Geotechnical Site Investigation

S8597 Mount Selwyn

Selwyn Trail, Mount Selwyn, NSW

Submitted To
CommPlan
Suite 3
Level 1, 100 New South Head Rd
Edgecliff NSW 2027

Site Number
119033

Date
18/12/2018

Intrax
Engineering Confidence

- Structural
- Geotechnical
- Civil
- Residential
- Forensic
- Building Services
- Surveying

Author
Prageeth Edirisinghe

Published
18/12/2018

Document Revision: 0
Template Version: i
Template Name: Master with Cover

Intrax Consulting Engineers Pty Ltd
ABN: 31 106 481 252

Head Office
35 Bank Street
South Melbourne, Vic 3205
p: 03 8371 0100 f: 03 8371 0199
w: www.intrax.com.au

Table of Contents

Document Revision History

Date	Rev	Author	Approved by	Comments
18-Dec-18	0	Prageeth Edirisinghe	Scott Emmett	First Edition

List of Appendices

APPENDIX A: Site Plan and Borehole Logs

APPENDIX B: Site Photography

APPENDIX C: Geotechnical Strength Reduction Factor

REFERENCED STANDARDS:

AS 1726-2017, Geotechnical site investigations, Standards Australia, Sydney, Retrieved from SAI Global

AS 2159-2009, Piling-Design and Installation, Standards Australia, Sydney, Retrieved from SAI Global

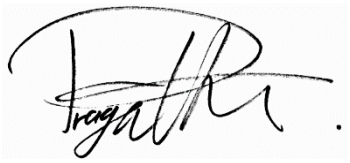
AS 2870-2011, Residential slabs and footings, Standards Australia, Sydney, Retrieved from SAI Global

AS 3798-2007, Guidelines on earthworks for commercial and residential developments, Standards Australia, Sydney, Retrieved from SAI Global

REPORT AUTHOR/S:

Mr Scott Emmett
Geologist
BSc (EarthScience) Hons, MAIG

Mr Prageeth Edirisinghe
Senior Geotechnical Engineer
BSc (Civil) Hons



REPORT CONTACT:

Prageeth Edirisinghe

03 8371 0100
Prageeth.e@intrax.com.au

Intrax Consulting Engineers Pty Ltd
Geotechnical Consultants
Unit 11, 85 Mt Derrimut Road
DEER PARK, VIC, 3023

1 Introduction

Intrax Consulting Engineers has completed a geotechnical investigation for the proposed Optus tower development at Selwyn Trail Mount Selwyn NSW.

The investigation was carried out in accordance with the fee proposal QU12184 commissioned by MYD Consulting Engineers.

This report outlines the geotechnical site investigation carried out on 17.12.2018. The report includes

- Site classification in accordance with AS2870-2011
- Geotechnical recommendations and design parameters for foundations
- Empirical soil properties
- Information about the ground water table and field P^H readings
- Soil resistivity test results
- Construction and precautions and recommendations

2 Project and Site Description

2.1 Project Description

The proposed development is a 30m Optus monopole tower supporting Optus panel antennas on a Hexagonal head frame as outlined in the draft drawing by Huawei Technologies (AU) Pty Ltd (Drawing No. S8597-P2, revision 01, dated 12.06.2018). The proposed development also contains an Optus equipment shelter and 3m wide gravel access track.

2.2 Site Description

The investigated site is located to south of Selwyn Trail, Mount Selwyn, located in a ridge of hilly formation. The proposed building envelope is bounded to the north by Selwyn Trail, to the east, south and west by existing forest. Large basalt rock out-crops were scattered throughout the. The ground cover mainly consisted of rock outcrops, grass and shrubs.

Site conditions on the date of inspection are visible in the attached photography in Appendix B with the site features indicated in the site plan, refer Appendix A.

3 Method of Investigation

3.1 Desktop Assessment

Geological maps from the Geological Survey of New South Wales, aerial photography and our local experienced were used to assess the anticipated site conditions and the area geology.

3.2 Fieldwork

The fieldwork consisted of drilling a total of one (1) boreholes to a maximum depth of 5.9 metres with solid flight auger drilling and NMLC coring on a ute mounted rig. The approximate locations of the boreholes are shown on the attached site plan in Appendix A. The subsurface materials were visually classified in accordance with AS1726-2017: *Geotechnical Site Investigation*.

4 Results of Investigation

4.1 Desktop Assessment

Investigation of geological maps from the Geological survey of NSW has identified the expected site geology is Tertiary aged Basalt. This geology was consistent with the visual identification of material on site. An extract of the local geological map is provided below.

