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Geotechnical Investigation Report

for

Proposed Industrial Subdivision

at

290-308 Aldington Road, Kemps Creek NSW 2178

Lot 13 in DP253503

Prepared for

ESR Group

25th October 2019

Report No: 9687-GR-1-1

We give you the right information to make the right decisions

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DOCUMENT CONTROL

Revision	Date	Description	Author	Reviewer
-	25th October 2019	"Issue to the client"	AA	TD

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APPENDICES

1. INTRODUCTION

This report presents the findings of a geotechnical investigation undertaken by Alliance Geotechnical Pty Ltd (AG) for ESR Group (the client) for the proposed industrial subdivision at 290-308 Aldington Road, Kemps Creek NSW 2178 Lot 13 in DP253503 (the site). The investigation was undertaken in accordance with the scope of works outlined in AG's proposal, estimate No. 2693, dated 13th September 2019. This report provides a summary of observations made by AG's engineering geologist during drilling, the results of in-situ, laboratory tests and interpretation of obtained information.

1.1. Project Description

It is understood that the site will be used for the development of an industrial subdivision that comprises three (3) industrial lots with total areas ranging from 19,790m^2 to 39,932m^2. Each lot is proposed to be occupied by a warehouse and a two (2) storey office building with associated car parking areas and access roads. Based on the provided concept master plan, it is understood that a substantial earthwork will be required to achieve the design level of the proposed developments.

For input as part of a feasibility study for this development, this geotechnical investigation has been undertaken to provide an assessment of the site subsurface conditions and geotechnical constraints for the development. General recommendations for pavement design of the associated access roads and carparks are also provided.

To aid in the preparation of this report, AG was supplied with the following document:

- Concept Master Plan of Aldington Road, Kemps Creek NSW, Prepared by ESR Group (Drawing number: 277086 BM08-003, dated 18.0.2018), including the Reduce Level (RL) of reference points and proposed Pad Levels.

1.2. Project Objectives

The geotechnical investigation has been carried out to address the following project objectives:

- Geotechnical subsurface profile and groundwater conditions;
- Determine geotechnical constraints which are likely to be encountered during construction of the development;
- Suitable footing types and associated geotechnical design parameters;
- Provide recommendations regarding excavations, bulk earthworks and temporary shoring systems;
- Provide recommendations for retaining wall design; and,
- CBR design values and pavement subgrade preparation.

1.3. Scope of Work

In order to achieve the project objectives, the following scope of work was carried out for the geotechnical investigation:

- Review of geological maps and available aerial photos;

- A walkover assessment of the site;
- Preparation of a Safe Work Method Statement (SWMS) for the proposed scope of work;
- Borehole drilling using a track-mounted rig to undertake the drilling of seven (7) boreholes in selected locations;
- Standard Penetration Tests (SPTs) carried out at 1.5m depth intervals to assess the soil consistency in depth of select boreholes;
- Dynamic Cone Penetrometer (DCP) tests to assess the soil consistency of shallow subsoil; and,
- Collect soil samples for soil laboratory tests, comprising:
    - Four (4) California Bearing Ratio (CBR)
    - Four (4) Atterberg Limits
    - Two (2) Soil Aggressivity.

2. SITE DESCRIPTION AND REGIONAL GEOLOGY

The site comprises a trapezoid block of land with an approximate area of 10 hectares. The site is located about 800m east of Kemps Creek in jurisdiction of Penrith City Council. At the time of investigation, the site was occupied by a few single and two storey brick dwellings with associated pool and garage and four disused fibro clad poultry sheds. Three (3) farm dams were also observed during the investigation.

The site is bounded by the Aldington Road to the west, Abbots and Abbey Roads to the south and adjacent lands to the north and east. Based on the provided concept design and the available aerial images, the Reduced Level (RL) of the site is in a range of RL 55m AHD and RL 89m AHD dipping down to the west.

The general overview of the site is provided in photographs in Appendix A. The site locality is presented in a satellite image in Figure 1.

Based on the 1:100,000 NSW Department of Mineral Resources Geological Map of the Penrith region (Geological Series Sheet 9030, Edition 1 – 1991) indicates that the site is underlain by Bringelly Shale of Wianamatta Group (Rwa). The Bringelly Shale geological unit is described as, "*Shale, carbonaceous claystone, claystone, laminite, fine to medium-grained lithic sandstone, rare coal and tuff*". The site is located approximately 700m to the east and 1300m to the west of Quaternary alluvial unit (Qal) which is described as *fine-grained sand, silt and clay*. This unit is made by the alluvial depositions transported by Kemps Creek and Ropes Creek.

Figure 1 – Site Location in Satellite View (Source: Google Earth)

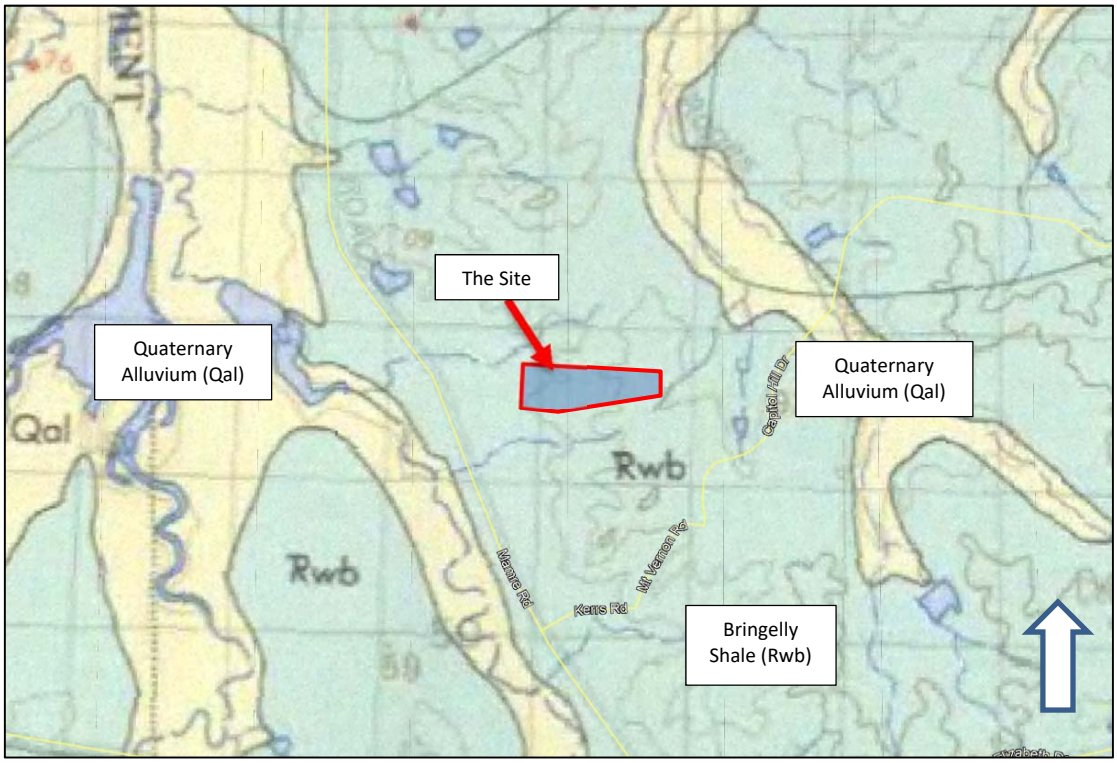

Figure 2 – Site location in an extract of the geological map of Penrith

3. GEOTECHNICAL INVESTIGATION

3.1. Fieldwork

The geotechnical site investigation was carried out on 4th October 2019. The investigation comprised the drilling of seven (7) boreholes to a maximum depth of 6.7m below the Existing Surface Level (ESL). Boreholes were drilled by a track-mounted drilling rig (Hanjin) operated by AG's nominated drilling subcontractor. All boreholes were drilled using a 110mm diameter solid flight augers fitted with a Tungsten Carbide (TC) drill bit. SPT tests were carried out at 1.5m intervals in selected boreholes to assess subsoil consistency versus depth. DCP tests were also conducted adjacent to the boreholes to evaluate the consistency of shallow subsoil.

An engineering geologist from AG was present at the site to witness the drilling and log the subsoil based on the retrieved drill cuttings, in-situ tests and observed performance of TC bit. Soil samples were collected from selected locations and depths for the required laboratory tests.

Selected site photographs taken during the fieldwork are attached in Appendix A. The location of the boreholes are shown on the Site Investigation Plan (Drawing 9687-GR-1-A) attached in Appendix B.

