ESWNMAN
25 YEARS EXPERIENCE

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Geotechnical Engineering Services

- *Geotechnical investigation*
- *Geotechnical design*
- *Footing inspections*
- *Permeability test and landslide risk assessment*

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To: RPDC,

Our Ref No.: ESWN-PR-2020-600
Date: 9th June 2020

RE: GEOTECHNICAL ASSESSMENT REPORT ON PROPOSED DWELLING AT NO. 2 CULLEN STREET, FORESTVILLE, NSW

1. INTRODUCTION

ESWNMAN Pty Ltd (ESWNMAN) was commissioned by RPDC to undertake a geotechnical investigation and assessment on a proposed development at No. 2 Cullen Street, Forestville, NSW 2087. The fieldwork was completed on 1st June 2020.

The purpose of the geotechnical investigation was to obtain the subsurface conditions, site classification, excavation conditions, recommend on geotechnical parameters for design of foundations and retaining walls, and comment on geotechnical related issues associated with proposed development.

This report presents results of investigation with interpretations, assessments and recommendations.

2. PROPOSED DEVELOPMENT

Based on project briefing and design sketch provided, the proposed development will comprise the construction of a two storey dwelling at middle of the site, an inground swimming pool at rear of the site and car parking area within front yard.

The following cut/fill and earthworks are likely to be required for the proposed development:

- Excavation typically 1.5m deep for an inground swimming pool, unless it is designed as elevated type;
- Minor excavation within structural footing areas (pad/strip footings, piers/piles);
- Trench excavation/backfilling for installation of water/sewer/stormwater pipes and associated facilities;
- Minor cut/fill earthworks for subgrade preparation, pavement and footpath; and
- Landscaping.

3. SITE DESCRIPTION

The site is located within Northern Beaches Council area and is approximately 12.5km to the north of Sydney CBD, 510m to the south of Carroll Creek and 220m to the north of Middle Harbour.

The site is identified as Lot 1, Section 44, Deposited Plan (DP)758421, with an approximate area of 822.05m^2.

At time of investigation, the site was a vacant land, which is characterised by a gentle sloping ground towards site rear boundary bounded by the reserve of Middle Harbour in the south.

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

4. LOCAL GEOLOGY

Reference to the Sydney 1:100,000 Geological Series Sheet 9130 (Edition 1), dated 1983, by the Geological Survey of New South Wales, Department of Mineral Resources, indicates the site is located within an area underlain by Hawkesbury Sandstone (Rh), which is described as “Medium to coarse-grained quartz sandstone, very minor shale and laminite lenses”.

Results of investigation provided in Section 6 confirmed the published geology.

5. METHODOLOGY OF INVESTIGATION

5.1 Borehole Drilling

During site investigation, three(3) boreholes, identified as BH1 to BH3 inclusive, were drilled to the refusal depth or inferred top of rock approximately between 0.5m and 0.75m below existing ground level (BGL) using a hand operated equipment.

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 explanatory notes are presented in Appendix C.

5.2 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. The DCP test is used to assess in-situ strength of undisturbed soil and/or compacted materials and define the rock profile. 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 three(3) DCP tests positioned next to boreholes, identified as DCPs 1 to 3, were also completed during site investigation. DCP tests reached refusal depth and bounce of DCP hammer occurred in a depth between 0.5m and 0.8m BGL.

The location of DCP tests is shown on the site location plan attached in Appendix A. The record of DCP test results is presented in Appendix D.

5.3 Geological Mapping

Geological mapping and detailed examination of sandstone outcrops exposed within the site by a Geotechnical Engineer or Engineering Geologist is proven to be an effective way of investigation if rock coring using machine drilling is not possible.

Geological mapping on rock outcrops exposed at front yard was also undertaken during the site investigation. The approximate location and extent of rock outcrops, grain size and colour, weathering degree, and estimated strength were recorded and assessed on-site by an experienced Geotechnical Engineer from ESWNMAN. The approximate locations of sandstone outcrops mapped are shown on Figure 1 – "Site Location Plan" as included in Appendix A, and also indicated on Photo 5 attached in Appendix B of this report.

