SORELL COUNCIL

Community Coast Country

NOTICE OF PROPOSED DEVELOPMENT

Notice is hereby given that an application has been made for planning approval for the following development:

SITE: 513 Shark Point Road, Penna

PROPOSED DEVELOPMENT:

DWELLING & CHANGE OF USE (DWELLING TO SECONDARY RESIDENCE)

The relevant plans and documents can be inspected at the Council Offices at 47 Cole Street, Sorell during normal office hours, or the plans may be viewed on Council's website at www.sorell.tas.gov.au until **Monday 23rd December 2024.**

Any person may make representation in relation to the proposal by letter or electronic mail (sorell.council@sorell.tas.gov.au) addressed to the General Manager. Representations must be received no later than **Monday 23rd December 2024.**

APPLICANT: **Woolcott Land Services**

APPLICATION NO: **DA 2024 / 00218 - 1**
DATE: **05 December 2024**

Part B: Please note that Part B of this form is publicly exhibited.

Full description of Proposal:	*Use:* Proposed single dwelling. Change of use to existing dwelling to becon
	Development: Single dwelling
	Large or complex proposals should be described in a letter or planning report.

Design and construction cost of proposal:	$ 510,300

Is all, or some the work already constructed:	No: ☑ Yes: ☐

Location of proposed works:	Street address: 513 SHARK POINT RD Suburb: PENNA Postcode: 7171 Certificate of Title(s) Volume: 60637/10 Folio: and 60637

Current Use of Site	Vacant and residential

Current Owner/s:	Name(s) MARK R & DEBORAH E ACKERLY

Is the Property on the Tasmanian Heritage Register?	No: ☑ Yes: ☐	*If yes, please provide written advice from Heritage Tasmania*
Is the proposal to be carried out in more than one stage?	No: ☑ Yes: ☐	*If yes, please clearly describe in plans*
Have any potentially contaminating uses been undertaken on the site?	No: ☑ Yes: ☐	*If yes, please complete the Additional Information for Non-Residential Use*
Is any vegetation proposed to be removed?	No: ☑ Yes: ☐	*If yes, please ensure plans clearly show area to be impacted*
Does the proposal involve land administered or owned by either the Crown or Council?	No: ☑ Yes: ☐	*If yes, please complete the Council or Crown land section on page 3*

If a new or upgraded vehicular crossing is required from Council to the front boundary please complete the Vehicular Crossing (and Associated Works) application form
https://www.sorell.tas.gov.au/services/engineering/

Sorell Council
Development Application: 5.2024.218.1 - Response to Request for Information - 513 Shark Point Road, Penna.pdf
Plans Reference: P2
Date received: 28/11/2024

Part B continued: Please note that Part B of this form is publicly exhibited

Declarations and acknowledgements
• I/we confirm that the application does not contradict any easement, covenant or restriction specified in the Certificate of Title, Schedule of Easements or Part 5 Agreement for the land. • I/we consent to Council employees or consultants entering the site and have arranged permission and/or access for Council's representatives to enter the land at any time during normal business hours. • I/we authorise the provision of a copy of any documents relating to this application to any person for the purposes of assessment or public consultation and have permission of the copyright owner for such copies. • I/we declare that, in accordance with s52(1) of the *Land Use Planning and Approvals Act 1993*, that I have notified the owner(s) of the intention to make this application. • I/we declare that the information in this application is true and correct. *Details of how the Council manages personal information and how you can request access or corrections to it is outlined in Council's Privacy Policy available on the Council website.*
• I/we acknowledge that the documentation submitted in support of my application will become a public record held by Council and may be reproduced by Council in both electronic and hard copy format in order to facilitate the assessment process, for display purposes during public exhibition, and to fulfil its statutory obligations. I further acknowledge that following determination of my application, Council will store documentation relating to my application in electronic format only.
• Where the General Manager's consent is also required under s.14 of the *Urban Drainage Act 2013*, by making this application I/we also apply for that consent.

Applicant Signature:	Signature: .... Date: 28 November 2024

Crown or General Manager Land Owner Consent
If the land that is the subject of this application is owned or administered by either the Crown or Sorell Council, the consent of the relevant Minister or the Council General Manager whichever is applicable, must be included here. This consent should be completed and signed by either the General Manager, the Minister, or a delegate (as specified in s52 (1D-1G) of the *Land Use Planning and Approvals Act 1993*). Please note: • If General Manager consent if required, please first complete the General Manager consent application form available on our website www.sorell.tas.gov.au • If the application involves Crown land you will also need a letter of consent. • Any consent is for the purposes of making this application only and is not consent to undertaken work or take any other action with respect to the proposed use or development.
I ______________________________ being responsible for the administration of land at ______________________________ declare that I have given permission for the making of this application for ______________________________

Signature of General Manager, Minister or Delegate:	Signature: .... Date: ....

September 2024

PLANNING REPORT

SINGLE DWELLING

513 Shark Point Road PENNA

Woolcott LAND SERVICES

EAST COAST SURVEYING CONSULTING SURVEYORS & LAND PLANNERS

Prepared by
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Town Planner

Rev.no	Description	Date
1	Review	19 August 2024
2	Draft	3 September 2024
3	Final	11 September 2024
4	Amended	27 November 2024
5	Reviewed	28 November 2024

Contents

1. Introduction

This report has been prepared in support of a planning permit application under Section 57 of the *Land Use Planning and Approvals Act 1993*.

Proposed development
Building and works – development of a single dwelling

This application is to be read in conjunction with the following supporting documentation:

Document	Consultant
Proposal Plan	Engineering Plus / Tasbuilt Homes

This application refers to the following specific definitions:

Term	Definition
single dwelling	means a dwelling on a lot on which no other dwelling, other than a secondary residence, is situated.
secondary residence	means an additional residence which is self-contained and: a. has a gross floor area not more than 60m2; b. is appurtenant to a single dwelling; c. shares with the single dwelling access and parking, and water, sewerage, gas, electricity and telecommunications connections and meters; and d. may include laundry facilities.
site	means the lot or lots on which a use or development is located or proposed to be located.

2. Subject site and proposal

2.1 Site details

Address	513 Shark Point Road, Penna TAS 7171
Property ID	5908210
Title	60637/10 & 60637/11 (subject site) **Subject to adhesion order DA 2024 / 205 – 1 upon approval**
Land area	710.73m^2 & 814.43m^2 est. from title plan

Planning Authority	Sorell Council
Planning Scheme	Tasmanian Planning Scheme – Sorell (Scheme)
Easements	None on folio plan Neighbouring drain on public land.
Application status	Discretionary application
Existing Access	Single crossover from Shark Point Road
Zone	Low Density Residential
General Overlay	Dispersive Soils Specific Area Plan
Overlays	Waterway and coastal protection area Bushfire-prone areas Airport obstacle limitation area Low landslip hazard band
Existing development	Existing outbuilding with stormwater tank. Existing onsite wastewater system Existing vehicle crossing (access).
Existing services and infrastructure	
Water	Serviced
Sewer	Not serviced
Stormwater	Neighbouring lot via headwall connection.

2.2 Proposal

At the time of application, the proposal is for the development of a single dwelling on the lot Volume: 60637, Folio:10. The proposal also includes a change of use of the existing dwelling on Volume: 60637, Folio: 11 to be a secondary residence, appurtenant to the proposed dwelling. The existing building is $58m^2$.

The proposed dwelling will have 3 bedrooms and study; 2 bathrooms; laundry; and living areas with kitchen. The building includes two decked areas and has a building area of $160.27m^2$.

The proposal includes existing on site servicing for sewer. This is located on Volume: 60637, Folio: 11. The adhesion order to be enacted on the land will ensure that the proposed dwelling has continued access and right to the onsite wastewater system.

Water will be connected and stormwater will be directed to the existing discharge point via the existing tank with overflow on the north east of the lot.

The drainage easement is identified on the title plan, see Figure 2).

2.3 Subject site

The subject site is comprised of two lots (adjoining and under same ownership). Existing development includes a small Class 1a dwelling (BA 2019 / 20 - 1 5908210) together with an onsite wastewater system on 60637/11.

The site has existing access built to 60637/10 serving both lots.

The site is gently sloped down to the coast at the south east.

Figure 1 Aerial view of the subject site (Source: LIST)

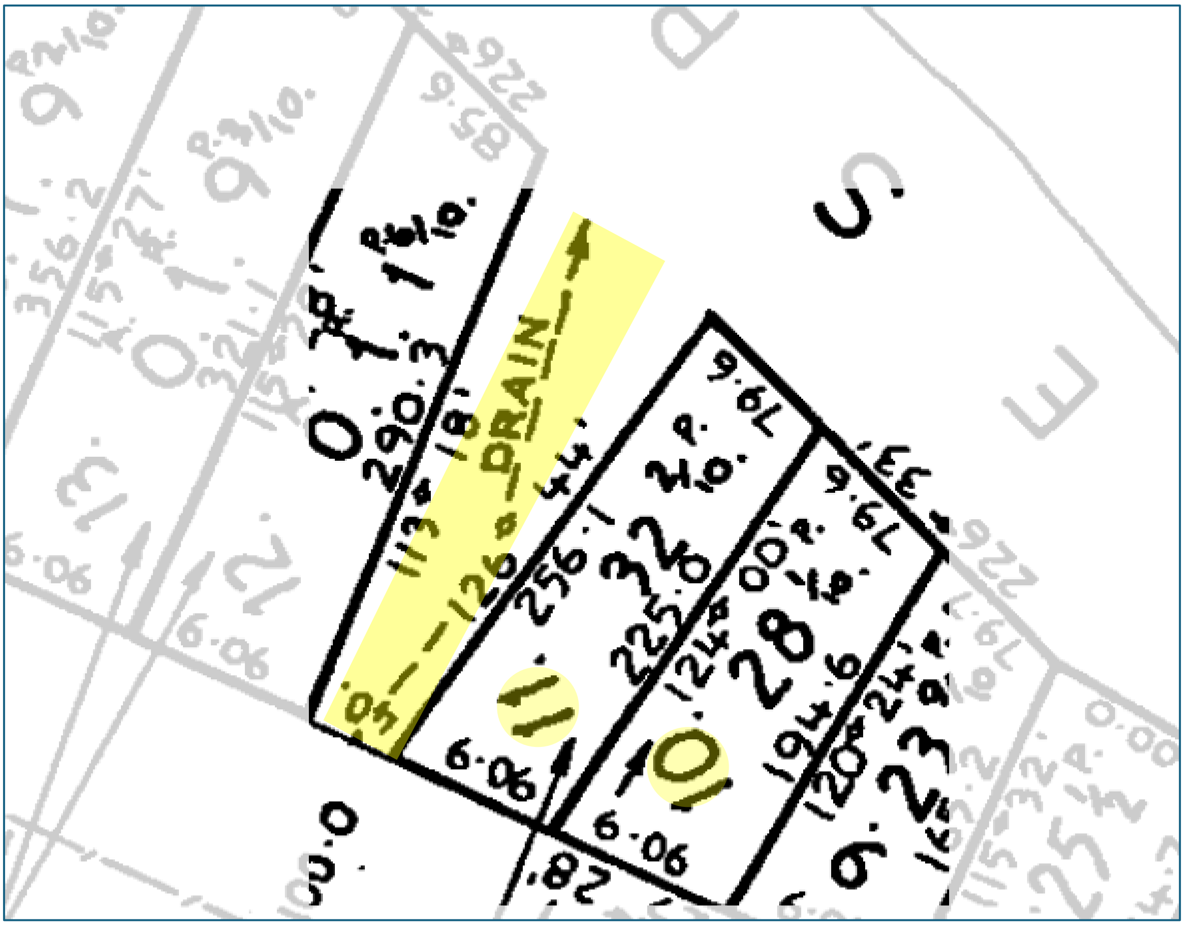


Figure 2 Extracted from folio plan 60637/1

3. Zoning and overlays

3.1 Zoning

The site is zoned Low Density Residential under the Scheme.

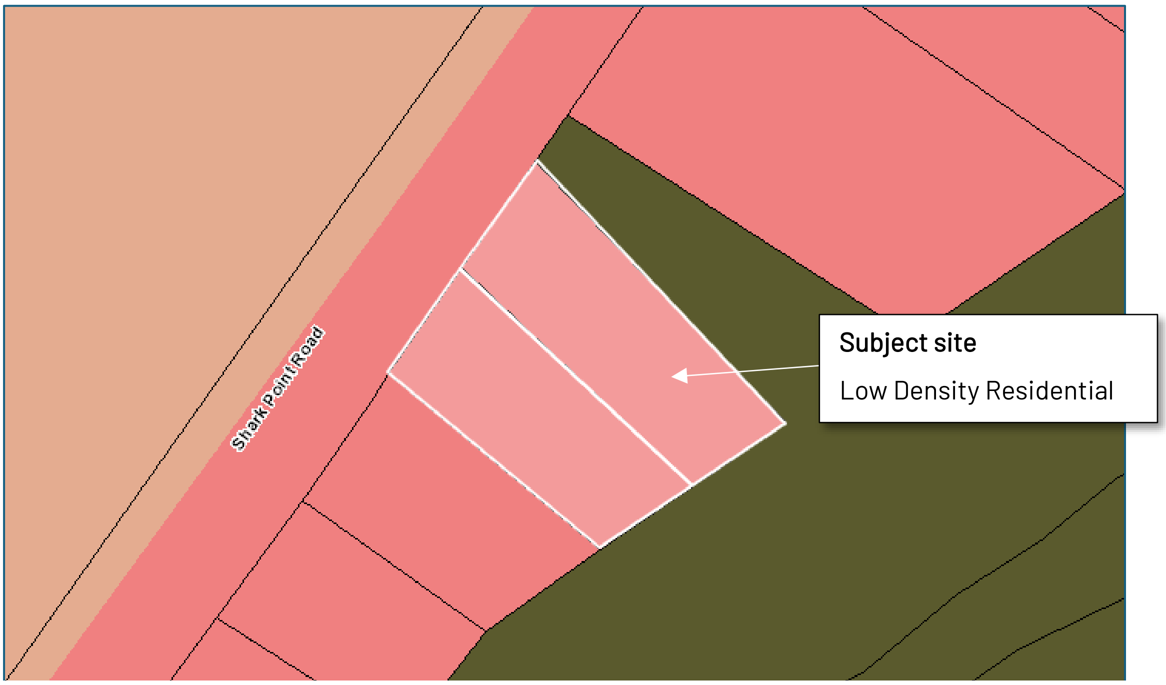


Figure 3 Zoning of the subject site and surrounding area (Source: LIST)

3.2 General Overlays

The subject site is included in the Dispersive Soils Specific Area Plan (SAP)

Figure 4 Area included in the SAP (Source: LIST)

3.3 Overlays

The site is Affected by the Waterway and coastal protection area; Bushfire-prone areas (not shown); Airport obstacle limitation area (not shown); and Low landslip hazard band overlays.

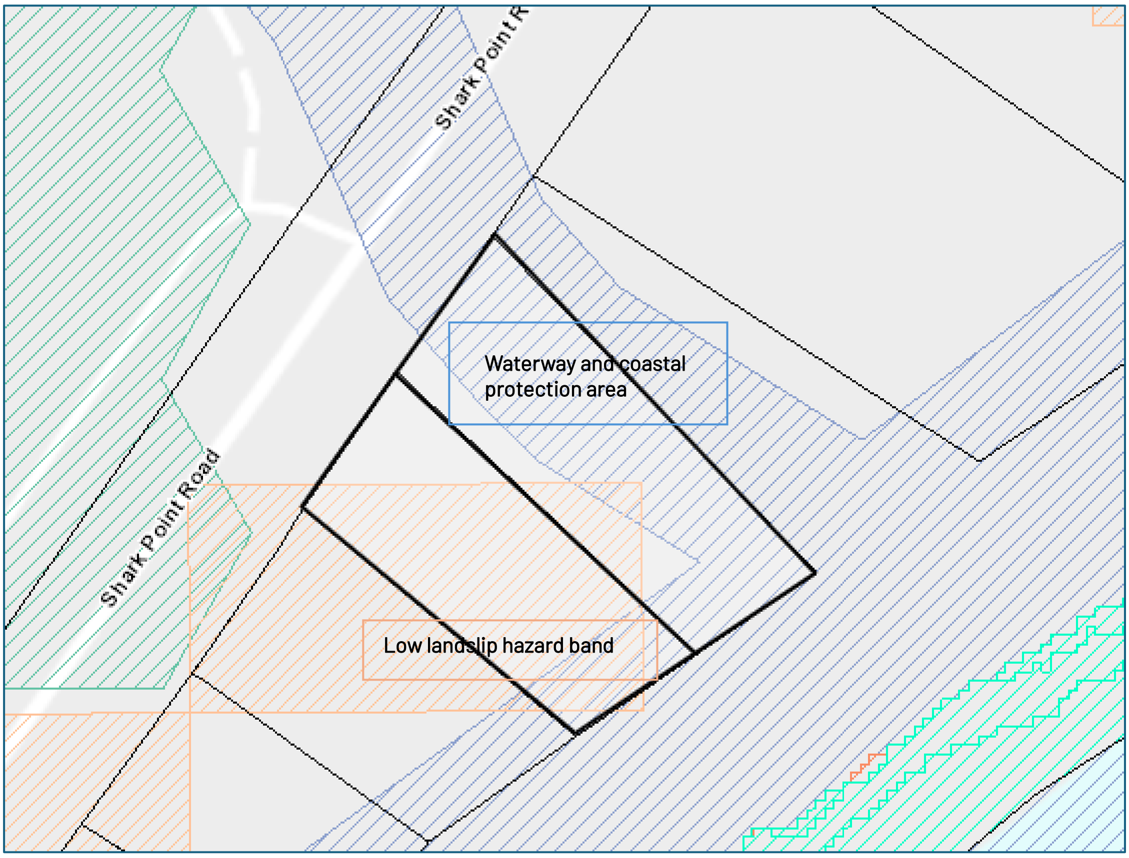


Figure 5 Overlays affecting the subject site (Source: LIST)

4. Planning Scheme Assessment

4.1 Zone assessment

SOR-S1.0 Dispersive Soils Specific Area Plan

SOR-S1.7 Development Standards for Buildings and Works

SOR-S1.7.1 Development on dispersive soils

Objective
That buildings and works with the potential to disturb dispersive soil are appropriately located or managed: a. to minimise the potential to cause erosion; and b. to reduce risk to property and the environment to an acceptable level.

Acceptable Solutions		Performance Criteria	
A1	Buildings and works must be for: a) works not involving the release of concentrated water or the disturbance of soils; b) additions or alterations to an existing building, or the construction of a non-habitable building, provided the development area is not more than 100m2; or c) forestry operations in accordance with a certified Forest Practices Plan.	P1	Buildings and works must be designed, sited and constructed to minimise the risks associated with dispersive soil to property and the environment, having regard to: a) the dispersive potential of soils in the vicinity of proposed buildings, driveways, services and the development area generally; b) the potential of the development to affect or be affected by erosion, including gully and tunnel erosion; c) the dispersive potential of soils in the vicinity of water drainage lines, infiltration areas and trenches, water storages, ponds, dams and disposal areas; d) the level of risk and potential consequences for property and the environment from potential erosion, including gully and tunnel erosion; e) management measures that would reduce risk to an acceptable level; and f) the advice contained in a dispersive soil management plan.

RESPONSE

P1 The performance criteria apply. The supplied Soil Report provides information that is site specific and informs the performance criteria response. Please refer to Annexure 3.

10.0 Low Density Residential Zone

10.1 Zone Purpose

10.1.1	To provide for residential use and development in residential areas where there are infrastructure or environmental constraints that limit the density, location or form of development
10.1.2	To provide for non-residential use that does not cause an unreasonable loss of amenity, through scale, intensity, noise, traffic generation and movement, or other off site impacts.
10.1.3	To provide for Visitor Accommodation that is compatible with residential character.

RESPONSE

The proposed residential use and development is in accord with the purpose of the zone.

10.2 Use Table

No Permit Required	
Residential	If for a single dwelling.

RESPONSE

The proposed Use is a *No Permit Required* Use. The secondary residence is a *No Permit Required* Use.

10.4 Development Standards for Dwellings

10.4.2 Building height

Objective	
That the height of dwellings is compatible with the streetscape and do not cause an unreasonable loss of amenity for adjoining properties.	
Acceptable Solutions	**Performance Criteria**
A1 A dwelling must have a building height not more than 8.5m.	P1 The height of dwellings must be compatible with the streetscape and not cause an unreasonable loss of amenity to adjoining properties having regard to: a) the topography of the site; b) the height of buildings on the site and adjacent properties; c) the bulk and form of existing and proposed buildings; d) sunlight to habitable rooms and private open space of dwellings; and e) (e) any overshadowing of adjoining properties.

RESPONSE

A1 The acceptable solution is achieved. The dwelling is 7.41m in height at the highest point.

10.4.3 Setback

Objective	
That the siting of dwellings is compatible with the streetscape and does not cause an unreasonable loss of amenity for adjoining properties.	
Acceptable Solutions	**Performance Criteria**
A1 Dwellings, excluding protrusions that extend not more than 0.9m into the frontage setback, must have a setback from a frontage not less than 8m	P1 The siting of a dwelling must be compatible with the streetscape and character of development existing on established properties in the area, having regard to: a) the topography of the site; b) the setbacks of surrounding buildings; c) the height, bulk and form of existing and proposed buildings; d) the appearance when viewed from roads and public open space adjacent to the site; and

	e) (e) the safety of road users.