3.2. Generalised Subsurface Profile

The general subsurface conditions encountered are summarised in Table 1 below. For a detailed description, engineering borehole logs and explanatory notes are provided in Appendix C.

Table 1 - Summary of Subsurface Profile

Unit	Description	Consistency/Strength	Depth to Top of Unit (m)	Thickness (m)
Topsoil fill	Topsoil Fill: Silty Clay to Clay, low to medium plasticity, trace sand and gravel (In BH4: Sandy Gravel)	Appears moderate to well compacted	0.0	0.1 – 0.5
Residual	Silty CLAY to CLAY, medium to high plasticity	Stiff to Hard, (increasing with depth)	0.1 – 0.5	0.5 – 3.5
Bedrock	SHALE, extremely to highly weathered, with frequent clay bands (inferred as Class V or better)	Very low strength to Low Strength (increasing with depth)	0.8 – 2.2	--

The subsoil generally comprises of a fill layer with a nominal thickness of 0.3m overlying a residual clay layer with consistency estimated as stiff to hard, increasing with depth. The residual soil is underlain by Shale bedrock with frequent clay bands within the weathered profile. The bedrock level varies across the site with a minimum depth of 0.8m on the eastern side of the site. Based on the rock classification system developed for Sydney Sandstones and Shales as per the Australian Geomechanics publication (Pells et al., 1998), the bedrock is inferred as Class V at the top and becoming Class IV close to the target depth of the deeper boreholes.

The provided subsurface soil consistency is based on the SPT and DCP test results together with observations made on mechanical characteristics of the drilling cuttings.

Groundwater seepage was not observed during the drilling across the site. However, groundwater seepage is affected by seasonal climate variations and commonly occurs at the interface of bedrock and its overlying layer after prolonged rainfall events.

4. LABORATORY TESTING

Sampled soils have been tested in AG's NATA accredited laboratory to identify the physical and mechanical parameters of representative soil layers. Based on the project's objectives and proposed scope of work following laboratory testings are considered:

- California Bearing Ratio (CBR): AS 1289 6.1.1 and 2.1.1
- Atterberg Limits: AS 1289 3.1.2, 3.2.1 and 3.3.1
- Soil Aggressivity

The results are summarised in Table 2 to Table 4. All certificates of the laboratory tests are enclosed in Appendix E.

4.1. California Bearing Ratio (CBR) Test

CBR tests were carried out on four (4) bulk soil samples collected from BH4, BH7, BH11 and BH103 across the site.

Table 2 - Summary of CBR Results

Location and Depth	Material Type	FMC (%)	OMC (%)	MDD (t/m^3)	CBR (%)
BH2 (0.3m – 0.7m)	CLAY, medium to high plasticity	15.7	18.6	1.71	5.0
BH4 (0.3m – 0.7m)	Silty CLAY, medium plasticity	12.2	15.8	1.83	5.0
BH5 (1.0m – 1.5m)	Silty CLAY, medium to high plasticity	21.9	23.4	1.58	3.5
BH6 (0.3m – 0.7m)	CLAY, high plasticity	21.9	21.5	1.63	3.5

4.2. Atterberg Limits

Atterberg Limits test was performed on collected bulk samples in order to obtain the variations of soil types across the site.

Table 3 - Summary of Atterberg Limits Results

Borehole No.	Sample Depth (m)	Soil Type	Atterberg Limits (%)		
			LL	PL	PI
BH3	0.5 – 0.9	Silty CLAY, medium to high plasticity	52	19	33
BH5	0.5 – 1.0	Silty CLAY, medium to high plasticity	56	22	34
BH6	0.5 – 0.6	CLAY, high plasticity	61	24	37

4.3. Soil Aggressivity Test

Three samples were collected from top soil and fill material for aggressivity assessment. All samples were analysed for soil pH, sulphates, chlorides and electrical conductivity tests based on guidelines provided by AS 2159 – 2009 Piling Design and Installation. The results are summarised in Table 4 below.

Table 4 - Summary of Soil Aggressivity Test Results

Location and Depth	Chloride (mg/kg)	pH – 1:5 extract	Sulphate (mg/kg)	Resistivity Ohm.m	Conductivity uS/cm
BH2 (0.5 – 0.6m)	230	7.1	43	560	90
BH5 (1.5 – 1.6m)	490	5.6	<10	380	130

Based on the results, all soil samples are classified as “Non-Aggressive” to both steel and/or concrete structures.

5. COMMENTS AND RECOMMENDATIONS

5.1. Geotechnical Constraints

Based on the results of the investigation and the provided concept design plan, the major geotechnical constraints for the proposed development are the required excavation and bulk filling to achieve the founding levels of the proposed industrial warehouses.

Based on the supplied concept plan, maximum excavation depth of about 9m in the north eastern part of the site and fill placements in the order of 8 to 10m in the southern part of the site are required to achieve the final pad levels of the proposed warehouse and office buildings. Recommendations on fill placement and excavation conditions are discussed in sections 5.3 and 5.4.

5.2. Groundwater Seepage

Although no groundwater seepage was observed during investigations, it is crucial to consider a proper drainage system behind retaining walls and/or temporary shoring systems. The natural gradient of the site’s terrain will generate water pressure build-up behind retaining structures or shoring systems to be used in the site. The water seepage through the bedrock joints and seams will highly affect the stability of bedrock cuts in the long-term.

5.3. Subsoil Geotechnical Design Parameters

The subsoil and bedrock geotechnical parameters are provided in Table 5 below. These parameters are defined based on the subsoil’s physical and mechanical conditions observed during the

investigation, results of geotechnical laboratory testing and AG's past experiences with similar soil and rock formations in the region.

Table 5 – Subsoil Geotechnical Design Parameters

Unit	Description	Top of Layer from ESL (m)	γ (kN/m^3)	C_u (kPa)	C' (kPa)	ϕ'	E' (MPa)	ν
1	CLAY – Stiff to Very Stiff	0.1 – 0.5	19	80	6	26	20	0.4
2	CLAY – Very Stiff to Hard	0.25 – 2.5	20	180	10	27	50	0.35
3	SHALE – Very Low to Low Strength (Class V)	0.8 – 2.2	23	-	25	28	50	0.3
4	SHALE – Very Low to Low Strength (Class IV)	2.5 – 5.5	23	-	75	28	150	0.2

Legend:
γ: Bulk Unit Density
C_u: Undrained Cohesion
C': Drained Cohesion
ϕ': Drained Internal Friction Angle
E': Long Term Elastic Modulus
ν: Poisson's ratio

5.4. Excavation Conditions and Vibrations

Based on the provided concept plan, the development comprises excavations to the extent of 9m in the northern half of the site. With the bedrock observed in shallow depths, it is expected that bedrock excavation is required for the major part of the proposed cuts. Based on the results of the investigation, the bedrock strength changes from very low strength to low strength increasing with depth. It is highly recommended to consider a supplementary investigation including rock coring and associated laboratory testings in order to provide the necessary information prior to the design phase of the required retaining walls as well as to better inform expected excavatibility and rippability.

The presence of potentially unstable wedges, joints, clay seams, fracture zones and extremely weathered seams within the shale bedrock may adversely affect the stability of the cut faces and/or footings located close to the crests of cut faces. Such features would need to be identified by geotechnical inspections and require shotcreting to be carried out during the excavation phase. In lack of additional information, it is recommended that every 1.5m of excavation be benched in locations with more than 3m of excavation in the bedrock at 1H:2V.

Based on the subsurface conditions encountered during the investigation, excavations are expected to encounter Top soil/fill, residual soil and very low strength (Class V) and higher strength Shale bedrock. Excavations through the subsoil and very low strength shale are expected to be readily achieved using conventional excavation equipment. Excavation within low or higher strength shale bedrock can be achieved using rock hammers or using dozers

Considering the open areas around the site and the distance of the site boundaries to other structures, it is anticipated that the excavation induced vibration will not be critical. If underground services sensitive to vibration inducted damage do exist near the excavation points, further advice should be sought to mitigate any potential damages due to the induced vibrations.

5.5. Temporary Batter Slopes and Shoring

The maximum depth of temporary unsupported excavations using batter slopes should be considered based on minimum available setback to adjacent structures and underground services and the maximum allowable gradients as provided in Table 6 below.

Batter slopes in soil should not be extended below the 'zone of influence' of any adjacent structures, road and infrastructures (i.e. a 45° line drawn from the foundation level of any adjacent structure in soil profile). Wherever the batter slopes are not feasible due to limited setbacks and/or technical constraints, excavation walls should be supported by a properly designed shoring system.

