GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER

FORM NO. 1 – To be submitted with Development Application

Development Application for ______________________________

Name of Applicant

Address of site **37 Terama Street, Bilgola Plateau**

Declaration made by geotechnical engineer or engineering geologist or coastal engineer (where applicable) as part of a geotechnical report

I, Peter Thompson (insert name) *on behalf of* Hodgson Consulting Engineers Pty Ltd (Trading or Company Name)

on this the 6th July, 2019 certify that I am a geotechnical engineer or engineering geologist or coastal engineer as defined by the Geotechnical Risk Management Policy for Pittwater - 2009 and I am authorised by the above organisation/company to issue this document and to certify that the organisation/company has a current professional indemnity policy of at least $2million.

Please mark appropriate box

☒ Prepared the detailed Geotechnical Report referenced below in accordance with the Australia Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009

☒ I am willing to technically verify that the detailed Geotechnical Report referenced below has been prepared in accordance with the Australian Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009

☐ Have examined the site and the proposed development in detail and have carried out a risk assessment in accordance with paragraph 6.0 of the Geotechnical Risk Management Policy for Pittwater - 2009. I confirm the results of the risk assessment for the proposed development are in compliance with the Geotechnical Risk Management Policy fro Pittwater - 2009 and further detailed geotechnical reporting is not required for the subject site.

☐ Have examined the site and the proposed development/alteration in detail and am of the opinion that the Development Application only involves Minor Development/Alterations that do not require a Detailed Geotechnical Risk Assessment and hence my report is in accordance with the Geotechnical Risk Management Policy for Pittwater – 2009 requirements for Minor Development/Alterations.

☐ Have examined the site and the proposed development/alteration is separate form and not affected by a Geotechnical Hazard and does not require a Geotechnical report or Risk Assessment and hence my Report is in accordance with the Geotechnical Risk Management Policy for Pittwater – 2009 requirements

☐ Provided the coastal process and coastal forces analysis for inclusion in the Geotechnical Report

Geotechnical Report Details:

Report Title: RISK ANALYSIS & MANAGEMENT FOR PROPOSED SWIMMING POOL & ALTERATIONS AND ADDITIONS AT 37 TERAMA STREET, BILGOLA PLATEAU– PX 00009

Report Date: 6th July, 2019

Author : PETER THOMPSON

Author's Company/Organisation : HODGSON CONSULTING ENGINEERS PTY LTD

Documentation which relate to or are relied upon in report preparation:

Architectural drawings prepared by JJ Drafting, Job number 718/19, Drawing numbers DA.01 – DA.13 and dated June 2019.

I am aware that the above Geotechnical Report, prepared for the abovementioned site is to be submitted in support of a Development Application for this site and will be relied on by Pittwater Council as the basis for ensuring that the Geotechnical Risk Management aspects of the proposed development have been adequately addressed to achieve an "Acceptable Risk Management" level for the life of the structure, taken as at least 100 years unless otherwise stated and justified in the Report and that reasonable and practical measures have been identified to remove foreseeable risk.

Signature [signature]

Name Peter Thompson

Chartered Professional Status MIE Aust CPEng

Membership No. 146800

Company Hodgson Consulting Engineers Pty Ltd

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER
FORM NO. 1(a) - Checklist of Requirements for Geotechnical Risk Management Report for Development Application

Development Application for ______________________________
Name of Applicant

Address of site **37 Terama Street, Bilgola Plateau**

The following checklist covers the minimum requirements to be addressed in a Geotechnical Risk Management Geotechnical Report. This checklist is to accompany the Geotechnical Report and its certification (Form No. 1).