RESPONSE

A1 The acceptable solution is achieved. The dwelling has a front setback of 15m+.

A2 Dwellings, excluding outbuildings with a building height of not more than 2.4m and protrusions that extend not more than 0.9m horizontally from the building, must have a setback from side and rear boundaries of not less than 5m.	P2 The siting of a dwelling must not cause an unreasonable loss of amenity to adjoining properties, having regard to: a) the topography of the site; b) the size, shape and orientation of the site; c) the setbacks of surrounding buildings; d) the height, bulk and form of existing and proposed buildings; e) the existing buildings and private open space areas on the site; f) sunlight to private open space and windows of habitable rooms on adjoining properties; and g) the character of development existing on established properties in the area.

RESPONSE

P2 The performance criteria are addressed. The setback to the side boundary (south west) is reduced.

a. The site is sloping down to the south east but the topography has little bearing on the setback reduction.
b. The site is rectangular with a width of 18.29m (at the frontage). The two sites together have a combined frontage of 36.58m. However, existing development provides some constraint to the placement of the proposed dwelling and setbacks to the onsite wastewater system must be considered. Further constraint is provided by the (general) south east – north west axis of the lot allowing some amount of overshadowing to the southern located land.
c. From the available aerials of the site, it appears that many dwellings have a reduced or no setback to side boundaries (allowing for inconsistencies in the cadastre to aerial image). The setback proposed is 3.7m minimum (where the building protrudes and 4m to the majority of the building wall extent. This is reasonable in the context of the surrounds.
d. The proposed is single storey but elevated at one end due to the slope of the land. Dwellings with similar terrain in the area are similarly built, or, to two storeys. The proposed is consistent with the existing development in the area being south/south east facing to the waterside.
e. The lot is undeveloped but there is existing development on the site. In particular, the onsite wastewater system (purpose built) is considerable in area. To also allow for private open space, a setback from the system's area is required.

f. Shadow plans are provided. The neighbouring site (to the south west) will receive shadow in the a.m. which is tapered off in the p.m. The majority of the neighbouring site will have access to sunlight for the majority of the day.

g. The surrounding built character is similar to the proposed in form, style and bulk. Many lots have very reduced or no setbacks and there are many dwellings that are two storey or elevated according to the slope of the land. The lots are generally oriented for water views and generally on an east west (varied) axis.

10.4.4 Site coverage

Objective	
That site coverage: a) is consistent with the character of existing development in the area; b) provides sufficient area for private open space and landscaping; and c) assists with the management of stormwater runoff.	
Acceptable Solutions	**Performance Criteria**
A1 Dwellings must have a site coverage of not more than 30%.	P1 The site coverage of dwellings must be consistent with that existing on established properties in the area, having regard to: a) the topography of the site; b) the capacity of the site to absorb runoff; c) the size and shape of the site; d) the existing buildings and any constraints imposed by existing development; e) the provision for landscaping and private open space; f) the need to remove vegetation; and g) the site coverage of adjacent properties

RESPONSE

A1 The acceptable solution is achieved.

The site coverage is estimated at 14 percent.

10.4.5 Frontage fences for all dwellings

Objective
The height and transparency of frontage fences: a. provides adequate privacy and security for residents; b. allows the potential for mutual passive surveillance between the road and the dwelling; and

c. is reasonably consistent with that on adjoining properties.

Acceptable Solutions	Performance Criteria
A1 No Acceptable Solution.	P1 A fence (including a free-standing wall) for a dwelling within 4.5m of a frontage must: a) provide for security and privacy, while allowing for passive surveillance of the road; and b) be consistent with the height and transparency of fences in the street, having regard to: i. the topography of the site; and ii. traffic volumes on the adjoining road.

RESPONSE

A1 The acceptable solution is achieved – no front fences are included in this proposal.

4.2 Code Assessment

C2.0 Parking and Sustainable Transport Code

C2.5 Use Standards

RESPONSE

A1 The acceptable solution is achieved. There is ample area provided on the site for two car parking spaces which meets the requirement under Table C2.1.

C2.6 Development standards for buildings and works

C2.6.1 Construction of parking areas

RESPONSE

A1 The proposed driveway and parking area are to be sealed according to the acceptable solution.

C2.6.2 Design and layout of parking areas

RESPONSE

A1 Parking and access provision is compliant and a turning areas are provided noting that the site does not provide more than 4 parking spaces.

C2.6.3 Number of accesses for vehicles

RESPONSE

A1 The site has an existing single access point.

C7.0 Natural Assets Code

C7.6 Development Standards for Buildings and Works

C7.6.1 Buildings and works within a waterway and coastal protection area or a future coastal refugia area

RESPONSE

The building is not within the waterway and coastal protection area (noting that the building eaves project to the area as shown on the site plan).

C13.0 Bushfire-Prone Areas Code

C13.2 Application of this Code

C13.2.1 This code applies to:

(a) subdivision of land that is located within, or partially within, a bushfire-prone area; and

(b) a use, on land that is located within, or partially within, a bushfire-prone area, that is a vulnerable use or hazardous use.

RESPONSE

The Code does not apply to a building application for a dwelling.

C15.0 Landslip Hazard Code

C15.4 Use or Development Exempt from this Code

C15.4.1 The following use or development is exempt from this code:

(a) use of land within a low or medium landslip hazard band, excluding for a critical use, hazardous use or vulnerable use;

(d) development on land within a low or medium landslip hazard band that requires authorisation under the Building Act 2016;

RESPONSE

The proposal is exempt from this Code.

C16.0 Safeguarding of Airports Code

C16.4 Use or Development Exempt from this Code

C16.4.1 The following use or development is exempt from this code:

(a) development that is not more than the AHD height specified for the site of the development in the relevant airport obstacle limitation area.

RESPONSE

The proposal is exempt from the Code.

3. Conclusion

This application is for a single dwelling and for the existing dwelling to be classed as a secondary residence on the site. Use of the secondary residence is a 'no permit required' use class and the development of it is previously approved. The use and development on the lot, according to the proposal plan, is dependent on the adhesion of the site which will be completed upon issue of planning permit.

The proposed is in accord with the provisions of the Scheme and a planning permit is sought from Council.

Annexures

Annexure 1 Copy of Title plan and Folio text

Annexure 2 Proposal Plan

Annexure 3 Soil Report

WILLIAM C. CROMER PTY. LTD.
ACN 009 531 613 ABN 48 009 531 613
ENVIRONMENTAL, ENGINEERING AND GROUNDWATER GEOLOGISTS

NEW HOUSE AND GARAGE
513 SHARK POINT ROAD, PENNA

GEOTECHNICAL SUMMARY

In general accordance with AS1726 (1993) *Geotechnical Site Investigations*

SITE (SOIL TEST) CLASSIFICATION

In general accordance with AS2870 (2011) *Residential slabs and footings*

AND

WIND LOAD CLASSIFICATION

In general accordance with AS4055 (2006) *Wind loads for housing*

Municipality	**Sorell**
Client	**M. and D. Ackerly**
Location	**513 Shark Point Road, Penna**
Development	**New house and garage**
Date of inspection	**17 February 2012**

Cover photo
View looking south over Pitt Water from 513 Shark Point Road, Penna, February 2012.

Refer to this report as
Cromer, W. C. (2013). *Geotechnical summary, site classification and wind classification, new house and garage, 513 Shark Point Road, Penna.* (Unpublished report for M. and D. Ackerly by William C. Cromer Pty. Ltd., 8 April 2013; 37 pages.

William C Cromer Pty Ltd may submit hard or electronic copies of this report to Mineral Resources Tasmania to enhance the geotechnical database of Tasmania.

Important Note
Permission is hereby given by William C. Cromer as author, and the client, for this report to be copied and distributed to interested parties, but only if it is reproduced in colour, and only distributed in full. No responsibility is otherwise taken for the contents.

SUMMARY STATEMENTS

Geotechnical risk

Risks associated with a variety of geotechnical issues potentially affecting proposed house extensions and a separate water tank/workshop at 513 Shark Point Road, Penna are mainly in the Very low to Moderate range (see Attachment 6) and can be addressed by standard management techniques. A very high risk is associated with reactive clayey soils. Recommendations are made to manage this and other issues. Subject to these recommendations, development of this site should proceed.

AS2870 Site Classification

In accordance with Australian Standard 2870 (2011) *Residential slabs and footings*, the areas abcd (garage) and efgh (house) in Attachment 3 to this report are classified as **Class E** (see Attachment 5). Footings for Class E sites require certification by an engineer experienced in footing design and AS2870. However, if all footings (strip footings, piers or a combination) are extended through the reactive clay soil profile into underlying non-plastic weathered dolerite bedrock, or bedrock itself, then the classification for the garage and house sites is **Class S**. Excavation depths to achieve this are presented in Attachment 5.

AS4055 Wind Classification

In accordance with Australian Standard 4055 (2006) *Wind loads for housing*, the following wind load classification is made for the proposed extensions at 513 Shark Point Road, Penna:

Wind Region	**A**
Terrain Category classification	**TC2**
Topographic classification	**T1**
Shielding classification	**PS**
Wind classification	**N2**
Max. Design Gust Wind Speed	**26m/s** [Serviceability limit state ($V_{h,\ s}$)]
	40m/s [Ultimate limit state ($V_{h,\ u}$)]

W. C. Cromer

Principal

8 April 2013

The 1-page classification is and must remain accompanied by the following Attachments

Attachment 1. Location, aerial photography and published geology of the property (1 page)
Attachment 2. Satellite imagery of the property (1 page)
Attachment 3. Site plan showing test pit locations and the areas abcd and efgh to which the AS2870 site classification refers (1 page)
Attachment 4. Site and test pit photographs (7 pages)
Attachment 5. Summary of test pits, interpretation of site geology; AS2870 site classification and Notes for Designers, Builders and Owners (5 pages)
Attachment 6. Summary of geotechnical issues, risks and consequences to development site, and suggested risk treatment practices (1 page)
Terminology used in geotechnical risk assessment (1 page), and
Examples of good and poor hillside engineering practices (2 pages)
Attachment 7. Three 4-page CSIRO pamphlets (13 pages):
CSIRO Information sheet BTF 18. *Foundation Maintenance and Footing Performance*: *A Homeowner's Guide* (replaces Information Sheet 10/91; dated 2003)
CSIRO Building Technology File No. 19. *A builder's guide to preventing damage to dwellings. Part 1 – Site investigation and preparation* (February 2003)

CSIRO Building Technology File No. 22. *A builder's guide to preventing damage to dwellings. Part 2 – Sound construction methods* (August 2003)

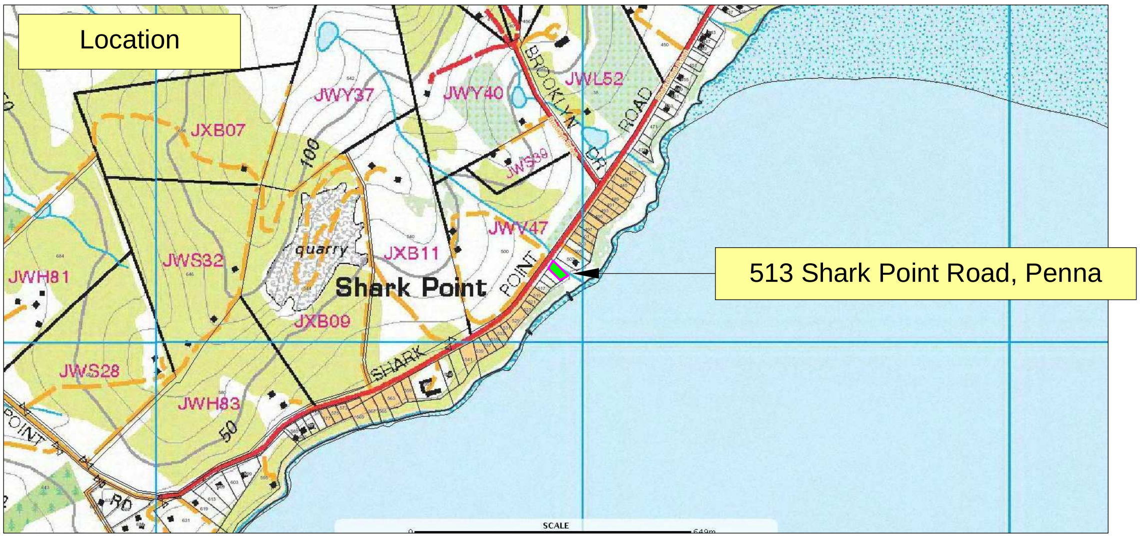
Designers, builders and developers are encouraged to read these publications, and the other Attachments to this report.

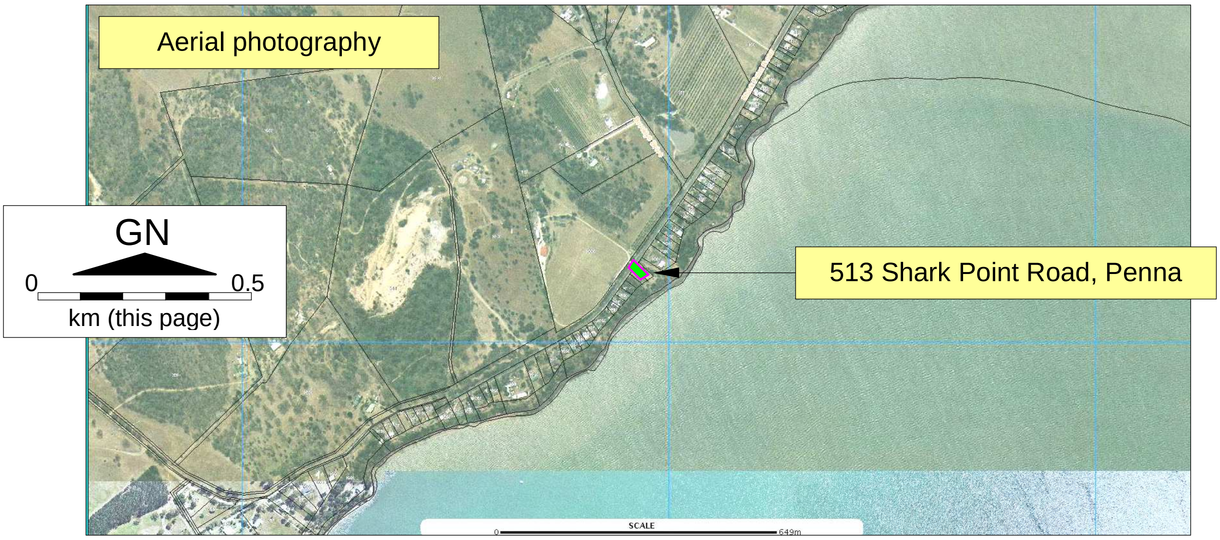
Attachment 1

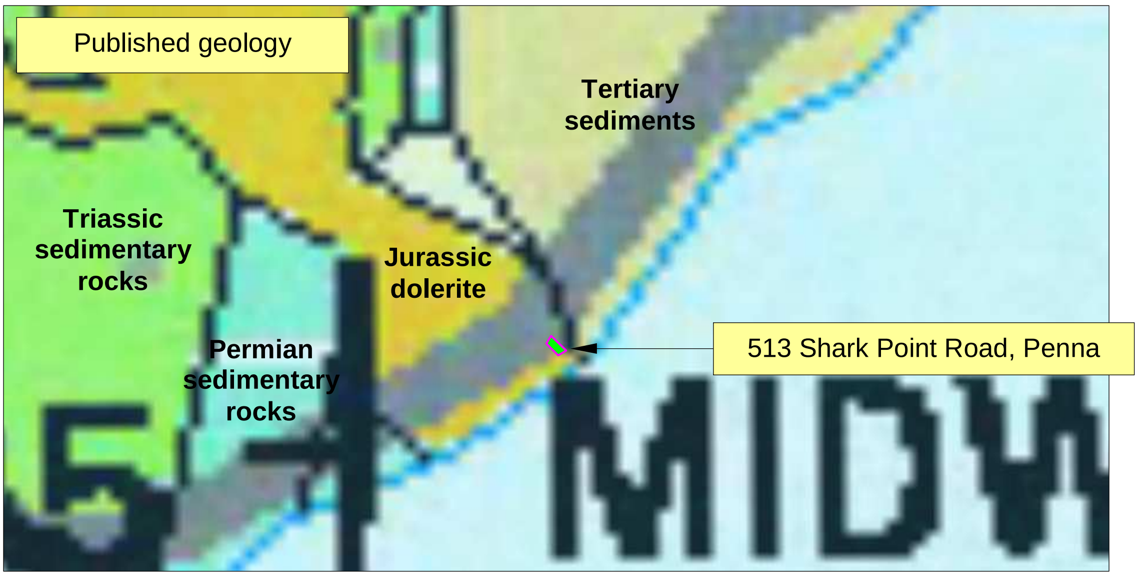
(1 page)

Location, aerial photography and published geology of the property

Sources www.thelist.tas.gov.au, Mineral Resources Tasmania







Attachment 2

(1 page)

Satellite imagery of the property

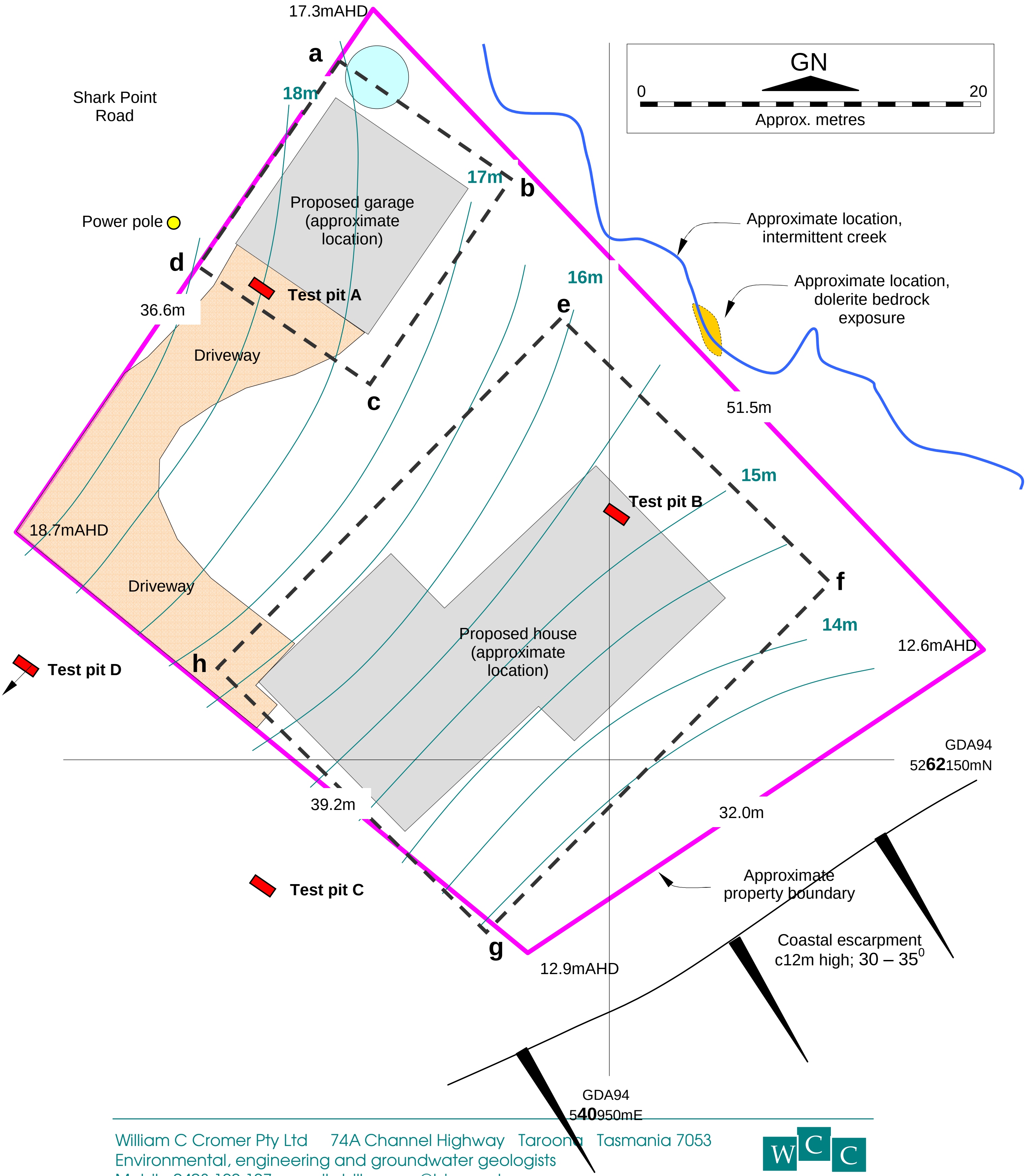
Property boundaries (in pink) are approximate. Do not scale.
(Sources: Google Earth; image date 2009, and Bob Ford Surveyors, Bellerive)

Attachment 3

(1 page)

Site plan showing test pit locations and the areas abcd and efgh to which the AS2870 site classification refers

Source: Base plan and elevations from Bob Ford Surveyors, Bellerive



Attachment 4

(7 pages)

Site and test pit photographs

Plate 1 (above). View southwest on the foreshore below 513 Shark Point Road, showing baked, strongly fractured sandstone bedrock (right foreground) intruded by Jurassic dolerite.

Plate 2 (below). Fine grained, strongly fractured Jurassic dolerite bedrock exposed on the foreshore below 513 Shark Point Road.

