Geotechnical Assessment

Proposed Residential Development

460 Kolodong Road, Taree NSW

Report Ref: G1246-SCFP-001-Rev0

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Client: Wattle Court Mid-Coast

10 September 2025

Prepared for

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Project Details

Site Address:	460 Kolodong Road, Taree NSW
Project Type:	Proposed Residential Development

Project no	Report type	Report no
G1246	SCFP	001

Report Register

Revision Number	Reported By	Reviewed By	Date
Rev0	DP	DS	10/09/25

We confirm that the following report has been produced for Wattle Court Mid-Coast, based on the described methods and conditions within.

For and on behalf of Hunter Geotechnical Services,

Daniel Soffer
Senior Geotechnical Engineer

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Annex List:

1 Introduction

At the request of Wattle Court Mid-Coast, Hunter Geotechnical Services (HGS) have undertaken a Geotechnical Investigation in accordance with AS2870-2011 Residential Slabs and Footings for the proposed residential development to be constructed at 460 Kolodong Road, Taree NSW.

Details of the development have not been provided; however, it is anticipated that the structure would be of concrete slab on ground construction with minimal site regrading works required to form a level building pad. The investigation works were undertaken in accordance with HGS services agreement Q4095, dated 22 August 2025.

The purpose of the investigation was to provide recommendations on the following:

- Desktop review of published geological and soil landscape mapping and review supplied plans and assessment of geotechnical conditions present informed by geomorphology mapping
- A geotechnical model of the site that includes the following (if encountered);
    - Presence of fill
    - Depth and characterisation of soil profiles
    - oDepth to weathered rock
    - Identification of poor or potentially problematic ground conditions.
    - Ground water levels including evidence of spring activity
- Estimated surface movements calculated on the basis of the shrink-swell properties of the soil
- profile
- Site Classification to AS2870-2011 Residential Slabs and Footings;
- Foundation conditions including the presence of fill;
- Recommended foundation types to support the proposed structures within the subdivision,
- including:
    - Suitable shallow footing types and foundation design parameters (Allowable Bearing
    - Capacity)
    - Bored and screw pile design parameters and founding depths
- Earthworks advice including site preparation to support concentrated building loads, safe batterslopes and temporary support for excavations, excavation conditions and geotechnical suitability of excavated material for re-use as filling;
- Retaining wall parameters (γ – unit weight, Φ' – angle of friction, C' – drained cohesion, Cu – undrained cohesion, Ka – Coefficient of active earth pressure, Kp – Coefficient of passive earth pressure and Ko – Coefficient of at rest earth pressure)
- Recommended safe temporary and permanent batter slopes

This report provides details of the investigation, laboratory testing and provides recommendations for the proposed development.

2 Site Description

The site is located at 460 Kolodong Road, Taree NSW, bounded to the west by Kolodong Road, with existing residential development to the north, east, and south. The block forms part of a developed residential enclave on the eastern side of Kolodong Road, situated within a landscape of gently to moderately undulating terrain.

The landform reflects a residual ridge environment incised by north–south trending drainage lines that convey runoff towards the Manning River floodplain to the east. Locally, the site occupies the southeasterly facing lower slopes of a subdued hill, which rises to approximately 80 m AHD in the surrounding terrain. The site itself sits around RL 40–45 m AHD, with surface gradients of approximately 3° trending to the northeast. These gradients provide natural surface drainage and a clear expression of the residual slope form.

Figure 1: Aerial image obtained from 'Nearmap' depicting site and site boundaries

At the time of inspection, the site had been largely cleared, presenting as grassed ground with scattered regrowth vegetation. The central and eastern portions of the block contained immature shrubs and small trees, while several mature eucalypts (up to ~25 m in height) remain within the influence of the proposed building footprint along the frontage. These trees represent both a visual feature and a geotechnical consideration in relation to soil moisture variability.

Surface drainage occurs via overland sheet flow directed downslope to the northeast, supplemented by infiltration into the sandy topsoils. There was no evidence of concentrated erosion or water ponding across the lot. Given the surrounding drainage framework, the site forms part of a subdued slope element that integrates with the broader undulating ridge terrain.

Access to the lot is gained from Kolodong Road via an internal sealed driveway, consistent with surrounding residential development.

Figure 2: Looking west towards Kolodong Drive, showing a 3° slope to the southeast

Figure 3: Looking across the southwest boundary showing the existing dwelling

Figure 4: looking to the rear of the site, showing multiple scrubs and smaller immature trees

Figure 5: Looking towards the front of the development, showing large mature tress within influence of the proposed building footprint

3 Desktop Review

3.1 Geological & Soil Landscape Setting

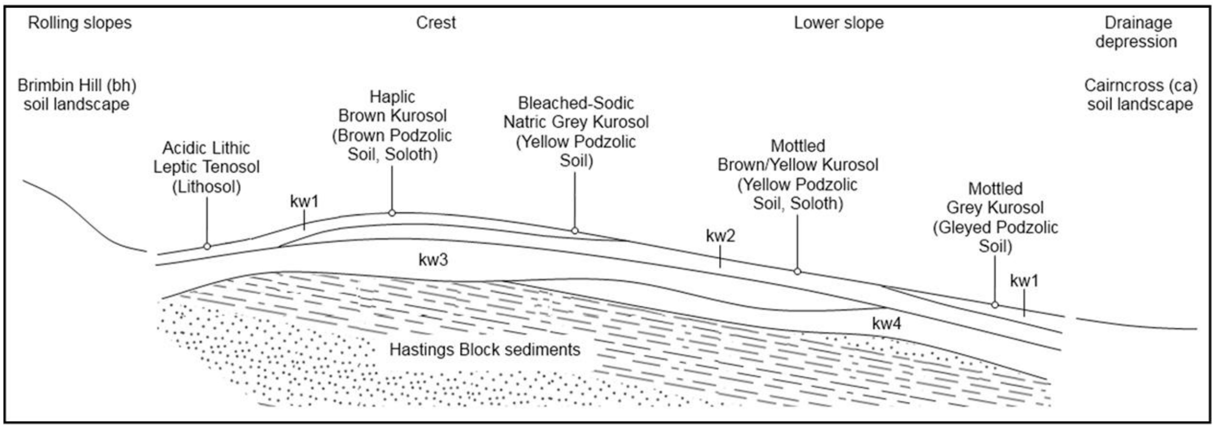
Reference to the Taree 1:100,000 Coastal Quaternary Geological Sheet indicates that the site within the fringe of the TQpat unit (Tertiary to Quaternary high-level terrace deposits). These deposits comprise deeply weathered gravels, sands, silts, and clays preserved on elevated benches above the Manning River floodplain.

