ASSET GEOTECHNICAL
geotechnical engineering consultants

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27 November 2014

Elizabeth Pugh Building Design
Suite 01 - 3 Gippsland Street
Jindabyne NSW 2667

By email: info@elizabethpugh.com.au

Attention: Ms Liggy Pugh

Dear Libby,

PROPOSED ATHOL LODGE EXTENSION, 7 DIGGINGS TERRACE, THREDBO
GEOTECHNICAL INVESTIGATION

1. INTRODUCTION

1.1 General

This report presents the results of a geotechnical investigation for the above project. The investigation was commissioned by Ms Libby Pugh of Elizabeth Pugh Building Design. The work was carried out in accordance with a proposal by Asset Geotechnical Engineering Pty Ltd dated 24 September 2014 reference 2703-P1.

We understand that the development will involve extending to the north and south as well as re-configuring the car parking area to the northwest of the building. This will require excavation of less than about 1m depth to form a level area for the extension and construction of new footings.

The building is within the G line as defined in DIPNR's *"Geotechnical Policy – Kosciuszko Alpine Resorts"*, November 2003. We note that the proposed works will likely present a minor geotechnical impact on the site or related land, and a Form 4 "Minimal Impact Certification" in accordance with DIPNR's policy is proposed.

2. SCOPE OF WORK

The main objectives of the investigation were to assess the surface and subsurface conditions and to provide comments and recommendations relating to:

- Site Classification to AS2870 'Residential Slabs and Footings' (2011)
- Suitable foundations and founding stratum
- Allowable bearing pressure

In order to achieve the project objectives, the following scope of work was carried out:

- A review of existing regional maps and reports relevant to the site, held within our files.
- Visual observations of surface features.
- Review of a previous geotechnical report for an extension to the Lodge, carried out in 2013, Douglas Partners project 77363-L1
- Excavation of two hand augered boreholes (BH2 and BH3) as per as the original scope the as well as an additional borehole (BH1) due to shallow refusal.

- DCP tests at two main locations (BH2 and BH3), as well as additional DCP testing at BH1 and DCP4.
- Engineering assessment and reporting

This report should be read in conjunction with the attached Information Sheets. Particular attention is drawn to the limitations inherent in site investigations and the importance of verifying the subsurface conditions inferred herein.

3. FIELDWORK

Three boreholes, BH1 to BH3 were excavated to refusal on rock at 0.1m, 0.3m and 0.65m, respectively. DCP tests were conducted adjacent to the boreholes to solid refusal at 0.1m, 0.4m, 0.35m respectively, and 0.6m at DCP4.

The test locations were located by tape measurements from existing site features. The subsurface conditions encountered were recorded during the excavation. Engineering logs and explanatory notes are attached to this report.

4. SITE DESCRIPTION

The site is located on the southern side of Diggings Terrace. The site is bounded by a vacant reserve sloping down to a creek on the west, vacant land sloping up to another residential lodge to the south, and a lodge to the east.

The site comprises:

- The lodge building, which appears to have been constructed on a level platform excavated partially into sloping ground. The two storey building appears to be of timber construction with a masonry veneer over the lower level. No obvious signs of cracking in the masonry were observed during the site visit.

- At the rear of the building, granite boulders which appear partially retain the slope, followed by a grassed slope at about 25 to 35 degrees, leading up to a top-slope platform which holds the neighbouring lodge.

- The north-west corner of the site, the location of the proposed extension, is comprised of a level car parking area, a series of granite boulders border the car park and appear to form a retaining structure about 1.5m high, with the Athol Lodge building located on the platform above. This platform is retained on the western side by a timber retaining structure about 1m high and 2 to 3m in length.

- The western side of the site comprises a level veranda which extends 1 to 2m out from the building, followed by grassed ground which increases in gradient from about 5 to about 25 degrees down to a creek.

Drainage at the site is via overland flow, following the existing gradient towards the north, and north-west towards the creek. The slope at the rear of the site drains directly to the foot of the building.

Vegetation at the site comprises grass and medium to large eucalypt trees.

No significant protrusions, tension cracking or seepage were observed on the slopes at the time of the site visit.

5. SUBSURFACE CONDITIONS

5.1 Geology

The Tallanagatta 1:250 000 Geological Map indicates that the site is underlain by granitic igneous rock. These rocks typically weather to form residual sandy or clay soils of medium plasticity.

5.2 Stratigraphy

The following summary description is provided for the conditions observed at the test locations for this investigation. The detailed conditions at each test location are recorded on the attached logs. For specific design input, reference should be made to the logs and/or the specific test results, in lieu of the following summary.

Table 1 – Generalised Subsurface Profile

Layer	Description	BH1 (m)	BH2 (m)	BH3 (m)	DCP4 (m)
Topsoil / Fill	Silty CLAY, low to medium plasticity, dark brown, with some rootlets and organic matter. Gravel is fine grained.	0.0-0.1	0.0 – 0.3	0.0 – 0.55	-
Rock / Boulders	Granite, medium grained, pale yellow/pink, high strength.	0.1m+	0.3m+	0.55m+	0.6m+
Residual Soil	Silty CLAY, medium plasticity, mid brown, Firm (Inferred from local experience, not encountered at test locations)	-	-	-	-
Bedrock	Granite, extremely weathered, extremely low strength. (Inferred from local experience, not encountered at test locations)	-	-	-	-

The results of the field investigation indicate the ground conditions at the site comprise fill and boulders placed during earthworks for the development of the area. We infer the lodge building has been constructed on a platform cut into the slope, which may also include fill at the north west corner.

6. DISCUSSIONS & RECOMMENDATIONS

6.1 Lot Classification

Due to the presence of fill, boulders and trees, the site is assessed to be Class P (Problem site) in accordance with AS 2870–2011 "Residential Slabs and Footings". Footings should be designed in accordance with recommendations in Section 6.2 of this report.