Plate 3 (above). View southwest across the 30 – 350 slopes of the embankment below 513 Shark Point Road. Hummocky ground and leaning and curved tree trunks indicate shallow-seated slope instability (mainly soil creep and small scale landsliding)

Plates 4 (left) and 5 (below). In-situ, strongly fractured Jurassic dolerite bedrock exposed in the banks of the intermittent creek along the northeastern boundary to 513 Shark Point Road.

In the following photos of test pit profiles, the staff is graduated in metre long red and black segments. The symbol "E" and its reverse are 5cm high and the numbers are decimetres (tenths of a metre).


513 SHARK
POINT ROAD
PENNA
17 FEB 2012
PIT 1B


POINT ROAD
PENNA
17 FEB 2012
PIT C
PENNA
17 FEB 2012
PIT C


17 FEB 2012
PIT D

Attachment 5

(5 pages including this page)

Summary of test pits, interpretation of site geology, AS2870 site classification and Notes for Designers, Builders and Owners

Table 5.1 Summary of test pits

Client ACKERLY
Location 513 Shark Point Road, Penna
Date dug 17-Feb-12

Test hole	A	B	C	D
Depth dug (m)	2.2	1.9	1.3	1.3
Northing (GDA94)	540930	540950	540930	540905
Easting (GDA94)	5262177	5262165	5262142	5262150
Water inflow (depths in m)	None	None	None	None
Standing water level (m)	N/A	N/A	N/A	N/A

Figures are depths to top and bottom of layer, in metres

No.	Layer	Details	USCS	Interp.	A	B	C	D
1	CLAY	Black to dark grey; high plasticity; pedal, cloddy; M<PL; Fb-H	CH	Topsoil or A horizon	0 to 0.5 DCP 0 to 1.6m	0 to 0.6 DCP 0 to 1.0m	0 to 0.5; SV = 260kPa @ 0.1m	0 to 0.8; U50 0.4 to 0.7; SV>260kPa @0.2m
2	CLAY	Includes silty clay; olive brown with numerous small creamm travetine patches; trace sand increasing with depth; high plasticity grading to low plasticity; M<>PL; H	CH grading to CL	Subsoil or B horizon	0.5 to 1.4 U50 0.5 to 0.8	0.6 to 1.3 SV >260kPa @ 0.4m	0.5 to 0.7	
3	Gravelly silty SAND	Includes clayey varieties; olive brown, orange brown; yellowish brown; low plasticty to nonplastic; numerous EW dolerite clasts in pit C (clast-supported); D; Fb-D-	SP, SC, GM	Extremely weathered dolerite bedrock (CB horizon) beneath possible thin wedge of Tertiary sediment	1.4 to 2.2 EAR		0.7 to 1.6 SV >260kPa @0.7m	0.8 to 1.3
4	DOLERITE	Orange brown; extremely weathered		Dolerite bedrock		1.3 to 1.9	CR 1.6	CR 1.3

Notes and abbreviations

USCS = Unified Soil Classification System
Grey cells indicate a missing layer or layers in a test pit
Easting and Northing coordinates from Google Earth. Datum is GDA94.

Sampling U50 0.5 to 0.8 means an undisturbed 50mm diam drive tube sample over stated depth interval
D 0.1 means a disturbed sample at 0.1m depth

Testing HP = hand penetrometer reading in kPa; SV = shear vane; DCP = dynamic cone penetrometer

Excavability Equipment = 4.5 tonne excavator; 0.45m bucket; 4 teeth; Operator: Scott Fletcher-Jones
EAR = end as required; NR = no refusal; CR = close to refusal; R = refusal.

Weathering For rock only. F = fresh; SW = slightly weathered; MW = moderately weathered; HW = highly weathered;
EW = extremely weathered (ie soil properties; material can be remolded in the hand, with or without water)

Moisture D = dry; M = moist (M<=>PL = moisture less than, equal to or greater than Plastic Limit); W = wet.

Consistency Fb = Friable (crumbles to powder when scraped with thumbnail)
S = Soft (Easily penetrated by fist; 25 – 50kPa)
F = Firm (Easily penetrated by thumb; 50 – 100kPa)
St = Stiff (Indented with thumb; penetrated with difficulty; 100 – 200kPa)
VSt = Very stiff (Easily indented with thumbnail; 200 – 400kPa)
H = Hard (Indented by thumbnail with difficulty; >400kPa)

Rel density VL = Very loose (ravelling)
L = Loose (easy shovelling)
MD = Medium dense (hard shovelling)
D = Dense (picking)
VD = Very dense (hard picking)

Interpretation of site geology and soils

Published geology

The published geology of the property and environs (Attachment 1) shows the property wholly underlain by dolerite bedrock of Jurassic age, with the SE-trending intermittent creek along the NE boundary of 513 Shark Point Road marking the geological boundary between the dolerite, and unconsolidated, Tertiary sediments to the NE.

Observed geology

Dolerite intruding Triassic or Permian sandstone and siltstone is well exposed on the foreshore below 513 Shark Point Road (Plates 1 and 2, Attachment 4), where it is moderately weathered and strongly fractured.

Dolerite bedrock is also exposed on the banks of the intermittent creek along the property's northeastern boundary (Attachment 3; Plates 4 and 5, Attachment 4), and was observed in three of the four test pits dug for the present investigations (Attachment 3, and Table 5.1 this Attachment).

Soils

Soils are weakly duplex (two-layered) profiles (Layers 1 and 2 in Table 5.1, this Attachment) of high plasticity dark clay up to about 1.3m thick (range 0.7 to 1.4m; average 1.1m). They overlie light-coloured, non-plastic or low plasticity extremely weathered dolerite bedrock (Layer 3) or dolerite bedrock (Layer 4).

Fill

No fill was observed on site.

Reactivity of clay soils

To test the reactivity of the clayey subsoil materials, and to assist in site classification in accordance with AS2870 (1996) *Residential slabs and footings – Construction*, two undisturbed samples (one each from pits A and D) were collected for testing[1] to estimate their Shrink-Swell Indices (I_{ss}). The test results were:

Pit A (0.5 – 0.8m: Sandy CLAY (CH); olive brown, high plasticity, on weathered dolerite

Initial moisture content	21%
Swelling strain	4.5%
Shrinkage strain	2.9%
Shrink swell index (I_{ss}) =	**2.9%**

Pit D (0.4 – 0.7m: CLAY (CH); dark grey to black, high plasticity, on weathered dolerite

Initial moisture content	31%
Swelling strain	9.0%
Shrinkage strain	7.2%
Shrink swell index (I_{ss}) =	**6.5%**

The first of these (2.9%, of the Layer 2 subsoil) is low to moderate; the latter (6.5%; Layer 1 topsoil) is relatively high. are moderate to low values. When each is applied to the Layer 1 and 2 clay thicknesses in each test pit the following estimated ground surface movements[2] result.

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[1] Although William C. Cromer Pty. Ltd. is not NATA registered, testing was performed essentially in accordance with AS1289.7.1.1-1998. Methods of testing soils for engineering purposes. Method 7.1.1. Soil reactivity tests – Determination of the shrinkage index of a soil – Shrink-swell index. *Standards Australia*. From the Shrink-Swell index, the maximum ground surface movement can be estimated, and hence the site classification.

[2] **Notes**

1 Regional suction base depth = 2m
2 Change in suction at surface = 1.5pF
3 Assumes layer will be completely dry and completely wet at surface during a 50 year period
4 AS2870 classifications

Class	Ground surface movement

Test pit A	Estimate ground surface movement = 85mm (Class E)
Test pit B	Estimate ground surface movement = 80mm (Class E)
Test pit C	Estimate ground surface movement = 50mm (Class H1)
Test pit D	Estimate ground surface movement = 75mm (Class H2 – E)

Layer 3 in Table 5.1 is non-reactive or only very slightly reactive, and compared to Layers 1 and 2, would not contribute in any significant way to ground surface movement. Layer 4 is also non-reactive.

Soil strengths and estimated bearing capacities of materials

Layers 1 and 2

Shear vane readings in test pits B, C and D at depths ranging from 0.1 2 – 0.7m consistently returned undrained shear strengths around 260kPa or higher, corresponding to safe bearing capacities (at the time of inspection) of about 100kPa or more (Table 5.2). The minimum safe bearing capacity for a house is 50kPa (Figure 4.1), so under the moisture conditions pertaining at the time of investigation, the Layer 1 and 2 materials would have had adequate bearing capacity. Bearing capacity, however, decreases with increasing moisture content in clayey materials, and across the site may fall to inadequate levels in wet conditions.

Layers 3 and 4

Layers 3 and 4 are of adequate bearing capacity under changing moisture conditions.

Evidence of slope instability

No evidence of slope instability was observed, and none is expected, within the boundaries of this gently sloping property.

However, the 30 – 35^0 slopes on the coastal embankment show hummocky ground and tilting trunks of trees, indicative of landslides and soil creep. Since bedrock dolerite is exposed on the nearby foreshore, and based on test pitting is also expected at shallow depth beneath the embankment, the slope instability is inferred to be shallow seated and therefore relatively small scale. This process of landward retreat of a steep coastal escarpment is normal, but the rate of retreat in this area is expected to be acceptably slow and little or no observable regression would be expected over the life of a house.

Fill

No fill was observed on the surface, or noted in test pits.

Tunnel erosion and soil dispersion

No tunnel erosion was observed on site, and the Layer 1 and 2 clay soils are expected to be non-dispersive.

AS2870 site classification

At the house site

On the basis of the foregoing, the existing garage and house sites (areas abcd and efgh in Attachment 2) are classified as **Class E**, based on the thickness and assumed reactivity of the

A	0 – 10mm
S	10 – 20mm
M	20 – 40mm
H1	40 – 60mm
H1	60 – 75mm
E	>75mm

Layer 1 and 2 clayey materials. Footings for Class E sites require certification by an engineer suitably experienced in footing design and AS2870.

If all footings (strip footings, piers or a combination) are extended through and into Layer 3 or 4 materials, so that no part of them is weight bearing on Layer 1 or 2 materials, then the classification for the garage and house sites is **Class S**. The excavation depths required to achieve this are expected to be in the range 1.5 – 2m in area abcd, and 0.8 – 1.5m in area efgh (Attachment 3).

Table 5.2 Some suggested correlations between consistency of clay, penetration resistance using various field devices, and safe bearing capacity estimated using a factor of safety of 2.5. See Figure 5.1 for clarification.

Consistency	Field Test	Undrained Shear Strength c_u Torvane (kPa)	Unconfined Compressive Strength q_u Pocket Penetrometer (kPa) **	Dynamic Cone Penetrometer blows/100 mm *	CPT Resistance MPa	Estimated safe bearing capacity (kPa) (Factor of Safety = 2.5)
Very soft	Easily penetrated >40 mm by thumb. Exudes between thumb and fingers when squeezed in hand.	<12	<25	<1	<0.2	<5
Soft	Easily penetrated 10 mm by thumb. Moulded by light finger pressure	12 - 25	25 - 50	1	0.2 - 0.4	5 – 10
Firm	Impression by thumb with moderate effort. Moulded by strong finger pressure	25 - 50	50 - 100	1-2	0.4 - 0.8	10 – 20
Stiff	Slight impression by thumb cannot be moulded with finger.	50 - 100	100 - 200	2 -4	0.8 - 1.5	20 – 40
Very Stiff	Very tough. Readily indented by thumbnail.	100 - 200	200 - 400	4 - 8	1.5 - 3.0	40 – 80
Hard	Brittle. Indented with difficulty by thumbnail.	>200	>400	>8	>3.0	>80

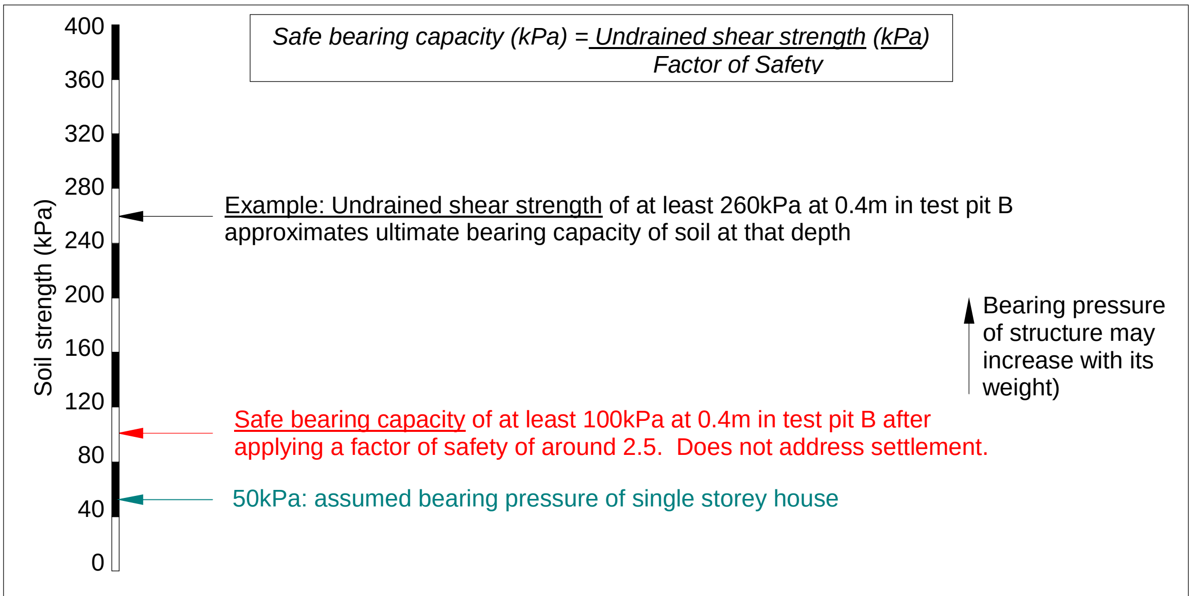


Figure 5.1 Relationships between shear vane readings of undrained shear strength, estimated safe bearing capacity, and the assumed bearing pressure of a structure

Groundwater

Groundwater is expected to be present under unconfined conditions in the fractured dolerite bedrock beneath the property. Residential development is expected to have little or no observable affect on groundwater conditions, and vice versa.

Notes for designers and builders

Variability of subsurface conditions'

Subsurface variability is expected on site: eg the thickness of clayey soil is expected to vary across the site. Excavation depth for footings must therefore be similarly varied to avoid the Layer 1 and 2 materials.

The target materials for footings (Layer 3 or 4 materials) are readily recognised by their light colour, relatively coarse grain size and non-plastic nature.

Subsurface conditions encountered during construction which appear to differ significantly from those described here should be immediately brought to my attention.

Footings

It is suggested that footings for all proposed structures are everywhere founded into Layer 3 or 4 materials.

Drainage

As a general comment, all surface and roof runoff shall be adequately controlled and either diverted around any development, or collected in tanks for later use. Site drainage shall not compromise the operation of on-site wastewater treatment and disposal.

Preventing damage to buildings

In conjunction with the site specific suggestions in the present report, read the CSIRO Bulletins BTF19 and 22 in Attachment 7.

Notes for owners and occupiers

Read the CSIRO Bulletin BTF18 in Attachment 7 of this report.

Risks associated with a variety of geotechnical issues potentially affecting development at the site are mainly in the Very Low to Low range (see Attachment 6) and can be addressed by standard management techniques.

Attachment 6

(4 pages)

Summary of geotechnical issues, risks and consequences to development site, and suggested risk treatment practices (1 page)
Terminology used in geotechnical risk assessment (1 page), and
Examples of good and poor hillside engineering practices (2 pages)

Table 6.1 Summary of geotechnical issues, risks and consequences to development site, and suggested risk treatment practices

	Issue	Likelihood of occurrence	Consequences to property	Level of risk to property	Risk treatment
1	**Surface soil erosion**	Possible	Minor	Low	Control upslope surface runoff and roof runoff.
2	**Tunnel erosion**	Unlikely	Minor	Very low	As for issue 1
3	**Soil creep**	Unlikely	Minor	Very low	As for issue 1
4	**Shallow-seated landslide (involving, for example, soil, boulder beds, talus, colluvium, etc)**	Rare (Likely off-site on embankment)	Minor	Very low (Moderate off-site on embankment)	As for issue 1. Ensure adequate support for excavations. Avoid loading colluvium. Footings to bedrock..
5	**Deep-seated landslide (involving, eg boulder beds, talus, colluvium, bedrock etc)**	Rare	Major	Low	No action required
6	**Foundation movement due to reactive or unstable soils**	Almost certain	Medium to Major	Very high	Design footings in accordance with the AS2870 site classification and related comments in this report
7	**Low strength materials (eg uncontrolled fill, soft soils)**	Unlikely	Medium	Low	As for issue 6
8	**Vegetation removal**	Unlikely	Minor	Low	Avoid removal or planting large trees close to buildings
9	**Flooding or waterlogging**	Unlikely	Minor	Low	As for issue 1. Ensure adequate drainage behind retaining walls. Consider upslope cutoff drain above house.
10	**Riverbank collapse**	Unlikely	Minor	Low	
11	**On-site wastewater disposal**	N/A. Site has reticulated Council sewerage			
12	**Site contamination from previous activities**	Unlikely	Minor	Low	Visual inspection during site construction, and cover or clean up as required
13	**Earthquake risk**	Almost certain (magnitude <5); Likely (magnitude>5)	Insignificant to Minor	Low to Moderate	Generally accept risk. A similar range of risks exists throughout Tasmania.
14	**Sea level rise**	Likely	Minor	Moderate	No action required
15	**Storm surge**	Likely	Minor	Moderate	As above
16	**Shoreline recession**	Likely	Minor	Moderate	As above

1. The assessments are unavoidably subjective to varying degrees.
2. See next page for an explanation of the terms used in this table.
3. Further reading: Australian Geomechanics Society Subcommittee (2007). Landslide Risk Management Aust. Geomechanics 42(1) March 2007, pp 1 – 219.

Terminology used in geotechnical risk assessment (1 page)

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	1: CATASTROPHIC 200%	2: MAJOR 60%	3: MEDIUM 20%	4: MINOR 5%	5: INSIGNIFICANT 0.5%
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or L (5)
B - LIKELY	10^{-2}	VH	VH	H	M	L
C - POSSIBLE	10^{-3}	VH	H	M	M	VL
D - UNLIKELY	10^{-4}	H	M	L	L	VL
E - RARE	10^{-5}	M	L	L	VL	VL
F - BARELY CREDIBLE	10^{-6}	L	VL	VL	VL	VL

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.
(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

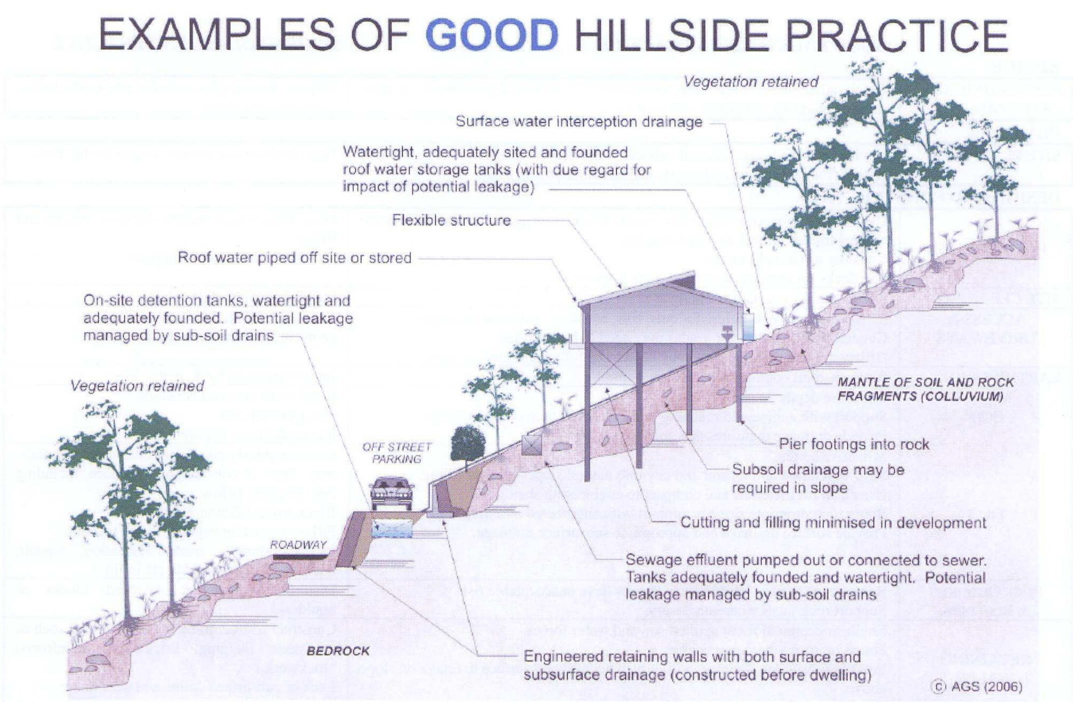
RISK LEVEL IMPLICATIONS

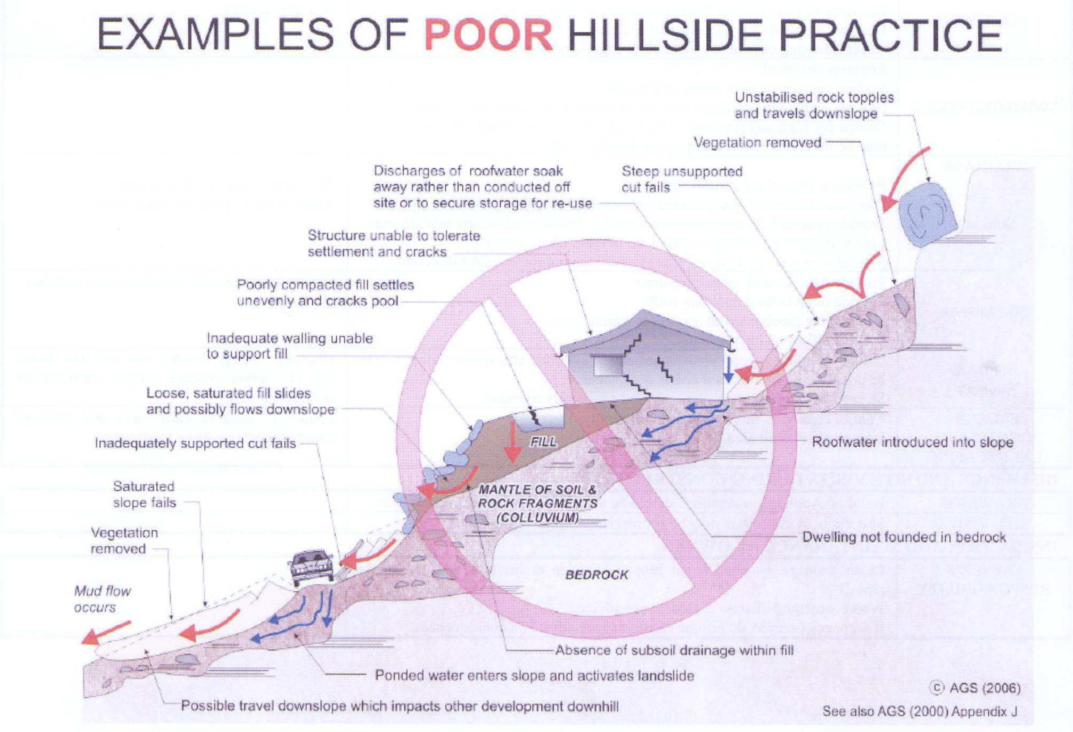
Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

Examples of good and poor hillside engineering practices

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007





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APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
DESIGN AND CONSTRUCTION		
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminatory bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto property below. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill.
ROCK OUTCROPS & BOULDERS	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within rock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE		
SURFACE	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide general falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge roof runoff into absorption trenches.
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.
DRAWINGS AND SITE VISITS DURING CONSTRUCTION		
DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	
INSPECTION AND MAINTENANCE BY OWNER		
OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	

Attachment 7

(13 pages including this page)

Three 4-page CSIRO pamphlets

CSIRO Information sheet BTF 18. *Foundation Maintenance and Footing Performance*: *A Homeowner's Guide* (replaces Information Sheet 10/91; dated 2003)

CSIRO Building Technology File No. 19. *A builder's guide to preventing damage to dwellings. Part 1 – Site investigation and preparation* (February 2003)

CSIRO Building Technology File No. 22. *A builder's guide to preventing damage to dwellings. Part 2 – Sound construction methods* (August 2003)

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).

