Alexandria Property Development Pty Ltd c/- Johnstaff Projects (NSW) Pty Ltd
Level 12, 70 Pitt Street
Sydney NSW 2000
Via email: Jonathan.moss@johnstaff.com.au

Supplementary Statement

EP Risk Management Pty Ltd (EP Risk) engaged Fortify Geotech to provide a Geotechnical Investigation Report (the Assessment) to accompany a State Significant Development Application (SSDA) for the proposed mental health hospital and medical centre at 28-32 Bourke Road, Alexandria, NSW 2015 in the City of Sydney Local Government Area (LGA). The Site is legally described as Lot 1-3 of DP324707.

This report has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) issued for the project (SSD-59006709) dated 08 June 2023. It is understood that Alexandria Property Development Pty Ltd c/- Johnstaff are planning to redevelop the Site from its current industrial land use. The SSDA seeks consent for the following in accordance with the Concept SSDA approval:

- Site establishment including earthworks.
- Construction of the Alexandria Health Centre:
    - Total Gross Floor Area (GFA) of 11,436sqm
    - Maximum Floor Space Ratio (FSR) of 3.85:1
    - Maximum height of 34.95m, Maximum Reduced Level (RL). 45.4
- Ancillary development including:
    - Car parking – 77 car parking spaces distributed across basement, ground, and ground mezzanine levels.
    - Utility infrastructure and services connections.
    - Building identification signage and wayfinding signage.
    - Stormwater management.
    - Landscaping.
- Laneway for vehicle and pedestrian access along with western boundary of the site
- Operation of the Alexandria Health Centre as a mental health hospital and medical centre with ancillary uses.

It is understood the development will involve the excavation of the soil within the Site to a maximum depth of 5.25 mAHD, measured at approximately 3.4 meters below the existing ground level (mBGL) (ground level adopted as 8.8 mAHD across the Site), for the purposes of the construction of a semi-underground car park and subservices. The proposed basement is noted to have a floor level of 7.35 mAHD (excluding subservices), measuring approximately 1.6 mBGL (assuming a nominal slab depth of 150mm and subgrade stabilisation of 150 mm).

This Supplementary Statement is intended to accompany the Geotechnical Investigation Report (issued 25 February 2022). It is noted that this statement provides an amended description of the proposed development, which supersedes the description provided within the Geotechnical Investigation Report. The findings and conclusions of the Fortify Report are not considered to be materially impacted by the amended description of the proposed development.

CLOSURE

Thank you for your time regarding this matter. Please do not hesitate to contact the undersigned if you require additional information or clarification.

Yours sincerely,

Loek Munnichs
Principal Environmental Scientist
NSW Accredited Contaminated Land Site Auditor
Certified Environmental Practitioner Site Contamination Specialise (CEnvP – SC)

EP Risk Management Pty Ltd
ABN: 81 147 147 591

Fortify Geotech Pty Ltd

Allison Baillie
Director | Senior Geotechnical Engineer
MIEAust B.E (Civil)

QUALITY CONTROL

Version	Author	Date	Reviewer	Date	Reviewer	Date
v1	E. Handley	15.12.2023	L. Munnichs	15.12.2023	A. Baillie	20.12.2023

DOCUMENT CONTROL

Version	Date	Reference	Submitted to
v1	*20.12.2023*	*EP2515.001_Fortify Geotech Supplementary Statement _v1*	*Alexandria Property Development Pty Ltd c/- Johnstaff Projects (NSW) Pty Ltd*

GEOTECHNICAL INVESTIGATION REPORT

FORTIFY
GEOTECH

Proposed Commercial Development

CLIENT

EP Risk Management

ADDRESS

28-32 Bourke Road,
Alexandria, NSW

DATE

February 2022

2/538 Gardeners Road, Alexandria NSW 2015
PO Box 9225, Deakin ACT 2600

Consulting Engineers

(02) 9188 4033
FortifyGeotech.com.au

25 February 2022
Our ref: MM/S1413

EP Risk Management
Via email: loek.munnichs@eprisk.com.au

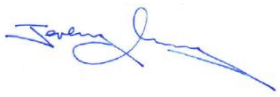
Proposed Commercial Development – 28-32 Bourke Road, Alexandria, NSW
Geotechnical Investigation Report

We are pleased to present our geotechnical investigation report for the commercial development at 28-32 Bourke Road, Alexandria, NSW.

The report outlines the methods and results of exploration, describes site subsurface conditions, and provides recommendations for building footing design, excavation conditions, preparation of subgrades, stability of cut and fill batters, temporary and permanent excavation support, earthquake design and site drainage.

Should you require any further information regarding this report, please do not hesitate to contact our office.

Yours faithfully
Fortify Geotech



Jeremy Murray
Director
Senior Geotechnical Engineer

About us

We work with our clients to provide practical advice and solutions tailored to each project. Our professional services are reliable, responsive and efficient.

Our highly capable Geotechnical Engineers and Geologists have a comprehensive understanding of the industry. We provide the best engineering solution for complicated geotechnical engineering issues. This has earned us a solid reputation with our Construction Industry, Municipal and Government clients

INDUSTRIES WE WORK IN

- Residential
- Commercial
- Transport Infrastructure
- Industrial Developments of all sizes.

SERVICES

- Geotechnical Site Investigations and Reporting;
- Engineering Geology;
- Mining/Rock Geotechnics;
- Foundation Engineering;
- Dam Engineering; Embankment Design and Specification;
- Geotechnical Design Recommendations;
- Pavement Engineering and Design;
- Pavement Condition Surveys;
- Slope Stability and Risk Assessments;
- Geotechnical and Hydrological Instrumentation and Monitoring;
- Footing and Excavation Supervision and Certifications;
- Excavated soil/rock assessments and VENM assessments;
- Supervision and Certification of Earthworks and Controlled Fill, including Level 1 supervision;
- Geotechnical Construction Specifications;
- Deep Excavation Support; and
- Slope/Retaining Structure Analysis and Design

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Proposed Commercial Development
28-32 Bourke Road, Alexandria, NSW

Geotechnical Investigation Report

1 INTRODUCTION

At the request of EP Risk Management, Fortify Geotech Pty Ltd carried out a geotechnical investigation for the proposed commercial development at 28-32 Bourke Road, Alexandria, NSW. It is understood the development will comprise the construction of a multi-storey commercial structure, with a potential single level basement. Basement excavations are expected to extend to ~1.5m depth below existing ground surface levels.

The aim of the investigation was to:

I. Identify subsurface conditions including the extent and nature of any fill materials, soil strata, bedrock type and depth, and groundwater presence.

II. Provide site classification to AS2870 “Residential Slabs & Footings”.

III. Advise on suitable footings systems, founding depths, allowable bearing pressures and design parameters for ground slabs.

IV. Provide guidelines for design and construction of controlled fill platforms and preparation of subgrades.

V. Advise on excavation conditions and suitability of excavated material for use as structural fill.

VI. Advise on stable batter slopes and excavation support (temporary and permanent).

VII. Provide earthquake design parameters and site sub-soil class.

VIII. Drainage and other geotechnical advice.

2 SITE DESCRIPTION & GEOLOGY

The site of the proposed commercial development at 28-32 Bourke Road, Alexandria, NSW is bounded by Bourke Road to the north, and existing commercial developments to the east, west and south. The ~3000m^2 site is currently occupied by an existing commercial structure which has a relatively level floor. The site locality is shown in Figure 1. A recent aerial photograph of the site and the approximate location of the investigation boreholes are shown in Figure 2.

The geological information provided by the Department of Regional NSW (Reference 1) indicates the area to be underlain by Coastal deposited dune facies over Triassic Age Ashfield Shale. Ashfield Shale consists of black to light grey shale and laminite.

3 INVESTIGATION METHODS

The site investigation was conducted on the 8th to the 11th of February 2022, comprising eight boreholes, designated BH1-BH5, BH10, BH11, and BH13. Coring of the bedrock was conducted in two of the boreholes, BH1 and BH2. The boreholes ranged in depth from 2m to 13.35m from existing groundsurface levels. Standard Penetrometer Testing (SPT's) were conducted in BH1, BH2 and BH5. The locations of the boreholes are shown in Figure 2, and the detailed borehole logs are included in Appendix A.

BH1, BH2 and BH5 were drilled using a Drilltechniques D-4T drilling rig. The boreholes were augered to depths where water seepage and borehole collapse occurred, then wash-bored to bedrock before coring of the bedrock was carried out. BH3, BH4, BH10, BH11 and BH13 were drilled using a Geoprobe 6712DT drilling rig. Boreholes BH4, BH10 & BH11 were augered to target depths of ~2m/7.6m and boreholes BH3, BH5 and BH13 were augered to near refusal in extremely weathered (XW) bedrock at ~7.5m/8m.