6.2 Footings

High level footings may be designed for the proposed structure for an allowable bearing capacity of 200kPa on rock or residual soil with a minimum footing depth of 1m, as the rock present may represent floating boulders. If footings are founded on rock, sounding of the rock after excavation for footings, or additional excavation should be conducted to ensure the load is applied onto a boulder of minimum 1m diameter.

Higher bearing capacities may be attributed to continuous bedrock, however this would require additional investigation or inspection during construction to confirm.

Footings on the western side of the side, particularly for the extension of the car park, should be founded a minimum of 1m below the existing surface, to place the footing below future erosion levels. Boulders as rip-rap or other form of protection should be placed on the western side, in order to provide protection from erosion.

Where some footings are to be on residual soil, and others on rock / bedrock, differential settlements are likely. In this case the structure should be designed to tolerate differential settlements by incorporating architectural joints; connecting services should also be designed accordingly.

The above classification and footing recommendations are provided on the basis that the performance expectations set out in Appendix B of AS2870–2011 are acceptable and that future site maintenance is in accordance with CSIRO BTF 18, a copy of which is attached.

An experienced geotechnical engineer should review footing designs to check that the recommendations of the geotechnical report have been included, and should assess footing excavations prior to pouring concrete, to confirm the design assumptions.

6.3 Excavation

The proposed extension at the rear of the site is expected to require minor excavation, less than about 1m depth. This excavation may also encroach into the slope, comprised of boulders and soil.

Plastic sheeting or other measures should be used during excavation to ensure groundwater does not enter the excavation. The excavation should not remain open for greater than 4 weeks. The permanent walls of the excavation should be stabilised with an engineered retaining structure.

6.4 Groundwater Control

The existing drainage at the rear of the site deposits storm water at the foot of the building. Sealing of the surface to prevent ingress of water towards the foundations, and additional drainage measures to lead water this away from the site are recommended.

6.5 Earthworks

6.5.1 Subgrade Preparation

The following general recommendations are provided for subgrade preparation for earthworks, pavements, slab-on-ground (or waffle pod) construction, and minor (residential) structures:

- Strip existing fill and topsoil. The existing fill observed on site was assessed to be generally unsuitable for use as pavement subgrade or foundations.
- Remove unsuitable materials from site (e.g. material containing deleterious matter). Stockpile remainder for re-use as landscaping material or remove from site.

- Excavate residual soils and bedrock where required to design subgrade level, stockpiling for re-use as engineered fill or remove to spoil. Rock could be stockpiled separately from clayey soils, for select use beneath pavements.
- Where rock is exposed in bulk excavation level beneath pavements, rip / excavate a further 150mm.
- Where rock is exposed at footing invert level, it should be free of loose, "drummy" and softened material before concrete is poured.
- Where soil is exposed at bulk excavation level, compact the upper 150mm depth to a dry density ratio (AS1289.5.4.1–2007) not less than 100% Standard. Areas which show visible heave under compaction equipment should be over-excavated a further 0.3m and replaced with approved fill compacted to a dry density ratio not less than 100%.

Further advice should be sought where filling is required to support structures.

Any waste soils being removed from the site must be classified in accordance with current regulatory authority requirements to enable appropriate disposal to an appropriately licensed landfill facility. Further advice should be sought from a specialist environmental consultant if required.

6.5.2 Filling

Filling within 1.5m of the rear of retaining walls should be compacted using light weight equipment (e.g. hand-operated plate compactor or ride-on compactor not more than 3 tonnes static weight) in order to limit compaction-induced lateral pressures. The layer thickness should be reduced to 0.2m maximum loose thickness.

Any soils to be imported onto the site for the purpose of back-filling and re-instatement of excavated areas should be free of contamination and deleterious material, and should include appropriate validation documentation in accordance with current regulatory authority requirements which confirms its suitability for the proposed land use. Further advice should be sought from a specialist environmental consultant if required.

7. LIMITATIONS

In addition to the limitations inherent in site investigations (refer to the attached Information Sheets), it must be pointed out that the recommendations in this report are based on assessed subsurface conditions from limited investigations. In order to confirm the assessed soil and rock properties in this report, further investigation would be required such as coring and strength testing of rock, and should be carried out if the scale of the development warrants, or if any of the properties are critical to the design, construction or performance of the development.

It is recommended that a qualified and experienced geotechnical engineer be engaged to provide further input and review during the design development; including site visits during construction to verify the site conditions and provide advice where conditions vary from those assumed in this report. Development of an appropriate inspection and testing plan should be carried out in consultation with the geotechnical engineer.

This report and details for the proposed development must be submitted to relevant regulatory authorities that have an interest in the property (e.g. Council) or are responsible for services that may be within or adjacent to the site, for their review prior to commencement of construction.

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Please do not hesitate to contact the undersigned if you have any questions regarding this report or if you require further assistance.

For and on behalf of
Asset Geotechnical Engineering Pty Ltd

Mark Bartel

Mark Bartel
BE MEngSc GMQ RPEQ CPEng NPER (Civil)
Managing Director / Senior Principal Geotechnical Engineer

Encl:

Information Sheets (3 sheets)
CSIRO BTF 18 (4 sheets)
Borehole & DCP Logs (7 sheets)
Figure 1 Site Locality
Figure 2 Test Locations

Important Information

SCOPE OF SERVICES

The geotechnical report ("the report") has been prepared in accordance with the scope of services as set out in the contract, or as otherwise agreed, between the Client and Asset Geotechnical Engineering Pty Ltd ("Asset"). The scope of work may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

RELIANCE ON DATA

Asset has relied on data provided by the Client and other individuals and organizations, to prepare the report. Such data may include surveys, analyses, designs, maps and plans. Asset has not verified the accuracy or completeness of the data except as stated in the report. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations ("conclusions") are based in whole or part on the data, Asset will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Asset.

GEOTECHNICAL ENGINEERING

Geotechnical engineering is based extensively on judgment and opinion. It is far less exact than other engineering disciplines. Geotechnical engineering reports are prepared for a specific client, for a specific project and to meet specific needs, and may not be adequate for other clients or other purposes (e.g. a report prepared for a consulting civil engineer may not be adequate for a construction contractor). The report should not be used for other than its intended purpose without seeking additional geotechnical advice. Also, unless further geotechnical advice is obtained, the report cannot be used where the nature and/or details of the proposed development are changed.