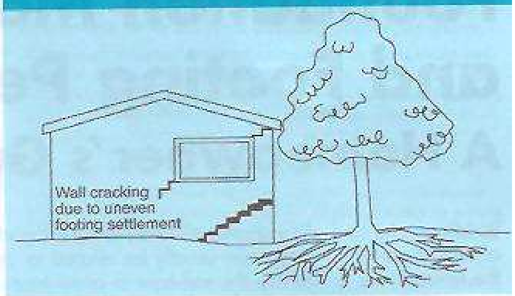
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

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 th external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other crack 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 b 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 footing whereas soil subject to drying because of tree or shrub roots will te 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 buildin resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all thes forces is usually rotational. This resultant force often complicates t 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 rem unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to devel 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 case return to its original position after completion of a cycle, however 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 a will resist the forces trying to return it to its original position. Th means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remai after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will beco wider until the sections of brickwork become virtually independe

With repeated cycles, once the cracking is established, if there is 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 als 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

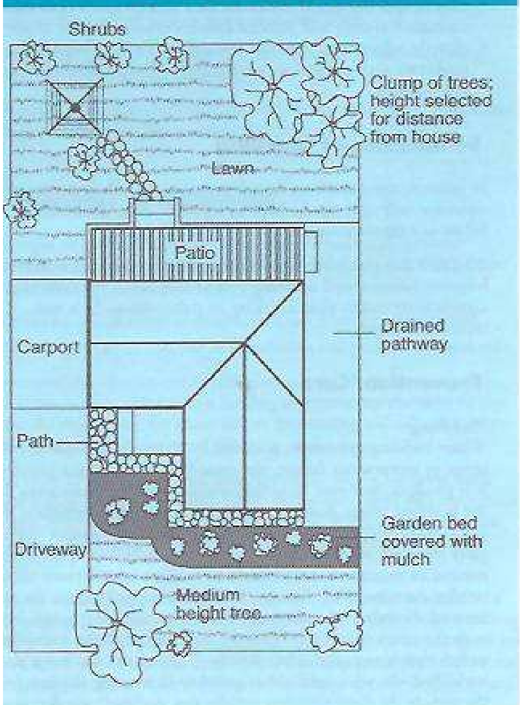
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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



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

-s prudent to relocate drainage pipes away from this paving, if -sible, to avoid complications from future leakage. If this is not -ctical, earthenware pipes should be replaced by PVC and -kfilling should be of the same soil type as the surrounding soil -l compacted to the same density.

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

-nay be desirable to install a grated drain at the outside edge of the -ing on the uphill side of the building. If subsoil drainage is -ded this can be installed under the surface drain.

-ndensation

-buildings with a subfloor void such as where bearers and joists -port flooring, insufficient ventilation creates ideal conditions for -ndensation, particularly where there is little clearance between the -or and the ground. Condensation adds to the moisture already -sent in the subfloor and significantly slows the process of drying -. Installation of an adequate subfloor ventilation system, either -ural or mechanical, is desirable.

-rning: Although this Building Technology File deals with -cking in buildings, it should be said that subfloor moisture can -ult in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber buildin- 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 - 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 pavin- 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. -it is necessary to use these systems, it is important to remove gard- 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 a- 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 the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree sho- be made to the local authority. A prudent plan is to transplant lik- 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 o- information. For information on plant roots and drains, see Build- 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 ang- 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 requir- Remediation of footings and foundations is generally the realm of specialist consultant.

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

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BUILDING TECHNOLOGY file

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A builder's guide to preventing damage to dwellings

Part 1 – Site investigation and preparation

THE PROBLEMS

History
Many homes in Australia suffer from one or more of the several maladies that result from conditions that could have been prevented had the engineer and/or builder undertaken thorough site investigation and subsequent site preparation. This work is just as important as employing sound practice in construction – in fact, at law it is increasingly seen as part of sound building practice. The result is that a reasonably competent builder is now expected to know more about building movement caused by foundation soils than was the case before the landmark legal battles of the middle 1990s.

The growth of consumerism has led to the notion that a consumer can rely on the builder to be competent in all matters related to construction. We know that the builder relies on the competence of specialists and professionals, but in the end it is the builder's duty to the customer to ensure that the building is not adversely affected by defective foundations. There are many builders who are sufficiently competent in soils to carry out the level of elementary investigation required for most small sites. For them, this document may serve as a checklist for their initial inspection and a reminder that if they discover any soil problems, they should engage a suitably qualified engineer. For those builders who are not familiar with site investigation, this document is designed to give the rudiments of soils as they affect housing in most parts of Australia, and to help the practitioner on the road toward an understanding of the issues. Such builders, while in the process of learning, would be wise to engage an expert engineer for site investigation prior to finalisation of the engineering design drawings.

The predominant practice in residential construction is for the builder to ignore the soil except for the provision of bearing surfaces for footings. In fact, Clause 3.2 of AS 1684 requires the site to be clear of tree roots etc. and to be well drained. AS 2870 requires soil classification and gives a brief description of the allowable methods. AS 3798 details a number of issues that should be covered in a site investigation. All of these standards have been incorporated into the Building Code of Australia (BCA). Because the BCA has been adopted by every relevant jurisdiction in the nation, the law requires the builder to abide by the provisions in the standards or have an engineered solution accepted that will meet the performance requirements of the BCA.

Results of soil problems
The upshot of all the above is that no longer are defects such as falls in floor levels, cracking in floor tiles, cracking in concrete slabs, cracking in walls and ceilings (especially cornices), squeaky flooring, binding doors and windows, deflecting roof slopes, and cracked mortar bedding to ridge and hip caps believed to be caused by a natural phenomenon beyond the responsibility of the builder. The builder should therefore carry out proper site investigation and prepare the site accordingly.

Water problems
The principal enemy is water – either flowing, ponding, seep by gravitational force, migrating by capillary action or in the vapour. Any masonry product that can absorb water can be damaged by it or by the chemicals carried with water; any permeable mortar is also susceptible; timber will decay in contact with water or vapour; gypsum plasterboard decompos steel is obviously also vulnerable.

Aside from direct damage to building elements, water very commonly causes damage to buildings indirectly by workin the foundation soil – erosion, subsidence, swelling and shrinkage of soil by absorption and shedding of moisture.

Buildings with subfloor voids, such as found when timber or s frame floors are constructed, also suffer from high humidit the subfloor when water flows or ponding exist. This can encourage decay of the timber, cup the floorboards and rai the humidity level in the living space.

This introduces another dimension of the problems created water – that of living organisms. The presence of water attra insects including termites. In turn, predators such as spide are also attracted. Perhaps the most insidious and serious hazard is introduced by dust mites and some types of fung that have been shown to greatly increase the incidence of respiratory ailment symptoms in susceptible occupants.

Slab-on-ground construction is also subject to water incursi problems. The added problem this method has is the ease which water can gain access to the cavity via weepholes. On the cavity, it creates a damp environment which is very slow dry, transferring moisture to the inner leaf walls and timber finishes and creating high humidity in the living space.

Vegetation problems
The other source of instability to structures that this BTF de with is vegetation and organic matter. Tree roots can cause upheaval when growing and subsidence when decomposed, well as creating uneven moisture content by taking in water Organic material generally in the subsoil is not stable and d not properly compact, therefore making a poor foundation f structure.

SOIL TYPES

The types of soils usually present under the topsoil in land zo for residential buildings can be split into two approximate grou granular and cohesive. Quite often foundation soil is a mixtur both types. The general problems associated with soils having granular content are usually caused by erosion. Cohesive s are either clay or silt. Clay soils are by far the more commo and are subject to saturation and swell/shrink problems. As most buildings suffering continuing movement problems founded on clay soils, there is an emphasis on classificatio soils according to the amount of swell and shrinkage they experience with variations of water content. The following ta is reproduced from AS 2870.

TABLE 2.1
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 (see Clause 2.4.6)
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

* For examples of clay sites classified as Class S, refer to Appendix D.

SOIL PROBLEMS

Rock
Excluding movement caused by seismic events, monolithic rock is not subject to movement problems. However, there are things to watch for:
- Footings may be founded on boulders or 'floaters' which can move due to erosion of soil around them.
- Rock is susceptible to water migration via faults and between strata. Many dwellings founded on sandstone suffer from water in the subfloor.

Granular soils
There are a number of problems to be avoided:
- These soils are not cohesive and can be susceptible to local shear failure when not confined. For this reason, building on sand dunes is inadvisable.
- Sandy soils are prone to erosion so service trenches, pipes, surface water and ground water flows can be hazards.
- Organic material left in the soil may be eaten by termites, leaving a void which will be filled by surrounding granular soil, thus reducing the bearing capacity of the foundation in that area.
- Sand expands when damp – surface tension will adhere water to grains, thus expanding the volume. Conversely, when saturated, sand is at its lowest volume. The fact that these changes occur means that care must be exercised to ensure that sand is well-compacted when constructing footings.

Silt
The chief risk presented by silt is its susceptibility to erosion, so the hazards that apply to granular soils may also apply to silt.

Clay
Most clays provide good residential foundations when dry, but most clays react significantly to the introduction of water:
- Local shear failure is not uncommon when soft clays are wet.
- When saturated, virtually any clay substantially loses its bearing capacity.
- The cohesive quality of clay makes it slower to compress under load than other soil types.
- A small volume of water can have a significant effect on clay.
- Clay absorbs and sheds water slowly.

CAUSES OF MOVEMENT

Settlement due to construction
There are two types of settlement that occur as a result of construction:
- Immediate settlement takes place 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 largely take place during the first few months after construction, but has bee known to take many years in exceptional cases.

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

Saturation
This is particularly a problem in clay soils. Saturation creates bog-like suspension of the soil that causes it to lose virtually of its bearing capacity. To a lesser degree, sand is affected l saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blindir layers – however this usually occurs as immediate settlemer

Seasonal swelling & shrinkage of soil
As can be seen in the table above, all clays react to the presence of water by slowly absorbing it, making the soil increase in volume. The degree of increase varies considera in various clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Becau of the low absorption and expulsion rate, this phenomenon \ not usually be significant unless there are prolonged rainy o periods, usually of weeks or months, depending on the land soil characteristics.

The swelling of soil creates an upward force on the footings the building and shrinkage creates subsidence that takes aw 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. This can occur through saturation of clay, failure of a damp reactive clay when attempting to raise a footing that is being acted on by a superior downward force, or any soil that lose: compaction.

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.

In addition, roots that are left in the ground after the tree is felled can be eaten by termites and/or destroyed by decay. leaves a void which can turn into a watercourse and/or caus subsidence under or adjacent to the footings.

SITE INVESTIGATION

Factors
The factors that need to be investigated are:
- Soil classification.
- Soil condition.
- Watertable.
- Ground slope.
- Trees, shrubs and organic material.
- Service trenches.
- Water run-off.

Soil classification test
AS 2870 requires that the soil to be used as foundation for construction be classified. The requirement is that the soil t classified not by its geotechnic type, but by its reactivity. Reactivity can be defined as the change in volume brought about in the soil by the introduction or removal of water – in other words, the swell and shrinkage. Soil classes A, S, M, I and E cover the range of reactivity, and P is used where soil has abnormalities that do not allow normal classification. In some long-established areas, information on soil class may obtained from buildings adjacent to the site, where the buildings are footed on lightly stiffened strip footings or slat on-ground. AS 2870 Tables 2.2, C1 and C2 are a guide to determining soil class by measuring differential movement c masonry cracking.

This easy classification method should, however, be regarded as the exception rather than the rule, because the majority of new buildings are constructed in areas where adjacent buildings, if they exist, are not sufficiently well established to enable sound data to be taken. In years gone by, local councils assumed some responsibility for providing soil classification to applicants for developments, but local authorities are increasingly divesting themselves of this type of service and, in any case, council area classifications do not necessarily apply to specific sites. Therefore, the job falls back on the engineer and the builder to ascertain the soil class which will determine the footing and masonry design.

It is desirable to inspect the site before clearing and/or excavation, because although the ground may be covered with topsoil, organic material or vegetation, there may be valuable evidence that will not be apparent after excavation. Usually, test pits or boreholes can, without difficulty, be dug to reach the depth required by Clause 2.3.3 and Table 2.4 of AS 2870, reproduced below.

> ***2.3.3 Depth of investigation*** *The soil profile shall be examined to a minimum depth equal to 0.75 times the depth of the suction change, H_s, as given in Table 2.4, but not less than 1.5 m, unless rock is encountered or in the opinion of the classifier, further drilling is unnecessary for the purpose of identifying the soil profile in accordance with Clause 2.2.1(a).*

TABLE 2.4
RECOMMENDED SOIL SUCTION CHANGE PROFILES FOR CERTAIN LOCATIONS

Location	Change in suction at the soil surface (Δu) pF	Depth of design suction change (H_s) m
Adelaide	1.2	4.0
Albury/Wodonga	1.2	3.0
Brisbane/Ipswich	1.2	1.5–2.3 (see Note)
Hobart	1.5	2.0
Hunter Valley	1.5	2.0
Launceston	1.2	2.0
Melbourne	1.2	1.5–2.3 (see Note)
Newcastle/Gosford	1.5	1.5
Perth	1.2	3.0
Sydney	1.5	1.5
Toowoomba	1.2	1.8–2.3 (see Note)

NOTE: The variation in H_s depends largely on climatic variation.

This investigation is necessary if correct soil classification has not been ascertained by other means. For a Class 1 building, a single test hole is usually sufficient for soil classification. However, if at a predominantly clay site, the clay extends to the bottom of the borehole, or if abnormalities are apparent, further investigation will be required. This may need to be carried out or followed up by a suitably qualified engineer and, in the case of clay soil, some laboratory analysis may be needed. In any case, while soil class may be ascertained by one borehole, a better picture of class and condition will emerge if investigation extends to the footprint extremities, particularly on sloping sites. For most purposes, a manually dug test pit is more useful than a borehole, but if boreholes are to be used, 400 mm diameter gives good vision.

The site investigation will also incorporate examination of the surface for cracking, gilgais, grades, identification of tree species and their locations relative to the proposed building, signs of ponding, saturation or erosion, condition of the road, kerbs, gulleys, surrounding land as to water run-off, and filled trenches carrying services such as stormwater, sewer, telephone, gas, electricity.

There is a trend, particularly in the case of standard designs like project homes, for engineers to assume a soil class when designing a structure, then visit the site when the footings excavation is under way in order to verify their assumption or, if the soil turns out to be less stable, order more and/or deeper piers. This practice has shortcomings:

- The engineer tends to rely on the excavation contractor to report on issues instead of carrying out his/her own tests.
- It is usually not possible to ascertain the difference betw S, M and H class soils by a site inspection undertaken s after excavation has been carried out, particularly where imported fill is used.
- In the event of a change being deemed necessary, the ensuing instructions become ad hoc corrective measures rather than holistic design considerations which would b worked through if the design were undertaken with the s characteristics in mind.
- The instructions inevitably mean that the consumer pays variation due to 'latent conditions' that were within the builder's power to discover.
- Site drainage characteristics and requirements are never addressed.

This is not to say that the engineer should not visit the site view the footings excavations, but rather to point out that t not the time to be designing the structure.

Soil condition

When assessing the condition of soil for use as foundation material, the primary concerns are moisture content, depth watertable, evidence of surface and ground water flows or moisture migration, and voids which may cause subsidence and/or act as ducts for water flows.

Ignoring any topsoil, which will be skimmed off before construction, the walls of the test pit will give an indication the moisture content of the soil:

- Dry sand will tend not to hold its shape when squeezed.
- Moist or wet sand will tend to hold its shape when squee
- Dry clay, even soft clay, tends to be firm.
- Moist clay tends to be plastic.
- Saturated clay tends to be boggy.

The next sign to look for is seepage, which will usually but always emanate from the uphill side of the hole. The depth compaction, amount of flow and type of soil should be note should be realised that seepage or any other form of moist migration may not show itself immediately and, where testi for moisture migration, it may be necessary to seal the top the pit and leave it for several days or longer.

Watertable

A hole that is 1.5 m or more deep is likely to show the watertable, especially in deforested or built-up areas. The watertable becomes important where it is high and can aff the ability of the soil surface to dry out and, in the case of to achieve a reasonably even moisture content throughout footprint.

Ground slope

The fall of the land is important for two reasons:

- In order to achieve even settlement and maintain equilibri across the structure, it is essential to found it on similar throughout. With a sloping site this can become difficult because strata may not be consistently deep around the footprint: they may not, in fact, even be continuous as th slope continues down. It is not unusual for a slope to cu through strata and in this event it is essential for the designer to know beforehand because it may affect the v approach to footings.
- Either because of discontinuous strata or because of the necessity to cut at the uphill elevation, water flows often reach the surface adjacent to the footings or in the subflo

For both the above reasons it is advisable to dig holes at t upper and lower extremities, first to check for a satisfactor common soil, then to look for seepage. To check for water surfacing within the footprint, it is only necessary to inspec walk on the soil. Another sign may be profusion of vegetati a different type of vegetation.

Trees, shrubs & organic material

It is important to mark on a site plan the location of any tr large shrub or stump within or adjacent to the footprint. It i unusual for arborists to grub out stumps after felling but le major roots. The same result can occur when trees are rem by a machine. It is essential to ensure that the stump and significant roots are removed and the soil is compacted in void. The excavator should be instructed to remove any organic material while cutting or skimming. In addition, particularly where a sandy foundation exists, it is good practice to probe the subsoil in the immediate area around where a stump has been removed. A good tool to use is a 1 m length of 6–10 mm round reinforcement bar. Driven with a hammer, this will discover not only tree roots, but floaters and voids or poorly compacted areas. In some cases, poorly compacted areas are composed of leaves and other decayed vegetable matter. This material must not be left under or adjacent to the location of any footings as it will reduce in volume and cause a void.

Service trenches

It is not unusual to find that trenches that are dug to house services are not well backfilled or compacted. Often the trench is used as a repository for trade spoil. Where a subsoil water flow picks up such a trench, a watercourse is provided where water may be delivered alongside or even under footings. Typically, sewer and stormwater pipes run adjacent to and/or under footings. Where building additions are being constructed it is important to check around existing service trenches that may carry water to the proposed construction. Of course, it is also imperative to ensure that trenches dug for the new project are properly located, backfilled and compacted, but this topic is dealt with in BTF 20. During the site investigation, other than any pre-existing domestic service trenches, the following are some of the possible problems:

- Trenches under the footpath or roadway for telephone cables, gas, electricity, stormwater or sewer all have risers to the surface. Often, water can gain access to the trench from around the riser or manhole, then flow along or pond in the trench until finding a way to flow out, through the proposed domestic feed, or just by permeating the soil in the area.
- Street stormwater gullies can also be vulnerable, particularly older ones with brickwork in their structure.
- The possibility of leaking water, stormwater or sewer piping should not be ignored.