Where feasible the batter slopes should be covered to maintain the moisture and prevent the water runoff on the exposed face. This will help retain the natural cohesion of the materials and prevent degradation of the batter face through wetting and drying. Based on generally geomechanics principals unsupported temporary batter slopes are generally not recommended to be left exposed for more than 3 weeks. It is noted that this duration is unpractical for many construction projects. Batters can maintained for durations of more than 3 weeks provided the stability of the excavation is periodically checked by a geotechnical engineer and the relevant risks managed. Vertical cuts in soil to the maximum depth of 1.5m can be conducted and maintained for a short time subject to an inspection of the experienced geotechnical engineer.

Although, AG has not cored the bedrock past refusal depths it is likely that in the deeper sections of excavation low to medium strength shale or better may be encountered. Temporary vertical excavations in this rock are feasible but require ongoing advice from an experienced geotechnical engineer.

Table 6 - Maximum Allowable Batter Gradients

Material	Maximum Batter Slope (H : V)
	Temporary
Topsoil/Fill	1.5 : 1
Residual Soil (Stiff to Hard)	1 : 1
Shale Bedrock (very low strength or better)	1 : 2*
* Subject to inspection by an experienced Geotechnical Engineer and carrying out remedial works if recommended (shotcrete, rock bolting, etc.)	

5.6. Retaining Structures

The permanent earth retaining structures should be designed to withstand the applied lateral pressures of the subsurface soil layers and the existing surcharge loads within the zone of influence of the structure and traffic loading. The level of the adjacent buildings' footings and their zone of influence should be considered in the design of the temporary or permanent retaining structures.

For the design of flexible retaining structures, where some lateral movement is acceptable, an 'active' lateral earth pressure coefficient (k_a) is recommended. If it is critical to limit the horizontal

deformation of a retaining structure, the 'at rest' earth pressure coefficient (k_0) should be considered. The required parameters for retaining wall design is presented in the following table.

Geotechnical parameters for controlled fill to be placed in the site could be provided following an inspection by a geotechnical engineer.

Table 7 – Parameters for Retaining Structure Design

Geotechnical Parameter	Residual Soil	Very Low Strength Shale
Unit Weight (KN/m^3)	19	23
C' (kPa)	6	25
K_a (Active earth pressure)	0.39	0.36
K_o(Earth pressure at rest)	0.56	0.53
K_p (Passive earth pressure)	2.56	2.77

The structures should be designed using a triangular earth pressure distribution and the following formula if the retaining system is designed as a cantilever wall:

$$P_h = (\gamma \cdot h + q) \cdot K_a - 2C'\sqrt{K_a}$$

Where:

P_h = Horizontal active pressure (kN/m^2)

γ = Unit weight of soil (kN/m^3)

K_a = Co-efficient of active earth pressure

h = Retained height *(m)*

q = Surcharge pressure behind retaining wall (kN/m^2)

It should be noted that the above-mentioned equation does not take into account any potential rock wedge loads that would require bolting and /or other treatment to be assessed by the geotechnical engineer during inspections.

A triangular stress distribution should be used for the design of permanently restrained walls if the walls are designed as a cantilever. The surcharge pressure including the pressure applied by any construction plant and machinery placed within the zone of influence of the excavation should be added to the above stress distribution.

5.7. Fill Placement and Compaction

It is recommended that any fill to be placed at the site be subject to a site-specific earthworks specification, which would incorporate information provided in the relevant Australian Standard.

The fill should be placed in a controlled manner as defined in the Australian Standard. Fill materials shall not contain vegetation or other organic matter. Existing fill material and residual soil observed in

this investigation seem satisfactory for use as general fill material. In-situ material should be placed and compacted to achieve the density ratio and moisture content as specified in Table 8 below.

Filling within 1.5m of the rear of retaining structures (if any) should be compacted using light-weight equipment (e.g. hand-operated plate compactor or static roller of not more than 3 tonnes gross weight) in order to limit compaction-induced lateral pressures. It is recommended that all compaction control testing in areas that will support buildings and pavements be undertaken under the supervision of a suitable Geotechnical Inspection Testing Authority (GITA).

It is recommended to place a final layer of compacted granular fill with a minimum thickness of 300mm, to finish the building pad to protect the subgrade from soil moisture changes.

General fill (with a compaction ratio of less than 98%) shall be used for site works only and they should not be adopted as a foundation for structures or pavement. Engineered fill with compaction specified in Table 8 can be used for achieving the footing level across the footprint of the development.

Table 8 - Compaction Specifications for Fill Material

Filling	Loose layer thickness (mm)	Minimum density ratio (cohesive soils)	Moisture Content when compacted
Engineered Filling	250	98%	±2% OMC

5.8. Building Footings

The general fill is not considered suitable for building structural loads. Based on the subsurface geotechnical condition encountered and the anticipated loads applied by the proposed development, the building load could be catered with a combination of shallow and deep footings across the site. Very low strength shale can provide an allowable bearing pressure of 700kPa for shallow footings. For shallow footings on controlled engineered fill, the bearing pressure of 200kPa can be adopted. This value can be increased if the continuous supervision during the earthwork take place. A minimum footing embedment depth of 0.8m is recommended.

Wherever the building is supported partially by shale bedrock, it is recommended that all the building footings be taken to bedrock to minimise differential settlements and induced structural damages. The recommended bearing capacity for piles footings is presented the Table 9 below.

Table 9 - Recommended Geotechnical Design Parameters for Deep Foundation

Description	Approximate depth * (m)	Serviceability End Bearing Pressure (kPa)	Serviceability Shaft Adhesion (kPa)	Elastic Modulus (MPa)
Extremely weathered, very low strength Shale	0.8 – 2.2	700	75	50
* The depths are estimated based on drilled borehole location and may vary across the site.				

Before pouring concrete, the excavations for the installation of footings should be inspected by a geotechnical engineer to confirm that the founding material and the bases of the footing excavations are clean, dry and free of soft, loose soil/debris and the design bearing capacity is achievable.

5.9. Subgrade Preparation

The following recommendations are provided for subgrade preparation for internal roads and slab-on-ground construction:

- Strip topsoil, root affected soil and unsuitable materials and stockpile for reuse in landscaped areas, or remove from site;
- For areas where no cutting or filling is required rip, moisture condition and rework the upper 0.5 m to make good the existing cracked zone. Once reworked, proof roll the prepared surface using a minimum 10 tonne smooth drum roller without vibration. The surface should be rolled a minimum of six times with the at least two passes observed by an experienced geotechnical engineer to detect any 'soft spots'. Remove any additional unsuitable soil identified during proof rolling. For areas requiring filling, proof roll the prepared surface using a minimum 10 tonne smooth drum roller in non-vibration mode. The surface should be rolled a minimum of six times with the last two passes observed by an experienced geotechnical engineer to detect any 'soft spots'. Remove any additional unsuitable soil identified during proof rolling. Identified 'soft spots' should be over-excavated a further 0.3m and replaced with approved fill compacted to a dry density ratio not less than 98% SMDD;
- To achieve design subgrade level, filling should be placed in 300 mm maximum thickness layers and compacted to 98% SMDD maintaining the moisture content of the filling within 2% of Standard OMC;
- A level 1 supervision of earthworks by a registered GITA geotechnical engineer is required for the earthwork in the site.

Any soils being removed from the site must be classified in accordance with current regulatory authority requirements to enable appropriate disposal to a licensed landfill facility, AG offers this service.

6. CBR DESIGN PARAMETERS

AG has undertaken a general flexible pavement assessment of the design requirements. The indicative pavement design provided are preliminary and should be confirmed by a civil or pavement engineer. It is understood that CBR design values are required for the pavement design of parking areas and access roads which will branch off from the Abbots Road. Based on the CBR test results, the suggested parameters for the pavement design are as follows:

- Design CBR Value: 3.0%
- Elasticity (Young's) Modulus: 30 MPa
- Subgrade Reaction (k): 25 kPa/mm
- Poisson's Ratio (ν): 0.4

7. FURTHER INVESTIGATION

Based on the results of the investigation for the proposed development addressing the specific site condition in 290-308 Aldington Road, Kemps Creek, it is recommended that further geotechnical investigation be carried out prior to the detail design of the development. The proposed investigation should include rock coring to 3m below the base of the proposed rock cuts and laboratory rock testings to provide rock strength and defects of the rock mass. The results of the investigation should address bedrock conditions for stability analysis, retaining wall design and required earthworks based on architectural design of development.

