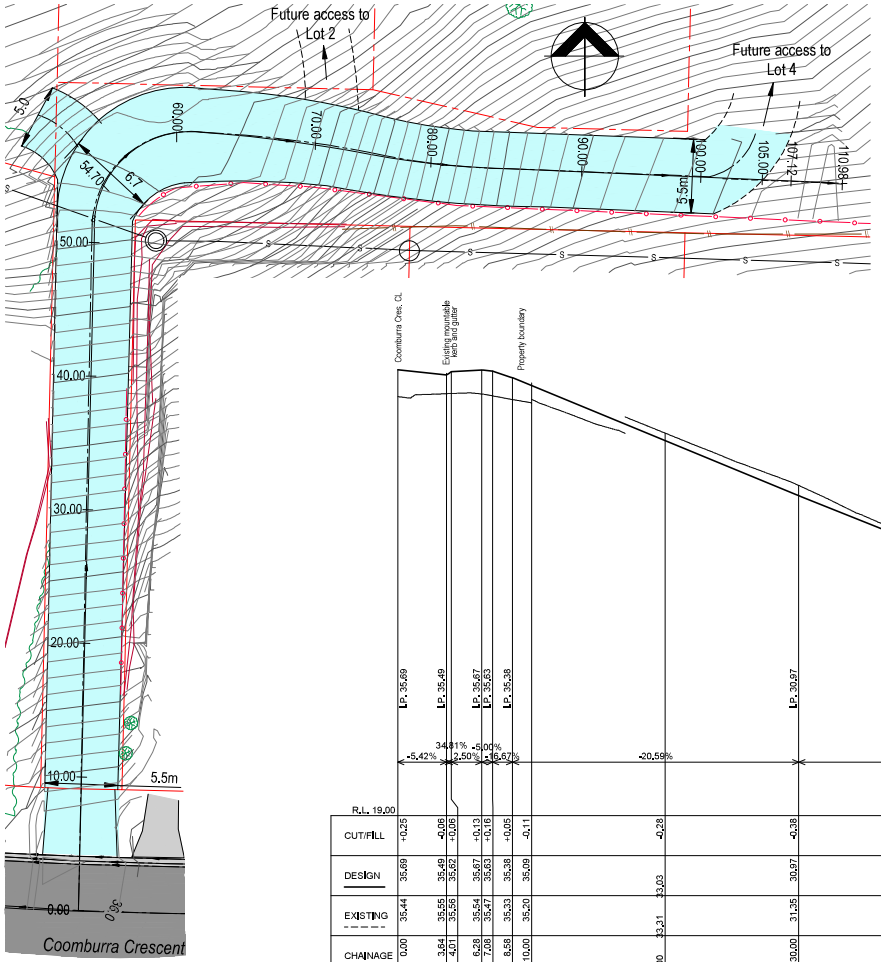

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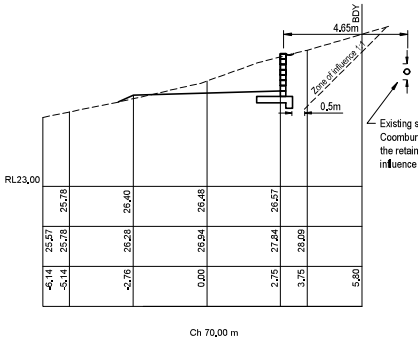
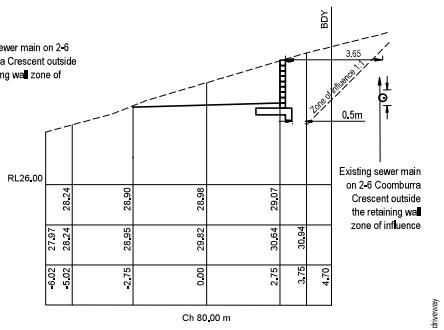
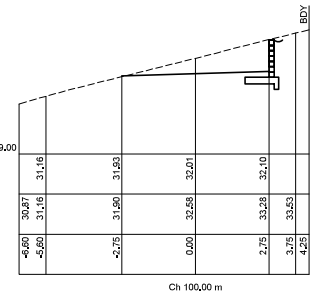
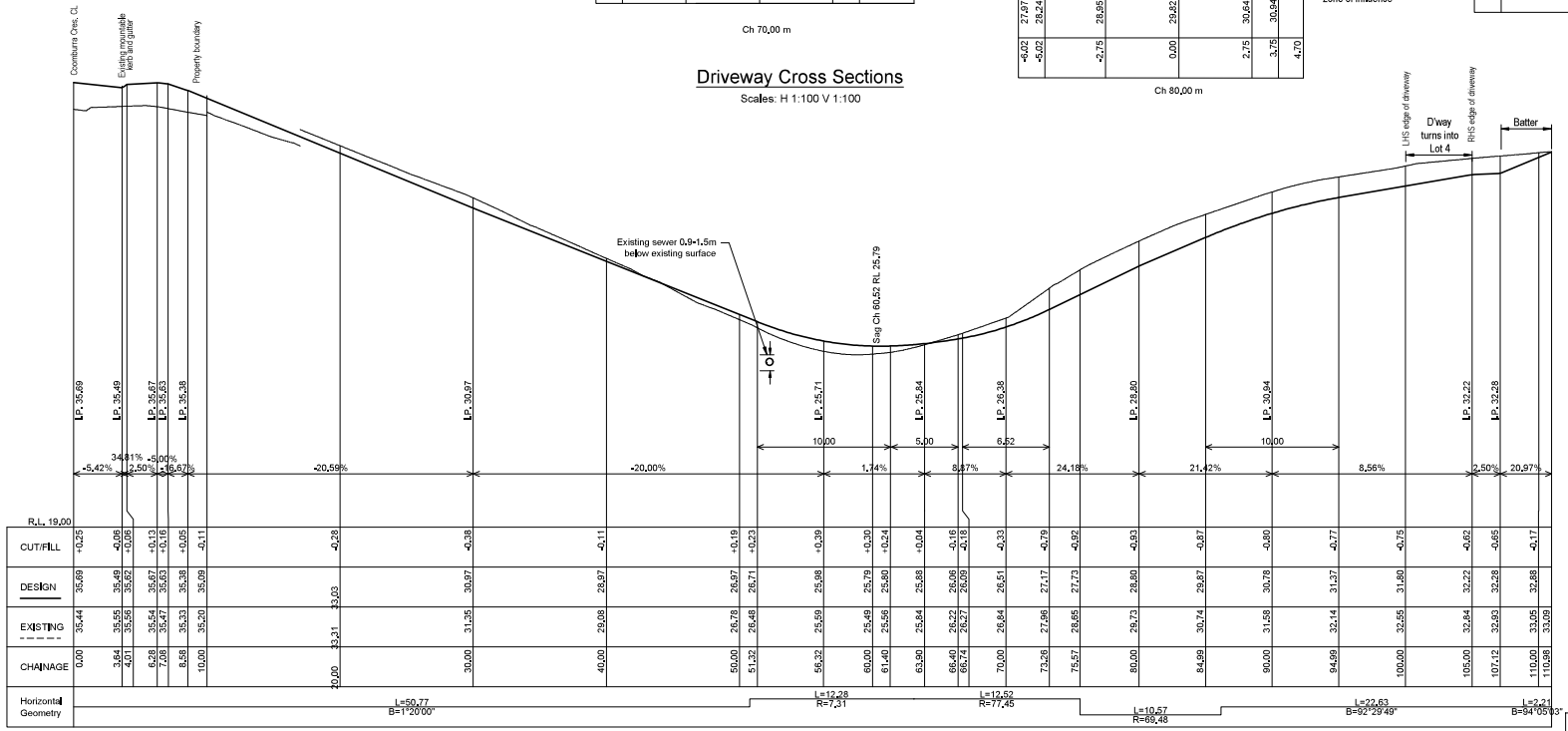






Driveway Cross Sections
Scales: H 1:100 V 1:100



Longitudinal Section - Scales: Horizontal 1:200 Vertical 1:100

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C	16/03/2018	Amendments - Council RFI Dated 01-03-2018	TC
B	27/02/2018	Amendments - Council RFI Dated 22-01-2018	TC
A	21/09/2017	Development Application Issue	PS

Client: Adam Mangleson

Project: 8 Coomburra Crescent
Ocean Shores
Lot 1577 DP 243995

Title: Proposed Development
Driveway Plan and Sections

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& Partners
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ENVIRONMENTAL PROJECT MANAGEMENT
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A.B.N. 51 808 558 977 e-mail: info@ardillpayne.com.au