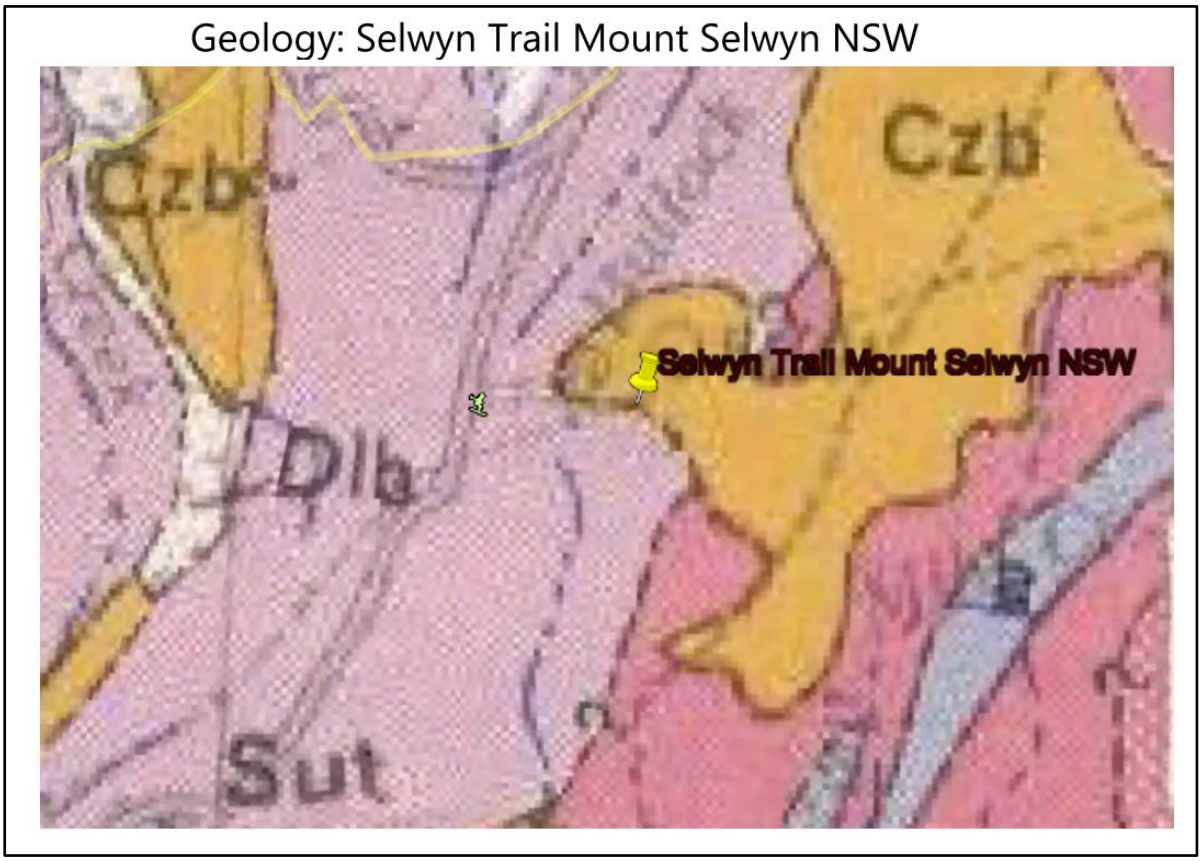


Figure 1: Extract of local geology, Intrax GIS database (Geovic Seamless)

4.2 Subsurface Conditions

The boreholes revealed the substrata typically consisted of the following soil profile. Variation from this profile existed across the site, refer to borehole logs in Appendix A for details.

RESIDUAL	Clayey SILT, dark brown, some organic matters, moist, loose up to 200mm below the surface level
BASALT	Extremely weathered to fresh BASALT was encountered within the bore hole.

Borehole was terminated at 5.9m below the surface level.

4.2.1 Ground Water

Groundwater was not intersected at a depth of 5.9 metres during borehole drilling.

Substrata conditions encountered are such that infiltration and occurrence of perched water at the interface between different material layers should not be disregarded. Foundation excavation should take note of this.

4.3 Soil Resistivity

The Wenner 4 pin method was adopted following AS1768 – 2003 to determine the soil resistivity on site. The test was repeated eight (8) times, changing the directions and the probe (pin) intervals. Initially the test was propagated towards the North South direction latter towards the East-West direction. Obtained results from the test is illustrated in below table.

Table 1: Soil Resistivity results

Test No:	Direction	Pin Spacing (m)	Measured Resistance (Ω)	Mean value of resistivity (Ωm)	Ω/m³
1	N-S	1.0	771	4,845	3.73×10^6
2	N-S	2.0	261	3,280	1.71×10^6
3	N-S	5.0	99	3,110	1.54×10^6
4	N-S	10.0	54	3,393	1.83×10^6
5	E-W	1.0	696	4,373	3.04×10^6
6	E-W	2.0	242	3,041	1.47×10^6
7	E-W	5.0	110	3,456	1.90×10^6
8	E-W	10.0	48	3,016	1.45×10^6

Note: As resistivity measurements are often distorted and invalidated by underground pieces of metal, underground aquifers, building footings and alike, it is advisable that the resistivity at the site is checked after the tower/pole and service buildings have been built.

5 Discussion and Recommendations

5.1 Site Reactivity – AS 2870

After considering the area geology, the soil profile encountered in the bores, and the climatic zone of the area, this site has been classified as CLASS A with respect to foundation construction (Australian Standard 2870-2011 Residential Slabs and Footings). It is anticipated that the seasonal surface movement under normal moisture conditions at this site considered negligible. Note that, this classification is only applicable to Class 1 and 10a structures in accordance with the Building Code of Australia, for other structures this classification should be used as a guide only.

5.2 Tower Foundation

5.2.1 Working Loading

Below table illustrates the estimated working loading on the proposed footing system to support a 30m Optus monopole tower. It should be noted that these values are based on this office previous experiences with similar projects, wind region as per AS/NZS 1170.2 and terrain category. These parameters must be re-evaluated against the actual loading by a qualified structural engineer.

Table 1: Tower working loading

Monopole Height (m)	Axial Loading (kN)	Shear Loading (kN)	Moment (kNm)
30m	100	95	6,500

5.2.2 Isolated Pad (Mass Pad) Footings

Mass concrete Pad footings are an appropriate footing arrangement for the proposed structure. Based on the site investigation, pad and strip footings founded at least on to the naturally occurring moderately weathered or slightly weathered BASALT as described in the logs.

The pad should sufficiently sized such that the self-weight of the concrete pad is able to restrain against overturning moments and lateral shear; determination of overturning moments, lateral shear and pad sizing should be completed by a suitably qualified structural engineer. It should be noted no lateral restraint is to be adopted within any filling or natural sand soils.