Geotechnical Report Details:

Report Title: RISK ANALYSIS & MANAGEMENT FOR PROPOSED SWIMMING POOL & ALTERATIONS AND ADDITIONS AT 37 TERAMA STREET, BILGOLA PLATEAU– PX 00009

Report Date: 6th July, 2019

Author: PETER THOMPSON

Author's Company/Organisation: HODGSON CONSULTING ENGINEERS PTY LTD

Please mark appropriate box

☒ Comprehensive site mapping conducted 4/07/2019
(date)
☒ Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:200 (as appropriate)
☒ Subsurface investigation required
- ☐ No Justification ....
- ☒ Yes Date conducted 4/07/2019

☒ Geotechnical model developed and reported as an inferred subsurface type-section
☒ Geotechnical hazards identified
- ☐ Above the site
- ☒ On the site
- ☐ Below the site
- ☐ Beside the site

☒ Geotechnical hazards described and reported
☒ Risk assessment conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- ☒ Consequence analysis
- ☒ Frequency analysis

☒ Risk calculation
☒ Risk assessment for property conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
☒ Risk assessment for loss of life conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
☒ Assessed risks have been compared to "Acceptable Risk Management" criteria as defined in the Geotechnical Risk Management Policy for Pittwater - 2009
☒ Opinion has been provided that the design can achieve the "Acceptable Risk Management" criteria provided that the specified conditions are achieved.
☒ Design Life Adopted:
- ☒ 100 years
- ☒ Other 15 to 20
specify

☒ Geotechnical Conditions to be applied to all four phases as described in the Geotechnical Risk Management Policy for Pittwater – 2009 have been specified
☒ Additional action to remove risk where reasonable and practical have been identified and included in the report.
☐ Risk Assessment within Bushfire Asset Protection Zone

I am aware that Pittwater Council will rely on the Geotechnical Report, to which this checklist applies, as the basis for ensuring that the geotechnical risk management aspects of the proposal have been adequately addressed to achieve an "Acceptable Risk Management" level for the life of the structure, taken as at least 100 years unless otherwise stated, and justified in the Report and that reasonable and practical measures have been identified to remove foreseeable risk.

Signature Peter Thompson
Name Peter Thompson
Chartered Professional Status MIE Aust CPEng
Membership No. 146800
Company Hodgson Consulting Engineers Pty Ltd

GEOTECHNICAL | CIVIL | STRUCTURAL

RISK ANALYSIS & MANAGEMENT FOR PROPOSED SWIMMING POOL & ALTERATIONS AND ADDITIONS AT 37 TERAMA STREET, BILGOLA PLATEAU

1. INTRODUCTION.

1.1 This assessment has been prepared to accompany an application for Development Approval with Northern Beaches Council - Pittwater. The requirements of the Geotechnical Risk Management Policy for Pittwater, 2009 have been met.

1.2 The definitions used in this Report are those used in the Geotechnical Risk Management Policy for Pittwater, 2009.

1.3 The methods used in this Assessment are based on those described in Landslide Risk Management March 2007, published by the Australian Geomechanics Society and as modified by the Geotechnical Risk Management Policy for Pittwater, 2009.

1.4 The experience of the principal of Hodgson Consulting Engineers spans a time period over 25 years in the Northern Beaches Council area and Greater Sydney Region.

2. PROPOSED DEVELOPMENT.

2.1 Construct new swimming pool and various alterations and additions to the existing residence.

2.2 Details of the proposed development are shown on a series of architectural drawings prepared by JJ Drafting, Job number 718/19, Drawing numbers DA.01 – DA.13 and dated June 2019.

3. DESCRIPTION OF SITE & SURROUNDING AREA.

3.1 The site was inspected on the 4th July, 2019.

3. DESCRIPTION OF SITE & SURROUNDING AREA. (Continued)

3.2 This rectangular shaped block is located on the low side of the road on the corner of Terama Street and Raymond Road. The property has a north westerly aspect. It is located near the top of a slope that rises from the waters of Pittwater to the crest of the hill near Argyle Street. From the road frontage, the moderate slope of the land falls across the property at maximum average angles of 0 to 5 degrees.

3.3 Access to the property is via the concrete driveway which starts from the edge of the Raymond Road adjacent north western corner of the property, Photo 1. Pedestrian access is also via the driveway where the main entry to the existing residence is on the ground floor level. The ground floor level garage is attached to the existing residence. A masonry retaining wall supports the fill material running along the western side of the existing residence, Photo 2. A lawn area slopes away to the north western corner of the property and is split into three separate levels by two concrete block retaining walls, Photos 3 & 4. A treated timber sleep retaining wall runs along the northern boundary, Photo 5. The above retaining walls were observed to stable and the time of our inspection. The rear yard directly to the north of the existing residence is a level lawn and paved area that extends to the eastern side of the existing residence, Photo 6. The south eastern corner of the property is landscaped area, Photo 7.

