Civil & Structural Engineering Design Services Pty. Ltd.

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25th July 2019

Mr Jack Zhang
12-14 Gladys Avenue
FRENCHS FOREST, NSW 2086

D-11-267243

Dear Sir & Madam,

Geotechnical Assessment

Proposed New Subdivision at 12-14 Gladys Avenue, Frenchs Forest

INTRODUCTION

I, Edward A Bennett, practicing Civil, Structural, Geotechnical & Environmental engineer, hereby confirm that I have arranged for one of our officers to inspect the above site, subject to a new subdivision proposal and submission of a Development Application. I confirm that in reviewing Council's Policy, a full geotechnical report will be required, refer WSC Web-site under "eServices", Warringah Development Control Plan, Part E, the Natural Environment, E10:

iii) For land identified as being in Area C or Area E: A geotechnical report, prepared by a suitably qualified and experienced geotechnical engineer/ engineering geologist, must be submitted with the development application. Also, a hydrological assessment of stormwater discharge and subsurface flow conditions, prepared by a suitably qualified geotechnical/ hydrological engineer, must be submitted with the development application and

iv) When a geotechnical report is required to be submitted, (determined in accordance with i) to iii) above), the report must include a risk assessment of landslip in relation to both property and life. The risk assessment must have regard to any guidelines published by the Australian Geomechanics Society.

PROPOSED DEVELOPMENT

The proposed development (refer Appendix "A") consists of providing demolition, excavation and construction of minor roads and parking bays, services in corridors, stormwater management planning including internal pipelines & pits and on-site detention storage facility with discharge, yet to be determined, but to follow guidelines, refer Appendix "C".

These works are provided within a consolidation of both Nos. 12 & 14 Gladys Avenue, Frenchs Forest.

DESCRIPTION OF SITE & SURROUNDING AREA

These works are provided within a consolidation of both Nos. 12 & 14 Gladys Avenue, Frenchs Forest.

The Development is located within three (3) Areas, A, B & C in accordance with the Land Slip Risk Mapping provided as a guideline for Geotechnical hazard Assessment, refer the following Figures 1 & 2 and Table 1 below:

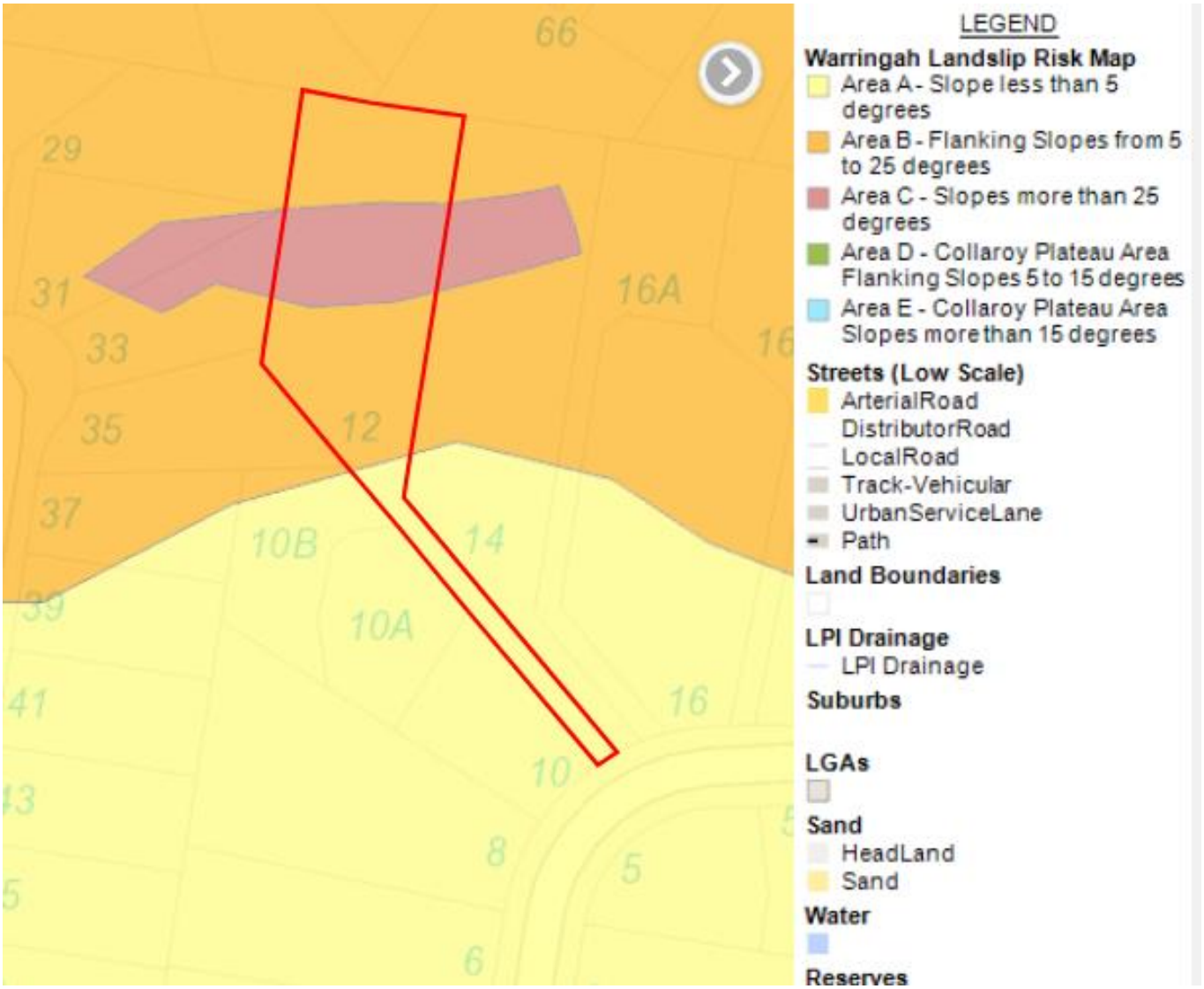

Figure 1: Land slip risk map for 12 Gladys Avenue, Frenchs Forest (site location marked in red)

And

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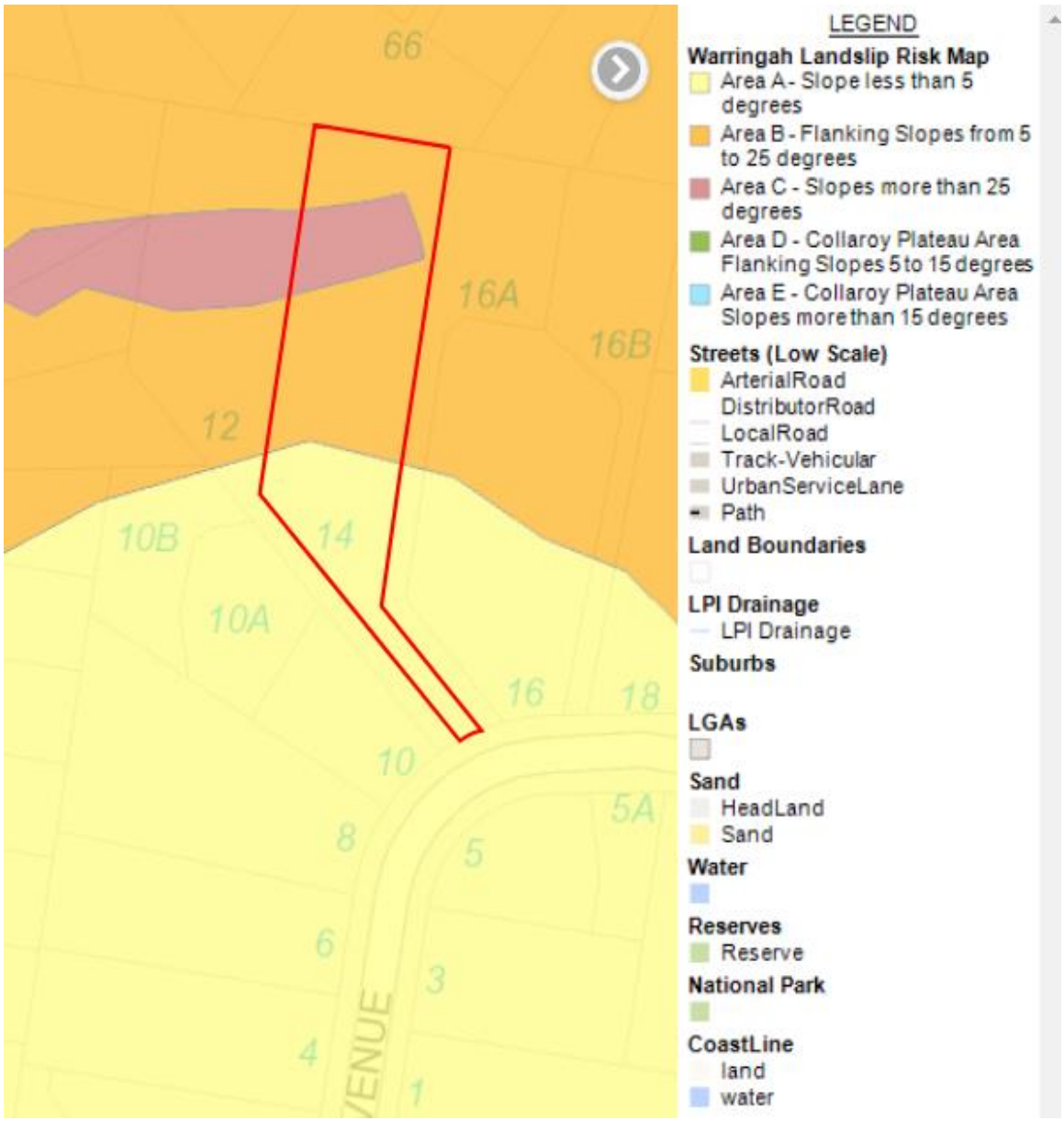

Figure 2: Land slip risk map for 14 Gladys Avenue, Frenchs Forest (site location marked in red)