8. LIMITATIONS

This report has been prepared by AG for this project at 290 – 308 Aldington Road, Kemps Creek NSW 2178 for the proposed development works described in the report. The work was undertaken under AG's Terms of Engagement for the purposes outlined in the introduction. This report should not be relied on as geotechnical advice for other projects or other parties on this site or any other site. Any party relying on this report outside its exclusive use stated herein and without AG's consent does so entirely at their own risk and without any recourse to AG for any loss or damage.

The results provided in this report are indicative of subsurface conditions on site only at the specific sampling or testing locations and only to the depths investigated at the time the works were undertaken. Subsurface conditions can vary significantly due to geological or human processes. This report has been prepared on the assumptions and the conditions revealed by the geotechnical investigation and represent the actual conditions beneath the site. The assumptions on this report cannot be substantiated until earthworks and /or foundation construction is near completion. Where variations in conditions are encountered, further geotechnical advice should be sought from AG.

REFERENCES

- Australian Standard, AS1726-2017 - *Geotechnical Site Investigations;*
- Australian Standard, AS 1289 – 2006 - *Method of testing soils for engineering purposes;*
- Australian Standard, AS 3798 – 2007 – *Guidelines on earthworks for commercial and residential developments;*
- P.J.N. Pells, G. Mostyn and B.F. Walker - 1998 - *Foundations on sandstone and shale in the Sydney region*; and,
- The 1:100,000 NSW Department of Mineral Resources Geological Map of Penrith.

APPENDIX A – Selected Site Photographs

Figure 1 – General overview of the site

Figure 2 – Drilling rig setup in the location of BH4

Figure 3 – SPT sample retrieved from residual soil after the test

Figure 4 – General site overview and drilling rig setup in the location of BH1

APPENDIX B – Drawing: 9687-GR-1-A

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Borehole Location Plan

Client Name:	ESR Group	N	Figure / Drawing Number:	9687-GR-1-A
Project Name:	Proposed Industrial Subdivision		Figure / Drawing Date:	21/10/2019
Project Location:	290-308 Aldington Road, Kemps Creek NSW 2178		Report Number:	9687-GR-1-1

APPENDIX C – Borehole Logs, Explanatory Notes and DCP Results

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BH No: BH 01
Sheet: 1 of 1
Job No: 9687

Borehole Log

Client: ESR Group
Project: Proposed Industrial Subdivision
Location: 290-308 Allington Road, Kemps Creek NSW 2178

Started: 4/10/19
Finished: 4/10/19
Borehole Size 110mm

Rig Type: Hanjin 8D | **Hole Location:** Refer Drawing 9687-GR-1-A | **Driller:** CB | **Logged:** MS
RL Surface: | **Contractor:** BG Drilling Pty Ltd | **Bearing:** --- | **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Groundwater Not Encountered		0		--	FILL: Clay, medium to high plasticity, MC<PL, brown-grey, with silt (Appears moderately compacted).	DS	M	--	FILL
			1		CH	CLAY, high plasticity, orange-brown mottled grey, MC<PL, trace silt, trace fine gravel.		M	St - VSt	RESIDUAL
			2		--	SHALE, extremely to highly weathered, very low strength, brown, with frequent clay layers.	DS	--	--	BEDROCK
			3			Borehole BH 01 terminated at 3m				
			4							
			5							
			6							

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BH No: BH 02
Sheet: 1 of 1
Job No: 9687

Borehole Log

Client: ESR Group
Project: Proposed Industrial Subdivision
Location: 290-308 Allington Road, Kemps Creek NSW 2178

Started: 4/10/19
Finished: 4/10/19
Borehole Size 110mm

Rig Type: Hanjin 8D
Hole Location: Refer Drawing 9687-GR-1-A
Driller: CB
Logged: MS

RL Surface:
Contractor: BG Drilling Pty Ltd
Bearing: ---
Checked: LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Groundwater Not Encountered				--	TOPSOIL/FILL: Silty Clay, low to medium plasticity, MC~PL, grey-brown, with rootlets	DS	M	--	TOPSOIL/FILL
					CI-CH	CLAY, medium to high plasticity, MC>PL, red-brown mottled grey, trace fine gravel.	DS	M - W	F	RESIDUAL
			1							
						- As above, but MC<PL	SPT 4, 5, 7 N=12	M	St	
			2							
					CI-CH	Silty CLAY, medium to high plasticity, MC<PL, orange-grey, with shale layers.		M	H	
			3				SPT 7, 15, 15 N=30			
						Borehole BH 02 terminated at 3.5m				
			4							
			5							
			6							

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BH No: BH 03
Sheet: 1 of 1
Job No: 9687

Borehole Log

Client: ESR Group
Project: Proposed Industrial Subdivision
Location: 290-308 Allington Road, Kemps Creek NSW 2178

Started: 4/10/19
Finished: 4/10/19
Borehole Size 110mm

Rig Type: Hanjin 8D
Hole Location: Refer Drawing 9687-GR-1-A
Driller: CB
Logged: MS
RL Surface:
Contractor: BG Drilling Pty Ltd
Bearing: ---
Checked: LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Groundwater Not Encountered				--	TOPSOIL/FILL: Silty Clay, low plasticity, grey, trace fine gravel.	DS	D	--	TOPSOIL/FILL
			1		CI-CH	Silty CLAY, medium to high plasticity, MC~PL, orange-brown mottled grey.		M	St	RESIDUAL
						- As above, but MC<PL, with shale layers.	SPT 7, 25/120mm		H	
			2		--	SHALE, extremely to highly weathered, very low strength, grey-brown, with frequent clay layers.		D	--	BEDROCK
			3		--	SHALE, highly weathered, very low to low strength, grey.		D	--	
						Borehole BH 03 terminated at 3.1m				TC Bit Refusal
			4							
			5							
			6							

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BH No: BH 04
Sheet: 1 of 1
Job No: 9687

Borehole Log

Client: ESR Group
Project: Proposed Industrial Subdivision
Location: 290-308 Allington Road, Kemps Creek NSW 2178

Started: 4/10/19
Finished: 4/10/19
Borehole Size 110mm

Rig Type: Hanjin 8D | **Hole Location:** Refer Drawing 9687-GR-1-A | **Driller:** CB | **Logged:** MS
RL Surface: | **Contractor:** BG Drilling Pty Ltd | **Bearing:** --- | **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Groundwater Not Encountered				--	FILL: Sandy Gravel, medium to coarse grained, well graded, fine to medium grained sand, grey-brown, with clay (Appears well compacted).	DS	D	--	FILL
					CI	Silty CLAY, medium plasticity, orange-brown-grey, MC<PL, with shale gravel.	DS	D	H	RESIDUAL
			1		CI	Silty CLAY, medium plasticity, orange-brown, MC<PL, with shale layers.		D	H	
			2		--	SHALE, extremely weathered, very low strength, grey-brown, with clay layers.		D	--	BEDROCK
			3			Borehole BH 04 terminated at 3m				
			4							
			5							
			6							

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Job No: 9687

Borehole Log

Client: ESR Group
Project: Proposed Industrial Subdivision
Location: 290-308 Allington Road, Kemps Creek NSW 2178

Started: 4/10/19
Finished: 4/10/19
Borehole Size 110mm

Rig Type: Hanjin 8D | **Hole Location:** Refer Drawing 9687-GR-1-A | **Driller:** CB | **Logged:** MS
RL Surface: | **Contractor:** BG Drilling Pty Ltd | **Bearing:** --- | **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Groundwater Not Encountered				--	TOPSOIL/FILL: Silty Clay, low plasticity, trace fine sand, trace roots.	DS	D	--	TOPSOIL/FILL
					CI-CH	Silty CLAY, medium plasticity, MC>PL, orange-brown mottled grey.		M	St	RESIDUAL
			1			- As above but dry, hard.		D	H	
						- As above with shale layers.	SPT 10, 12, 18 N=30	D	H	
			2		--	SHALE, highly weathered, very low to low strength, grey, with clay bands.		D	--	BEDROCK
			3				SPT 17, 25/5mm Hammer Bounce			
			4							
			5							
					--	SHALE, highly weathered, low strength, dark grey.		D	--	
			6							

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BH No: BH 05
Sheet: 2 of 2
Job No: 9687

Borehole Log

Client: ESR Group
Project: Proposed Industrial Subdivision
Location: 290-308 Allington Road, Kemps Creek NSW 2178

Started: 4/10/19
Finished: 4/10/19
Borehole Size 110mm

Rig Type: Hanjin 8D
Hole Location: Refer Drawing 9687-GR-1-A
Driller: CB
Logged: MS

