Aargus

ENVIRONMENTAL - REMEDIATION - GEOTECHNICAL ENGINEERING - WORK HEALTH & SAFETY - LABORATORIES - DRILLING

GEOTECHNICAL INVESTIGATION REPORT

AND

LANSLIDE RISK ASSESSMENT

122-128 Crescent Road
Newport NSW 2106

Prepared for

Essex Development Pty Ltd.

Report No. GS8649-2B

23rd December 2022

CONTROLLED DOCUMENT

DISTRIBUTION AND REVISION REGISTER

Copy No.	Custodian	Location
1	Nick Kariotoglou	Aargus (Library)
2 (Electronic)	Marco Silva	marco@essexdevelop.com.au

Note: This register identifies the current custodians of controlled copies of the subject document.

It is expected that these custodians would be responsible for:

- The storage of the document.
- Ensuring prompt incorporation of amendments.
- Making the document available to pertinent personnel within the organisation.
- Encouraging observance of the document by such personnel.
- Making the document available for audit.

DOCUMENT HISTORY

Revision No.	Issue Date	Description	Issued By:
(GS8649-2A)	29/11/2022	Initial Issue	Rafael Furniss
(GS8649-2B)	23/12/2022	Revised Issue	Rafael Furniss

R. Furniss

Aargus

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

REFERENCES

1. Australian Standard – AS 1726-2017 Geotechnical Site Investigation.
2. Australian Standard – AS 1170.4-2007 Structural Design Actions – Part 4: Earthquake actions in Australia.
3. Australian Standard – AS3798-2007 Guidelines on Earthworks for Commercial and Residential Developments.
4. Australian Standard – AS 2870-2011 Residential slabs and footings.
5. Australian Standard – AS 2159-2009 Piling - Design and installation.
6. Pells P.J.N, Mostyn, G. & Walker B.F., “Foundations on Sandstone and Shale in the Sydney Region”, Australian Geomechanics Journal, 1998.

7. Australian Standard – AS 1289 5.4.1-2007 Soil Compaction and Density Tests – Compaction Control Test – Dry Density Ratio, Moisture Variation and Moisture Ratio.
8. Assessing Vibration: A Technical Guideline, Department of Environment and Conservation NSW, February 2006.
9. Australian Geomechanics Society Practice Note “Some Guidelines For Hillside Construction” (Practice note guidelines for landslide risk management 2007 – Appendix G).
10. CSIRO guide “Foundation Maintenance and Footing Performance - A Homeowners Guide”.
11. Geotechnical Risk Management Policy for Pittwater (by Pittwater Council, Council policy No. 178, dated 20 July 2009).
12. “Practice Note Guidelines for Landslide Risk Management 2007” by the Australian Geomechanics Society (AGS), 2007.
13. “Commentary on Practice Note Guidelines for Landslide Risk Management 2007” by the Australian Geomechanics Society, 2007.
14. Australian Geoguide LR8 (Construction Practice) – Hillside Construction Practice by AGS 2007.

1. INTRODUCTION

Aargus Pty Ltd (Aargus) has been commissioned by Essex Developments Pty Ltd., to undertake a geotechnical site investigation for the development that will comprise amalgamation of seven (7) lots and sub-division into nine (9) new lots with access road and access to the marina.

The geotechnical site investigation was carried out on the 26-28th of October 2022 in accordance with Aargus proposal P2022-105 and in general accordance with Australian Standard AS1726-2017 Geotechnical Site Investigations.

The purpose of the investigation was to assess the ground conditions for the new sub-division, including landslide risk assessment and site lot classification.

This report presents the results of the geotechnical site investigation, laboratory testing of retained soil and rock samples, interpretation, and assessment of the existing geotechnical conditions and constraints within the site, as a basis to provide recommendations for design and construction of ground structures for the proposed development.

To assist in reading this report, reference should be made to the "Important Information about Your Geotechnical Report" attached in Appendix A.

2. ABOUT THE DEVELOPMENT

Prior to undertaking the agreed geotechnical investigation and preparation of this report, the following documents/information was made available to Aargus:

- A detail survey plan, prepared by Platform Architects, Plan Reference: ERC RFI DA – Number: A3.02., overlaid on satellite imagery.
- Geotechnical Risk Management Policy for Pittwater prepared by Pittwater Council, Council policy No. 178, dated 20 July 2009.
- Architectural Envelopment Plan prepared by Scott Carver, Ref. No. 20220005, Drawing No. AD-DA903, Review D, dated 26th May 2022.
- Site survey plan "Plan of Site Detail and Levels" 122-128 Crescent Rd, Newport by Boxall Surveyors, dated 5/5/22, Drawing Number 11369-001-A Rev A.

3. SCOPE OF WORK

In accordance with the brief, fieldwork for the geotechnical site investigation was carried out by an experienced Geotechnical Engineer from Aargus; following the general guidelines provided in the Australian Standard AS 1726-2017 Geotechnical Site Investigations (Reference 1) and comprised the following:

- A site walk-over inspection by a Geotechnical Engineer in order to determine the overall surface conditions and to identify relevant site features.
- A comprehensive desktop review of DBYD plans, and service location carried out on the site using a specialised subcontractor to ensure that the investigation area is free from underground services utilities.

- Machine drilling of nine boreholes to depths between 0.7m and 6.66m below the ground surface, comprising auger drilling to TC bit refusal, followed by NMLC coring in three of the boreholes.
- Installation of four standpipe piezometers for measurements of groundwater levels in the boreholes near the four corners of the site.
- The wells were developed (ie bailed dry) and the groundwater level in each of the wells was recorded on the 8th and 23rd of November 2022, after groundwater level stabilisation.
- Representative soil samples from the auger drilled boreholes were sampled, labelled and taken from the auger holes for subsequent laboratory testing for Atterberg limits tests and soil salinity / aggressivity testing.
- Preparation of a geotechnical investigation report collating onsite test results, soil and rock borehole logs, laboratory test results and interpretation of the obtained test results.

The approximate locations of the boreholes completed during the geotechnical site investigation are shown on “Figure 1 - Site Plan” attached in Appendix B.

Based on the results of the site investigation and laboratory testing, Aargus carried out geotechnical interpretation and assessment of the main potential geotechnical issues that may be associated with the proposed development on this site. A geotechnical report (this report) was prepared to summarise the results of the geotechnical site investigation and to provide relevant comments and recommendations.

4. SITE CONDITIONS

The site is located within the Northern Beaches Council area, has an approximate area of 6480m^2 and consists of the properties at 122-128 Crescent Road, Newport, NSW. The site is bounded by;

- Crescent Road to the east,
- The Avenue to the north,
- To the south a double storey rendered brick residential apartment building, and
- To the west, marine coast of Winji Jimmi Bay with the Sirsi Newport Marina.

The site is currently occupied by four single to double-storey brick or weatherboard residential dwellings and two commercial buildings in the southern area, with associated grassed areas, gardens, footpaths and driveways.

The site elevation varies from approximately RL 19.4 m AHD in the north-eastern corner to RL 0.00 m AHD in the western side at sea-level, sloping from east/north-east to the shoreline at the west with slopes generally from 9° to 12° degrees, with some flat areas and localised cut faces up to 26° adjacent to the flat areas.

Along the western edge of the site there is a retaining wall from the south at the access road for the marina to the shed due west of the house at No. 57 The Avenue, with a localised slope near the shed up to 35°, and slopes north of the shed sloping down at 35-40° to the west.

5. PROPOSED DEVELOPMENT

Based on the information provided in Section 2, the proposed development includes demolition of the existing buildings, amalgamation of the seven existing lots and subdivision into nine new lots with associated re-grading earthworks and access road construction for residential dwellings.

6. SUBSURFACE CONDITIONS

6.1 Geology

Reference to the 1:100,000 Sydney Geological Series, Map Sheet 9130 (1983), by the New South Wales, Department of Mineral Resources, indicates that the site is underlain by Newport Formation rock types comprising “Interbedded laminite, Shale and quartz to lithic-quartz Sandstone” of the Triassic period.

From the site investigation subsurface materials comprise Silty Clay to Gravelly / Sandy Fill overlying residual and alluvial Silty to Sandy Clay soils of variable plasticity, overlying weathered Laminite (interbedded Shale and Sandstone) and Sandstone bedrock.

The geotechnical investigation on the site confirms the published geology.

6.2 Ground Profile

The subsoil conditions encountered within the boreholes are summarised in Table 1 and described in detail on the Engineering Borehole Logs presented in Appendix C with Core Photographs in Appendix D. Note that reference should be made to the logs and specific test results for design purposes.

Table 1. Geotechnical Subsurface Model (Summary of Subsurface Conditions)

Unit	Description	BH1 (m)	BH2 (m)	BH3 (m)	BH4 (m)	BH5 (m)	BH6 (m)	BH7 (m)	BH8 (m)	BH9 (m)
	Ground Surface Level RL (m AHD)	***15.27***	***8.5***	***7.0***	***11.0***	***12.6***	***7.5***	***14.0***	***17.86***	***8.5***
Asphalt	Pavement	-	0.0 – 0.06	-	0.0 – 0.1	0.0 – 0.06		-	-	0.0 – 0.02
Fill	Gravelly SAND to Sandy GRAVEL, fine grained sand brown, with medium to coarse grained gravel, moist.	-	0.06 – 0.1	0.0 – 0.2	0.1 – 1.0	0.06 – 0.1	0.00-0.05	-	0.0 – 0.3	0.02 – 0.5
Fill/ Topsoil	Silty Clay, low to high plasticity, brown, moist	0.00 - 0.7	-	-	-	0.1 – 0.8	0.05 – 1.20	0.0 – 0.3	-	-
Alluvial Soil	Silty CLAY, low plasticity, black, soft to firm, moist	-	-	-	-	0.8 – 1.2		0.3 – 0.6	-	-
Residual Soils	Silty to Sandy CLAY, medium to high plasticity, firm to stiff or very stiff, ± gravel, moist.	0.7-1.07-	0.1 – 1.0	0.2 – 2.0	1.0 – 2.0	0.8 – 3.0	1.2 - 2.0	0.6 – 0.8	0.3 – 1.0	0.5 – 1.5
Weathered Bedrock[1]	SANDSTONE or LAMINITE, extremely weathered, extremely low to soil strength, moist.	1.07-1.10-	1.0 – 3.88	2.0-2.02	2.0 – 2.5	3.0–6.66	2.0 – 3.0	0.8 – 2.4	1.0 – 3.33	1.5 – 2.0
	SANDSTONE, distinctly bedded at 0-5°, dark grey to grey green to orange, generally slightly weathered with clay bands, low estimated strength. Class V Sandstone.	-	-	-	-	-	-	-	-	2.0-3.9

Note. In BH2, “No core” sections from 1.62-1.76m and 2.73m-3.00m are inferred to be soft clay bands.
Note. Rock coring undertaken in BH2, BH8, BH9.
[1] Pells P.J.N, Mostyn G. & Walker B.F. Foundations on Sandstone and Shale in the Sydney Region, Australian Geomechanics Journal, December 1998

6.3 Groundwater

Groundwater was encountered during augering only in BH3 as a perched water-table at 0.5m depth. Due to the introduction of water required for coring, measurement of water levels during rock coring was not possible.

Groundwater measurements taken on 23 November 2022 in the installed groundwater wells are shown below.

Table 2. Groundwater Levels

Borehole	BH2	BH6	BH8	BH9
Date	23 Nov 2022	23 Nov 2022	23 Nov 2022	23 Nov 2022
Groundwater Level (m bgl)	0.91	1.52	2.33	3.66

From the borehole logs, it is likely that groundwater seepage is at the soil-rock contact surface and through joints and defects in the underlying weathered bedrock. It should also be noted that groundwater levels may be associated with infiltration through soils into the fractured rock mass and may be subject to seasonal and daily fluctuations, influenced by factors such as broken services, leakage from existing pipes onsite and future development of the surrounding land.

7. GEOTECHNICAL ASSESSMENT

7.1 General Conditions

The site is generally underlain by fill (0.2-1.2m thick) and residual or alluvial soil overlying Laminite or Sandstone bedrock at depths of between 0.8m and 3.0m, varying within the site. It is understood that the proposed works do not require bulk excavation; however, some minor cut and fill may be required for regrading of the area and for forming safe slope angles and potentially for retaining wall construction or repair.

Groundwater was encountered at 0.91m to 3.66m below ground level (bgl).

Key geotechnical constraints to the development include excavation conditions, groundwater and surface water control (during construction and long-term), temporary shoring, permanent retaining walls, foundation conditions, construction in a potential landslide risk area. Recommendations for the sub-division and construction of new residential dwellings are provided in the following sections.

7.2 Excavation Conditions

Any excavation or earthworks for re-grading will be in the fill and residual or alluvial soils. Sandstone / Laminite bedrock may be encountered in the vicinity of Borehole BH1.

Excavation within the soils and extremely low to low strength bedrock would be readily carried out using a standard excavator of 10-15 tonne capacity.

The rock classification system (Pells, Mostyn and Walker 1998) in Table 1 above is intended for use in the design of foundations and should not be used to directly assess rock excavation characteristics. Contractors should refer to the engineering logs and core photographs when assessing the suitability of their excavation equipment.

7.3 Earth Pressures

There are several timber sleeper and timber log retaining walls on the site, and due to the age and state of the retaining walls – some are bulging and tilting – some of these may need to be replaced during the preparation of the site for the new sub-division.

The area to the west of the house at No. 57 The Avenue will require some form of retention as the areas shows signs of slow-moving soil creep in the form of tilted trees and slowly opening cracks in the house.

Earth retaining structures should be designed to withstand the lateral earth pressure, hydrostatic and earthquake (if applicable) pressures, and the applied surcharge loads in their zone of influence, including existing structures, traffic and construction related activities.

For the design of flexible retaining structures, where some lateral movement is acceptable, it is recommended the design should be based on active lateral earth pressure. Should it be critical to limit the horizontal deformation of a retaining structure, use of an earth pressure coefficient "at rest" should be considered such as the case when the shoring wall is in the final permanent state and is restrained by a concrete slab in its final state.

Recommended parameters for the design of earth retaining structures in the soils and rock horizons underlying the site are presented in Table 3.

Table 3. Geotechnical Design Parameters for Retaining Walls

Units	Unit Weight (kN/m^3)	Effective Cohesion c' (kPa)	Angle of Friction ϕ' (°)	Modulus of Elasticity E_{sh} (Mpa)
Top-Soil/ Fill	16	0	22	3
Residual Soil	18	5	24	8
Alluvial Soil	18	0	22	5
Extremely weathered bedrock	20	5-10	26	30
Class V Sandstone/Laminite	22	50	28	75

Table 4 below provides preliminary coefficients of lateral earth pressure for the soils and rocks encountered during the geotechnical investigation. The coefficients provided are based on horizontal ground surface and fully drained conditions.

Table 4. Coefficients of Lateral Earth Pressure

Units	Coefficient of Active Lateral Earth Pressure Ka	Coefficient of Active Lateral Earth Pressure at Rest Ko	Coefficient of Passive Lateral Earth Pressure Kp
Topsoil/Fill	0.39	0.56	2.56
Residual Soil	0.42	0.59	2.37
Alluvial Soil	0.42	0.59	2.37
Extremely weathered bedrock	0.3	0.5	3.0
Class V Sandstone/Laminite	0.3	0.5	3.0

- If present, adverse jointing systems in the rock may result in higher active earth pressures than those outlined above. Potential areas of block or wedge failure should therefore be identified during construction and appropriate stabilization measures adopted.
- Coefficient of active and passive lateral earth pressure K_a and K_p, respectively, can be calculated using Rankine's or Coulomb's equations, as appropriate.
- Coefficient of lateral earth pressure at rest K_o for soils, can be calculated using Jacky's equation.

The coefficients of lateral earth pressure should be verified by the project Structural Engineer prior to use in the design of retaining walls. Simplified calculations of lateral active (or at rest) earth pressures can be carried out for braced retaining walls using a uniform lateral earth pressure as follows;

$P_a = 0.65\,K\,\gamma\,H$ For calculation of active earth pressure

where,

P_a = Active (or at rest) Earth Pressure (kN/m^2)
P_p = Passive Earth Pressure (kN/m^2)
γ = Bulk density (kN/m^3)
K = Coefficient of Earth Pressure (K_a or K_o)
K_p = Coefficient of Passive Earth Pressure
H = Retained height (m)
c = Effective Cohesion (kN/m^2)

Anchors will require embedment in Class IV to Class III Sandstone, or better – these classes of Sandstone were not encountered during the site investigation. The recommended allowable bond stresses for anchors socketed within rock underlying the site are presented in Table 5.

Table 5. Allowable Bond Stress for Rock Anchors

Unit	Allowable Bond Stress (kPa)
Class IV Sandstone/Laminite	200
Class III Sandstone/Laminite	600

* Note – Class III and IV Laminite (Shale) not encountered during the geotechnical site investigation.

Anchors should undergo proof testing following installation. The anchors can be designed for the parameters recommended above providing:

- The bond (socket) length in Sandstone bedrock to be at least 3.0m; and
- Anchors are proof tested to 1.3 times the design working load specified by the structural engineer, before they are locked off at working load. Anchor testing should constitute as a "Hold Point".

7.4 Subgrade Preparation and Earthworks

The following general procedure is provided for site preparation of building platforms and pavements:

- Strip topsoil and fill and remove any unsuitable material from site.
- Excavate any residual soils and rock stockpiling for re-use as engineered fill or remove to spoil.
- Where clayey soil is exposed at formation level, the exposed surface should be treated, and moisture conditioned to within 2% of optimum moisture content (OMC) followed by proof rolling with a smooth drum roller. Soft or loose areas should be excavated and replaced with approved fill material.
- Where rock is exposed at footing level, it should be free of loose or softened material.

The suitability of imported materials for filling should be subject to the following criteria:

- The materials should be clean (i.e., free of contaminants, deleterious or organic material), free of inclusions of >120mm in size; high plasticity material and soft material be removed and suitably conditioned to meet the design assumptions where fill material is proposed to be used.
- Material with excessive moisture content should not be used without conditioning.
- The materials should satisfy the Australian Standard AS 3798-2007 (Reference 3).

The final surface levels of all cut and fill areas should be compacted in order to enable the subgrade to achieve adequate strength for the proposed building platforms.

For the fill construction, the recommended compaction targets should be the following:

- Moisture content of ±2% of OMC (Optimal Moisture Content);
- Minimum density ratio of 98% of the maximum dry density for the building platforms of the proposed dwellings;
- The loose thickness of layer should not exceed 300mm during the compaction.