Given that the site is underlain by shallow moderately to slightly weathered BASALT, a combination of shallow pad footing with rock anchors considered more practical solution for this site. The rock anchors are required to resist the overturning forces at the base of the foundation.

The below table illustrates allowable bearing capacities for different soils groups at different depths below existing surface level, where the design engineer can be adopted them during the design stage.

Table 3: Ultimate bearing capacities

Material	Depth Below Existing Surface Level (mm)	Ultimate Bearing Capacity (kPa)
MW-BASALT	500-2000mm	4000kPa
FR/SW-BASALT	2000-3000mm	6500kPa

The ultimate bearing pressures provided in the report are the maximum values.

Allowable bearing capacity values provided within this report should result in total settlement of less than 25mm, should accurate settlement calculations be required, specific loading values and further laboratory testing of the soil characteristics will be required.

5.2.3 Piled Foundations

The piled foundation must be socketed in to BASALT rock to restrain the ultimate lateral resistance of the pile. The embedded depth of the pile or group of piles are can be determined using Broms method*. The pile foundation can be designed based on the material parameters and ultimate end bearing values listed in table below.

Table 4: Ultimate bearing capacities for pile

Soil Material	Embedded depth below existing surface level (mm)	Ultimate Skin Friction (kPa)	Ultimate End Bearing (kPa)
MW-BASALT	2000mm	600kPa	6000kPa
FR/SW-BASALT	3000mm	900kPa	9000kPa

5.2.4 Geotechnical Strength Reduction Factor

Requirements

Piled foundations should be designed in accordance with AS2159-2009: *Piling – Design and installation.* AS2159-2009 requires that a geotechnical strength reduction factor (φ_g) be applied to the design ultimate geotechnical strength ($R_{d,ug}$) of the pile to provide the design geotechnical strength ($R_{d,g}$) of the pile. The $R_{d,g}$ should less than the design action effect (E_d) on the pile.

Geotechnical Strength Reduction Factor

The geotechnical strength reduction factor is computed as follows:

$$\phi_g = \phi_{gb} + (\phi_{tf} - \phi_{gb})K \geq \phi_{gb}$$

where:

ϕ_{gb} = basic geotechnical strength reduction factor

ϕ_{tf} = intrinsic test factor (dependant on the type of load testing completed)

K = testing benefit factor

The basic geotechnical strength reduction factor (ϕ_{gb}) is determined via assentation of the Individual Risk Ratings (IRR) and Average Risk Rating (ARR), refer to Appendix C for computation.

Based on site conditions, design procedures and expected construction practices and subsequent monitoring procedures, the following geotechnical reduction factor is recommended for proposed construction:

φ_g = 0.45, *which represents a moderate to high risk average risk*

5.2.5 General Conditions – Foundations

Where footings are founded in different soil groups (especially reactive and non-reactive soils), the designer should provide articulation for the structure to accommodate to for potential damages which could be caused by differential movement of the soil due to seasonal moisture variation.

Note it is our preference that the design engineer adopt the same founding material across the structure where possible.

After excavation for the footings has been completed if there is any doubt as to the bearing capacity of the founding soil, then Intrax should be contacted and an inspection of the sites founding conditions carried out.

Foundations proposed for founding in and on existing fill, if any, then the fill must be stripped and the surface of the natural soil must be compacted with the soil in a moist condition. Stripped or imported fill meeting the minimum suitability requirements of section 4 of AS3798 must be placed at minimum 150mm uncompacted layers and each layer shall be compacted to minimum 98% dry density ratio at moisture contents between 90% and 110% of the optimum moisture content. Following the above ground preparation, an allowable bearing pressure of 80kPa can be assumed at 200mm below the compacted surface. Should additional filling depths exceed 1.0m it is recommended that a specification for earthworks be prepared.

5.3 Construction Precautions

- Trafficability is anticipated to be sufficient while soil conditions remain dry, however following significant or sustained rainfall periods trafficability is likely to be restricted to tracked machinery only. To improve trafficability during wet periods access roads can be created by stripping the saturated material most likely upper silty soils and removing from site, then placing a coarse aggregate non-descript crushed rock or similar. If adverse weather proceeds construction a geotextile may be required prior to placement of the crushed rock to prevent soft spot development.

5.4 Inspections (Hold Points)

Intrax **must** be engaged at the following stages:

1. In the event soil conditions encountered differ significantly from those described within this report.
2. If project design is altered significantly from drawings reviewed and outlined or project described within this report

Intrax should be engaged at the following stages:

1. To confirm founding materials and allowable bearing pressures.

6 Limitations of Report

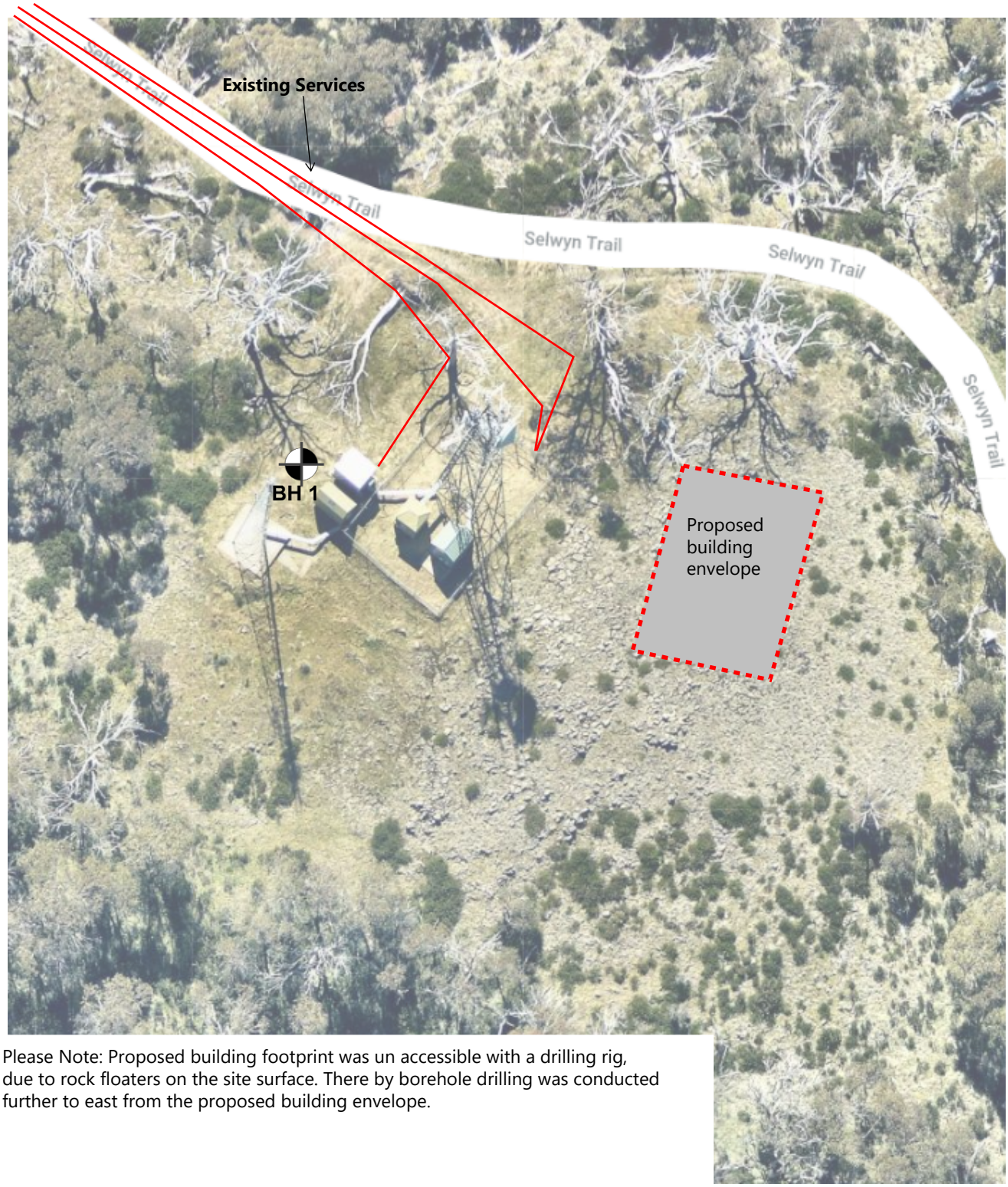
1. The recommendations in this report are based on the following:
    a. Information about the site & its history, proposed site treatment and building type conveyed to us by the client and or their agent
    b. Professional judgements and opinions using the most recent information in soil testing practice that is available to us.
    c. The location of our test sites and the information gained from this and other investigations.

    Should the client or their agent neglect to supply us with correct or relevant information, including information about previous buildings, trees or past activities on the site, or should changes be made to the building type, size and or/position, this report may be made obsolete, irrelevant or unsuitable. In such cases, Intrax will not accept any liability for the consequences and Intrax reserves the right to make an additional charge if more testing or a change to the report is necessary.
2. The recommendations made in this report may need to be reviewed should any site works disturb any soil 200mm below the proposed founding depth.
3. The descriptions of the soils encountered in the boreholes follow those outlined in AS1726-2017; Geotechnical Site Investigations. Colour descriptions can vary with soil moisture content and individual interpretation.
4. If the site conditions at the time of construction differ from those described in this report then Intrax must be contacted so a site inspection can be carried out prior to any footing being poured. The owner/builder will be responsible for any fees associated with this additional work.
5. This report assumes that the soil profile observed in the boreholes are representative of the entire site. If the soil profile and site conditions appear to differ substantially from those reported herein, then Intrax should be contacted immediately and this report may need to be reviewed and amended where appropriate. The owner/builder will be responsible for any fees associated with this additional work.
6. The user of this report must take into account the following limitations. Soil and drilling depths are given to a tolerance of +/- 200mm.

    It must be understood and a condition of acceptance of this report is that whilst every effort is made to identify fill material across the site, difficulties exist in determining fill material, in particular, for example, well compacted site or area derived fill, when utilising a small diameter auger. Consequently Intrax emphasises that we will not be responsible for any financial losses, consequential or otherwise, that may occur as a result of not accurately determining the fill profile across the site.
7. Finally, no responsibility will be taken for this report if it is altered in any way or is not reproduced in full.

Appendix A

Site Plan and Borehole Logs



Please Note: Proposed building footprint was un accessible with a drilling rig, due to rock floaters on the site surface. There by borehole drilling was conducted further to east from the proposed building envelope.