Where the new structure is downhill from these water sources, moisture can surface under the building or at the external footing where the soil has been cut. Builders sometimes believe that running agricultural pipe around the external side of the footing excavation solves the problem. This is not always the case, because some systems in common use may collect only a moderate percentage of the water, particularly when not expertly installed. In fact, this practice often delivers water directly to the footing area.

Water run-off

Surface water must not be allowed to flow to the building. A thorough inspection of the topography is necessary in order to properly allow for finished ground falls and water run-off collection. Particularly on a sloping site, the finished falls can be critical to the maintenance of good drainage.

REMEDIAL MEASURES

Other than the exception of water flow through rock faults, which is very difficult to stop, almost all of the problems above can be addressed by correct drainage of the soil or, in the case of poor existing trenches, removal of poor ballast material then refilling and compacting.

Correct drainage is an engineering matter and, unless very straightforward, should be the province of a suitably qualified person, however in essence the job is to prevent water from coming into contact with the building or entering the soil within the footprint and its environs.

The object of good ground drainage should be to exclude all possible water from the building, the foundation and its area of influence. There is a notion that reactive clays should be kept at a constant moisture content in order to provide equilibrium. Irrigation systems have been developed to try to provide constant moisture content to subfloor areas, but these can fail because there are other factors involved, i.e.:

- A building creates its own environment and predominant weather conditions will either create moisture flow toward the centre of the subfloor or away from it. This influence is never evenly distributed but varies with several factors.
- Solar influence dries some areas more rapidly than others.
- Ground slope or other factors can result in uneven water content at various parts of the perimeter.

These and other naturally occurring factors mean that the irrigation system would have to be very sophisticated indeed in order to keep all the foundation soil and immediately adjacent soil at the same stage of volumetric expansion.

In practice, the best solution in all but extreme cases is to drain the ground and surface water away from the building and keep the foundations dry. In reactive clay this is likely to result in cracking due to some shrinkage, and this needs to be redressed, but once this has been remedied and providing the drainage system is kept in working order, the building will remain stable.

This document has covered the bulk of the issues that a builder should deal with in regard to discovery of pre-existing conditions that can affect the stability of the foundation soil. There are also several construction do's and don'ts that the builder must know about and put into practice in order to make sure that the building itself does not contribute to instability of the soil and resultant movement in the structure. These matters are dealt with in BTF 22.

FURTHER READING

AS 1684, *Residential Timber-Framed Construction*, Standards Australia, Sydney, 1999.

AS 2870, *Residential Slabs and Footings – Construction*, Standards Australia, Sydney, Amdt 2, 2003.

AS 3798, *Guidelines on Earthworks for Commercial and Residential Developments*, Standards Australia, Sydney, 1996.

BTF 22, *A Builder's Guide to Preventing Damage to Dwellings: Part 2 – Sound Construction Methods*, CSIRO, Highett, Victoria, 2003.

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BUILDING TECHNOLOGY *file*

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A builder's guide to preventing damage to dwellings

Part 2 – Sound construction methods

THE PROBLEMS

Site water problem identification
It is essential to investigate the site and prepare it in such a way that ground and surface water are prevented from entering the building footprint, whether the building has suspended floors or is footed on a ground slab. Site investigation methods are dealt with in BTF 19, which should be read prior to reading this BTF. It is also recommended that BTF 18 be read as additional information on this subject.

Legal considerations
Good site drainage always addresses both surface and ground water flows. Lack of attention to potential building movement caused by moisture migration can be a costly oversight for the builder, who may be found liable for damage long after any statutory warranty has expired. The Building Code of Australia (BCA) has not made site drainage mandatory, although it does set out acceptable construction practice in Volume 2, Clause 3.1.2, to be used where a local drainage authority deems it necessary. This makes for uncertainty in the minds of builders as to their responsibilities, but the courts tend to view the builder as the expert and, where some foreseeable damage occurs, it is usually found that the builder should have used methods that would have prevented the damage.

Where site investigation has revealed that there is existing or potential erosion problem, or where reactive clay subsoil is present, the builder is wise to give written advice to the owner and strongly recommend that ground drainage be installed. Where the owner declines in writing, some jurisdictions are known to have accepted that it is within the contractor's rights to continue the project. However, ground drainage is an area where contractors ignore or try to side-step at their own peril.

As to water entering a building, the BCA is quite clear. It is the task of the builder to prevent rainwater from entering a building, even when the rainwater is propelled by a storm of a magnitude that would only be expected to occur, on average, once in a hundred years. What is not so obvious to many is that water should not be allowed to enter the cavity, which is there not as a drain or repository for water that enters through openings, but as a break between the outer and inner leaves of exterior walls to prevent water from permeating through as it used to do when buildings were constructed of 230 mm solid brick-work. When water enters the cavity in volume, a wet, dark and enclosed environment is set up that can result in serious consequences for the health and amenity of the occupants.

Water problems in buildings are usually cumulative, resulting from several oversights rather than from a single source. This BTF is designed as a general checklist of commonly occurring flaws in construction methods, to help the builder deliver a product that will be durable, weatherproof and provide a healthy environment.

SURFACE AND GROUND WATER PREVENTION

It is no longer acceptable for a builder to claim that building movement is outside his or her power to prevent. The subsoil of land that is available for building development normally has a allowable bearing capacity well in excess of the loads impose by class 1a buildings. The movement problems that are experienced by buildings are very often brought about by the failure of the builder and designers to deal with site water.

Surface and ground water that is allowed within the footprint o the building causes erosion and foundation soil movement, whic in turn causes an exacerbation of cracking in slabs; cracking and failure in masonry and finishes; doming and dishing of floors; cupping and lifting of timber flooring; decay to timber members; degradation of metals and mortar; doming and dishing of roofs, leading to breakage of tiles and degradation of mortar beds.

Surface drainage methods
The basis of good surface water drainage is to:

- Have the finished exterior ground level at the building perimete a minimum of 150 mm below finished floor level, ground floor cavity flashing weepholes or subfloor vents, whichever are the lowest. However, where a slab is used as part of a termite management system, 75 mm at the top of the slab edge must be visible or able to be made visible.
- In the finished ground, provide a 1:20 fall away from the building for at least the first metre. Nothing that needs to b watered, including lawn, should be within this graded area and it should preferably be a hard surface.

The above requirements mean that thought may need to be given to finished floor level etc. before the plans go to council.

Where there is natural topography that leads to surface wate being encouraged toward the building, a dish or other surface drain should be installed and connected to the stormwater system through a pit.

Ground water drainage methods
If it is desired to keep the soil dry in areas other than the building footprint, it should be realised that this other drainage may not be sufficient to prevent water entering the footprint, and additional drainage for the building may be necessary. It should be understood that ground drainage is a complex subject often requiring the expertise of an engineer who is suitably com petent in hydrology and geotechnics. For anything other than straightforward problems, even drainers or builders experienced in installing ground drainage should engage a consultant to assist in the design. This section is therefore intended to give reminders to already competent people, and to assist others toward a rudimentary understanding to help them discuss the issues with a consultant. In addition, it is essential for a builder or drainer to comply with the minimum requirements o BCA Volume 2, Clause 3.1.2, and AS 3500.3.2, Sections 6–8, unless installing a system certified by an engineer.

The first step is to investigate the depth and volume of the subsoil flow of water. Test pits, particularly on the uphill perimeter of the footprint should be dug as outlined in BTF 19. It is, how ever, important to remember that ground drainage problems are not restricted to sloping sites. Some of the most susceptible sites are on flat land, particularly where the area is ringed by higher ground. In addition, as explained in BTF 18, where warm, wet summers and colder, dry winters are experienced, the building itself will tend to cause inward water migration.

In any case, the minimum depth of drainage should comply with BCA Volume 2, Clause 3.1.2.4, that the top of the drain be a minimum of 400 mm below ground and 100 mm below the adjacent footing. This means that the trench should be dug at a safe distance from the footing to ensure that the foundation is not affected. If this is not practicable, temporary measures to support the trench walls may be needed and/or the strength of the pipe material may need to be increased. It is important to remember that in clay the allowable angle between the external bottom corner of the footing and the nearest part of the bottom of the trench is usually 45°, whereas the normally applicable angle for compact granular soil is 30°. These may be exceeded where the trench fill is well compacted and the piping is non-compressible, but supervision by a competent engineer is normally necessary for soil classification and strength issues. A good working arrangement is to locate the trench toward the edge of the area that is graded away from the building to allow run-off of surface water.

Having discovered the required depth, the next step is to establish whether it is above the depth of the local authority's stormwater system, to determine the method of dispersal of the captured water. It must be borne in mind that the BCA's minimum fall for ground drainage is 1:300, and a silt arrestor requires a minimum drop of 50 mm from the invert of the inlet to the inner roof of the outlet. If the depth of the ground drainage is too low for the council system, councils may allow a soakage pit for any naturally occurring ground water, so that the drainage can divert the water from the uphill side of the building to the downhill side. The builder should confirm this with the council.

Next, the type of drainage should be determined. For general purposes, a geocomposite system using 90 mm slotted stormwater pipe with fabric sock and geofabric perimeter material is adequate, however suppliers can advise on other systems. It is desirable in any ground drainage system and essential where the fall is shallower than 1:100 to install inspection openings to enable the system to be flushed out. These should be at changes of direction greater than 45° and at the connection to the stormwater system. Where practicable, pits make the ideal inspection opening, particularly when configured as silt arrestors.

Drainage to rock substrates
BTF 19 discusses the special drainage problems with rock foundations. While a solid rock foundation remains stable regardless of water flows, water damage to building elements and high subfloor relative humidity can have potentially serious consequences. When the ground floor is to be suspended, and particularly when using timber framing and/or flooring, drains should be cut around the perimeter where water can otherwise enter the subfloor. Totally preventing water entering the subfloor area can be impracticable because of faults and interstrata gaps. Where water flows on rock foundations cannot be prevented, the design should allow for an open subfloor and an increased minimum clearance between the floor and the ground, commensurate with the volume of water experienced. If a completely open subfloor is impracticable, openings should be as large as possible, particularly where subfloor walls would otherwise dam water. Watercourses should be cut out to divert water if this is beneficial to the aim of removing water as soon as possible. A mechanical ventilation system may need to be installed as an augmentation to the measures discussed above, but when relied upon without sufficient other precautions, such a system may be inadequate.

Subfloor ponding
When constructing dwellings with suspended floors, it is essential to grade the subfloor area so that no depressions remain that can allow water to pond. With rock foundations it may be necessary to use concrete to fill depressions.

Dampproof courses
Ground moisture usually carries salts and other chemicals. When moisture migrates through masonry by capillary action, some chemicals may be transported. It is often these chemicals that attack the building elements. Different dampproof course (DPC) materials are susceptible to different chemicals.

It is not always possible to predict the nature of pollutants to which the underside of a DPC will be exposed. This is one of the reasons that moisture should be kept away from the building. DPCs that have poor plasticity or develop poor plasticity through exposure to water and chemicals, are unsuited for use where building movement cannot be totally prevented, because they tend to break. When a DPC is discontinuous it allows water to penetrate the gap. This is one common way that rising damp occurs in buildings constructed in the modern era.

The safest suggestion for overcoming the problem of lack of durability in DPCs for applications where high moisture content is expected, is to double up, perhaps using two different types one on top of the other.

Antcapping
Antcapping should never be used as a DPC unless is has been tested and designed for this purpose. Galvanising will break down over time when in constant contact with moisture, particularly when salts are present. It is essential to isolate the antcapping from any water in the masonry by using a DPC between. The galvanising should also be checked for quality and any cuts or damage should be coated with cold galvanising, because even when the antcapping is isolated from direct contact with water, constant high humidity in the air will tend to attack the steel. Once corrosion has eaten through the metal, termites are given a path of entry to the building. This is not a rare condition.

RAINWATER PREVENTION

In addition to surface and ground water considerations, there are several issues of construction that builders must address in order to prevent rainwater from entering the building.

Rainwater is not only a problem when it enters the living area as water, but also when it is allowed into the cavities and voids and onto building members that can degrade or decay. In addition, rainwater has a more insidious danger in that it gives life to fungus and promotes pests like dust mites – these conditions are conducive to illness in people who are abnormally susceptible to breathing disorders.

Builders and tradespeople often attempt to make a building weatherproof by the use of sealants. It should be realised that sealants cannot be regarded as a durable solution to most weatherproofing problems. Durability can only be attained by sound construction method.

Ridge capping
Mortar bedding to ridge capping is permeable, even with flexible pointing applied over it. Water can migrate through the bedding and pond on the tile above the bedding. Any condensation tends to perpetuate the moisture and, in addition, where summers are warm and wet and winters are cold and dry the tendency is for moisture to be drawn in. The above factors tend to create an overflow of water that may drip into the roof space or run down the soffit of the tiling, decaying battening or framing and/or eventually damaging fastenings. This flow adds to flows caused by the natural absorption of water through tiles and any wind-driven rain that penetrates the gaps between tiles. These are the flows that lead to inundation of the roof. Weepholes should be created in the beds at the depressions in tiles to allow water to flow to the top surface of the tiles.

Where footing movement occurs, usually due to the action of water on the foundation soil, the roof moves. Cut and pitched roofs will dome and dish in the same way that floors do, because of the uneven rise and fall of reactive clay soils. This movement causes a stress on rigid members of the roof structure such as mortar beds to hips, ridges and verges, which hog and sag tending to crack the mortar and/or the tiles. When 1:2 cement sand mortar pointing is used, this will retard the cracking, but it will eventually crack and when it does, the water entry will increase accordingly. On truss roofs the effect is less but still sufficient to cause cracking. If there is no footing movement, the pointing tends to last many years. Where some movement is expected, it is recommended that flexible pointing be used.

Sarking
In general, roof tiles are of marginal suitability for installing on a roof slope of less than 18° and should never be used where the pitch is lower than 15° For other roof slopes below 25°, the manufacturer's recommendations should be checked before

installing a particular profile. Where flat profile tiles are to be used on a roof that has a pitch below 25° or where any tiles are to be used on a roof below 20°, sarking should be installed to prevent water entering the roof void. Where the common rafter length is greater than 4500 mm and sarking is not fitted to the whole slope, the table shown below (source: AS 2050, Table 5) should be consulted and sarking may have to be fitted to the lower end of the slope.

SARKING REQUIREMENTS IN RELATION TO PITCH/RAFTER LENGTH

Roof (degrees of pitch)	Maximum rafter length without sarking (mm)
≥18<20	4500
≥20<22	5500
≥22	6000

In addition, on any slope with a pitch of 20° or less, an anti-ponding board should be installed between the bottom batten and the oversail to ensure that the sarking does not sag sufficiently to create ponding, or allow rainwater into the eaves or structural elements.

Guttering too high

The front bead of eaves guttering is usually higher than the highest point of the rear vertical face that sits against the fascia board. A common mistake where there is a long run to the downpipe, is to install the guttering with the front bead level with or above the top of the fascia so as to allow for fall to the downpipe. The reasons why this is an error are:

- Where there is a roof overhang, this allows water to overflow onto the eaves lining. In the case of framed external leaf walls, the rainwater is fed into the frame.
- Where there is no overhang and extruded bricks are used for the external leaf, the overflowing water spills into the core holes and saturates the brickwork from within.
- Where water cannot feed entirely into the extruded brick-work or where pressed clay bricks are used, rainwater falls directly into the cavity if one is present.

This is one of the reasons that the BCA calls for downpipes at a maximum of 12 m intervals. Such intervals mean that 6 m should be the maximum distance away from a downpipe for any part of the guttering. The minimum fall for eaves gutters is 1:500, so gutters can be installed with a 12 mm fall from the highest point to the downpipe.

Section 3 of AS 3500.3.2 requires that the front bead of the guttering is lower than the top of the fascia, so as to allow overflow and prevent rainwater entering the building. A process contained in AS 3500.3.2, Appendices G and H, is used to determine how much lower the front bead of the guttering must be than the top of the fascia board. Appendix G also contains some examples of acceptable alternatives.

Roof flashings

All metal materials on a roof should be compatible. Lead flashings should not be used with Colorbond/Zincalume roofing. Galvanic action will degrade the zinc and cause corrosion that will lead to roof leakage. In the event that re-roofing introduces Colorbond/Zincalume to a roof that has existing lead flashings, the lead should be coated on both sides using a suitable paint. Other incompatibilities are listed in AS 3500.3.2, Tables 4.2 and 4.3.

Rainwater spreaders

Where water is collected by guttering to an upper roof and deposited onto a lower roof via a spreader, the lower slope is called upon to carry an additional volume of water – sometimes too great a volume. It must be realised that tile systems are designed to prevent water entry in accordance with the performance requirements of the BCA Volume 2, Clause 2.2.1 (b), which states: '*(b) Surface water, resulting from a storm having an average recurrence interval of 100 years must not enter the building.*'

When rainwater is gathered from a large catchment and concentrated by a spreader on another catchment, the volume of water on that catchment may well be above the capacity of the tiling to cope, particularly in a case where wind is tending to drive the rain up the slope. This type of overloading cannot be taken into account by tile designers or building designers. If it is intended to use a rainwater spreader on a tiled roof, the tile manufacturer should be consulted. Spreaders may also create a local guttering overflow.

Another even more serious problem is caused by the practice of locating a spreader on a flashing. This allows the combination of wind and the proximity of the flashing and the tile to push water up and over the top of the tile, then into the roof space. This practice should never occur. If a spreader is allowable on a roof slope, it should always be well below any flashing, but the best practice is to run the water from the upper roof to the ground by a downpipe.

Roof/wall interfaces

Where a roof meets a cavity wall and the wall then becomes internal, such as a garage abutting a two-storey dwelling, a tray flashing is necessary to carry water to an external wall cavity flashing. Where the roof slopes away from the wall this can be a horizontal combination of overflashing and cavity flashing. The most important consideration is the provision of a positive method of transferral from the tray flashing to the standard floor-level cavity flashing so that no water can escape.

Where the roof slopes along the wall the combination overflashing/cavity flashing is stepped. A requirement of this is that the 'uphill' end of the cavity flashing be turned up to ensure that water follows the steps down to the standard floor-level cavity flashing. Other information is available in BCA Volume 2, Clause 2.2.4.10.

Cavity flashings

Brickwork is permeable. A single leaf of brickwork will allow water to migrate from the exterior to the cavity. This is the main reason that a cavity is necessary. In fact, when significant wind-driven rain falls against single-leaf brickwork, water can be plainly seen running down the internal face.

More and more is being learned about the problems associated with water that is trapped in the cavity. This water can quickly accumulate, but because it is not exposed to sunlight, it can take a significant time to dissipate. Water in a cavity is not just harmful to building elements, but it also promotes fungal growth and creates an ideal environment for termites, other insects, spiders and mites, including dust mites, which are known to be harmful to people who are susceptible to respiratory ailments. In addition, the humidity that is created can transfer moisture into the inner leaf of walling that is measurable on the internal face. This is particularly true in southern exposure rooms and is undesirable, particularly in living or bedroom areas.

Because cavity flashings are bedded into the masonry during the building of the wall, mortar is dropped into the flashing as the wall rises. These droppings accumulate and harden. Because of their height inconsistency, water will inevitably be dammed in the cavity. Also, weepholes become partially or fully blocked by these mortar droppings, further reducing the possibility that water will escape.

Mortar droppings should be cleaned out of the flashing before they become difficult to remove, at least once a day during the bricklaying process. As the wall rises and cleaning by hand becomes impracticable, a hose can be used, provided that the mortar beds at the flashing level are sufficiently cured to resist deterioration by the water. Anything that bridges the cavity between the inner and outer leaves of walling and allows the transfer of water to the inner leaf must be removed.

Another common defect is that the flashing does not extend to the outer edge of the external leaf. The function of a cavity flashing is to gather water and direct it to the external face of the brickwork. It usually also acts as a DPC whose function is to prevent vertical moisture migration (either up or down). A DPC or flashing that does not extend to the outer edge of the brickwork will allow migration down by gravity or up by capillary action.

If the brickwork is to be cement rendered, the flashing should be continuous to the face of the render. A neat way to overcome this is to create a v-joint at the flashing, then cut the flashing off at the inner extremity of the v-joint. This method creates a control joint that will prevent unsightly cracking of the render.

Weepholes
AS 3700, Clause 12.7.2.3, requires that weepholes are formed immediately above the cavity flashing and that mortar is removed from the joint so that the opening is clean and the flashing is exposed. This is to ensure the free flow of water from the cavity. It is not uncommon to find blocked weepholes, recessed DPCs and fouled cavity flashings all on the same job.

Window and door openings
The popularity of unevenly faced bricks has led to a problem at openings. The problem arises where brickwork reveals do not present a straight line against windows, and is exacerbated by the fact that these bricks are generally not suited to flush mortar bedding. Consequently, it is common to see gaps at window/reveal interfaces caused by brick unevenness and raked joints. Such gaps mean that the building envelope is not weatherproof within the requirements of the BCA.

