GEOTECHNICAL INVESTIGATION REPORT

No. 17 Anembo Avenue
Georges Hall, NSW

Prepared for

Ms Cheryl Nguyen
c/- OIC Design

Reference No. ESWN-PR-2022-1240

28th February 2022

Geotechnical Engineering Services

- *Geotechnical investigation*
- *Lot classification*
- *Geotechnical design*
- *Footing inspections*
- *Excavation methodology and monitoring plans*
- *Slope stability analysis*
- *Landslide risk assessment*
- *Permeability test*
- *Finite Element Analysis(FEA)*

ESWNMAN
25 YEARS EXPERIENCE

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Author: Jiameng Li...

Signed: .....JLi...

Date: 28/02/2022 ....

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REFERENCES

1. Australian Standard – AS 1726-2017 Geotechnical Site Investigation.
2. Australian Standard AS 1289.6.3.2 – Determination of the penetration resistance of a soil – 9 kg dynamic cone penetrometer test.
3. Australian Standard – AS 2870-2011 Residential Slabs and Footings.
4. Australian Standard – AS 2159-2009 Piling - Design and Installation.
5. Australian Standard – AS 3798-2007 Guidelines on Earthworks for Commercial and Residential Developments.
6. Australian Standard – AS 1170.4-2007 Structural Design Actions – Part 4: Earthquake actions in Australia.
7. Australian Standard – AS 4678-2002 Earth-retaining Structures.
8. 'NSW WorkCover: Code of Practice – Excavation' July 2015.
9. Pells, P.J.N, Mostyn, G. & Walker B.F., "Foundations on Sandstone and Shale in the Sydney Region", Australian Geomechanics Journal, 1998.
10. Austroads – "Pavement Design – A Guide to the Structural Design of Road Pavements", 2004.
11. CSIRO, BTF 18 - "Foundation Maintenance and Footing Performance: A Homeowner's Guide".

1. INTRODUCTION

ESWNMAN Pty Ltd (ESWNMAN) was commissioned by Ms Cheryl Nguyen c/- OIC Design to undertake a geotechnical investigation for a proposed development at No. 17 Anembo Avenue, Georges Hall, NSW 2198. The fieldwork was completed on 21st February 2022 by an experienced Geotechnical Engineer from ESWNMAN.

The purpose of investigation was to assess feasibility of the site in geotechnical prospective for a proposed alteration and addition.

This report presents results of geotechnical investigation & in-situ tests, interpretation and assessment, and provides comments on geotechnical related issues and recommendations.

1.1 Available Information

The following information was provided to ESWNMAN prior to the fieldwork:

- Architectural drawings titled "17 Anembo Avenue, Georges Hall" prepared by Art'itects, including drawing nos. 301LG, 301GF, 301FF, 302LG, 302GF & 302FF, Issue B and dated 25th July 2021;
- A site survey plan titled "Plan Showing Detailed Topographic Survey, 17 Anembo Avenue, Georges Hall, NSW 2198, Lot 5 in DP235447" prepared by Shepherd Surveys, sheet 1 and dated 28th April 2021.

1.2 Proposed Development

Based on the information provided in Section 1.1, the proposed development will comprise the partial demolition of existing structures and construction of proposed alterations and additions to an existing dwelling, including a garage at Lower Ground Level.

1.3 Scope of Work

The fieldwork was completed by an experienced Geotechnical Engineer from ESWNMAN, including the following:

- Collection and review of Dial-Before-You-Dig (DBYD) plans;
- A site walkover to assess site accessibility and surface conditions, identify relevant site features, and nominate borehole and testing locations;
- Drilling of boreholes using a hand operated equipment assisted with in-situ tests;
- Conducting of Dynamic Cone Penetrometer (DCP) Test to assess strength of soils with depth and rock profile;

- Geotechnical logging of rocks and soils retrieved from boreholes by an experienced Geotechnical Engineer;
- Reinstatement of site with soil cuttings from boreholes;
- Interpretation of investigation data and results of test; and
- Preparation of a geotechnical report.

The approximate locations of borehole and DCP tests completed during site investigation are shown on Figure 1 - "Site location plan" as included in Appendix A of this report.

2. SITE DESCRIPTION

The site is located within Canterbury-Bankstown Council area, approximately 20.1km to the west of Sydney CBD, 590m to the north of Georges Hall Public School and 930m to the south of Bass High School.

The site is identified as Lot 25 in Deposited Plan (DP)235447, with an approximate area of 961.1m^2.

At time of site investigation, the site was occupied by a one & two storey brick house, which was likely supported by shallow type foundation.

Based on site walkover and survey plan provided, the site is characterised by a gentle sloping ground, with an average slope angle of 6°-8° towards the west and northwest.

Selected site photographs recorded during site investigation are provided in Appendix B.

3. LOCAL GEOLOGY

Reference to the Penrith 1:100,000 Geological Series Sheet 9030 (Edition 1), dated 1991, by the Geological Survey of New South Wales, Department of Minerals and Energy, indicates the site is located within an area underlain by Triassic Age Bringelly Shale(Rwb) of the Wianamatta Group. The Bringelly Shale is described as "Shale, carbonaceous claystone, claystone, laminite, fine to medium-grained lithic sandstone, rare coal and tuff."

The map also shows the site is very close to another geotechnical unit, i.e. Ashfield Shale (Rwa), which consists of "Dark-grey to black claystone-siltstone and fine grained sandstone-siltstone laminite."

Results of the investigation, as provided in Section 5.2 confirmed the published geology.

