GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER

FORM NO. 1 – To be submitted with Development Application

Development Application for _____
Name of Applicant

Address of site 30 KANANOOK AVENUE BAYVIEW

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* Jack Hodgson Consultants Pty Ltd (Trading or Company Name)

on this the 5TH NOVEMBER, 2018 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 ALTERATIONS AND ADDITIONS AT 30 KANANOOK AVENUE BAYVIEW SECTION 4.55 FOR DEVELOPMENT APPLICATION NO: N0255/17

Report Date: 5-11-18

Author : PETER THOMPSON

Author's Company/Organisation : JACK HODGSON CONSULTANTS PTY LTD

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

Architectural drawings prepared by CCD Drafting Job No: 1902 Dwg No: A-100 to A-105 Revision D dated 17th October, 2018.

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 Peter Thompson

Name Peter Thompson

Chartered Professional Status MIE Aust CPEng

Membership No. 146800

Company Jack Hodgson Consultants 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 **30 KANANOOK AVENUE BAYVIEW**

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 ALTERATIONS AND ADDITIONS AT 30 KANANOOK AVENUE BAYVIEW SECTION 4.55 FOR DEVELOPMENT APPLICATION NO: N0255/17

Report Date: 4TH NOVEMBER, 2018

Author: PETER THOMPSON

Author's Company/Organisation: JACK HODGSON CONSULTANTS PTY LTD

Please mark appropriate box

☒ Comprehensive site mapping conducted 19/12/2016 (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 19//12/2016

☒ 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 Peter Thompson
Name Peter Thompson
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ABN: 94 053 405 011

RISK ANALYSIS & MANAGEMENT FOR PROPOSED ALTERATIONS AND ADDITIONS AT 30 KANANOOK AVENUE BAYVIEW

Section 4.55 for Development Application No: N0255/17

1. INTRODUCTION.

1.1 This assessment has been prepared to accompany an application for development approval. 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 Northern Beaches Council - 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 Northern Beaches Council - Pittwater, 2009.

1.4 The experience of Jack Hodgson Consultants spans a time period over 40 years in the Pittwater area and greater Sydney region.

2. PROPOSED DEVELOPMENT.

2.1 Construct new concrete driveway and carport at north-western corner of the block. A new storage area will be constructed under the proposed carport.

2.2 Construct new timber access stairs on northern side of existing residence.

2.3 Various internal alterations to existing ground floor to enclose proposed granny flat.

2.4 Details of the proposed development are shown on a series of architectural drawings developed by CCD Drafting Job No: 1902 Dwg No: A-100 to A-105 Revision D dated 17th October, 2018.

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3. DESCRIPTION OF SITE & SURROUNDING AREA.

3.1 The site was inspected on the 19th December, 2016.

3.2 This roughly triangular shaped block is located on the low side of the road and has an easterly aspect. It is located toward the middle of a slope that rises from the Pittwater waterfront to the crest of the ridge near Minkara Road. From the road frontage, the slope of the land falls across the property at average angles of approximately 25 degrees.

3.3 From the road frontage pedestrian only access is via a series of concrete stairs that provide access to a covered timber deck and the entrance to the residence (Photos 1 & 2). The road reserve is largely level and lawn covered. The southern half of the block is largely undeveloped and is populated with numerous medium to large trees and shrubs. Stable sandstone stack rock walls and terraces support the bank that extends along the western boundary of the block (Photos 3 & 4). A concrete patio and timber deck extend from the western and southern sides of the ground floor level of the house (Photos 5 & 6). The timber deck is supported on timber bearers and metal posts founded on concrete slabs (Photo 7). The steep bank underneath is nominally supported by a dilapidated treated timber wall, and a stable concrete crib wall (Photos 8 & 7). The batter slope situated in the foundation space of the residence and that extends to the east is supported by a concrete coating under the residence and a stable sandstone boulder wall at its eastern end (Photos 9 & 10). Below the residence the slope continues at similar levels and is populated with trees and shrubs.

3.4 The existing brick and timber residence is in average condition for its age. The house is supported on concrete block retaining walls and steel posts on concrete footings. No evidence of significant cracking or movement was identified at the time of our inspection.

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 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. GEOLOGY OF THE SITE. (Continued)

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 1.0 to 2.5 metres or deeper where filling has been carried out.