It should be realised that the cavity is not envisaged as a part of a water removal system, but is there to prevent moisture permeation from the outer skin to the inner skin. It may also act as a last line of defence in the event of an extraordinary event, however the idea that a builder should leave gaps in the building envelope through which water can penetrate into the cavity is in direct conflict with the objectives and requirements of the BCA. An external wall that routinely allows water to enter the cavity, turns that cavity into a hazard to the building elements, and to the health and amenity of the occupants. It is the job of the builder to make the envelope weatherproof. The construction system must prevent significant volumes of water entering the cavity.

In the case of window and door reveals, the bricklayer, while being mindful of the danger of ceramic growth, should not rake or iron the joint past the leading edge of the frame. In some cases where gaps must be left because long walls make ceramic growth a hazard, or where the brick profile is badly uneven, storm moulds should be installed, and bedding should be left flush with the leading edge of the storm mould.

It is also common to see cases where an overwide cavity creates insufficient overlap between the window and the brickwork reveal. Where this occurs, storm moulds are also called for.

Window gaskets
When fitted to brick veneer construction, windows need to be clear of the brickwork sill so as to allow for timber shrinkage in the frame. The usual allowance is 5–10 mm clearance to ground floor windows and a minimum of 15 mm on the second storey. For this purpose, aluminium window assemblies are fitted with neoprene gaskets to bridge the gap between the window frame and the brickwork sill. As with reveals, the brickwork sill should have joints left flush from the leading edge of the gasket to the rear edge of the sill. Commonly, little attention is paid to seating the gasket to provide a waterproof surface. Mortar is left on top of sill bricks which, when timber shrinkage reduces or closes the gap, pushes the gasket up and away from the brick and allows water to enter the cavity. Mortar should be cleaned off the top of bricks while laying. In addition, bricklayers commonly turn the ends of gaskets down into the perpends at the sill/ reveal joints. This is poor practice, as it leaves a gap above the gasket where water can gain entry to the cavity and which also encourages water into the mortar where the gasket turns down. These gaskets should be cleanly cut off flush with the reveal and the mortar should be flush with the sill brickwork. If the reveal bed aligns with the gasket there is no reason that the gasket cannot be bedded into it.

Sills and thresholds
Where brickwork sills are significantly sloped, it is common to find that the bricks are cut to have a minimal overlap with the gasket. These gaskets need a minimum 15 mm overlap with the sill bricks where the sill is at 30° to the horizontal. For lesser angles the necessary overlap increases.

Brickwork patio and other door thresholds are often laid without any fall away from the building. This will always result in water entering the cavity. Some bricklayers fill the cavity in at the doorway to prevent water incursion, but this does not work and only inhibits the operation of the flashing. The builder must provide the bricklayer with sufficient height to allow for weepholes to be continued across the doorway as necessary, and for either a soldier course sill with sufficient fall or room to lay a sloped tiling threshold.

Subfloor vents
In dwellings having suspended ground floors, particularly where timber floor framing is used, adequate cross-flow ventilation must be installed to counteract condensation. BCA Volume 2, Section 3.4.1, gives minimum ventilation standards that are deemed to satisfy the performance requirements. The required ventilation area is based on the perimeter length of the building and differs depending on:

- The zone in which the dwelling is located.
- The moisture content of the foundation soil.

It is also important to realise that where the floor is lower to the ground, there is less volume of air to dissipate the moisture that is transferred to it from the ground.

Landscaping
Two important aspects of landscaping that relate to water entry were introduced in the surface drainage section above, viz.:

- The finished exterior ground level at the building perimeter should be a minimum of 150 mm below finished floor level, ground floor cavity flashing weepholes or subfloor vents, whichever are the lowest. However, if paving is to be used around the building perimeter, the clearance may be 50 mm. Where a slab is used as part of a termite management system, 75 mm at the top of the slab edge must be visible or able to be made visible.
- The finished ground should have a 1:20 fall away from the building for at least the first metre. Nothing that needs to be watered, including lawn, should be within this graded area and it should preferably be a hard surface.

In addition, the landscaper should only install automatic watering systems where the beds that they service are lower than the base of the footings or where they are separated from the building by a properly engineered surface and ground water drainage system.

FURTHER READING/REFERENCED DOCUMENTS

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BTF 19, *A Builder's Guide to Preventing Damage to Dwellings: Part 1 – Site Investigation and Preparation*, CSIRO, Highett, Victoria, 2003.
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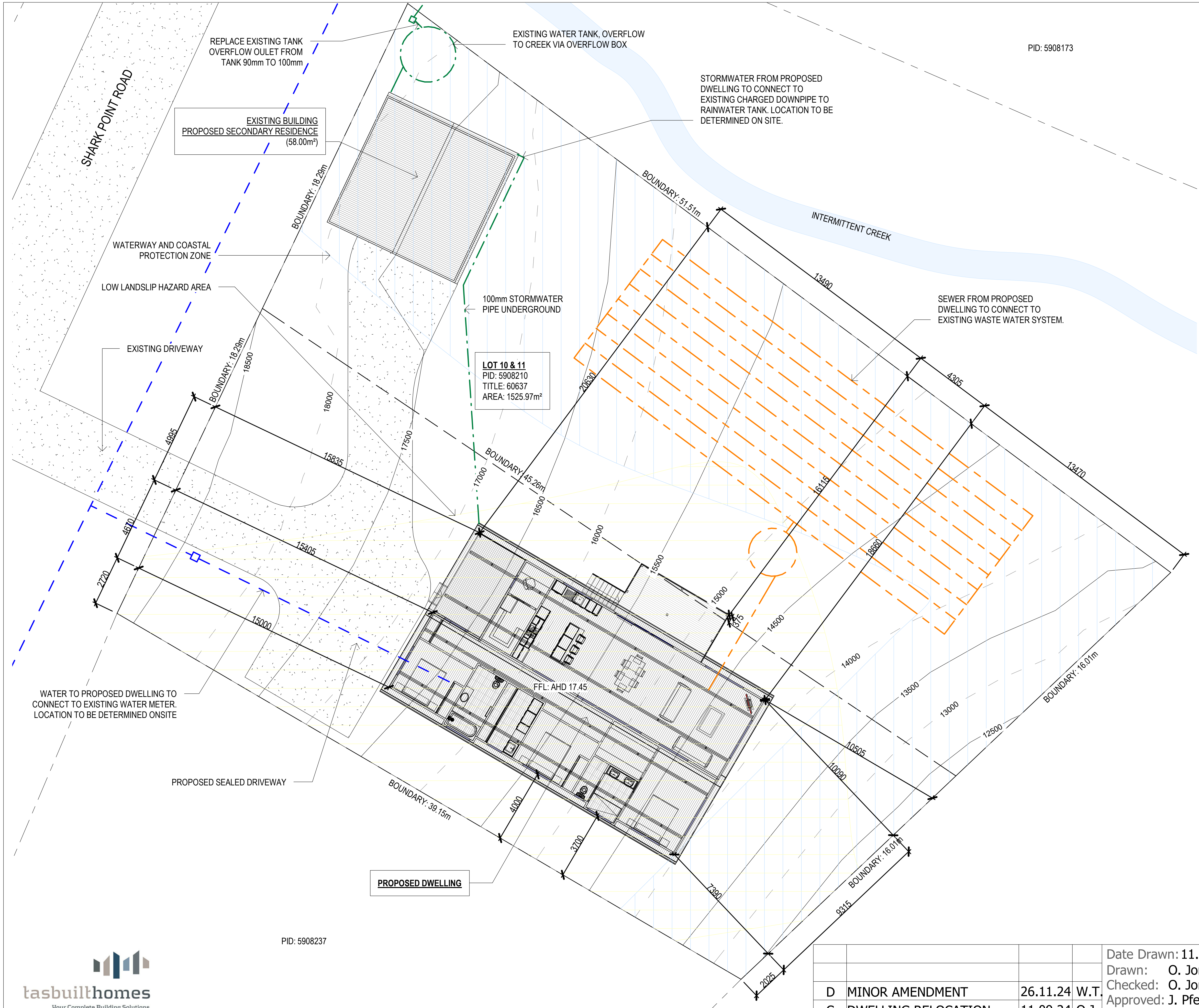

Sorell Council
Development Application: 5.2024.218.1 - Response to Request for Information - 513 Shark Point Road, Penna.pdf
Plans Reference: P2
Date received: 28/11/2024

LEGEND	
– – – –	SEWER
– – – –	WATER
—·—·—	STORMWATER

DRAINAGE
ALL DRAINAGE WORK SHOWN IS PROVISIONAL ONLY AND IS SUBJECT TO AMENDMENT TO COMPLY WITH THE REQUIREMENTS OF THE LOCAL AUTHORITIES. ALL WORK IS TO COMPLY WITH THE REQUIREMENTS OF NATIONAL PLUMBING AND DRAINAGE CODE AS3500 AND MUST BE CARRIED OUT BY A LICENCED TRADESMAN ONLY.

ISSUED FOR APPROVAL

Client: M. & D. ACKERLY
Project: PROPOSED DWELLING
Address: 513 SHARK POINT ROAD, PENNA

ENGINEERING PLUS
BUILDING DESIGN
PROJECT MANAGEMENT
CIVIL/STRUCTURAL ENGINEERING
Mob 0417 362 783 or 0417 545 813
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Date Drawn: 11.07.24
Drawn: O. Jones
Checked: O. Jones
Approved: J. Pfeiffer
Scale: As Shown @ A3

Accredited Building Designer
Designer Name: J.Pfeiffer
Accreditation No: CC2211T

Drawing No: 2112023 A01 / A07
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SITE PLAN
SCALE 1 : 200

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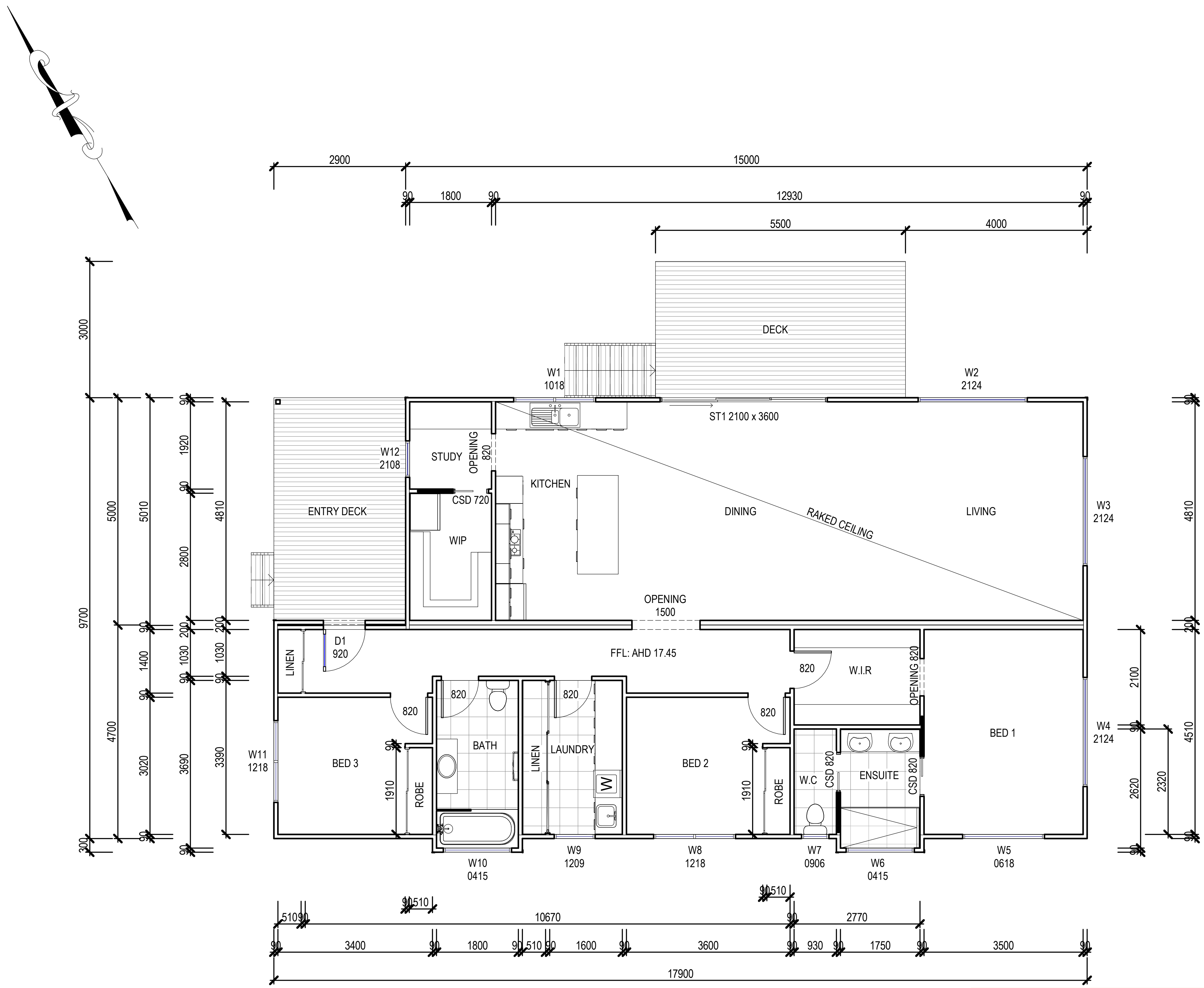

CONSTRUCTION PLAN
SCALE 1 : 100

ENGINEERING PLUS BUILDING DESIGN PROJECT MANAGEMENT CIVIL/STRUCTURAL ENGINEERING

WINDOW SCHEDULE

MARK	HEIGHT	WIDTH	TYPE	U-VALUE	SHGC
W1	1000	1800	DG	4.3	.55
^W2	2100	2400	DG	4.3	.55
^W3	2100	2400	DG	4.3	.55
^W4	2100	2400	DG	4.3	.55
W5	600	1800	DG	4.3	.55
W6	400	1500	DG	4.3	.55
W7	900	600	DG	4.3	.55
W8	1200	1800	DG	4.3	.55
W9	1200	900	DG	4.3	.55
W10	400	1500	DG	4.3	.55
W11	1200	1800	DG	4.3	.55
^W12	2100	800	DG	4.3	.55
*W13	350	1500	DG	4.3	.55
*W14	350	1800	DG	4.3	.55
*W15	350	4000	DG	4.3	.55
*W16	350	1800	DG	4.3	.55
SD1	2100	4200	DG	4.0	.61

*REFER ELEVATIONS FOR HIGHLIGHT WINDOWS

^ - IF HEIGHT TO GROUND IS GREATER THEN 2.0m WINDOW TO HAVE PERMANENTLY FIXED ROBUST SCREEN INSTALLED OR HAVE AN OPENING RESTRICTED TO 125mm

DISCLAIMER:
ALL WINDOWS SHOWN ON PLAN ARE APPROX. BASED OFF STANDARD MANUFACTURING SIZES. ALL WINDOW DIMENSIONS TO BE CONFIRMED ON SITE BY BUILDER PRIOR TO ORDERING AND MANUFACTURING.

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Area Schedule (Gross Building)

Name	Area	Area (sq)
PROPOSED DWELLING	160.27 m²	17.25
DECK	16.50 m²	1.78
ENTRY DECK	14.53 m²	1.56
EXISTING BUILDING	58.00 m²	6.24
	249.30 m²	26.84

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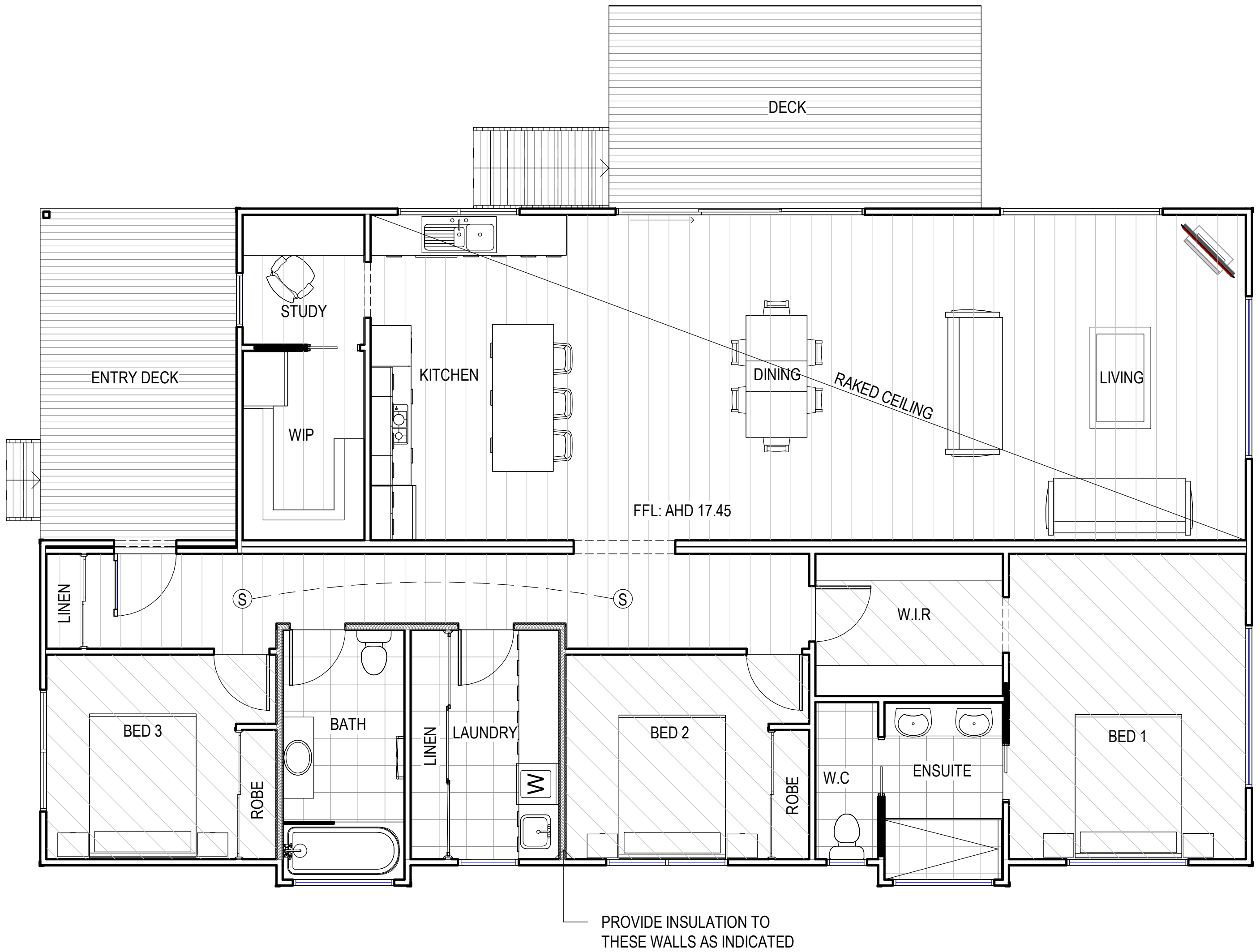

FLOOR PLAN
SCALE 1 : 100

FLOOR COVERINGS
CARPET
CONCRETE
TIMBER DECKING
TILE
VINYL TIMBER FLOORING

SMOKE ALARMS
PROVIDE AND INSTALL SMOKE ALARMS & HARD WIRE TO BUILDING POWER SUPPLY TO AS 3786.
CEILING MOUNTED WITH 9VDC ALKALINE BATTERY BACKUP
TO LOCATIONS INDICATED ON PLAN AND IN ACCORDANCE WITH NCC PART 3.7.5.2

(S) - DENOTES INTERCONNECTED SMOKE DETECTORS

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EAVE & SOFFIT CONSTRUCTION ABCB VOLUME 2 PART 7.4.5

EAVE WIDTH - 300MM

SOFFIT / EAVE LINED WITH 'HARDIFLEX' CEMENT SHEETING

- TRIMMERS LOCATED WITHIN 1200 MM OF EXTERNAL CORNERS TO BE SPACED @ 500 MM CENTERS, REMAINDER OF SHEET - 700 MM CENTERS
- FASTENER / FIXINGS WITHIN 1200 MM OF EXTERNAL CORNERS @ 200 MM CENTERS, REMAINDER OF SHEET - 300 MM CENTERS