The Tamworth–Hastings 1:250,000 Geological Sheet refines this interpretation further, indicating that the site lies across the transition between high-level Tertiary gravels and the underlying Carboniferous basement sequences of the Boonanghi, Kiwarrak, and Koorainghat Beds, together with the Taree Limestone. These older sequences comprise a complex assemblage of mudstone, laminated siltstone (laminite), lithic sandstone, volcaniclastic tuff, minor limestone lenses, and conglomerate, reflecting the diverse depositional and volcanic history of the region.

To the north, these Carboniferous formations are more extensively exposed, forming the ridgeline country that separates the Kolodong–Taree corridor from the Wingham plateau. Their close proximity indicates that the Tertiary terrace deposits at the site are likely to be relatively thin and transitional, grading down into weathered bedrock or colluvial mantles at shallow depths.

Previous geotechnical experience within the Wingham Road precinct indicates that groundwater seepage is prone to daylighting at the interface between Tertiary terrace deposits and residual Carboniferous bedrock, particularly where excavation cuts intercept these transitional zones. Such seepage conditions represent a key consideration for excavation stability and site drainage management.

Reference to published soil landscape mapping (eSPADE), indicates that the site is underlain by the Kew Colluvial Landscape, characterised by undulating rises on Devonian and Carboniferous sediments of the Hastings Block in the Kempsey-Myall Low Hills, and soils comprised of shallow to moderately deep, imperfectly drained Yellow Kurosols on crests, and moderately deep to deep, poorly drained Mottled Yellow Kurosols downslope.



Distribution diagram illustrating occurrence and relationship of dominant soil materials

Figure 6: Kew Colluvial Landscape (eSPADE)

3.2 Acid Sulfate Soils Risk Maps

Reference to the NSW Office of Environment and Heritage's online database 'ESPADE' indicates that the site lies in an area of no known occurrences of acid sulfate soils.

4 Fieldwork Methodology

Fieldwork was undertaken on 01 September 2025 and comprised a general site walk over and observation of the site and surrounding features. Two boreholes were drilled with a Ute mounted drilling rig and augering methods to a depth of up to 0.7m. The boreholes were logged and sampled by a Senior Engineering Technician from HGS in accordance with AS1726-2017, within the proposed development footprint.

5 Fieldwork Results

Two boreholes (BH1 and BH2) were advanced to refusal depths of 0.7 m and 0.6 m respectively. The logs show a thin soil profile overlying extremely to highly weathered sandstone at very shallow depth, consistent with the residual ridge terrain identified across the site. The encountered stratigraphy is summarised in Table 5.1.

Table 5.1: Summary of the soil unit depths encountered

Unit	Unit Description	Unit Depth (m)	
		BH1	BH2
UNIT 1A TOPSOIL	Silty CLAY, low plasticity, brown, with fine to medium grained sand, with rootlets	0.1	0.2
UNIT 2A Residual	Sandy CLAY, medium plasticity, grey, fine to coarse grained sand, ***soft***	0.5	--
UNIT 3A EW SAST	Extremely Weathered SANDSTONE as Sandy CLAY, medium to high plasticity, fine to coarse grained sand, very stiff, grading sharply to highly weathered sandstone	0.65	0.35
UNIT 3B HW SAST	Highly Weathered SANDSTONE: fine grained, pale brown mottled orange, inferred low strength, resulting in rapid Tungsten Carbide Bit refusal	≥0.7*	≥0.6*

Note: ≥ Indicates that base of material layer was not encountered
-- Indicates that the material layer was not encountered
* Indicates TC Bit Refusal on HW rock

Groundwater inflows were not encountered at the site. It is further noted that groundwater conditions are dependent on factors such as soil permeability and recent weather conditions and will vary with time.

Refer to **Annex A** for the borehole location plan and **Annex B** for detailed borehole logs.

6 Laboratory Test Results

The subsurface soil conditions encountered at test locations are presented in detail in the borehole logs.

The laboratory test results are summarised below in **Table 6.1** below.

Table 6.1 - Atterberg Limit test results

Borehole	Depth (m)	Soil description	Plasticity Index (%)	Linear Shrinkage (%)	Correlated Iss (%)
BH#	0.2 – 0.35	EW SAST as Sandy CLAY	8	4.5	1.25

Laboratory test results from the soil sample can be found in **Annex C.**

7 Comments and Discussion

Subsurface investigations at 460 Kolodong Road encountered a very thin veneer of silty clay topsoil (0.1–0.2 m), underlain by a localised soft sandy clay horizon in BH1 to 0.5 m, overlying extremely weathered sandstone logged as stiff to very stiff sandy clay, grading sharply to Highly Weathered Sandstone resulting in Tungsten Carbide Bit refusal at 0.7m in BH1 and 0.6m in BH2.

The fieldwork results and ground model for the Kolodong Road site highlight several geotechnical considerations that are relevant to the proposed residential development.

- Shallow Soft Clay Horizon: A thin horizon of soft sandy clay was encountered in BH1 to a depth of 0.5 m, with low pocket penetrometer strengths (30–40 kPa). Although this layer is relatively thin, it presents a potential bearing weakness if footings are founded within it, particularly for lightly loaded strip or pad foundations.
- Shallow Bedrock and Differential Settlement: Both boreholes terminated at refusal depths of less than 1.0 m, confirming that highly weathered sandstone occurs very close to the surface. This condition is generally favourable for foundation support; however, the irregular nature of the rockhead profile can lead to variations in founding depth across short distances.