Design and construction of earthworks should be carried out in accordance with Australian Standard AS 3798-2007 (Reference 3).

Inspections by the project Geotechnical Engineer will be required during earthworks, subgrade preparation. The inspections should constitute as "Hold Points".

7.5 Foundations

The new subdivision may require regrading of the site in some areas.

It is recommended that all foundations for new buildings should be in accordance with the Australian Geomechanics Society Practice Note "Some Guidelines For Hillside Construction"

(Reference 9, attached in Appendix H) comprising piles socketed a minimum of 0.5m into low strength Sandstone bedrock or stronger to maintain the long-term stability of the site.

These may comprise raft slab footings founded on bedrock or raft slab on piles to rock, or if on poles then the poles should be founded on piles into weathered bedrock.

Installation of piles is expected to be required in cases where axial loads on columns and walls exceed the bearing pressure of the bearing stratum or where structural loads need to be transferred to deeper bedrock to mitigate against the influence of stress from neighbouring properties or lateral soil pressure on slopes.

Piles may also be required to increase the resistance against lateral seismic and wind loads.

Design of shallow and pile foundations should be carried out in accordance with Australian Standards AS2870-2011 (Reference 4) and AS2159-2009 (Reference 5), respectively.

Table 6 provides geotechnical parameters recommended for design of shallow and piled foundations. Rock classification follows Pells et al (1998) paper (Reference 6).

Table 6. Geotechnical Foundation Design Capacities

Unit	Allowable Capacity Values (kPa)		Ultimate (MPa)
	Serviceability End Bearing Pressure[1]	Shaft Adhesion Compression (Tension)[2]	Ultimate End Bearing Pressure[4]
Fill	N/A[3]	N/A[3]	N/A
Residual Soils	100	N/A[3]	N/A
Extremely weathered bedrock	Up to 500	10 (5)	Max. 1.5
Class IV Laminite[5] or Class V Sandstone	1,000	50 (25)	Max. 3

[1] With a minimum embedment depth of 0.5m for deep foundations and 0.4m for shallow foundations. End bearing pressure to cause settlement of <1% of minimum footing dimension.

[2] Clean rock socket of roughness category of at least R2 or better with grooves of depth 1mm to 4mm and width greater than 5mm at spacing of 50mm to 200mm, values may have to be reduced because of smear. Shaft Adhesion in Tension is 50% of Compression, applicable to piles only.

[3] N/A, Not Applicable, not recommended for the proposed building of this development.

[4] Ultimate values occur at large settlements (> 5% of minimum footing dimensions).

[5] Class IV Laminite and Class IV Sandstone were not encountered during the geotechnical site investigation, but may be encountered during bored pile construction.

Shaft adhesion may be applied to socketed piles adopted for foundations provided socket shaft lengths conform to appropriate classes of Laminite (Shale) and accepted levels of shaft sidewall cleanliness and roughness. The rock socket sidewalls should be free of soil and/or crushed rock to the extent that natural rock is exposed over at least 80% of the socket sidewall. Shaft adhesion should be reduced or ignored within socket lengths that are smeared and fail to satisfy cleanliness requirements. Additional attention to cleanliness of socket sidewalls may be required where presence of clay seams and weathered sandstone bands is evident over socket lengths.

Where the piles penetrate soils that are susceptible to shrinkage and swelling, we recommend that the shaft adhesion be ignored in the zone of seasonal moisture variations due to the potential of the soils for shrinkage cracking.

Due to the presence of groundwater, bored piles may require dewatering as well as liners to support overburden soils.

Any groundwater seepage or surface water run-off should be removed from any excavation prior to concrete pouring. Any loose debris and wet soils should also be removed from excavations.

An experienced Geotechnical Engineer should review foundation designs to ensure compliance with the recommendations in the geotechnical report and assess foundation excavations to ensure suitable materials of appropriate bearing capacity have been reached. The presence of water within foundation excavations may negate satisfactory examination of founding surfaces and certification of founding materials quality. Foundation inspections should only be undertaken under conditions satisfying WHS requirements.

As the site is a sloping site, Aargus recommends following the Australian Geomechanics Society Practice Note “Some Guidelines For Hillside Construction” (Practice note guidelines for landslide risk management 2007) and the CSIRO guide “Foundation Maintenance and Footing Performance : A Homeowners Guide”, both attached to this report., and the recommendations in Section 7.

Verification of the capacity of shallow and pile foundations by inspections would be required and inspections should constitute as “Hold Points”.

The site is located in a Category ‘H1’ Landslide Hazard Area. To minimise the risk of potential landslides, the additional recommendations in Section 8 Landslide Risk Assessment must be complied with.

7.6 Groundwater Management

From the four groundwater wells installed on the site, groundwater levels vary from 0.91m to 3.66m below ground level. These levels are generally at or near the soil-rock contact or below in the weathered bedrock. In deeper excavations and in bored piles some inflow is expected in the form of slight seepage within the joints and fractures of weathered Class V and Class IV/ Laminite bedrock.

Pooled groundwater should be removed from footings in the natural clays and in bored piers prior to pouring of concrete, as the natural clays will soften in contact with water.

Surface run-off water should be channelled and directed away from footings for future residential dwellings.

7.7 Atterburg Limits and Linear Shrinkage

Atterburg limit and linear shrinkage testing was carried out on disturbed soil samples recovered from the boreholes. The results of the tests are presented in Table 8 below and detailed on the attached Lab Test Results presented in Appendix E. The results plot above Casagrande’s A-Line and indicate that the soils comprise inorganic clay of low plasticity.

Linear shrinkage values generally of between 3.5% and 12% are consistent with the Atterburg limits and indicate low to medium swelling potential in these clays, with one sample from BH8 (LS value of 12%) indicating high shrink-swell potential.

Table 7. Results of Atterburg Limit Tests

Borehole ID	Depth (m)	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity index (%)	Linear Shrinkage (%)
BH1	0.5	15.7	21	16	5	3.5
BH2	0.8-1.2	18.7	40	17	23	9.0
BH3	0.6-0.8	22.8	23	16	7	4.0
BH4	1.0-1.2	21.1	25	16	9	5.5
BH5	1.0-1.2	34.7	34	19	15	7.0
BH6	0.5	19.8	38	17	21	10.5
BH7	0.6-0.8	20.6	38	18	20	10.0
BH8	0.3-1.0	27.5	55	25	30	12.0
BH9	1.2	8.6	29	15	14	8.5

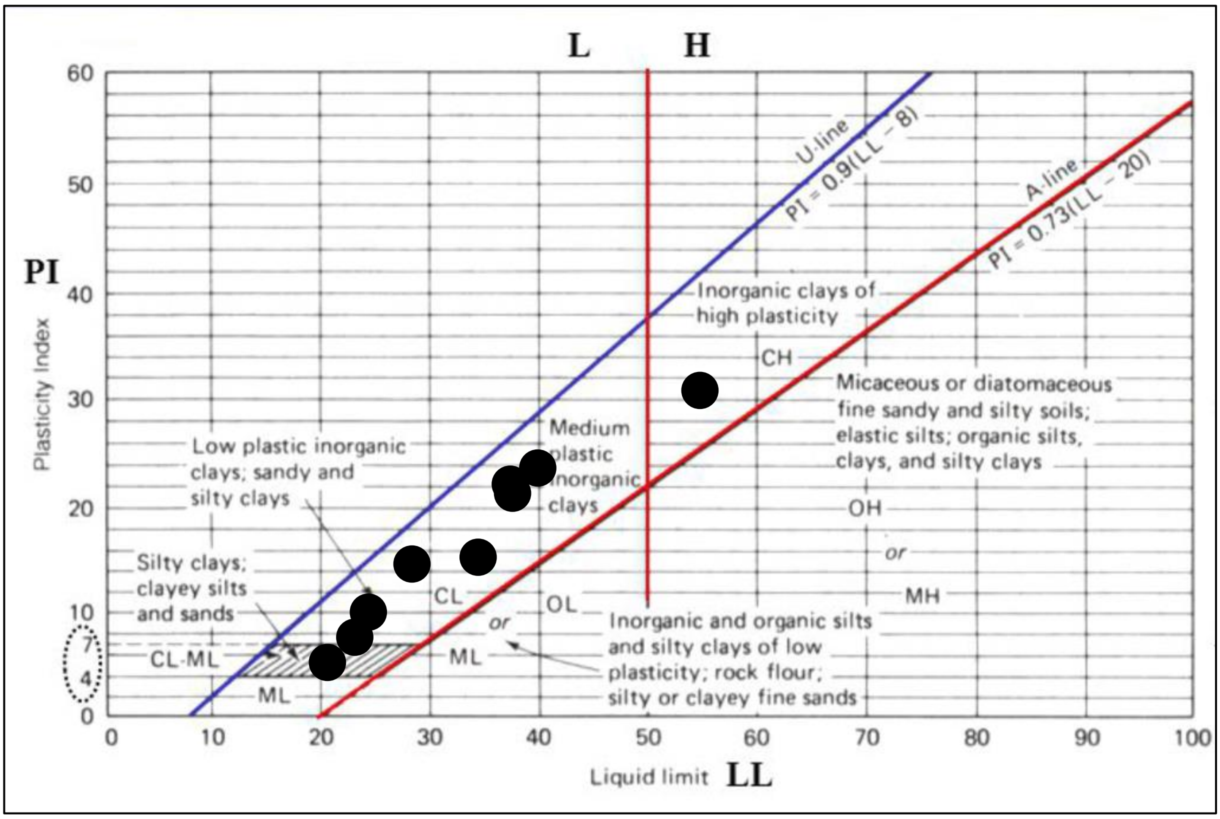


Figure 1. A-Line plot showing Atterberg test results.

7.8 Site Lot Classification

Atterberg Limits tests were undertaken on soil samples from within the footprint of each of the new lot areas to establish site lot classification. The Atterberg Limits Test results show that that the Residual Clay soils are mostly low to medium plasticity.

For those lots with shallow fill or topsoil > 0.4m thickness of clayey fill or > 0.8m thickness of sandy fill, the Lot Class is ‘P’. If the footings will be founded in the underlying Residual Clay soils, the lots are classified as ‘S’, ‘M’ or ‘H1’ dependent on the clay thickness.

Table 8. Site Lot Classification

(New) Lot No.	Borehole No.	Fill Thickness	Clay Thickness	Lot Class	Lot Class (if foundations on Clay)
1	BH7	0.6	0.2	P	S
2	BH8	0.3	0.7	M	M
3	BH1	0.7 (Clay)	0.45	P	S
4	BH5	0.76 (Clay and Sand)	2.2	P	H1
5	BH4	0.9 (Sandy)	1.0	P	M
6	BH2	0.14 (Sandy)	0.8	M	M
7	BH6	1.2 (Clay)	0.8	P	M
8	BH3	0.2 (Sandy)	1.8	M	M
9	BH9	0.5 (Gravel)	1.0	M	M

For ‘A’ class sites, characteristic surface movement of $0 < y_s \leq 20$ mm is possible, in accordance with Australian Standard AS2870-2011 Residential Slabs and Footings.

For ‘M’ class sites, characteristic surface movement of $20 < y_s \leq 40$ mm is possible, in accordance with Australian Standard AS2870-2011 Residential Slabs and Footings.

For ‘H1’ class sites, characteristic surface movement of $40 < y_s \leq 60$ mm is possible, in accordance with Australian Standard AS2870-2011 Residential Slabs and Footings.

7.9 Soil Salinity and Aggressivity Test Results

Soil samples recovered from the boreholes were tested for salinity, electrical conductivity (EC), pH, chloride (Cl-), and Sulphate (S04) content. A NATA accredited laboratory carried out these tests. The required soil samples for salinity and aggressivity tests were taken from the depths of approximately 0.8m to 1.2m bgl, corresponding to the natural layer. The results are presented in Table 2, with the details attached in Appendix E. Results are assessed in conjunction with the exposure classification for soil aggressivity levels for buried concrete and steel elements, following AS 2159-2009.

Table 9. Soil Salinity and Aggressivity Test Results

Borehole	Depth (m (bgl)	pH	Resistivity (ohm.cm)	Moisture %	Sulphate (SO4) (mg/kg or ppm)	Chloride (mg/kg)	ECe (dS/m)	Salinity Condition
BH1	0.6	6.4	50,000	14	< 10	< 10	0.14	Non-saline
BH2	0.8	6.9	12,658	16	110	10	0.55	Non-saline
BH3	0.5	6.6	41,667	18	< 10	< 10	0.17	Non-saline
BH4	1.0-1.2	6.5	31,250	18	33	< 10	0.22	Non-saline
BH5	0.8	6.8	21,739	13	< 10	15	0.32	Non-saline
BH8	0.3-1.0	7.1	35,714	21	< 10	< 10	0.20	Non-saline

Reference to AS2159-2009, "Piling–Design and Installation", and the results of soil electrical conductivity, pH, Chloride, and Sulphate tests summarised in Table 4 indicate that the soil samples tested have an exposure classification for soil condition B (low permeability soils) of:

- "Non-aggressive" to concrete piles or structures in low permeability soils based on the pH and Sulphate test results.
- "Non-aggressive" to steel piles or structures in low permeability soils based on the electrical resistivity, Chloride and pH test results.

The Australian Standard AS2159-2009 states "pH alone may be a misleading measure of aggressivity without a full analysis of causes", and that pH may change over the lifetime of the pile. Refer to Appendix E for laboratory test results and further explanatory notes on the exposure classifications for concrete and steel structures, extracted from Australian Standard AS2159-2009 "Piling - Design and Installation".

Through the introduction of a multiplying factor to the test results, as stipulated in the Department of Natural Resources (DNR) publication "Site Investigations for Urban Salinity" – 2002 (Reference 7), the resultant electrical conductivity of saturated extracts (ECe) ranged from approximately 0.17 to 0.55 dS/m, indicating a "Non-saline" condition.

7.10 Site Earthquake Classification

The results of the site investigation indicate the presence of fill and residual soil extending to a depth of 1m and underlain by variable strength bedrock. In accordance with Australian Standard AS 1170.4-2007 (Reference 2) the site may be classified as a "Shallow Soil Site" (Class C_e) for design of foundations and retaining walls embedded in the underlying soils or as a "Rock" site (Class B_e) for the design of foundations and retaining walls embedded into weathered bedrock. The Hazard Factor (Z) for this site within Sydney, in accordance with AS 1170. 4-2007 is considered to be 0.08.

8. LANDSLIDE RISK ASSESSMENT

Information from the Northern Beaches Council shows that the site is in an area classified as Category H1 Geotechnical Hazard Area.

5. **Geotechnical Hazard "H1" (PLEP 2014)**
A Geotechnical Report as the development is on land classified as H1 on the Pittwater Geotechnical Hazard Map in accordance with Geotechnical Risk Management Policy for Pittwater. The report is to be prepared by a suitably qualified geotechnical consultant. The report is to be accompanied by completed Forms 1 & 1A, as per the Policy.

8.1 General

The stability of a site is generally governed by site factors such as slope angles, depth of soils, strength of sub-surface material, drainage, movements of groundwater and surface runoff, potential sliding planes such as interface of rock/soil and faults in bedrock.

Due to the sloping nature of this site, geotechnical investigation and assessment in accordance with guidelines published by the Australian Geomechanics Society (Reference 12) and the Geotechnical Risk Management Policy for Pittwater (by Pittwater Council, Council Policy No. 178, dated 20 July 2009, Reference 11) is required in order to demonstrate that the proposed development is justified in terms of geotechnical stability.

In this section, the stability of the site before and after construction of the proposed development is assessed based on the AGS guidelines.

The Landslide Risk Assessment presented below should be reviewed when the proposed development plans are finalised.

8.2 Pre-development

The seven lots on site are to be amalgamated, the houses and other structures demolished, and nine new lots created with an access driveway to run south from The Avenue.

The site has variable slopes. Elevation data was taken from a site survey plan "Plan of Site Detail and Levels" 122-128 Crescent Rd, Newport by Boxall Surveyors, dated 5/5/22, Drawing Number 11369-001-A Rev A.

The following features were observed during the fieldwork:

- The site is currently occupied by four single to double-storey brick or weatherboard residential dwellings and two commercial buildings in the southern area, with associated grassed areas, gardens, footpaths and driveways.
- The site elevation varies from approximately RL 19.4 m AHD in the north-eastern corner to RL 1.74 m AHD in the western side at the marina deck, sloping from east/north-east to the shoreline at the west with slopes from 9° to 12° degrees, with some relatively level areas (4°) and localised cut faces up to 29° adjacent to these areas. Slopes to the top of the western retaining wall and in the treed slope west of No. 57 The Avenue were at 26-29°.
- Apart from the houses and garages, most of the ground surface was covered with grass, pavement areas and trees.

- There are three main retaining walls; along the northern edge of the current access road to the marina (0.3m up to 2.6m high, timber log in parts and timber sleeper and timber log construction in the higher parts), one to the west of No. 126 Crescent Rd (dry wall brick, angled), and the third oriented approximately NW-SE above the marina flat concrete area (timber log with vertical retaining posts, c. 1.2m high).
- Some of the retaining walls showed slight bulging (see Figure 2). There were no signs of ground movement associated with the bulging.
- Visible tension cracks in some asphalt surfaces were observed, parallel to retaining walls or slope edges (see Figure 2). A tension crack was visible in the ground near the small pedestrian bridge over the gully near the SW corner the house at No. 57 The Avenue.
- There were no cracks in the ground, slumping, or other signs of landslip observed in the parts of the site outside this area.
- The house at No. 57 The Avenue, a double storey brick house, shows vertical and horizontal cracks associated with ground movement. From discussion with the current resident, the cracks are slowly opening and the existing vertical cracks (from 5-8mm wide) have opened over a 7-8 year period.
- The other houses on site are perhaps 30-50 years old, based on the style of construction and appear to be in good condition, with no signs of cracking or movement of retaining walls.
- Curved, tilted or bent trees can indicate rotation due to soil creep or movement. A variety of trees are present on the site, including camphor-laurel, jacaranda, Sydney Red Gum, Stringy Bark, palm trees and other shrubs and bushes. Some of the trees are up to 15m in height. Some trees adjacent to and down-slope from the House at No. 57 The Avenue showed tilting, up to 30°, which is indicative that some ground movement such as soil creep is occurring. This area is defined on the site plan (Figure 2). Trees on the other parts of the site showed no signs of bending or tilting,
- No surface water ponding or seepage was observed during the fieldwork, and the soil was generally moist.
- A gully to the south of the SW corner of the house at No. 57 drains to the backfill retained by a timber log retaining wall at the edge of the concrete marina deck. This wall shows signs of tilting up to 12°.
- The surrounding areas to the north, east and south of the site were also assessed, as far as was possible. The area to the west is Windji Jimmi Bay. To the north is The Avenue, which showed no signs of ground movement down to No 57. Beyond No. 57 is a steep treed slope down to the marina – discussed previously. To the east is Crescent Rd, which showed no tension cracks, differential kerb movement or settlement. To the south is No. 118-120 Crescent Rd, comprising residential dwellings. There is a low retaining wall 0.3-0.6m high which shows some signs of rotation towards the site. This retaining wall supports a driveway approximately 5m wide within 118-120 Crescent Rd. Any preparation and planning for earthworks on-site should take potential movement along this boundary into account.