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Table 1: Landslip risk classes - from Warringah Council DCP Part E10 Landslip Risk

LANDSLIP *RISK* CLASS			
Landslip *Risk* Class	**Topographic Position**	**Slope Angle (degrees)**	**Geology**
A	Plateau areas, ridge crests, major spur slopes, footslope areas; and beach, foredune and alluvial flats.	< 5	At higher elevations, generally shallow residual soils developed on Hawkesbury Sandstone. Hawkesbury Sandstone exposed in occasional outcrops and in near vertical *road* cuts. Some areas of*fill*. At lower elevations, unconsolidated marine and alluvial sands often overlying deep marine sediments.
B	Flanking slopes.	5 to 25	Colluvial and residual soils, possibly deeper than in Class A, developed on Hawkesbury Sandstone. Minor detached sandstone blocks, occasional exposures of sandstone in cliffs and *road*cuts. Occasional *fill* areas associated with playing fields, roads and some developments.
C	Steeper slopes, generally near coastal areas and adjacent to creeks and major gullies.	> 25	Colluvial soils and bouldery talus, with detached blocks of sandstone on steep escarpment areas, developed on Hawkesbury Sandstone. Near vertical cliffs to approximately 50m high at Dee Why Head.
D	Flanking slopes (Collaroy Plateau area)	5 to 15	Colluvial and residual soils (possibly deeper than in Class A) developed on Narrabeen Group or Hawkesbury Sandstone. Minor detached sandstone blocks, occasional exposures of sandstone in cliffs and *road* cuts. Occasional *fill* areas associated with playing fields, roads and some developments.
E	Steeper slopes (Collaroy Plateau area)	> 15	Colluvial & residual soils & bouldery talus, with detached blocks of sandstone on steeper escarpment areas, developed on Narrabeen Group or Hawkesbury Sandstone. Near vertical cliffs up to about 20m high.

SITE GEOLOGY

The underlying site geology is a Mesozoic era sandstone containing medium to coarse-grained quartz sandstone with shale and laminate lenses. Refer to 1:100 000 Sydney geologic mapping for more details (available via references).

OBSERVATIONS

- The slope at the Front of the Development Property is < 5 degrees (Southern Section)
- The slope at the Middle of the Development Property is 5 to 25 degrees
- The slope at the Rear of the Development Property is > 25 degrees (Northern Section)
- The Soil profile is typical residual clay overlaying sandstone of varying strengths.
- There is presently NO evidence of particularly high risk/hazard zones (unstable slip zones).
- Parts of the existing structures may need to be demolished and removed from site
- All new significant structures such as suspended sections of roadway, OSD storage tanks and high retaining walls, should piered and anchored to underlying rock with minimum bearing capacity of 500kPa.
- Recommendations in respect to the work to be carried out during excavation in rock and the effect on neighboring properties will need to be considered as mandatory for works within the zone of influence of Areas B and C. Measures such as vibration monitoring may be necessary.

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- A Slope Instability Risk Assessment is required however, this has been carried out in a previous Assessment by Martens Consulting Engineers on 12/6/2018 and I confirm that this Risk Assessment may be relied upon and is attached as Appendix "C"

EXTRACTS FROM PREVIOUS PRELIMINARY GEOTECHNICAL INVESTIGATION

The Client has made me aware of some extremely important information, which may be extracted from the Preliminary Geotechnical Investigation, provided by Martens & Associates in June 2018 by way of Borehole and DCP tests and is referenced in Appendix "D".

RECOMMENDATIONS

Some practices which assist to mitigate risk are as follows and should be adhered to:

CLEARING - GOOD hillside practice, refer Appendix "E"

Provide siltation fencing and proper barriers along the norther boundary of the property and up the side boundary fences.

Provide a diversion spoon drain across the rear northern boundary sloping towards the western side from approx. midway to collect and divert any surface run-off that may affect the rear properties and this measure, when implemented will avoid localized slippage from scouring effects of any excavations within that zone.

Cover any exposed rock faces to prevent loss of moisture and prevent risk to spall overnight

EXCAVATION

The proposed Development does require detailed excavation and mechanical equipment will be employed. There is the likelihood that temporary shoring or underpinning will be necessary to prevent ground loss when excavating near or adjacent to cliff faces, to ensure safety to the workers.

The excavation for the proposed structure(s) should not create a build-up of disposable material which, if not being utilized as on-site suitable fill, shall be placed in special stock piles and be protected and maintained with suitable batters and cover so as not to be transported off-site by natural localised slippage or cause instability of existing batters through heavy rains before being used at a future date.

FOUNDATION MATERIALS AND FOOTINGS

It is recommended that all footings for the foundations to be supported on the underlying shale/rock using reinforced concrete piers where necessary. Allow for end bearing piers to penetrate the medium strength sandstone surface by at least 150mm.

The allowable bearing capacity for the piers shall be not less than **500kPa,** unless further testing such as rock coring and point load testing is carried on the collected rock samples.

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SUBSURFACE DRAINAGE

Any retaining walls are to have adequate subsurface drains such as “strip drains” or sock covered agricultural pipes placed at the rear of the walls to prevent undue hydrostatic pressure.