Proposed building works at the site are therefore expected to encounter variable founding conditions, with some footings bearing on residual clays and others directly on weathered sandstone. To limit differential shrink-swell related movements and settlement, <u>it is recommended that all **footings be deepened to found uniformly on the weathered rock profile**</u>.

Given the shallow depth to rock and the variable nature of the intervening residual soils, it is recommended that all footings be founded directly on the weathered sandstone profile. Two suitable foundation approaches are:

1. **Short bored piers founded in highly weathered sandstone**, extending through the overlying soft or residual soils to achieve a consistent founding stratum; or
2. **Thickened shallow strip or pad footings bearing directly on rock**, provided excavations expose competent highly weathered sandstone across the entire footing length.

An allowable bearing capacity of up to **600 kPa** is recommended for footings or piers founded within highly weathered sandstone. The use of shallow footings in residual clay is not recommended due to the presence of soft sandy clay in BH1 and the associated risk of differential settlement.

All footings, edge beams and internal beams should be founded on similar material outside or below the zones of influence resulting from existing or future service trenches, retaining walls or other subsurface structures.

Bearing pressures of all exposed foundation areas should be confirmed at the time of earthworks and prior to concrete pour by a qualified geotechnical engineer.

The footing systems must be designed by a structural engineer in accordance with engineering principles and AS2870 - 2011 “Residential Slabs and Footings” for no less than the minimum requirements for the site classification and soil reactivity given below.

7.1 Site Classification

The site was assessed by a suitably qualified Senior Geotechnical Engineer to determine the Site Classification in accordance with AS2870-2011 “Residential Slabs & Footings”. The Site Classification provides an indication of the characteristic surface movement due to shrink-swell properties of the underlying soils and ground moisture variations. The Site Classification provided is based on review of the subsurface profile and laboratory testing as well as an assessment of the site at the time of the investigation including depths of cut and fill.

The proposed building area is located within the influence distance of mature native trees. Potential surface movements must take into account the potential drying effects of trees and be calculated in accordance with the methodology outlined in AS2870-2011 (Appendix H). In accordance with AS2870, the site is classified as **Class P**, due to the abnormal moisture conditions influenced by the drought resistant trees.

In assessing the estimated characteristic shrink swell related surface movement (y_s) values the following has been adopted:

- The engineering design for the adjacent retaining walls allows for any surcharge affecting the wall such as proposed footings, structures or sloping surfaces
- Where there was cut undertaken the depth of cracked zone was reduced by the depth of cut
- Suction change at ground surface of pf 1.2
- Depth of suction change of 1.5 m
- Depth of cracked zone of 0.75 m
- A Correlated Characteristic Iss for residual clay 1.25%
- Mature trees are present within 5 m of the proposed building area
    - Tree height is (HT) = 25 m, and Di = 2.0 x HTg
    - Maximum design drying depth for Taree (Ht) = 3.0m where a group of trees is present within the influence distance

- Maximum extra suction change of pf =0.38 where a group of trees is present within the influence distance.

The density profile encountered up to 1.8m of firm clays. In accordance with AS2870-2011, the site is classified as a **Class P** site due to insufficient bearing capacity (<100kPa) within upper portion of the site. In accordance with AS2870-2011, residential footings on Class P sites must be designed in accordance with engineering principles based on specific site conditions. The preferred option on sites containing soils with inadequate bearing strength is to extend structural foundations to found on a suitable underlying founding stratum with a bearing capacity of at least 100 kPa and the slabs connecting to the piers will need to be designed as a suspended structure.

Based on the existing profiles encountered at the time of the field investigation, the expected shrink-swell related characteristic free surface movement ($Ys + Ytmax$) estimated for the profile encountered during the field investigations less than 40mm, which includes drying effects from surrounding trees.

Classification of the site **has not** taken into account the effects of abnormal moisture conditions listed in **Section 7.1.1** below. If the site undergoes any earthworks operations, the site shall be reclassified in accordance with AS2870-2011.

7.1.1 Abnormal Moisture Effects

Abnormal moisture conditions in the foundation can be caused by the following:

- existing development
- leaking water services
- prolonged periods of draught or heavy rainfall
- trenches or other man-made water courses
- poor roof plumbing or obstruction to the roof plumbing system
- poor rainfall runoff control
- corroded gutters or downpipes

Abnormal moisture conditions specified above can cause adverse effects to the development's foundation such as:

- erosion significantly effecting the lateral and founding support of the structure's footing system;
- saturation of the founding material which can cause a significant decrease in the strength of the founding material
- shrinkage creating subsidence of the founding material and causing additional stresses within the building structure
- swelling which creates an upward force in the footings which causes additional stresses within the building structure

7.1.2 Effects from Trees

The existence of trees within or adjacent to the building footprint can cause significant soil movement due to the following:

- roots growing within the foundation and causing an upward force on footings
- roots drawing in and absorbing the moisture below a footing system causing subsidence due to shrinkage of the soil volume

The site should take into account the tree score effect in accordance with and designed to AS2870-2011. The site was found to have a "high" tree score effect and been taken into consideration in the characteristic surface movement calculation.

7.1.3 Footing Construction

All footings should be excavated, cleaned and inspected by a qualified Geotechnical Engineer. Concrete should be poured with minimal delay. If delays in pouring mass concrete footings is anticipated, a concrete blinding layer should be provided to protect the foundation material.

Should softening of exposed foundation occur, the effected material should be over excavated and backfilled to design footing level by engineered fill or mass concrete.

7.1.4 Ongoing Footing Maintenance

Foundations including effective site drainage are required to be maintained over the life of the development to ensure footing performance. Refer to **Annex D** for the following:

- Foundation Maintenance and Footing Performance (CSIRO, 2024)

7.2 Retaining Walls

Proposed new retaining walls exceeding 1m / 2m high or which support a footing should be engineer designed for appropriate earth pressures. In general, design of retaining walls requires determination of the earth pressure coefficient. This depends on the nature of the wall such that:

- where walls are not propped and some rotation of the wall away from the support soil is permissible, the active earth pressure coefficient (K_a) may be taken as 0.35 for fill and residual soil or 0.3 for extremely low to low strength rock
- where the walls can move towards the support soil either during or after construction, passive earth pressures would apply. A Passive Earth Pressure coefficient (K_p) may be taken as 2.5 for: fill, residual soil or extremely low to low strength rock
- where the walls cannot move towards or away from the support soil then the design should be undertaken using an at rest coefficient (K_o) of 0.5

Parameters shown assume horizontal and free draining granular backfill behind the retaining wall.