Geotechnical investigation using hand auger equipment and truck-mounted drilling rig encountered refusal at a maximum depth of > 6.66m on low strength weathered Sandstone bedrock.

It should be noted that the trees and grass present on site are considered to be contributing towards the stability of the site, especially in the steeper areas of the site to the west.

Based on the topography, the ground conditions of the site, and the height and condition of the trees on the site, the following hazards have been identified as potential landslide mechanisms:

- Soil creep
- Shallow slip

8.3 Risk to Property and Life

The assessed risk levels of the hazards and risk to property at the existing conditions are summarised in Table 10. These risk ratings are based on the "Qualitative Risk Analysis Matrix" in Appendix C of "Practice note guidelines for Landslide Risk Management 2007" (Reference 12). In the assessment, consideration was given to the potential effects of instability on the adjoining properties, including effects on the land, buildings and occupiers within the adjoining properties.

Table 10. Assessed Risk to Property – Pre-development

Potential Hazard	Qualitative Measures of Likelihood	Qualitative Measures of Consequences to Property	Qualitative Risk Analysis – Level of Risk to Property
Soil Creep	A – Almost Certain (10^{-1})	4: Minor 5%	High
Shallow Slip	C – Possible (10^{-3})	4: Minor 5%	Moderate

It should be noted that these potential hazards occur in different parts of the site. Potential Hazard 1 (soil creep) may occur anywhere across the site. Potential Hazard 2 may occur at the western edges of the site where there are limited steep slopes above the flat working area of the marina – some of these slopes are retained by timber sleeper retaining walls.

It should also be noted that there is some evidence for Potential Hazard 1 (soil creep) only in the vicinity of the western edge of the site where the site has some steep un-retained and retained slopes down to the marina. It is an active extremely slow-moving moist earth flow, causing some cracking in the double storey brick residence at No. 57 The Avenue, and tilting of trees down-slope.

There is no visible evidence of the occurrence of Potential Hazard 1 (soil creep) in any other part of the site nor evidence for Potential Hazard 2 (shallow slip) anywhere on the site.

The overall slope instability risk of the site under existing conditions prior to construction of the currently proposed development is assessed to be **"Moderate to high"** resulting from actual down-slope soil creep in the vicinity of boreholes BH3 and BH9 and potential shallow slip and down-slope soil creep in other areas. According to "Practice Note Guidelines for Landslide Risk Management 2007", the "Moderate Risk Level" may be tolerated in certain circumstances but requires investigation, planning and implementation of treatment options required to reduce the risk to a "Low Risk Level". The "High" risk level is considered to be unacceptable without treatment. Treatment recommendations follow, in Section 8.5 Mitigation and Control Measures.

Using the calculation methods in the AGS "Practice Note Guidelines for Landslide Risk Management 2007" (Reference 12) and "Commentary on Practice Note Guidelines for Landslide Risk Management 2007" (Reference 13) current loss of life risk for the person most at risk for the "existing slopes" before the development sub-division of the site is 2.5 x 10^{-4} /annum.

The AGS guidelines recommend tolerable loss of life risk for the person most at risk for "new constructed slopes/new development" is 1 x 10^{-5}/annum.

The risk to life for the person most at risk post-development due to the above listed hazards was calculated to be in the order of 1.0 x 10^{-6}/annum. This risk value assumes compliance with the recommendations below.

8.4 Post-Development

Details of the proposed development include the demolition of the existing buildings on the site, amalgamation of the existing seven lots (apart from the marina lot) and sub-division into nine new lots, with a single access road from The Avenue. The new lots are for residential dwellings.

Without appropriate batter slopes or retaining walls (where required), earthworks activities may lead to a "High Risk" of instability, especially along the western/ north-western edge of the site where some of the soil is retained by retaining walls along the edge of Lot111 DP 556902 running north-west to a small shed directly west of the house at No. 57 The Avenue, with slopes of 35-40° dipping to the west north of this shed.

Therefore, appropriate measures to mitigate against slope instability should be incorporated into the design of the proposed sub-division, specifically into the design and construction of retaining walls and, in the future, foundations for dwellings.

The mitigation and control measures recommended for the proposed development are summarised in Section 8.4 of this report.

On the condition that the recommendations and design parameters provided in this report are taken into consideration during design and implementation of earthworks and other works for the sub-division, as well as post earthworks and sub-division works, then the assessed risks relating to stability of the site at completion of the sub-division works are as shown in Table 11 below.

Table 11. Assessed Risk to Property – Post-development

Potential Hazard	Qualitative Measures of Likelihood	Qualitative Measures of Consequences to Property	Qualitative Risk Analysis – Level of Risk to Property
Soil Creep (Earth Flow)	D – Unlikely (10^{-4})	4: Minor 5%	Low
Shallow Slip (Shallow Rotational Earth Slide or Slump)	D – Unlikely (10^{-4})	4: Minor 5%	Low

The overall slope instability risk of the site after the subdivision is assessed to be **"Low"** if activities within the site and design and construction of the development are in accordance with Aargus recommendations**.**

The AGS guidelines recommend that post-development tolerable loss of life risk for the person most at risk is 1 x 10^{-5}/annum.

8.5 Mitigation and Control Measures

At present there are no construction plans for building on the new lots. As such, the development comprises only the new sub-division, potential new service installation (potable water, drainage, electricity etc.), potentially some regrading / earthworks of the site.

To reduce the level of risk of instability, the proposed development (sub-division) of this site should be undertaken according to the recommendations presented in this report together with following provisions:

- In general, the design and construction of earthworks, foundations, retaining structures, excavation stabilisation and drainage measures for the proposed development and the existing house should adhere to "Good engineering practice for hillside construction" as set out in Appendix G of "Practice Note Guidelines for Landslide Risk Management 2007" by the Australian Geomechanics Society (AGS), 2007", attached as Appendix F in this report.
- Any future proposed excavations within the site should be accompanied by site observations by a suitably experienced Geotechnical Practitioner and monitoring for ground movement and vibration as appropriate.
- Vibration levels should be monitored if methods of excavation adopted are likely to produce vibration intensities that may be detrimental to existing structures or that may trigger instability in the soils and rock within the site.
- Any vertical cut or fill exceeding 0.5m in depth in soil should be retained by appropriately designed retaining walls.
- Foundation systems for the retaining walls and any building structures, water tanks, etc. are to be founded and embedded into bedrock and where necessary designed for lateral earth pressures induced by translational soil movement along the interface between the soils and the underlying rock.

- Any cause of instability of the ground profile within the neighbouring properties should be addressed prior to commencement of excavation and proper stabilisation action needs to be implemented.
- Backfill behind walls within the development area should be placed and compacted to engineering standards in accordance with Australian Standard AS3798-2007 (Reference 3), which provides the criteria for earthworks associated with residential developments, including materials, compaction criteria, site preparation and fill construction, methods of testing and inspection and testing frequencies. Appropriate backfill drainage is to be provided.
- Appropriate drainage measures should be incorporated to ensure all surface and subsurface water flows and waste-water or collected roof water flows are diverted away from the western slopes and away from areas of retained fill into rain-water tanks, the stormwater drainage system or other appropriate discharge.
- It was noted in the geotechnical assessment of the site that some of the retaining walls showed bulging, along the marina access road and above the flat areas of the marina running along the western side of Lot 111 DP 556902. To reduce risk to people planning to build on the new lots, and to reduce the risk to life and property of users of the properties and the marina below, these walls should be replaced by retaining walls designed by a structural engineer. Surface water and drainage should be directed away from these walls and not feed into the fill that is retained by these walls.
- The slope areas west of the house at No. 57 The Avenue show evidence of slow-moving soil creep, e.g. trees tilted up to 30°, cracks in the house brickwork. This area must be retained to halt further movement.
- Existing drainage should be checked for leaks.
- Retaining walls and shoring should be constructed and supported in such a manner as not to induce instability that may be associated with construction procedures and sequencing or exposure of unsupported faces.
- Earth pressure coefficients for sloping ground should be adopted for design purposes as required.
- All retaining walls and footings to be designed by a qualified, practising Structural Engineer in accordance with the recommendations in the Geotechnical Report.
- Inspection and maintenance of permanent retaining walls should be carried out periodically.
- Future construction activities should be carefully planned and observed by a Geotechnical Engineer for further assessment of the necessary mitigation and control measures.

Implementation of the measures recommended above should constitute as “Hold Points”.

The site is suitable, or can be made suitable, for the proposed sub-division from a geotechnical perspective, and the site and development proposal can achieve the Acceptable Risk

Management levels required by the Geotechnical Risk Management Policy for Pittwater, 2009", provided that the recommendations described in this geotechnical report are adhered to.

In accordance with Pittwater Council "Geotechnical Risk Management Policy for Pittwater – 2009" the following geotechnical conditions apply:

- Structural designs for any form of construction must be checked and certified by a suitably qualified and experienced Geotechnical Engineer/Engineering Geologist as being in accordance with the geotechnical recommendations in this Geotechnical Site Investigation Report and Landslide Risk Assessment, in order to achieve the Acceptable risk management level described in Table 10 above.
- Geotechnical aspects of any works on site including construction of retaining walls, buildings, footing assessment, cut and fill etc. require the sign-off or certification of a suitably qualified and experienced Geotechnical Engineer/Engineering Geologist as being in accordance with the geotechnical recommendations in this Geotechnical Site Investigation Report and Landslide Risk Assessment, in order to achieve the Acceptable risk Management level described above.
- For the ongoing maintenance of the site and mitigation of any potential landslip, it is recommended that future purchasers of the new lots are made aware of their obligations with regards to maintenance of retaining walls, channelling of surface waters away from retaining wall backfill and following the recommendations in the AGS Guidelines "Good Hillside Construction Practice".

9. LIMITATIONS

The geotechnical assessment of the subsurface profile and geotechnical conditions within the proposed development area and the conclusions and recommendations presented in this report have been based on available information obtained during the work carried out by Aargus and in the provided documents listed in Section 2 of this report. Inferences about the nature and continuity of ground conditions away from and beyond the locations of field exploratory tests are made but cannot be guaranteed.

It is recommended that should ground conditions including subsurface and groundwater conditions, encountered during construction and excavation vary substantially from those presented within this report, Aargus Pty Ltd be contacted immediately for further advice and any necessary review of recommendations. Aargus does not accept any liability for site conditions not observed or accessible during the time of the inspection.

This report and associated documentation and the information herein have been prepared solely for the use of **Essex Developments Pty Ltd** and any reliance assumed by third parties on this report shall be at such parties' own risk. Any ensuing liability resulting from use of the report by third parties cannot be transferred to Aargus Pty Ltd, directors or employees.

The conclusions and recommendations of this report should be read in conjunction with the entire report.

For and on behalf of

Aargus Pty Ltd

Reviewed by

R. Furniss

Rafael Furniss
Senior Engineering Geologist
BSc (Applied Geology), Hons, MSc
MAGS, MAIG, ISSMGE

APPENDIX A

Information About Geotech Report

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL ENGINEERING REPORT

More construction problems are caused by site subsurface conditions than any other factor. As troublesome as subsurface problems can be, their frequency and extent have been lessened considerably in recent years, due in large measure to programs and publications of ASFE/ The Association of Engineering Firms Practicing in the Geosciences.

The following suggestions and observations are offered to help you reduce the geotechnical-related delays, cost-overruns and other costly headaches that can occur during a construction project.

A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

A geotechnical engineering report is based on a subsurface exploration plan designed to incorporate a unique set of project-specific factors. These typically include the general nature of the structure involved, its size and configuration, the location of the structure on the site and its orientation, physical concomitants such as access roads, parking lots, and underground utilities, and the level of additional risk which the client assumed by virtue of limitations imposed upon the exploratory program.

To help avoid costly problems, consult the geotechnical engineer to determine how any factors which change subsequent to the date of the report may affect its recommendations.

Unless your consulting geotechnical engineer indicates otherwise, *your geotechnical engineering report should NOT be used:*

- when the nature of the proposed structure is changed: for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an un-refrigerated one,
- when the size or configuration of the proposed structure is altered,
- when the location or orientation of the proposed structure is modified,
- when there is a change of ownership, or

for application to an adjacent site.

Geotechnical engineers cannot accept responsibility for problems which may develop if they are not consulted after factors considered in their report's development have changed.

Geotechnical reports present the results of investigations carried out for a specific project and usually for a specific phase of the project. The report may not be relevant for other phases of the project, or where project details change.

The advice herein relates only to this project and the scope of works provided by the Client.

Soil and Rock Descriptions are based on AS1726-1993, using visual and tactile assessment except at discrete locations where field and/or laboratory tests have been carried out. Refer to the attached terms and symbols sheets for definitions.

MOST GEOTECHNICAL "FINDINGS" ARE PROFESSIONAL ESTIMATES

Site exploration identifies actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent laboratory testing are extrapolated by geotechnical engineers who then render an opinion about overall subsurface conditions, their likely reaction to proposed construction activity, and appropriate foundation design. Even under optimal circumstances actual conditions may differ from those inferred to exist, because no geotechnical engineer, no matter how qualified, and no subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predictions. *Nothing can be done to prevent the unanticipated, but steps can be taken to help minimize their impact. For this reason, most experienced owners retain their geotechnical consultants through the construction stage*, to identify variances, conduct additional tests which may be needed, and to recommend solutions to problems encountered on site.

SUBSURFACE CONDITIONS CAN CHANGE

Subsurface conditions may be modified by constantly changing natural forces. Because a geotechnical engineering report is based on conditions which existed at the time of subsurface exploration, *construction decisions should not be based on a geotechnical engineering report whose adequacy may have been affected by time.* Speak with the geotechnical consultant to learn if additional tests are advisable before construction starts.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations may also affect subsurface conditions, and thus, the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

Subsurface conditions can change with time and can vary between test locations. Construction activities at or adjacent to the site and natural events such as flood, earthquake or groundwater fluctuations can also affect the subsurface conditions.

GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND PERSONS

Geotechnical engineers' reports are prepared to meet the specific needs of specific individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor, or even some other consulting civil engineer. Unless indicated otherwise, this report was prepared expressly for the client involved and expressly for purposes indicated by the client. Use by any other persons for any purpose, or by the client for a different purpose, may result in problems.

No individual other than the client should apply this report for its intended purpose without first conferring with the geotechnical engineer. No person should apply this report for any purpose other than that originally contemplated without first conferring with the geotechnical engineer.

A GEOTECHNICAL ENGINEERING REPORT IS SUBJECT TO MISINTERPRETATION

Costly problems can occur when other design professional develop their plans based on misinterpretations of a geotechnical engineering report. To help avoid these problems, the geotechnical engineer should be retained to work with other appropriate design professionals to explain relevant geotechnical findings and to review the adequacy of their plans and specifications relative to geotechnical issues.

The interpretation of the discussion and recommendations contained in this report are based on extrapolation/interpretation from data obtained at discrete locations. Actual conditions in areas not sampled or investigated may differ from those predicted

BORING LOGS SHOULD NOT BE SEPARATED FROM THE ENGINEERING REPORT

Final boring logs are developed by geotechnical engineers based upon their interpretation of field logs (assembled by site personnel) and laboratory evaluation of field samples. Only final boring logs customarily are included in geotechnical engineering reports. These logs should not under any circumstances be redrawn for inclusion in architectural or other design drawings because drafters may commit errors or omissions in the transfer process. Although photographic reproduction eliminates this problem, it does nothing to minimize the possibility of contractors misinterpreting the logs during bid preparation. When this occurs, delays, disputes and unanticipated costs are the all-too-frequent result.

To minimise the likelihood of boring log misinterpretation, give contractors ready access in the complete geotechnical engineering report prepared or authorized for their use. Those who do not provide such access may proceed under mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes which aggravate them to disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY

Because geotechnical engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against geotechnical consultants. To help prevent this problem, geotechnical engineers have developed model clauses for use in written transmittals. These are not exculpatory clauses designed to foist geotechnical engineers' liabilities onto someone else. Rather, they are definitive clauses which identify where geotechnical engineers' responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your geotechnical engineering report, and you are encouraged to read them closely. Your geotechnical engineer will be pleased to give full and frank answers to your questions.

OTHER STEPS YOU CAN TAKE TO REDUCE RISK

Your consulting geotechnical engineer will be pleased to discuss other techniques which can be employed to mitigate risk. In addition, ASFE has developed a variety of materials which may be beneficial. Contact ASFE for a complimentary copy of its publications directory.