LIMITATIONS OF SITE INVESTIGATION

The investigation programme undertaken is a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions. The data derived from the site investigation programme and subsequent laboratory testing are extrapolated across the site to form an inferred geological model, and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Despite investigation, the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies.

The engineering logs are the subjective interpretation of subsurface conditions at a particular location and time, made by trained personnel. The actual interface between materials may be more gradual or abrupt than a report indicates.

SUBSURFACE CONDITIONS ARE TIME DEPENDENT

Subsurface conditions can be modified by changing natural forces or man-made influences. The report is based on conditions that existed at the time of subsurface exploration. Construction operations adjacent to the site, and natural events such as floods, or ground water fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. Asset should be kept appraised of any such events, and should be consulted to determine if any additional tests are necessary.

VERIFICATION OF SITE CONDITIONS

Where ground conditions encountered at the site differ significantly from those anticipated in the report, it is a condition of acceptance of the report that Asset be notified of any variations and be provided with an opportunity to review the recommendations of this report. Recognition of change of soil and rock conditions requires experience and it is recommended that a suitably experienced geotechnical engineer be engaged to visit the site with sufficient frequency to detect if conditions have changed significantly.

REPRODUCTION OF REPORTS

This report is the subject of copyright and shall not be reproduced either totally or in part without the express permission of this Company. Where information from the accompanying report is to be included in contract documents or engineering specification for the project, the entire report should be included in order to minimize the likelihood of misinterpretation from logs.

REPORT FOR BENEFIT OF CLIENT

The report has been prepared for the benefit of the Client and no other party. Asset assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of Asset or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own inquiries and obtain independent advice in relation to such matters.

OTHER LIMITATIONS

Asset will not be liable to update or revise the report to take into account any events or emergent circumstances or fact occurring or becoming apparent after the date of the report.

Abbreviations, Notes & Symbols

METHOD

borehole logs

AS	auger screw *
AD	auger drill *
RR	roller / tricone
W	washbore
CT	cable tool
HA	hand auger
D	diatube
B	blade / blank bit
V	V-bit
T	TC-bit

* bit shown by suffix e.g. ADV

excavation logs

NE	natural excavation
HE	hand excavation
BH	backhoe bucket
EX	excavator bucket
DZ	dozer blade
R	ripper tooth

coring

NMLC, NQ, PQ, HQ

SUPPORT

borehole logs

N	nil
M	mud
C	casing
NQ	NQ rods

excavation logs

N	nil
S	shoring
B	benched

CORE—LIFT

casing installed

barrel withdrawn

NOTES, SAMPLES, TESTS

D	disturbed
B	bulk disturbed
U50	thin-walled sample, 50mm diameter
HP	hand penetrometer (kPa)
SV	shear vane test (kPa)
DCP	dynamic cone penetrometer (blows per 100mm penetration)
SPT	standard penetration test
N*	SPT value (blows per 300mm) * denotes sample recovered
Nc	SPT with solid cone
R	refusal of DCP or SPT

USCS SYMBOLS

GW	Well graded gravels and gravel-sand mixtures, little or no fines.
GP	Poorly graded gravels and gravel-sand mixtures, little or no fines.
GM	Silty gravels, gravel-sand-silt mixtures.
GC	Clayey gravels, gravel-sand-clay mixtures.
SW	Well graded sands and gravelly sands, little or no fines.
SP	Poorly graded sands and gravelly sands, little or no fines.
SM	Silty sand, sand-silt mixtures.
SC	Clayey sand, sand-clay mixtures.
ML	Inorganic silts of low plasticity, very fine sands, rock flour, silty or clayey fine sands.
CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays.
OL	Organic silts and organic silty clays of low plasticity.
MH	Inorganic silts of high plasticity.
CH	Inorganic clays of high plasticity.
OH	Organic clays of medium to high plasticity.
PT	Peat muck and other highly organic soils.

MOISTURE CONDITION

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

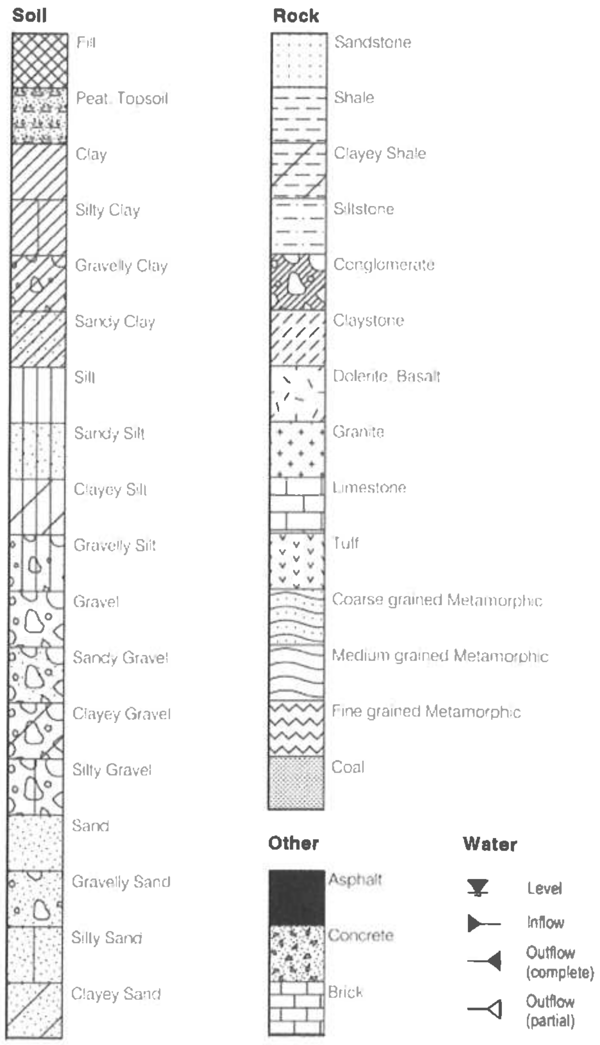
CONSISTENCY

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable

DENSITY INDEX

VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

GRAPHIC LOG



Boundaries

known — probable — possible

WEATHERING

XW	extremely weathered
HW	highly weathered
MW	moderately weathered
SW	slightly weathered
FR	fresh