5. SUBSURFACE INVESTIGATION.

5.1 Two 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 locations of these tests are shown on the site plan provided and the results of these tests are as follows:

NUMBER OF BLOWS - Conducted using a 9kg hammer, 510mm drop and conical tip.		
DEPTH (m)	**DCP1**	**DCP2**
0.0 to 0.3	**Drilled**	**Drilled**
0.3 to 0.6	**17**	**Drilled**
0.6 to 0.9	**7**	**Drilled**
0.9 to 1.2	**10**	**15**
1.2 to 1.5	**3**	**15**
1.5 to 1.8	**8**	**19**
1.8 to 2.1	**19**	**17**
2.1 to 2.4	**17**	**27**
2.4 to 2.7	**23**	**23**
2.7 to 3.0	**26/**	
	Refusal @ 2.95m bouncing on rock.	**Refusal @ 2.55m bouncing on rock**

DCP TESTING NOTES:

DCP#1	Refusal @ 2.95m bouncing on rock. Tip:- Damp with orange brown material.
DCP#2	Refusal @ 0.85m bouncing on rock. Tip – Damp with orange material.
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.

5.2 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

5. SUBSURFACE INVESTIGATION AND SITE CLASSIFICATION. (Continued)

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.

6. DRAINAGE OF THE SITE.

6.1 ON THE SITE.

The block is naturally drained to the east.

6.2 SURROUNDING AREA.

Overland stormwater flow entering the site from the adjoining properties 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.

7.2 ON THE SITE.

7.2.1 By reference to Pittwater Councils Geotechnical Hazard mapping, the block is classified as a H1 Hazard zone. The slope of the land surface that falls across the property is considered a potential hazard (**HAZARD ONE**).

7.2.2 The excavation required for the storage room under the proposed carport will be approximately 2.0 metres in depth. The proximity of the excavation to the road reserve batter and the depth of the excavation is considered a potential hazard (**HAZARD TWO**).

7.3 BELOW THE SITE.

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

7. GEOTECHNICAL HAZARDS. (Continued)

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

The slope of the land surface falls across the property at average angles of approximately 25 degrees toward the east. No evidence of significant slope instability was identified at the time of our inspection. The likelihood of the slope failing and impacting on the house is assessed as 'Unlikely' (10^{-4}). The consequences to property of such a failure are assessed as 'Low' (5%). The risk to property is 'Low' (5×10^{-6}).

8.2.2 HAZARD ONE Quantitative Risk Assessment on Life

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

8.2.2.1 Annual Probability
No evidence of significant slope instability was identified at the time of inspection.
$\mathbf{P_{(H)}} = 0.0001$/annum

8.2.2.2 Probability of Spatial Impact
The house is situated toward the middle of moderate to steep slope.
$\mathbf{P_{(SH)}} = 0.1$

8.2.2.3 Possibility of the Location Being Occupied During Failure
The average household is taken to be occupied by 4 people. It is estimated that 1 person is in the house for 20 hours a day, 7 days a week. It is estimated 3 people are in the house 12 hours a day, 5 days a week.

For the person most at risk:

$\frac{20}{24} x \frac{7}{7} = 0.83$

$\mathbf{P_{(TS)}} = 0.83$

8.2.2.4 Probability of Loss of Life on Impact of Failure

Based on the volume of land sliding and its likely velocity when it fails, it is estimated that the vulnerability of a person to being killed in the house when a landslide occurs is 0.01

$\mathbf{V_{(DT)}} = 0.01$

8.2.2.5 Risk Estimation

$\mathbf{R_{(LoI)}} = 0.0001 \times 0.1 \times 0.83 \times 0.01$

$= 0.000000083$

$\mathbf{R_{(LoI)}} = 8.3 \times 10^{-8}$/annum **NOTE:** This level of risk is **'ACCEPTABLE'** provided the recommendations provided in **Section 10** are followed.

8.2.3 HAZARD TWO Qualitative Risk Assessment on Property

The excavation required for the storage room under the proposed carport will be approximately 2.0 metres in depth and also the proximity of the excavation to the road reserve. Provided good engineering and building practices are followed and the recommendations given in **Section 10** are undertaken the likelihood of the cut failing and impacting on the worksite 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}).

8.2.4 HAZARD Two Quantitative Risk Assessment on Life

For loss of life, risk can be calculated as follows:

$\mathbf{R_{(LoI)}} = \mathbf{P_{(H)}} \times \mathbf{P_{(SH)}} \times \mathbf{P_{(TS)}} \times \mathbf{V_{(DT)}}$ (See Appendix for full explanation of terms)

8.2.4.1 Annual Probability

Provided recommendations in Section 10 are followed and any soil portions of the cut are battered back and kept dry, batter failure is considered unlikely.

$\mathbf{P_{(H)}} = 0.00001$/annum

8.2.4.2 Probability of Spatial Impact

People will be working below the cut.