RL Surface:
Contractor: BG Drilling Pty Ltd
Bearing: ---
Checked: LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT					--	SHALE, highly weathered, low strength, dark grey. *(continued)*		D	--	
			7			Borehole BH 05 terminated at 6.7m				TC bit refusal
			8							
			9							
			10							
			11							
			12							

BOREHOLE (NO COORD/RL) 9687 - 290-308 ALDINGTON ROAD, KEMPS CREEK LOGS.GPJ GINT STD AUSTRALIA.GDT 18/10/19

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BH No: BH 06
Sheet: 1 of 1
Job No: 9687

Borehole Log

Client: ESR Group
Project: Proposed Industrial Subdivision
Location: 290-308 Allington Road, Kemps Creek NSW 2178

Started: 4/10/19
Finished: 4/10/19
Borehole Size 110mm

Rig Type: Hanjin 8D
Hole Location: Refer Drawing 9687-GR-1-A
Driller: CB
Logged: MS
RL Surface:
Contractor: BG Drilling Pty Ltd
Bearing: ---
Checked: LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Groundwater Not Encountered				--	TOPSOIL/FILL: Silty Clay, low plasticity, MC>PL, dark grey, trace fine sand, trace rootlets.	DS	M	--	TOPSOIL/FILL
					CH	CLAY, high plasticity, MC~PL, orange-brown mottled grey.		M	St	RESIDUAL
			1		--	SHALE, extremely to highly weathered, very low to low strength, grey-brown, with clay bands.		D	--	BEDROCK
			2				SPT 4, 12, 23 N=35			
			3							
			4							
			5		--	SHALE, highly weathered, very low to low strength, dark grey.		D	--	
			6			Borehole BH 06 terminated at 5.7m				TC bit refusal

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BH No: BH 07
Sheet: 1 of 1
Job No: 9687

Borehole Log

Client: ESR Group
Project: Proposed Industrial Subdivision
Location: 290-308 Allington Road, Kemps Creek NSW 2178

Started: 4/10/19
Finished: 4/10/19
Borehole Size 110mm

Rig Type: Hanjin 8D
Hole Location: Refer Drawing 9687-GR-1-A
Driller: CB
Logged: MS

RL Surface:
Contractor: BG Drilling Pty Ltd
Bearing: ---
Checked: LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Groundwater Not Encountered				--	TOPSOIL/FILL: Silty Clay, low plasticity, grey, with rootlets.		M	--	TOPSOIL/FILL
					CH	CLAY, high plasticity, MC~PL, pale grey mottled red, with silt.	DS DS	M	St	RESIDUAL
			1		CI	Silty CLAY, medium plasticity, MC<PL, orange-brown mottled grey.		D	St - VSt	
			2		--	SHALE, extremely to highly weathered, very low strength, grey-brown, with clay bands.	SPT 3, 25/140mm Hammer Bounce	D	--	BEDROCK
			3		--	SHALE, highly weathered, very low to low strength, dark grey.		D	--	
			4			Borehole BH 07 terminated at 3.5m				TC bit refusal
			5							
			6							

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EXPLANATORY NOTES - DRILL & EXCAVATION LOGS

General

Information obtained from site investigations is recorded on log sheets. Soils and very low strength rock are commonly drilled using a combination of solid-flight augers with a Tungsten-Carbide (TC) bit. Descriptions of these materials presented on the "Borehole Log" are based on a combination of regular sampling and in-situ testing. Rock coring techniques commences once material is encountered that cannot be penetrated using a combination of solid-flight augers and Tungsten-carbide bit. The "Cored Borehole Log" presents data from drilling where a core barrel has been used to recover material - commonly rock.

The "Excavation - Geological Log" presents data and drawings from exposures of soil and rock resulting from excavation of pits or trenches.

The heading of the log sheets contains information on Project Identification, Hole or Test Pit Identification, Location and Elevation. The main section of the logs contains information on methods and conditions, material description and structure presented as a series of columns in relation to depth below the ground surface which is plotted on the left side of the log sheet. The scale is presented in the depth column as metres below ground level.

As far as is practicable the data contained on the log sheets is factual. Some interpretation is included in the identification of material boundaries in areas of partial sampling, the location of areas of core loss, description and classification of material, estimation of strength and identification of drilling induced fractures, and geological unit. Material description and classifications are based on Australian Standard Geotechnical Site Investigations: AS 1726 - 2017 with some modifications as defined below.

These notes contain an explanation of the terms and abbreviations commonly used on the log sheets.

Drilling

Drilling, Casing and Excavating

Drilling methods deployed are abbreviated as follows

AS	Auger Screwing
ADV	Auger Drilling with V-Bit
ADT	Auger Drilling with TC Bit
BH	Backhoe
E	Excavator
HA	Hand Auger
HQ	HQ core barrel (~63.5 mm diameter core) *
HMLC	HMLC core barrel (~63.5 mm diameter core) *
NMLC	NMLC core barrel (~51.9 mm diameter core) *
NQ	NQ core barrel (~47.6 mm diameter core) *
RR	Rock Roller
WB	Wash-bore drilling

* Core diameters are approximate and vary due to the strength of material being drilled.

Drilling Fluid/Water

The drilling fluid used is identified and loss of return to the surface estimated as a percentage. It is introduced to assist with the drill process, in particular, when core drilling. The introduction of drill fluid/water does not allow for accurate identification of water seepages.

Drilling Penetration/Drill Depth

Core lifts are identified by a line and depth with core loss per run as a percentage. Ease of penetration in non-core drilling is abbreviated as follows:

VE	Very Easy
E	Easy
F	Firm
H	Hard
VH	Very Hard

Groundwater Levels

Date of measurement is shown.

Standing water level measured in completed borehole

Level taken during or immediately after drilling

Groundwater inflow water level

Samples/Tests

Samples collected and testing undertaken are abbreviated as follows

ES	Environmental Sample
DS	Disturbed Sample
BS	Bulk Sample
U50	Undisturbed (50 mm diameter)
C	Core Sample
SPT	Standard Penetration Test
N	Result of SPT (*sample taken)
VS	Vane Shear Test
IMP	Borehole Impression Device
PBT	Plate Bearing Test
PZ	Piezometer Installation
HP	Hand Penetrometer Test
HB	Hammer Bouncing

Excavation Logs

Explanatory notes are provided at the bottom of drill log sheets. Information about the origin, geology and pedology may be entered in the "Structure and other Observations" column. The depth of the base of excavation (for the logged section) at the appropriate depth in the "Material Description" column. Refusal of excavation plant is noted should it occur. A sketch of the exposure may be added.

Material Description – Soil

Material Description - In accordance with AS 1726-2017

Classification Symbol - In accordance with the Unified Classification System (AS 1726-2017).

Abbreviation	Typical Names
GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
GP	Poorly graded gravels and gravel-sand mixtures, little or no fines, uniform gravels
GM	Silty gravels, gravel-sand-silt mixtures
GC	Clayey gravels, gravel-sand-clay mixtures.
SW	Well graded sands, gravelly sands, little or no fines.
SP	Poorly graded sands and gravelly sands; little or no fines, uniform sands.
SM	Silty sand, sand-silt mixtures.
SC	Clayey sands, sand-clay mixtures.
ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
CL, CI	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. *
MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, clastic silts.
CH	Inorganic clays of high plasticity, fat clays
OH	Organic clays of medium to high plasticity, organic silts. *
Pt	Peat and other highly organic soils. *

* Additional details may be provided in accordance with the Von Post classification system (1922).

Organic Soils - Identification using laboratory testing:

Material	Organic Content - % of dry mass
Inorganic	<2
Organic Soil	<2 ≤ 25
Peat	> 25

Organic Soils - Descriptive terms for the degree of decomposition of peat:

Term	Decomposition	Remains	Squeeze
Fibrous	Little or none	Clearly recognizable	Only water No solid
Pseudo-fibrous	Moderate	Mixture of fibrous and amorphous	Turbid water < 50% solids
Amorphous	Full	Not recognizable	Paste > 50% solids

EXPLANATORY NOTES - DRILL & EXCAVATION LOGS

Particle Characteristics– Definitions are as follows:

Fraction	Component (& subdivision)		Size (mm)
Oversize	Boulders		> 200
	Cobbles		> 63 ≤ 200
Coarse grained soils	Gravel	Coarse	> 19 ≤ 63
		Medium	> 6.7 ≤ 19
		Fine	> 2.36 ≤ 6.7
	Sand	Coarse	> 0.6 ≤ 2.36
		Medium	> 0.2 ≤ 0.6
		Fine	> 0.075 ≤ 0.21
Fine grained soils	Silt		0.002 ≤ 0.075
	Clay		< 0.002

Secondary and minor soil components

In coarse grained soils – The proportions of secondary and minor components are generally estimated from a visual and tactile assessment of the soils. Descriptions for secondary and minor soil components in coarse grained soils are as follows.