3.4 The two storey residence is supported on a concrete raft slab, pad & strip footings and is good condition. No significant movement attributed slope instability was observed in the existing residence.

3.5 The subject property and adjoining properties are not mapped as H1 hazard areas on the Council Geotechnical Hazard Map. Our observations indicate the surrounding slopes do not present a significant risk of instability to the subject property.

4. GEOLOGY OF THE SITE.

4.1 The Sydney geological series sheet, at a scale of 1:100,000 indicates the site is underlain by Hawkesbury Sandstones of the Wianamatta Group. These sandstones are of Middle Triassic age and were probably laid down in braided streams. The sand grains are mainly quartz with some sand grade claystone fragments. There are lenticular deposits of mudstones and laminates which are thought to have been deposited in abandoned channels of the main streams. The sandstones generally have widely spaced sub vertical joints with some current

4. GEOLOGY OF THE SITE. Continued

bedding. The joint directions are approximately north/south and east/west. The beds vary in thickness from 0.5 to in excess of 5 metres.

4.2 The slope materials are colluvial at the surface and residual at depth. They consist of sandy loams over sandy clays that merge into the weathered zone of the underlying rocks at depths expected to be in the range of 1.0 to 2.0 metres, or deeper where filling has been carried out.

5. SUBSURFACE INVESTIGATION AND SITE CLASSIFICATION.

5.1 Three Dynamic Cone Penetrometer (DCP) tests were conducted in the location shown on the site plan. The test was conducted to the Australian Standard for ground testing: AS 1289.6.3.2 – 1997 (R2013). The results of these tests are as follows:

NUMBER OF BLOWS - Conducted using a 9kg hammer, 510mm drop and conical tip -			
DEPTH (m)	**DCP#1**	**DCP#2**	**DCP#3**
0.0 to 0.3	7	3/Drop 0.150	5
0.3 to 0.6	7	11	5
0.6 to 0.9	**17/0.235**	13	23
0.9 to 1.2		10	31
1.2 to 1.5		13	35
1.5 to 1.8		12	19
1.8 to 2.1		53	18
2.1 to 2.4		**8/0.015**	**12/0.040**
End of Test	**0.925**	**2.015**	**2.040**
~ RL top of test AHD	**136.78**	**136.67**	**136.64**
~ RL end of test AHD	**135.855**	**134.655**	**134.60**

DCP TESTING NOTES:

DCP#1	17 Blows for 0.235m then 8 blows for 0.015m. Slight Double Bounce. Refusal in weathered rock or floater. Tip – Dry with red orange fragments.
DCP#2	8 Blows for 0.015m then 8 blows for 0.010m. Slight Double Bounce. Refusal in weathered rock or floater. Rocky fill mater encountered 1.0 to 1.5m. Tip – Damp with some red fragments.
DCP#3	12 Blows for 0.040m then 8 blows for 0.000m. Double Bounce. Refusal in weathered rock or floater. Tip – Damp last 0.300 with some sandstone fragments on very tip.
Further Notes	When ringing bouncing rock is not encountered, end of test occurs when there is less than 0.02m of penetration for 8 blows or danger of equipment damage is imminent. No significant standing water table was identified in our testing.

5. SUBSURFACE INVESTIGATION AND SITE CLASSIFICATION. (Continued)

5.2 The equipment chosen to undertake ground investigations provides the most cost effective method for understanding the subsurface conditions. Our interpretation of the subsurface conditions is limited to the results of testing undertaken and the known geology in the area. While every care is taken to accurately identify the subsurface conditions on-site, variation between the interpreted model presented herein, and the actual conditions onsite may occur. Should actual ground conditions vary from those anticipated, we would recommend the geotechnical engineer be informed as soon as possible to advise if modifications to our recommendations are required.