The parameters above are unfactored and appropriate factors of safety should be used in design.

The design of retaining walls should account for the separate hydrostatic water pressures behind the walls unless adequate subsurface and surface drainage is provided behind the wall to prevent build-up of water pressure including the provision for maintenance (i.e. flushing points).

The pressure distribution given above assumes that no surcharging of the walls occurs from nearby footings. If the footings behind retaining walls from existing retaining walls, or proposed structures are not taken below the retaining wall zone of influence (which is approximated by a line drawn at 45° above the horizontal from the base of the wall) or to low strength rock or stronger, than additional allowance should be made for the load from the footings.

Cantilever walls should not be used to support nearby building foundations or underground services.

Where drainage is provided behind retaining walls, retaining wall backfill should include geotextile encapsulated free draining backfill (ie single sized aggregate) behind the wall with a slotted drainage pipe at the base of this backfill. The slotted drain should discharge downslope of the wall. If the retaining wall is integral to the proposed building, an impermeable membrane should be installed between the geotextile encapsulated free draining material and the wall of the building.

Existing retaining walls should be assessed by a qualified engineer. Adequate subsurface drainage should be maintained behind existing retaining walls to prevent build-up of water pressure including the provision for maintenance.

7.3 Earthworks

Any earthworks conducted at the site should be controlled in accordance with AS3798-2007 and guided by the sections below.

7.3.1 Site Preparation

It is recommended that the following be undertaken where controlled filling is to be undertaken:

- Proposed foundation areas should be stripped to remove all vegetation, root affected soils, topsoil, existing fill to expose natural soils. Stripped topsoil material should be stockpiled for landscaping purposes only;
- Following stripping, the exposed subgrade materials should be proof rolled to identify any wet or excessively deflecting material. Any such areas should be over excavated and backfilled with an approved select material;
- Proposed fill material should comprise suitable fill as defined in AS 3798-2007 *Guidelines on Earthworks for Residential and Commercial Developments*. Inspection by a geotechnical authority may be required to confirm suitability of proposed fill material;
- All fill for the support of structures should be placed and compacted in accordance with the recommendations outlined in AS3798-2007 *Guidelines on Earthworks for Residential and Commercial Developments*, under Level 1 supervision.

7.3.2 Controlled Fill

Any earthworks conducted at the site should be controlled in accordance with AS3798-2007. Based on the soil profile, visual observations and in-situ testing, the material encountered at the site is deemed suitable for re-use on site as controlled fill from a geotechnical perspective given the following is considered:

- Topsoil – it is recommended that where topsoil is encountered that is high in organic content, this soil is separated and stockpiled and assessed for potential re-use as topsoil in landscaped areas on site
- Natural soils and weathered rock – the results of the investigation suggest that the natural soils and weathered rock would typically be suitable for re-use as engineered fill, provided sufficient energy is applied during fill placement and compaction to break down oversize rock to a particle size that is no greater than one-third of the uncompacted fill layer thickness
- Where natural soils are encountered with an elevated moisture condition, drying back of the material will be required. It should be taken into account that the time taken to dry back the material will likely be a function of material properties, prevailing weather conditions at the time of earthworks, size and area available to spread out the material and moisture re-conditioning methodology used

If the sub-surface conditions encountered at the site during construction differ from those discussed in **Section 5**, then HGS should be consulted to determine if the material is suitable for controlled fill. Similarly, any won material imported from external sites should consult HGS to determine if the fill is suitable for controlled fill.

7.3.3 Compaction Criteria

Fill material should be compacted in near-horizontal uniform layers with a maximum compacted thickness of 300mm. It is important to ensure layers are placed in such a way that provides adequate drainage and prevent ponding during construction. The thickness of fill placed during construction should take into account the compaction equipment available.

The moisture of the fill material should be controlled within a specified range of OMC in order to achieve the compaction criteria. In general, soils should be compacted within a moisture range of $\pm$2% of OMC.

For residential developments the following compaction criteria applies:

- cohesive soils – 95% Minimum Density Ratio (standard compactive effort)
- non-cohesive soils – 70% Minimum Density Index

Where fill is placed on sloping ground, any slope wash/deleterious should be removed and the fill should be adequately keyed/benched into the sloping ground profile.

Geotechnical inspections and testing should be performed in accordance with Level 1 procedures with reference to AS3798-2007.

7.3.4 Excavations Conditions

Excavations across the site are expected to encounter a very thin veneer of topsoil (0.1–0.2 m), underlain by localised soft sandy clay (noted in BH1 to 0.5 m), grading into extremely weathered sandstone as stiff sandy clay at shallow depth. TC Bit Refusal on highly weathered sandstone was recorded at 0.6–0.7 m in both boreholes.

Bulk excavation is therefore expected to be limited in depth and will rapidly expose weathered sandstone. In most cases, excavation into the extremely to highly weathered sandstone should be achievable with conventional medium-sized earthmoving equipment.

Bulk excavations within the highly weathered sandstone are likely to require ripping prior to excavation with a large excavator. Some allowance should also be made, for the use of hydraulic rock breakers for when bands of high strength rock are encountered in confined detail excavations such as for footings and service trenches.

Excavation of the thin residual and extremely weathered clay horizons is anticipated to be readily achievable using standard earthmoving plant. The shallow rock profile, however, should be anticipated in all excavation planning, and consideration given to variable rockhead levels across short distances.

Excavations should be conducted in accordance with The Safe Work Australia “Excavation Work” Code of Practice October 2018.

https://www.safeworkaustralia.gov.au/doc/model-codes-practice/model-code-practice-excavation-work

Excavations can seriously affect the stability of adjacent buildings. Careful consideration must be taken in order to prevent the collapse of partial collapse of adjacent structures.