Designation of components	Percentage fines	Terminology (as applicable)	Percentage accessory coarse fraction	Terminology (as applicable)
Minor	≤ 5	Trace clay / silt	≤ 5	Trace sand / gravel
	> 5 ≤12	With clay / silt	> 5 ≤12	With sand / gravel
Secondary	> 12	Silty or clayey	> 30	Sandy or gravelly

Descriptions for secondary and minor soil components in fine grained soils are as follows.

Designation of components	Percentage coarse grained soils	Terminology (as applicable)
Minor	≤ 5	Trace sand / gravel / silt / clay
	> 5 ≤12	With sand / gravel / silt / clay
Secondary	> 30	Sandy / gravelly / silty / clayey

Plasticity Terms – Definitions for fine grained soils are as follows:

Descriptive Term	Range of Liquid Limit for silt	Range of Liquid Limit for clay
Low Plasticity	≤ 50	≤ 35
Medium Plasticity	N/A	> 35 ≤50
High Plasticity	> 50%	> 50

Particle Characteristics

Particle shape and angularity are estimated from a visual assessment of coarse-grained soil particle characteristics. Terminology used includes the following:

Particle shape – spherical, platy, elongated,

Particle angularity –angular, sub-angular, sub-rounded, rounded.

Moisture Condition – Abbreviations are as follows:

D	Dry, looks and feels dry
M	Moist, No free water on remoulding
W	Wet, free water on remoulding

Moisture content of fine-grained soils is based on judgement of the soils moisture content relative to the plastic and liquid limit as follows:

MC < PL	Moist, dry of plastic limit
MC ≈ PL	Moist, near plastic limit
MC > PL	Moist, wet of plastic limit
MC ≈ LL	Wet, near liquid limit
MC > LL	Wet of liquid limit

Consistency - of cohesive soils in accordance with AS 1726-2017, Table 11 are abbreviated as follows:

Consistency Term	Abbreviation	Indicative Undrained Shear Strength Range (kPa)
Very Soft	**VS**	< 12
Soft	**S**	12 ≤ 25
Firm	**F**	25 ≤ 50
Stiff	**St**	50 ≤ 100
Very Stiff	**VSt**	100 ≤ 200
Hard	**H**	≥ 200
Friable	**Fr**	-

Density Index (%) of granular soils is estimated or is based on SPT results. Abbreviations are as follows:

Description	Abbreviation	Relative Density	SPT N
Very Loose	VL	< 15%	0 - 4
Loose	L	15 - 35%	4 - 10
Medium Dense	MD	35 - 65%	10 - 30
Dense	D	65 - 85%	30 - 50
Very Dense	VD	> 85%	> 50

Structures - Fissuring and other defects are described in accordance with AS 1726-2017 using the terminology for rock defects

Origin - Where practicable an assessment is provided of the probable origin of the soil, e.g. fill, topsoil, alluvium, colluvium, residual soil.

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EXPLANATORY NOTES - DRILL & EXCAVATION LOGS

MATERIAL DESCRIPTION - ROCK

Material Description

Descriptions of rock for geotechnics and engineering geology in civil engineering

Identification of rock type, composition and texture based on visual features in accordance with AS 1726-2017.

Rock Naming – Where possible conventional geological names are used within the logs. Engineering properties cannot be inferred directly from the rock names in the table, but the use of a particular name provides an indicative range of characteristics to the reader. Lithological identification of rock is provided to appreciate the geology of an area, to correlate geological profiles seen in boreholes or to distinguish boulders from bedrock.

Grain Size – Grain size is done in accordance with AS1726-2017 as follows:

Coarse grained	Mainly 0.6 to 2 mm
Medium grained	0.2 – 0.6 mm
Fine grained	0.06 – 0.2 mm

Colour – Rock colour is described in the moist condition.

Texture and Fabric - Frequently used terms include:

Sedimentary Rock	Metamorphic Rock	Igneous
Bedded	Cleaved	Massive
Interbedded	Foliated	Flow banded
Laminated	Schistose	Folded
Folded	Banded	Lineated
Massive	Lineated	Porphyritic
Graded	Gneissose	Crystalline
Cross-bedded	Folded	Amorphous

Bedding and Laminated – AS 1726 – 2017 bedding and laminated rock descriptions are provided below with additional detail from BS EN ISO 14689-1 as guidance.

Description	Spacing (mm)
Very Thickly Bedded	> 2000
Thickly Bedded	> 600 ≤ 2000
Medium Bedded	> 200 ≤ 600
Thinly Bedded	> 60 ≤ 200
Very Thinly Bedded	> 20 ≤ 60
Thickly Laminated	> 6 ≤ 20
Thinly Laminated	< 6

Features, inclusions and minor components – Features, inclusions and minor components within the rock material shall be described where those features could be significant such as gas bubbles, mineral veins, carbonaceous material, salts, swelling minerals, mineral inclusions, ironstone or carbonate bands, cross-stratification or minerals the readily oxidise upon atmospheric exposure.

Moisture content – Where possible descriptions are made by the feel and appearance of the rock using one according to following terms:

Dry	Looks and feels dry.
Moist	Feels cool, darkened in colour, but no water is visible on the surface
Wet	Feels cool, darkened in colour, water film or droplets visible on the surface

The moisture content of rock cored with water may not be representative of its in-situ condition.

Durability – Descriptions of the materials durability such as tendency to develop cracks, break into smaller pieces or disintegrate upon exposure to air or in contact with water are provided where observed.

Rock Material Strength – The strength of the rock material is based on uniaxial compressive strength (UCS). The following terms are used:

Rock Strength Class	Abbreviation	UCS (MPa)	Point Load Strength Index, $I_{s\,(50)}$ (MPa)
Very Low	VL	> 0.6 ≤ 2	> 0.03 ≤ 0.1
Low	L	> 2 ≤ 6	> 0.1 ≤ 0.3
Medium	M	> 6 ≤ 20	> 0.3 ≤ 1
High	H	> 20 ≤ 60	> 1 ≤ 3
Very High	VH	> 60 ≤ 200	> 3 ≤ 10
Extremely High	EH	> 200	> 10

Strengths are estimated and where possible supported by Point Load Index Testing of representative samples. Test results are plotted on the graphical logs as follows:

D	Diametral Point Load Test
A	Axial Point Load Test

Where the estimated strength log covers more than one range it indicates the rock strength varies between the limits shown. Point Load Strength Index test results are presented as $I_{s\,(50)}$ values in MPa.

Weathering - Weathering classification assists in identification but does not imply engineering properties. Descriptions are as follows:

Term (Abbreviation)	Description
Fresh (F)	No signs of mineral decomposition or colour change.
Slightly Weathered (SW)	partly stained or discoloured. Not or little change to strength from fresh rock.
Moderately Weathered (MW)	material is completely discoloured, little or no change of strength from fresh rock.
Highly Weathered (HW)	material is completely discoloured, significant decrease in strength from fresh rock.
Extremely Weathered (EW)	Material has soil properties. Mass structure, material texture and fabric of original rock are still visible.
Residual Soil (RS)	Material has soil properties. Mass structure and material texture and fabric of original rock not visible, but the soil has not been significantly transported.

Alteration – Physical and chemical changes of the rock material due to geological processes by fluids at depth at pressures and temperatures above atmospheric conditions. Unlike weathering, alteration shows no relationship to topography and may occur at any depth. When altered materials are recognized, the following terms are used:

Term		Abbreviation		Definition
Extremely Altered		XA		Material has soil properties. Structure, texture and fabric of original rock are still visible. The rock name is replaced with the name of the parent material, e.g. Extremely Altered basalt. Soil descriptive terms are used.
Highly Altered	Distinctly altered	HA	DA	The whole of the rock material is discoloured. Rock strength is changed by alteration. Some primary minerals are altered to clay minerals. Porosity may be higher or lower due to loss of minerals or precipitation of secondary minerals in pores.
Moderately Altered	Distinctly altered	MA	DA	The whole of the rock material is discoloured Little or no change of strength from fresh rock. The term 'Distinctly Altered' is used where it is not practicable to distinguish between 'Highly Altered' and 'Moderately Altered'. Distinctly Altered is defined as follows: The rock may be highly discoloured; Porosity may be higher due to mineral loss; or may be lower due to precipitation of secondary minerals in pores; and Some change of rock strength.
Slightly Altered		SA		Rock is slightly discoloured Little or no change of strength from fresh rock.

