GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER
FORM NO. 1 – To be submitted with Development Application

Development Application for _____
Name of Applicant

Address of site **3 Beaconsfield Street, Newport**

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

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

on this the 2nd 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 GARAGE & ALTERATIONS AND ADDITIONS AT 3 Beaconsfield Street, Newport– PX 00005

Report Date: 1st 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 THW Architects, Job number 144, Drawing numbers A00 – A04, A10 - A13, A20 – A21, A100, A104 – A108, Issue A, dated 31st May, 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 _____

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 **3 Beaconsfield Street, Newport**

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 GARAGE & ALTERATIONS AND ADDITIONS AT 3 Beaconsfield Street, Newport– PX 00005

Report Date: 1st July, 2019

Author: PETER THOMPSON

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

Please mark appropriate box

☒ Comprehensive site mapping conducted 1/07/2019 (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 1/07/2019

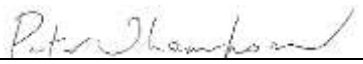
☒ Geotechnical model developed and reported as an inferred subsurface type-section
☒ Geotechnical hazards identified
- ☐ Above the site
- ☒ On the site
- ☐ Below the site
- ☐ Beside the site

☒ 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 ..... 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 

Name Peter Thompson

Chartered Professional Status MIE Aust CPEng

Membership No. 146800

Company Hodgson Consulting Engineers Pty Ltd

RISK ANALYSIS & MANAGEMENT FOR PROPOSED GARAGE & ALTERATIONS AND ADDITIONS AT 3 BEACONSFIELD STREET, NEWPORT

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 garage 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 THW Architects, Job number 144, Drawing numbers A00 – A04, A10 - A13, A20 – A21, A100, A104 – A108, Issue A, dated 31st May, 2019.

3. DESCRIPTION OF SITE & SURROUNDING AREA.

3.1 The site was inspected on the 1st July, 2019.

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

3.2 This trapezoidal shaped block is located on the low side of the road on the corner of Beaconsfield Street and Barrenjoey Road. The property has a westerly aspect. It is located toward near the top of a slope that rises from the waters of Pittwater to the crest of the Bush Rangers Hill. From the road frontage, the slope of the land falls across the property at maximum average angles of 5 to10 degrees before steepening to 20 to 25 degrees near the south western boundary of the property.

3.3 Access to the property is via the gravel driveway which starts from the edge of the Beaconsfield Street adjacent north western corner of the property, Photo 1. A terraced masonry retaining wall supports the cut on the eastern side of the driveway, Photo 2. A pathway from the side of the driveway provides pedestrian access to the main entrance, Photo 3. A level courtyard area is on the eastern side of the existing residence, Photo 4. On the western side of the existing residence the driveway continues to the south providing access to rear of the property changing into concrete, Photo 5. A series landscaping retaining walls are providing support at the south western corner of the property, Photo 6. These retaining walls are located on neighbouring properties and were observed to be in good condition with no signs of significant movement. A concrete block retaining wall supports the fill material at the north eastern corner of the property and was observed to be in good condition with no signs of significant movement, Photo 7.

3.4 The multi-storey residence is cut into the natural slope supported on concrete strip footings and most likely piers. Masonry walls support the floor slabs. No significant movement attributed slope instability was observed in the existing residence and driveway area.

3.5 The southern part of the subject property and adjoining properties are 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 interbedded sandstones, siltstones and shales of the Upper Narrabeen Group. The Narrabeen Group Rocks are Late Permian to Middle Triassic in age with the early rocks not outcropping in the area under discussion. The materials from which the rocks were formed consist of gravels, coarse to fine

4. GEOLOGY OF THE SITE. Continued

sands, silts and clays. They were deposited in a riverine type environment with larger floods causing fans of finer materials. The direction of deposition changed during the period of formation. The lower beds are very variable with the variations decreasing as the junction with the Hawkesbury Sandstones is approached. This is marked by the highest of persistent shale beds over thicker sandstone beds which are similar in composition to the Hawkesbury Sandstones.