Client: CommPlan Pty Ltd	Scale (A4): Not to scale
Project: Selwyn Trail, Mount Selwyn, NSW	Date: 18.12.2018
	Sheets: 1
Drawing: Site Plan	Project No. 119033 Ver. 1

Intrax
Engineering Confidence

Civil
Forensic
Hydraulic
Structural
Surveying
Residential
Geotechnical
Building Services

35 Bank Street South Melbourne
VIC 3205 03 8371 0100

Geelong 03 5221 8282
New South Wales 02 4869 5666
Queensland 07 3813 5617
South Australia 08 8165 0122

A.B.N. 31 106 481 252
www.intrax.com.au

Borehole Log: Sheet: 1 of 3

Client: CommPlan Pty Ltd Location: Selwyn Trail, Mount Selwyn, NSW

Project: Optus Tower Coordinates: -

Job Number: 119033 Surface RL: -

Contractor: - Datum: - Logged: JH Date: 17.12.2018

Drill Rig: - Inclination: - Checked: PE Date: 20.12.2018

Intrax Engineering Confidence

Civil
Forensic
Hydraulic
Structural
Surveying
Residential
Geotechnical
Building Services

Method	Resistance	Water	Depth (m)	RL	Sample or Field Test	Recovered	Graphic Log	Soil Classification	Material Description	Moisture	Consistency / Density	Soil Origin & Additional Observations
			0.0				....	ML	clayey SILT; dark brown roo material	M	L	Residual
							XOXOXOXOX XOXOXOXOX XOXOXOXOX	XW	gravelly SILT; grey	D	D	Extremely weathered BASALT
									refer next sheet for continuation			
			1.0									
			2.0									
			3.0									
			4.0									
			5.0									
			6.0									
			7.0									
			8.0									
			9.0									
			10.0									

This borehole log is to be read in conjunction with the explanatory notes appended to the set of logs. This borehole log is not be reproduced without the full inclusion of all explanatory notes.

Borehole Log: Sheet: 2 of 3

Client: CommPlan Pty Ltd Location: Selwyn Trail, Mount Selwyn, NSW

Project: Optus Tower Coordinates: -

Job Number: 119033 Surface RL: -

Contractor: - Datum: - Logged: JH Date: 17.12.2018

Drill Rig: - Inclination: - Checked: PE Date: 20.12.2018

Intrax Engineering Confidence

Civil
Forensic
Hydraulic
Structural
Surveying
Residential
Geotechnical
Building Services

Method	Water	TCR (%)	RQD (%)	Depth (m)	RL	Graphic Log	Material Description	Weathering	Inferred Rock Strength (<VL, VL, L, M, H, VH, EH)	Defects & Additional Observations	Defect Spacing (mm) (10, 30, 100, 300, 1000, 3000)
				0.0							
NLMC Coring		100	64	1.0			BASALT; fine grained dark grey mottled red-brown moderately weathered, high strength	MW		0.5-0.65m; Fractures Zone 0.8m; J10°, IR, VN, Fe ST 0.87m; J10°, IR, VN, Fe ST 0.9m-1.1m; J70°, UN, VN, Fe ST 1.2m; J40°, UN, RO, VN 1.27m; J40°, UN, RO, CL 1.55m; J40°, PL, VR, CL 1.7m, J10°, UN, VR, VN	
				2.0			dark grey	SW		2.0m; J50°, UN, RO, VN 2.25m, J20°, IR, VR, VN 2.65m; J40°, CR, RO, VN 2.75-2.8m; SZ 3.1m; J45°, UN, RO, VN 3.4m; J50°, UN, RO, VN 3.55m; J60°, IR, VR, VN	
		100	68	4.0				FR		3.95m; 2xJ20°, UN, RO, VN 4.4m; J30°, UN, VR, CL 4.8m; J40°, UN, VR, CL 5.1m; J20°, UN, VR, VN 5.2m; J40°, UN, VR, VN 5.2-5.4m; J80°, UN, RO, VN 5.4-5.8m; 3xJ85°, UN, RO, VN 5.8-5.9m; Fractured Zone	
				6.0			End of borehole at 5.9m				
				7.0							
				8.0							
				9.0							
				10.0							

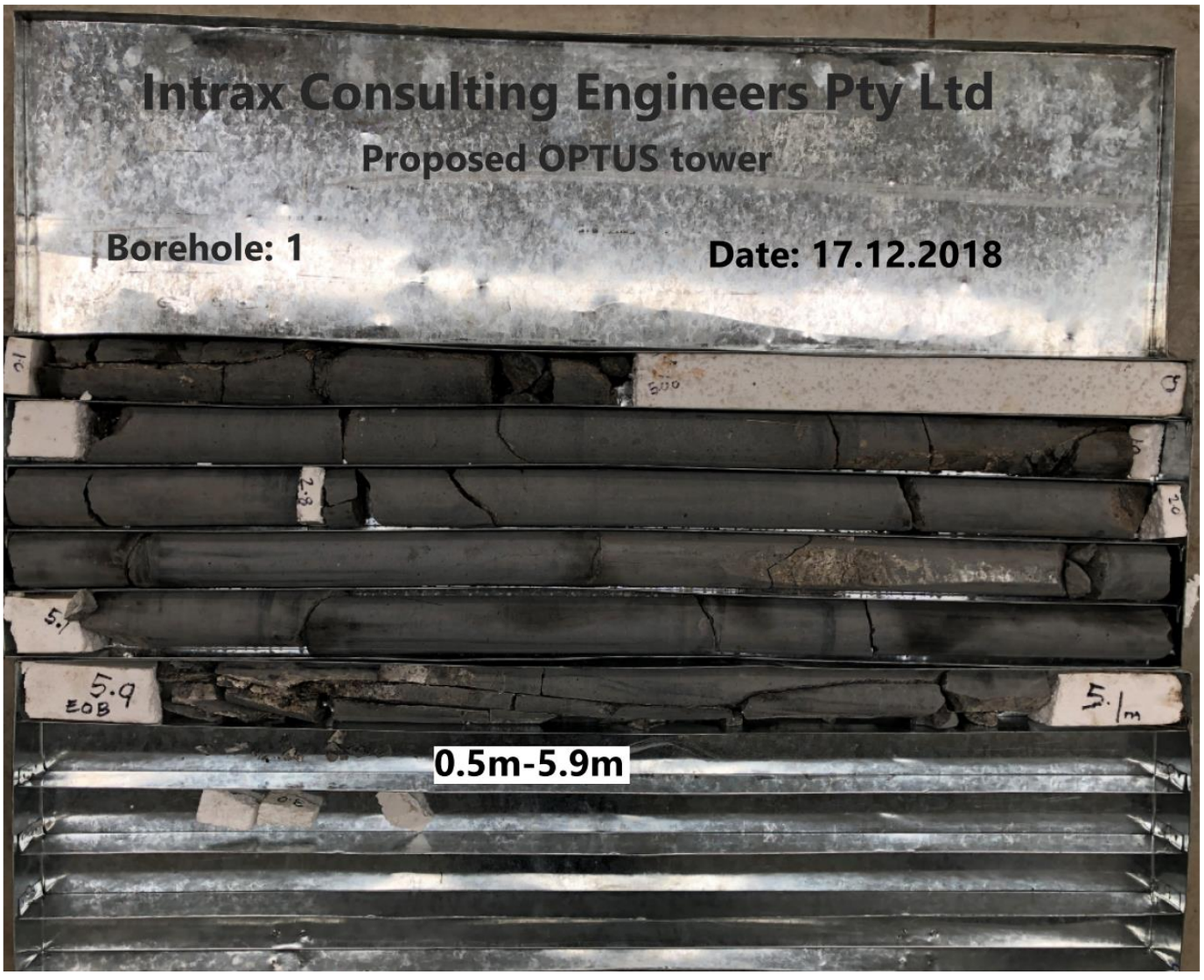
This borehole log is to be read in conjunction with the explanatory notes appended to the set of logs. This borehole log is not be reproduced without the full inclusion of all explanatory notes.