STRENGTH

EL	extremely low
VL	very low
L	low
M	medium
H	high
VH	very high
EH	extremely high

RQD (%)

$$= \frac{\text{sum of intact core pieces} > 2 \times \text{diameter}}{\text{total length of section being evaluated}} \times 100$$

DEFECTS

type

JT	joint
PT	parting
SZ	shear zone
SM	seam

coating

cl	clean
st	stained
ve	veneer
co	coating

shape

pl	planar
cu	curved
un	undulating
st	stepped
ir	irregular

roughness

po	polished
sl	slickensided
sm	smooth
ro	rough
vr	very rough

inclination

measured above axis and perpendicular to core

AS1726-1993

Soils and rock are described in the following terms, which are broadly in accordance with AS1726-1993.

SOIL

MOISTURE CONDITION

Term	Description
Dry	Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through the hand.
Moist	Feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	As for moist, but with free water forming on hands when handled.

Moisture content of cohesive soils may also be described in relation to plastic limit (W_P) or liquid limit (W_L) [>> much greater than, > greater than, < less than, << much less than].

CONSISTENCY OF COHESIVE SOILS

Term	Su (kPa)	Term	Su (kPa)
Very soft	< 12	Very Stiff	100 – 200
Soft	12 – 25	Hard	> 200
Firm	25 – 50	Friable	–
Stiff	50 – 100		

DENSITY OF GRANULAR SOILS

Term	Density Index(%)	Term	Density Index (%)
Very Loose	< 15	Dense	65 – 85
Loose	15 – 35	Very Dense	>85
Medium Dense	35 – 65		

PARTICLE SIZE

Name	Subdivision	Size (mm)
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
Silt & Clay		< 0.075

MINOR COMPONENTS

Term	Proportion by Mass coarse grained	fine grained
Trace	≤ 5%	≤ 15%
Some	5 – 2%	15 – 30%

SOIL ZONING

Layers	Continuous exposures.
Lenses	Discontinuous layers of lenticular shape.
Pockets	Irregular inclusions of different material.

SOIL CEMENTING

Weakly	Easily broken up by hand.
Moderately	Effort is required to break up the soil by hand.

USCS SYMBOLS

Symbol	Description
GW	Well graded gravels and gravel-sand mixtures, little or no fines.
GP	Poorly graded gravels and gravel-sand mixtures, little or no fines.
GM	Silty gravels, gravel-sand-silt mixtures.
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OL	Organic silts and organic silty clays of low plasticity.
MH	Inorganic silts of high plasticity.
CH	Inorganic clays of high plasticity.
OH	Organic clays of medium to high plasticity.
PT	Peat muck and other highly organic soils.

ROCK

SEDIMENTARY ROCK TYPE DEFINITIONS

Rock Type	Definition (more than 50% of rock consists of .....)
Conglomerate	... gravel sized (>2mm) fragments.
Sandstone	... sand sized (0.06 to 2mm) grains.
Siltstone	... silt sized (<0.06mm) particles, rock is not laminated.
Claystone	... clay, rock is not laminated.
Shale	... silt or clay sized particles, rock is laminated.

LAYERING

Term	Description
Massive	No layering apparent.
Poorly Developed	Layering just visible. Little effect on properties.
Well Developed	Layering distinct. Rock breaks more easily parallel to layering.

STRUCTURE

Term	Spacing (mm)	Term	Spacing
Thinly laminated	<6	Medium bedded	200 – 600
Laminated	6 – 20	Thickly bedded	600 – 2,000
Very thinly bedded	20 – 60	Very thickly bedded	> 2,000
Thinly bedded	60 – 200		

STRENGTH

Term	Is50 (MPa)	Term	Is50 (MPa)
Extremely Low	<0.03	High	1.0 – 3.0
Very low	0.03 – 0.1	Very High	3.0 – 10.0
Low	0.1 – 0.3	Extremely High	>10.0
Medium	0.3 – 1.0		

NOTE: Is50 = Point Load Strength Index

WEATHERING

Term	Description
Residual Soil	Soil derived from weathering of rock; the mass structure and substance fabric are no longer evident.
Extremely	Rock is weathered to the extent that it has soil properties (either disintegrates or can be remoulded). Fabric of original rock is still visible.
Highly	Rock strength usually highly changed by weathering; rock may be highly discoloured.
Moderately	Rock strength usually moderately changed by weathering; rock may be moderately discoloured.
Slightly	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh	Rock shows no signs of decomposition or staining.

DEFECT DESCRIPTION

Type

Joint	A surface or crack across which the rock has little or no tensile strength. May be open or closed.
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub-parallel to layering/ bedding. May be open or closed.
Sheared Zone	Zone of rock substance with roughly parallel, near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects.
Seam	Seam with deposited soil (infill), extremely weathered insitu rock (XW), or disoriented usually angular fragments of the host rock (crushed).

Shape

Planar	Consistent orientation.
Curved	Gradual change in orientation.
Undulating	Wavy surface.
Stepped	One or more well defined steps.
Irregular	Many sharp changes in orientation.

Roughness

Polished	Shiny smooth surface.
Slickensided	Grooved or striated surface, usually polished.
Smooth	Smooth to touch. Few or no surface irregularities.
Rough	Many small surface irregularities (amplitude generally <1mm). Feels like fine to coarse sandpaper.
Very Rough	Many large surface irregularities, amplitude generally >1mm. Feels like very coarse sandpaper.

Coating

Clean	No visible coating or discolouring.
Stained	No visible coating but surfaces are discoloured.
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	Visible coating ≤1mm thick. Thicker soil material described as seam.