INSPECTIONS

It is recommended that the rock jointing be discovered and inspected by the engineer. The foundation material and pier placement are to be inspected and approved prior to casting any concrete.

It is an obligation for the certifier/builder/contractor to organise the inspections noted above within 24 hours notice notwithstanding that the principal certifying authority and the structural engineer needs to be notified in advance.

ON-GOING MAINTENANCE

The property is to be maintained in good order and in accordance with the guidelines set out in CSRIO - BTF 18 “Foundation Maintenance and Footing Performance: A Homeowner’s Guide” and the Australian Geomechanics Article “Landslide Risk Management Concepts and Guidelines” May 2002.

All retaining walls are to be inspected at intervals not exceeding 20 years.

From evidence obtained during the site inspection, as well as assessment of existing geological data for the site, it has been determined that the proposed works will not adversely affect the geotechnical stability of the site.

Provided all recommendations above are adhered to, the works will be completed following good geotechnical and structural engineering practice.

The development will not cause detrimental impacts because of stormwater discharge from the land onto other properties.

RISK MANAGEMENT AND MITIGATION

The main hazards identified for this site are:

Hazard A: Shallow Rotational Slide.
Hazard B: Deep Seated Rotational Slide
Hazard C: Soil Creep
Hazard D: Cliff Overhang failure

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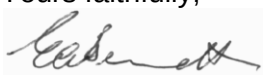
	HAZARD A	***HAZARD B***	***HAZARD C***	***HAZARD D***
DESCRIPTION	Shallow Rotational Slide	Deep Seated Rotational Slide	Soil Creep	Cliff Overhang Failure
Likelihood of hazard occurring (P_H)	Likely to Unlikely (<=10-4)	RARE <=10-5	LIKELY TO UNLIKELY (<=10-4)	UNLIKELY (<=10-4)
Consequence to property	MINOR	MEDIUM	INSIGNIFICANT	MEDIUM
Risk to property	LOW RISK	LOW RISK	INSIGNIFICANT	LOW RISK
Probability of building impact ($P_{S,H}$)	0.01	0.01	0.01	0.01
Probability of building occupation ($P_{T,S}$)	0.5	0.5	0.5	0.5
Vulnerability of Individual (Likelihood of loss of life given hazard occurring) ($V_{D:T}$)	0.3	0.5	0.3	0.3
Risk to Life ($R_{LoL} = P_H * P_{S:H} * P_{T:S} * V_{D:T}$)	1.5x10-7	2.5x10-8	1.5x10-4	1.5x10-4
Conclusion	Acceptable	Acceptable	Acceptable	Acceptable

From evidence obtained during the site inspection, as well as assessment of existing geological data for the site, it has been determined that the proposed works will not adversely affect the geotechnical stability of the site. Provided all recommendations above are adhered to, the works will be completed following good geotechnical and structural engineering practice.

The development will not cause detrimental impacts due to stormwater discharge from the land or from the existing subsurface flow conditions including those to and from other properties.

Yours faithfully,



E.A. Bennett M.I.E. Aust. Cp Eng. NPER 198230, Member AGS, BPB 0820

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REFERENCES

NSW Dept. of Resourced & Energy, “Sydney 1:100 000 Geological Map”, Accessed 16 July 2014 from <http://www.resourcesandenergy.nsw.gov.au/miners-and-explorers/geoscience-information/geological-maps/1-100-000/sydney-1100-000-geological-map>

Warringah Council eServices, Warringah Council Development Control Plan 2011, Part E10, Accessed 16 July 2014 from https://eservices1.warringah.nsw.gov.au/ePlanning/live/Public/XC.Plan/PlanningMapsEsri.aspx?cid=&a=&l=529