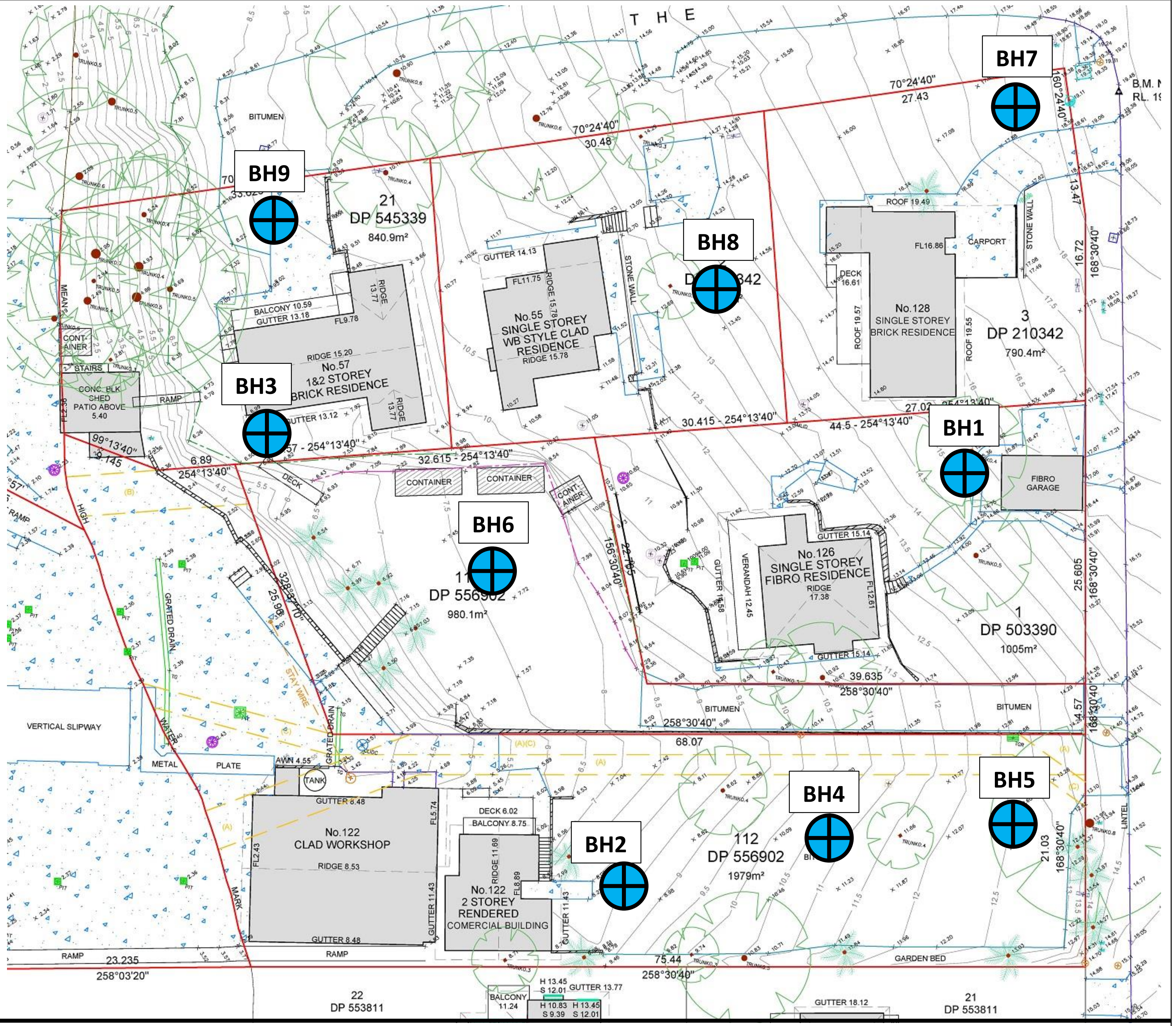
FURTHER GENERAL NOTES

Groundwater levels indicated on the logs are taken at the time of measurement and may not reflect the actual groundwater levels at those specific locations. It should be noted that groundwater levels can fluctuate due to seasonal and tidal activities.

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

APPENDIX B

Site Plan (Figure 1)

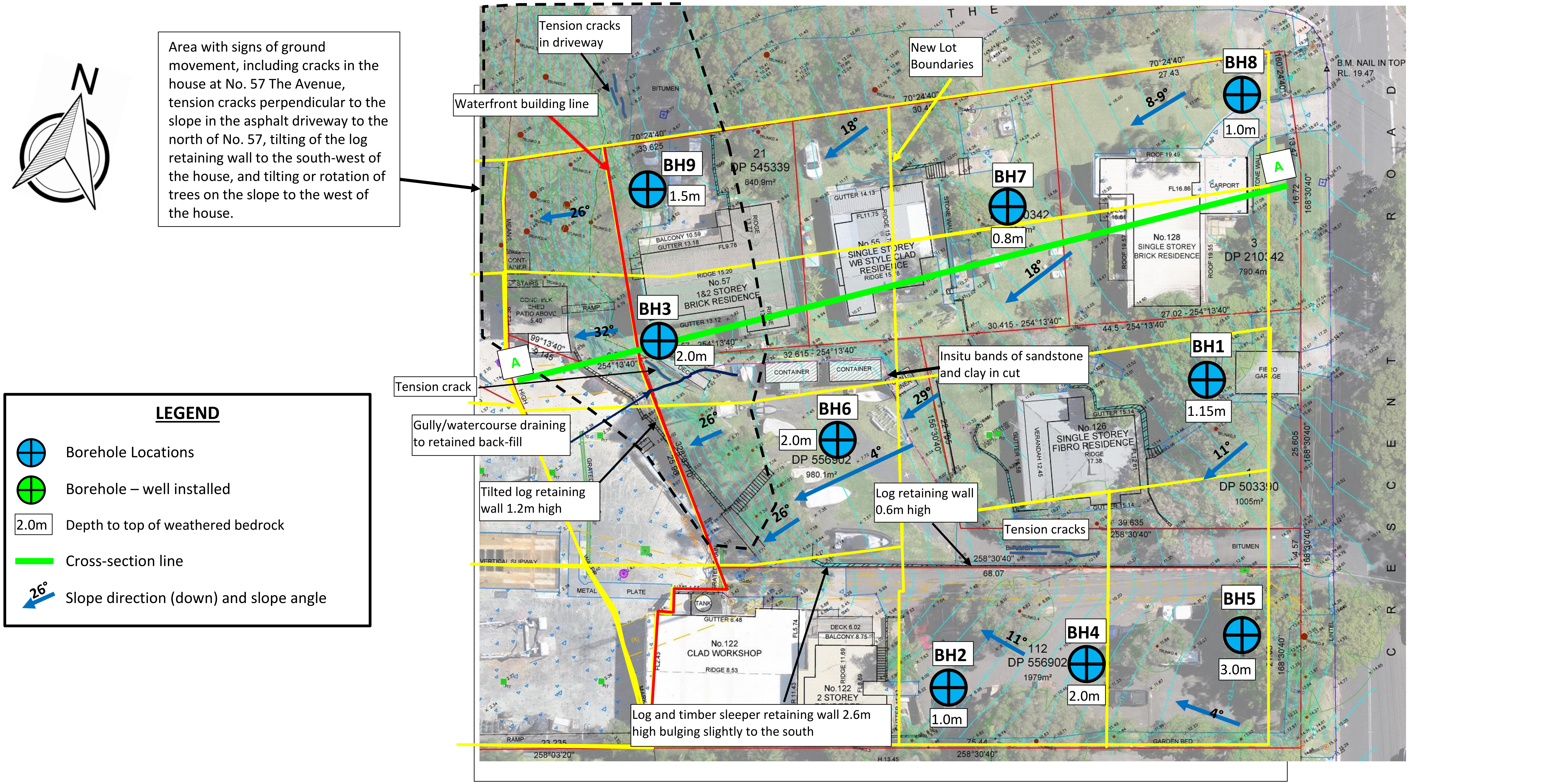


LEGEND

Borehole Locations

Aargus: ENVIRONMENTAL - ENGINEERING - DRILLING - LABORATORIES - ASBESTOS

Drawn	RF	**Essex Developments Pty Ltd** **Geotechnical Investigation Report for Proposed Sub-division** **122 Crescent Road, Newport, NSW 2009**	**Figure** 1
Checked	RF		**Title** Site Plan
Date	28/11/2022		
Scale @ A3	NTS		**Job No** GS8649-2A



Aargus: ENVIRONMENTAL - ENGINEERING - DRILLING - LABORATORIES - ASBESTOS

Drawn	RF	**Essex Developments Pty Ltd** **Geotechnical Investigation Report for Proposed Sub-division** **122 Crescent Road, Newport, NSW 2009**	**Figure** 1
Checked	RF		**Title** Site Plan and Geomorphological Map
Date	22/12/2022		
Scale @ A3	NTS		**Job No** GS8649-2A

Aargus

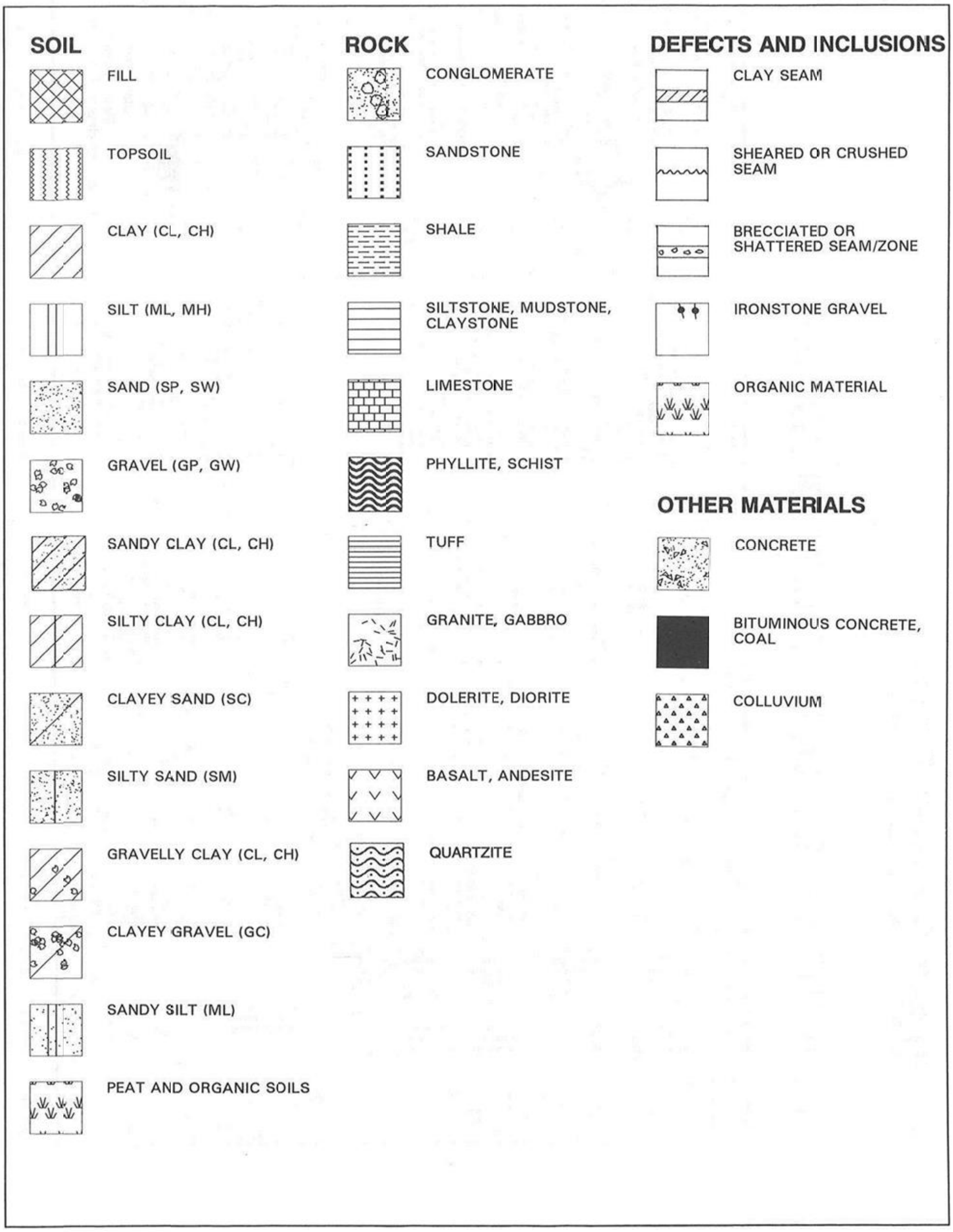
APPENDIX C

Engineering Borehole Logs

Aargus Pty Ltd

GRAPHIC LOG SYMBOLS FOR SOIL AND ROCK

The following information is intended to assist in the interpretation of terms and symbols used in geotechnical borehole logs, test pit logs and reports issued by or for Aargus Pty Ltd. More detailed information relating to specific test methods is available in the relevant Australian



Standard AS1726-2017.

Aargus

Soil Description

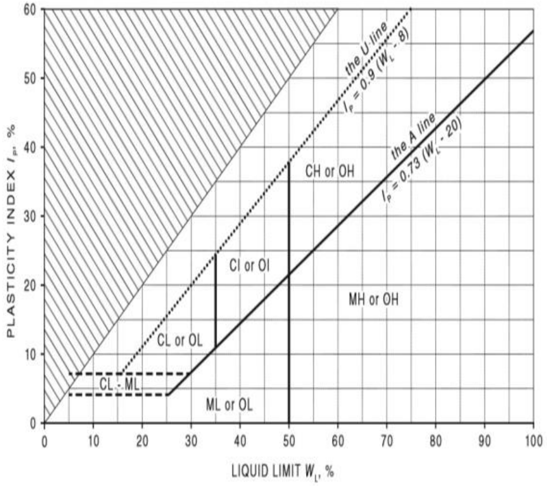
Description and Classification of Soils for Geotechnical Purposes: Refer to AS1726-2017 (Clause 6.1.6)

The following chart (adapted from AS1726-2017, Clause 6.1.6, Table A1) is based on the Unified Soil Classification System (USCS). Table 1

Major Divisions		Particle size mm	USCS Group Symbol	Typical Names	Field classification of sand and gravel	Laboratory Classification				
						% < 0.075 mm	Plasticity of fine fraction	$C_u = \frac{D_{60}}{D_{10}}$	$C_u = \frac{(D_{30})^2}{(D_{10})(D_{60})}$	NOTES
COARSE GRAINED SOILS (more than 65% of soil excluding oversize fraction is greater than 0.075 mm)	BOULDERS	200								
	COBBLES	63				Use the gradation curve of material passing 63 mm for classification of fractions				
	GRAVELS (more than half of coarse fraction is larger than 2.36 mm)		GW	Gravel and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	—	>4	Between 1 and 3	(1) Identify fines by the method given for fine-grained soils.
		coarse	GP	Gravel and gravel-sand mixtures, little or no fines, uniform gravels	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	—	Fails to comply with above		
		20 medium	GM	Gravel-silt mixtures and gravel-sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	Below 'A' line or PI<4	—	Fines behave as silt	(2) Borderline classifications occur when the percentage of fines (fraction smaller than 0.075 mm size) is greater than 5% and less than 12%. Borderline classifications require the use of SP-SM, GW-GC.
		6 fine	GC	Gravel-clay mixtures and gravel-sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	Above 'A' line and PI>7	—	Fines behave as clay	
	SANDS (more than half of coarse fraction is smaller than 2.36 mm)	2.36	SW	Sand and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	—	>6	Between 1 and 3	
		coarse 0.6	SP	Sand and gravel-sand mixtures, little or no fines	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	—	Fails to comply with above		
		medium 0.2	SM	Sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	Below 'A' line or PI<4	—	—	
		fine 0.075	SC	Sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	Above 'A' line and PI>7		—	

Classification of fine-grained soils

Major Divisions		USCS Group Symbol	Typical Names	Field classification of sand and gravel			Laboratory classification
				Dry Strength	Dilatancy	Toughness	% < 0.075 mm
FINE GRAINED SOILS (more than 35% of soil excluding oversize fractions is less than 0.075 mm)	SILT and CLAY (low to medium plasticity, %) (Liquid Limit ≤50%)	ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or silt with low plasticity	None to low	Slow to rapid	Low	Below A line
		CL CI	Inorganic clay of low to medium plasticity, gravelly clay, sandy clay	Medium to high	None to slow	Medium	Above A line
		OL	Organic silts and clays of low plasticity	Low to medium	Slow	Low	Below A line
	SILT and CLAY (high plasticity) (Liquid Limit >50%)	MH	Inorganic silts, mic- aceous or diato-maceous fine sands or silts, elastic silts	Low to medium	None to slow	Low to medium	Below A line
		CH	Inorganic clays of high plasticity, fat clays	High to very high	None	High	Above A line
		OH	Organic clay of medium to high plasticity, organic silt	Medium to high	None to very slow	Low to medium	Below A line
	HIGHLY ORGANIC SOILS	PT	Peat and other highly organic soils	-	-	-	-



Aargus

Soil Colour: Is described in the moist condition using black, white, grey, red, brown, orange, yellow, green or blue. Borderline cases can be described as a combination of two colours, with the weaker followed by the stronger. Modifiers such as pale, dark or mottled, can be used as necessary. Where colour consists of a primary colour with secondary mottling, it should be described as follows: (Primary) mottled (Secondary). Refer to AS 1726-2017, Clause 6.1.5

Soil Moisture Condition: Is based on the appearance and feel of soil. Refer to AS 1726-2017, Clause 6.1.7

Term	Description
Dry (D)	Cohesive soils; hard and friable or powdery, well dry of plastic limit. Granular soils; cohesionless and free-running.
Moist	Soil feels cool, darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	Soil feels cool, darkened in colour. Cohesive soils usually weakened and free water forms on hands when handling. Granular soils tend to cohere and free water forms on hands when handling.

Consistency of Cohesive Soils: May be estimated using simple field tests, or described in terms of a strength scale. In the field, the undrained shear strength (s_u) can be assessed using a simple field tool appropriate for cohesive soils, in conjunction with the relevant calibration. Refer to AS 1726-2017, Table 11.

Consistency - Essentially Cohesive Soils					
Term	**Field Guide**	**Symbol**	**SPT "N" Value**	**Undrained Shear Strength s_u (kPa)**	**Unconfined Compressive Strength q_u (kPa)**
Very soft	Exudes between the fingers when squeezed in hand	VS	0-2	<12	<25
Soft	Can be moulded by light finger pressure	S	2-4	12-25	25-50
Firm	Can be moulded by strong finger pressure	F	4-8	25-50	50-100
Stiff	Cannot be moulded by fingers	St	8-15	50-100	100-200
Very stiff	Can be indented by thumb nail	VSt	15-30	100-200	200-400
Hard	Can be indented with difficulty by thumb nail.	H	>30	>200	>400
Friable	Can be easily crumbled or broken into small pieces by hand	Fr	-	-	-

Soil Particle Sizes	
Term	**Size Range**
BOULDERS	>200 mm
COBBLES	63-200 mm
Coarse GRAVEL	20-63 mm
Medium GRAVEL	6-20 mm
Fine GRAVEL	2.36-6 mm
Coarse SAND	0.6-2.36 mm
Medium SAND	0.2-0.6 mm
Fine SAND	0.075-0.2 mm
SILT	0.002-0.075 mm
CLAY	<0.002 mm

Note: SPT - N to q_u correlation from Terzaghi and Peck, 1967. (General guide only).