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

6. SUBSURFACE CONDITIONS

The subsurface conditions, based on our site observations, borehole information and results of DCP test at testing locations, consisted of the following:

- **Fill** (Unit 1): Gravelly CLAY, low plasticity, brown – light grey, some medium grained sand, fine to medium grained sandstone gravel, moist, trace boulder on surface, approximately between 0.2m and 0.3m in thickness at testing locations; overlying
- **Residual Soils** (Unit 2): Clayey SAND, medium grained, brown, moist, medium dense, extending to inferred top of rock at 0.8m, 0.5m and 0.5m at location of DCPs 1 to 3 respectively; overlying
- **Weathered Sandstone** (Unit 3): Class V Sandstone, highly and moderately weathered, low and medium strength. Classification of the rock was carried out in accordance with Pells et al (Reference 6). During fieldwork, sandstone boulders and outcrops encountered during investigation were mapped as

indicated on Figure 1 – "Site Location Plan" in Appendix A. The rock outcrops are also shown on Photo 5 included in Appendix B.

The subsurface conditions described on the above are summarised in Table 1 below.

Table 1 – Subsurface Conditions at Testing Locations

Geotechnical Unit and Description		**Inferred Depth to Top of Unit** (m, BGL)		
		BH1/DCP1	BH2/DCP2	BH3/DCP3
Fill (Unit 1)	Gravelly CLAY	0	0	0
Residual Soils (Unit 2)	Clayey SAND, medium dense	0.3	0.2	0.2
Weathered Sandstone (Unit 3)	Class V Sandstone, low and medium strength	0.8	0.5	0.5

No groundwater was encountered during drilling of in any boreholes. However, some wet materials were observed within front yard as indicated on Photo 6 in Appendix B. We assessed it may be surface runoff caused by rainfall in previous days and/or water inflow/seepage.

7. GEOTECHNICAL ASSESSMENTS AND RECOMMENDATIONS

7.1 Site Classifications

(a) Site reactivity classification

Based on ground profile of the site and the criteria specified in AS 2870 (Reference 2), the site can be assessed as Class A – "Most sand and rock sites" with little or no 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 8) 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 site investigation indicate the presence of fill and residual soils, underlain by Class V Sandstone or better rock. In accordance with Australian Standard AS 1170.4 (Reference 5), the site may be classified as a "Rock site" (Class B_e) for design of foundations and retaining walls embedded in the underlying Sandstone. The Hazard Factor (Z) for Forestville in accordance with AS 1170.4 is considered to be 0.08.

7.2 Excavation Conditions and Methodology

Based on design information in Section 2, some excavation are likely to be required for proposed swimming pool, footing excavation for structures, trench excavation and backfilling for installation of underground water/sewer/stormwater pipes, subgrade preparation for pavement and landscaping.

Subsurface conditions in Section 6 indicate the presence of fill, residual soils underlain by weathered sandstone during excavation.

Excavation of soils and extremely low strength and low strength sandstone should be feasible using conventional earthmoving equipment.

The excavations should be carried out in accordance with the 'NSW WorkCover: Code of Practice – Excavation' July 2015 (Reference 9).

Temporary excavations through the underlying fill and residual soils to a maximum depth of 1.5m, may be excavated near vertical provided that:

- They are barricaded when not in use;
- They are not left open for more than 24 hours;
- No surcharge loading is applied within 1.5m 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 safe excavation batters should be re-graded to no steeper than 2 Horizontal (H) to 1 Vertical (V) for the soils above the natural groundwater level, or supported by a suitable temporary shoring measure.

Any permanent excavation (or filling) greater than 0.5m in height should be retained by a permanent retaining wall to be designed by a qualified Engineer in accordance with geotechnical parameters provided in Section 7.5.

To avoid induced vibration due to construction excavation within rock, saw cutting and/or jack hammer maybe required to pre-cut and break sandstone bedrock or sandstone boulders if are encountered during excavation of proposed swimming pool.

A geotechnical inspection and advices are required if any abnormal or unexpected ground conditions occur.