Core retrieved from the boreholes were placed in metal core trays. Following drilling, the core was photographed, and selected core was tested for point load strength index testing. Borehole logs, including core photographs, are presented in Appendix A and Figure 3 respectively.

The borehole profiles were visually logged in accordance with the Unified Soil Classification System (USCS). Definitions of geotechnical engineering terms used in the report on the borehole logs, including a copy of the USCS chart, are provided in Appendix C.

4 INVESTIGATION RESULTS

4.1 SUBSURFACE CONDITIONS

The subsurface conditions of the proposed development were investigated by eight boreholes designated BH1-BH5, BH10, BH11, and BH13. The borehole logs in Appendix A can be referred to for more detail.

The investigation boreholes found the subsurface profile to comprise:

Geological Profile	Typical Interval Depth	Description
CONCRETE/ FILL	0m to 0.6m/1.9m	CONCRETE, SANDY GRAVEL, SILTY GRAVELLY SAND, SILTY SANDY GRAVEL, SILTY CLAYEY SAND, SAND, GRAVELLY CLAYEY SAND, SILTY SAND; fine to medium sand, fine to coarse sand, low plasticity clay, medium plasticity clay, angular gravels to 15mm size, sub-angular gravels to 50mm size, black, dark grey, dark brown, brown, grey, dry to moist, moist, moist to wet, loose, loose to medium dense, medium dense.
ALLUVIAL/ RESIDUAL SOILS	0.6m/1.9m to 7.3m/8.5m	SAND, CLAYEY SAND/SAND, CLAYEY SAND/SANDY CLAY, SANDY CLAY, CLAY, SANDY CLAY/CLAY, SANDY GRAVELLY CLAY, SILTY SAND/SAND, CLAYEY SANDY GRAVEL; fine sand, fine to medium sand, fine to coarse sand, low plasticity clay, low to medium plasticity clay, medium plasticity clay, sub-angular gravels to 30mm size, dark grey, dark brown, pale brown, pale grey, mottled orange/red, dark red, grey, black, yellow-brown, ironstone gravels, dry, dry to moist, moist, moist to wet, wet,

		loose to medium dense, medium dense, medium dense to dense, dense, dense to very dense, firm to stiff, stiff, stiff to very stiff, very stiff, very stiff to hard, hard.
BEDROCK	Below 7.3m/8.5m	SANDSTONE; extremely weathered (XW) at the bedrock surface, quickly becoming slightly weathered (SW) and high strength fresh (FR), medium to coarse grained, grey, pale grey, red, dry, wet

Note: USCS - Unified Soil Classification System

4.2 POINT-LOAD STRENGTH TESTING

A total of nine (9) point-load strength index tests were carried out on select rock core specimens. The test method and calculation of point-load strength index "Is(50)" was in accordance with the International Society for Rock Mechanics. The index was used to estimate the rock compressive strength using the empirical relationship "qu = 24 x Is(50)", where qu is the ultimate compressive strength. Testing was conducted using a diametrial point-load. Results of the point-load testing are presented in Appendix B, which show the sandstone bedrock to be of high strength.

Estimated values of compressive strengths of the site bedrock are summarized in Table 1.

TABLE 1
Estimated Rock Compressive Strengths

Rock Weathering	Estimated Compressive Strength			Number of Point Load Tests
	Test Method	**Range (MPa)**	**Average (MPa)**	
MW to SW Bedrock	Diametrial	25.68 – 68.88	44.51	9

4.3 GROUNDWATER

Permanent groundwater was encountered from ~1.8m/3.0m depth in investigation boreholes BH1-BH5 and BH13. Natural soils above this depth were mostly moist and moist to wet. Temporary perched seepages could also occur at shallower depths following rainfall, particularly within the upper more pervious alluvial soils.

5 DISCUSSION & RECOMMENDATIONS

5.1 SITE CLASSIFICATION

Due to the presence of uncontrolled fill material to a depth of up to ~1.9m depth, the site is designated as Class “P” (problem) site in accordance with AS2870 “Residential Slabs & Footings”. If the fill is removed, and replaced with controlled fill, or if footings are founded in the natural soil below the fill, a Class “M” (moderately reactive) category can be used in design of new footings (Ys is estimated to be between 20mm and 40mm).

Deemed-to-comply footing designs provided by AS2870 are applicable specifically to residential-style one and two-storey structures, or buildings with similar loads and superstructure stiffness.

5.2 BUILDING FOOTINGS

AS2870 provides “deemed-to-comply” footing/slab designs, which for a class “M” site includes stiffened rafts, stiffened footing slabs, waffle rafts, and strip and/or pad footings with above ground floors. Footings and slabs should be in accordance with the principles of AS2870 (Reference 2).

For structures founded at existing grade, footings, including thickened sections of slabs forming footings should be founded below any uncontrolled fill, loose to medium dense alluvial soils and founded in medium dense alluvial soils. A depth of ~1m/3m from existing levels may be required to reach a suitable founding stratum. Shallow footings could be founded in any newly placed controlled fill following removal of any uncontrolled fill material (see Section 5.6). Alternatively, piles founded in weathered bedrock could be used. Given the collapsible nature of the sandy soils and the presence of shallow groundwater, driven piles, screw piles or CFA piles would be the most practical.

Recommended allowable end-bearing pressures and shaft adhesion values for various footing systems and likely foundation materials are provided in Table 2.

Table 2 – Recommended Allowable End-Bearing Pressures for Footings

Foundation Material Type	Depth Below Existing Surface Level	Allowable End-Bearing Pressure			Allowable Shaft Adhesion on Piles and Anchors	
		Strips	Pads	Piles	Downward Loading	Uplift
Newly Placed Controlled Fill	-	100kPa	125kPa	N.A	N.A	N.A
Medium Dense Alluvial Soils	~1m/3m	100kPa	125kPa	150kPa	15kPa	7kPa
MW & Less Weathered Bedrock (Class III Bedrock)	Below ~8.1m/9m	2000kPa	2500kPa	3000kPa	300kPa	150kPa

All footings should be inspected and approved by an experienced geotechnical engineer to confirm the foundation material and design values, and to ensure the excavations are clean and stable.

Groundslabs can be constructed on the natural soils or newly placed controlled fill, following the removal of any uncontrolled fill material. Following excavation to required level, slab areas on soil should be proof-rolled by a pad foot

roller to check for any weak, wet or deforming soils that may require replacement. Suitable replacement fill should be compacted in not thicker than 150mm layers to not less than 98%StdMDD.

If required for design of ground slabs, a modulus of subgrade reaction of 50kPa/mm can be assumed for a natural soil or controlled fill foundation.

5.3 EXCAVATION CONDITIONS & USE OF EXCAVATED MATERIAL

It is understood that excavations up to ~1.5m depth are anticipated for the development. Such excavations will be through uncontrolled fill and alluvial material. The fill and alluvial material are readily diggable by backhoe and medium sized excavator to ~8.1m/9m depth. Moderately weathered and less weathered bedrock could be encountered below ~8.1m depth and would require heavy excavator, bulldozer ripping and rock hammering.

Any low/medium plasticity alluvial clays can be used in controlled fill construction of building platforms, provided any rock particles are broken down to <75mm size and the fill is environmentally suitable for re-use on site. Fill material and any medium to high and high plasticity, clayey soils should not be used in controlled fill construction.

If imported fill is required, a suitable select fill material would include a low or medium plasticity soil such as clayey sand or gravelly clayey sand, containing between 25% and 50% fines less than 0.075mm size (silt and clay), and no particles greater than 75mm size.

5.4 BASEMENT EXCAVATION TEMPORARY SUPPORT

Temporary basement excavation batters should be formed no steeper than 1(H):1(V) in soil. The soil batter surfaces should be temporarily protected against deterioration due to the weather by covering in plastic, held by pinned chain-link mesh. Excavations that encounter groundwater will be prone to collapse and shoring would be required.

Where space limitations preclude battering back to stable slopes, temporary support options include CFA soldier piles with tie-back anchors, and horizontal lagging or reinforced shotcrete supporting the spaces between piers. CFA soldier piles, spaced at about three to five pier diameters, socketed below basement level, and secured by tensioned anchors, may be a suitable option. CFA pile holes would typically be drilled from existing surface levels prior to bulk excavation. The excavation could then proceed in maximum 3m depth stages, with tie-back anchors installed and tensioned prior to excavation of the next level. Lateral support would also be provided by the passive and cantilever resistance of pier-sections socketing below final excavation level. Horizontal lagging or structural facing shotcrete between piers should be installed in sequence with deepening of the excavation. Alternatively, contiguous CFA piles or sheet piles could be used.