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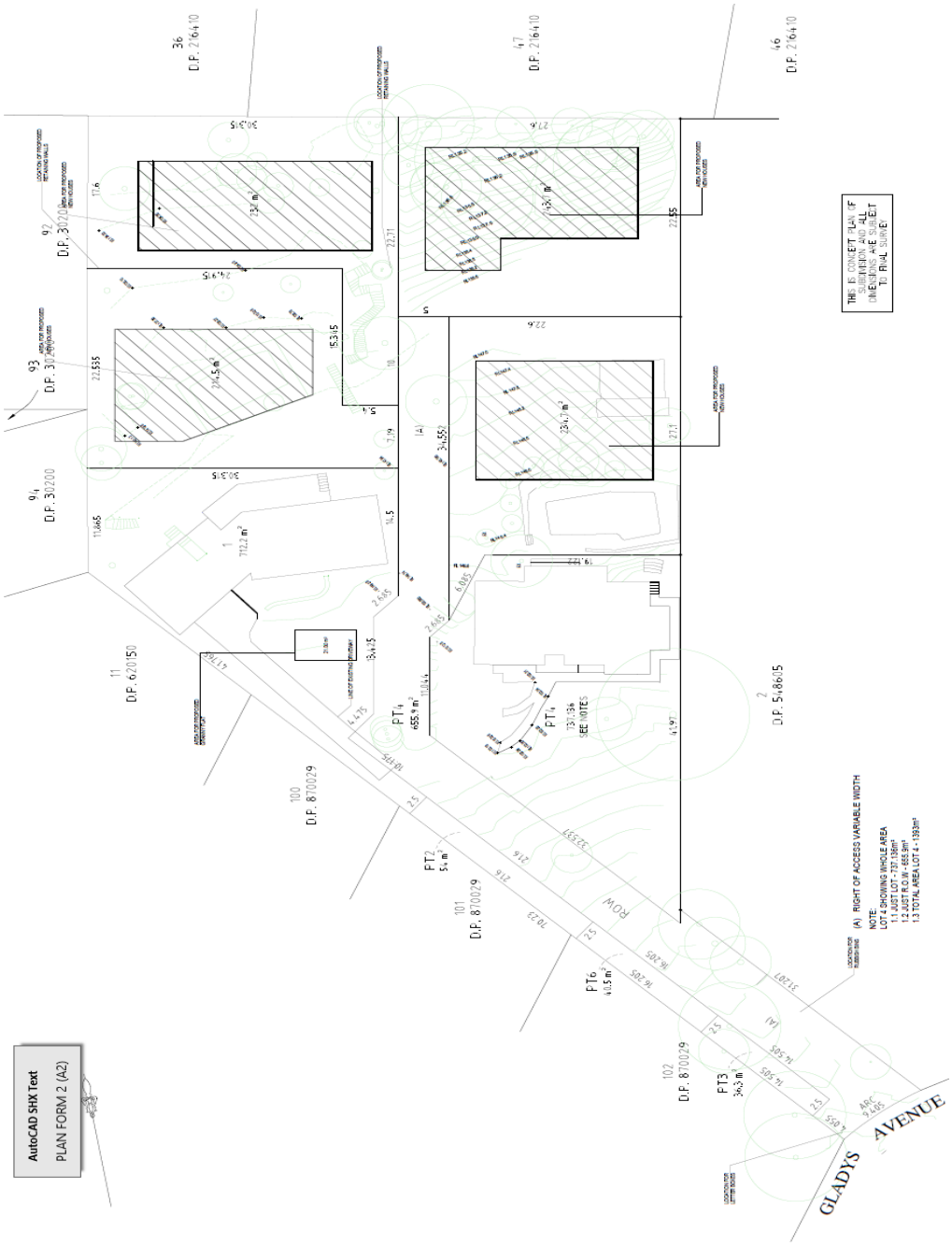
APPENDIX "A" – Proposed Development



Site Plan

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APPENDIX "B" – Guidelines for SW disposal

2.2 Zone R2 Low Density Residential Dwelling House (for all new dwelling houses or alteration and additions to existing dwelling houses) where on-site stormwater detention is required

A Development Application for a Zone R2 Low Density Residential Dwelling House where an on-site stormwater detention system is required will require stormwater disposal from the site to be in accordance with the following steps:

STEP 1

i. Connection of stormwater to an existing Council stormwater drainage line located within the subject site, subject to the drainage line having sufficient capacity.

OR

ii. Connection of stormwater to an existing inter-allotment drainage easement and pipeline subject to the property owner demonstrating the inter-allotment pipeline has sufficient capacity and the property owner having a formal drainage easement(s) created over the inter-allotment pipeline within the downstream property(s).

STEP 2

Where the means of disposal in Step 1(i) is not available – stormwater disposal from the site is to be via a new gravity fed pipeline. This will require an easement to drain stormwater to Council's drainage infrastructure through the downstream property(s).

Noting there may be difficulties obtaining an easement through multiple properties, the property owner is ascertain which adjoining downstream property(s) it may be feasible and practical to drain stormwater through, and then approach the owner(s) to request an easement be granted for the purpose of draining stormwater to Council's drainage system (refer Attachment 1 - Sample Letter). If the property owner is unable to attain any written approval from the adjacent downstream property owner(s), the property owner is to then enclose a Statutory Declaration stating the above.

OR

Where the means of disposal in Step 1(ii) is not available – Council will accept the use of an on-site absorption system subject to the following:

i. The on-site absorption system will not have an adverse impact upon adjoining and/or downstream properties by the direction or concentration of stormwater on those properties and,

ii. Soil absorption characteristics and other physical constraints indicate the on-site absorption system is appropriate for the property (refer Attachment 2 – On-site Absorption Design Guidelines), and

iii. The on-site absorption system shall require the creation of a Positive Covenant and Restriction on Use of Land over the system.

STEP 3

Where the means of disposal in Steps 1 and 2 are not available, the use of a charged line to drain roof runoff to the kerb and gutter system fronting the site will be acceptable provided:

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i. Stormwater is discharged into the same catchment (or sub-catchment), in comparison to stormwater being discharged to follow the natural fall of the land to the rear of the subject site, and
ii. The property owner demonstrating that the kerb and gutter system including any low level driveways fronting the street has sufficient capacity to cater for the 1 in 100 year ARI storm event from roof runoffs from all applicable properties fronting the same road, and
iii. On-site absorption system will be required to collect stormwater from impervious areas of the development that cannot drain by gravity to the kerb and gutter system (refer Attachment 2 – On-site Absorption Design Guidelines), and
iv. The on-site absorption system shall require the creation of a Positive Covenant and Restriction on Use of Land over the system.