Consistency of Non-Cohesive Soils: Is described in terms of the density index, as defined in AS 1289.0-2014. This can be assessed using a field tool appropriate for non-cohesive soils, in conjunction with the relevant calibration. Refer to AS 1726-2017, Table 12

Consistency - Essentially Non-Cohesive Soils				
Term	**Symbol**	**SPT N Value**	**Field Guide**	**Density Index (%)**
Very loose	VL	0-4	Foot imprints readily	0-15
Loose	L	4-10	Shovels Easily	15-35
Medium dense	MD	10-30	Shoveling difficult	35-65
Dense	D	30-50	Pick required	65-85
Very dense	VD	>50	Picking difficult	85-100

Standard Penetration Test (SPT): Refer to. AS 1289.6.3.1-2004 (R2016). Example report formats for SPT results are shown below:

Test Report	Penetration Resistance (N)	Explanation / Comment
4, 7, 11	N=18	Full penetration; N is reported on engineering borehole log
18, 27, 32	N=59	Full penetration; N is reported on engineering borehole log
4, 18, 30/15 mm	N is not reported	30 blows causes less than 100 mm penetration (3rd interval) – test discontinued
30/80 mm	N is not reported	30 blows causes less than 100 mm penetration (1st interval) – test discontinued
rw	N<1	Rod weight only causes full penetration
hw	N<1	Hammer and rod weight only causes full penetration
hb	N is not reported	Hammer bouncing for 5 consecutive blows with no measurable penetration – test discontinued

Rock Descriptions

Refer to AS 1726-2017 Clause 6.2.3 for the description and classification of rock material composition, including:

(a) Rock name (Table 15, 16, 17, 18)
(b) Grain size
(c) Texture and fabric
(d) Colour (describe as per soil)
(e) Features, inclusion and minor components.
(f) Moisture content
(g) Durability

The condition of a rock material refers to its weathering characteristics, strength characteristics and rock mass properties.
Refer to AS 1726-201 7Clause 6.2.4 Tables 19, 20 and 21).

Weathering Condition (Degree of Weathering):

The degree of weathering is a continuum from fresh rock to soil. Boundaries between weathering grades may be abrupt or gradational.

Rock Material Weathering Classification

Weathering Grade		Symbol		Definition
Residual Soil (Note 1)		RS		Material is weathered to such an extent that it 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
Extremely Weathered Rock (Note 2)		XW		Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible
Highly Weathered Rock (Note 2)	Distinctly Weathered (Note 2)	HW	DW	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. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering
Moderately Weathered Rock (Note 2)		MW		The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable, but shows little or no change of strength from fresh rock.
Slightly Weathered Rock		SW		Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock
Fresh Rock		FR		Rock shows no sign of decomposition of individual minerals or colour changes.

Notes:

1. Minor variations within broader weathering grade zones will be noted on the engineering borehole logs.
2. Extremely weathered rock is described in terms of soil engineering properties.
3. Weathering may be pervasive throughout the rock mass, or may penetrate inwards from discontinuities to some extent.
4. Where it is not practicable to distinguish between 'Highly Weathered' and 'Moderately Weathered' rock the term 'Distinctly Weathered' may be used. 'Distinctly Weathered' is defined as follows: 'Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores. There is some change in rock strength.

Strength Condition (Intact Rock Strength):

Strength of Rock Material

(Based on Point Load Strength Index, corrected to 50 mm diameter – $I_{s(50)}$. Field guide used if no tests available. Refer to AS 4133.4.1-2007 (R2016).

Term	Sym	Point Load Index (MPa) $I_{s(50)}$	Field Guide to Strength
Extremely Low	EL	≤0.03	Easily remoulded by hand to a material with soil properties.
Very Low	VL	>0.0 ≤0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 3 cm thick can be broken by finger pressure.
Low	L	>0.1 ≤0.3	Easily scored with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150 mm long by 50 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.

Medium	M	>0.3	≤1.0	Readily scored with a knife; broken by hand with difficult a piece of core 150 mm long by 50 mm diameter can be y.
High	H	>1	≤3	A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	VH	>3	≤10	pick after more than one blow; rock rings under hammer.
Extremely High	EH	>10		Specimen requires many blow rock ring with geological pick to break through intact material; under hammer

Notes:

1. These terms refer to the strength of the rock material and not to the strength of the rock mass which may be considerably weaker due to the effect of rock defects.
2. Anisotropy of rock material samples may affect the field assessment of strength.

Discontinuity Description: Refer to AS 1726-2017, Table 22.

Anisotropic Fabric	
BED	Bedding
FOL	Foliation
LIN	Mineral lineation
Defect Type	
LP	Lamination Parting
BP	Bedding Parting
FP	Cleavage / Foliation Parting
J, Js	Joint, Joints
SZ	Sheared Zone
CZ	Crushed Zone
BZ	Broken Zone
HFZ	Highly Fractured Zone
AZ	Alteration Zone
VN	Vein

Roughness (e.g. Planar, Smooth is abbreviated Pl / Sm)		Class
Stepped (Stp)	Rough or irregular (Ro)	I
	Smooth (Sm)	II
	Slickensided (Sl)	III
Undulating (Un)	Rough (Ro)	IV
	Smooth (Sm)	V
	Slickensided (Sl)	VI
Planar (Pl)	Rough (Ro)	VII
	Smooth (Sm)	VIII
	Slickensided (Sl)	IX

Aperture		**Infilling**		
Closed	CD	No visible coating or infill	Clean	Cn
Open	OP	Surfaces discoloured by mineral/s	Stain	St
Filled	FL	Visible mineral or soil infill <1mm	Veneer	Vr
Tight	TI	Visible mineral or soil infill >1mm	Coating	Ct

Other	
Cly	Clay
Fe	Iron
Co	Coal
Carb	Carbonaceous
Sinf	Soil Infill Zone
Qz	Quartz
CA	Calcite
Chl	Chlorite
Py	Pyrite
Int	Intersecting
Inc	Incipient
DI	Drilling Induced
H	Horizontal
V	Vertical

Note: Describe 'Zones' and 'Coatings' in terms of composition and thickness (mm).

Discontinuity Spacing: On the geotechnical borehole log, a graphical representation of defect spacing vs depth is shown. This representation takes into account all the natural rock defects occurring within a given depth interval, excluding breaks induced by the drilling / handling of core. Refer to AS 1726-2017, BS5930-2015.

Defect Spacing			**Bedding Thickness (Sedimentary Rock**	
Spacing/Width (mm)	**Descriptor**	**Symbol**	**Descriptor**	**Spacing/Width (mm)**
			Thinly Laminated	< 6
<20	Extremely Close	EC	Thickly Laminated	6 – 20
20 – 60	Very Close	VC	Very Thinly Bedded	20 – 60
60 – 200	Close	C	Thinly Bedded	60 – 200
200 – 600	Medium	M	Medium Bedded	200 – 600
600 – 2000	Wide	W	Thickly Bedded	600 – 2000
2000 – 6000	Very Wide	VW	Very Thickly Bedded	> 2000
>6000	Extremely Wide	EW		

Defect Spacing in 3D	
Term	**Description**
Blocky	Equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greater than cross section

Defect Persistence (areal extent)
Trace length of defect given in metres

Aargus

Symbols

The list below provides an explanation of terms and symbols used on the geotechnical borehole, test pit and penetrometer logs.

Test Results			
PI	Plasticity Index	c'	Effective Cohesion
LL	Liquid Limit	c_u	Undrained Cohesion
LI	Liquidity Index	c'_R	Residual Cohesion
DD	Dry Density	ϕ'	Effective Angle of Internal Friction
WD	Wet Density	ϕ_u	Undrained Angle of Internal Friction
LS	Linear Shrinkage	ϕ'_R	Residual Angle of Internal Friction
MC	Moisture Content	c_v	Coefficient of Consolidation
OC	Organic Content	m_v	Coefficient of Volume Compressibility
WPI	Weighted Plasticity Index	$c_{\alpha\varepsilon}$	Coefficient of Secondary Compression

Test Symbols	
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetration Test
CPTu	Cone Penetrometer (Piezocone) Test
PANDA	Variable Energy DCP
PP	Pocket Penetrometer Test
U50	Undisturbed Sample 50 mm (nominal diameter)
U100	Undisturbed Sample 100mm (nominal diameter)
UCS	Uniaxial Compressive Strength
Pm	Pressuremeter

Test Results			
WLS	Weighted Linear Shrinkage	e	Voids Ratio
DoS	Degree of Saturation	ϕ'_{cv}	Constant Volume Friction Angle
APD	Apparent Particle Density	q_t / q_c	Piezocone Tip Resistance (corrected / uncorrected)
s_u	Undrained Shear Strength	q_d	PANDA Cone Resistance
q_u	Unconfined Compressive Strength	$I_{s(50)}$	Point Load Strength Index
R	Total Core Recovery	*RQD*	Rock Quality Designation

Test Symbols	
FSV	Field Shear Vane
DST	Direct Shear Test
PR	Penetration Rate
A	Point Load Test (axial)
D	Point Load Test (diametral)
L	Point Load Test (irregular lump)

28/11/19 Groundwater level on the date shown	Water Inflow	Water Outflow

BOREHOLE NUMBER BH01

Aargus

Aargus

CLIENT Essex Developments Pty Ltd

PROJECT NAME New Subdivision

PROJECT NUMBER GS8649-2A

PROJECT LOCATION 122 Crescent Road, Newport, NSW

DATE STARTED 27/10/22 **COMPLETED** 27/10/22 **R.L. SURFACE** 15.27 **DATUM** m AHD

DRILLING CONTRACTOR R and B Drilling Co. Pty Ltd **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand auger **HOLE LOCATION** Refer Figure 1 - Site Plan

HOLE SIZE 100 **LOGGED BY** RS **CHECKED BY** RF

NOTES Surface levels and depths of lithological units are approximate.

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
HA	Not encountered	15				FILL. Silty Clay, low plasticity, dark brown. Moist.		FILL
						FILL. Silty Clay, low plasticity, dark brown to light brown, orange. Moist.		
						FILL. Silty Clay, low plasticity, light brown. Moist.		
					CH	Silty to Sandy CLAY, high plasticity, orange brown.		RESIDUAL SOIL
			1					
		14				SANDSTONE (inferred from DCP test refusal). Borehole BH01 terminated at 0.7m		WEATHERED BEDROCK
			2					
		13						
			3					
		12						
			4					
		11						
			5					
		10						
			6					
		9						
			7					
		8						
			8					

Aargus

BOREHOLE NUMBER BH02

CLIENT Essex Developments Pty Ltd
PROJECT NAME New Subdivision
PROJECT NUMBER GS8649-2A
PROJECT LOCATION 122 Crescent Road, Newport, NSW

DATE STARTED 26/10/22 **COMPLETED** 26/10/22
R.L. SURFACE 8.5 **DATUM** m AHD
DRILLING CONTRACTOR R and B Drilling Co. Pty Ltd
SLOPE 90° **BEARING** ---
EQUIPMENT Truck mounted drilling rig
HOLE LOCATION Refer Figure 1 - Site Plan
HOLE SIZE 100
LOGGED BY RS **CHECKED BY** RF
NOTES Surface levels and depths of lithological units are approximate.

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
ADT							Asphaltic CONCRETE. 60mm.		PAVEMENT
							FILL. Gravelly Sand, fine to medium grained, fine to medium basalt gravel. Moist.		FILL
			8			CH	Silty CLAY, high plasticity, brown, trace of sandstone gravel, with sand, Moist.		RESIDUAL SOIL
	23 Nov 22			1			SANDSTONE, fine to medium grained, dark grey, extremely to highly weathered, very low to low estimated strength.		WEATHERED SANDSTONE BEDROCK
							1.27m. TC bit refusal. Borehole BH02 continued as cored hole		
			7	2					
			6	3					
			5	4					
			4	5					
			3	6					
			2	7					
			1	8					

BOREHOLE NUMBER BH02

Aargus

CLIENT Essex Developments Pty Ltd
PROJECT NAME New Subdivision
PROJECT NUMBER GS8649-2A
PROJECT LOCATION 122 Crescent Road, Newport, NSW

DATE STARTED 26/10/22 **COMPLETED** 26/10/22
R.L. SURFACE 8.5 **DATUM** m AHD
DRILLING CONTRACTOR R and B Drilling Co. Pty Ltd
SLOPE 90° **BEARING** ---
EQUIPMENT Truck mounted drilling rig
HOLE LOCATION Refer Figure 1 - Site Plan
HOLE SIZE 100
LOGGED BY RS **CHECKED BY** RF
NOTES Surface levels and depths of lithological units are approximate.

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL VL L M H VH EH)	$Is_{(50)}$ MPa (D- diametral, A- axial)	RQD %	Defect Spacing mm (30 100 300 1000 3000)	Defect Description
			8	1		Continued from non-cored borehole						
NMLC			7			SANDSTONE & CLAY. Comprising bands of SANDSTONE, distinctly bedded at 0-10°, pale red to dark red, 30-80mm thick, 35%, and Silty CLAY, high plasticity, pale yellow to pale grey, stiff to very stiff, moist (65%).	EW					
						NO CORE. 1.62-1.76m.						
			6	2		SANDSTONE & CLAY. Comprising bands of SANDSTONE, distinctly bedded at 0-10°, pale red to dark red, 30-80mm thick, 35%, and Silty CLAY, high plasticity, pale yellow to pale grey, stiff to very stiff, moist (65%).	EW			0		
						NO CORE. 2.73-3.00m.						
			5	3		SANDSTONE & CLAY. Comprising bands of SANDSTONE, distinctly bedded at 0-10°, pale red to dark red, 30-80mm thick, 35%, and Silty CLAY, high plasticity, pale yellow to pale grey, stiff to very stiff, moist (65%).	EW					
			4	4		BH02 terminated at 3.88m						
			3	5								
			2	6								
			1	7								
				8								

BOREHOLE NUMBER BH03

Aargus

CLIENT Essex Developments Pty Ltd
PROJECT NAME New Subdivision
PROJECT NUMBER GS8649-2A
PROJECT LOCATION 122 Crescent Road, Newport, NSW

DATE STARTED 27/10/22 **COMPLETED** 27/10/22
R.L. SURFACE 7.0 **DATUM** m AHD
DRILLING CONTRACTOR R and B Drilling Co. Pty Ltd
SLOPE 90° **BEARING** ---
EQUIPMENT Hand auger
HOLE LOCATION Refer Figure 1 - Site Plan
HOLE SIZE 100
LOGGED BY RS **CHECKED BY** RF
NOTES Surface levels and depths of lithological units are approximate.

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
HA						FILL. Sandy Gravel, brown, yellow, pale brown, Moist.		FILL
	Perched water table				CH	Silty CLAY, medium plasticity, dark brown, pale brown. Moist.		RESIDUAL SOIL
					CH	Silty CLAY, low to medium plasticity, brown, dark brown. Moist.		
		6	1		CH	Silty CLAY, low to medium plasticity, dark grey, brown, dark brown. Moist.		
					CH	Silty CLAY, medium to high plasticity, pale brown, pale yellow, dark brown, brown. Moist.		
					CH	Silty CLAY, medium to high plasticity, pale brown, pale yellow, dark brown, brown. Moist.		
		5	2			SANDSTONE (inferred from DCP test)		
						Borehole BH03 terminated at 1.75m		
		4	3					
		3	4					
		2	5					
		1	6					
		0	7					
		-1	8					

Aargus

BOREHOLE NUMBER BH04

CLIENT Essex Developments Pty Ltd
PROJECT NAME New Subdivision
PROJECT NUMBER GS8649-2A
PROJECT LOCATION 122 Crescent Road, Newport, NSW

DATE STARTED 26/10/22 **COMPLETED** 26/10/22 **R.L. SURFACE** 11.0 **DATUM** m AHD
DRILLING CONTRACTOR R and B Drilling Co. Pty Ltd **SLOPE** 90° **BEARING** ---
EQUIPMENT Truck mounted drilling rig **HOLE LOCATION** Refer Figure 1 - Site Plan
HOLE SIZE 100 **LOGGED BY** RS **CHECKED BY** RF
NOTES Surface levels and depths of lithological units are approximate.

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
ADT	Not encountered					Asphaltic CONCRETE. 100mm.		ASPHALT
						FILL. Sandy Gravel, grey. Moist.		FILL
		10	1			FILL. Gravelly Sand, fine to coarse grained, with clay. Moist.		
					CH	Silty CLAY, dark grey to black. Moist.		RESIDUAL SOIL
		9	2		CH	Silty CLAY to Sandy CLAY, high plasticity, orange, brown. Moist.		
						SANDSTONE, laminated, dark red, extremely weathered, extremely low to very low strength. Becoming medium strength at 2.5m		WEATHERED BEDROCK
		8	3			2.5m. TC bit refusal Borehole BH04 terminated at 2.5m		
		7	4					
		6	5					
		5	6					
		4	7					
		3	8					

BOREHOLE NUMBER BH05

Aargus

CLIENT Essex Developments Pty Ltd | **PROJECT NAME** New Subdivision

PROJECT NUMBER GS8649-2A | **PROJECT LOCATION** 122 Crescent Road, Newport, NSW

DATE STARTED 26/10/22 | **COMPLETED** 26/10/22 | **R.L. SURFACE** 12.6 | **DATUM** m AHD

DRILLING CONTRACTOR R and B Drilling Co. Pty Ltd | **SLOPE** 90° | **BEARING** ---

EQUIPMENT Truck mounted drilling rig | **HOLE LOCATION** Refer Figure 1 - Site Plan

HOLE SIZE 100 | **LOGGED BY** RS | **CHECKED BY** RF

NOTES Surface levels and depths of lithological units are approximate.

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
ADT							Asphaltic CONCRETE. 60mm.		PAVEMENT
							FILL. Gravely Sand, fine to coarse grained, dark grey, fine to medium basalt gravel, angular to subangular.		FILL
							FILL. Silty Clay, high plasticity, dark grey.		
			12				FILL. Silty Clay, high plasticity, orange, pale grey, pale brown, with sand & fine siltstone gravel. Moist		
				1		CH	Silt CLAY, low plasticity, black with tree roots. Moist.		RESIDUAL SOIL
	23 Nov 22		11			CH	Silt CLAY, high plasticity, yellow to brown yellow, pale brown, black with tree roots. Moist.		
			10	2			becoming dark orange at 2.5m		
			9	3			SANDSTONE, laminated, pale grey, extremely weathered sandstone, extremely low to soil strength		WEATHERED BEDROCK
			8	4			SANDSTONE, fine to medium grained, dark red, brown grey, extremely weathered, extremely low strength		
			7	5					
			6	6			becoming low strength at 6.0m		
			5	7			Borehole BH05 terminated at 6.66m		
				8					

BOREHOLE NUMBER BH06

Aargus

CLIENT Essex Developments Pty Ltd
PROJECT NAME New Subdivision
PROJECT NUMBER GS8649-2A
PROJECT LOCATION 122 Crescent Road, Newport, NSW

DATE STARTED 27/10/22 **COMPLETED** 27/10/22
R.L. SURFACE 7.5 **DATUM** m AHD
DRILLING CONTRACTOR R and B Drilling Co. Pty Ltd
SLOPE 90° **BEARING** ---
EQUIPMENT Truck mounted drilling rig
HOLE LOCATION Refer Figure 1 - Site Plan
HOLE SIZE 100
LOGGED BY RF **CHECKED BY** RF
NOTES Surface levels and depths of lithological units are approximate.