Foundation Maintenance and Footing Performance: A Homeowner's Guide

CSIRO

BTF 18
replaces
Information
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

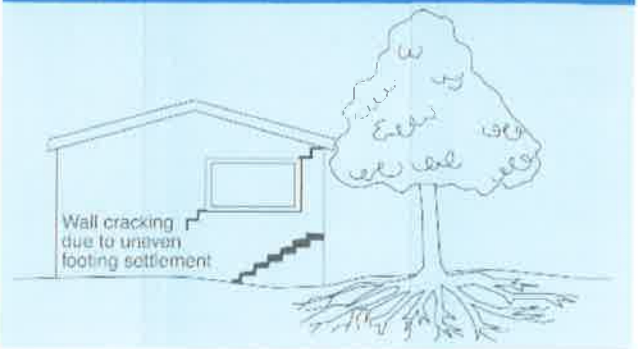
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

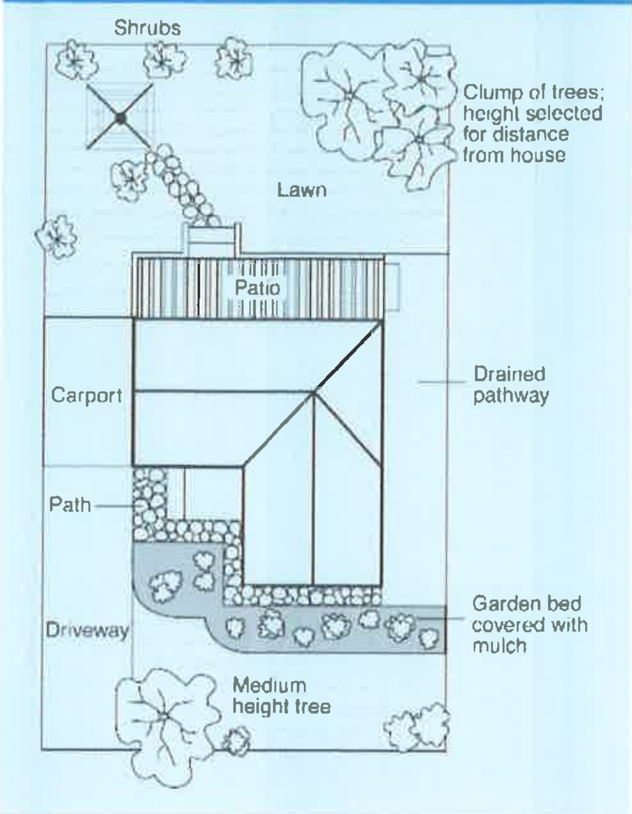
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4

Gardens for a reactive site



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation
In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden
The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees
Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs
State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation
Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

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Borehole Log

BH no:	BH1
sheet:	1 of 1
job no.:	2703

client:	ELIZABETH PUGH BUILDING DESIGN	**started:**	21.10.2014
principal:		**finished:**	21.10.2014
project:	PROPOSED ATHOL LODGE EXTENSION	**logged:**	JAH
location:	7 DIGGINS TERRACE, THREDBO	**checked:**	MAB
equipment:	HA	**RL surface:**	approx.
diameter:	100mm **inclination:** -90° **bearing:** --- **E:** **N:**	**datum:**	

drilling information						material information						
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	**material description** soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro-meter kPa (100 200 300 400)	**structure and additional observations**
HA								Silty CLAY, low to medium plasticity, dark brown, with some organic material and rootlets.	<Wp	-		TOPSOIL
					0.1			Borehole No: BH1 terminated at 0.1m				HA refusal on GRANITE, medium to high strength.
					0.5							
					1.0							

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Borehole Log

BH no:	BH2
sheet:	1 of 1
job no.:	2703

client:	ELIZABETH PUGH BUILDING DESIGN	started:	21.10.2014
principal:		finished:	21.10.2014
project:	PROPOSED ATHOL LODGE EXTENSION	logged:	JAH
location:	7 DIGGINS TERRACE, THREDBO	checked:	MAB
equipment:	HA	RL surface:	approx.
diameter:	100mm inclination: -90° bearing: --- E: N:	datum:	

drilling information						material information							
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
HA								Silty CLAY, low to medium plasticity, dark brown, with some organic material and rootlets.	<Wp	-		TOPSOIL
					0.3			Borehole No: BH2 terminated at 0.3m				HA refusal on GRANITE, medium to high strength.
					0.5							
					1.0							

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Borehole Log

BH no:	BH3
sheet:	1 of 1
job no.:	2703

client:	ELIZABETH PUGH BUILDING DESIGN	started:	21.10.2014
principal:		finished:	21.10.2014
project:	PROPOSED ATHOL LODGE EXTENSION	logged:	JAH
location:	7 DIGGINS TERRACE, THREDBO	checked:	MAB
equipment:	HA	RL surface:	approx.
diameter:	100mm Inclination: -90° bearing: --- E: N:	datum:	

drilling information / **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
HA					0.5			Silty CLAY, low to medium plasticity, dark brown, with some organic material and rootlets.	<Wp	-		TOPSOIL
					0.55			Silty CLAY, low to medium plasticity, pale to mid brown.		F		FILL? / RESIDUAL?
					0.65			Borehole No: BH3 terminated at 0.65m				HA refusal on GRANITE, medium to high strength.
					1.0							

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Dynamic Cone Penetrometer

Test No:	**BH1**
Sheet:	1 of 1
Job no:	2703

client:	ELIZABETH PUGH BUILDING DESIGN	**started:**	21/10/2014
principal:		**finished:**	21/10/2014
project:	PROPOSED ATHOL LODGE EXTENSION	**logged:**	JAH
location:	7 DIGGINGS TERRACE, THREDBO	**checked:**	MAB
equipment:	9kg hammer, 510mm drop, cone tip	**RL:**	
standard:	AS1289.6.3.2-1997	**datum:**	