5.3 SITE CLASSIFICATION.

The natural soil profile of the existing site is classified Class M, defined as 'Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes' as defined by AS 2870 - 2011. Where bedrock is encountered the site is classified as Class A.

6. DRAINAGE OF THE SITE.

6.1 ON THE SITE.

The site is naturally well drained with surface and subsurface runoff draining toward the rear north western boundary. No natural watercourses were observed on site.

6.2 SURROUNDING AREA.

Overland stormwater flow entering the site from the adjoining properties and the surrounding road was not evident. Normal overland runoff could enter the site from above during heavy or extended rainfall.

7. GEOTECHNICAL HAZARDS.

7.1 ABOVE THE SITE.

No geotechnical hazards likely to adversely affect the subject property were observed above the site.

7. GEOTECHNICAL HAZARDS. (Continued)

7.2 ON THE SITE.

The excavation for the proposed swimming pool will be to an approximate depth of 1.8 to 2.0 metres. The excavation for the proposed swimming pool is considered to be a potential hazard **(HAZARD ONE)**.

7.3 BELOW THE SITE.

No geotechnical hazards likely to adversely affect the subject property were observed below the site.

7.4 BESIDE THE SITE.

The areas beside the site are also not classed as slip affected hazard areas. These blocks have similar elevation and geomorphology to the subject property. No significant geotechnical hazards likely to adversely affect the subject property were observed beside the site at the time of our inspection.

8. RISK ASSESSMENT.

8.1 ABOVE THE SITE.

As no geotechnical hazards likely to adversely impact upon the subject site were observed above the site, no risk analysis is required.

8.2 ON THE SITE.

8.2.1 HAZARD ONE Qualitative Risk Assessment on Property.

An excavation approximately 1.8 to 2.0 metres deep is required to construct the proposed swimming pool. As long as good engineering practices are followed, a detailed excavation management plan is prepared before excavation with contractors experienced in this kind of excavation being engaged and the recommendations given in Section 10 are undertaken the likelihood of the cut failing and impacting on the work area is assessed as ‘Rare’ (10^{-5}). The consequences to property of such a failure are assessed as ‘Medium’ (20%). The risk to property is ‘Low’ (2×10^{-6}).

8. RISK ASSESSMENT. (Continued)

8.2.2 HAZARD ONE Quantitative Risk Assessment on Life.

For loss of life risk can be calculated as follows:
$R_{(Loll)} = P_{(H)} \times P_{(SH)} \times P_{(TS)} \times V_{(DT)}$ (See Appendix for full explanation of terms)

8.2.2.1 Annual Probability
The cut will be supported in accordance with good engineering practice, a detailed excavation management plane prepared and the recommendations given in Section 10 followed.
$P_{(H)}$ = 0.0001/annum

8.2.2.2 Probability of Spatial Impact
People will be working below the cut but it will be appropriately supported.
$P_{(SH)}$ = 0.2

8.2.2.3 Possibility of the Location Being Occupied During Failure
The worksite is taken to be occupied by 6 people. It is estimated that 1 person is below the cut for 8 hours a day, 7 days a week.
For the person most at risk:

$$\frac{8}{24} x \frac{7}{7} = 0.33$$

$P_{(TS)}$ = 0.33

8.4.4 Probability of Loss of Life on Impact of Failure
Based on the volume of land sliding and its likely velocity when it hits the worksite, it is estimated that the vulnerability of a person to being killed working on the project when the cut fails is 0.2
$V_{(DT)}$ = 0.2

8.2.2.5 Risk Estimation
$R_{(Lol)}$ = 0.0001 x 0.2 x 0.33 x 0.2
= 0.00000132
$R_{(Lol)}$ = 1.32 x 10^{-6}/annum **NOTE:** This level of risk is **'ACCEPTABLE'** provided the recommendations given in **Section 10** are undertaken.

8. RISK ASSESSMENT. (Continued)

8.3 BELOW THE SITE.

As no geotechnical hazards likely to adversely impact upon the subject site were observed below the site, no risk analysis is required.