4. METHODOLOGY OF INVESTIGATION

4.1 Pre-fieldwork

Prior to the commencement of fieldwork, a desktop study on local geology and our in-house dataset near the subject site was undertaken.

A 'Dial Before You Dig' (DBYD) underground services search was also conducted with plans reviewed prior to the mobilisation and in-situ tests.

4.2 Borehole Drilling

Due to presence of existing site structures and concrete surfaces over majority of site, drilling of boreholes could only be carried out in very limited areas.

One borehole was completed in a garden area within front yard to check the thickness of fill and property of natural soils during site investigation. The boreholes were drilled to refusal depth of 1.4m approximately below the existing ground level (BGL) using a using a hand operated equipment assisted with in-situ tests.

The borehole locations are shown on Figure 1 – "Site Location Plan" attached in Appendix A. Engineering logs of boreholes processed using Bentley gINT software together with borehole explanatory notes are presented in Appendix C.

4.3 Dynamic Cone Penetrometer (DCP) Test

The Dynamic Cone Penetrometer (DCP) Test involves hammering cone tipped rods using a standard weight and drop height. The number of blows required to penetrate each 100 mm is recorded in accordance with AS 1289.6.3.2 (Reference 2). The DCP test is used to assess in-situ strength of undisturbed soil and/or compacted materials. The penetration rate of the 9-kg DCP can be used to estimate in-situ CBR (California Bearing Ratio) and to identify strata thickness and other material characteristics.

A total of four(4) DCP tests, donated as DCPs 1 to 4, were also completed at some selected locations through pre-drilled holes to assess strength of soils with depth and rock profile. DCP tests reached refusal depth and inferred top of rock at an approximate depth of 1.7m, 1.6m, 1.1m and 1.5m BGL at location of DCPs 1 to 4 respectively.

The location of DCP tests is shown on Figure 1 attached in Appendix A. The record of DCP test results is presented in Appendix D.

All fieldwork was supervised on a full time basis by an experienced Geotechnical Engineer who was responsible for nominating locations of boreholes and DCP test, preparing field engineering logs of the subsurface strata encountered in accordance with AS 1726 for Geotechnical Site Investigation(Reference 1), conducting in-situ tests and taking site photographs.

The approximate reduced levels of borehole and DCP tests, which were estimated based on the plans provided as referenced in Section 1.1, are presented in the attached engineering log and record sheet of DCP tests.

5. RESULTS OF INVESTIGATION

5.1 Surface Conditions

At time of site investigation, the site was occupied by existing dwelling, an inground swimming pool, fish pond and concrete surfaces, and some limited garden area within front yard.

5.2 Subsurface Conditions

Based on borehole information and results of in-situ tests, subsurface conditions encountered at testing locations consisted of the following:

- **Fill** (Unit 1): Silty CLAY, low plasticity, grey, trace gravel, variable compaction, typically 0.5m in thickness at testing location; overlying
- **Residual Soils** (Unit 2): Silty CLAY, low to medium plasticity, brown and brown with red mottling, moist, varying from “stiff” to “hard” consistency, extending to inferred top of rock at approximate depth of 1.7m, 1.6m, 1.1m and 1.5m BGL at location of DCPs 1 to 4 respectively; overlying
- **Weathered Claystone/Shale** (Unit 3): Class V CLAYSTONE/SHALE, grey-dark grey, extremely weathered, extremely low and low strength, based on interpreted results of DCP test. Classification of the rock was carried out in accordance with Pells et al (Reference 9).

The subsurface conditions described above are also summarised in Table 1 overleaf.

Table 1 - Subsurface Conditions at Testing Locations

Geotechnical Unit and Description			**Inferred Depth at Top of Unit** (m BGL)			
			BH1/ DCP1	BH2/ DCP2	BH3/ DCP3	BH4/ DCP4
Fill(Unit 1)		Silty/gravelly CLAY, variable compaction	0	0	0	0
Residual Soils (Unit 2)	Unit 2a	Silty CLAY, stiff & very stiff	0.3*	0.5*	0.4*	0.5
	Unit 2b	Silty CLAY, hard	1.1	1.3	0.9	1.1
Weathered Claystone/shale (Unit 3)		Class V CLAYSTONE/SHALE, extremely low & low strength	1.7	1.6	1.1	1.5

Note: * - Inferred based on interpreted results of DCP test

5.3 Groundwater

No groundwater was encountered during drilling of borehole up to 1.4m BGL. No indication of water seepage/inflow or we soil materials were observed on DCP tools up to 1.7m BGL when DCP accessories were extracted onto ground surface upon completion of DCP tests.

6. GEOTECHNICAL ASSESSMENT

The main geotechnical aspects associated with proposed development are assessed to include the following:

- Site classifications;
- Excavation conditions;
- Excavation support/stability of excavation;
- Earth retaining structures;
- Foundations;
- Foundation/subgrade preparation; and
- Earthworks and material use.

The assessment of geotechnical aspects listed above and recommendations for the proposed development are presented in the following sections.

6.1 Site Classifications

(a) Site reactive classification

Based on soil profile on the above and the criteria specified in AS2870 (Reference 3), the site can be classified as Class M – "Moderately reactive clay or silt sites", which may experience moderate ground movement from moisture changes.

The above classification and footing recommendations are provided on the basis that the performance expectations set out in Appendix B of AS2870 are accepted.

Design, construction and maintenance of plumbing, ground drainage, protection of building perimeter, the garden, etc. should be carried out in accordance with CSIRO BTF18 (Reference 11) to avoid any water related problems or significant changes of moisture in building foundations, which may contribute to surface movement.