Depth (m)	Blows / 100mm	Plot (blows/100mm vs depth) 0 5 10 15 20 25	Soil Type c-cohesive g-granular	Inferred Parameters (not to be used for design) Density Index	Phi (°)	Con-sistency	Cu (kPa)	E (MPa)
0.00 – 0.10	2		C			F	40	24
0.10 – 0.20								
0.20 – 0.30		Solid refusal at 0.1m						
0.30 – 0.40								
0.40 – 0.50								
0.50 – 0.60								
0.60 – 0.70								
0.70 – 0.80								
0.80 – 0.90								
0.90 – 1.00								
1.00 – 1.10								
1.10 – 1.20								
1.20 – 1.30								
1.30 – 1.40								
1.40 – 1.50								
1.50 – 1.60								
1.60 – 1.70								
1.70 – 1.80								
1.80 – 1.90								
1.90 – 2.00								
2.00 – 2.10								
2.10 – 2.20								
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2.30 – 2.40								
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2.50 – 2.60								
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2.70 – 2.80								
2.80 – 2.90								
2.90 – 3.00								
3.00 – 3.10								
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4.20 – 4.30								
4.30 – 4.40								
4.40 – 4.50								
4.50 – 4.60								
4.60 – 4.70								
4.70 – 4.80								
4.80 – 4.90								
4.90 – 5.00								

Notes:
Practical refusal = 25+ blows per 100mm, "Solid" refusal = no further penetration and "solid" ringing sound from slide hammer
** Insufficient data to derive inferred parameters

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Dynamic Cone Penetrometer

Test No: BH2
Sheet: 1 of 1
Job no: 2696

client:	ELIZABETH PUGH BUILDING DESIGN	**started:**	21/10/2014
principal:		**finished:**	21/10/2014
project:	PROPOSED ATHOL LODGE EXTENSION	**logged:**	JAH
location:	7 DIGGINGS TERRACE, THREDBO	**checked:**	MAB
equipment:	9kg hammer, 510mm drop, cone tip	**RL:**	
standard:	AS1289.6.3.2-1997	**datum:**	

Depth (m)	Blows / 100mm	Plot (blows/100mm vs depth) 0 5 10 15 20 25	Soil Type c-cohesive g-granular	Inferred Parameters (not to be used for design) Density Index	Phi (°)	Con-sistency	Cu (kPa)	E (MPa)
0.00 – 0.10	2		c			F	40	24
0.10 – 0.20	2		c			F	40	24
0.20 – 0.30	2		c			F	40	24
0.30 – 0.40	2		c			F	40	24
0.40 – 0.50								
0.50 – 0.60		Solid refusal at 0.4m						
0.60 – 0.70								
0.70 – 0.80								
0.80 – 0.90								
0.90 – 1.00								
1.00 – 1.10								
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4.30 – 4.40								
4.40 – 4.50								
4.50 – 4.60								
4.60 – 4.70								
4.70 – 4.80								
4.80 – 4.90								
4.90 – 5.00								

Notes:
Practical refusal = 25+ blows per 100mm, "Solid" refusal = no further penetration and "solid" ringing sound from slide hammer
** Insufficient data to derive inferred parameters

Refer to Information Sheets for Terms and Symbols

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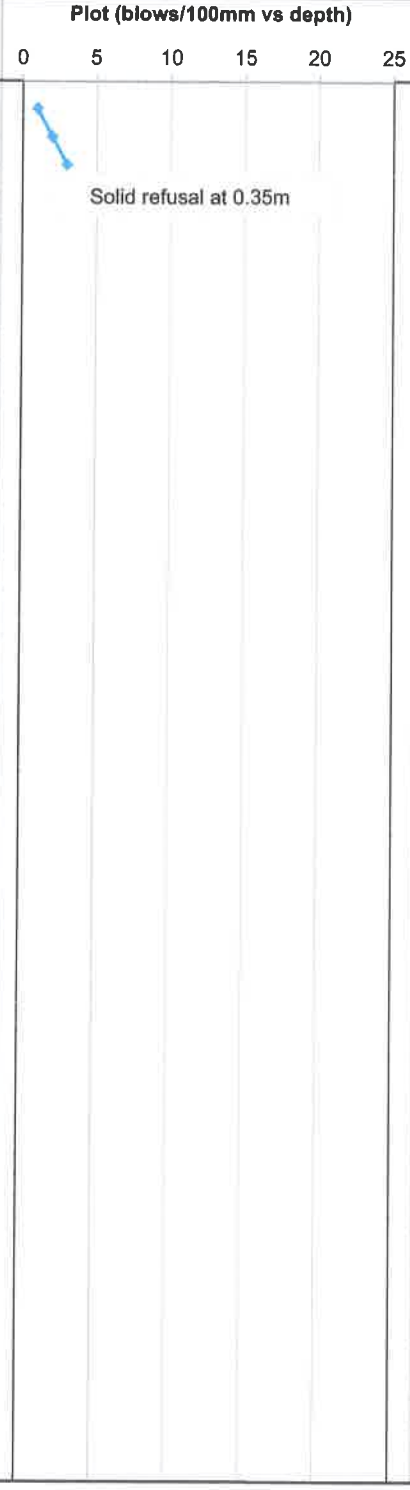
Dynamic Cone Penetrometer

Test No:	**BH3**
Sheet:	1 of 1
Job no:	2696

client:	ELIZABETH PUGH BUILDING DESIGN	**started:**	21/10/2014
principal:		**finished:**	21/10/2014
project:	PROPOSED ATHOL LODGE EXTENSION	**logged:**	JAH
location:	7 DIGGINGS TERRACE, THREDBO	**checked:**	MAB
equipment:	9kg hammer, 510mm drop, cone tip	**RL:**	
standard:	AS1289.6.3.2-1997	**datum:**	