8.4 BESIDE THE SITE.

As no geotechnical hazards likely to adversely impact upon the subject site were observed beside the site, no risk analysis is required.

9. SUITABILITY OF DEVELOPMENT FOR SITE.

9.1 GENERAL COMMENTS.

The proposed development is considered suitable for the site.

9.2 GEOTECHNICAL COMMENTS.

No geotechnical hazards will be created by the completion of the proposed development in accordance with the requirements of this Report and good engineering and building practice.

9.3 CONCLUSIONS.

The site and the proposed development can achieve the Acceptable Risk Management criteria outlined in the Pittwater Geotechnical Risk Policy provided the recommendations given in **Section 10** are undertaken.

10. RISK MANAGEMENT.

10.1. TYPE OF STRUCTURE.

The proposed structures are considered suitable for this site.

10.2. EXCAVATIONS.

10.2.1 All excavation recommendations as outlined below should be read in conjunction with Safe Work Australia's *'Excavation Work – Code of Practice'*, published October, 2013.

10. RISK MANAGEMENT. (Continued)

10.2.2 Excavations to an approximate maximum depth of 1.8 to 2.0 metres are required for the construction of the swimming pool. The cuts are expected to be through fill material, sandy topsoils and clays before the Hawkesbury sandstones are encountered near the base of the swimming pool. It is possible that minor temporary support may be required as the cut progresses. The swimming pool is to be founded on the underlying bedrock using piers as necessary. If piers are used then these piers are to be socketed a minimum 0.300 metres into the bedrock.

10.2.3 The existing retaining wall structures are to be investigated during the excavation and construction phase of the project. We would recommend that the swimming pool designed to be self-supporting so as not to add additional load to the existing retaining walls. The life expectancy for the treated timber retaining especially cannot meet for Council's required 100 years life span and more reasonable to be 15 to 20 years before replacement or major redial works would be required. Details of this investigation are to be confirmed by the licenced builder or structural engineer before construction takes place. If the existing retaining walls are to be used to support the pool then the structural engineer designing the swimming pool we be recommended to issue a structural adequacy letter with a recommendation of maintenance works to meet the decided upon design life.

10.2.4 The unconsolidated material at the top of the excavation cut face will need to be battered back at angles of not greater than 45 degrees for the short term where possible and temporary shoring placed where batters are not possible. Any new or replaced retaining walls are to be installed as soon as possible after the excavations are complete. The cut batters for the swimming pool are to be covered to prevent loss of moisture in dry weather and to prevent access of moisture in wet weather. Upslope runoff must be diverted from the cut faces by sandbag mounds or similar diversion works. Temporary support may be necessary on the cut batters, depending upon the material encountered in the cuts, the likelihood of heavy rain and the length of period before permanent support is installed. The design Coefficient of Lateral Pressure is 0.6.

10.2.5 All excavated materials left onsite will need to comply with the conditions in Section 10.3 or be retained by an engineer designed retaining wall or structure.

10. RISK MANAGEMENT. (Continued)

10.2.6 All excavated material is to be removed from the site in accordance with current Office of Environment and Heritage (OEH) regulations.

10.3. FILLS.

10.3.1 If filling is required, all fills are to be placed in layers not more than 250 mm thick and compacted to not less than 95% of Standard Optimum Dry Density at plus or minus 2% of Standard Optimum Moisture Content.

10.3.2 The fill batters are to be not steeper than 1 vertical to 1.7 horizontal or they are to be supported by properly designed and constructed retaining walls.

10.4. FOUNDATION MATERIALS AND FOOTINGS.

It is recommended that all footings be supported on and socketed into the underlying bedrock, using piers as necessary. The design allowable bearing pressures are 600 kPa for spread footings or shallow piers. All footings are to be founded on material of similar consistency to minimise potential for differential settlement.

Note: The local geology is comprised of highly variable interbedded clays, shales and sandstones, with abundant detached joint blocks and sandstone floaters at surface and in the upper profile. Conditions may alter significantly across short distances. This variability should be anticipated and accounted for in the design and construction of any new foundations.