(b) Site earthquake classification

The results of the site investigation indicate the presence of fill and residual soils, underlain by Weathered Claystone/shale or better rock. In accordance with Australian Standard AS 1170.4(Reference 6), the site may be classified as "Shallow Soil Site" (Class C_e) for design of foundations and retaining walls within soils, or a "Rock site" (Class B_e) for foundation design of building and retaining walls embedded in the underlying shale. The Hazard Factor (Z) for Georges Hall in accordance with AS 1170.4 is considered to be 0.08.

6.2 Excavation Conditions and Excavation Methods

Based on design information for proposed development as provided in Section 1.2, minor excavation would be required for footing excavation during construction, such as piers/piles. Other excavation may include minor cut/fill for foundation/subgrade preparation, trench excavation for installation of underground water/sewer/stormwater pipes and landscaping.

Results of geotechnical investigation indicate the site is underlain by Fill (Unit 1), Residual Soils(Unit 2) and Weathered Claystone/shale(Unit 3).

Excavation of soils (Unit 1 & Unit 2) and low and extremely low strength Class V Claystone/Shale (Unit 3) (if required) will be typically feasible using conventional earthmoving equipment.

Based on groundwater conditions in Section 5.3, we assessed it is unlikely to encounter groundwater during construction excavation.

6.3 Excavation Support / Stability of Excavation

For shallow Excavation (i.e. <1.5 m in Depth), it should be carried out in accordance with the 'NSW WorkCover: Code of Practice – Excavation' (Reference 8).

Prior to demolition and any excavation, the following should be undertaken as designed and directed by the project Structural Engineer:

- **Bracing/support of existing walls and structural members adequately;**
- **Underpinning the existing structures as appropriate.**

During design and construction, the excavation methods and recommendations below should be considered:

- Saw cut through existing concrete slabs using a hand operated tools to minimise induced vibration; hammering is not allowed;

Temporary excavations away from site boundaries or site structures through the underlying soils to a maximum depth of 1.5m, may be excavated near vertical provided that:

- They do not encroach ZOI(Zone of Influence, defined as 45° angle of draw from nearest edge of footing underside) of any site or adjoining structures;
- They are barricaded when not in use;
- They are not left open for more than 24 hours;
- No surcharge loading is applied within 2.0m of the edge of the excavation;
- No groundwater flows are encountered; and
- They are not used for access by a worker.

Where access is required for workers, the temporary excavation batters should be re-graded to no steeper than 2 Horizontal (H) to 1 Vertical (V) for soils above the natural groundwater level, or supported by suitable temporary shoring measures.

Any permanent excavation (or filling) greater than 0.6m in height should be retained by a retaining wall to be designed by a qualified Engineer based on the recommendation provided in Section 6.4.

With recommended bracing/support and underpinning works, construction methods and control measures, excavation shoring/support, and engineering inspections, the construction of proposed development is unlikely to have adverse impacts on existing site structures, adjoining buildings, roads and public infrastructure.

6.4 Earth Retaining Structures

The earth retaining structure should be designed to withstand the applied lateral pressures of the subsurface layers, the surcharges in their zone of influence, including loading from existing structures, construction machinery, traffic and construction related activities. The design of retaining structures should also take into consideration hydrostatic pressures and lateral earthquake loads as appropriate.

The retaining wall design should be carried out in accordance with AS 4678 (Reference 7).

The recommended preliminary parameters for design of retaining structures are presented in Tables 2 and 3 below. The coefficients provided are based on drained conditions.

Table 2 - Preliminary Geotechnical Design Parameters for Retaining Walls

Geotechnical Unit	Unit Weight (kN/m^3)	Effective Cohesion c′ (kPa)	Angle of Effective Internal Friction ϕ' (degree)	Modulus of Elasticity $E_{s\,(h)}$ (MPa)	Poisson's Ratio (ν)
Fill (Unit 1)	17	2	27	10	0.35
Residual Soils (Unit 2)	18	5	28	20	0.35
Weathered Claystone/Shale (Unit 3)	23	50	29	80	0.25

Table 3 - Preliminary Coefficients of Lateral Earth Pressure

Geotechnical Unit	Coefficient of Active Lateral Earth Pressure (Ka)	Coefficient of Lateral Earth Pressure at Rest (Ko)	Coefficient of Passive Lateral Earth Pressure (Kp)
Fill (Unit 1)	0.38	0.55	2.7
Residual Soils (Unit 2)	0.36	0.53	2.8
Weathered Claystone/Shale(Unit 3)	0.35	0.52	2.9

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) and passive earth pressures can be carried out using Rankine's equation shown below:

$Pa = K\,\gamma\,H - 2c\sqrt{K}$ For calculation of Lateral Active or At Rest Earth Pressure

$Pp = K_p\,\gamma\,H + 2c\sqrt{K_p}$ For calculation of Passive 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)

Kp = Coefficient of Passive Earth Pressure

H = Retained height (m)

c = Effective Cohesion (kN/m^2)

6.5 Foundations

Based on design information and results of geotechnical investigation, we assessed the ground condition at this site is suitable for proposed alterations and additions.

Based on proposed development, subsurface conditions and sloping ground effects, we assessed a footing system consisting of **piers/piles founded in founded in Unit 3 – "Weathered Claystone/shale"** (approx. 1.1m-1.7m BGL at testing locations), would be applicable for proposed new structures and underpinning design (if required).

Preliminary geotechnical capacities and parameters recommended for design of shallow and piers/piled foundations are provided in Table 4 below.