Depth (m)	Blows / 100mm	Soil Type c-cohesive g-granular	Inferred Parameters (not to be used for design): Density Index	Phi (°)	Con-sistency	Cu (kPa)	E (MPa)
0.00 – 0.10	1	c			S	20	12
0.10 – 0.20	2	c			F	40	24
0.20 – 0.30	3	c			St	60	36
0.30 – 0.40							
0.40 – 0.50							
0.50 – 0.60							
0.60 – 0.70							
0.70 – 0.80							
0.80 – 0.90							
0.90 – 1.00							
1.00 – 1.10							
1.10 – 1.20							
1.20 – 1.30							
1.30 – 1.40							
1.40 – 1.50							
1.50 – 1.60							
1.60 – 1.70							
1.70 – 1.80							
1.80 – 1.90							
1.90 – 2.00							
2.00 – 2.10							
2.10 – 2.20							
2.20 – 2.30							
2.30 – 2.40							
2.40 – 2.50							
2.50 – 2.60							
2.60 – 2.70							
2.70 – 2.80							
2.80 – 2.90							
2.90 – 3.00							
3.00 – 3.10							
3.10 – 3.20							
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4.70 – 4.80							
4.80 – 4.90							
4.90 – 5.00							

Notes:
Practical refusal = 25+ blows per 100mm, "Solid" refusal = no further penetration and "solid" ringing sound from slide hammer
** Insufficient data to derive inferred parameters

Refer to Information Sheets for Terms and Symbols

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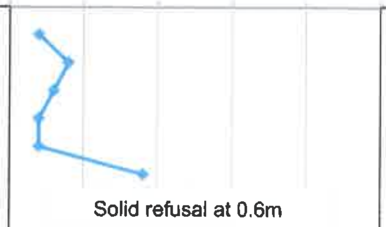
Dynamic Cone Penetrometer

Test No:	**DCP4**
Sheet:	1 of 1
Job no:	2696

client:	ELIZABETH PUGH BUILDING DESIGN	**started:**	21/10/2014
principal:		**finished:**	21/10/2014
project:	PROPOSED ATHOL LODGE EXTENSION	**logged:**	JAH
location:	7 DIGGINGS TERRACE, THREDBO	**checked:**	MAB
equipment:	9kg hammer, 510mm drop, cone tip	**RL:**	
standard:	AS1289.6.3.2-1997	**datum:**	



Depth (m)	Blows / 100mm	Plot (blows/100mm vs depth) 0 5 10 15 20 25	Soil Type c-cohesive g-granular	Inferred Parameters (not to be used for design) Density Index	Phi (°)	Con-sistency	Cu (kPa)	E (MPa)
0.00 – 0.10	2		c			F	40	24
0.10 – 0.20	4		c			St	80	48
0.20 – 0.30	3		c			St	60	36
0.30 – 0.40	2		c			F	40	24
0.40 – 0.50	2		c			F	40	24
0.50 – 0.60	9		c			VSt	180	108
0.60 – 0.70								
0.70 – 0.80								
0.80 – 0.90								
0.90 – 1.00								
1.00 – 1.10								
1.10 – 1.20								
1.20 – 1.30								
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1.50 – 1.60								
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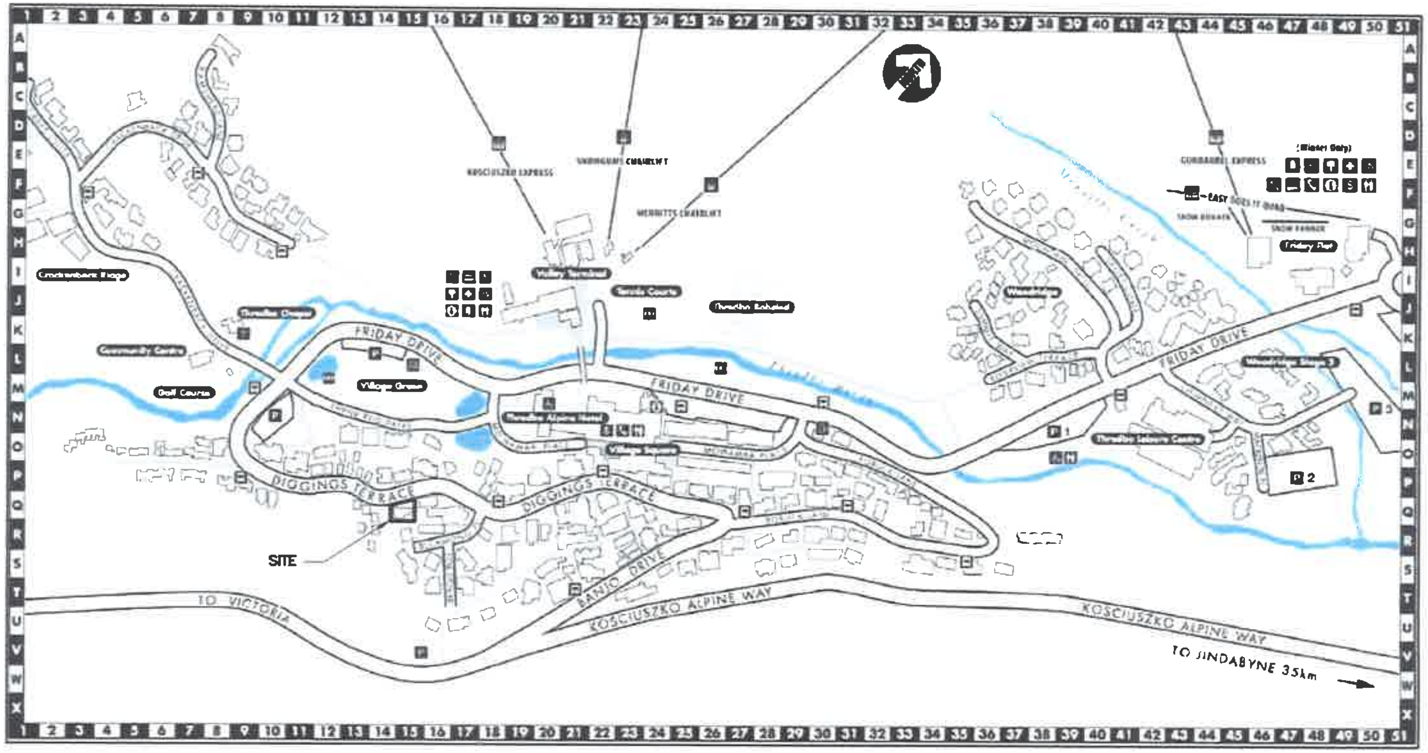
Notes:
Practical refusal = 25+ blows per 100mm, "Solid" refusal = no further penetration and "solid" ringing sound from slide hammer
** Insufficient data to derive inferred parameters

Refer to Information Sheets for Terms and Symbols



APPROXIMATE ONLY – SUBJECT TO DETAIL SURVEY.