Borehole Log:		Sheet:					
Client:	CommPlan Pty Ltd	Location:	Selwyn Trail, Mount Selwyn, 2629				
Project:	Optus Tower	Coordinates:	-				
Job Number:	119033	Surface RL:	-				
Contractor:	-	Datum:	-	Logged:	JH	Date:	17.12.2018
Drill Rig:	-	Inclination:	-	Checked:	PE	Date:	20.12.2018

Intrax Engineering Confidence

Civil
Forensic
Hydraulic
Structural
Surveying
Residential
Geotechnical
Building Services

CORE BOX PHOTOGRAPH



This borehole log is to be read in conjunction with the explanatory notes appended to the set of logs. This borehole log is not be reproduced without the full inclusion of all explanatory notes.

EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT LOGS

DRILLING/EXCAVATION METHOD

HA	Hand Auger	W	Washbore	PT	Push Tube
MA-	Mechanical Auger Drilling	HQ	Diamond Core - 63 mm	EX	Excavator
-V	V-Bit	NMLC	Diamond Core - 52 mm	HAD	Hollow Auger Drilling
-TC	TC-Bit, e.g. ADT	NQ	Diamond Core - 47 mm		

PENETRATION/EXCAVATION RESISTANCE

L	Low resistance. Rapid penetration possible with little effort from the equipment used.
M	Medium resistance. Excavation/possible at an acceptable rate with moderate effort from the equipment used
H	High resistance. Further penetration is possible at a slow rate and requires significant effort from the equipment
R	Refusal or Practical Refusal. No further progress possible without the risk of damage or unacceptable wear to the digging implement or machine.

These assessments are subjective and are dependent on many factors including the equipment power, weight, condition or excavation or drilling tools, and experience of the operator.

WATER

∇	Water level at date shown	$\Leftarrow$	Partial water loss
$\Rightarrow$	Water inflow	$\|\Leftarrow\|$	Complete water loss

NO	Ground Water Not Observed: Ground water obersvation not possible. Ground water may or may not be present
NE	Ground Water Not Encountered: Ground water was not evident during excavation or a short time after completion. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

SAMPLING AND TESTING

SPT	Standard Penetration Test to AS1289.6.3.1 - 2004
3,6,9 N=15	3,6,9 = blows per 150mm. N = blows per final 300mm penetration
30/80mm	Practical refusal, with blows and depth of penetration before refusal occurred
RW	Penetration caused under rod weight only
HW	Penetration caused under hammer and rod weight only
HB	Hammer bounce without penetration
R	Refusal to test
DCP	Dynamic Cone Penetrometer Test to AS1289.6.3.2 - 1997
DCP (p)	Dynamic Cone Penetrometer Test to AS1289.6.3.3 - 1997 Perth Sand Penetrometer
6	6 = blows per 100mm of penetration

DS	Disturbed sample
BDS	Bulk disturbed sample
U63	Undisturbed thin wall push tube sample, nominal sample diameter denoted in millimetres
W	Water sample
G	Gas sample
V	pilcon shear vane (kPa)
PP	Pocket penetrometer (kPa)
FP	Field permeability test over section noted
ES	Environmental sample
PI	Plastic Index (%)
PL	Plastic Limit (%)
LL	Liquid Limit (%)
MC	Moisture Content (%)
CBR	Californian Bearing Ration (%)

ROCK CORE RECOVERY

TCR = Total Core Recovery (%)

$$= \frac{Length\ of\ core\ recovered}{Length\ of\ core\ run} \times 100$$

RQD = Rock Quality Designation (%)

$$= \frac{\sum Axial\ lengths\ of\ core > 100\ mm}{Length\ of\ core\ run} \times 100$$

EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT LOGS - SOIL DESCRIPTION (AS1726 - 2017)