Alteration is only described in the context of the project where it has relevance to the civil and structural design.

Defect Descriptions

General and Detailed Descriptions – Defect descriptions are provided to suit project requirements. Generalized descriptions are used for some projects where it is unnecessary to describe each individual defect in a rock mass, or where multiple similar defects are present which are too numerous to log individually. The part of the rock mass to which this applies is delineated.

Detailed descriptions are given of defects judged to be particularly significant in the context of the project. For example, crushed seams in an apparently unstable slope. As a minimum, general descriptions outlining the number of defect sets within the rock mass and their broad characteristics are provided where it is possible to do so.

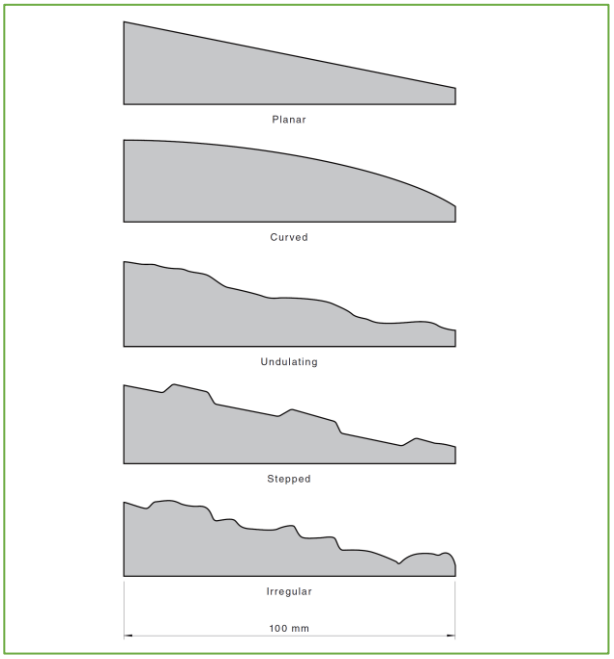
Defect Type – Defect abbreviations are as follows:

BP	Bedding Parting	FL	Foliation	SP	Shear Plane
CL	Cleavage	FZ	Fracture Zone	SZ	Shear Zone
CS	Crushed Seam	HB	Handling break	VN	Vein
DB	Drilling break	JT	Joint		
DL	Drill Lift	SM	Seam		

EXPLANATORY NOTES - DRILL & EXCAVATION LOGS

Defect Orientation – The dip and dip direction are recorded as a two-digit and three-digit number separated by a slash, e.g. 50/240 only when orientated core are collected and there is not core loss that could obscure core orientation. If alternative measurements are made, such as dip and strike or dip direction relative to magnetic north this shall be documented.

Surface Shape –At the medium scale of observation, description of the roughness of the surface shall be enhanced by description of the shape of the defect surface using the following terms, as illustrated below:



Defect Coatings and Seam Composition – Coatings are described using the following terms:

(a) *Clean* No visible coating.
(b) *Stained* No visible coating but surfaces are discoloured.
(c) *Veneer* A visible coating of soil or mineral, too thin to measure; may be patchy.
(d) *Coating* A visible coating up to 1 mm thick. Soil in-fill greater than 1 mm shall be described using defect terms (e.g. infilled seam). Defects greater than 1 mm aperture containing rock material great described as a vein.

Defect Spacing, Length, Openness and Thickness –described directly in millimetres and metres. In general descriptions, half order of magnitude categories are used, e.g. joint spacing typically 100 mm to 300 mm, sheared zones 1 m to 3 m thick.

Depending on project requirements and the scale of observation, spacing may be described as the mean spacing within a set of defects, or as the spacing between all defects within the rock mass. Where spacing is measured within a specific set of defects, measurements shall be made perpendicular to the defect set.

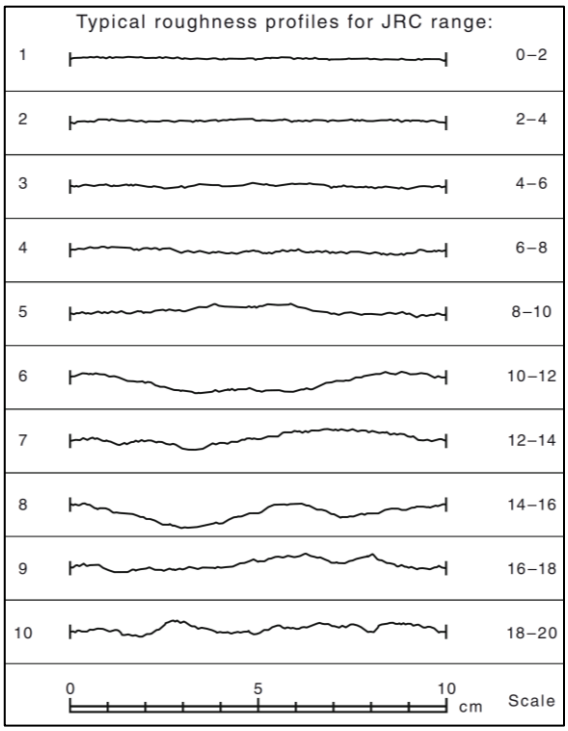
Defect spacing and length (sometimes called persistence), shall be described directly inmillimetres and metres.

Stratigraphic Unit - Geological maps related to the project are used for the designation of lithological formation name and, where possible geological unit name, e.g. Bringelly Shale, Potts Hill Sandstone Member.

Defect Roughness and Shape – Defect surface roughness is described as follows:

Very rough	Many large surface irregularities with amplitude generally more than 1 mm.
Rough	Many small surface irregularities with amplitude generally less than 1 mm.
Smooth	Smooth to touch. Few or no surface irregularities.
Polished	Shiny smooth surface
Slickensided	Grooved or striated surface, usually polished.

Where applicable Joint Roughness Range (JRC) is provided as follows:



Joint roughness profiles and corresponding JRC range based on Barton, N and Choubey, V. The Shear Strength of Rock Joints in Theory and Practice. *Rock Mechanics.* Vol. 10 (1977), pp. 1–54.

Where possible the mineralogy of the coating is identified.

Defect Infilling - abbreviated as follows:

CA	Calcite	KT	Chlorite
CN	Clean	MS	Secondary Mineral
Cy	Clay	MU	Unidentified Mineral
CS	Crushed Seam	Qz	Quartz
Fe	Iron Oxide	X	Carbonaceous

PARAMETERS RELATED TO CORE DRILLING

Total Core Recovery – T

Defect Spacing or Fracture Index – T

Rock Quality Designation – Y

Core Loss – Core loss occurs when material is lost during the drilling process It is shown at the bottom of the run unless otherwise indicated where core loss is known.

Dynamic Cone Penetrometer (DCP) Test Report

Client:	ESR Group	Report Number:	9687-GR-1-1
Project Name:	Proposed Industrial Subdivision	Project Number:	9687
Project Location:	290-308 Aldington Road, Kemps Creek NSW 2178	Date Tested:	4/10/2019
Test Method:	AS 1289.6.3.2		

Test Number	DCP-2	DCP-3	DCP-4	DCP-5	DCP-6	DCP-7
Test Locations	BH2	BH3	BH4	BH5	BH6	BH7
Surface Material	Topsoil	Topsoil	Fill	Topsoil	Topsoil	Topsoil
Surface R.L (m)	--	--	--	--	--	--
Depth (metres)						
0.00 – 0.15	4	5	>25/100mm	4	4	6
0.15 – 0.30	3	5	Solid Refusal	6	4	5
0.30 – 0.45	3	3		3	3	4
0.45 – 0.60	3	3		4	3	5
0.60 – 0.75	4	4		5	4	6
0.75 – 0.90	6	6		6	7	20
0.90 – 1.05	7	7		17	14	>25/80mm
1.05 – 1.20	10	11		>25/130mm	>25/100mm	
1.20 – 1.35	10	17				
1.35 – 1.50	9	>25/140mm				
1.50 – 1.65	8					
1.65 – 1.80						
1.80 – 1.95						
1.95 – 2.10						

Notes:

1. This penetrometer test report is intended to be read in conjunction with the geotechnical report by Alliance Geotechnical (ref: 9687-GR-1-1).