Table 4 - Preliminary Geotechnical Foundation Design Capacities and Parameters

Geotechnical Unit		Allowable End Bearing Pressure (kPa[1])	Allowable Shaft Adhesion Compression[2] (kPa)	Modulus of Elasticity (Es,v, MPa)
Fill (Unit 1)		N/A[3]	N/A[3]	15
Residual Soils (Unit 2)	Unit 2a	150 (Shallow footings)	15	25
	Unit 2b	300 (Piers/piles)	30	60
Weathered Claystone/shale (Unit 3)		600 (Piers/piles)	70	100

[1] With a minimum footing embedment depth=300mm into bearing stratum.
[2] Shaft Adhesion applicable to piles only.
[3] N/A, being excavated or Not Applicable or not recommended, unless it is re-compacted for minor structure.

Design of shallow and piled foundations should be carried out in accordance with Australian Standards AS2870 (Reference 3) and AS2159 (Reference 4) respectively.

To minimise the potential effects of differential settlement under the buildings loads, it is recommended all foundations of the proposed building should be founded on consistent materials of similar properties or rock of similar class.

Any water, debris, loose and wet materials should be removed from excavations prior to placement of reinforcement and pouring of concrete.

A Geotechnical Engineer should be engaged to inspect footing excavations and construction to ensure foundation bases have suitable materials with adequate bearing capacity, and to check the adequacy of footing embedment or pile socket length if unexpected ground conditions are encountered.

6.6 Foundation/subgrade Preparation

For service pipes and slabs between walls and columns to fully or partially rely on soils underneath (existing fill or new fill), to achieve an allowable bearing capacity of 150kPa for existing fill or new fill, the following can be adopted as a guidance:

- Excavate and re-compact all existing Fill (Unit 1), typically 0.5m in thickness;
- Remove wood/timber and organic matters and oversized materials;
- Level off the existing natural ground surface and provide proof rolling;
- Place fill materials (preferably granular materials) at loose layer of not exceeding 200mm for cohesionless materials;
- Densify the fill mechanically, using a suitable roller or compaction equipment;
- Repeat the above till proposed FFL reached.

For compaction over a small area or inside a trench, a vibrating plate compactor is commonly used to compact and densify the subgrade/foundation areas. The requirements of fill materials and compaction criteria are provided in Section 6.7.

The final pass should be carried out in the presence of a Geotechnical Engineer to verify the results of compaction by in-situ soil tests and inspection.

6.7 Earthworks and Material Use

The excavated materials from excavation are assessed to be generally suitable for landscaping provided they are free of any contaminants.

The suitability of site excavated or imported materials should be subject to satisfying the following criteria:

- The materials should be Virgin Excavated Natural Material (VNEM) and clean (i.e. free of contaminants, deleterious or organic material), free of inclusions of >75mm in size, high plasticity material be removed and suitably conditioned to meet the design assumptions where fill material is proposed to be used.

- The materials should satisfy the Australian Standard AS 3798-2007 Guidelines on Earthworks for Commercial and Residential Developments (Reference 5).

The final surface levels of all excavation and filling areas should be compacted in order to achieve an adequate strength for subgrade.

As a guidance for fill construction, the following compaction targets can be adopted:

- Moisture content of ±2% of OMC (Optimal Moisture Content);
- Minimum density ratio of 100% of MDD (Maximum Dry Density) for filling within building/structural foundation areas;
- Minimum density ratio of 98% of MDD for backfilling surrounding the pipes within trenches or behind retaining walls unless otherwise specified on design drawings;
- The loose thickness of layer should not exceed 150mm for cohesive soils and 200mm for cohesionless soils; and
- For the footpath and pavement areas, minimum density ratio of 95% of MDD for general fill and 98% for the subgrade to 0.5m depth.

Design and construction of earthworks should be carried out in accordance with Australian Standard AS 3798-2007 (Reference 5).

7. CONCLUSIONS AND RECOMMENDATIONS

- Results of geotechnical investigation and assessment indicate ground conditions at this site are suitable for proposed alterations & additions and associated works.
- We assessed a footing system consisting of **piers/piles founded in Unit 3 – "Weathered Claystone/shale"**, would be applicable for the proposed new structures and underpinning of existing structures (if necessary). Footing system and recommended geotechnical design parameters are provided in Section 6.5.
- The construction, including excavation methods, excavation safe batter, excavation support/shoring measures, footing system, foundation/subgrade preparation, retaining walls, drainage works and earthworks should be implemented in accordance with the recommendations provided in Section 6 of this report.
- A Geotechnical Engineer should be engaged to inspect foundation excavations to ensure the foundation base have been taken to suitable materials of appropriate bearing capacity and adequate embedment depth/socket length if unexpected ground conditions are encountered.

- If our recommendations in report are adopted in the design and during construction, the potential impacts of the proposed development on existing site structures, surrounding properties, road and public infrastructure are expected to be negligible.

8. LIMITATIONS

This report should be read in conjunction with the "Limitations of Geotechnical Investigation Statement" attached as Appendix E, which provides important information regarding geotechnical investigation, assessment and reporting. If the actual subsurface conditions exposed during construction vary significantly from those discussed in this report, this report should be reviewed and the undersigned should be contacted for further advices.