5.4.1 Lateral Pressure on Temporary Support Systems

The loads in anchors or struts for tied-back walls used in the temporary support of vertical excavations, such as sheet piles or soldier piers tied back by tensioned ground anchors or internally strutted to the basement floor, can be calculated using a trapezoidal pressure distribution given by:

$$\sigma_h = (5H \times \frac{4z}{H}) + 0.4q \qquad \text{For } z < 0.25H$$

$$\sigma_h = (5H) + 0.4q \qquad \text{For } z > 0.25H$$

where,

σ_h is the apparent horizontal earth/rock pressure acting on the back of the wall, in kPa

H is the total height of the full excavation to be supported, in metres

z is the distance from the top of the excavation, in metres

q is any uniformly distributed vertical surcharge acting on the ground surface at the top of the excavation, in kPa

The above expression takes no account of groundwater pressure, as it is assumed the temporary walls will be fully drained. Where the walls are to be covered by shotcrete and/or where these will be incorporated into a permanent basement wall, synthetic drainage strips should be installed vertically against the excavated face, draining to collector pipes at the base of the excavation, taken to a basement pump-out sump.

5.4.2 Resistance Parameters for Temporary Support Systems

The allowable horizontal passive resistance provided by socketed sections of soldier piers or other retaining systems in hard soils below the basement excavation floor level can be calculated as:

$$\sigma_p = 50z \qquad \text{(Hard soil socket only)}$$

where,

σ_p is the allowable passive pressure acting on the front of the pier/footing at depth z, in kPa

z is the pier socket length below excavation level in weathered bedrock, in metres

The effective width of a socketed pier for calculation of allowable passive resistance can be assumed to be equivalent to twice its actual width, except where the centre-to-centre distance between the piers is two diameters or less, in which case the soldier piers can be considered to act as one continuous wall.

If internal struts are used, propped to anchor blocks in the basement floor, the allowable passive resistance provided by the anchor blocks can be calculated using the same pressure distribution given above, although the effective width of the footing or block can be taken as 1.5 times its actual width. In addition, an allowable base friction factor (tanδ) of 0.35, and allowable base adhesion (c) of 5kPa can be used for calculation of sliding resistance of concrete anchor blocks in the hard soil.

An average ultimate bond value of 30kPa can be assumed for cement-grouted ground anchors in the hard soils. It is important that at least a few of the anchors should be proof-tested by pull-out tests to confirm or adjust bond values. It is recommended that ground anchors be inclined downward at between 5^o and 20^o, and that the “fixed” (anchored) section be assumed to extend beyond a line inclined upward from the batter toe at 45^o. Tensioned multi-strand cable anchors are recommended rather than using passive (non-tensioned) anchors.

5.5 BASEMENT EXCAVATION PERMANENT SUPPORT

Permanent unsupported batters in soil would need to be formed no steeper than 2(H):1(V). Permanent batters should be protected against erosion by stone pitching, shotcreting, or other suitable means.

Permanent basement walls can be integrated into the temporary excavation support systems, or constructed separately from these, but with the space between backfilled or spanned by horizontal struts.

The walls and floor slabs for basement walls incorporated with or strutted to the temporary excavation supports should be designed to cater for the pressures given in Section 5.4.1.

Where basement walls are constructed in open excavation and backfilled later, or for soldier piles or CFA soldier piles that are cantilevered below basement floor level without propping or anchoring, the wall and floor slabs can be designed to resist lateral pressure using a distribution given by:

$$\sigma_h = (8d) + 0.4q$$

where,

d is the depth below the top of the backfill or retained ground, in metres

q is any uniformly distributed surcharge acting on the surface of the backfill, in kPa

The first term of the expression is a triangular pressure distribution, the second a uniform pressure distribution. The design pressure takes no account of hydrostatic pressure, as it is assumed that the walls will be provided with permanent backfill drainage, and that any groundwater is drawn below the level of the lower basement. Backfill materials for walls constructed in open excavation should be clean, granular and free-draining, and preferably the upper backfill can be a clayey soil to reduce infiltration of surface water.

5.6 STABLE EXCAVATION BATTERS

Temporary site excavations to 1.5m depth should be cut back at no steeper than 1(H):1(V). If required and space allows, deeper temporary cuts can be formed at 2(H):1(V) or benched at 1.5m intervals in soils. A geotechnical engineer should inspect all cut batters during construction to confirm stability. Exposed temporary batters should be protected from the weather by black plastic pinned to the face with link-wire mesh, or similar. Excavations that extend below the groundwater level will be prone to collapse, and temporary support, such as shoring boxes, will be required.

Permanent cut & fill batter slopes should be formed at no steeper than 2(H):1(V) in soil and should be protected against erosion by shotcreting, stone pitching or other suitable methods. Alternatively, permanent excavations can be supported by structural retaining walls.

5.7 CONTROLLED FILL CONSTRUCTION

For construction of any new fill foundation platforms and road subgrades, it is recommended that:

- Areas be fully stripped of all uncontrolled fill. A stripping depth of ~0.6m/1.9m could be required. Stripped foundations should be proof-rolled by a vibratory pad-foot roller of not less than 9 tonne static mass to check for any weak or wet areas that would require replacement. No fill should be placed until a geotechnical engineer has confirmed the suitability of the foundation.

- Controlled fill comprising suitable site excavated or imported materials of not greater than 75mm maximum particle size, be compacted in not greater than 150mm layers to a Density Ratio of not less than 98%StdMDD at about OMC. If clean sand is used as fill material, it must be compacted to a Density Index of not less than 75%.

- Fill placement and control testing be overviewed and certified by a geotechnical engineer at Level 1 or 2 involvement of AS3798 – 1996 “Guidelines on Earthworks for Commercial & Residential Developments” (Reference 3).

5.8 EARTHQUAKE SITE FACTOR

The Geoscience Australia Earthquake Hazard Map (Reference 5) indicates the earthquake acceleration coefficients for Australia to be used in structural design. The Alexandria area has an acceleration coefficient of 0.06. The minimum value permitted by AS1170.4 “minimum Design Loads on Structures – Part 4: Earthquake Loads” (Reference 4) is 0.08.

Section 4.2 of AS1170.4 “Minimum Design Loads on Structures – Part 4: Earthquake Loads” lists the site sub-soil classes to be considered in structural design. The site is classified as a “Class C_e – Shallow Soil Site”.

5.9 SITE DRAINAGE

Suitable surface drainage should be provided to ensure rainfall run-off or other surface water cannot pond against buildings or pavements. Drainage should be provided behind all retaining walls, and subsoil drains should be installed along the upslope sides of access Streets and carparks.

Groundwater was encountered from ~1.8m/3.0m depth in the investigative boreholes BH1-BH5 and BH13. Excavations deeper than 1.8m could encounter significant groundwater inflow. Temporary perched seepages could also be present at shallower depth following rain but should be readily controllable using pumps during construction.

If the single-level basement excavations extend below the groundwater table then the basement retaining walls will have to be fully tanked, and the retaining walls and groundslabs designed to withstand hydrostatic pressures. Dewatering may be required during excavations. As dewatering could negatively impact surrounding properties, it is recommended that a hydrogeologist be engaged to provide further advice.

It may be prudent to allow for installation of a permanent sub-floor gravel blanket drain, and for a grid of gravel-filled trench drains below the basement floor slab. A layer of crushed volcanic rock at least 150mm thick would be suitable and the drains should lead to the collector sump(s) and pump-out unit, which would also cater for any internal flooding. The requirement for underslab drains can be assessed by inspection during excavation of the basement.