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	Not encountered	7				FILL. Fine angular basalt Gravel.		FILL
						FILL. Silty Clay, high plasticity, orange, appears to be well compacted.		
			1			FILL. Silty Clay, low plasticity, brown, orange, red. Moist.		
		6	2		CH	Silty CLAY, high plasticity, pale grey, orange, dark red 1.5m. Pale grey, mottled orange		RESIDUAL SOIL
		5	3			SANDSTONE, fine to medium grained, dark red, pale grey, extremely weathered, extremely low estimated strength. 2.5m. Becoming low to medium strength		WEATHERED SANDSTONE BEDROCK
		4, 3, 2, 1, 0	4, 5, 6, 7, 8			3.0m. TC bit refusal Borehole BH06 terminated at 3m		

BOREHOLE NUMBER BH07

Aargus

CLIENT Essex Developments Pty Ltd
PROJECT NAME New Subdivision
PROJECT NUMBER GS8649-2A
PROJECT LOCATION 122 Crescent Road, Newport, NSW

DATE STARTED 27/10/22 **COMPLETED** 27/10/22
R.L. SURFACE 14.0 **DATUM** m AHD
DRILLING CONTRACTOR R and B Drilling Co. Pty Ltd
SLOPE 90° **BEARING** ---
EQUIPMENT Truck mounted drilling rig
HOLE LOCATION Refer Figure 1 - Site Plan
HOLE SIZE 100
LOGGED BY RF **CHECKED BY** RF
NOTES Surface levels and depths of lithological units are approximate.

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
ADT	Not encountered					TOPSOIL. Silty Clay, low plasticity, dark brown, with sand and organic material, with grass roots.		TOPSOIL
						FILL. Silty Clay, high plasticity, brown, grey, orange, with fine to coarse sandstone gravel.		FILL
					CH	Silty CLAY, high plasticity, orange to red		RESIDUAL SOIL
		13	1			SANDSTONE, fine to medium grained, orange to dark red, extremely to highly weathered, extremely low to low estimated strength, in dark red and pale grey bands.		WEATHERED SANDSTONE BEDROCK
		12	2			Becoming medium to high strength sandstone at 2.4m.		
						2.4m. TC bit refusal Borehole BH07 terminated at 2.4m		
		11	3					
		10	4					
		9	5					
		8	6					
		7	7					
		6	8					

BOREHOLE NUMBER BH08

Aargus

CLIENT	Essex Developments Pty Ltd	**PROJECT NAME**	New Subdivision
PROJECT NUMBER	GS8649-2A	**PROJECT LOCATION**	122 Crescent Road, Newport, NSW

DATE STARTED	28/10/22	**COMPLETED**	28/10/22	**R.L. SURFACE**	17.88	**DATUM**	m AHD
DRILLING CONTRACTOR	R and B Drilling Co. Pty Ltd			**SLOPE**	90°	**BEARING**	---
EQUIPMENT	Truck mounted drilling rig			**HOLE LOCATION**	Refer Figure 1 - Site Plan		
HOLE SIZE	100			**LOGGED BY**	RS	**CHECKED BY**	RF

NOTES Surface levels and depths of lithological units are approximate.

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
ADT							FILL. Gravel, dark brown		FILL
						CH	Silty CLAY, high plasticity, brown, yellow, trace of sandy gravel		RESIDUAL SOIL
			17	1		CH	Silty CLAY, medium to high plasticity, orange brown, orange, yellow brown, light brown, dark brown, trace of sandstone gravel		
							SANDSTONE, orange, light grey, pale orange, extremely weathered, extremely low estimated strength. Moist.		WEATHERED SANDSTONE BEDROCK
							SANDSTONE, orange, pale red, extremely weathered, low to medium estimated strength. Moist. 1.70m. TC bit refusal. Borehole BH08 continued as cored hole		
			16	2					
			15	3					
			14	4					
			13	5					
			12	6					
			11	7					
			10	8					

CLIENT	Essex Developments Pty Ltd	**PROJECT NAME**	New Subdivision
PROJECT NUMBER	GS8649-2A	**PROJECT LOCATION**	122 Crescent Road, Newport, NSW

DATE STARTED	28/10/22	**COMPLETED**	28/10/22	**R.L. SURFACE**	17.88	**DATUM**	m AHD
DRILLING CONTRACTOR	R and B Drilling Co. Pty Ltd			**SLOPE**	90°	**BEARING**	---
EQUIPMENT	Truck mounted drilling rig			**HOLE LOCATION**	Refer Figure 1 - Site Plan		
HOLE SIZE	100			**LOGGED BY**	RS	**CHECKED BY**	RF

NOTES Surface levels and depths of lithological units are approximate.

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL VL L M H VH EH)	Is(50) MPa D- diametral A- axial	RQD %	Defect Spacing mm (30 100 300 1000 3000)	Defect Description
			17	1								
						Continued from non-cored borehole						
NMLC	23 Nov 22		16	2		SANDSTONE & CLAY. Comprising bands of SANDSTONE, distinctly bedded at 0-10°, dark red, 20-150mm thick, 50%, and bands of Silty CLAY, high plasticity, pale grey, stiff to very stiff, moist, 10-90mm thick.	EW			0		
			15	3								
						BH08 terminated at 3.33m						
			14	4								
			13	5								
			12	6								
			11	7								
			10	8								

Aargus

CLIENT Essex Developments Pty Ltd

PROJECT NAME New Subdivision

PROJECT NUMBER GS8649-2A

PROJECT LOCATION 122 Crescent Road, Newport, NSW

DATE STARTED 28/10/22 **COMPLETED** 28/10/22 **R.L. SURFACE** 8.5 **DATUM** m AHD

DRILLING CONTRACTOR R and B Drilling Co. Pty Ltd **SLOPE** 90° **BEARING** ---

EQUIPMENT Truck mounted drilling rig **HOLE LOCATION** Refer Figure 1 - Site Plan

HOLE SIZE 100 **LOGGED BY** RS **CHECKED BY** RF

NOTES Surface levels and depths of lithological units are approximate.

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
ADT							Asphaltic CONCRETE. 20mm.		PAVEMENT
							FILL. Gravel, base material. Dry.		FILL
							FILL. Gravel, grey, pale grey, orange. Dry.		
			8			CH	Silty CLAY, low plasticity, brown, grey. Moist.		RESIDUAL SOIL
				1		CH	Silty CLAY, pale yellow, brown, trace of sand. Moist.		
						CH	Silty CLAY, high plasticity, grey, dark brown, trace of sandstone gravel.		WEATHERED SANDSTONE BEDROCK
			7				SANDSTONE, fine grained, orange, grey, low estimated strength.		
				2			SANDSTONE, fine grained, orange, grey, pale grey, low estimated strength.		
							SANDSTONE, fine grained, orange, grey, pale grey, medium estimated strength.		
			6						
							2.64m. TC bit refusal. Borehole BH09 continued as cored hole		
				3					
			5						
				4					
			4						
				5					
			3						
				6					
			2						
				7					
			1						
				8					

BOREHOLE NUMBER BH09

Aargus

CLIENT Essex Developments Pty Ltd
PROJECT NAME New Subdivision
PROJECT NUMBER GS8649-2A
PROJECT LOCATION 122 Crescent Road, Newport, NSW

DATE STARTED 28/10/22 **COMPLETED** 28/10/22
R.L. SURFACE 8.5 **DATUM** m AHD
DRILLING CONTRACTOR R and B Drilling Co. Pty Ltd
SLOPE 90° **BEARING** ---
EQUIPMENT Truck mounted drilling rig
HOLE LOCATION Refer Figure 1 - Site Plan
HOLE SIZE 100
LOGGED BY RS **CHECKED BY** RF
NOTES Surface levels and depths of lithological units are approximate.

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL VL L M H VH EH)	$Is_{(50)}$ MPa (D- diametral, A- axial)	RQD %	Defect Spacing mm (30 100 300 1000 3000)	Defect Description
			8	1								
			7	2								
			6			Continued from non-cored borehole						
NMLC	23 Nov 22		5	3		SANDSTONE, distinctly bedded at 0-5°, dark grey to grey green to orange.	SW EW SW EW SW			30		2.71m. BP, 0°, PL, SM, SN 2.77m. JT, 20°, PL, SM, CN 2.77m. EW SM, 0°, PL, 20mm Silty Clay 2.84m. JT, 30°, PL, SM, SN 2.93m. JT, 40-80°, CU, RO, SN 3.07m. SM, 0-5°, PL, 5mm, iron oxides 3.07-3.17m. JT, 90°, PL, RO, CN, discontinuous 3.24m. SM, 20°, PL, 5mm, iron oxides 3.29m. SM, 10°, PL, 8mm, iron oxides 3.32m. SM, 0°, PL, 5mm, iron oxides 3.35m. EW SM, 0°, PL, 12mm Silty Clay 3.37m. EW SM, 0°, PL, 20mm Silty Clay 3.40m. SM, 10°, PL, 20mm, iron oxides 3.42m. EW SM, 0°, PL, 40mm Silty Clay 3.47m. JT, 10-50°, CU, closed 3.59m. BP, 5-10°, PL, RO, SN 3.61m. SM, 5°, PL, 5-10mm, iron oxides 3.64m. JT, 20°, PL, CO, clay, 2mm 3.67m. SM, 0°, PL, 10mm, iron oxides 3.71m. JT, 45°, PL, RO, CN 3.75m. EW SM, 0°, PL, 2mm Silty Clay 3.81m. JT, 10°, ST, SN, closed 3.87m. EW SM, 0°, PL, 30mm Silty Clay
				4		BH09 terminated at 3.9m	EW					
			4	5								
			3	6								
			2	7								
			1	8								

APPENDIX D

Rock Core Photographs

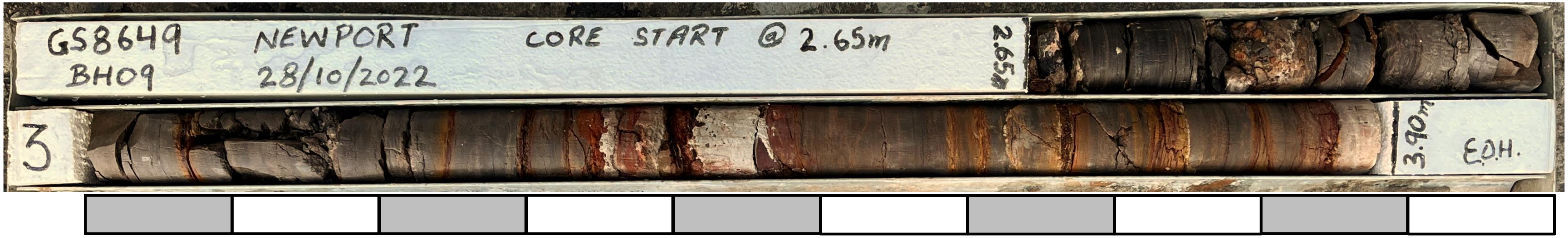
100 mm

Rock Core Photographs, BH02, Depths: 1.27m to 3.88m

Aargus ENVIRONMENTAL - ENGINEERING - DRILLING - LABORATORIES - ASBESTOS

Drawn	RF	**Essex Developments Pty Ltd Geotechnical Investigation Report for Proposed Subdivision 122 Crescent Road, Newport NSW 2106**	Figure **2**
Checked	RF		Title **Rock Core Photographs**
Date	28/11/2022		Job No **GS8649-2A**
Scale @ A3	NTS		

Aargus



100 mm

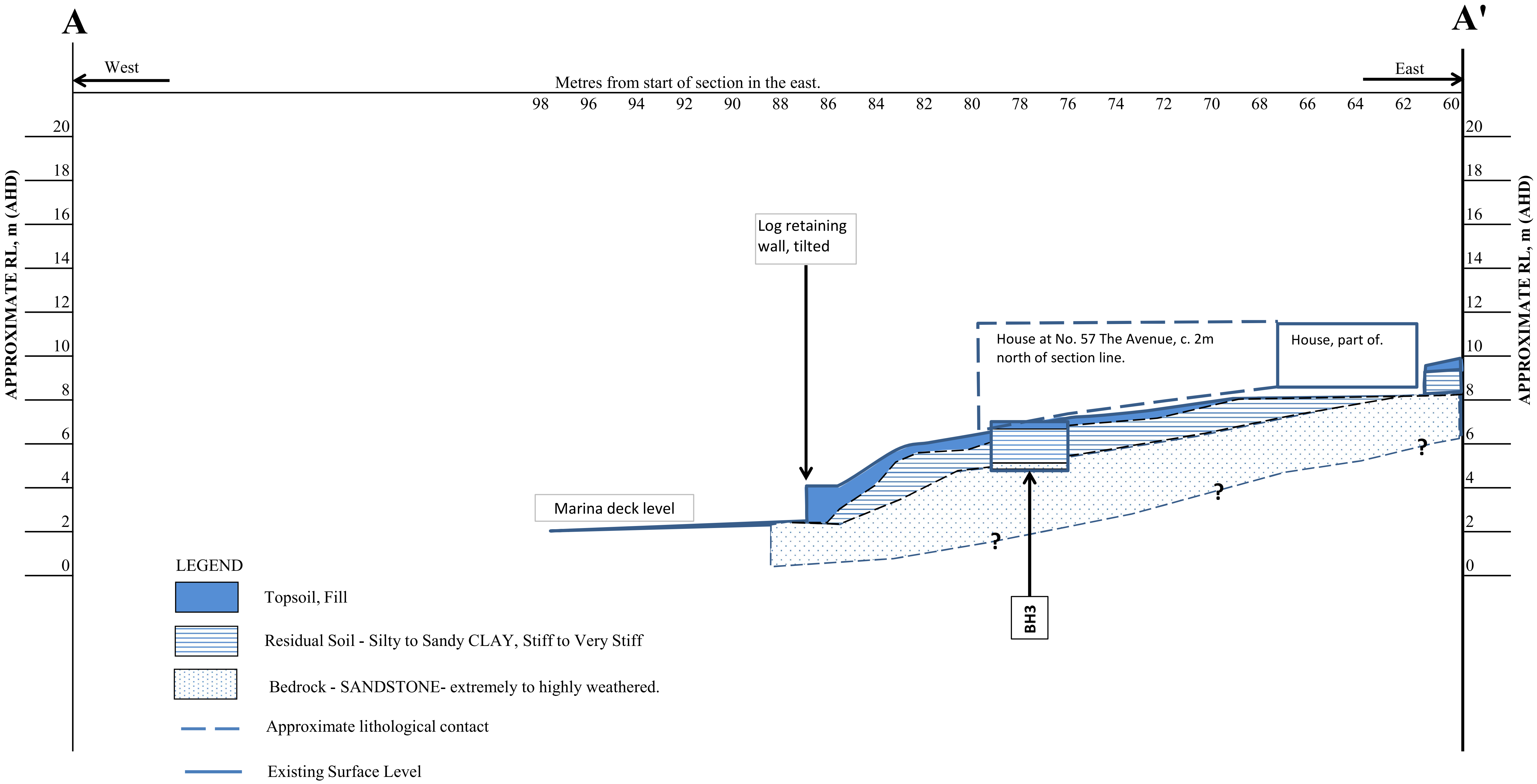
Rock Core Photographs, BH8 Depths: 1.70m to 3.33m
Rock Core Photographs, BH9 Depths: 2.65m to 3.90m

Aargus ENVIRONMENTAL - ENGINEERING - DRILLING - LABORATORIES - ASBESTOS

Drawn	HS	**Essex Developments Pty Ltd Geotechnical Investigation Report for Proposed Subdivision 122 Crescent Road, Newport NSW 2106**	Aargus	Figure **3**
Checked	RF			Title **Rock Core Photographs**
Date	23/11/2022			
Scale @ A3	NTS			Job No **GS8649-2A**

APPENDIX E

Site Cross-section



Notes:
1. Do not scale the drawing.
2. Water level may fluctuate with time.
3. Depths and RLs are approximate.
4. Drawing was reproduced based on provided survey levels and subsurface conditions encountered during fieldwork.
5. No vertical exaggeration