For and on behalf of

ESWNMAN Pty Ltd

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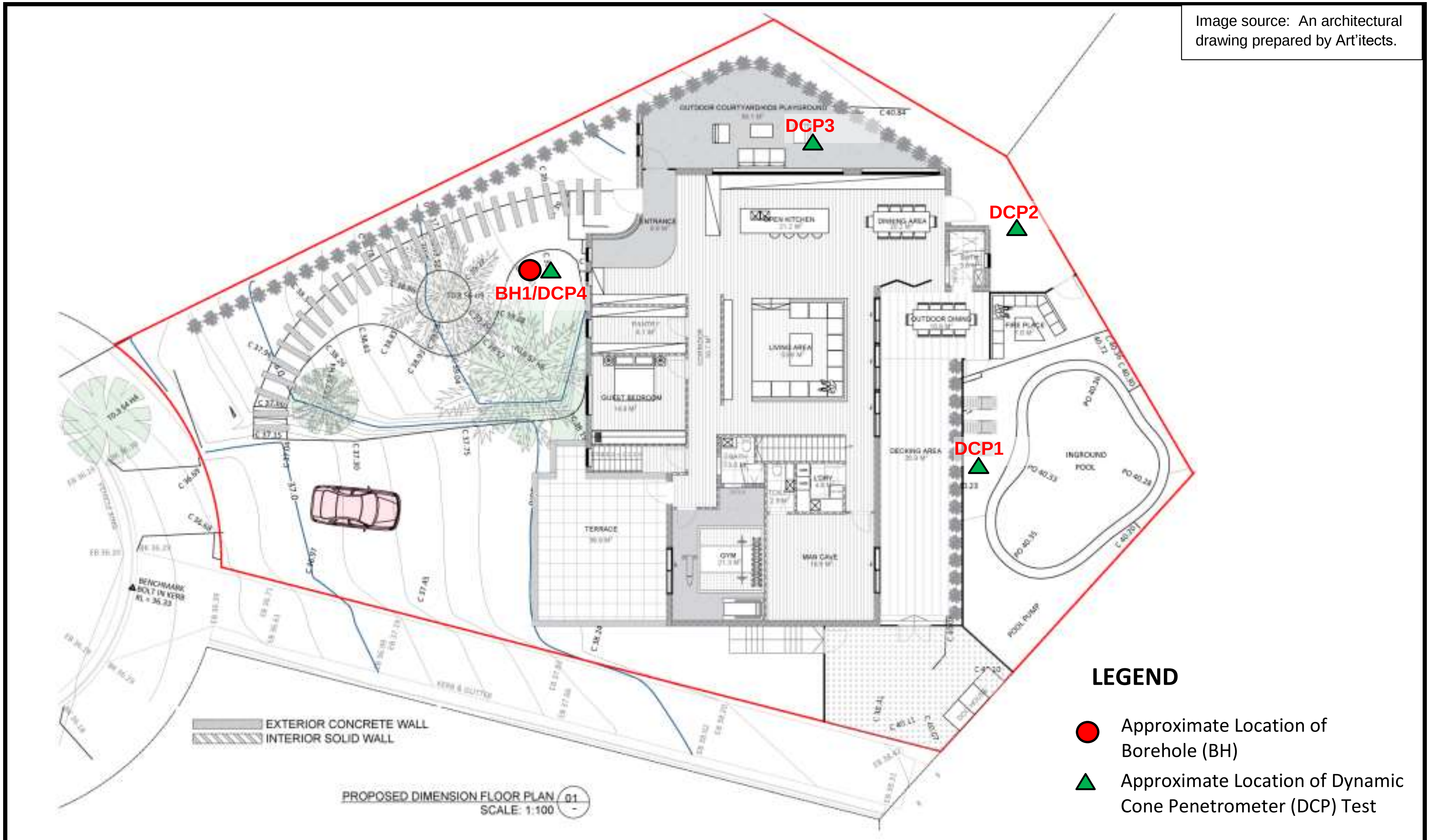
APPENDIX A

SITE LOCATION PLAN



PROJECT: 17 Anembo Avenue, Georges Hall, NSW	**DRAWN BY:** J.L.	ESWNMAN 25 YEARS EXPERIENCE	**CLIENT:** Ms Cheryl Nguyen	
PROJECT NO: ESWN-PR-2022-1240	**DATE:** 28/02/2022		**TITLE:** Site Location Plan	FIGURE 1

APPENDIX B

SITE PHOTOGRAPHS

ESWNMAN
25 YEARS EXPERIENCE

Photograph 1
Dynamic Cone Penetrometer(DCP) at location of DCP2 at rear portion

Photograph 2
DCP in progress at location of DCP3 at rear portion

Photograph 3
DCP in progress at location of DCP4 within front yard

Photograph 4
Drilling in progress at location of BH4 within front yard

Appendix B Site Photographs

APPENDIX C

ENGINGGERING BOREHOLE LOGS AND EXPLANATORY NOTES

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BOREHOLE NUMBER BH1

CLIENT Ms Cheryl Nguyen
PROJECT NAME Geotechnical Investigation
PROJECT NUMBER ESWN-PR-2022-1240
PROJECT LOCATION 17 Anembo Avenue, Georges Hall, NSW

DATE STARTED 21/2/22 **COMPLETED** 21/2/22
R.L. SURFACE 39.4 **DATUM** m AHD
DRILLING CONTRACTOR ESWNMAN Pty Ltd
SLOPE 90° **BEARING** ---
EQUIPMENT Hand auger & DCP test
HOLE LOCATION Refer to Figure 1
HOLE SIZE 110mm Diameter
LOGGED BY J.L. **CHECKED BY** J.L.
NOTES front yard

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
HA	NOT ENCOUNTERED	39.0			CL	Silty CLAY, low plasticity, dark grey - grey, some gravel, moist, fairly compacted.		FILL
		38.5	0.5		CL	Silty CLAY, low plasticity, brown, moist, stiff.		RESIDUAL SOILS
		38.0	1.0		CH	Silty CLAY, medium plasticity, reddish brown, moist, hard.		DCP test indicates top of rock below 1.5m depth
		37.5	1.5			Borehole BH1 terminated at 1.4m		
			2.0					

Explanatory Notes – Description for Soil

In engineering terms soil includes every type of uncemented or partially cemented inorganic material found in the ground. In practice, if the material can be remoulded by hand in its field condition or in water it is described as a soil. The dominant soil constituent is given in capital letters, with secondary textures in lower case. The dominant feature is assessed from the Unified Soil Classification system and a soil symbol is used to define a soil layer .