Construction material and equipment should not be placed within the zone of influence of an excavation unless a suitably qualified geotechnical engineer has designed ground support structures to withstand these loads. The zone of influence is dependent on the material encountered at the site and is the area in which possible failures can occur.

Refer to Council development guidelines before conducting any excavation works.

7.4 Batter Slopes

7.4.1 Temporary Batter Slopes

Temporary excavations in natural material or extremely low to very low strength rock may be near vertical provided that:

- the depth does not exceed 1.5m
- they are open for no more than 24hrs
- no surcharge loading is applied to the surface within 2.5m of the excavation
- no one enters the excavation e.g. workers

All other temporary batter slopes during construction should not exceed 1H:1V in soils and 1H:4V in rock and benched, planned and managed in accordance with Safe Work Australia "Excavation Work" Code of Practice October 2018.

7.4.2 Permanent Better Slopes

Recommended permanent batter slopes in general are as follows:

- 2H:1V in cohesive soils (e.g. clays) or extremely to very low weathered rock else retained by an engineered retaining wall
- 3H:1V in non-cohesive soils (e.g. sands) else retained by an engineered retaining wall
- 1H:1V in low strength rock or greater (permanent rock batters may be steepened to near vertical – subject to inspection by a qualified geotechnical engineer)

Flatter slopes of 3H:1V or flatter and/or provision of benching would be required for maintenance requirements and should be topsoiled (at least 100mm thickness) and vegetated. The optimum type of grass species selected to promote growth should be based on local climatic conditions and soil types. Also, regular watering during establishment and during dry weather periods along with initial fertilisation to promote growth is recommended. Specific geotechnical assessment will be required where permanent batters exceed 2m vertical height.

8 Report Limitations

This report has been prepared by HGS for the specific site and purposes described within this report. HGS will accept no responsibility or liability for the use of this report by any third party, without the express consent of HGS or the Client, or for use at any other site or purpose than that described in this report.

This report and the services provided have been completed in accordance with relevant professional and industry standards of interpretation and analysis. This report must be read in its entirety without separation of pages or sections and without any alterations, other than those provided by HGS.

The scope of the investigation described in this report is based on information and plans provided to HGS by the Client as well as any additional limitations imposed by either the Client and / or site restraints. Such limitations may include but are not limited to budget restraints, the presence of underground services or accessibility issues to a site. Where the report has been prepared for a specific design proposal the information and interpretation may not be relevant if the design proposal is changed. HGS should be consulted if site plans or design proposal is changed as the recommendations and / or opinions presented may not be suitable for the new revisions or variations made.

The conclusions, recommendations and opinions expressed within this report are subject to the specific conditions encountered and the limited geotechnical data gathered at the site during the time of the current investigation. The subsurface conditions and results presented in this report are indicative of the conditions encountered at the discrete sampling and testing locations within the site at the time of the investigation and within the depths investigated. Variations in ground conditions may exist between the locations that were investigated, and the subsurface profile cannot be inferred or extrapolated from the limited investigation conducted by HGS. For this reason, the report must be regarded as interpretative, rather than a factual document.

Subsurface conditions are subject to constant change and can vary abruptly as a result of human influences and /or natural geological and / or climatic processes and events. As such, conditions may exist at the site that could not be identified during or may develop after the current investigation has been conducted and as such, may impact the accuracy of this report. HGS should be contacted for further consultation and site re-assessment should sub-surface conditions differ from those conditions identified in this report.

HGS recommends geotechnical reports older than 5 years from the date shown on the report, reports submitted for a previous (unrelated) development application on the site, or sites that have been altered by earthworks be reviewed by a qualified geotechnical consultant to confirm that the scope of the investigation undertaken for the report and the contents of the report are appropriate for the current development being proposed.

We are pleased to present this report and trust that the recommendations provided are sufficient for your present requirements. If you have any further questions about this report, please contact the undersigned.

For and on behalf of

Hunter Geotechnical Services

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Annex A

HUNTER GEOTECHNICAL SERVICES

CLIENT:	Wattle Court Mid-Coast	JOB NO:	G1246
PROJECT:	Proposed Residential Development	DRAWN BY:	DP
LOCATION:	460 Kolodong Road, Taree NSW	DATE:	09/09/25
		SCALE:	1:200
TITLE:	Investigation Location Plan	FIGURE NO:	Figure 1

SIZE: A3

REVISION: 1

Annex B

1 Introduction

The following notes are provided to be used in conjunction with Hunter Geotechnical Services' report to explain the terms and abbreviations used throughout the report.

2 Material Descriptions

Descriptions of soil and rock are generally in accordance with the Unified Soil Classification System and Australian Standard AS1726-2017 – Geotechnical Site Investigations. The descriptions of soil and rock are based on field tests and observations and are independent of any laboratory test results. The data presented throughout this report is as factual as possible. However, some interpretations is unavoidable.

2.1 Unified Soil Classification Group Symbols

Soils are generally assigned one of the following unified soil classification group symbols:

Table 2.1 - Unified Soil Classification Group Symbols

Symbol	Description	Symbol	Description
OH	Organic clays of medium to high plasticity	Pt	Peat and other highly organic soils
OL	Organic silts of low plasticity	CH	Inorganic clays of high plasticity
MH	Inorganic silts of high plasticity	CI	Inorganic clays of low plasticity
ML	Inorganic silts of low plasticity	CL	Inorganic clays of low plasticity
GC	Clayey gravels	SC	Clayey sands
GM	Silty gravels	SM	Silty sands
GP	Poorly graded gravels	SP	Poorly graded sands
GW	Well graded gravels	SW	Well graded sands

2.2 Soil Description

Soils are described in general accordance with AS1726-2017, Section 6.1:

Table 2.2 - Particle Size Definitions (AS1726-2017, Table 1)