SOIL CLASSIFICATION SYSTEM

Coarse Grained Soil

GW	Well graded gravels, gravel-sand mixtures, little or no fines
GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines, uniform gravels
GM	Silty gravels, gravel-sand-silt mixtures
GC	Clayey gravels, gravel-sand-clay mixtures
SW	Well-graded sands, gravelly sands, little or no fines
SP	Poorly-graded sands, gravelly sand, little or no fines
SM	Silty sands, sand-silt mixtures
SC	Clayey sands, sand-clay mixtures

Fine Grained Soils

ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or silts with low plasticity
CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays
OL	Organic silts and organic silty clays of low plasticity
MH	Inorganic silts, micaceous or diatomaceous fine sand for silty soils
CH	Inorganic clays of high plasticity
OH	Organic clays of medium to high plasticity, organic silts
PT	Peat, humus, swamp soils with high organic contents

First Letter: G = Gravel, S = Sand, M = Silt, C = Clay; Second Letter: W = Well-graded, P = Poorly-graded, M = Mixture, O = Organic, L = Low plasticity, H = High plasticity

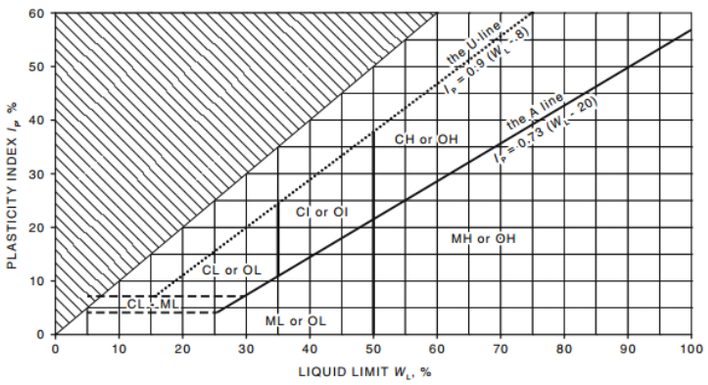
Soils may be a combination of multiple soil classifications where borderline

PARTICLE SIZE

Soil	Major Division	Sub-Division	Particle Size (mm)
Coarse	Boulders		>200
	Cobbles		63 - 200
	Gravel	Coarse	20 - 63
		Medium	6 - 20
		Fine	2.36 - 6
	Sand	Coarse	0.6 - 2.36
		Medium	0.2 - 0.6
		Fine	0.075 - 0.2
Fine	Silt		0.002 - 0.075
	Clay		< 0.002

0.075mm is the approximate minimum particle size discernible by eye

PLASTICITY CHART



MOISTURE CONDITION

Coarse	D	Dry	Sands and gravels are free flowing.
	M	Moist	Soils are darker than in the dry condition and may feel cool. Sands and gravels tend to cohere.
	W	Wet	Soils exude free water. Sands and gravels tend to cohere.
Fine	PL	Plastic Limit	Moisture content of fine grain soils are described; as below plastic limit (<PL), near to plastic limit (=PL), above plastic limit (>PL), near to the liquid limit (=LL), or above the liquid limit (>LL)
	LL	Liquid Limit	

CONSISTENCY AND DENSITY

Fine Grained Soils

			Pocket Pentrometer Reading (kPa)
VS	Very Soft	Exudes between fingers when squeezed	<25
S	Soft	Can be moulded by light finger pressure	20 - 50
F	Firm	Can be moulded by strong finger pressure	50 - 100
St	Stiff	Cannot be moulded by fingers. Can be indented by thumb	100 - 200
VSt	Very Stiff	Can be indented by thumb nail	200 - 400
H	Hard	Can be indented by thumb nail with difficulty	>400

Coarse Grained Soil

		Density Index %	'N' Value
VL	Very Loose	≤15	0 - 4
L	Loose	15 - 35	4 - 10
MD	Medium Dense	35 - 65	10 - 30
D	Dense	65 - 85	30 - 50
VD	Very Dense	>85	>50

SECONDARY OR MINOR SOIL COMPONENTS

Designation of components	In coarse grained soils				In fine grained soils	
	%Fines	Terminology	%Accessory Coarse Fraction	Terminology	%Sand/gravel	Terminology
Minor	≤5	'trace' clay/silt	≤15	'trace' sand/gravel	≤15	'trace' sand/gravel
	5 - 12	'with' clay/silt	15 - 30	'with' sand/gravel	15 - 30	'with' sand/gravel
Secondary	> 15	Prefix silty or clayey	>30	Prefix sandy or gravelly	>30	Prefix sandy or gravelly

EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT LOGS - ROCK DESCRIPTION (AS1726 - 2017)

STRENGTH OF INTACT ROCK

Symbol	Term	Point Load Index, (I_{s50}) MPa	Field Guide to Strength
VL	Very Low	$0.03 \le I_{s50} < 0.1$	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; pieces up to 30mm thick can be broken by finger pressure
L	Low	$0.1 \le I_{s50} < 0.3$	Easily scored with knife; indentations 1mm to 3mm after firm blow with pick point; core 150mm long and 50mm diameter can be broken by hand; sharp edges of core friable
M	Medium	$0.3 \le I_{s50} < 1.0$	Readily scored with knife; core 150mm long and 50mm diameter can be broken by hand with difficulty
H	High	$1.0 \le I_{s50} < 3$	Core 150mm long and 50mm diameter cannot be broken by hand but can be broken by single firm blow of pick; rock rings under hammer
VH	Very High	$3 \le I_{s50} < 10$	Hand held specimen breaks with pick after more than one blow; rock rings under hammer
EH	Extremely High	$10 \le I_{s50}$	Specimen requires many pick blows to break intact rock, rock rings under hammer

Material with rock strength less than 'Very Low' are described using soil properties