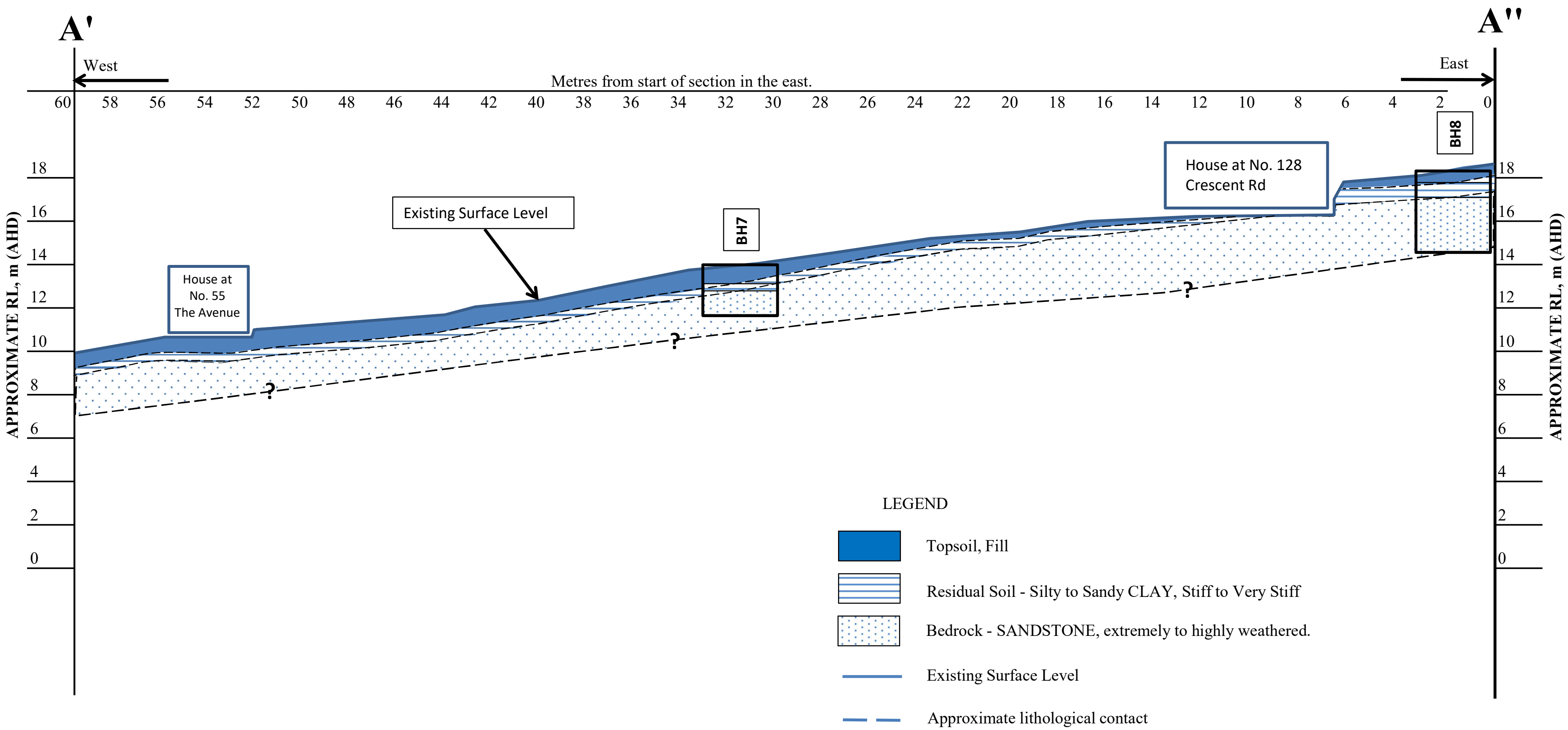
Drawn	RF	**Client**	Essex Developments Pty Ltd
Checked	RF	**Project**	Geotechnical Investigation
Dated	22/12/2022	**Address**	122-128 Crescent Rd, Newport NSW
Scale	NTS	**Title**	Generalised Geotechnical Cross Section A-A'

Aargus

Figure

2a

Job No. GS8649-2A



Notes:			Client	Essex Developments Pty Ltd	Figure
1. Do not scale the drawing. 2. Water level may fluctuate with time. 3. Depths and RLs are approximate. 4. Drawing was reproduced based on provided survey levels and subsurface conditions encountered during fieldwork. 5. No vertical exaggeration	Drawn	RF	Project	Geotechnical Investigation	2b
	Checked	RF	Address	122-128 Crescent Rd, Newport NSW	
	Dated	22/12/2022	Title	Generalised Geotechnical Cross Section A-A East part	Job No. GS8649-2A
	Scale	NTS			

Aargus

APPENDIX F

Laboratory Test Results

eurofins | Environment Testing

Certificate of Analysis

Aargus Pty Ltd
6 Carter Street
Lidcombe
NSW 2141

NATA Accredited
Accreditation Number 1261
Site Number 18217

Accredited for compliance with ISO/IEC 17025 – Testing
NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection, proficiency testing scheme providers and reference materials producers reports and certificates.

Attention: **- ALL INVOICES/SRA - Mark Kelly**

Report	**940559-S**
Project name	NEWPORT
Project ID	GS8649
Received Date	Nov 11, 2022

Client Sample ID			**BH1**	**BH2**	**BH3**	**BH4**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**S22-No0031205**	**S22-No0031206**	**S22-No0031207**	**S22-No0031208**
Date Sampled			**Oct 26, 2022**	**Oct 26, 2022**	**Oct 26, 2022**	**Oct 26, 2022**
Test/Reference	LOR	Unit				
Chloride	10	mg/kg	< 10	10	< 10	< 10
Conductivity (1:5 aqueous extract at 25 °C as rec.)	10	uS/cm	20	79	24	32
pH (1:5 Aqueous extract at 25 °C as rec.)	0.1	pH Units	6.4	6.9	6.6	6.5
Resistivity*	0.5	ohm.m	510	130	410	310
Salinity* (1:5 aqueous extract calc. from EC at 25C)	1	mg/kg	20	50	23	27
Sulphate (as SO4)	10	mg/kg	< 10	110	< 10	33
% Moisture	1	%	14	16	18	18

Client Sample ID			**BH5**	**BH8**
Sample Matrix			**Soil**	**Soil**
Eurofins Sample No.			**S22-No0031209**	**S22-No0031210**
Date Sampled			**Oct 26, 2022**	**Oct 26, 2022**
Test/Reference	LOR	Unit		
Chloride	10	mg/kg	15	< 10
Conductivity (1:5 aqueous extract at 25 °C as rec.)	10	uS/cm	46	28
pH (1:5 Aqueous extract at 25 °C as rec.)	0.1	pH Units	6.8	7.1
Resistivity*	0.5	ohm.m	220	360
Salinity* (1:5 aqueous extract calc. from EC at 25C)	1	mg/kg	32	26
Sulphate (as SO4)	10	mg/kg	< 10	< 10
% Moisture	1	%	13	21

Environment Testing

Sample History

Where samples are submitted/analysed over several days, the last date of extraction is reported.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Chloride	Sydney	Nov 16, 2022	28 Days
- Method: LTM-INO-4270 Anions by Ion Chromatography			
Conductivity (1:5 aqueous extract at 25 °C as rec.)	Sydney	Nov 16, 2022	7 Days
- Method: LTM-INO-4030 Conductivity			
pH (1:5 Aqueous extract at 25 °C as rec.)	Sydney	Nov 16, 2022	7 Days
- Method: LTM-GEN-7090 pH by ISE			
Sulphate (as SO4)	Sydney	Nov 16, 2022	28 Days
- Method: In-house method LTM-INO-4270 Sulphate by Ion Chromatograph			
Salinity* (1:5 aqueous extract calc. from EC at 25C)	Sydney	Nov 18, 2022	21 Days
- Method: LTM-INO-4030			
% Moisture	Sydney	Nov 13, 2022	14 Days
- Method: LTM-GEN-7080 Moisture			

Company Name:	Aargus Pty Ltd	**Order No.:**		**Received:**	Nov 11, 2022 6:48 PM
Address:	6 Carter Street Lidcombe NSW 2141	**Report #:**	940559	**Due:**	Nov 18, 2022
		Phone:	02 9568 6159	**Priority:**	5 Day
		Fax:	02 9566 6179	**Contact Name:**	- ALL INVOICES/SRA - Mark Kelly
Project Name:	NEWPORT				
Project ID:	GS8649				

Eurofins Analytical Services Manager : Asim Khan

Sample Detail						Salinity* (1:5 aqueous extract calc. from EC at 25C)	Aggressivity Soil Set	Moisture Set
Sydney Laboratory - NATA # 1261 Site # 18217						X	X	X
External Laboratory								
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**			
1	BH1	Oct 26, 2022		Soil	S22-No0031205	X	X	X
2	BH2	Oct 26, 2022		Soil	S22-No0031206	X	X	X
3	BH3	Oct 26, 2022		Soil	S22-No0031207	X	X	X
4	BH4	Oct 26, 2022		Soil	S22-No0031208	X	X	X
5	BH5	Oct 26, 2022		Soil	S22-No0031209	X	X	X
6	BH8	Oct 26, 2022		Soil	S22-No0031210	X	X	X
Test Counts						6	6	6

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

Units

mg/kg: milligrams per kilogram	**mg/L:** milligrams per litre	**µg/L:** micrograms per litre
ppm: parts per million	**ppb:** parts per billion	**%:** Percentage
org/100 mL: Organisms per 100 millilitres	**NTU:** Nephelometric Turbidity Units	**MPN/100 mL:** Most Probable Number of organisms per 100 millilitres

Terms

APHA	American Public Health Association
COC	Chain of Custody
CP	Client Parent - QC was performed on samples pertaining to this report
CRM	Certified Reference Material (ISO17034) - reported as percent recovery.
Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
LOR	Limit of Reporting.
LCS	Laboratory Control Sample - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
SRA	Sample Receipt Advice
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
TBTO	Tributyltin oxide (*bis*-tributyltin oxide) - individual tributyltin compounds cannot be identified separately in the environment however free tributyltin was measured and its values were converted stoichiometrically into tributyltin oxide for comparison with regulatory limits.
TCLP	Toxicity Characteristic Leaching Procedure
TEQ	Toxic Equivalency Quotient or Total Equivalence
QSM	US Department of Defense Quality Systems Manual Version 5.4
US EPA	United States Environmental Protection Agency
WA DWER	Sum of PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC - Acceptance Criteria

The acceptance criteria should be used as a guide only and may be different when site specific Sampling Analysis and Quality Plan (SAQP) have been implemented

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR: No Limit

Results between 10-20 times the LOR: RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

NOTE: pH duplicates are reported as a range not as RPD

Surrogate Recoveries: Recoveries must lie between 20-130% for Speciated Phenols & 50-150% for PFAS

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.4 where no positive PFAS results have been reported have been reviewed and no data was affected.

.

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling. Therefore, laboratory analysis is unlikely to be completed within holding time.Analysis will begin as soon as possible after sample receipt.
4. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of recovery the term "INT" appears against that analyte.
5. For Matrix Spikes and LCS results a dash "-" in the report means that the specific analyte was not added to the QC sample.
6. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank									
Chloride			mg/kg	< 10			10	Pass	
Conductivity (1:5 aqueous extract at 25 °C as rec.)			uS/cm	< 10			10	Pass	
Sulphate (as SO4)			mg/kg	< 10			10	Pass	
LCS - % Recovery									
Chloride			%	104			70-130	Pass	
Conductivity (1:5 aqueous extract at 25 °C as rec.)			%	86			70-130	Pass	
Resistivity*			%	91			70-130	Pass	
Sulphate (as SO4)			%	110			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Spike - % Recovery									
				Result 1					
Chloride	W22-No0027306	NCP	%	118			70-130	Pass	
Sulphate (as SO4)	W22-No0027306	NCP	%	77			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
				Result 1	Result 2	RPD			
Conductivity (1:5 aqueous extract at 25 °C as rec.)	S22-No0029857	NCP	uS/cm	91	94	3.1	30%	Pass	
pH (1:5 Aqueous extract at 25 °C as rec.)	W22-No0027305	NCP	pH Units	6.9	6.8	<1	30%	Pass	
Resistivity*	S22-No0029857	NCP	ohm.m	110	110	3.1	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
% Moisture	S22-No0031208	CP	%	18	19	9.7	30%	Pass	

eurofins | Environment Testing

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Authorised by:

Asim Khan	Analytical Services Manager
Roopesh Rangarajan	Senior Analyst-Inorganic
Ryan Phillips	Senior Analyst-Inorganic

Glenn Jackson
General Manager

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

Aargus Pty Ltd ACN: 050 212 710
Environmental - Remediation - Engineering - Laboratories - Drilling
Unit 12 1 Bounty Close, Tuggerah NSW 2259
Ph: (02) 4353 0332 Fax: (02) 4353 0221

ATTERBERG LIMITS AND LINEAR SHRINKAGE TEST REPORT

Client	Essex Developments P/L	Job Number	LC8649-1a
Project	Geotechnical Site Investigation	Date	24-11-2022
Location	122 Crescent Rd, Newport	Page	1 of 1

SAMPLE DETAILS

Sample Number		MT1	MT2	MT3	MT4
Date Sampled		26-10-2022	27-10-2022	26-10-2022	27-10-2022
Sample Location / Source		BH2 0.8 - 1.2m	BH3 0.6 - 0.8m	BH4 1.0 - 1.2m	BH5 1.0 - 1.2m
Material Description		Clay with some Gravel, Brown	Silty Clay, Dark Brown	Silty Clay, Dark Grey Brown	Silty Clay, Dark Brown
Sample History		Oven Dried	Oven Dried	Oven Dried	Oven Dried
Method of Preparation		Dry Sieved	Dry Sieved	Dry Sieved	Dry Sieved
Shrinkage Mould Length	mm	250	254	254	250
TEST METHOD		**TEST RESULTS**			
Liquid Limit AS1289 3.1.2 ☑ RMS (NSW) T108 ☐	%	40	23	25	34
Plastic Limit AS1289 3.2.1 ☑ RMS (NSW) T109 ☐	%	17	16	16	19
Plasticity Index AS1289 3.3.1 ☑ RMS (NSW) T109 ☐	%	23	7	9	15
Linear Shrinkage AS1289 3.4.1 ☑ RMS (NSW) T113 ☐	%	9.0	4.0	5.5	7.0
Cracking Occurred		Yes ☐ No ☑	Yes ☑ No ☐	Yes ☐ No ☑	Yes ☐ No ☑
Crumbling Occurred		Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑
Curling Occurred		Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑

Notes:

NATA

Accredited for compliance with ISO/IEC 17025 - Testing

Accreditation No. 5452

Approved Signatory: Mark Hoveling
M Hoveling
Date: 24-11-2022

Aargus Pty Ltd ACN: 050 212 710
Environmental - Remediation - Engineering - Laboratories - Drilling
Unit 12 1 Bounty Close, Tuggerah NSW 2259
Ph: (02) 4353 0332 Fax: (02) 4353 0221

ATTERBERG LIMITS AND LINEAR SHRINKAGE TEST REPORT

Client	Essex Development P/L	Job Number	LC8649-1b
Project	Geotechnical Site Investigation	Date	24-11-2022
Location	122 Crescent Rd, Newport	Page	1 of 1

SAMPLE DETAILS				
Sample Number	MT5	MT6	MT7	MT8
Date Sampled	27-10-2022	28-10-2022	28-10-2022	28-10-2022
Sample Location / Source	BH7 0.6 - 0.8m	BH8 0.3 - 1.0m	BH9 1.2m	BH1 0.5m
Material Description	Clay with some Gravel, Brown	Clay with rock fragments, Brown	Silty Clay, Light Brown	Sandy Silty Clay, Dark Brown
Sample History	Oven Dried	Oven Dried	Oven Dried	Oven Dried
Method of Preparation	Dry Sieved	Dry Sieved	Dry Sieved	Dry Sieved
Shrinkage Mould Length (mm)	250	250	250	254
TEST METHOD	**TEST RESULTS**			
Liquid Limit (%) — AS1289 3.1.2 ☑; RMS (NSW) T108 ☐	38	55	29	21
Plastic Limit (%) — AS1289 3.2.1 ☑; RMS (NSW) T109 ☐	18	25	15	16
Plasticity Index (%) — AS1289 3.3.1 ☑; RMS (NSW) T109 ☐	20	30	14	5
Linear Shrinkage (%) — AS1289 3.4.1 ☑; RMS (NSW) T113 ☐	10.0	12.0	8.5	3.5
Cracking Occurred	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑
Crumbling Occurred	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑
Curling Occurred	Yes ☐ No ☑	Yes ☑ No ☐	Yes ☐ No ☑	Yes ☐ No ☑

Notes:

NATA

Accredited for compliance with ISO/IEC 17025 - Testing
This document shall not be reproduced, except in full.
Accreditation No. 5452

Approved Signatory: Mark Hoveling

M Hoveling

Date: 24-11-2022

Aargus Pty Ltd ACN: 050 212 710
Environmental - Remediation - Engineering - Laboratories - Drilling
Unit 12 1 Bounty Close, Tuggerah NSW 2259
Ph: (02) 4353 0332 Fax: (02) 4353 0221

ATTERBERG LIMITS AND LINEAR SHRINKAGE TEST REPORT

Client	Essex Development P/L	Job Number	LC8649-1c
Project	Geotechnical Site Investigation	Date	24-11-2022
Location	122 Crescent Rd, Newport	Page	1 of 1

SAMPLE DETAILS						
Sample Number Date Sampled			MT9 17-11-2022			
Sample Location / Source			BH6 0.5m			
Material Description			Silty Clay with Gravel, Grey & Brown			
Sample History			Oven Dried			
Method of Preparation			Dry Sieved			
Shrinkage Mould Length		mm	250			
TEST METHOD			**TEST RESULTS**			
Liquid Limit						
AS1289 3.1.2	☑	%	38			
RMS (NSW) T108	☐					
Plastic Limit						
AS1289 3.2.1	☑	%	17			
RMS (NSW) T109	☐					
Plasticity Index						
AS1289 3.3.1	☑	%	21			
RMS (NSW) T109	☐					
Linear Shrinkage						
AS1289 3.4.1	☑	%	10.5			
RMS (NSW) T113	☐					
Cracking Occurred			Yes ☐ No ☑	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
Crumbling Occurred			Yes ☐ No ☑	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
Curling Occurred			Yes ☐ No ☑	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐

Notes:

NATA

Approved Signatory: Mark Hoveling

M Hoveling

Date: 24-11-2022

Aargus

Aargus Pty Ltd ACN: 050 212 710

Environmental - Remediation - Engineering - Laboratories - Drilling

Unit 12 1 Bounty Close, Tuggerah NSW 2259
Ph: (02) 4353 0332 Fax: (02) 4353 0221

MOISTURE CONTENT TEST REPORT

Client	Essex Developments P/L	Job Number	LC8649-1f
Project	Geotechnicial Site Investigation	Date	24-11-2022
Location	122 Crescent Rd, Newport	Page	1 of 1
Test Method:	AS 1289.2.1.1 ☑ RMS T120 ☐	Date Sampled:	17/11/2022

Test No.	Sample Location	Description	Moisture Content (%)
MT9	BH6 0.5m	Silty Clay with Gravel, Grey & Brown	19.8

Notes:

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.
This document shall not be reproduced, except in full.
Accreditation No. 5452

Approved Signatory: Mark Hoveling M Hoveling 24-11-22

Aargus Pty Ltd ACN: 050 212 710
Environmental - Remediation - Engineering - Laboratories - Drilling

Unit 12 1 Bounty Close, Tuggerah NSW 2259
Ph: (02) 4353 0332 Fax: (02) 4353 0221

MOISTURE CONTENT TEST REPORT

Client	Essex Developments P/L	Job Number	LC8649-1d
Project	Geotechnicial Site Investigation	Date	24-11-2022
Location	122 Crescent Rd, Newport	Page	1 of 1
Test Method:	AS 1289.2.1.1 ☑ RMS T120 ☐	Date Sampled:	26-11-2022 & 27/11/2022

Test No.	Sample Location	Description	Moisture Content (%)
MT1	BH2 0.8 - 1.2m	Clay with some Gravel, Brown	18.7
MT2	BH3 0.6 - 0.8m	Silty Clay, Dark Brown	22.8
MT3	BH4 1.0 - 1.2m	Silty Clay, Dark Grey Brown	21.1
MT4	BH5 1.0 - 1.2m	Silty Clay, Dark Brown	34.7