7.3 Foundations

The results of geotechnical investigation and assessment indicate the ground conditions at this site are suitable for the proposed development.

Based on proposed development and subsurface conditions discussed in Section 6 and, we assessed a footing system consisting of **cast-in-situ reinforced concrete shallow footings**, such as, pad and strip footings under columns and walls/raft slab, would be applicable for the proposed development. **A minimum footing embedment of 500mm into low strength Class V Sandstone or 300mm into medium strength Class IV Sandstone or better rock is required,** in accordance with our recommendations for hillside construction provided in Section 7.8

The preliminary geotechnical parameters recommended for design of foundations are provided in Table 2 below.

Table 2 - Preliminary Geotechnical Foundation Design Parameters

Geotechnical Unit[3]	Allowable Bearing Capacity (kPa[1])	Modulus of Elasticity (Es,v MPa)
Fill (Unit 1)	N/A[2]	N/A[2]
Residual Soils (Unit 2)	N/A[2]	25
Class V Sandstone (Unit 3)	500(Shallow footings)	100

[1] A minimum embedment depth of 300mm into Class IV Sandstone or 500mm into Class V Sandstone.
[2] N/A, Not Applicable, not recommended for the proposed development.
[3] Refer to Table 1 for approximate depth to top of each unit.

Design of shallow footings should be carried out in accordance with Australian AS2870 (Reference 2).

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 within the excavated footing areas should be removed prior to placement of reinforcement and pouring the concrete.

An experienced Geotechnical Engineer should be engaged to inspect footing excavations to ensure foundation bases have suitable materials with adequate bearing capacity, and to check adequacy of footing embedment. Verification of embedment/socket depth, bearing capacity of foundation material by inspections would be required and inspections should constitute as “Hold Points”.

7.4 Foundation/Subgrade Preparation

For slabs relying on existing fill and/or new fill (instead of suspended slabs fully supported by footings), to achieve an allowable bearing capacity of 150kPa, the following can be adopted as a guidance:

- Remove wood/timber and organic matters and oversized materials;
- Level off the surface;

- Densify the loose sand mechanically, as a minimum, rolling at least 8 passes of a smooth drum roller of 7 to 8 tonnes minimum deadweight over a large area; and a vibrating plate compactor within a small area.
- Place fill materials (preferably granular materials) at loose layer of not exceeding 200mm in thickness & compact/densify as above.

The requirements for fill materials and compaction should be carried out in accordance with our recommendations provided in Section 7.6.

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.

7.5 Earth Retaining Structures

If an earth retention structure is required, it should be designed to withstand the applied lateral pressures of the subsurface layers, the existing surcharges in their zone of influence, including existing structures, construction machines, traffic and construction related activities. The design of retaining structures should also take into consideration hydrostatic pressures and lateral earthquake loads as appropriate. Subsoil drain and erosion control should be considered during retaining wall design.

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'(°)	Modulus of Elasticity (E_{sh}, MPa)	Poisson Ratio ν
Fill (Unit 1)	17	2	27	10	0.35
Residual Soils (Unit 2)	18	0	33	20	0.35
Weathered Sandstone (Unit 3)	23	50	35	100	0.30

Table 3 - Preliminary Coefficients of Lateral Earth Pressure

Geotechnical Unit	Coefficient of Active Lateral Earth Pressure (Ka)	Coefficient of Active 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)	0.29	0.46	3.4
Weathered Sandstone (Unit 3)	0.27	0.43	3.7

7.6 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 won materials or imported materials should be subject to satisfying the following criteria:

- The materials should be Virgin Excavated Natural Materials(VENM) and clean (i.e. free of contaminants, wood material, 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 4).

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 Maximum Dry Density (MDD) for filling within building/structural foundation areas;
- Minimum density ratio of 98% of MDD for backfilling surrounding the pipes within trench;
- The loose thickness of layer should not exceed 200mm for cohesionless soils or granular materials; and
- For the footpath and pavement areas, minimum density ratio of 95% of the maximum dry density 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 (Reference 4).