OR

The use of a level spreader to discharge stormwater will be acceptable to Council subject to the following:
Stormwater flows from the whole site are to be restricted to the 1 in 5 year ARI "state of nature" storm event, for all storm events up to and including the 1 in 100 year ARI storm event. This system will require the provision of an on-site stormwater detention system.
Council may, at its discretion, consider other methods of stormwater disposal only if all of the methods outlined above have been exhaustively investigated and were considered not appropriate for this development.

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APPENDIX "C"

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

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.

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Quantitative risk estimation involves integration of the frequency analysis and the consequences.
For property, the risk can be calculated from:

$$\mathbf{R}_{(Prop)} = \mathbf{P}_{(H)} \times \mathbf{P}_{(S:H)} \times \mathbf{P}_{(T:S)} \times \mathbf{V}_{(Prop:S)} \times \mathbf{E} \quad \textbf{(1)}$$

Where

$\mathbf{R}_{(Prop)}$	is the risk (annual loss of property value).
$\mathbf{P}_{(H)}$	is the annual probability of the landslide.
$\mathbf{P}_{(S:H)}$	is the probability of spatial impact by the landslide on the property, taking into account the travel distance and travel direction.
$\mathbf{P}_{(T:S)}$	is the temporal spatial probability. For houses and other buildings $\mathbf{P}_{(T:S)}$= 1.0. For Vehicles and other moving elements at risk1.0< $\mathbf{P}_{(T:S)}$ >0.
$\mathbf{V}_{(Prop:S)}$	is the vulnerability of the property to the spatial impact (proportion of property value lost).
E	is the element at risk (e.g. the value or net present value of the property).

For loss of life, the individual risk can be calculated from:

$$\mathbf{R}_{(LoL)} = \mathbf{P}_{(H)} \times \mathbf{P}_{(S:H)} \times \mathbf{P}_{(T:S)} \times \mathbf{V}_{(D:T)} \quad \textbf{(2)}$$

Where

$\mathbf{R}_{(LoL)}$	is the risk (annual probability of loss of life (death) of an individual).
$\mathbf{P}_{(H)}$	is the annual probability of the landslide.
$\mathbf{P}_{(S:H)}$	is the probability of spatial impact of the landslide impacting a building (location) taking into account the travel distance and travel direction given the event.
$\mathbf{P}_{(T:S)}$	is the temporal spatial probability (e.g. of the building or location being occupied by the individual) given the spatial impact and allowing for the possibility of evacuation given there is warning of the landslide occurrence.
$\mathbf{V}_{(D:T)}$	is the vulnerability of the individual (probability of loss of life of the individual given the impact).

A full risk analysis involves consideration of all landslide hazards for the site (e.g. large, deep seated landsliding, smaller slides, boulder falls, debris flows) and all the elements at risk.