METHOD

Method	Description
AS	Auger Screwing
BH	Backhoe
CT	Cable Tool Rig
EE	Existing Excavation/Cutting
EX	Excavator
HA	Hand Auger
HQ	Diamond Core-63mm
JET	Jetting
NMLC	Diamond Core –52mm
NQ	Diamond Core –47mm
PT	Push Tube
RAB	Rotary Air Blast
RB	Rotary Blade
RT	Rotary Tricone Bit
TC	Auger TC Bit
V	Auger V Bit
WB	Washbore
DT	Diatube

WATER

Water level at date shown

Partial water loss

Water inflow

Complete water loss

NFGWO: The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.

NFGWE: The borehole/test pit was dry soon after excavation. Inflow may have been observed had the borehole/test pit been left open for a longer period.

SAMPLING

Sample	Description
B	Bulk Disturbed Sample
D	Disturbed Sample
Jar	Jar Sample
SPT	Standard Penetration Test
U50	Undisturbed Sample –50mm
U75	Undisturbed Sample –75mm

UNIFIED SOIL CLASSIFICATION

The appropriate symbols are selected on the result of visual examination, field tests and available laboratory tests, such as, sieve analysis, liquid limit and plasticity index.

USC Symbol	Description
GW	Well graded gravel
GP	Poorly graded gravel
GM	Silty gravel
GC	Clayey gravel
SW	Well graded sand
SP	Poorly graded sand
SM	Silty sand
SC	Clayey sand
ML	Silt of low plasticity
CL	Clay of low plasticity
OL	Organic soil of low plasticity
MH	Silt of high plasticity
CH	Clay of high plasticity
OH	Organic soil of high plasticity
Pt	Peaty Soil

MOISTURE CONDITION

Dry - Cohesive soils are friable or powdery
Cohesionless soil grains are free-running

Moist - Soil feels cool, darkened in colour
Cohesive soils can be moulded
Cohesionless soil grains tend to adhere

Wet - Cohesive soils usually weakened
Free water forms on hands when handling

For cohesive soils the following codes may also be used:

MC>PL Moisture Content greater than the Plastic Limit.
MC~PL Moisture Content near the Plastic Limit.
MC<PL Moisture Content less than the Plastic Limit.

PLASTICITY

The potential for soil to undergo change in volume with moisture change is assessed from its degree of plasticity. The classification of the degree of plasticity in terms of the Liquid Limit (LL) is as follows:

Description of Plasticity	LL (%)
Low	<35
Medium	35 to 50
High	>50

COHESIVE SOILS - CONSISTENCY

The consistency of a cohesive soil is defined by descriptive terminology such as very soft, soft, firm, stiff, very stiff and hard. These terms are assessed by the shear strength of the soil as observed visually, by hand penetrometer values and by resistance to deformation to hand moulding.

A Hand Penetrometer may be used in the field or the laboratory to provide an approximate assessment of the unconfined compressive strength (UCS) of cohesive soils. The undrained shear strength of cohesive soils is approximately half the UCS. The values are recorded in kPa as follows:

Strength	Symbol	Undrained Shear Strength, C_u (kPa)
Very Soft	VS	< 12
Soft	S	12 to 25
Firm	F	25 to 50
Stiff	St	50 to 100
Very Stiff	VSt	100 to 200
Hard	H	> 200

COHESIONLESS SOILS - RELATIVE DENSITY

Relative density terms such as very loose, loose, medium, dense and very dense are used to describe silty and sandy material, and these are usually based on resistance to drilling penetration or the Standard Penetration Test (SPT) 'N' values. Other condition terms, such as friable, powdery or crumbly may also be used.

Term	Symbol	Density Index	N Value (blows/0.3 m)
Very Loose	VL	0 to 15	0 to 4
Loose	L	15 to 35	4 to 10
Medium Dense	MD	35 to 65	10 to 30
Dense	D	65 to 85	30 to 50
Very Dense	VD	>85	>50

COHESIONLESS SOILS PARTICLE SIZE DESCRIPTIVE TERMS

Name	Subdivision	Size
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 µm to 2.36 mm
	medium	200 µm to 600 µm
	fine	75 µm to 200 µm

Description for Rock

The rock is described with strength and weathering symbols as shown below. Other features such as bedding and dip angle are given.

METHOD

Refer soil description sheet

WATER

Refer soil description sheet

ROCK QUALITY

The fracture spacing is shown where applicable and the Rock Quality Designation (RQD) or Total Core Recovery (TCR) is given where:

$$TCR\ (\%) = \frac{\text{length of core recovered}}{\text{length of core run}}$$

$$RQD\ (\%) = \frac{\text{Sum of Axial lengths of core > 100mm long}}{\text{length of core run}}$$

ROCK MATERIAL WEATHERING

Rock weathering is described using the abbreviations and definitions used in AS1726. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between (but not including) XW and SW. For projects where it is not practical to delineate between HW and MW or it is deemed that there is no advantage in making such a distinction, DW may be used with the definition given in AS1726.