10.5. STORM WATER DRAINAGE.

All storm water runoff from the development is to be connected to the existing storm water system for the block through any tanks or onsite detention systems that may be required by the regulating authorities. This drainage work is to comply with the relevant Australian standards (AS/NZS 3500 Plumbing and Drainage).

10.6. SUBSURFACE DRAINAGE.

Any retaining walls are to be back filled with non-cohesive free draining material to provide a drainage layer immediately behind the wall. The free draining

10. RISK MANAGEMENT. (Continued)

material is to be separated from the ground materials by geotextile fabric. Standard under pool drainage is acceptable.

10.7. INSPECTIONS.

It is essential that the foundation materials of all footing excavations be inspected and approved before concrete is placed. This includes retaining wall footings. Failure to advise the geotechnical engineer for these inspections could delay or stop the issuance of relevant certificates.

11. GEOTECHNICAL CONDITIONS FOR ISSUE OF CONSTRUCTION CERTIFICATE.

It is recommended that the following geotechnical conditions be applied to the Development Approval:-

The work is to be carried out in accordance with the Risk Management Report PX 00009 dated 6th July, 2019.

The Geotechnical Engineer is to inspect and approve the foundation materials of any footing excavations before concrete is placed.

12. GEOTECHNICAL CONDITIONS FOR ISSUE OF OCCUPATION CERTIFICATE.

The Geotechnical Engineer is to certify the following geotechnical aspects of the development:-

The work was carried out in accordance with the Risk Management Report PX 00009 dated 6th July, 2019.

The Geotechnical Engineer inspected and approved the foundation material of all footing excavations.

13. RISK ANALYSIS SUMMARY.

HAZARDS	Hazard One
TYPE	The excavation for the proposed garage is considered to be a potential hazard
LIKELIHOOD	'Rare' (10^{-5})
CONSEQUENCES TO PROPERTY	'Minor' (20%)
RISK TO PROPERTY	'Low'(2×10^{-6})
RISK TO LIFE	1.32×10^{-6}/annum
COMMENTS	This level of risk is **'ACCEPTABLE'** provided the conditions in **Section 10** are followed.

HODGSON CONSULTING ENGINEERS PTY. LTD.

Garth Hodgson MIE Aust
Member No. 2211514
Civil/Geotechnical & Structural Engineer

Peter Thompson MIE Aust CPEng
Member No. 146800
Civil/Geotechnical Engineer

Photo 1

Photo 2

Photo 3

Photo 4

DIRECTOR: G. HODGSON
PO Box 389 Mona Vale NSW 1660
Telephone: 0410 664 359
ABN 92 164 537 973