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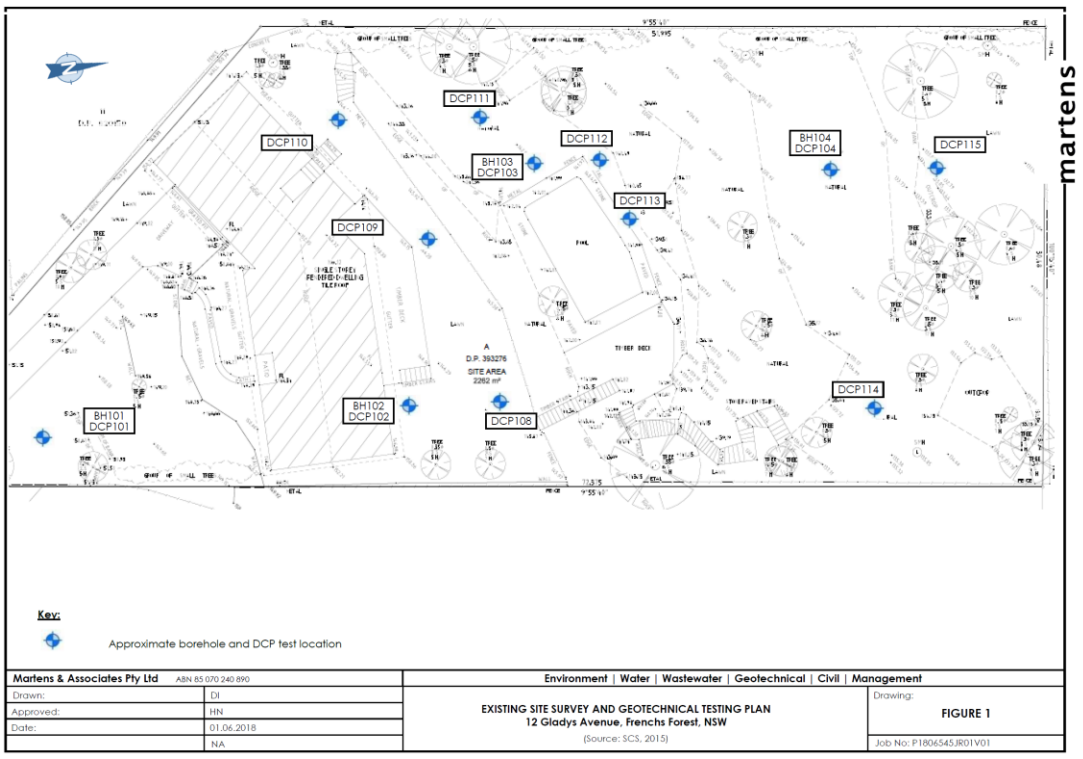
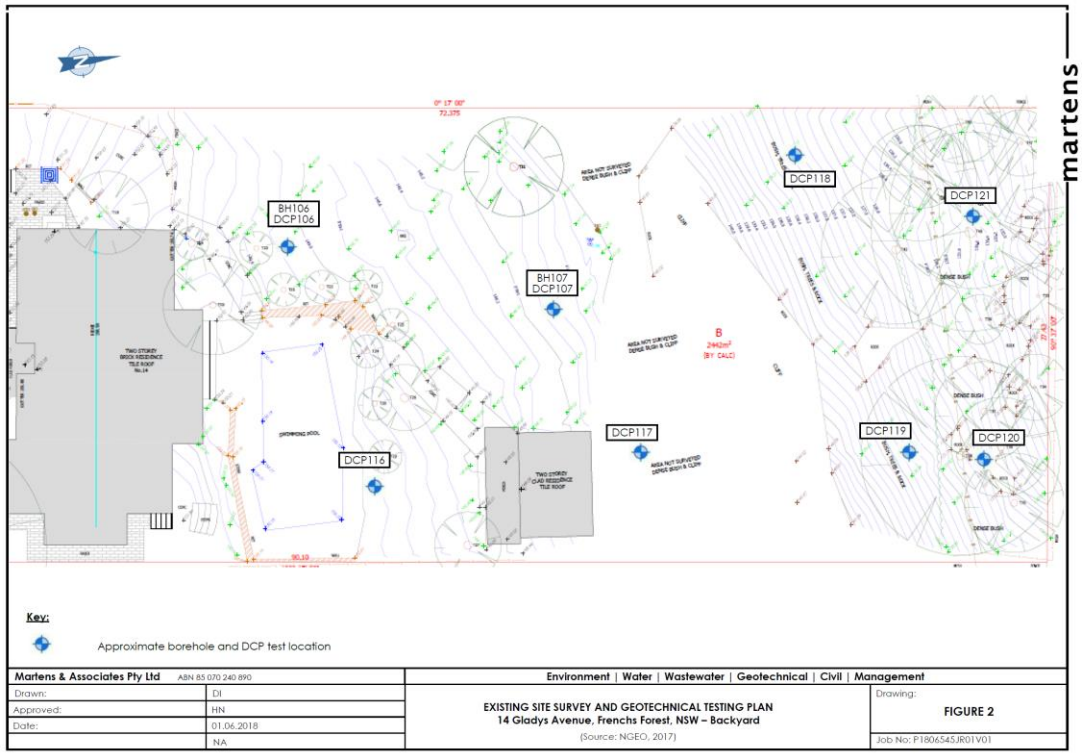
APPENDIX "D"