7.7 Preliminary Comments on Pavement Subgrade

It is recommended that pavement can be designed on a CBR value of 3% on stiff residual soils or medium dense granular subgrade.

Any loose or soft materials that may be present during construction, as confirmed by a site inspection and in-situ testing, should be either removed or improved by compaction in order to increase the strength of the material. The final levels of subgrade should be tested/proof rolled and inspected by an experienced Geotechnical Engineer.

Pavement design should be carried out in accordance with “Pavement Design – A Guide to the Structural Design of Road Pavements” (Reference 7) and should be complemented by the provision of adequate surface and subsurface drainage.

7.8 Site Instability and Landslip Mitigation Measures

Though the site is on a gentle sloping ground with shallow rock and typically has low risk in terms of site instability, in order to control any ground movement or landslip potential towards downslope or Middle Harbour reserve, we recommend the following precautionary measures and provisions should be adopted for construction of proposed development in accordance with AGS Landslide Risk Management Concepts and Guidelines (Reference 10):

- Footings for all proposed structures, such as building, swimming pool, retaining walls(if any) and rainwater/detention tanks, **should be founded in underlying rock and keyed into underlying sandstone** (instead of floaters or boulders) **adequately designed to reduce the risk of instability**. A minimum embedment depth of 500mm into underlying Class V Sandstone (Unit 3) or 300mm into Class IV Sandstone or stronger rock is recommended.
- **An experienced Geotechnical Engineer should be engaged to inspect excavations to ensure the foundation bases have suitable materials with adequate bearing capacity and embedment depth.** Verification of the founding material, embedment depth and bearing capacity of by a geotechnical inspection would be required.
- All stormwater systems, including pipe lines, pits and spreaders(if any) should be founded in stable natural ground with surrounding areas compacted adequately and provided with adequate surface erosion control measures.
- Adequate surface drain and subsoil drain should be provided. Inspection and maintenance of batter slopes, erosion control and drainage system should be carried out periodically.
- The design and construction works should be carried out in accordance with AGS guidelines for hillside construction (Reference 10).
- Construction activities should be carefully planned and be observed by an experienced Geotechnical Engineer familiar with content of this report for further assessment of the necessary mitigation and control measures.
- Implementation of the above measures should constitute as “Hold Points”.

Provided that the above provisions and recommendations in this report are taken into consideration during design and construction, **the level of risk of the overall site instability due to proposed development can be considered to be low and reduced to normally acceptable levels.**

8. CONCLUSIONS AND RECOMMENDATIONS

- The results of geotechnical investigation and assessment indicate ground conditions at this site are suitable for proposed development.

- A footing system consisting of cast-in-situ reinforced concrete shallow footings, such as, pad and strip footings under columns and walls/raft slab, would be applicable for the proposed development. **A minimum footing embedment of 500mm into low strength Class V Sandstone or 300mm into medium strength Class IV Sandstone or better rock is required.**
- It is recommended that an experienced 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.
- Our recommendations in Section 7.8 for hillside construction in accordance with AGS Landslide Guidelines 2007 should be adopted during design and construction.
- It is recommended the final civil and structural design drawings for the proposed development should be provided to us for further assessment and confirmation of suitable mitigation measures, foundation system, adopted safe excavation batters, erosion control measures, fill compaction, bearing capacity of founding material and embedment depth and drainage systems.

9. 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 inspection, 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.

10. REFERENCES

1) *Australian Standard – AS 1726-2017 Geotechnical Site Investigation.*
2) *Australian Standard – AS 2870-2011 Residential Slabs and Footings.*
3) *Australian Standard – AS 2159-2009 Piling - Design and Installation.*
4) *Australian Standard – AS 3798-2007 Guidelines on Earthworks for Commercial and Residential Developments.*
5) *Australian Standard – AS 1170.4-2007 Structural Design Actions – Part 4: Earthquake actions in Australia.*
6) *Pells, P.J.N, Mostyn, G. & Walker B.F., "Foundations on Sandstone and Shale in the Sydney Region", Australian Geomechanics Journal, 1998.*
7) *Austroads – "Pavement Design – A Guide to the Structural Design of Road Pavements", 2004.*