$\mathbf{P_{(SH)}} = 0.3$

8. RISK ASSESSMENT. (Continued)

8.2.4.3 Possibility of the Location Being Occupied During Failure

The average domestic worksite is taken to be occupied by 5 people. It is estimated that 1 person is below the cut for 10 hours a day, 6 days a week. It is estimated 4 people are below the cut 7 hours a day, 5 days a week.

For the person most at risk:

$$\frac{10}{24} x \frac{6}{7} = 0.36$$

$\mathbf{P_{(TS)}} = 0.36$

8.2.4.4 Probability of Loss of Life on Impact of Failure

Based on the volume of land failing and its likely velocity when it hits the work area, it is estimated that the vulnerability of a person to being killed below the cut when the batter fails is 0.2

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

8.2.4.5 Risk Estimation

$\mathbf{R_{(LoI)}} = 0.00001 \times 0.3 \times 0.36 \times 0.2$

$= 0.000000216$

$\mathbf{R_{(LoI)}} = 2.16 \times 10^{-7}$/annum **NOTE:** This level of risk is **'ACCEPTABLE'** provided the recommendations given in **Section 10** are undertaken.

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. SUITABILITY OF DEVELOPMENT FOR SITE. (Continued)

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 Northern Beaches Council - 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.

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 March, 2015.

10.2.2 Temporary/permanent structural support will be required during the excavation and construction phase of the project. This is to be designed, approved and supervised by the structural engineer.

10.2.3 Excavation and piers will be necessary to construct suitable footings for the proposed works. It is expected that weathered rock material for the footing will be found at levels between 2.0m to 3.0m. Weathered shale and sandstone rock should be found at these depths. More competent sandstone may be found at depths below these layers. Further testing would need to be carried out to find an exact depth.

10.2.4 It is recommended that detailed dilapidation reporting be undertaken on the adjacent structures before demolition or excavation work commences.

10.2.5 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

10. RISK MANAGEMENT. (Continued)

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. If this is not possible then we recommend the following.

That suitable vibration monitors be used to monitor and limit vibration effects on the adjacent 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

10.2.6 Any new or replaced retaining walls are to be installed as soon as possible after the excavations are complete. The cut batters for the dwelling 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 for the footings, 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.

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

10. RISK MANAGEMENT. (Continued)

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.

10.3.3 New retaining walls will be required for the cut of the storage room of the proposed development. These retaining walls are to be designed by the structural engineer with any foundations support by piers and footings taken to the weathered rock material.

10.4. FOUNDATION MATERIALS AND FOOTINGS.

It is recommended that all footings be supported on and potted into the underlying weathered rock, using piers as necessary. The design allowable bearing pressures are 600 kPa for spread footings or 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. The slope is also subject to filling which was likely pushed downslope during the construction of the road. Subsequently ground conditions on site 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.

Any storm water generated from any new works is to be piped to the existing stormwater system for the block through any water tanks, onsite detention or dispersion systems that may be required by the regulating authorities.

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. RISK MANAGEMENT. (Continued)

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 MR 30951B dated 4th November, 2018.

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 MR 30951B dated 4th November, 2018.

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

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13. RISK ANALYSIS SUMMARY.

HAZARDS	Hazard One	Hazard Two
TYPE	By reference to Pittwater Councils Geotechnical Hazard mapping, the block is identified as an H1 Hazard Zone. The slope of the land surface that falls across the property is considered a potential hazard.	The excavations required for the proposed development are considered a potential hazard.
LIKELIHOOD	'Unlikely' (10^{-4})	'Rare' (10^{-5})
CONSEQUENCES TO PROPERTY	'Minor' (5%)	'Medium' (20%)
RISK TO PROPERTY	'Low'(5×10^{-6})	'Low'(2×10^{-6})
RISK TO LIFE	8.3×10^{-8}/annum	2.16×10^{-7}/annum
COMMENTS	This level of risk is **'ACCEPTABLE'** provided the conditions in **Section 10** are followed.	This level of risk is **'ACCEPTABLE'** provided the conditions in **Section 10** are followed.

JACK HODGSON CONSULTANTS PTY. LIMITED.

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

Photo 1

Photo 2

Photo 3

Photo 4

Photo 5

Photo 6

Photo 7

Photo 8

Photo 9

Photo 10

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:
R(Prop) = **P**(H) x **P**(S:H) x **P**(T:S) x **V**(Prop:S) x **E** **(1)**

Where
R(Prop) is the risk (annual loss of property value).

P(H) is the annual probability of the landslide.

P(S:H) is the probability of spatial impact by the landslide on the property, taking into account the travel
distance and travel direction.