Component	Subdivision	Size (mm)
BOULDERS		>200
COBBLES		63 - 200
GRAVEL	Coarse	19 - 63
	Medium	6.7 - 19
	Fine	2.36 - 6.7
SAND	Coarse	0.6 - 2.36
	Medium	0.21 - 0.6
	Fine	0.075 - 0.21
SILT		0.002 - 0.075
CLAY		<0.002

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Table 2.3 - Descriptive Terms for Accessory Soil Components (AS1726-2017, Table 2)

Designation of Components	In Coarse Grained Soils				In Fine Grained Soils	
	% Fines	Terminology	% Accessory Coarse Fraction	Terminology	% Sand / Gravel	Terminology
Minor	≤ 5	Add 'trace clay / silt' to description where applicable	≤ 15	Add 'trace sand / gravel' to description where applicable	≤ 15	Add 'trace sand / gravel' to description where applicable
Minor	> 5, ≤ 12	Add 'with clay / silt' to description where applicable	> 15, ≤ 30	Add 'with sand / gravel' to description where applicable	> 15, ≤ 30	Add 'with sand / gravel' to description where applicable
Secondary	> 12	Prefix soil name as 'Silty' or 'Clayey', as applicable	> 30	Prefix soil name as 'Sandy' or 'Gravelly', as applicable	> 30	Prefix soil name as 'Sandy' or 'Gravelly', as applicable

Table 2.4 - Descriptive Terms for Plasticity (AS1726-2017, Table 6)

Descriptive Term	Range of Liquid Limit for SILT	Range of Liquid Limit for CLAY
Non-Plastic	Not applicable	Not applicable
Low Plasticity	≤ 50	≤ 35
Medium Plasticity	Not applicable	> 35 and ≤ 50
High Plasticity	> 50	> 50

Table 2.5 - Moisture Condition (AS1726-2017, Clause 6.1.7 (a))

Material	Term	Abbreviation	Field Description Terms
Coarse Grained Soil	Dry	D	Non-cohesive and free-running
	Moist	M	Soil feels cool, darkened in colour; Soil tends to stick together
	Wet	W	Soil feels cool, darkened in colour; Soil tends to stick together, free water forms when handling
Fine Grained Soil	Moist, dry of plastic limit	w < PL	Hard and friable or powdery
	Moist, near plastic limit	w ≈ PL	Soil can be moulded at a moisture content approximately equal to the plastic limit
	Moist, wet of plastic limit	w > PL	Soil usually weakened and free water forms on hands when handling
	Wet, near liquid limit	w ≈ LL	Near liquid limit
	Wet, wet of liquid limit	w > LL	Wet of liquid limit

Table 2.6 - Consistency Terms for Cohesive Soils (AS1726-2017, Table 11)

Consistency	Abbreviation	Field Guide to Consistency
Very Soft	VS	Exudes between the fingers when squeezed in hand
Soft	S	Can be moulded by light finger pressure
Firm	F	Can be moulded by strong finger pressure
Stiff	St	Cannot be moulded by fingers
Very Stiff	VSt	Can be indented by thumb nail
Hard	H	Can be indented with difficulty by thumb nail
Friable	Fr	Can be easily crumbled or broken into small pieces by hand

Table 2.7 - Relative Density of Non-Cohesive Soils (AS1726-2017, Table 12)

Relative Density	Abbreviation	Density Index (%)
Very Loose	VL	≤ 15
Loose	L	> 15 and ≤ 35
Medium Dense	MD	> 35 and ≤ 65
Dense	D	> 65 and ≤ 85
Very Dense	VD	> 85

Table 2.8 - Soil Origin (AS1726-2017, Clause 6.1.9)

Origin	Description
Residual Soil	Formed directly from in situ weathering of geological formations. These soils no longer retain any visible structure of fabric of the parent soil or rock material.
Extremely weathered material	Formed directly from in situ weathering of geological formations. Although this material is of soil strength, it retains the structure and / or fabric of the parent rock material.
Alluvial soil	Deposited by streams and rivers.
Estuarine soil	Deposited in coastal estuaries, and including sediments carried by inflowing rivers and streams, and tidal currents.
Marine soil	Deposited in a marine environment.
Lacustrine soil	Deposited in freshwater lakes.
Aeolian soil	Carried and deposited by wind.
Colluvial soil	Soil and rock debris transported down slopes by gravity, with or without the assistance of flowing water and generally deposited in gullies or at the base of slopes. Colluvium is often used to refer to thicker deposits such as those formed from landslides, whereas the term 'slopewash' may be use for thinner and more widespread deposits that accumulate gradually over longer geological timeframes.
Topsoil	Surface and / or near surface soils often, but not always, defined by high levels of organic material.
Fill	Material placed by anthropogenic processes.

2.3 Rock Description

Rocks are described in general accordance with AS1726-2017, Clause 6.2.

Table 2.9 - Rock Material Strength Classification (AS1726-2017, Table 19)

Strength	Abbreviation	Field Assessment
Very Low Strength	VLS	Material crumbles under firm blows with sharp end of pick; Can be peeled with sharp knife; Too hard to cut a triaxial sample by hand; Pieces up to 30mm thick can be broken by finger pressure.
Low Strength	LS	Easily scored with a knife; Indentations 1mm to 3mm show in the specimen with firm blows of the pick point; Has dull sound under the hammer; A piece of core 150mm long by 50mm diameter may be broken by hand; Sharp edges of core may be friable and break during handling.
Medium Strength	MS	Readily scored with a knife; A piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High Strength	HS	A piece of core 150mm long by 50mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; Rock rings under hammer.
Very High Strength	VH	Hand specimen breaks with pick after more than one blow; Rock rings under hammer.
Extremely High Strength	EH	Specimen required many blows with geological pick to break through intact material; Rock rings under hammer.

Note: Material with strength less than 'Very Low' shall be described using soil characteristics. The presence of an original rock structure, fabric or texture should be noted, if relevant.