8) *CSIRO, BTF 18 - "Foundation Maintenance and Footing Performance: A Homeowner's Guide".*

9) *"NSW WorkCover: Code of Practice – Excavation" July 2015.*

10) *Australian Geomechanics Society, Landslide Risk Management Sub-Committee Guidelines: Landslip Risk Management Concepts and Guidelines, March 2007.*

For and on behalf of
ESWNMAN PTY LTD

Yours sincerely,

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ESWNMAN
25 YEARS EXPERIENCE

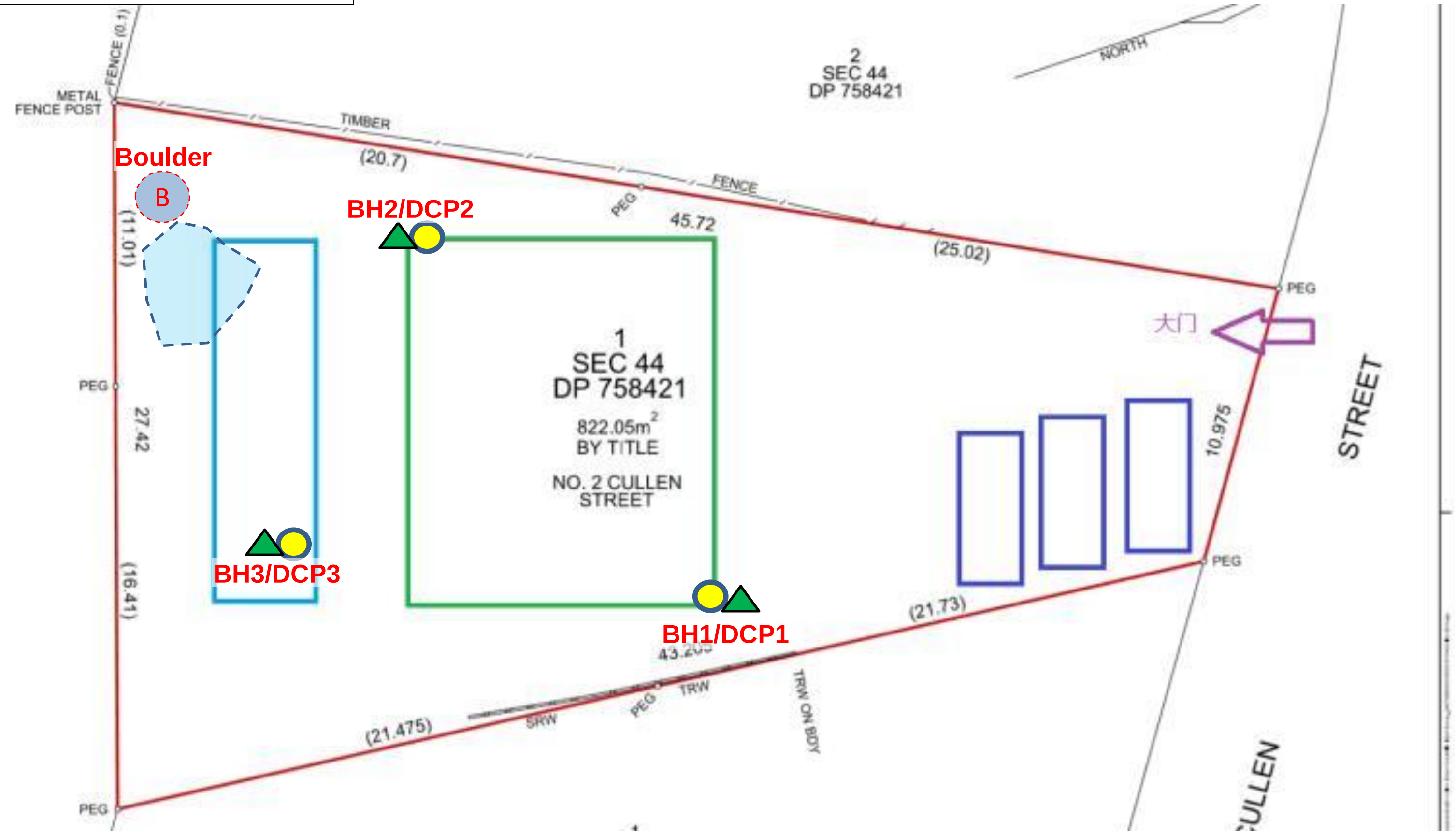
Attachments

Appendix A – Site Location Plan
Appendix B – Site Photographs
Appendix C – Engineering Borehole Logs and Explanatory Notes
Appendix D – Results of Dynamic Cone Penetrometer(DCP) Test
Appendix E – Limitations of Geotechnical Investigation

APPENDIX A

SITE LOCATION PLAN

Image source: Design sketch prepared by RPDC.



LEGEND

Approximate Location of Dynamic Cone Penetrometer (DCP) Test

Approximate Location of Borehole (BH)

Approximate Location of Sandstone Outcrop and Shallow Rock Area

PROJECT: No. 2 Cullen Street, Forestville, NSW	**DRAWN BY:** J.L.	ESWNMAN 25 YEARS EXPERIENCE	**CLIENT:** RPDC
PROJECT NO: ESWN-PR-2020-600	**DATE:** 9th June 2020		**TITLE:** Site Location Plan / FIGURE 1