P(T:S) is the temporal spatial probability. For houses and other buildings **P**(T:S)= 1.0. For Vehicles and other
moving elements at risk1.0< **P**(T:S) >0.

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:

R(LoL) = **P**(H) x **P**(S:H) x **P**(T:S) x **V**(D:T) **(2)**
Where

R(LoL) is the risk (annual probability of loss of life (death) of an individual).

P(H) is the annual probability of the landslide.

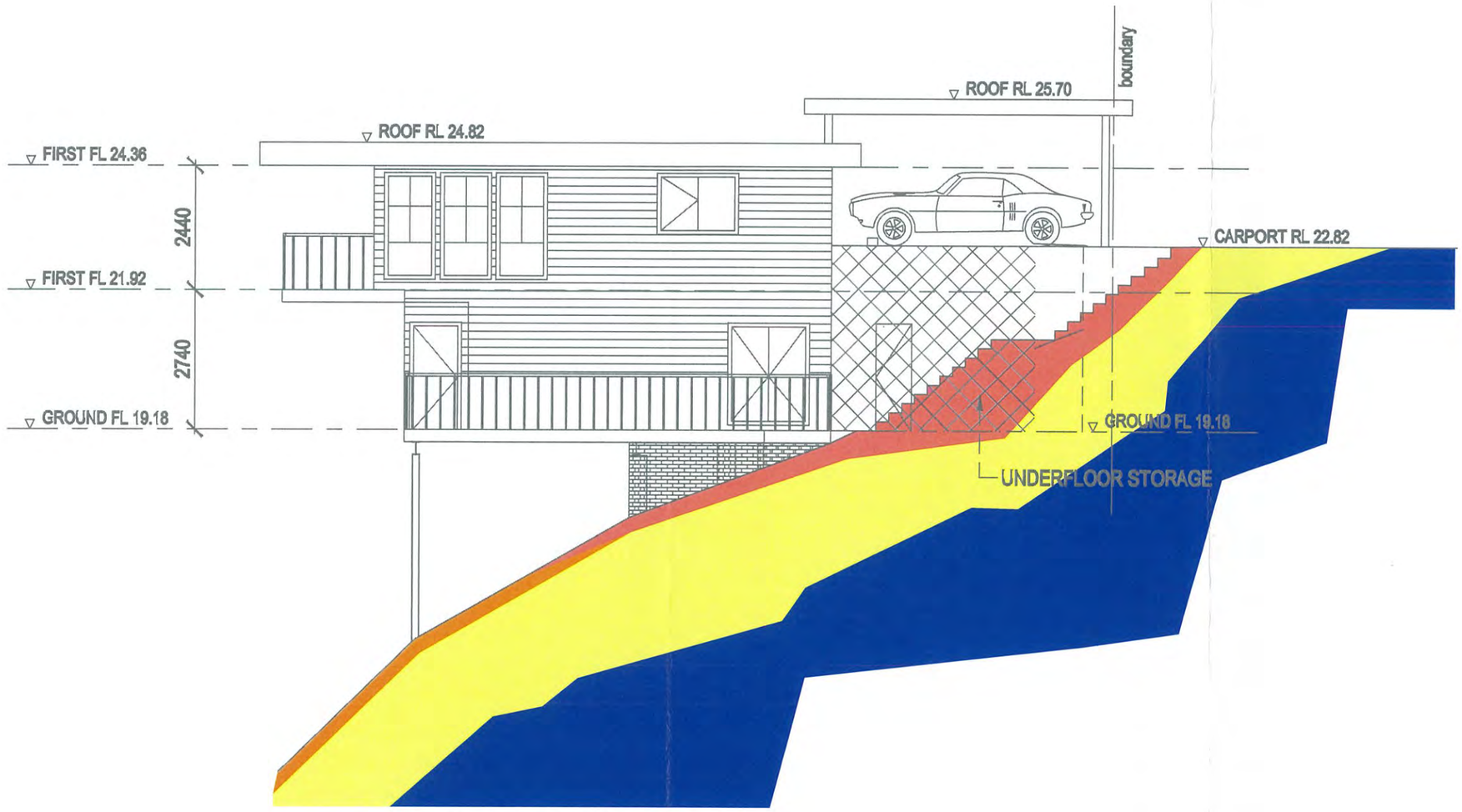
P(S:H) is the probability of spatial impact of the landslide impacting a building (location) taking into account
the travel distance and travel direction given the event.

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.

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'.