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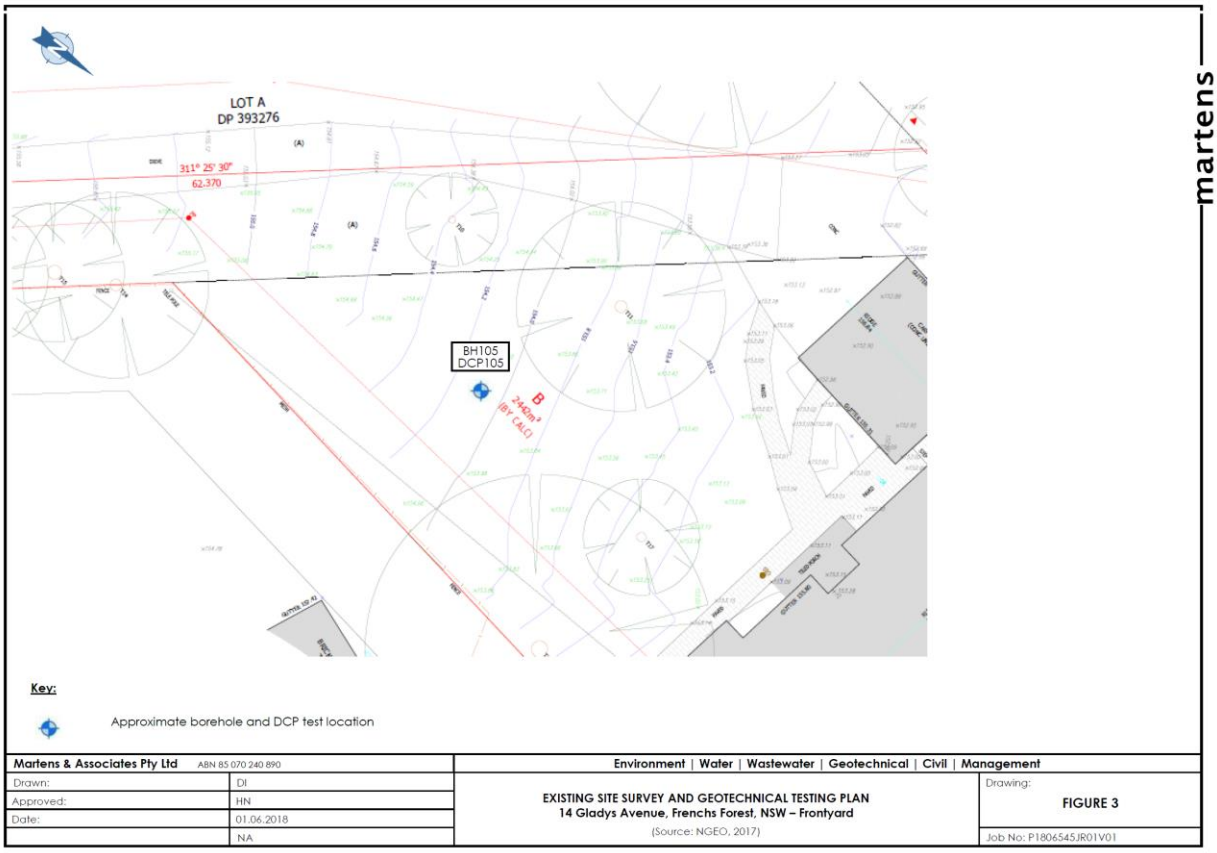

And Borehole and DCP results within

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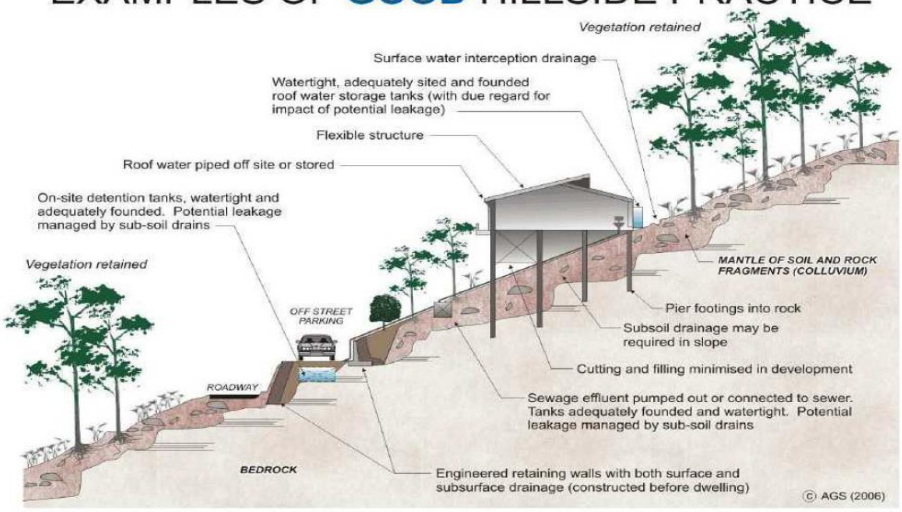
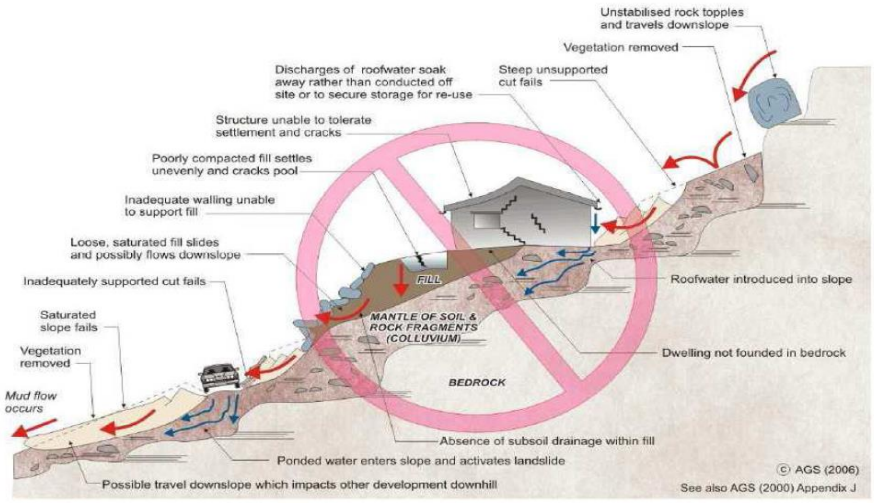
APPENDIX "E"

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

EXAMPLES OF **GOOD** HILLSIDE PRACTICE



EXAMPLES OF **POOR** HILLSIDE PRACTICE



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