ENGINEERING PLUS
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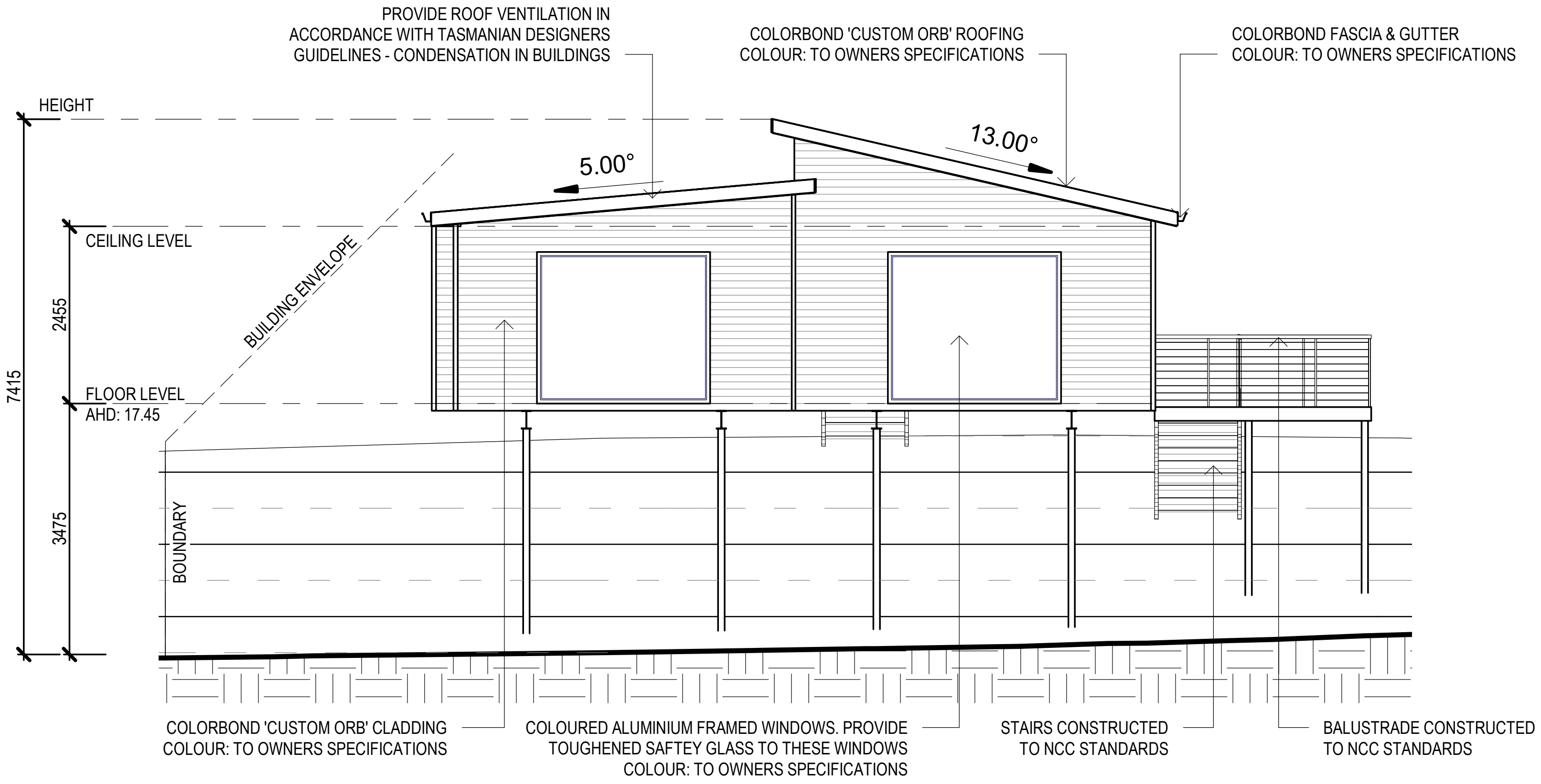
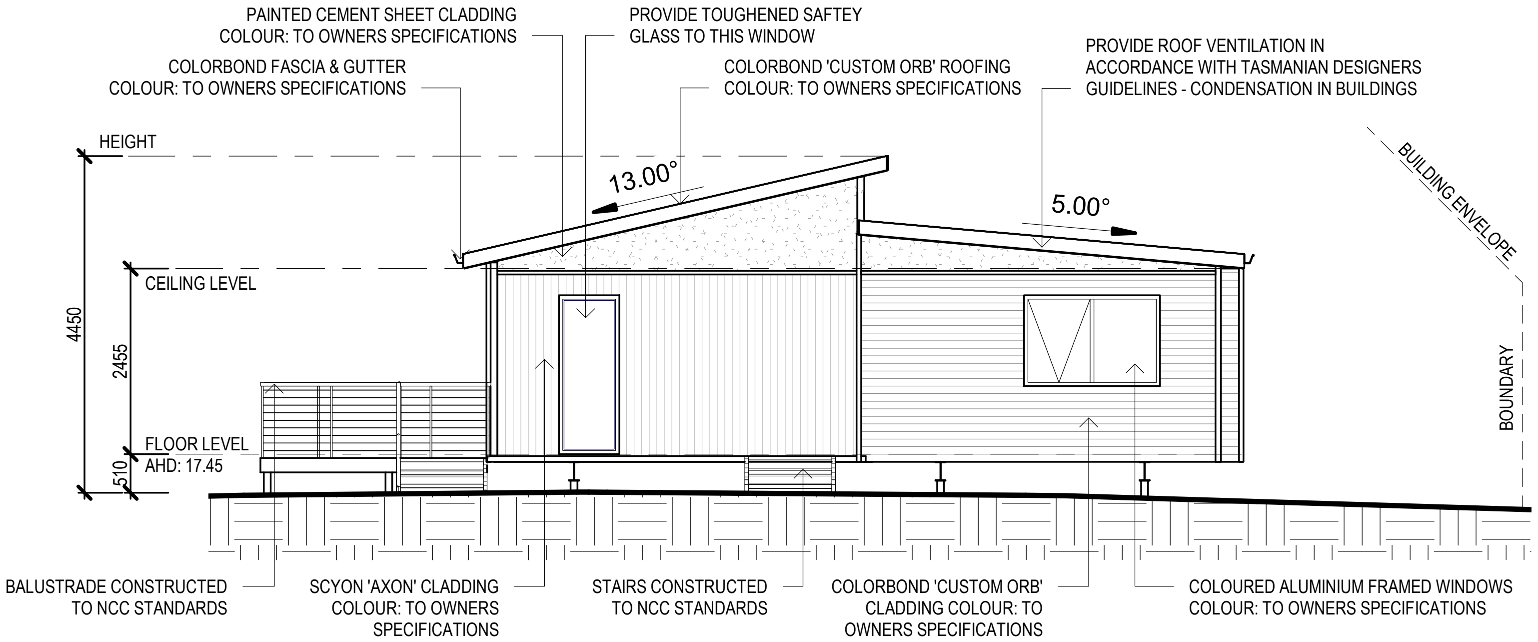


SOUTH EAST ELEVATION

SCALE 1 : 100



NORTH WEST ELEVATION

SCALE 1 : 100

STAIR CONSTRUCTION. ABCB VOLUME 2 PART 11.2

- TREADS: 240 MM
- RISERS: 180 MM
- TREATED PINE TIMBER STAIR MATERIAL TO AS1684
- TREATMENT LEVELS H4 FOR INGROUND USE & H3 FOR ABOVE GROUND USE.
- ALL FIXINGS FITTING BRACKETS AND CONNECTORS TO BE GALVANISED.
- STRINGER: 300X50 F5 TREATED PINE
- TREADS: 240X45 F5 TREATED PINE MAXIMUM TREAD SPAN 1000

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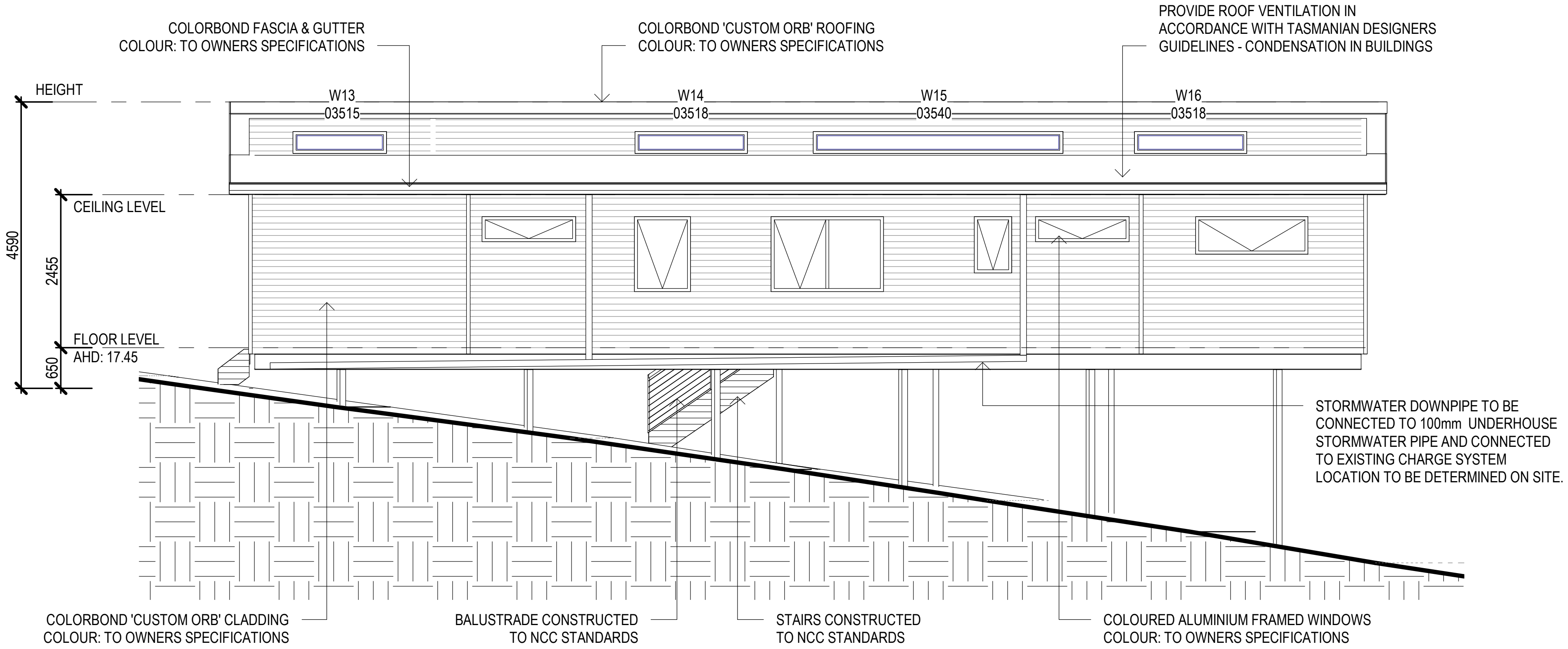
SUB FLOOR VENTILATION. NCC VOL 2 PART 6.2.1

- A MINIMUM OF 150 MM OF SUB FLOOR CLEARANCE IS TO BE PROVIDED BETWEEN FINISHED SURFACE LEVEL & THE UNDERSIDE OF THE FLOOR BEARER.
- A MINIMUM OF 6000 MM2 PER METRE OF SUB FLOOR VENTILATION IS TO BE UNIFORMLY DISTRIBUTED AROUND THE EXTERNAL AND INTERNAL WALLS OF THE BUILDING.
- VENTS TO BE LOCATED NO GREATER THAN 600 MM FROM AN INTERNAL OR EXTERNAL CORNER.

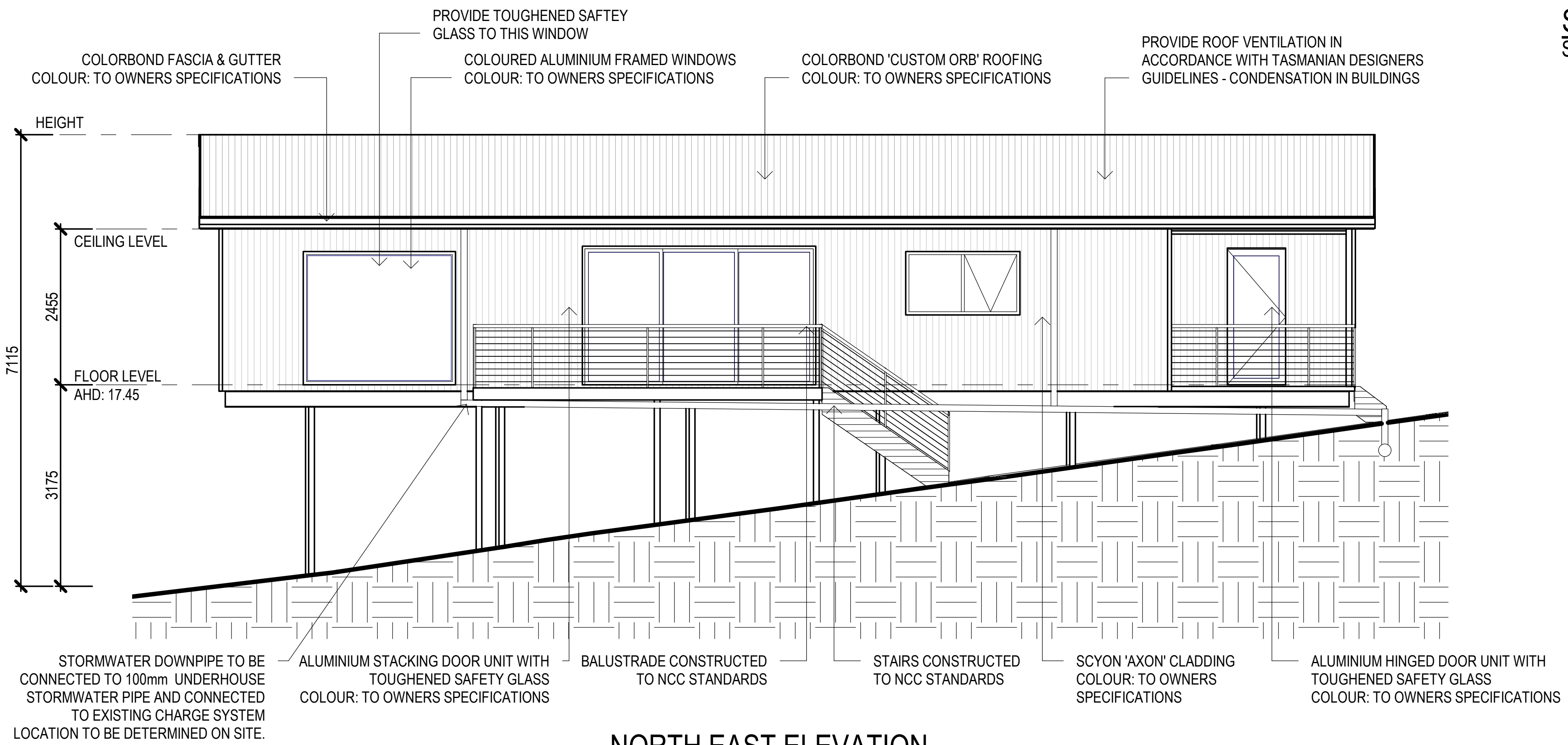
PRYDA 230X75 - 52 HOLE VENT MAXIMUM SPACING 1050 MM ALONG WALL OR
PRYDA 230X165 - 117 HOLE VENT MAXIMUM SPACING 2350 MM ALONG WALL

ADDITIONAL VENTILATION PROVISIONS TO BE INSTALLED WHERE OBSTRUCTIONS SUCH AS CONCRETE VERANDAH'S, DECKS, PATIOS AND PAVING ARE INSTALLED & OBSTRUCT VENTILATION.

ENGINEERING PLUS — BUILDING DESIGN, PROJECT MANAGEMENT, CIVIL/STRUCTURAL ENGINEERING



SOUTH WEST ELEVATION
SCALE 1 : 100



NORTH EAST ELEVATION
SCALE 1 : 100

SELECTED ALUMINIUM FRAMED WINDOWS - ABCB VOLUME 2 PART 8.3

POWDER COATED ALUMINIUM WINDOW & DOOR FRAMES, UNLESS OTHERWISE NOTED.

PRIMED PINE REVEALS AND TRIMS. ALL FLASHING AND FIXINGS TO MANUFACTURERS SPECIFICATIONS.

GLAZING & FRAME CONSTRUCTION TO AS 2047 & AS 1288

ALL FIXINGS AND FLASHINGS TO MANUFACTURERS REQUIREMENTS

ISSUED FOR APPROVAL

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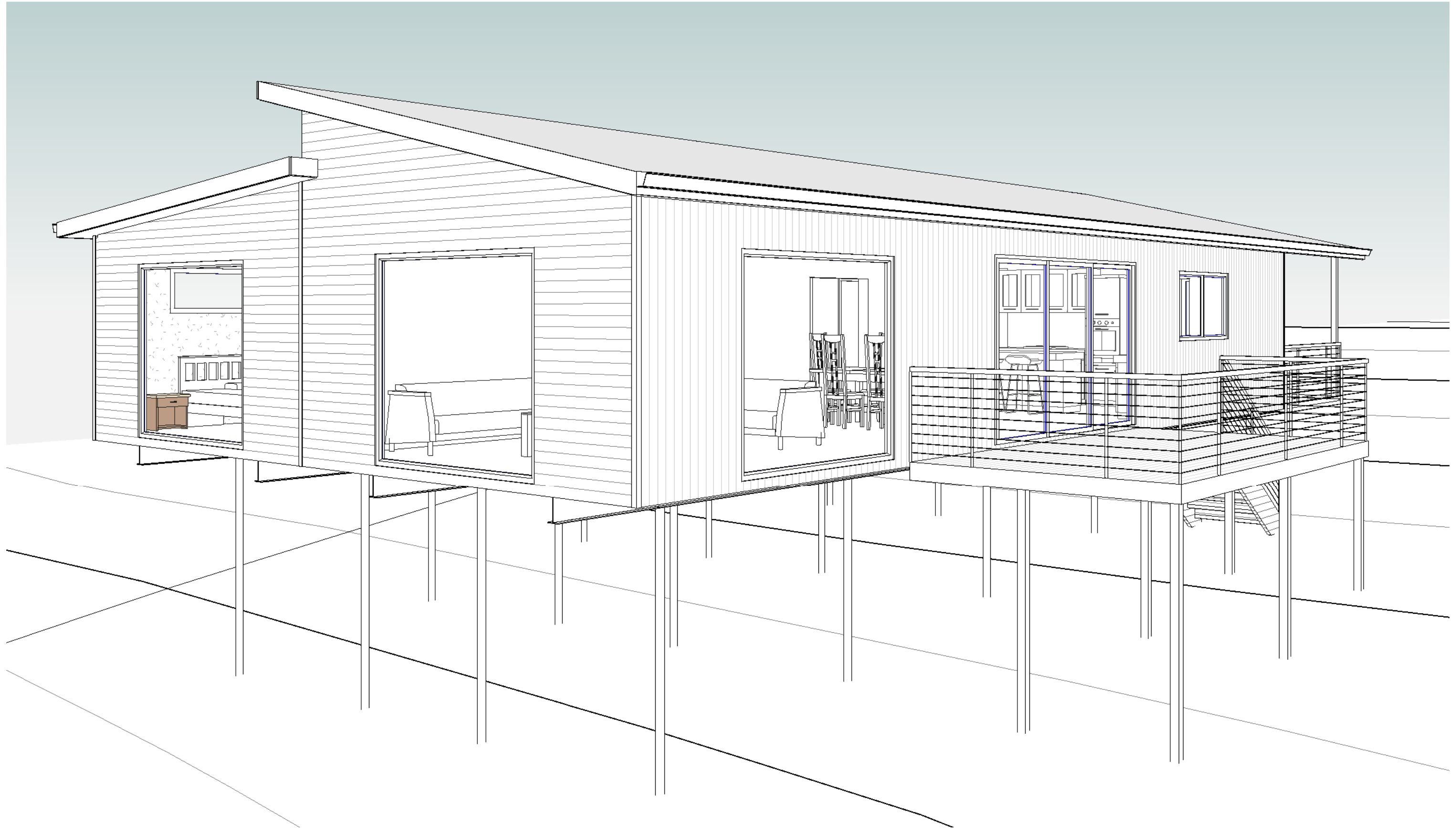