REFERENCES

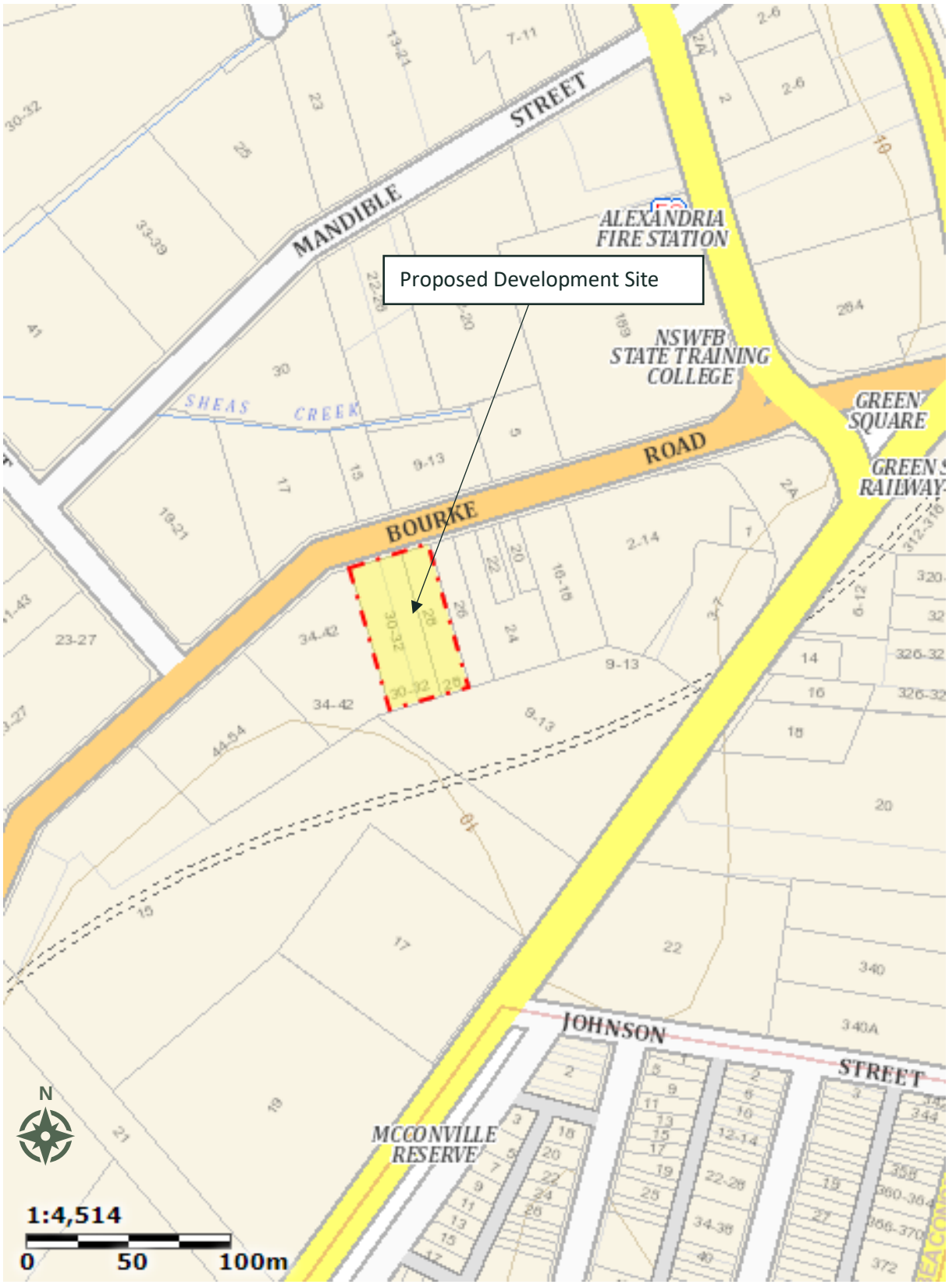
Reference 1: MinView – geological map - https://minview.geoscience.nsw.gov.au - Accessed 23/02/2022

Reference 2: Standards Australia, “AS2870 – Residential Slabs & Footings”, 2011.

Reference 3: AS3798, “Guidelines on earthworks for commercial and residential developments”.

Reference 4: Standards Australia, “AS1170.4 – 2007 – Minimum Design Loads on Structures – Part 4 Earthquake Loads”.

Reference 5: Geoscience Australia – earthquake hazards map - http://www.ga.gov.au/darwin-view/hazards.xhtml# - Accessed 24/02/2022



SITE LOCALITY	S1413	FIGURE 1

AERIAL PHOTOGRAPH & APPROXIMATE BOREHOLE LOCATIONS	S1413	FIGURE 2

BH01
9.0m to 13.45m depth

BH02
8.1m to 11.4m depth

ROCK CORE PHOTOS	S1413	FIGURE 3

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Appendix A

Borehole Logs BH1-BH5, BH10, BH11, BH13

Borehole Log

Borehole No.	**BH01**
Sheet	1 of 3
Job No.	S1413

CLIENT: EP Risk Management

PROJECT: Proposed Commercial Development
28-32 Bourke Rd, Alexandria

Location : See Report

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : Drilltechniques D-4T Drilling Rig
Hole Diameter : 150mm

Depth (Metres)	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
0.2			CONCRETE; double slab (~100mm each)			CONCRETE
0.3		GW	SANDY GRAVEL; fine to coarse sand, angular gravels to 10mm size, black-dark grey, dry to moist.	Medium Dense		FILL
		SW				
0.6		SW	SILTY GRAVELLY SAND; fine to medium sand, angular gravels to 15mm size, darkgrey-black, dry to moist.	Loose to Medium Dense		ALLUVIUM
		SW	SAND; fine to coarse sand, dark grey-dark brown, dry to moist.	Loose to Medium Dense		
1.0		SW	Dark brown, trace low plasticity clay.	Medium Dense	SPT 2, 2, 2 N=4	
		SW	Dark brown-dark red, trace low plasticity clay, moist.	Medium Dense		
1.9						
2.0		SW	CLAYEY SAND/SAND; fine to coarse sand, low to medium plasticity clay, pale brown-brown, moist.	Medium Dense		
2.3		SW	SAND; fine to coarse sand, pale brown, wet.	Medium Dense		
3.0					SPT 3, 5, 7 N=12	
4.0					SPT 4, 4, 4 N=8	
4.4		CL	CLAYEY SAND/SANDY CLAY; fine to coarse sand, medium plasticity clay, pale grey, trace brown, wet.	Firm to Stiff		
5						
5.0		SW	SAND; fine to coarse sand, pale grey-brown, wet.	Medium Dense		
			pale yellow.	Dense	SPT 4, 7, 17 N=24	
6.0						
7						
7.0		CL	SANDY CLAY; fine sand, medium plasticity clay, pale grey, trace orange/red, moist.	Stiff to Very Stiff	SPT 3, 8, 18 N=26	
			ironstone gravels, dark red.	Very Stiff		
8.0						
8.5			SANDSTONE; Extremely weathered (XW), medium to coarse grained, grey, red, wet.		SPT 15+ for 50mm N>15	
9						
9.0			CORING COMMENCED AT 9m			
9.5						

Logged By : JS Date : 8/2/22 | Checked By : Date :

BOREHOLE/EXCAVATION LOG S1413.GPJ ACT GEO.GDT 24/2/22

ACT Geotechnical Engineers

Fortify Geotech

Cored Borehole Log

Borehole No.	BH01
	2 of 3

CLIENT:	EP Risk Management	Job No. S1413
PROJECT	Proposed Commercial Development 28-32 Bourke Rd, Alexandria	Location : See Report
Drill Type : Barrel Type, Length, Drilling fluid :		Collar Level : Not Known Angle From Horizontal : 90° Bearing : N.A.

Method/Casing	R.Q.D./Lift	Water	Depth Metres	Graphic Log	Soil or Rock Substance Description	Degree of Weathering	Estimated Strength Range (EW, XW, HW, MS, S, VS, ES)	Is(50) MPa (D = diaxial, A = axial)	Core Length (mm) (30, 100, 300, 1000, 3000)	Defects	Defect Description
			1.0								
			2.0								
			3.0								
			4.0								
			5.0								
			6.0								
			7.0								
			8.0								
			9.0								
	90% 100%		9.5			SW					

Logged By :	JS	Date : 8/2/22	Checked By : Date :

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Cored Borehole Log

Borehole No. **BH01**

3 of 3

CLIENT: EP Risk Management

Job No. S1413

PROJECT: Proposed Commercial Development
28-32 Bourke Rd, Alexandria

Location : See Report

Collar Level : Not Known
Angle From Horizontal : 90°
Bearing : N.A.