Table 2.10 - Classification of Material Weathering (AS1726-2017, Table 20)

<table>
<tr><th colspan="2">Term</th><th colspan="2">Abbreviation</th><th>Definition</th></tr>
<tr><td colspan="2">Residual Soil</td><td colspan="2">RS</td><td>Material is weathered to such an extent that is has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported. The material is described using soil descriptive terms.</td></tr>
<tr><td colspan="2">Extremely Weathered</td><td colspan="2">XW</td><td>Material is weathered to such an extent that is has soil properties. Mass structure and material structure and fabric of original rock are still visible. The material is described using soil descriptive terms.</td></tr>
<tr><td>Highly Weathered</td><td rowspan="2">Distinctly Weathered</td><td>HW</td><td rowspan="2">DW</td><td>The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable. Rock strength is significantly changed by weathering.</td></tr>
<tr><td>Moderately Weathered</td><td>MW</td><td>The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable, but shows little or no change of strength from fresh rock.</td></tr>
<tr><td colspan="2">Slightly Weathered</td><td colspan="2">SW</td><td>Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.</td></tr>
<tr><td colspan="2">Fresh</td><td colspan="2">FR</td><td>Rock shows no sign of decomposition of individual minerals or colour changes.</td></tr>
</table>

3 Drilling, In Situ Testing & Sampling Methodology

Table 3.1 - Drilling Methods

Abbreviation	Method
HA	Hand Auger
EX	Excavator bucket
AV	Auger drilling with steel 'V' bit
AT	Auger drilling with tungsten carbide bit
AB	Auger for bulk sampling
WB	Wash bore rotary drilling
NMLC	Rock coring using a NMLC core barrel
HQ	Rock coring using a HQ core barrel

Table 3.2 - Field Sampling and In Situ Testing Key

Abbreviation	In Situ Test
DCP	Dynamic Cone Penetrometer (blows/100mm)
PSP	Perth Sand Penetrometer (blow/100mm)
SPT	Standard Penetrometer Test
PP	Pocket Penetrometer Measurement (kPa)
3,4,5 (example)	SPT blows per 150mm
N=9 (example)	STP 'blow count number' over 300mm after initial 150mm seating
VS	Handheld Shear Vane Measurement (kPa)
CPT	Cone Penetrometer Test
IS50 (D) (A)	Point Load Index Value (reported in MPA) (D) = Diametric (A) = Axial

Abbreviation	Sample Type
U	Undisturbed Sample (50mm)
D	Disturbed Sample
B	Bulk Disturbed Sample
ES	Environmental Sample
W	Water Sample

4 Groundwater Observations

Table 4.1 - Water Comments Key

Water Comment	Symbol
Water Inflow	▶—
Water / drilling fluid loss	—◀
Measurement of standing water level	▼
Water Noted	▽

Engineering Log - Borehole

Client:	Wattle Court Mid-Coast	Commenced:	1/9/2025
Project Name:	Proposed Residential Development	Completed:	1/9/2025
Hole Location:	460 Kolodong Road, Taree NSW	Logged By:	PR
Hole GPS Coords:	444933.0 m E 6473284.0 m N MGA2020-56	Checked By:	

Drill Model and Mounting:	4WD Mounted Drilling Rig	Inclination:	-90°	RL Surface: Not surveyed		**Project No.:**	**G1246**
Hole Diameter:	100 mm	Bearing:		Datum:	AHD	Operator:	PR

Drilling Information | ***Description*** | ***Observations***

Method	Penetration	Support	Water	Samples & Field Tests	Recovery	RL (m)	Depth (m)	Graphic Log	Group Symbol	Soil / Rock Material Field Description	Moisture Condition	Consistency Relative Density	Pocket Penetrometer UCS (kPa) 100 200 300 400 500	Structure and Additional Observations
AD/TC			Not Encountered						CL	Silty CLAY, low plasticity, brown, with fine to medium grained sand, with rootlets	w>PL			TOPSOIL
							0.10m		GP-GC	Sandy CLAY, medium plasticity, grey, fine to coarse grained sand, with fine to medium grained sub angular gravel		S		RESIDUAL SOIL
							0.2						×	0.20: PP =30 kPa
							0.4						×	0.40: PP =40 kPa
							0.50m		CI-CH	Extremely Weathered SANDSTONE as Sandy CLAY, medium to high plasticity, fine to coarse grained sand, with pale brown / orange fine to coarse sub angular gravels as highly weathered sandstone fragments		VSt	×	EXTREMELY WEATHERED MATERIAL 0.50: PP =200 kPa EXTREMELY WEATHERED MATERIAL
							0.6							
							0.65m			Highly Weathered SANDSTONE: fine grained, pale brown mottled orange, inferred low strength				ROCK
							0.70m			Hole Terminated at 0.70 m Refusal with TC bit				
							0.8							

Method
AS - Auger Screwing
ADV - Auger V Bit
ADT - Auger Tungsten Carbide Bit
RR - Rock Roller
WB - Washbore

Support
C - Casing

Penetration
▨ No resistance ranging to refusal

Water
Level (Date)
Inflow
Partial Loss
Complete Loss
Seepage

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
PP - Pocket Penetrometer

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Moisture Condition
D - Dry
M - Moist
W - Wet
w - Moisture Content
PL - Plastic Limit
LL - Liquid Limit

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Engineering Log - Borehole

Client:	Wattle Court Mid-Coast	Commenced:	1/9/2025
Project Name:	Proposed Residential Development	Completed:	1/9/2025
Hole Location:	460 Kolodong Road, Taree NSW	Logged By:	PR
Hole GPS Coords:	444929.0 m E 6473293.0 m N MGA2020-56	Checked By:	

Drill Model and Mounting:	4WD Mounted Drilling Rig	Inclination:	-90°	RL Surface: Not surveyed		**Project No.:**	**G1246**
Hole Diameter:	100 mm	Bearing:		Datum:	AHD	Operator:	PR