4.2 The slope materials are colluvial in origin at the surface and become residual with depth. They consist of topsoil over sandy clays and clays that merge into the weathered rock at depths varying from 0.5 to 1.6 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	4	10	10
0.3 to 0.6	11	**15/0.190**	43
0.6 to 0.9	25		**20/0.095**
0.9 to 1.2	20		
1.2 to 1.5	31		
1.5 to 1.8	**14/0.080**		
	End of Test @ 1.580m	**End of Test @ 0.490m**	**End of Test @ 0.695m**

DCP TESTING NOTES:

DCP#1	14 Blows for 0.080m then 8 blows for 0.014m. Double Bounce. Refusal in weathered rock or floater. Tip – Dry and with orange cream shale.
DCP#2	15 Blows for 0.190m then 8 blows for 0.010m. Double Bounce. Refusal in weathered rock or floater. Tip – Dry and with orange cream shale.
DCP#3	20 Blows for 0.095m then 8 blows for 0.020m. Double Bounce. Refusal in weathered rock or floater. Tip – Dry and with some orange cream shale.
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 eastern boundary. No natural watercourses were observed on site.

6.2 SURROUNDING AREA.

Overland stormwater flow entering the site from the adjoining properties and Barrenjoey 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.

Only the southern end of site is classed slip affected under Council's Policy and a H1 Hazard. The main excavation works are at the northern end of the site where the site is unclassified. The excavation for the proposed garage will be to an approximate depth of 2.0 metres. The excavation for the proposed garage 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 classed 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 2.0 metres deep is required to construct the proposed garage. 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:
$\mathbf{R_{(LoII)} = P_{(H)} \times P_{(SH)} \times P_{(TS)} \times V_{(DT)}}$ (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.
$\mathbf{P_{(H)}}$ = 0.0001/annum

8.2.2.2 Probability of Spatial Impact

People will be working below the cut but it will be appropriately supported.
$\mathbf{P_{(SH)}}$ = 0.3

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:

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

$\mathbf{P_{(TS)}}$ = 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
$\mathbf{V_{(DT)}}$ = 0.2

8.2.2.5 Risk Estimation

$\mathbf{R_{(Lol)}}$ = 0.0001 x 0.3 x 0.33 x 0.2
= 0.00000198
$\mathbf{R_{(Lol)}}$ = **1.98** 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 2.0 metres are required for the construction of the garage. The cuts are expected to be through sandy topsoils and clays before shales and sandstones of the Narrabeen group are encountered. It is possible that minor temporary support may be required as the cut progresses. The garage 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 Due to the depth of excavation required and proximity to adjoining structures, it is strongly recommended that an excavation contractor with demonstrable experience in this type of project be engaged to undertake the proposed works with the appropriate care and diligence. We would recommend that a construction methodology/excavation management plan be developed, reviewed and approved before bulk excavations commence. This should include contingency planning for rock bolting, shotcreting or similar support for the back and side walls if deemed necessary, and the environmental and logistical elements of the project.

10.2.4 The existing structures foundations are to be investigated during the excavation and construction phase of the project. Underpinning of the existing structures may be required if these structures are not founded on the underlying bedrock. This is to be confirmed by the licenced builder or structural engineer before construction takes place.

10.2.5 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 secondary dwelling and subsequent underpinning of existing footings 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. RISK MANAGEMENT. (Continued)

10.2.6 We recommend that any excavation through rock that cannot be readily achieved with a bucket excavator or ripper should be carried out initially using a rock saw to minimise the vibration impact and disturbance on the adjoining properties. Any rock breaking must be carried out only after the rock has been sawed and in short bursts (2-5 seconds) to prevent the vibration amplifying. The break in the rock from the saw must be between the rock to be broken and the closest adjoining structure.

It may be necessary to employ vibration monitoring to ensure excavation works are conducted within acceptable parameters to minimise disturbance to neighbouring properties and prevent vibrations damaging adjoining structures.

The Australian Standard AS2670.2-1990 "Evaluation of human exposure to whole-body vibrations – continuous and shock induced vibrations in buildings (1-80 Hz)" suggests a day time limit of 8 mm/s component PPV for human comfort is acceptable.

We would suggest allowable vibration limits be set at 5mm/s PPV. It is expected that rock hammers with an approximate weight of 600-800kg will be adequate to operate within these tolerances.

10.2.7 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.

10.2.8 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. RISK MANAGEMENT. (Continued)

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 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 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 00005 dated 1st 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 00005 dated 1st July,, 2019.