Symbol	Term	Definition
RS	Residual Soil	Soil definition on extremely weathered rock; the mass structure and substance are no longer evident; there is a large change in volume but the soil has not been significantly transported
XW	Extremely Weathered	Rock is weathered to such an extent that it has 'soil' properties, ie. It either disintegrates or can be remoulded in water
HW	Highly Weathered	The rock substance is affected by weathering to the extent that limonite staining or bleaching affects the whole rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength is usually decreased compared to the fresh rock. The colour and strength of the fresh rock is no longer recognisable.
DW (HW–MW)	*Distinctly Weathered (see AS1726 Definition below)*	
MW	Moderately Weathered	The whole of the rock substance is discoloured, usually by iron staining or bleaching, to the extent that the colour of the fresh rock is no longer recognisable
SW	Slightly Weathered	Rock is slightly discoloured but shows little or no change of strength from fresh rock
FR	Fresh	Rock shows no sign of decomposition or staining

"Distinctly Weathered: 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 the deposition of weathering products in pores." (AS1726)

ROCK STRENGTH

Rock strength is described using AS1726 and ISRM - Commission on Standardisation of Laboratory and Field Tests, "Suggested method of determining the Uniaxial Compressive Strength of Rock materials and the Point Load Index", as follows:

Term	Symbol	Point Load Index $Is_{(50)}$ (MPa)
Extremely Low	EL	<0.03
Very Low	VL	0.03 to 0.1
Low	L	0.1 to 0.3
Medium	M	0.3 to 1
High	H	1 to 3
Very High	VH	3 to 10
Extremely High	EH	>10

● Diametral Point Load Index test

■ Axial Point Load Index test

DEFECT SPACING/BEDDING THICKNESS

Measured at right angles to defects of same set or bedding.

Term	Defect Spacing	Bedding
Extremely closely spaced	<6 mm	Thinly Laminated
	6 to 20 mm	Laminated
Very closely spaced	20 to 60 mm	Very Thin
Closely spaced	0.06 to 0.2 m	Thin
Moderately widely spaced	0.2 to 0.6 m	Medium
Widely spaced	0.6 to 2 m	Thick
Very widely spaced	>2 m	Very Thick

DEFECT DESCRIPTION

Type:	Definition:
B	Bedding
BP	Bedding Parting
F	Fault
C	Cleavage
J	Joint
SZ	Shear Zone
CZ	Crushed Zone
DB	Drill Break

Planarity:	Roughness:
P – Planar	R – Rough
Ir – Irregular	S – Smooth
St – Stepped	Sl – Slickensides
U – Undulating	Po – Polished

Coating or Infill:	Description
Clean	No visible coating or infilling
Stain	No visible coating or infilling but surfaces are discoloured by mineral staining
Veneer	A visible coating or infilling of soil or mineral substance but usually unable to be measured (<1mm). If discontinuous over the plane, patchy veneer
Coating	A visible coating or infilling of soil or mineral substance, >1mm thick. Describe composition and thickness

The inclinations of defects are measured from perpendicular to the core axis.

Graphic Symbols for Soil and Rock

Graphic symbols used on borehole and test pit reports for soil and rock are as follows. Combinations of these symbols may be used to indicate mixed materials such as clayey sand.

Soil Symbols

Main Components

- CLAY
- SILT
- SAND
- GRAVEL
- BOULDERS / COBBLES
- PEAT (Organic)

Minor Components

- Clayey
- Silty
- Sandy
- Gravelly

Other Symbols

- TOPSOIL
- FILL
- ASPHALT
- CONCRETE
- NO CORE

Rock Symbols

Sedimentary Rocks

- SANDSTONE
- SILTSTONE
- CLAYSTONE, MUDSTONE
- SHALE
- LAMINITE
- CONGLOMERATE
- BRECCIA
- TILL
- COAL
- LIMESTONE

Igneous Rocks

- PLUTONIC IGNEOUS (eg: Granite)
- VOLCANIC IGNEOUS (eg: Basalt)
- PYROCLASTIC IGNEOUS (eg: Ignimbrite)

Metamorphic Rocks

- SLATE, PHYLLITE, SCHIST
- GNEISS
- QUARTZITE

Engineering classification of shales and sandstones in the Sydney Region - A summary guide

The Sydney Rock Class classification system is based on rock strength, defect spacing and allowable seams as set out below. All three factors must be satisfied.

CLASSIFICATION FOR SANDSTONE

Class	Uniaxial Compressive Strength (MPa)	Defect Spacing (mm)	Allowable Seams (%)
I	>24	>600	<1.5
II	>12	>600	<3
III	>7	>200	<5
IV	>2	>60	<10
V	>1	N.A.	N.A.

CLASSIFICATION FOR SHALE

Class	Uniaxial Compressive Strength (MPa)	Defect Spacing (mm)	Allowable Seams (%)
I	>16	>600	<2
II	>7	>200	<4
III	>2	>60	<8
IV	>1	>20	<25
V	>1	N.A.	N.A.

1. ROCK STRENGTH

For expedience in field/construction situations the uniaxial (unconfined) compressive strength of the rock is often inferred, or assessed using the point load strength index (Is_{50}) test (AS 4133.4.1 - 1993). For Sydney Basin sedimentary rocks the uniaxial compressive strength is typically about 20 x (Is_{50}) but the multiplier may range from about 10 to 30 depending on the rock type and characteristics. In the absence of UCS tests, the assigned Sydney Rock Class classification may therefore include rock strengths outside the nominated UCS range.