APPENDIX B

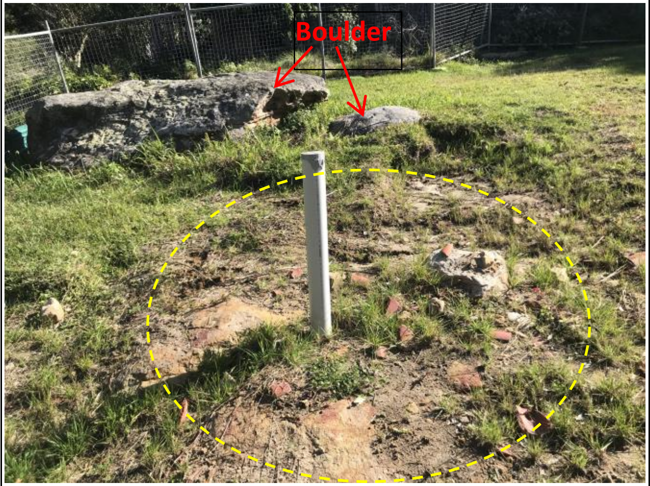
SITE PHOTOGRAPHS

Photograph 1
Borehole drilling at BH1 near front corner of proposed dwelling

Photograph 2
Dynamic Cone Penetrometer(DCP) at DCP1

Photograph 3
Drilling and DCP test at location of BH2/DCP2 at rear corner of proposed dwelling

Photograph 4
DCP test at location of DCP3 within rear garden at proposed swimming pool



Photograph 5
Shallow rock area in yellow circle within rear garden

Photograph 6
Wet area within front yard

Appendix B Site Photographs

APPENDIX C

ENGINGGERING BOREHOLE LOGS AND EXPLANATORY NOTES

BOREHOLE NUMBER BH1

ESWNMAN Pty Ltd
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Telephone: 02-79015582

CLIENT RPDC
PROJECT NAME Geotechnical Investigation
PROJECT NUMBER ESWN-PR-2020-600
PROJECT LOCATION No. 2 Cullen Street, Forestville, NSW

DATE STARTED 1/6/20 **COMPLETED** 1/6/20
R.L. SURFACE
DATUM
DRILLING CONTRACTOR ESWNMAN Pty Ltd
SLOPE 90°
BEARING ---
EQUIPMENT Hand Auger
HOLE LOCATION Refer to Figure 1 Site Location Plan
HOLE SIZE 70mm
LOGGED BY W.L.
CHECKED BY J.L.
NOTES Front yard, near corner of new dwelling