DEGREE OF ROCK WEATHERING

Term		Symbol		Definition
Residual Soil		RS		Soil derived from the weathering of rock; the mass structure and material fabric are no longer evident the soil has not been significantly transported.
Extremely Weathered		XW		Material is weathered to such an extent that it has soil properties, i.e. it either disintegrates or can be remoulded, in water. Fabric of original rock still visible.
Highly Weathered	Distinctly Weathered	HW	DW	Rock strength is changed by weathering. The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable. Some minerals are decomposed to clay minerals. Porosity may be increased by leach, or may be decreased due to deposition of weathering products in pores.
Moderately Weathered		MW		The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.
Slightly Weathered		SW		Rock is slightly discoloured but shows little or no change of strength from fresh rock
Fresh		FR		Rock shows no sign of decomposition or staining

Distinctly Weathered is to be used when it is not possible to differentiate between highly and moderately weathered.

Extremely Weathered material is to be described using soil properties

ROCK MASS PROPERTIES

Term	Separation of Stratification Planes
Thinly laminated	< 6mm
Laminated	6mm to 20 mm
Very thinly bedded	20mm to 60mm
Thinly bedded	60mm to 200mm
Medium bedded	0.2m to 0.6m
Thickly bedded	0.6m to 2.0m
Massive	< 2m

Term	Description
Fragmented	Primarily fragments < 20mm length and mostly of width < core diameter
Highly fractured	Core lengths generally less than 20mm to 40mm with occasional fragments
Fractured	Core lengths mainly 30mm to 100mm with occasional shorter and longer pieces
Slightly fractured	Core lengths generally 0.3m to 1.0m with occasional longer and shorter sections
Unbroken	Core has no fractures

DEFECT TYPES AND DESCRIPTIONS

Defect Type		Defect Shape		Surface Roughness		Defect Coatings	
BR	Bedding parting	PL	Planar	VR	Very rough	CL	Clean
JT	Joint	ST	Stepped	RO	Rough	ST	Stained
SR	Sheared surface	CR	Curved	SM	Smooth	VN	Veneer
SZ	Sheared zone	IR	Irregular	PO	Polished	CT	Coating
SS	Sheared seam	UN	Undulating	SL	Slickenside		
CS	Crushed seam						
IS	Infill seam						
XS	Extremely Weathered Seam						

Vertical Boreholes - The dip of the defect is given from the horizontal

Inclined Boreholes - The angle of the defect is given from the core axis

Appendix B

Site Photography

Appendix C

Geotechnical Strength Reduction Factor

AS2159 - 2009: Basic Geotechnical Strength Reduction Factor

ϕ_{gb} = basic geotechnical strength reduction factor

Risk Factor	Weighting Factor (w_i)	Idividual Risk Rating (IRR)
Site		
Geological complexity of site	2	3
Extent of ground investigation	2	3
Amount and quality of geotechnical data	2	5
Design		
Experience with similar foundations in similar geological conditions	1	3
Method of assessment of geotechnical parameters for design	2	5
Design method adopted	1	3
Method of utilizing results of in situ test data and installation data	2	4
Installation		
Level of construction control	2	4
Level of performance monitoring of the supported structure during and after construction	0.5	4
Average Risk Rating (ARR)		3.90

Building Redundancy Level = Low

ϕ_{gb} = **0.45** **Moderate to High**

AS2159 - 2009 - Table 4.3.2(A)

TABLE 4.3.2(A)

WEIGHTING FACTORS AND INDIVIDUAL RISK RATINGS FOR RISK FACTORS

Risk factor	Weighting factor (w_i)	Typical description of risk circumstances for individual risk rating (IRR)		
		1 (Very low risk)	3 (Moderate)	5 (Very high risk)
Site				
Geological complexity of site	2	Horizontal strata, well-defined soil and rock characteristics	Some variability over site, but without abrupt changes in stratigraphy	Highly variable profile or presence of karstic features or steeply dipping rock levels or faults present on site, or combinations of these
Extent of ground investigation	2	Extensive drilling investigation covering whole site to an adequate depth	Some boreholes extending at least 5 pile diameters below the base of the proposed pile foundation level	Very limited investigation with few shallow boreholes
Amount and quality of geotechnical data	2	Detailed information on strength compressibility of the main strata	CPT probes over full depth of proposed piles or boreholes confirming rock as proposed founding level for piles	Limited amount of simple in situ testing (e.g., SPT) or index tests only
Design				
Experience with similar foundations in similar geological conditions	1	Extensive	Limited	None
Method of assessment of geotechnical parameters for design	2	Based on appropriate laboratory or in situ tests or relevant existing pile load test data	Based on site-specific correlations or on conventional laboratory or in situ testing	Based on non-site-specific correlations with (for example) SPT data
Design method adopted	1	Well-established and soundly based method or methods	Simplified methods with well-established basis	Simple empirical methods or sophisticated methods that are not well established
Method of utilizing results of in situ test data and installation data	2	Design values based on minimum measured values on piles loaded to failure	Design methods based on average values	Design values based on maximum measured values on test piles loaded up only to working load, or indirect measurements used during installation, and not calibrated to static loading tests
Installation				
Level of construction control	2	Detailed with professional geotechnical supervision, construction processes that are well established and relatively straightforward	Limited degree of professional geotechnical involvement in supervision, conventional construction procedures	Very limited or no involvement by designer, construction processes that are not well established or complex
Level of performance monitoring of the supported structure during and after construction	0.5	Detailed measurements of movements and pile loads	Correlation of installed parameters with on-site static load tests carried out in accordance with this Standard	No monitoring

NOTE: The pile design shall include the risk circumstances for each individual risk category and consideration of all of the relevant site and construction factors.