2. DEFECT SPACING

The terms relate to spacing of natural fractures in NMLC, NQ and HQ diamond drill cores and have the following definitions:

Defect Spacing (mm)	Terms Used to Describe Defect Spacing[1]
>2000	Very widely spaced
600 – 2000	Widely spaced
200 – 600	Moderately spaced
60 – 200	Closely spaced
20 – 60	Very closely spaced
<20	Extremely closely spaced

[1]After ISO/CD14689 and ISRM.

3. ALLOWABLE SEAMS

Seams include clay, fragmented, highly weathered or similar zones, usually sub-parallel to the loaded surface. The limits suggested in the tables relate to a defined zone of influence. For pad footings, the zone of influence is defined as 1.5 times the least footing dimension. For socketed footings, the zone includes the length of the socket plus a further depth equal to the width of the footing. For tunnel or excavation assessment purposes the defects are assessed over a length of core of similar characteristics.

Source: Based on Pells, P.J.N, Mostyn, G. and Walker, B.F. (1998) – Foundations on sandstone and shale in the Sydney region. Australian Geomechanics Journal, No 33 Part 3

APPENDIX D

RESULTS OF DYNAMIC CONE PENETROMETER(DCP) TEST

RESULTS OF DYNAMIC CONE PENETROMETER TEST

ESWNMAN
25 YEARS EXPERIENCE

Client:	Ms Cheryl Nguyen	Ref No:	ESWN-PR-2022-1240
Project:	Geotechnical Investigation	Date Tested:	21/02/2022
Location:	17 Anembo Avenue, Georges Hall, NSW 2198	Tested By:	J.L.

Depth (mm)	DCP No.				Depth (mm)	DCP No.				
	DCP1	DCP2	DCP3	DCP4		5	6	7	8	9
0-100	Ex	Ex	Ex	2	0-100					
100-200				3	100-200					
200-300	5	3	8	3	200-300					
300-400	2	3	2	2	300-400					
400-500	3	4	2	2	400-500					
500-600	2	2	2	3	500-600					
600-700	3	2	3	4	600-700					
700-800	3	3	2	3	700-800					
800-900	4	5	2	4	800-900					
900-1000	9	8	15	3	900-1000					
1000-1100	5	5	10/90mm	4	1000-1100					
1100-1200	10	7	Bounce	13	1100-1200					
1200-1300	13	9		17	1200-1300					
1300-1400	13	10		10	1300-1400					
1400-1500	15	23		11/80mm	1400-1500					
1500-1600	20	14/50mm		Bounce	1500-1600					
1600-1700	23/50mm	Bounce			1600-1700					
1700-1800	Bounce				1700-1800					
1800-1900					1800-1900					
1900-2000					1900-2000					
2000-2100					2000-2100					
2100-2200					2100-2200					
2200-2300					2200-2300					
2300-2400					2300-2400					
2400-2500					2400-2500					
2500-2600					2500-2600					
2600-2700					2600-2700					
2700-2800					2700-2800					
2800-2900					2800-2900					
2900-3000					2900-3000					
3000-3100					3000-3100					
3100-3200					3100-3200					
3200-3300					3200-3300					
3300-3400					3300-3400					
3400-3500					3400-3500					
3500-3600					3500-3600					
3600-3700					3600-3700					
3700-3800					3700-3800					
RL(m, AHD)	40.2	40.8	40.6	39.4	RL(m, AHD)					

Notes:

DCP testing equipment designed and conducted in accordance with AS1289.6.3.2

APPENDIX E

LIMITATIONS OF GEOTECHNICAL INVESTIGATION

General

In making an assessment of a site from a limited number of boreholes or test pits there is the possibility that variations may occur between testing locations. Site exploration identifies specific subsurface conditions only at those points from which samples have been taken. The risk that variations will not be detected can be reduced by increasing the frequency of testing locations. The investigation program undertaken is a professional estimate of the scope of investigation required to provide a general profile of the subsurface conditions. The data derived from the site investigation program and subsequent laboratory testing are extrapolated across the site to form an inferred geological model and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Despite investigation the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies.

The borehole/test pit logs are the subjective interpretation of subsurface conditions at a particular location, made by trained personnel. The interpretation may be limited by the method of investigation, and cannot always be definitive.

Subsurface conditions

Subsurface conditions may be modified by changing natural forces or man-made influences. A geotechnical report is based on conditions which existed at the time of subsurface exploration.

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

Assessment and interpretation

A geotechnical engineer should be retained to work with other appropriate design professionals explaining relevant geotechnical findings and in reviewing the adequacy of their drawings/plans and specifications relative to geotechnical issues.

Information and documentations

Final logs are developed by geotechnical engineers based upon their interpretation of field description and laboratory results of field samples. Customarily, only the final logs are included in geotechnical engineering reports. These logs should not under any circumstances be redrawn for inclusion in architectural or other design drawings. To minimise the likelihood of bore/profile log misinterpretation, contractors should be given access to the complete geotechnical engineering report prepared or authorised for their use. Providing the best available information to contractors helps prevent costly construction problems.

Construction phase service (CPS)

During construction, excavation is frequently undertaken which exposes the actual subsurface conditions. For this reason geotechnical consultants should be retained through the construction stage, to identify variations if they are exposed and to conduct additional tests which may be required and to deal quickly with geotechnical problems if they arise.

Report

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

Other limitations

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