GEOTECHNICAL | CIVIL | STRUCTURAL

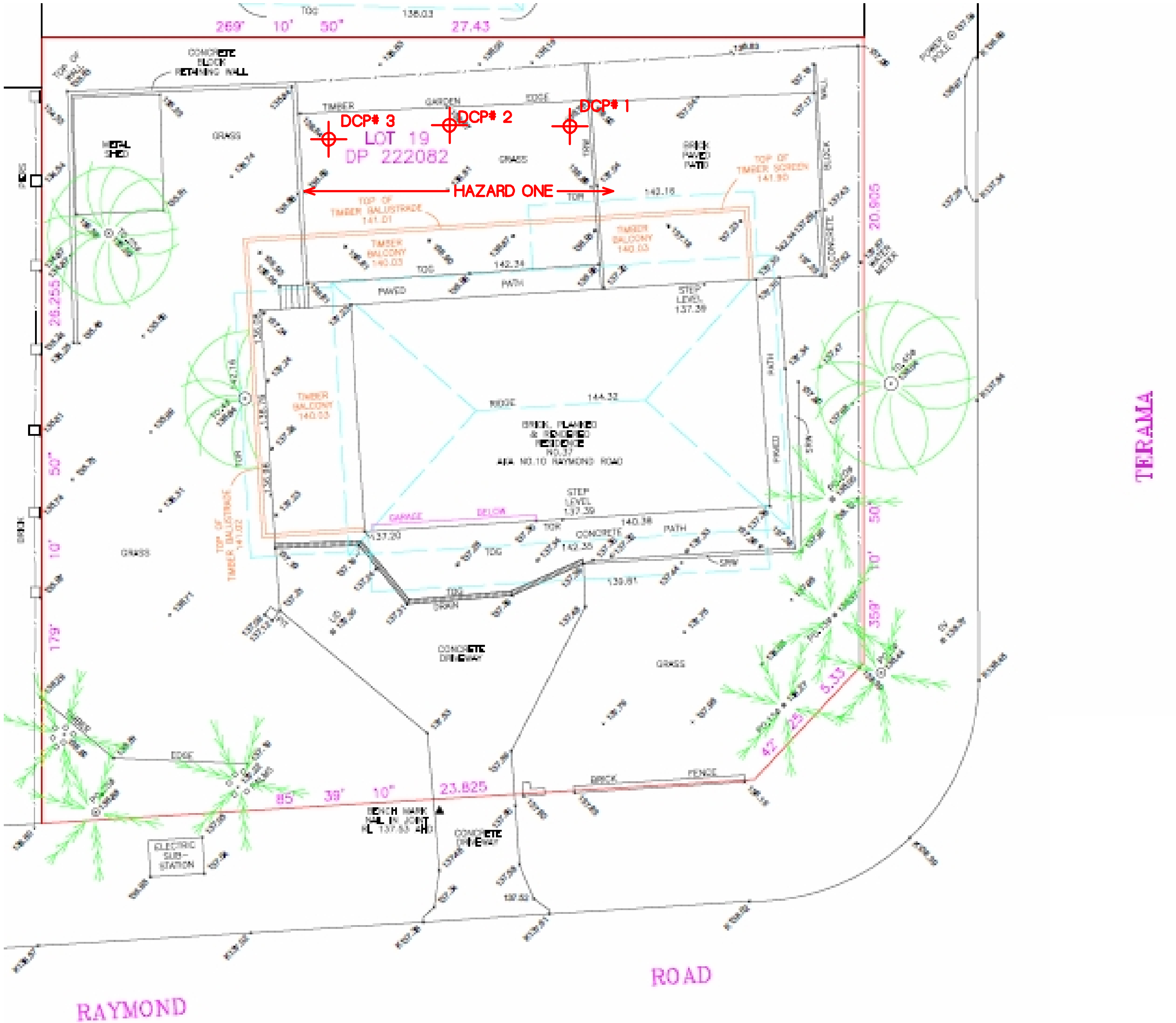
Photo 5

Photo 6

DIRECTOR: G. HODGSON
PO Box 389 Mona Vale NSW 1660
Telephone: 0410 664 359
ABN 92 164 537 973