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

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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	1.98×10^{-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

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Photo 3

Photo 4

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Photo 5

Photo 6

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Photo 7

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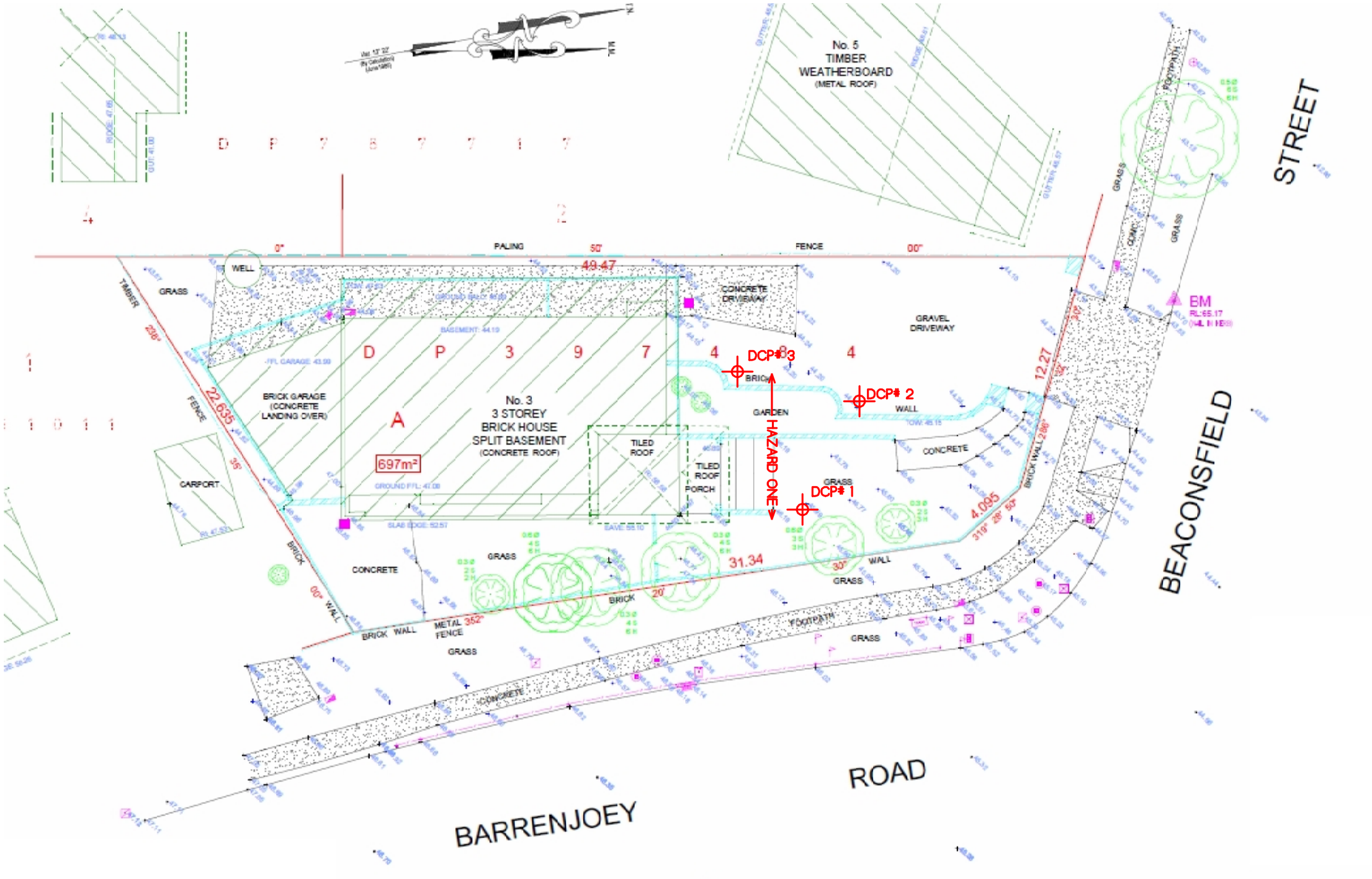