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
HA	Not Encountered				CL	Gravelly CLAY, low plasticity, brown & light grey, some medium grained sand, moist, fine to medium sandstone gravel.		FILL
			0.5		SC	Clayey SAND, medium grained, brown, moist, trace gravel, medium dense.		RESIDUAL SOILS
						SANDSTONE, medium grained, brown, moderately weathered, medium strength.		WEATHERED SANDSTONE
			1.0			Borehole BH1 terminated at 0.75m		

BOREHOLE NUMBER BH2

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CLIENT RPDC
PROJECT NAME Geotechnical Investigation
PROJECT NUMBER ESWN-PR-2020-600
PROJECT LOCATION No. 2 Cullen Street, Forestville, NSW

DATE STARTED 1/6/20 **COMPLETED** 1/6/20
R.L. SURFACE
DATUM
DRILLING CONTRACTOR ESWNMAN Pty Ltd
SLOPE 90°
BEARING ---
EQUIPMENT Hand Auger
HOLE LOCATION Refer to Figure 1 Site Location Plan
HOLE SIZE 70mm
LOGGED BY W.L.
CHECKED BY J.L.
NOTES Rear garden, near corner of new dwelling

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
HA	Not Encountered				CL	Gravelly CLAY, low plasticity, brown, some medium grained sand, moist, fine to medium sandstone gravel.		FILL
					SC	Clayey SAND, medium grained, brown, moist, some sandstone gravel, medium dense.		RESIDUAL SOILS
			0.5			Hand auger refusla at top of rock at 0.5m depth		DCP test indicates top of rock at 0.5m depth
						Borehole BH2 terminated at 0.5m		
			1.0					

BOREHOLE / TEST PIT ESWN-PR-2020-600.GPJ GINT STD AUSTRALIA.GDT 8/6/20

BOREHOLE NUMBER BH3

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CLIENT RPDC
PROJECT NAME Geotechnical Investigation
PROJECT NUMBER ESWN-PR-2020-600
PROJECT LOCATION No. 2 Cullen Street, Forestville, NSW

DATE STARTED 1/6/20 **COMPLETED** 1/6/20
R.L. SURFACE
DATUM
DRILLING CONTRACTOR ESWNMAN Pty Ltd
SLOPE 90°
BEARING ---
EQUIPMENT Hand Auger
HOLE LOCATION Refer to Figure 1 Site Location Plan
HOLE SIZE 70mm
LOGGED BY W.L.
CHECKED BY J.L.
NOTES At proposed swimming pool

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
HA	Not Encountered				CL	Gravelly CLAY, low plasticity, brown, some medium sand, moist, trace medium sandstone gravel.		FILL
					SC	Clayey SAND, medium grained, brown, moist, some gravel, medium dense to dense.		RESIDUAL SOILS
			0.5			Hand auger refusal at 0.45m depth		DCP test indicates top of rock at 0.5m depth
						Borehole BH3 terminated at 0.5m		
			1.0					

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 to 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:	RPDC	Ref No:	ESWN-PR-2020-600
Project:	Geotechnical Investigation	Date Tested:	1/06/2020
Location:	No. 2 Cullen Street, Forstville, NSW 2087	Tested By:	W.L./J.L.

Depth (mm)	DCP No.				Depth (mm)	DCP No.			
	DCP1	DCP2	DCP3	4		5	6	7	8
0-100	1	1	1		0-100				
100-200	2	3	6		100-200				
200-300	4	3	6		200-300				
300-400	3	3	7		300-400				
400-500	2	16	10/90mm		400-500				
500-600	2	Bounce	Bounce		500-600				
600-700	5				600-700				
700-800	20/90mm				700-800				
800-900	Bounce				800-900				
900-1000					900-1000				
1000-1100					1000-1100				
1100-1200					1100-1200				
1200-1300					1200-1300				
1300-1400					1300-1400				
1400-1500					1400-1500				
1500-1600					1500-1600				
1600-1700					1600-1700				
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2700-2800					2700-2800				
2800-2900					2800-2900				
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				
3800-3900					3800-3900				
3900-4000					3900-4000				
RL (m)					**RL (m)**				

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.