Drill Type :
Barrel Type, Length, Drilling fluid :

Method/Casing	R.Q.D./Lift	Water	Depth Metres	Graphic Log	Soil or Rock Substance Description	Degree of Weathering	Estimated Strength Range (EW, XW, HW, MS, S, VS, ES)	Is(50) MPa (D = diaxial, A = axial)	Core Length (mm) (30, 100, 300, 1000, 3000)	Defects	Defect Description
	90% 100%	None Encountered	10.0			SW		D = 1.9 A = 45.6			joint, 15°, planar, rough, -
											joint, 25°, planar, rough,
						SW/FR					joint, 30°, planar, rough, -
											joint, 30°, planar, rough, -
			11.0					D = 1.8 A = 43.7			
											joint, 5°, planar, rough, clay seam
											joint, 30°, planar, rough, clay seam
											joint, 20°, planar, rough, -
											joint, 20°, planar, rough, -
											joint, 0,10°, irregular, rough, -
			12.0					D = 2.5 A = 59.3			joint, 5°, planar, rough, -
											joint, 30°, planar, rough, -
	89% 100%					SW/FR					joint, 30°, planar, rough, -
								D = 2.2 A = 52.1			joint, 0°, planar, rough, clay seam
			13.0								
								D = 1.5 A = 35.5			joint, 5°, planar, rough, -
			14.0								
			15.0								
			16.0								
			17.0								
			18.0								
			19.0								

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Borehole Log

Borehole No.	**BH02**
Sheet	1 of 3
Job No.	S1413

CLIENT: EP Risk Management

PROJECT: Proposed Commercial Development
28-32 Bourke Rd, Alexandria

Location : See Report

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : Drilltechniques D-4T Drilling Rig
Hole Diameter : 150mm

Depth (Metres)	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
0.2			CONCRETE; double slab (~100mm each)			CONCRETE
0.3		GW	SILTY SANDY GRAVEL; fine to coarse sand, angular gravels to 10mm size, black-dark grey, dry to moist.	Medium Dense		FILL
0.6		SW	SILTY GRAVELLY SAND; fine to medium sand, angular gravels to 15mm size, darkgrey-black, dry to moist.	Loose to Medium Dense		ALLUVIUM
		SW	SAND; fine to coarse sand, dark grey-dark brown, dry to moist.	Loose to Medium Dense		
1.0			dark red, some dark brown, moist.	Medium Dense	SPT 2, 2, 8 N=10	
			moist to wet.	Medium Dense to Dense		
2.0				Dense		
3.0			pale brown, wet. pale grey.	Dense to Very Dense	SPT 4, 9, 13 N=22	
4.0		SW	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, mottled orange, moist.	Dense to Very Dense	SPT 3, 6, 11 N=17	RESIDUAL
5.0						
5.5		SW	CLAYEY SAND/SAND; fine to coarse sand, low plasticity clay, pale grey, pale orange, wet.	Dense to Very Dense	SPT 7, 15, 18 N=33	
6.0						
7.0						
7.1		CH	CLAY; medium to high plasticity clay, grey, trace red/white/orange, trace ironstone gravels to 5mm size, moist to wet.	Firm to Stiff	SPT 3, 4, 6 N=10	
7.35		CL	SANDY CLAY/CLAY; fine to medium sand, medium plastcity clay, grey, moist.	Stiff to Very Stiff		
7.5		CL	SANDY GRAVELLY CLAY; fine to coarse sand, medium plasticty clay, sandstone gravels to 30mm size, pale grey, mottled red, dry to moist.	Very Stiff to Hard		
8.0					SPT 8, 19, 25+ for 0mm N>44	
8.1			CORING COMMENCED AT 8.1m			
9.0						
9.5						

None Encountered

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Cored Borehole Log

Borehole No. **BH02**

2 of 3

CLIENT:	EP Risk Management
PROJECT	Proposed Commercial Development 28-32 Bourke Rd, Alexandria

Job No. S1413

Location : See Report

Collar Level : Not Known
Angle From Horizontal : 90°
Bearing : N.A.

Drill Type :
Barrel Type, Length, Drilling fluid :

Method/Casing	R.Q.D./Lift	Water	Depth Metres	Graphic Log	Soil or Rock Substance Description	Degree of Weathering	Estimated Strength Range (EW VW W MS S VS ES)	Is(50) MPa (D = diaxial, A = axial)	Core Length (mm) (30 100 300 1000 3000)	Defects	Defect Description
			1.0								
			2.0								
			3.0								
			4.0								
			5.0								
			6.0								
			7.0								
			8.0								
	87% 100%	None Encountered	9.0			SW SW		D = 1.1 A = 25.7 D = 2.9 A = 68.9			joint, 30°, planar, rough, - joint, 10°, planar, rough, - joint, 0, 10°, irregular, rough, - joint, 0°, planar, rough, Clay Seam joint, 0°, planar, rough, Clay Seam joint, 0°, planar, rough, -
			9.5								

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Cored Borehole Log

Borehole No. **BH02**

3 of 3

CLIENT: EP Risk Management

Job No. S1413

PROJECT: Proposed Commercial Development
28-32 Bourke Rd, Alexandria

Location : See Report

Collar Level : Not Known
Angle From Horizontal : 90°
Bearing : N.A.

Drill Type :
Barrel Type, Length, Drilling fluid :

Method/Casing	R.Q.D./Lift	Water	Depth Metres	Graphic Log	Soil or Rock Substance Description	Degree of Weathering	Estimated Strength Range (EW VW W MS S VS ES)	Is(50) MPa (D = diaxial A = axial)	Core Length (mm) (30 100 300 1000 3000)	Defects	Defect Description
	87% 100%	None Encountered	10.0			SW					joint, 10°, planar, rough, Clay Seam joint, 15°, planar, rough, Clay Seam joint, 10°, planar, rough, Ironstone gravels
						SW		D = 1.2 A = 29.3			joint, 10°, planar, rough, - joint, 0°, planar, rough, Clay Seam joint, 0°, planar, rough, Clay Seam
	73% 100%		11.0			SW		D = 1.7 A = 40.6			joint, 35°, planar, rough, - joint, 35°, planar, rough, -
			12.0								
			13.0								
			14.0								
			15.0								
			16.0								
			17.0								
			18.0								
			19.0								

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CORED BOREHOLE LOG S1413.GPJ ACT GEO.GDT 24/2/22

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Borehole Log

Borehole No.	**BH03**
Sheet	1 of 1
Job No.	S1413

CLIENT: EP Risk Management

PROJECT: Proposed Commercial Development
28-32 Bourke Rd, Alexandria

Location : See Report

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : Geoprobe 6712DT Drilling Rig
Hole Diameter : 150mm

Samples	Water	Casing	Depth (Metres)	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
			0.2			CONCRETE			CONCRETE
					SW	SILTY GRAVELLY SAND; fine to coarse sand, sub-angular gravels to 10mm size, dark brown, dry to moist.	Loose to Medium Dense		FILL
			0.8						
					SW	SILTY CLAYEY SAND; fine to coarse sand, medium plasticity clay, dark brown-black, some sub-angular gravels to 10mm size, dry to moist.	Loose to Medium Dense		
			1.0						
			1.2		SW	SILTY CLAYEY SAND; fine to medium sand, medium plasticity clay, black, moist.	Loose to Medium Dense		
			1.6		SW	SAND; fine to coarse sand, dark brown, moist to wet.	Medium Dense		ALLUVIUM
			2.0			wet.			
			3.0			brown-grey.			
			4.0						
			5.0						
	None Encountered		6.0		SW	CLAYEY SAND/SAND: fine to coarse sand, medium plasticity clay, grey, wet.	Medium Dense to Dense		
			6.8			trace clay.			
			7.0		SW	CLAYEY SAND/SANDY CLAY; fine to coarse sand, medium plasticity clay, grey, wet.	Medium Dense to Dense		
			7.3		CL	SANDY CLAY/CLAY; fine sand, low to medium plasticty clay, pale grey, dry.	Stiff to Very Stiff		RESIDUAL
			8.0			BOREHOLE TERMINATED AT 8m near Refusal in XW Sandstone			
			9.0						
			9.5						

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BOREHOLE/EXCAVATION LOG S1413.GPJ ACT GEO.GDT 24/2/22

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Borehole Log

Borehole No.	**BH04**
Sheet	1 of 1
Job No.	S1413

CLIENT: EP Risk Management

PROJECT: Proposed Commercial Development
28-32 Bourke Rd, Alexandria

Location : See Report

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : Geoprobe 6712DT Drilling Rig
Hole Diameter : 150mm