Photo 7

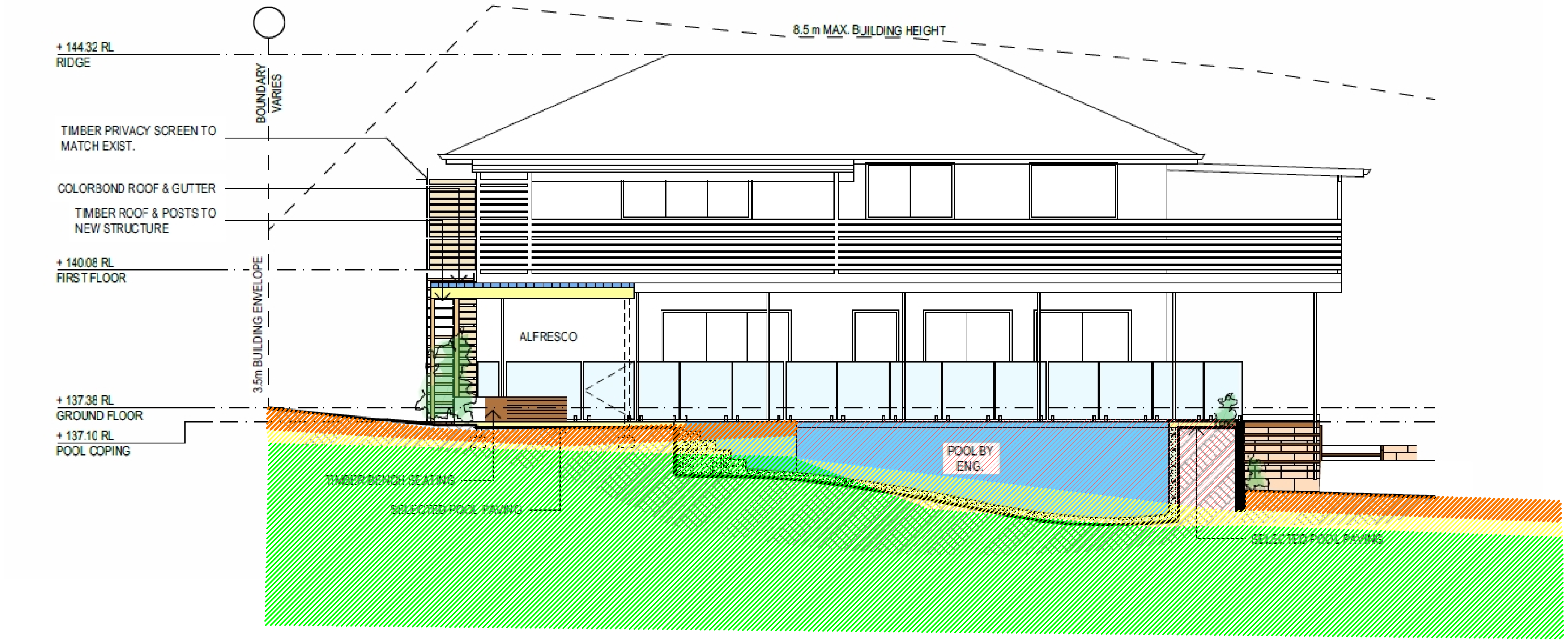
DIRECTOR: G. HODGSON
PO Box 389 Mona Vale NSW 1660
Telephone: 0410 664 359
ABN 92 164 537 973



HODGSON
CONSULTING ENGINEERS
GEOTECHNICAL | CIVIL | STRUCTURAL

SITE PLAN - DCP LOCATIONS & HAZARD

Job No	Address
PX 00009	37 TERAMA STREET
Scale	BILGOLA PLATEAU
NTS	NSW



NOTE
INTERPRETED SUB SURFACE SECTION ONLY.
ACTUAL GROUND CONDITIONS MAY VARY.

HODGSON CONSULTING ENGINEERS
GEOTECHNICAL | CIVIL | STRUCTURAL

TYPE SECTION	
Job No PX 00009	Address 37 TERAMA STREET BILGOLA PLATEAU NSW
Scale NTS	

STRATA PROFILE LEGEND
- Fill
- Sandy Topsoil
- Sandy Clay
- Narrabeen Group Rocks
- Hawkesbury Sandstone

7 RISK ESTIMATION

7.1 QUANTITATIVE RISK ESTIMATION

Quantitative risk estimation involves integration of the frequency analysis and the consequences.
For property, the risk can be calculated from:
$\mathbf{R}_{(Prop)} = \mathbf{P}_{(H)} \times \mathbf{P}_{(S:H)} \times \mathbf{P}_{(T:S)} \times \mathbf{V}_{(Prop:S)} \times \mathbf{E}$ **(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 risk$1.0< \mathbf{P}_{(T:S)} >0$.

$\mathbf{V}_{(Prop:S)}$ 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:

$\mathbf{R}_{(LoL)} = \mathbf{P}_{(H)} \times \mathbf{P}_{(S:H)} \times \mathbf{P}_{(T:S)} \times \mathbf{V}_{(D:T)}$ **(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.

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

For comparison with tolerable risk criteria, the individual risk from all the landslide hazards affecting the person most at risk, or the property, should be summed.

The assessment must clearly state whether it pertains to ‘as existing’ conditions or following implementation of recommended risk mitigation measures, thereby giving the ‘residual risk’.