EASTERN ELEVATION

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

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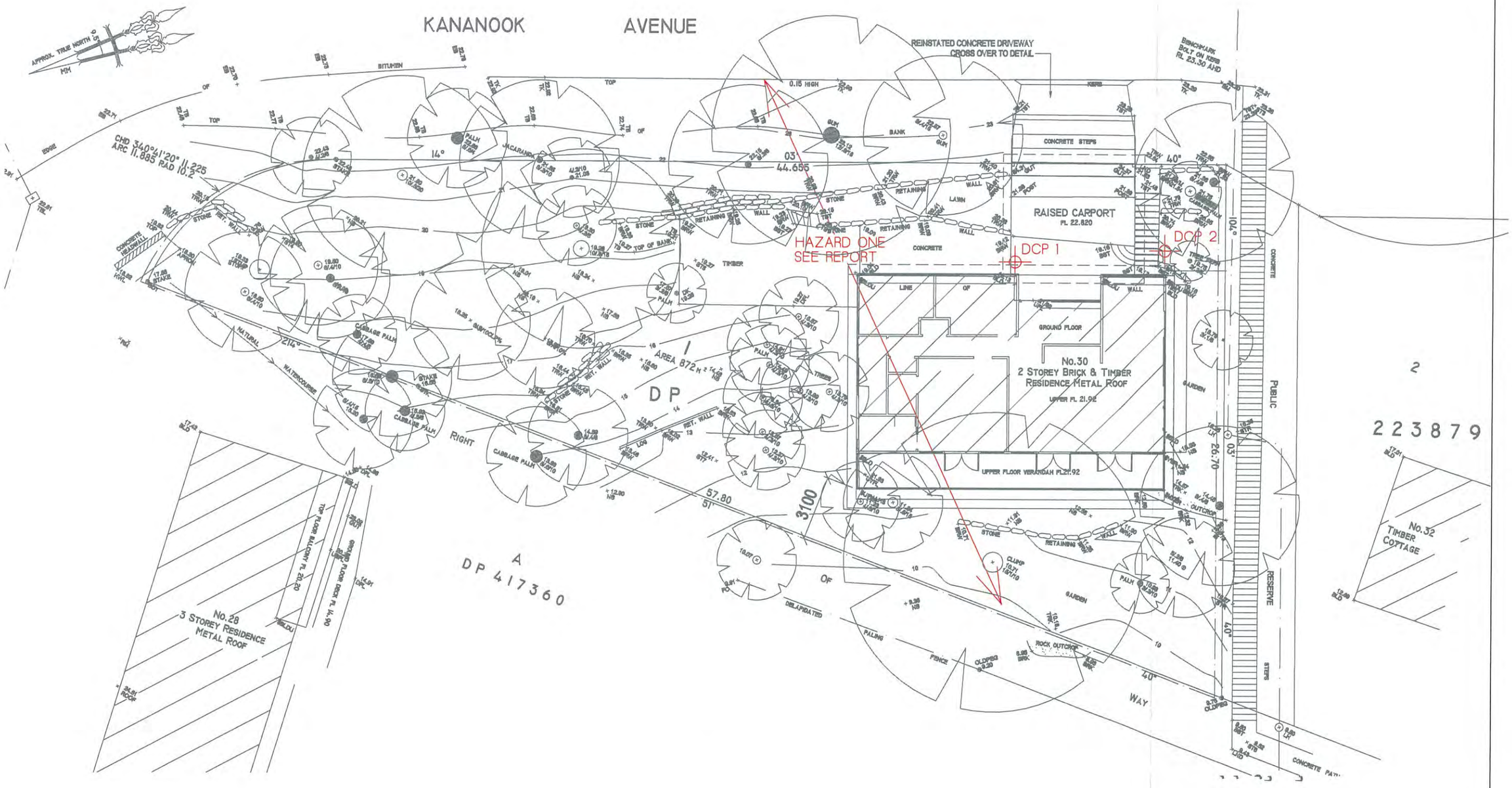
Jack Hodgson Consultants Pty Limited
CONSULTING CIVIL, GEOTECHNICAL AND STRUCTURAL ENGINEERS

TYPE SECTION

Job No	Address
MR 30951	30 KANANOOK AVENUE BAYVIEW NSW
Scale	
NTS	

Strata Profile Legend

- Fill
- Sandy Topsoil
- Sandy Clay
- Narrabeen Group Rocks



= DCP LOCATION

Jack Hodgson Consultants Pty Limited
ABN 94 053 405 011
CONSULTING CIVIL, GEOTECHNICAL AND STRUCTURAL ENGINEERS

SITE PLAN - HAZARD AND DCP LOCATIONS

Job No	Address
MR 30951	30 KANANOOK AVENUE
Scale	BAYVIEW
NTS	NSW