Samples	Water	Casing	Depth (Metres)	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.1			CONCRETE; first slab.			CONCRETE
			0.15			SANDY GRAVEL/GRAVELLY SAND; fine to coarse sand, sub-angular gravels to 50mm size, brown, moist.	Medium Dense		FILL
			0.45						CONCRETE
					SW	CONCRETE; second slab.	Loose to Medium Dense		FILL
						SAND; fine to coarse sand, brown, some silt, anthropogenic materials (ceramics), angular gravels to 5mm size, dry to moist.			
			1.0		SW	SILTY SAND/SAND; fine to coarse sand, brown, dry to moist.	Loose to Medium Dense		ALLUVIUM
						red-brown.			
			1.5		SW	SAND; fine to coarse sand, brown, moist.	Medium Dense		
			2.0			moist to wet.			
						wet.			
			3.0						
			4.0			grey			
			5.0						
			6.0						
			7.0						
			7.1			trace clay			
					CL	SANDY CLAY/CLAY; fine to medium sand, medium plasticity clay, yellow-brown, wet.	Stiff		
			7.6			BOREHOLE TERMINATED AT 7.6m at Target			
			8.0						
			9.0						
			9.5						

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Borehole Log

Borehole No.	**BH05**
Sheet	1 of 1
Job No.	S1413

CLIENT: EP Risk Management

PROJECT: Proposed Commercial Development
28-32 Bourke Rd, Alexandria

Location : See Report

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : Drilltechniques D-4T Drilling Rig
Hole Diameter : 150mm

Depth (Metres)	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
0.2			CONCRETE; double slab (~100mm each)			CONCRETE
0.4		SW	GRAVELLY CLAYEY SAND; fine to medium sand, low plasticity clay, sub-angular gravels to 10mm size, brown, dry to moist.	Loose		FILL
1.0		SW	GRAVELLY CLAYEY SAND; fine to medium sand, low plasticity clay, sub-angular gravels to 10mm size, grey, dry to moist. brown, trace orange/grey.	Loose		
1.3		SW	SILTY CLAYEY SAND; fine to medium sand, medium plastcity clay, black, moist.	Loose to Medium Dense		
1.6		SW	SILTY SAND; fine to coarse sand, black, moist to wet.	Loose to Medium Dense	SPT 2, 0, 1 N=1	
1.9		SW	SAND; fine to coarse sand, dark brown, moist to wet.	Loose to Medium Dense		ALLUVIUM
2.0			wet, sulphur smell.			
4.5		SW	CLAYEY SAND; fine to coarse sand, medium plasticity clay, pale orange, moist to wet.	Medium Dense to Dense	SPT 2, 8, 18 N=26	
4.65		SW	CLAYEY SAND/SAND; fine to coarse sand, medium plasticity clay, grey, moist to wet.	Medium Dense to Dense		
6.0			wet.			
6.1		CL	SANDY CLAY/CLAY, fine to medium sand, medium plasticity clay, brown, mottled red/orange/grey, dry to moist.	Hard	SPT 4, 22, 13 N=35	
6.4		GW	CLAYEY SANDY GRAVEL; fine to coarse sand, low to medium plasticity clay, sub-angular gravels to 20mm, red, trace dark red, moist to wet.	Dense		RESIDUAL
7.5			SANDSTONE; extremely weathered (XW), medium to coarse grained, pale grey, wet.		SPT 9, 25+ for 100mm N>25	BEDROCK
7.75			BOREHOLE TERMINATED AT 7.75m near Refusal in XW Sandstone			

Water: None Encountered

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BOREHOLE/EXCAVATION LOG S1413.GPJ ACT GEO.GDT 24/2/22

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Borehole Log

Borehole No.	**BH10**
Sheet	1 of 1
Job No.	S1413

CLIENT: EP Risk Management

PROJECT: Proposed Commercial Development
28-32 Bourke Rd, Alexandria

Location : See Report

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : Geoprobe 6712DT Drilling Rig
Hole Diameter : 150mm

Depth (Metres)	Samples	Water	Casing	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
0.13		None Encountered				CONCRETE			CONCRETE
0.2					SW	SAND; fine to coarse sand, orange, moist.	Loose		FILL
0.6					SW	GRAVELLY SILTY SAND; fine to medium sand, angular gravels to 15mm size, dark grey-black, some brown, moist.	Loose		
0.8					SW	SAND; fine to medium sand, brown, trace dark grey, some angular gravels to 20mm size, moist.	Loose		
1.0					SW	CLAYEY SILTY SAND; fine to coarse sand, low plasticity clay, dark grey-black, moist.	Loose to Medium Dense		ALLUVIUM
1.6					SW	CLAYEY SAND; fine to coarse sand, medium plasticity clay, dark borwn, moist to wet.	Loose to Medium Dense		
2.0						BOREHOLE TERMINATED AT 2m at Target			
3.0									
4.0									
5.0									
6.0									
7.0									
8.0									
9.0									
9.5									

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BOREHOLE/EXCAVATION LOG S1413.GPJ ACT GEO.GDT 24/2/22

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Borehole Log

Borehole No.	BH11
Sheet	1 of 1
Job No.	S1413

CLIENT: EP Risk Management

PROJECT: Proposed Commercial Development
28-32 Bourke Rd, Alexandria

Location : See Report

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : Geoprobe 6712DT Drilling Rig
Hole Diameter : 150mm

Samples	Water	Casing	Depth (Metres)	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.16			CONCRETE			CONCRETE
			0.8		SW	GRAVELLY SILTY SAND; fine to medium sand, angular gravels to 15mm size, dark grey-black, trace anthropogenic materials (glass), dry to moist.	Loose		FILL
			1.0		CL	CLAYEY SAND/SANDY CLAY; fine to coarse sand, low to medium plasticity clay, brown-red, mottled dark grey, moist.	Loose to Medium Dense/Firm		ALLUVIUM
			1.5		SW	CLAYEY SAND; fine to coarse sand, low plasticity clay, dark brown, trace grey, moist to wet.	Loose to Medium Dense		
			2.0			BOREHOLE TERMINATED AT 2m at Target			
			3.0						
			4.0						
			5.0						
			6.0						
			7.0						
			8.0						
			9.0						
			9.5						

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Borehole Log

Borehole No.	**BH13**
Sheet	1 of 1
Job No.	S1413

CLIENT: EP Risk Management

PROJECT: Proposed Commercial Development
28-32 Bourke Rd, Alexandria

Location : See Report

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : Geoprobe 6712DT Drilling Rig
Hole Diameter : 150mm

Samples	Water	Casing	Depth (Metres)	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.12			CONCRETE			CONCRETE
					CL	GRAVELLY SANDY CLAY; fine to coarse sand, low to medium plasticity clay, angular gravels to 40mm size, brown, grey, trace orange/black, trace anthropogenic materials (concrete, ceramics), dry.	Firm to Stiff		FILL
			0.8						
			1.0		CL	SANDY CLAY; fine to medium sand, medium plasticity clay, dark brown, trace sub-angular gravels to 2mm, moist.	Soft to Firm		ALLUVIUM
			2						
			2.0		CL	SANDY CLAY/CLAYEY SAND; fine to coarse sand, low to medium plasticity clay, dark brown, moist to wet.	Soft/Loose to Medium Dense		
			3						
			3.0		SW	CLAYEY SAND; fine to coarse sand, low plasticity clay, dark brown, wet.	Loose to Medium Dense		
			3.5		SW	SAND; fine to coarse sand, dark brown, wet.	Loose to Medium Dense		
			4.0						
			5.0						
			5.5		SW	CLAYEY SAND; fine to coarse sand, low to medium plasticity clay, pale brown, wet.	Loose to Medium Dense		
			6						
			6.0		CL	SANDY CLAY; fine to coarse sand, medium plasticity clay, pale red, trace grey, wet.	Firm to Stiff		
			6.5		CL	SANDY CLAY; fine to course sand, medium plasticity clay, pale red, some grey, wet.	Stiff		RESIDUAL
			7.0						
			7.3			SANDSTONE; extremely weathered (XW), fine to coarse grained, red, some grey, wet.			BEDROCK
			7.5			BOREHOLE TERMINATED AT 7.5m near Refusal in XW/HW Sandstone			
			8.0						
			9.0						
			9.5						

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BOREHOLE/EXCAVATION LOG S1413.GPJ ACT GEO.GDT 24/2/22

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Appendix B

Point Load Strength Test Results

Diametrial Tests								
Borehole	Depth (m)	Test No.	Equivalent Diameter (cm)	Gauge Reading (kN)	(Is)50	UCS (Mpa)	Weathering	Strength
BH1	9.9	2A	5.2	5.14	1.9	45.6	MW	H
	10.94	2B	5.2	4.93	1.82	43.68	MW	H
	11.84	2C	5.2	6.67	2.47	59.28	MW	H
	12.73	2D	5.2	5.86	2.17	52.08	MW	H
	13.43	2E	5.2	3.99	1.48	35.52	MW	H
BH2	8.5	2F	5.2	2.88	1.07	25.68	MW	H
	9.03	2G	5.2	7.76	2.87	68.88	MW	H
	10.55	2H	5.2	3.3	1.22	29.28	MW	H
	11.3	2I	5.2	4.58	1.69	40.56	MW	H

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Appendix C

Definitions of Geotechnical Engineering Terms

DESCRIPTION AND CLASSIFICATION OF SOILS

The methods of description and classification of soils used in this report are based on the Australian Standard 1726 – 1993, Geotechnical site investigations. In general, descriptions cover the following properties – soil type, colour, secondary grain size, structure, inclusions, strength or density and geological description.