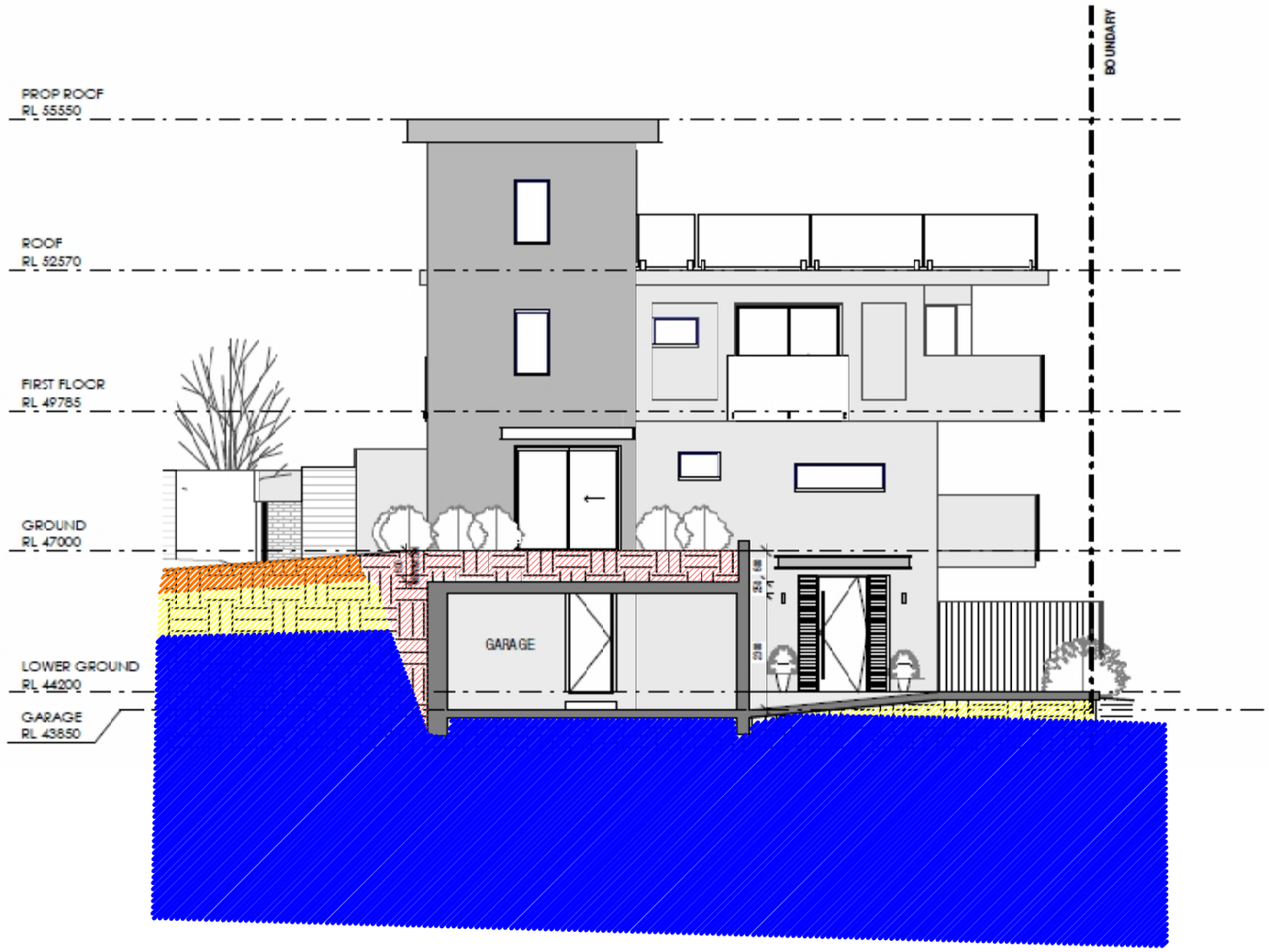


HODGSON CONSULTING ENGINEERS
GEOTECHNICAL | CIVIL | STRUCTURAL

SITE PLAN - DCP LOCATIONS & HAZARD

Job No	Address
PX 00005	3 BEACONSFIELD STREET
Scale	NEWPORT
NTS	NSW



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

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TYPE SECTION

Job No	Address
PX 00005	3 BEACONSFIELD STREET NEWPORT 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.

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’.