Drilling Information | **Description** | **Observations**

Method	Penetration	Support	Water	Samples & Field Tests	Recovery	RL (m)	Depth (m)	Graphic Log	Group Symbol	Soil / Rock Material Field Description	Moisture Condition	Consistency Relative Density	Pocket Penetrometer UCS (kPa) 100 200 300 400 500	Structure and Additional Observations
AD/TC			Not Encountered						CL	Silty CLAY, low plasticity, brown, with fine to medium grained sand, with rootlets	w>PL			TOPSOIL
				0.20m U			0.2		CH	0.20m Extremely Weathered SANDSTONE as Sandy CLAY, high plasticity, grey mottled pale grey, fine to coarse grained sand, trace fine to medium sub angular gravels as highly weathered sandstone fragments	w>PL	VSt	× (250)	EXTREMELY WEATHERED MATERIAL 0.30: PP =250 kPa
				0.35m			0.4			0.35m Highly Weathered SANDSTONE: fine grained, inferred low strength, highly fractured				ROCK
							0.6			0.60m Hole Terminated at 0.60 m Refusal with TC bit				
							0.8							

Method
AS - Auger Screwing
ADV - Auger V Bit
ADT - Auger Tungsten Carbide Bit
RR - Rock Roller
WB - Washbore

Support
C - Casing

Penetration
No resistance ranging to refusal

Water
Level (Date)
Inflow
Partial Loss
Complete Loss
Seepage

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
PP - Pocket Penetrometer

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Moisture Condition
D - Dry
M - Moist
W - Wet
w - Moisture Content
PL - Plastic Limit
LL - Liquid Limit

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Annex C

Material Test Report

Report Number:	**P24968-233**
Issue Number:	1
Date Issued:	09/09/2025
Client:	Geotechnical Engineering Department - Port Macquarie 11/35 Merrigal Road, Port Macquarie NSW 2444
Contact:	Daniel Soffer
Project Number:	P24968
Project Name:	Materials Testing
Project Location:	460 Kolodong Road, Taree NSW
Client Reference:	G1246
Work Request:	20297
Sample Number:	25-20297A
Date Sampled:	01/09/2025
Dates Tested:	02/09/2025 - 09/09/2025
Sampling Method:	Sampled by Engineering Department *The results apply to the sample as received*
Preparation Method:	AS 1289.1.1 - Sampling and Preparation of Soils
Site Selection:	Selected by Client
Sample Location:	**BH2, Depth: 0.2-0.35m**
Material:	Clay
Material Source:	Onsite Won

Hunter Geotechnical Services
62 Sandringham Avenue Thornton NSW 2322
Phone: (02) 4966 1844
Email: sp@huntercivilab.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Scott Picton
Technician

NATA Accredited Laboratory Number: 14975

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	29		
Plastic Limit (%)	21		
Plasticity Index (%)	**8**		
Sample crumbled during extrusion compromising the undisturbed sampling state.			

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**4.5**		
Cracking Crumbling Curling	None		
Sample crumbled during extrusion compromising the undisturbed sampling state.			

Annex D

FOUNDATION MAINTENANCE AND FOOTING PERFORMANCE

Preventing soil-related building movement

This Building Technology Resource is designed as a homeowner's guide on the causes of soil-related building movement, and suggested methods to prevent resultant cracking.

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 home owner 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. Generally soil classification is provided by a geotechnical report.

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.

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. Table 1 below is a reproduction of Table 2.1 from Australian Standard AS 2870-2011, Residential slabs and footings.

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 may be the province of the builder and should be taken into consideration as part of the preparation of the site for construction.

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, from AS 2870). 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.

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.

TABLE 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, which may experience only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes

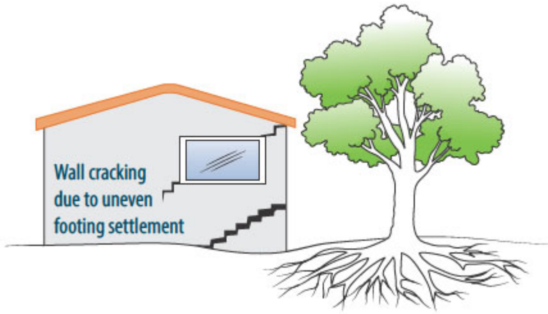

FIGURE 1 Trees can cause shrinkage and damage.

- 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 through absorption. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Shrinkage usually begins on the side of the building 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.

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

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

MOVEMENT CAUSED BY TREE ROOTS

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

COMPLICATIONS CAUSED BY THE STRUCTURE ITSELF

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

EFFECTS ON FULL MASONRY STRUCTURES

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

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

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

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

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

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

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

EFFECTS ON FRAMED STRUCTURES

Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation causes 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. Table 2 below is a reproduction of Table C1 of AS 2870-2011.

AS 2870-2011 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 AND 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 may 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 should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

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

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

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

CONDENSATION

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

TABLE 2. CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS.

Description of typical damage and required repair	Approximate crack width limit	Damage category
Hairline cracks	<0.1 mm	0 – Negligible
Fine cracks which do not need repair	<1 mm	1 – Very Slight
Cracks noticeable but easily filled. Doors and windows stick slightly.	<5 mm	2 – Slight
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 – Moderate
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 depends on number of cracks	4 – Severe

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

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

THE GARDEN

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

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

EXISTING TREES

Existing trees may cause problems with the upheaval of footings by their roots, or shrinkage from soil drying. If the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. Soil drying is a more complex issue and professional advice may be required before considering the removal or relocation of the tree.

INFORMATION ON TREES, PLANTS AND SHRUBS

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information.

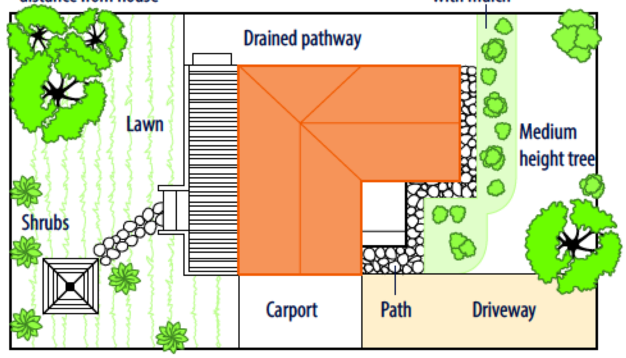

FIGURE 2 Gardens for a reactive site.

EXCAVATION

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

REMEDIATION

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

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