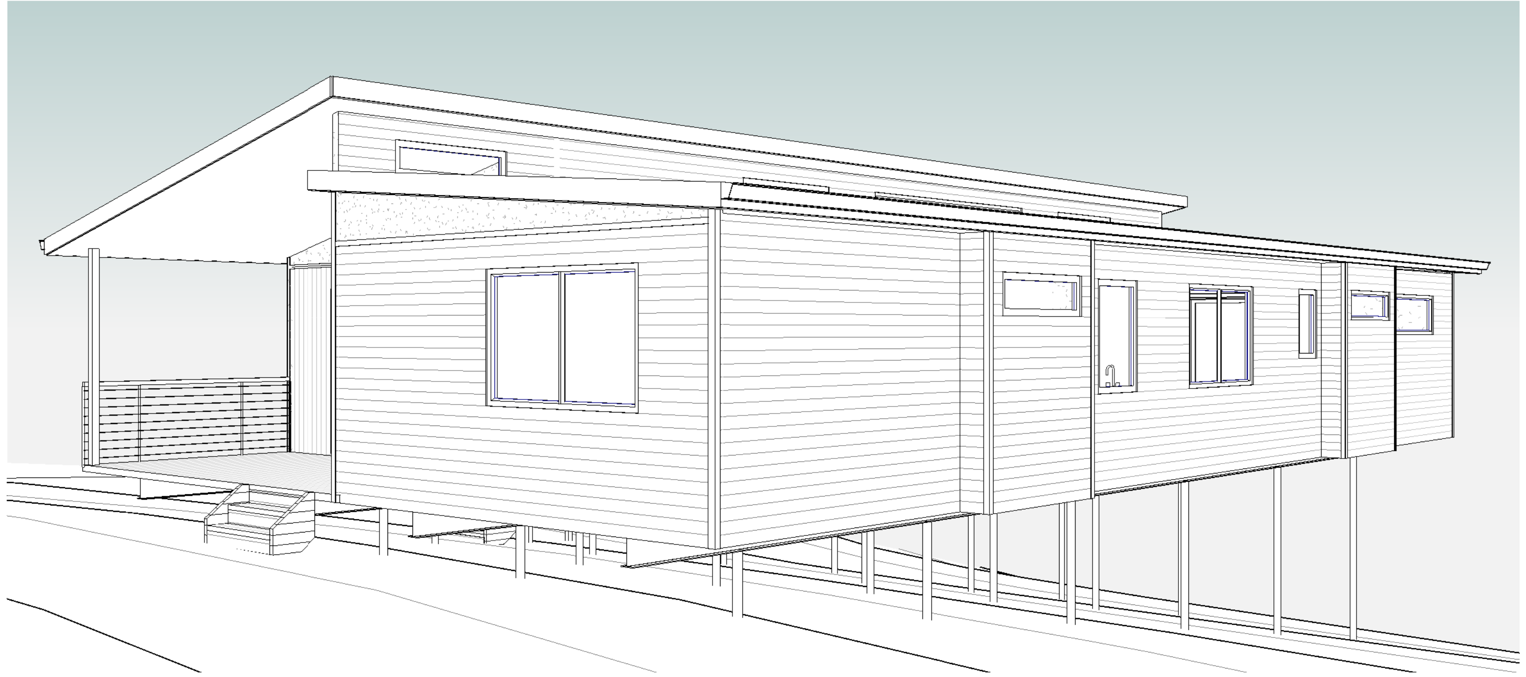

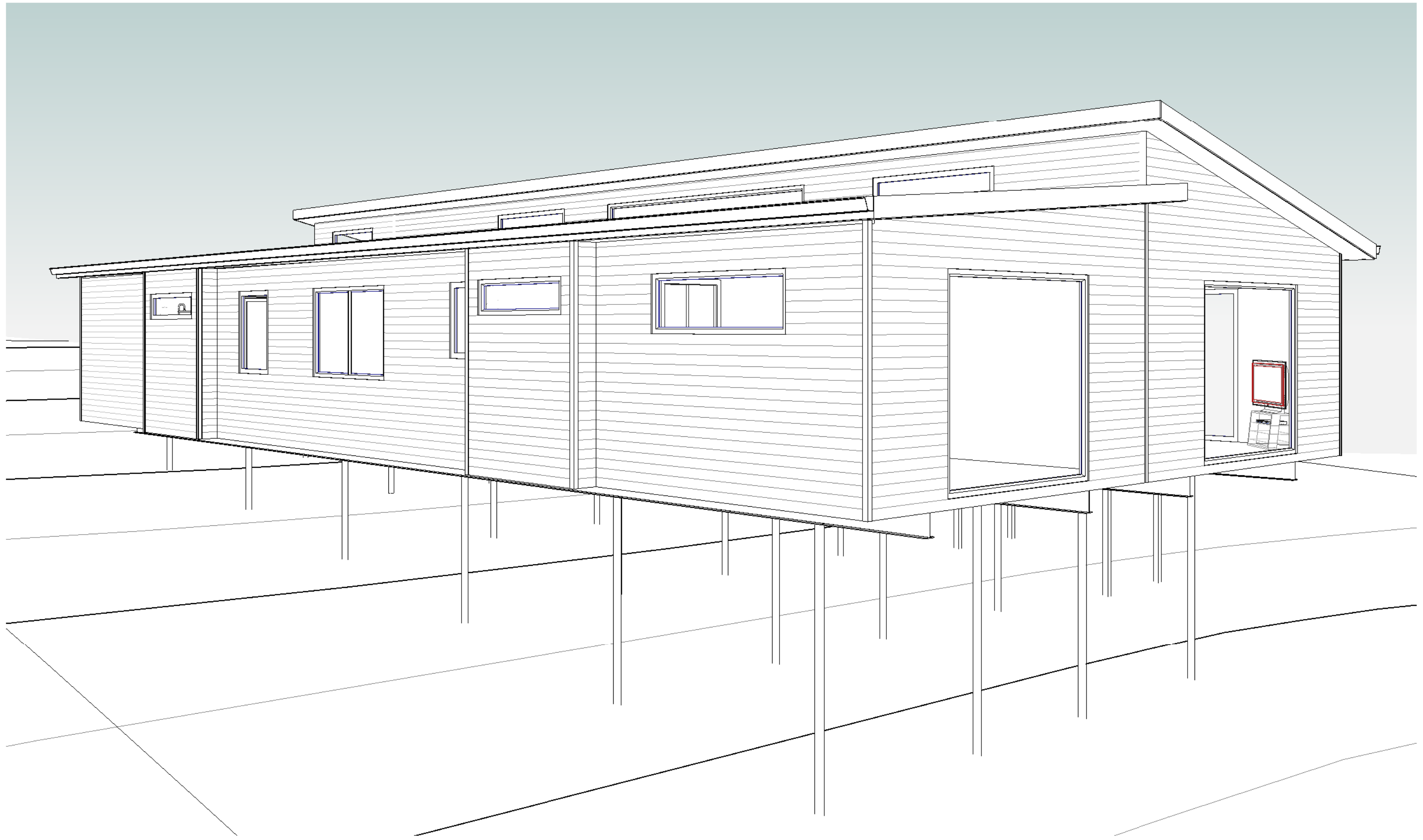

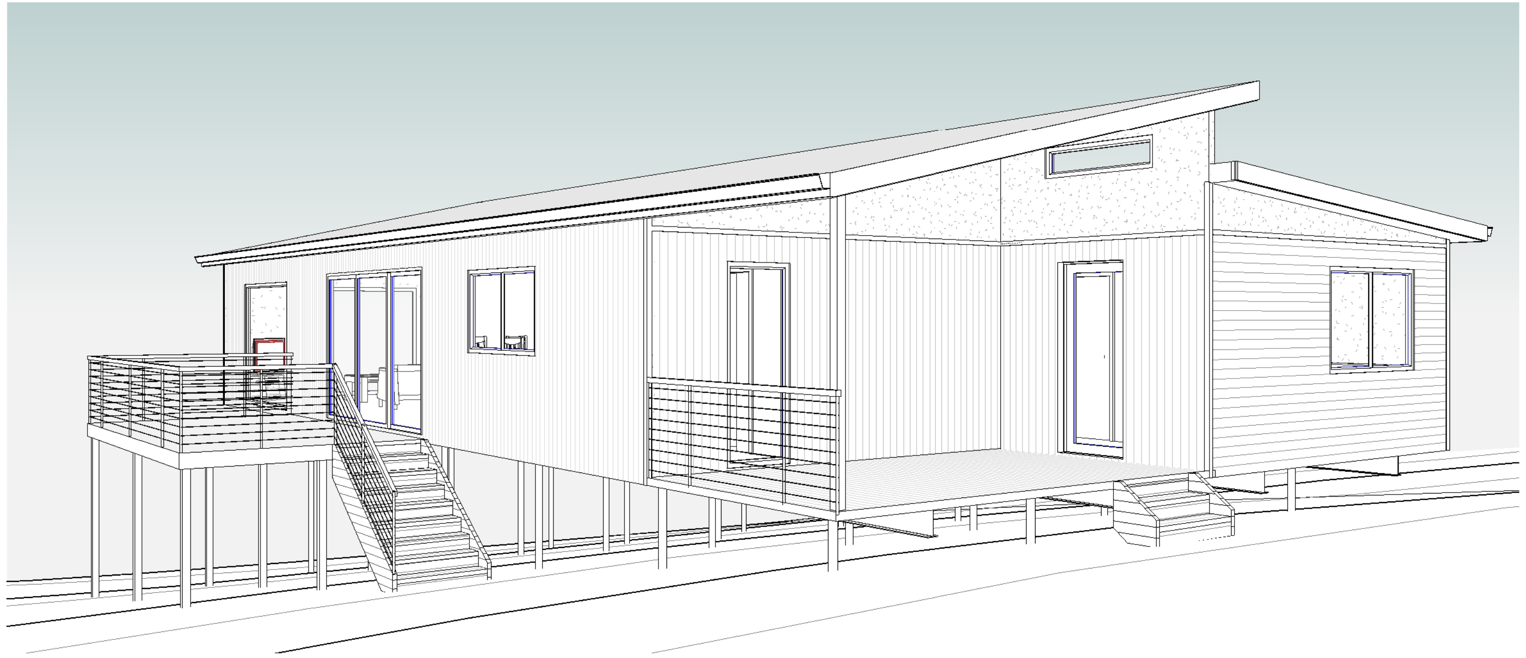

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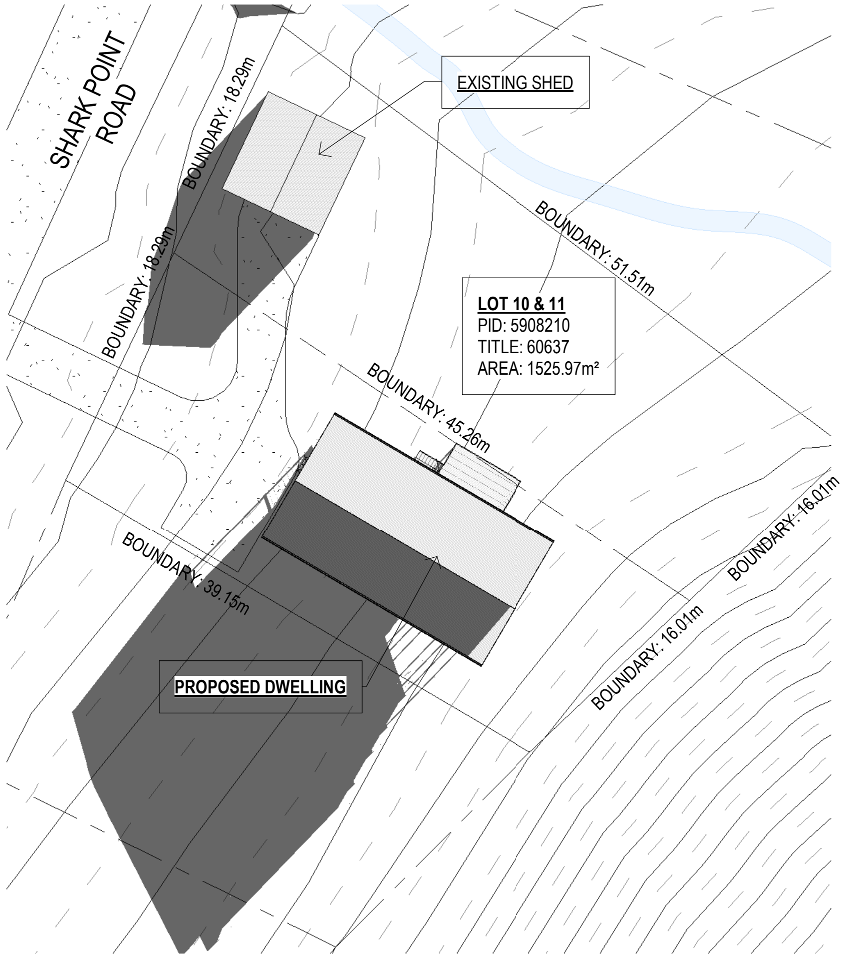
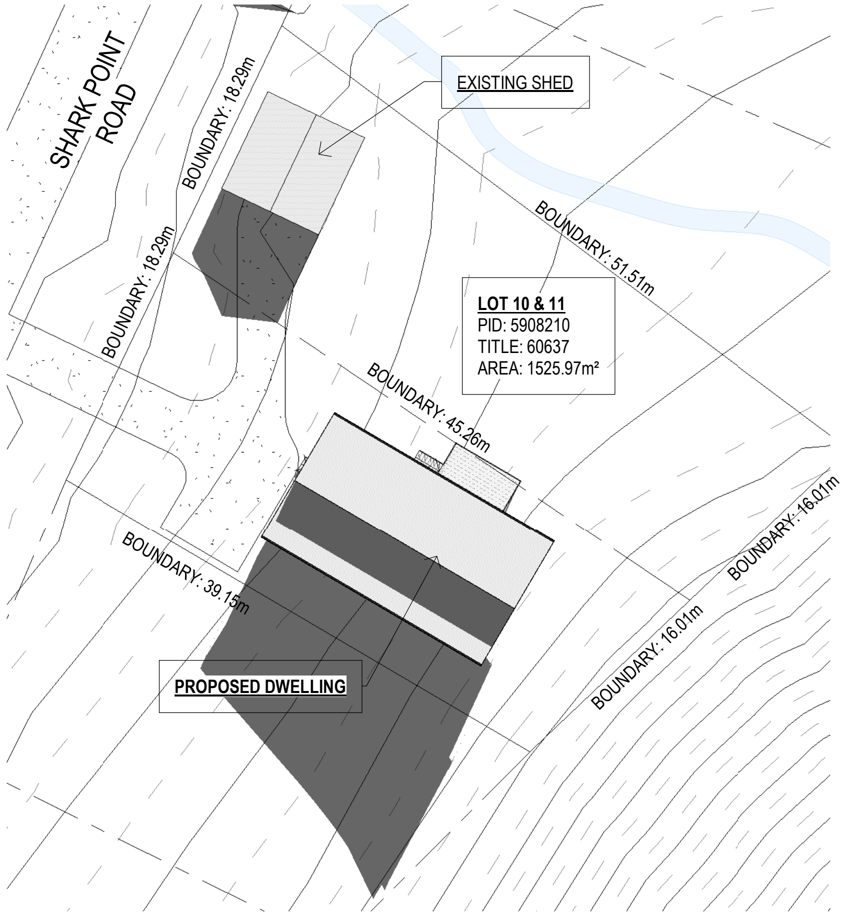
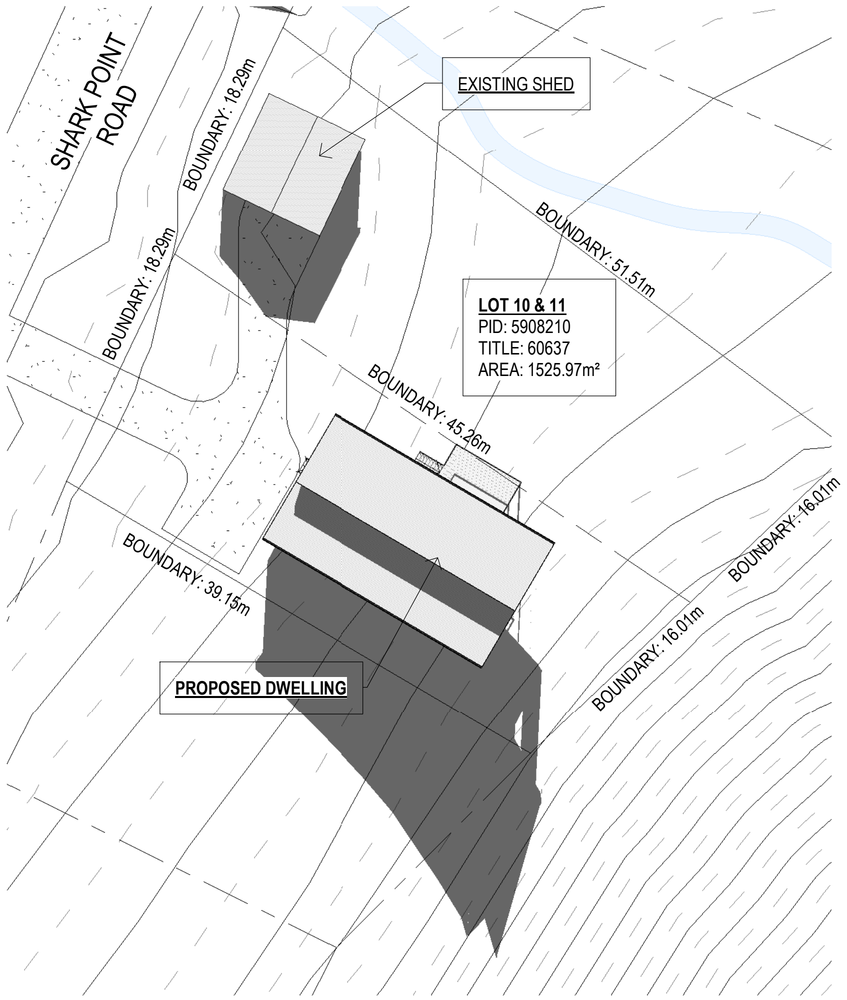


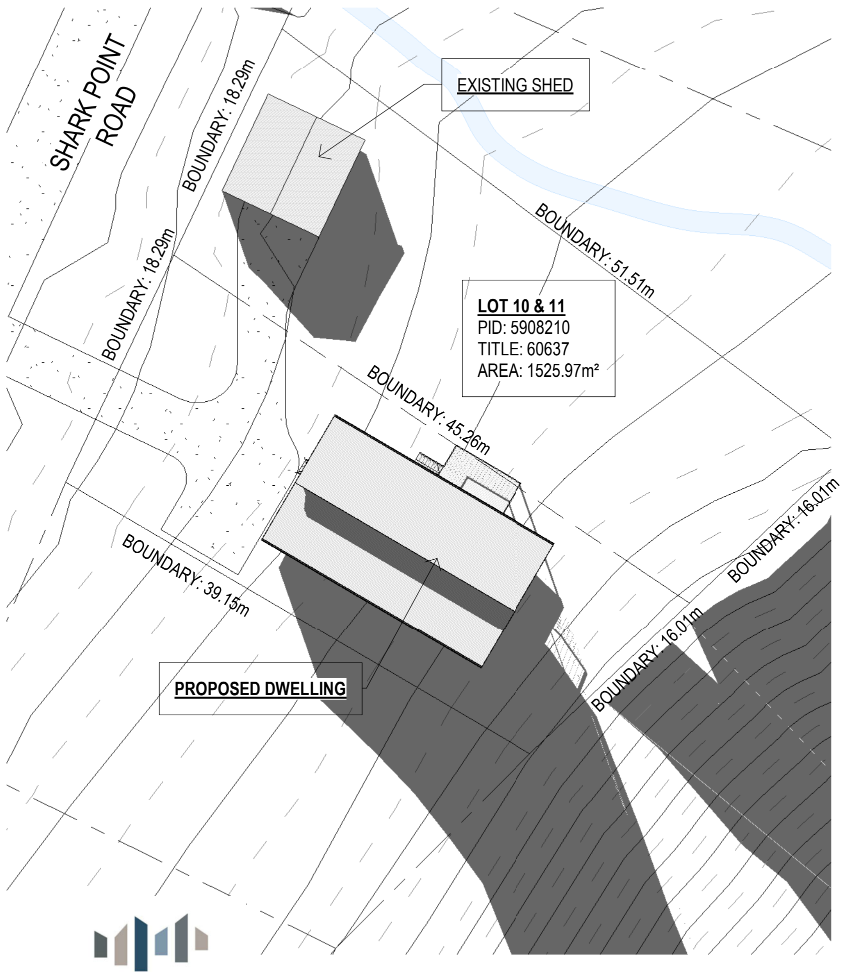
SHADOW PLAN 21.06.24 9AM
SCALE 1 : 550



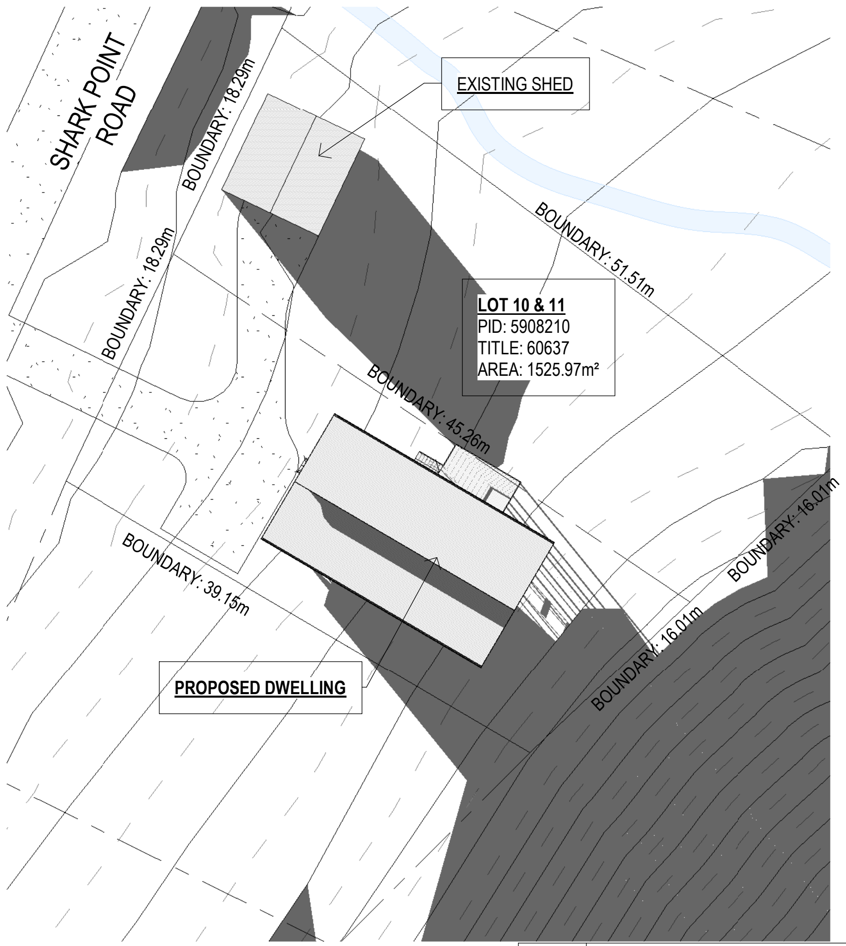
SHADOW PLAN 21.06.24 10.30AM
SCALE 1 : 550



SHADOW PLAN 21.06.24 12PM
SCALE 1 : 550



SHADOW PLAN 21.06.24 1.30PM
SCALE 1 : 550



SHADOW PLAN 21.06.24 3PM
SCALE 1 : 550

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