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (e.g. sandy clay) on the following basis:

Classification	**Particle Size**
Clay	Less than 0.002mm
Silt	0.002mm to 0.06mm
Sand	0.06mm to 2.00mm
Gravel	2.00mm to 60.00mm
Cobbles	60mm (63mm) to 200mm
Boulders	>200mm

Soils are also classified according to the Unified Soil Classifications System which is included in this Appendix. Rock types are classified by their geological names.

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination. The terms are defined as follows:

Consistency	**Shear Strength su(kPa) (Representative Undrained Shear)**	
Very soft	< 12	<2 (~SPT “N”)
Soft	12 - 25	2-4
Firm	25 - 50	4-8
Stiff	50 – 100	8-15
Very Stiff	100 – 200	15-30
Hard	> 200	>30

Non-cohesive soils are classified on the basis of relative density, generally from the results of in-situ standard penetration tests as below:

Term	**Relative Density (%)**	**SPT Blows/300mm ‘N’**
Very loose	< 15	<4
Loose	15-35	4-10
Medium dense	35-65	10-30
Dense	65-85	30-50
Very Dense	>85	>50

SAMPLING

Sampling is carried out during drilling to allow engineering examination (and laboratory testing where required) of soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are generally taken by one of two methods:

1. Driving or pushing a thin walled sample tube into the soil and withdrawing with a sample of soil in a relatively undisturbed state.

2. Core drilling using a retractable inner tube (R.I.T.) core barrel.

Such samples yield information on structure and strength in additions to that obtained from disturbed samples and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling are given in the report.

PENETRATION TESTING

The relative density of non-cohesive soils is generally assessed by in-situ penetration tests, the most common of which is the standard penetration test. The test procedure is described in Australian Standard 1289 “Testing Soils for Engineering Purposes” Testing Soils for Engineering Purposes” – Test No. F3.1.

The standard penetration test is carried out by driving a 50mm diameter split tube penetrometer of standard dimensions under the impact of a 63 kg hammer having a free fall of 750mm.

The “N” value is determined as the number of blows to achieve 300mm of penetration (generally after disregarding the first 150mm penetration through possibly disturbed material). The results of these tests can be related empirically to the engineering properties of the soil.

The test is also used to provide useful information in cohesive soils under certain conditions, a good quality disturbed sample being recovered with each test. Other forms of in situ testing are used under certain conditions and where this occurs, details are given in the report.

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DEFINITIONS OF ROCK, SOIL, AND DEGREES OF CHEMICAL WEATHERING

GENERAL DEFINITIONS – ROCK AND SOIL

ROCK In engineering usage, rock is a natural aggregate of minerals connected by strong and permanent cohesive forces.

Note: Since “strong” and “permanent” are subject to different interpretations, the boundary between rock and soil is necessarily an arbitrary one.

SOIL In engineering usage, soil is a natural aggregate of mineral grains which can be separated by such gentle mechanical means as agitation in water, can be remoulded and can be classified according to the Unified Soil Classification System. Three principal classes of soil recognized are:

Residual soils: soils which have been formed in-situ by the chemical weathering of parent rock. Residual soil may retain evidence of the original rock texture or fabric or, when mature, the original rock texture may be destroyed.

Transported soils: soils which have been moved from their places of origin and deposited elsewhere. The principal agents of erosion, transport and deposition are water, wind and gravity. Two important types of transported soil in engineering geology and materials investigations are:

Colluvium – a soil, often including angular rock fragments and boulders, which has been transported downslope predominantly under the action of gravity assisted by water. The principle forming process is that of soil creep in which the soil moves after it has been weakened by saturation. It may be water borne for short distances.

Alluvium – a soil which has been transported and deposited by running water. The larger particles (sand and gravel size) are water worn.

Lateritic soils: soils which have formed in situ under the effects of tropical weathering include all reddish residual and non residual soils which genetically form a chain of material ranging from decomposed rock through clay to sesqui-oxide rich crusts. The term does not necessarily imply any compositional, textural or morphological definition; all distinctions useful for engineering purposes are based on the differences in geotechnical characteristics.

ROCK WEATHERING DEFINITIONS

Extremely Weathered (EW)	Rock substance affected by weathering to the extent that the rock exhibits soil properties, i.e. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.
Highly Weathered (HW)	Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of the chemical or physical decomposition are evident. Porosity and strength may be increased or decreased compared to the fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original fresh rock substance is no longer recognisable.
Moderately Weathered (MW)	Rock substance affected by weathering to the extent that staining extends throughout the whole of the rock substance and the original colour of the fresh rock is no longer recognisable.
Slightly Weathered (SW)	Rock substance affected by weathering to the extent that partial staining or discolouration of the rock substance, usually by limonite, has taken place. The colour and texture of the fresh rock is recognisable.
Fresh (Fr)	Rock substance unaffected by weathering.

The degrees of rock weathering may be gradational. Intermediate stages are described by dual symbols with the prominent degree of weathering first (e.g. EW-HW).

The various degrees of weathering do not necessarily define strength parameters as some rocks are weak, even when fresh, to the extent that they can be broken by hand across the fabric, and some rocks may increase in strength during the weathering process.

Fresh drill cores of some rock types, such as basalt and shale may disintegrate after exposure to the atmosphere due to slaking, desiccation, expansion or contraction, stress relief or a combination of any of these factors.

AN ENGINEERING CLASSIFICATION OF SEDIMENTARY ROCKS

This classification system provides a standardised terminology for the engineering description of the sandstone and shales in the Sydney area, but the terms and definitions may be used elsewhere when applicable. Where other rock types are encountered, such as in dykes, standard geological descriptions are used for rock types and the same descriptions as below are used for strength, fracturing and weathering.

Under this system rocks are classified by Rock Type, Strength, Stratification Spacing, Degree of Fracturing and Degree of Weathering. These terms do not cover the full range of engineering properties. Descriptions of rock may also need to refer to other properties (e.g. durability, abrasiveness, etc) where these are relevant.

ROCK TYPE DEFINITIONS

ROCK TYPE	DEFINITION
Conglomerate:	More than 50% of the rock consists of gravel sized (greater than 2mm) fragments.
Sandstone:	More than 50% of the rock consists of sand sized (0.06 to 2mm) grains.
Siltstone:	More than 50% of the rock consists of silt-sized (less than 0.06mm) granular particles and the rock is not laminated.
Claystone:	More than 50% of the rock consists of silt or clay sized particles and the rock is not laminated.
Shale:	More than 50% of the rock consists of silt or clay sized particles and the rock is laminated.

Rocks possessing characteristics of two groups are described by their predominant particle size with reference also to the minor constituents, e.g. clayey sandstone, sandy shale.

STRATIFICATION SPACING

Term	Separation of Stratification Planes
Thinly Laminated	< 6mm
Laminated	6mm to 20mm
Very thinly bedded	20mm to 60mm
Thinly bedded	60mm to 0.2m
Medium bedded	0.2m to 0.6m
Thickly bedded	0.6m to 2m
Very thickly bedded	> 2m

DEGREE OF FRACTURING

This classification applies to diamond drill cores and refers to the spacing of all types of natural fractures along which the core is discontinuous. These include bedding plane partings, joints and other rock defects, but exclude known artificial fractures such as drilling breaks.

Term	Description
Fragmented:	The core is comprised primarily of fragments of length less than 20mm, and mostly of width less than the core diameter
Highly Fractured:	Core lengths are generally less than 20mm – 40mm with occasional fragments.
Fractured:	Core lengths are mainly 30mm – 100mm with occasional shorter and longer section.
Slightly Fractured:	Core lengths are generally 300mm – 1000mm with occasional longer sections and occasional sections of 100mm – 300mm.
Unbroken:	The core does not contain any fracture.

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Society of Rock Mechanics.