Notes:

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.
This document shall not be reproduced, except in full.
Accreditation No. 5452

Approved Signatory: Mark Hoveling M Hoveling 24-11-22

Aargus Pty Ltd ACN: 050 212 710
Environmental - Remediation - Engineering - Laboratories - Drilling

Aargus

Unit 12 1 Bounty Close, Tuggerah NSW 2259
Ph: (02) 4353 0332 Fax: (02) 4353 0221

MOISTURE CONTENT TEST REPORT

Client	Essex Developments P/L	Job Number	LC8649-1e
Project	Geotechnicial Site Investigation	Date	24-11-2022
Location	122 Crescent Rd, Newport	Page	1 of 1
Test Method:	AS 1289.2.1.1 ☑ RMS T120 ☐	Date Sampled:	27-28/10/2022,17/11/2022

Test No.	Sample Location	Description	Moisture Content (%)
MT5	BH7 0.6 - 0.8m	Clay with some Gravel, Brown	20.6
MT6	BH8 0.3 - 1.0m	Clay with Rock Fragments, Brown	27.5
MT7	BH9 1.2m	Silty Clay, Light Brown	8.6
MT8	BH1 0.5m	Sandy Silty Clay, Dark Brown	15.7

Notes:

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.
This document shall not be reproduced, except in full.
Accreditation No. 5452

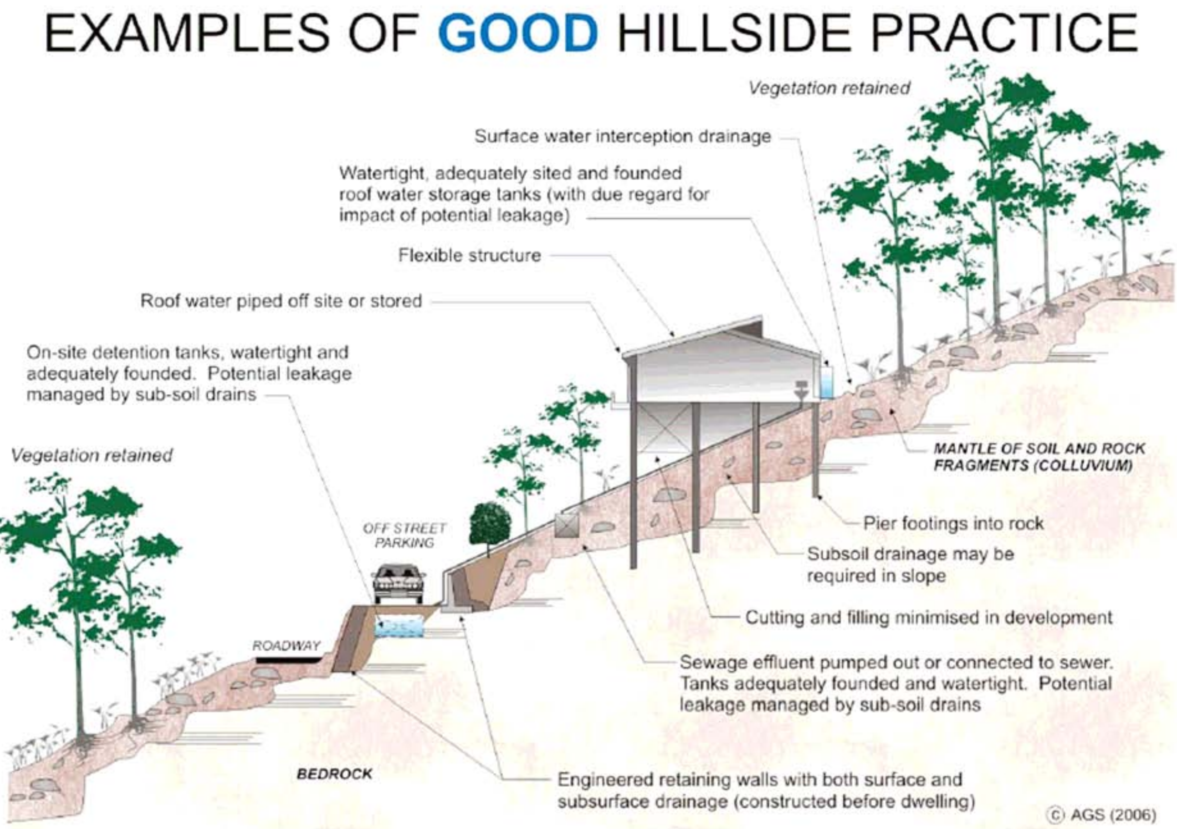
Approved Signatory: Mark Hoveling M Hoveling 24-11-22

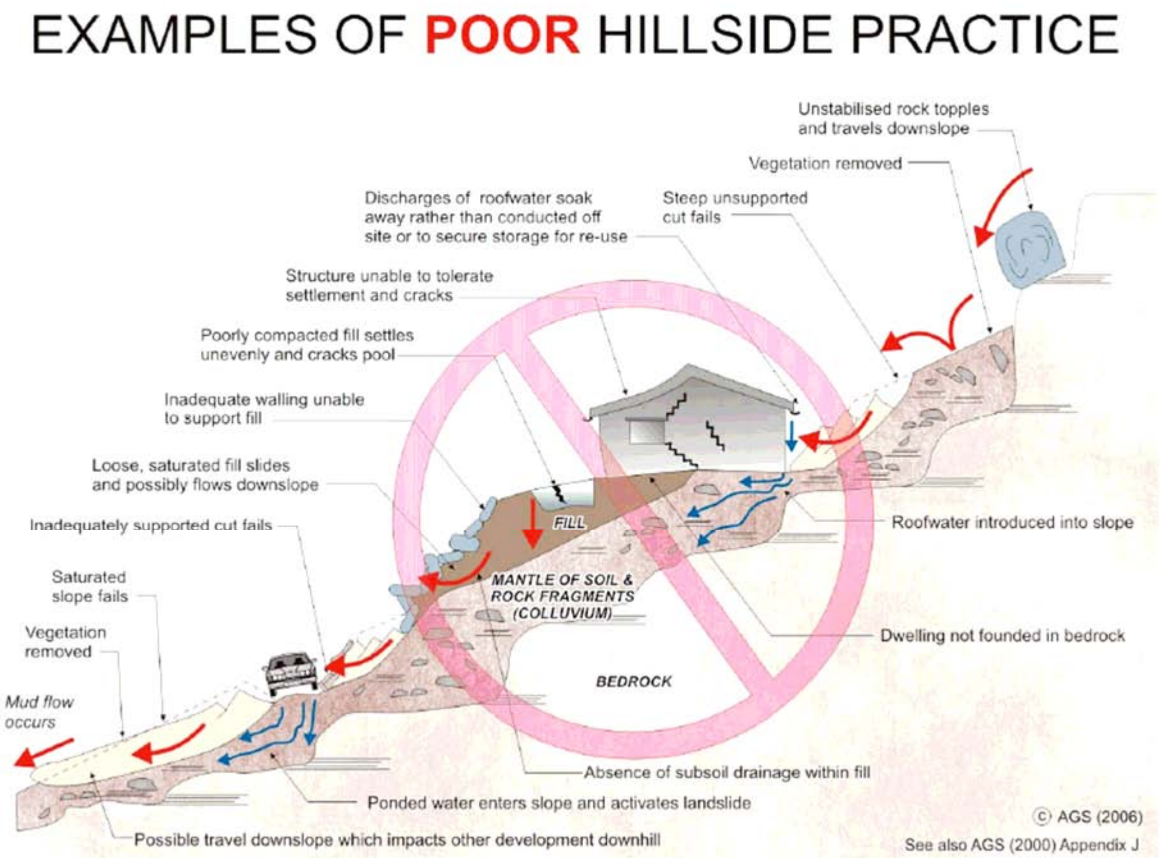
APPENDIX G

AGS Guidelines on Good Hillside Construction, CSIRO Guidelines on footing maintenance

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.	


EXAMPLES OF GOOD HILLSIDE PRACTICE
Vegetation retained
Surface water interception drainage
Watertight, adequately sited and founded roof water storage tanks (with due regard for impact of potential leakage)
Flexible structure
Roof water piped off site or stored
On-site detention tanks, watertight and adequately founded. Potential leakage managed by sub-soil drains
Vegetation retained
OFF STREET PARKING
ROADWAY
MANTLE OF SOIL AND ROCK FRAGMENTS (COLLUVIUM)
Pier footings into rock
Subsoil drainage may be required in slope
Cutting and filling minimised in development
Sewage effluent pumped out or connected to sewer. Tanks adequately founded and watertight. Potential leakage managed by sub-soil drains
BEDROCK
Engineered retaining walls with both surface and subsurface drainage (constructed before dwelling)
© AGS (2006)


EXAMPLES OF POOR HILLSIDE PRACTICE
Unstabilised rock topples and travels downslope
Vegetation removed
Discharges of roofwater soak away rather than conducted off site or to secure storage for re-use
Steep unsupported cut fails
Structure unable to tolerate settlement and cracks
Poorly compacted fill settles unevenly and cracks pool
Inadequate walling unable to support fill
Loose, saturated fill slides and possibly flows downslope
Inadequately supported cut fails
Saturated slope fails
Vegetation removed
Mud flow occurs
FILL
MANTLE OF SOIL & ROCK FRAGMENTS (COLLUVIUM)
BEDROCK
Roofwater introduced into slope
Dwelling not founded in bedrock
Absence of subsoil drainage within fill
Ponded water enters slope and activates landslide
Possible travel downslope which impacts other development downhill
© AGS (2006)
See also AGS (2000) Appendix J

Foundation Maintenance and Footing Performance: A Homeowner's Guide

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).

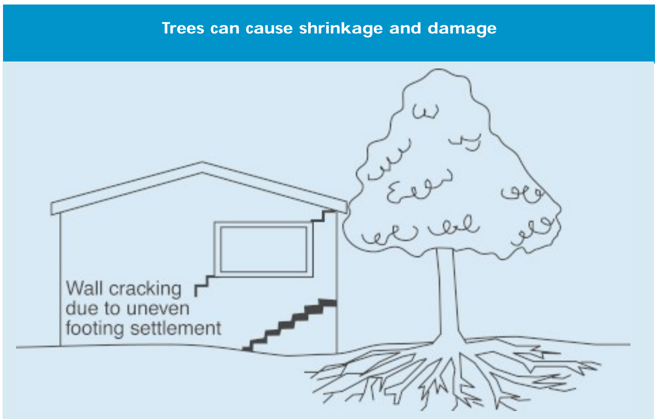
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

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.



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

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

Movement caused by tree roots

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

Complications caused by the structure itself

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

Effects on full masonry structures

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

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

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

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

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

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

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

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

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

Water Service and Drainage

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

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

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

Seriousness of Cracking

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

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

Prevention/Cure

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

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

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

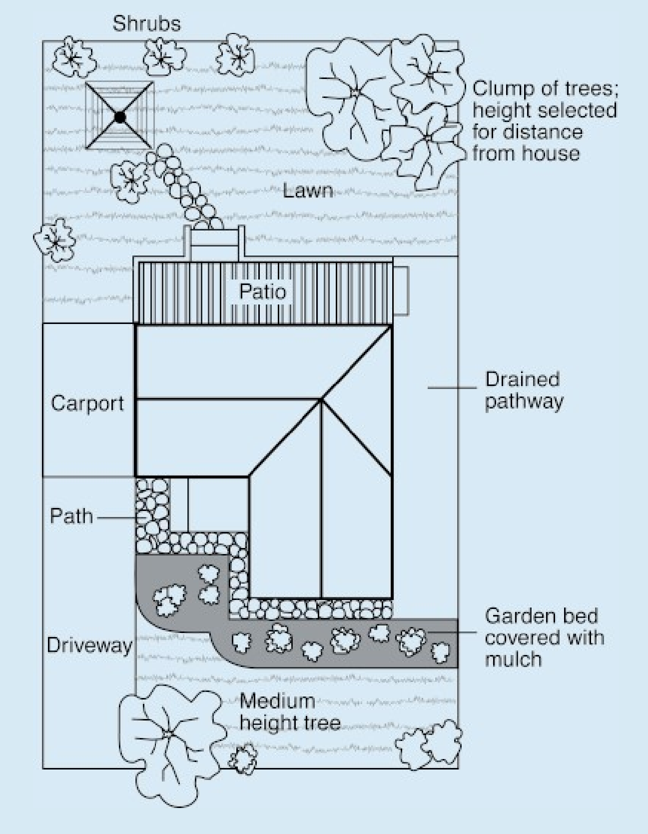
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

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

Gardens for a reactive site



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

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

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

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

Condensation

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

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

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

The garden

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

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

Existing trees

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

Information on trees, plants and shrubs

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

Excavation

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

Remediation

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

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

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

Distributed by

CSIRO PUBLISHING PO Box 1139, Collingwood 3066, Australia

Freecall 1800 645 051 Tel (03) 9662 7666 Fax (03) 9662 7555 www.publish.csiro.au

Email: publishing.sales@csiro.au

APPENDIX H

Northern Beaches Council Forms 1, 1a

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER
FORM NO. 1 – To be submitted with Development Application

Development Application for____Essex Developments Pty Ltd________________________
Name of Applicant
Address of site __Nos. 122-128 Crescent Road, Newport NSW 2106________________

Declaration made by geotechnical engineer or engineering geologist or coastal engineer (where applicable) as part of a geotechnical report

I, KENNETH BURGESS *on behalf of* MARTENS & ASSOCIATES
(Insert Name) (Trading or Company Name)

on this the ___23 December 2022__________________ certify that I am an geotechnical engineer or engineering geologist or coastal engineer as defined by the Geotechnical Risk Management Policy for Pittwater - 2009 and I am authorised by the above organisation/company to issue this document and to certify that the organisation/company has a current professional indemnity policy of at least $10million.

I:
Please mark appropriate box

- ∍ have prepared the detailed Geotechnical Report referenced below in accordance with the Australia Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009
- ∍ ✓ am willing to technically verify that the detailed Geotechnical Report referenced below has been prepared in accordance with the Australian Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009
- ∍ have examined the site and the proposed development in detail and have carried out a risk assessment in accordance with Section 6.0 of the Geotechnical Risk Management Policy for Pittwater - 2009. I confirm that the results of the risk assessment for the proposed development are in compliance with the Geotechnical Risk Management Policy for Pittwater - 2009 and further detailed geotechnical reporting is not required for the subject site.
- ∍ have examined the site and the proposed development/alteration in detail and I am of the opinion that the Development Application only involves Minor Development/Alteration that does not require a Geotechnical Report or Risk Assessment and hence my Report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements.
- ∍ have examined the site and the proposed development/alteration is separate from and is not affected by a Geotechnical Hazard and does not require a Geotechnical Report or Risk Assessment and hence my Report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements.
- ∍ have provided the coastal process and coastal forces analysis for inclusion in the Geotechnical Report

Geotechnical Report Details:

Report Title: GS8649-2B Newport Geotechnical Site Investigation Report and Landslide Risk Assessment

Report Date: 23 December 2022

Author: Rafael Furniss

Author's Company/Organisation: Aargus Pty Ltd

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

Site Survey Plan and Subdivision documents described in Section 2 of Aargus Report
Ref. No. GS8649-2B

I am aware that the above Geotechnical Report, prepared for the abovementioned site is to be submitted in support of a Development Application for this site and will be relied on by Pittwater Council as the basis for ensuring that the Geotechnical Risk Management aspects of the proposed development have been adequately addressed to achieve an "Acceptable Risk Management" level for the life of the structure, taken as at least 100 years unless otherwise stated and justified in the Report and that reasonable and practical measures have been identified to remove foreseeable risk.

Signature ....KBurgess............

Name ......KENNETH BURGESS..........

Chartered Professional Status....MEMBER..........

Membership No. 3789174..........

Company.....MARTENS & ASSOCIATES

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER
FORM NO. 1(a) - Checklist of Requirements For Geotechnical Risk Management Report for Development Application

Development Application for Essex Developments Pty Ltd
Name of Applicant
Address of site Nos. 122-128 Crescent Road, Newport NSW 2106

The following checklist covers the minimum requirements to be addressed in a Geotechnical Risk Management Geotechnical Report. This checklist is to accompany the Geotechnical Report and its certification (Form No. 1).

Geotechnical Report Details:

Report Title: GS8649-2B Newport Geotechnical Site Investigation Report and Landslide Risk Assessment
Report Date: dated 23 December 2022
Author: Rafael Furniss
Author's Company/Organisation: Aargus Pty Ltd

Please mark appropriate box

- ✓ Comprehensive site mapping conducted 26-28 October 2022 (date)
- ✓ Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:200 (as appropriate)
- ✓ Subsurface investigation required
  - No Justification ....
  - ✓ Yes Date conducted ...26-28 October 2022..........
- ✓ Geotechnical model developed and reported as an inferred subsurface type-section
- ✓ Geotechnical hazards identified
  - Above the site
  - ✓ On the site
  - Below the site
  - Beside the site
- ✓ Geotechnical hazards described and reported
- Risk assessment conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
  - Consequence analysis
  - Frequency analysis
- ✓ Risk calculation
- ✓ Risk assessment for property conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- ✓ Risk assessment for loss of life conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- ✓ Assessed risks have been compared to "Acceptable Risk Management" criteria as defined in the Geotechnical Risk Management Policy for Pittwater - 2009
- ✓ Opinion has been provided that the design can achieve the "Acceptable Risk Management" criteria provided that the specified conditions are achieved.
- ✓ Design Life Adopted:
  - ✓ 100 years
  - Other .... specify
- ✓ Geotechnical Conditions to be applied to all four phases as described in the Geotechnical Risk Management Policy for Pittwater - 2009 have been specified
- Additional action to remove risk where reasonable and practical have been identified and included in the report.
- Risk assessment within Bushfire Asset Protection Zone.

I am aware that Pittwater Council will rely on the Geotechnical Report, to which this checklist applies, as the basis for ensuring that the geotechnical risk management aspects of the proposal have been adequately addressed to achieve an "Acceptable Risk Management" level for the life of the structure, taken as at least 100 years unless otherwise stated, and justified in the Report and that reasonable and practical measures have been identified to remove foreseeable risk.

Signature ....
Name ....KENNETH BURGESS....
Chartered Professional Status....MEMBER....
Membership No. ....3789174....
Company....MARTENS & ASSOCIATES....