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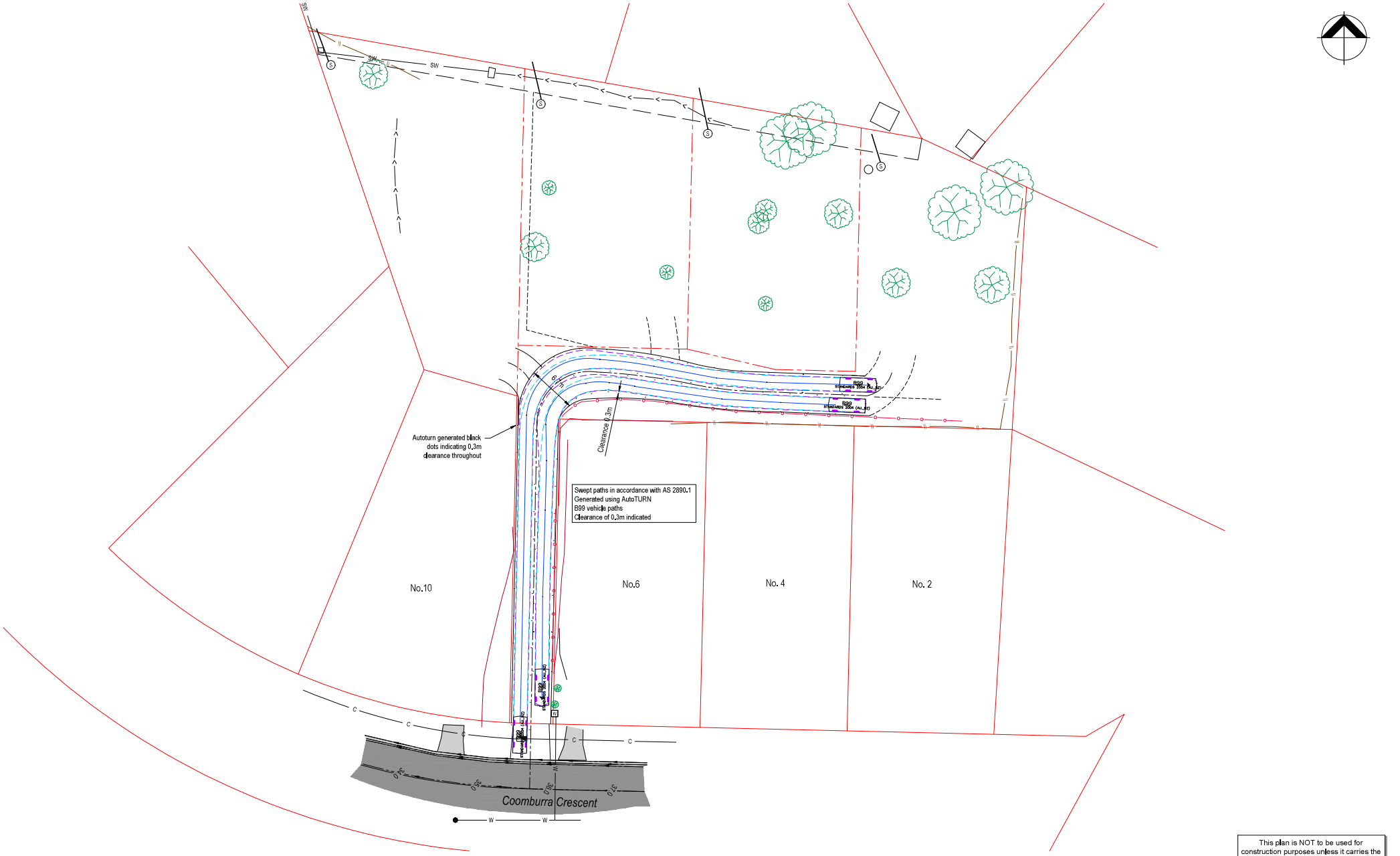

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A	27/02/2018	Amendments - Council RFI Dated 22-01-2018	TC

Client: Adam Mangleson

Project: 8 Coomburra Crescent
Ocean Shores
Lot 1577 DP 243995

Title: Swept Paths Layout Plan

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