SOURCE: "THREDBO VILLAGE MAP, WWW.THREDBO.COM.AU"

THIS DRAWING IS USED TO ILLUSTRATE TEST LOCATIONS ONLY, AND <u>MUST NOT BE USED FOR ANY OTHER PURPOSE</u>. COPYRIGHT OF SOURCE DRAWING REMAINS WITH THREDBO ALPINE VILLAGE

0 1:8000 500m

issue	date	description
A	OCT.14	INITIAL ISSUE

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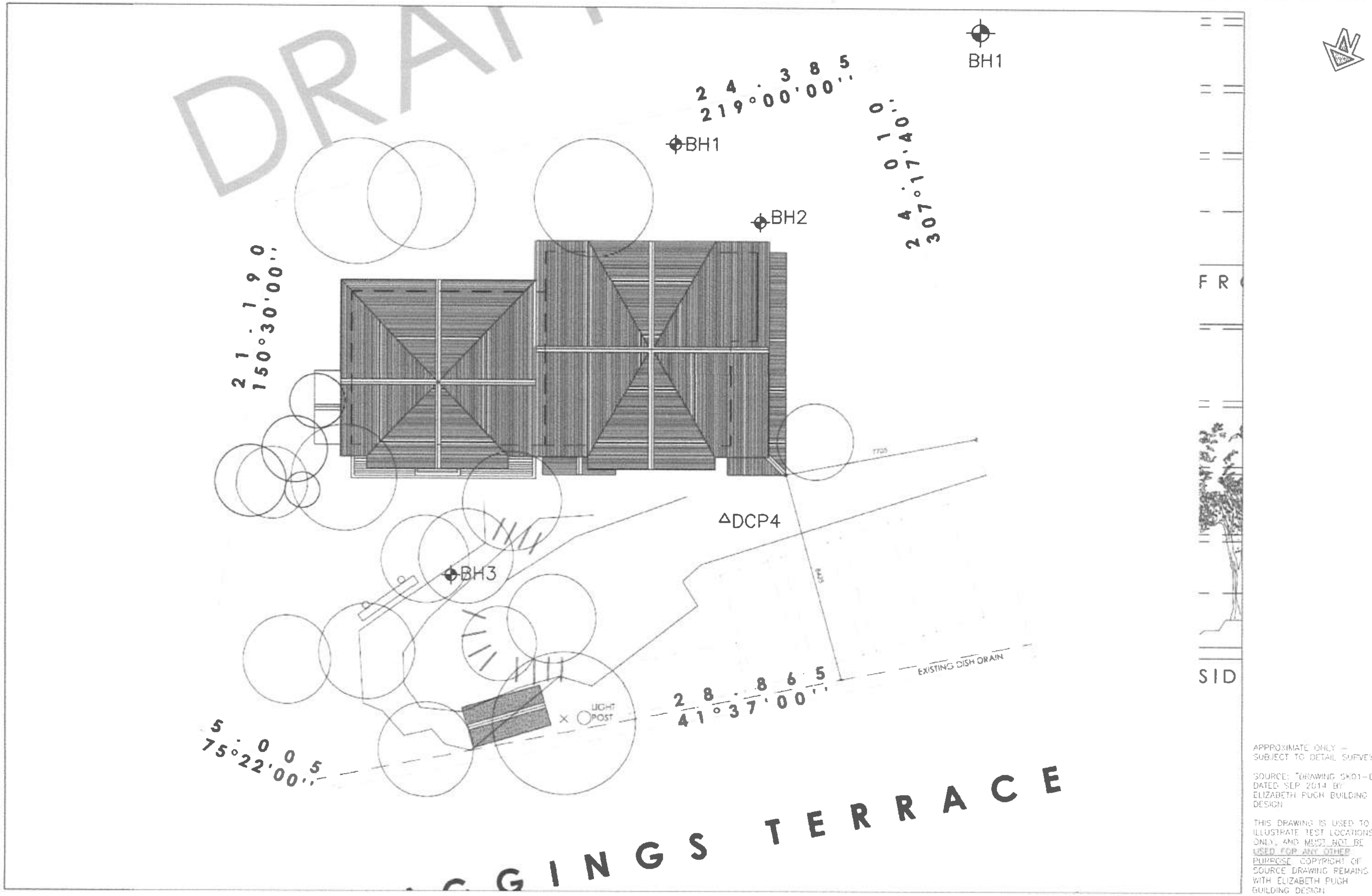
PROPOSED ATHOL LODGE EXTENSION
7 DIGGINGS TERRACE, THREDBO
for
ELIZABETH PUGH BUILDING DESIGN

SITE LOCALITY

drawn: JAH
date: 28.10.14
checked: MAB
scale: 1:8000 A4
job no.: 2703
fig: 1
issue: A



APPPROXIMATE ONLY — SUBJECT TO DETAIL SURVEY.

SOURCE: DRAWING SK01–DA DATED SEP 2014 BY ELIZABETH PUGH BUILDING DESIGN

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PROPOSED ATHOL LODGE EXTENSION
7 DIGGINGS TERRACE, THREDBO
for
ELIZABETH PUGH BUILDING DESIGN

TEST LOCATIONS

drawn: JAH	**job no.:** 2703
date: 28.10.14	
checked: MAB	**fig:** 2 / **issue:** A
scale: 1:150 A3	