Term	Point Load Index Is(50) MPa	Field Guide	Approx qu MPa*
Extremely Weak:	0.03	Easily remoulded by hand to a material with soil properties.	0.7
Very Weak:	0.1	May be crumbled in the hand. Sandstone is “sugary” and friable.	2.4
Weak:	0.3	A piece of core 150mm long x 50mm dia. May be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.	7
Medium Strong:	1	A piece of core 150mm long x 50mm dia. can be broken by hand with considerable difficulty. Readily scored with knife.	24
Strong: (SW)	3	A piece of core 150mm long x 50mm dia. core cannot be broken by unaided hands, can be slightly scratched or scored with knife.	70
Very Strong (SW)	10	A piece of core 150mm long x 50mm dia. may be broken readily with hand held hammer. Cannot be scratched with pen knife.	240
Extremely Strong (Fr)	>10	A piece of core 150mm long x 50mm dia. is difficult to break with hand held hammer. Rings when struck with a hammer.	>240

The approximate unconfined compressive strength (qu) shown in the table is based on an assumed ration to the point load index of 24:1. This ratio may vary widely.

Unified Soil Classification System (Metricated)
Data for Description Indentification and Classification of Soils

DESCRIPTION

MAJOR DIVISIONS			Group Symbol	Graphic Symbol	TYPICAL NAME	DESCRIPTIVE DATA
COARSE GRAINED SOILS: More than 50% by dry mass, less than 60mm is greater than 0.06mm.	GRAVELS: More than 50% of coarse grains are greater than 2.0mm	GRAVELLY SOILS	GW		Well graded gravels and gravel-sand mixtures, little or no fines	Give typical name, indicate approximate percentages of sand and gravel, maximum size, angularity, surface condition and hardness of the coarse grains, local or geological name and other pertinent descriptive information, symbols in parenthesis. For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics. EXAMPLE: Silty Sand, gravelly, about 20% hard, angular gravel particles, 10mm maximum size, rounded and sub angular sand grains coarse to fine, about 15% non-plastic fines with low dry strength, well compacted and moist in place, light brown alluvial sand, (SM)
			GP		Poorly graded gravels and gravel-sand mixtures, little or no fines	
			GM		Silty gravels, gravel-sand-silt mixtures	
			GC		Clayey gravels gravel-sand-clay mixtures	
	SANDS: More than 50% of coarse grains are greater than 2.0mm	SANDY SOILS	SW		Well graded sands and gravelly sands, little or no fines	
			SP		Poorly graded sands and gravelly sands, little or no fines	
			SM		Silty sand, sand-silt mixtures	
			SC		Clayey sands, sand-clay mixtures	
FINE GRAINED SOILS: More than 50% by dry mass, less than 0.06mm is less than 0.06mm	Liquid Limit less than 50%		ML		Inorganic silts, very fine sands, rock flour, silty or clayey fine sands.	Give typical name, indicate degree and character of plasticity, amount and maximum size of coarse grains, colour in wet condition, odour if any, local or geological name and r pertinent descriptive information, symbols in parenthesis. For undisturbed soil add information on structure, stratification, consistancy in undisturbed and remoulded states, moisture and drainage conditions. EXAMPLE Clayey Silt, brown, low plasticity, small percentage of fine sand, numerous vertical root-holes, firm and dry in place, fill, (ML).
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	
			OL		Organic silts and organic silty clays of low plasticity	
	Liquid Limit more than 50%		MH		Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts.	
			CH		Inorganic clays of high plasticity, fat clays.	
			OH		Organic clays of medium to high plasticity.	
			Pt		Peat muck and other highly organic soils.	

FIELD IDENTIFICATION

Determine approximate percentages of material over 60mm size, maximum size, shape, surface texture, hardness of material, geological description, identify on estimated percentage mass of the various fractions.

0.06mm is about the smallest particle visible to the naked eye

COARSE GRAINED SOILS — More than half of the material less than 60mm is larger than 0.06mm

GRAVELS AND SANDS

GRADATIONS		NATURE OF FINES	DRY STRENGTH	Group Symbol
GOOD	Wide range in grain size	"Clean" materials (not enough fines to band coarse grains)	None	GW
POOR	Predominantly one size or range of sizes			GP
GOOD TO FAIR	"Dirty" materials (Excess of fines)	Fines are non-plastic (1)	None to medium	GM
		Fines are plastic (1)		GC
GOOD	Wide range in grain size	"Clean" materials (not enough fines to band coarse grains)	None	SW
POOR	Predominantly one size or range of sizes			SP
GOOD TO FAIR	"Dirty" materials (Excess of fines)	Fines are non-plastic (1)	None to medium	SM
		Fines are plastic (1)		SC

FINE GRAINED SOILS — More than half of the material less than 50mm is less than 0.06mm

SILT AND CLAY FRACTION

Fraction smaller than 0 20mm AS sieve size

DRY STRENGTH	DILATANCY	TOUGHNESS	Group Symbol
None to low	Quick to slow	None	ML
Medium to high	None to very slow	Medium	CL
Low to medium	Slow	Low	OL
Low to medium	Slow to none	Low to medium	MH
High to very high	None	High	CH
Medium to high	None to very slow	Low to medium	OH

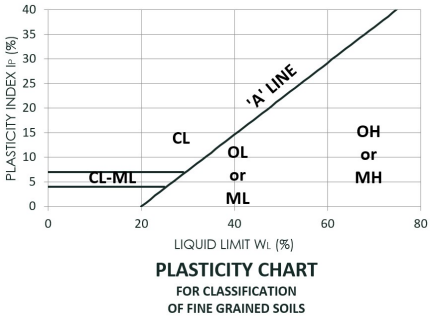
Readily identified by colour, odour, spongy feel and generally by fibrous texture — Pt*

LABORATORY CLASSIFICATION

Use the gradation curve of material passing 60mm for classification of fractions according to criteria given under "Major Division".

More than 50% passing 0.06mm	% [2] < 0.06mm	PLASTICITY OF FINE FRACTION			NOTES
	0-5	-	>4	Between 1 and 3	1. Identify Fines by the method given for fine grained soils.
	0-5	-	Fails to comply with above		2. Borderline classifications occur when the percentage of fines (fraction smaller than 0.06mm size) is greater than 5% and less than 12%.
	12-50	Below 'A' line and Ip >7	-	-	Borderline classifications require the use of dual symbols eg SP-SM GW-GC
	12-50	Above 'A' line and Ip > 7	-	-	
	0-5	-	>6	between 1 and 3	
	0-5	-	Fails to comply with above		
	12-50	Below 'A' line or Ip < 4	-	-	
	12-50	Above 'A' line and Ip > 7	-	-	
		Below 'A' line			
		Above 'A' line			
		Below 'A' line			
		Below 'A' line			
		Above 'A' line			
		Below 'A' line			

*Effervescence with H2O2



PLASTICITY CHART
FOR CLASSIFICATION OF FINE GRAINED SOILS

FORTIFY GEOTECH

Limitations in the Use and Interpretation of this Geotechnical Report

Our Professional services were performed, our findings obtained, and our recommendations prepared in accordance with generally accepted engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

The geotechnical report was prepared for the use of the Owner in the design of the subject facility and should be made available to potential contractors and/or the Contractor for information on factual data only. This report should not be used for contractual purposes as a warranty of interpreted subsurface conditions such as those indicated by the interpretive boring and test pit logs, cross- sections, or discussion of subsurface conditions contained herein.

The analyses, conclusions and recommendations contained in the report are based on site conditions as they presently exist and assume that the exploratory borings, test pits, and/or probes are representative of the subsurface conditions of the site. If, during construction, subsurface conditions are found which are significantly different from those observes in the exploratory borings and test pits, or assumed to exist in the excavations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. If there is a substantial lapse of time between the submission of this report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, this report should be reviewed to determine the applicability of the conclusions and the recommendations considering the changed conditions and time lapse.

The Summary Boring Logs are our opinion of the subsurface conditions revealed by periodic sampling of the ground as the borings progressed. The soil descriptions and interfaces between strata are interpretive and actual changes may be gradual.

The boring logs and related information depict subsurface conditions only at the specific locations and at the particular time designated on the logs. Soil conditions at the other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the soil conditions at these boring locations.

Groundwater levels often vary seasonally. Groundwater levels reported on the boring logs or in the body of the report are factual data only for the dates shown.

Unanticipated soil conditions are commonly encountered on construction sites and cannot be fully anticipated by merely taking soil samples, borings or test pits. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. It is recommended that the Owner consider providing a contingency fund to accommodate such potential extra costs.

This firm cannot be responsible for any deviation from the intent of this report including, but not restricted to, any changes to the scheduled time of construction, the nature of the project or the specific construction methods or means indicated in this report: nor can our firm be responsible for any construction activity on sites other than the specific site referred to in this report.