APPENDIX D – Laboratory Test Certificates

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Web: allgeo.com.au
Post: PO Box 275, Seven Hills NSW 1730
Lab: 10 Welder Road, Seven Hills NSW 2147

Material Test Report

Report No: MAT:19-1226-S05
Date of Issue: 22/10/2019
Issue Number: 1

Client: Alliance Geotechnical Pty Ltd
10 Welder Road, Seven Hills NSW 2147
Project: DD Investigations
Project No: P191275
Location: 290-308 Aldington Road, Kemps Creek NSW

NATA Accreditation: 15100

Approved Signatory: Paul Haslam

Accredited for compliance with ISO/IEC 17025-Testing

Sample Details

Sample ID	19-1226-S05
Date Sampled	4/10/2019
Sampling Method	AS1289 1.2.1 6.5.3 - Power auger drilling
Sample Description	Refer to Borehole Log attached
Sample Location	BH 3 (0.5m-0.9m)

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	18.7	
Date Tested		8/10/2019	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	12.5	
Mould Length (mm)		250	
Crumbling		No	
Curling		Yes	
Cracking		No	
Liquid Limit (%)	AS 1289.3.1.1	52	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	19	
Plasticity Index (%)	AS 1289.3.3.1	33	
Date Tested		21/10/2019	

Comments

N/A

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Post: PO Box 275, Seven Hills NSW 1730
Lab: 10 Welder Road, Seven Hills NSW 2147

Material Test Report

Report No: MAT:19-1226-S06
Date of Issue: 22/10/2019
Issue Number: 1

Client: Alliance Geotechnical Pty Ltd
10 Welder Road, Seven Hills NSW 2147
Project: DD Investigations
Project No: P191275
Location: 290-308 Aldington Road, Kemps Creek NSW

NATA Accreditation: 15100

Approved Signatory: Paul Haslam

Accredited for compliance with ISO/IEC 17025-Testing

Sample Details

Sample ID	19-1226-S06
Date Sampled	4/10/2019
Sampling Method	AS1289 1.2.1 6.5.3 - Power auger drilling
Sample Description	Refer to Borehole Log attached
Sample Location	BH 5 (0.5m-1.0m)

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	14.5	
Date Tested		8/10/2019	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	10.5	
Mould Length (mm)		250	
Crumbling		No	
Curling		Yes	
Cracking		No	
Liquid Limit (%)	AS 1289.3.1.1	56	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	22	
Plasticity Index (%)	AS 1289.3.3.1	34	
Date Tested		18/10/2019	

Comments

N/A

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Lab: 10 Welder Road, Seven Hills NSW 2147

Material Test Report

Report No: MAT:19-1226-S07
Date of Issue: 22/10/2019
Issue Number: 1

Client: Alliance Geotechnical Pty Ltd
10 Welder Road, Seven Hills NSW 2147
Project: DD Investigations
Project No: P191275
Location: 290-308 Aldington Road, Kemps Creek NSW

NATA Accreditation: 15100

Approved Signatory: Paul Haslam

Accredited for compliance with ISO/IEC 17025-Testing

Sample Details

Sample ID	19-1226-S07
Date Sampled	4/10/2019
Sampling Method	AS1289 1.2.1 6.5.3 - Power auger drilling
Sample Description	Refer to Borehole Log attached
Sample Location	BH 6 (0.5m-0.6m)

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	22.1	
Date Tested		8/10/2019	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	14.0	
Mould Length (mm)		250	
Crumbling		No	
Curling		Yes	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	61	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	24	
Plasticity Index (%)	AS 1289.3.3.1	37	
Date Tested		18/10/2019	

Comments

N/A

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Lab: 10 Welder Road, Seven Hills NSW 2147

Material Test Report

Report No: MAT:19-1226-S08
Date of Issue: 22/10/2019
Issue Number: 1

Client: Alliance Geotechnical Pty Ltd
10 Welder Road, Seven Hills NSW 2147
Project: DD Investigations
Project No: P191275
Location: 290-308 Aldington Road, Kemps Creek NSW

NATA Accreditation: 15100

Approved Signatory: Paul Haslam

Accredited for compliance with ISO/IEC 17025-Testing

Sample Details

Sample ID	19-1226-S08
Date Sampled	4/10/2019
Sampling Method	AS1289 1.2.1 6.5.3 - Power auger drilling
Sample Description	Refer to Borehole Log attached
Sample Location	BH 7 0.5m-0.8m)

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	17.4	
Date Tested		8/10/2019	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	7.5	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	50	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	20	
Plasticity Index (%)	AS 1289.3.3.1	30	
Date Tested		18/10/2019	

Comments

N/A

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Lab: 10 Welder Road, Seven Hills NSW 2147

California Bearing Ratio Test Report

Report No: CBR:19-1226-S01
Date of Issue: 22/10/2019
Issue Number: 1

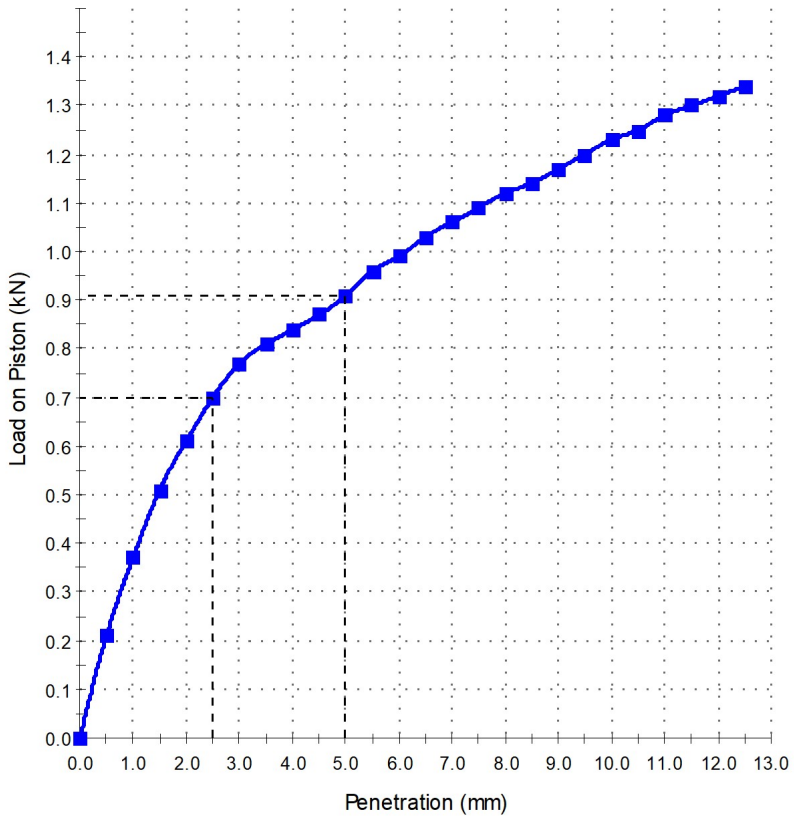
Client: Alliance Geotechnical Pty Ltd
10 Welder Road, Seven Hills NSW 2147
Project: DD Investigations
Project No: P191275
Location: 290-308 Aldington Road, Kemps Creek NSW

NATA Accreditation: 15100
Approved Signatory: Paul Haslam
Accredited for compliance with ISO/IEC 17025-Testing

Sample Details

Sample Location: BH 2 (0.3m-0.7m)
Sample Description: Refer to Borehole Log attached
Date Sampled: 4/10/2019
Date Tested: 21/10/2019

Load vs Penetration



Test Results

	AS 1289.6.1.1
CBR at 2.5mm (%):	5
Maximun Dry Density(t/m³):	1.71
Optimum Moisture Content(%):	18.6
Dry Density before Soaking (t/m³):	1.70
Density Ratio before Soaking (%):	99.5
Moisture Content before Soaking (%):	19.2
Moisture Ratio before Soaking (%):	103.5
Dry Density after Soaking (t/m³):	1.69
Density Ratio after Soaking (%):	99.0
Swell (%):	1.0
Moisture Content of Top 30mm (%):	21.7
Moisture Content of Remaining Depth (%):	20.3
Compaction Hammer Used:	Standard AS 1289.5.1.1
Surcharge Mass (kg):	4.50
Period of Soaking (Days):	4
Retained on 19 mm Sieve (%):	0
CBR Moisture Content Method:	AS 1289.2.1.1
Sample Curing Time (h):	147
Plasticity Determination Method:	Visual/Tactile
——— AS 1289.2.1.1 ———	
In Situ (Field) Moisture Content (%):	15.7

Comments

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California Bearing Ratio Test Report

Report No: CBR:19-1226-S02
Date of Issue: 22/10/2019
Issue Number: 1

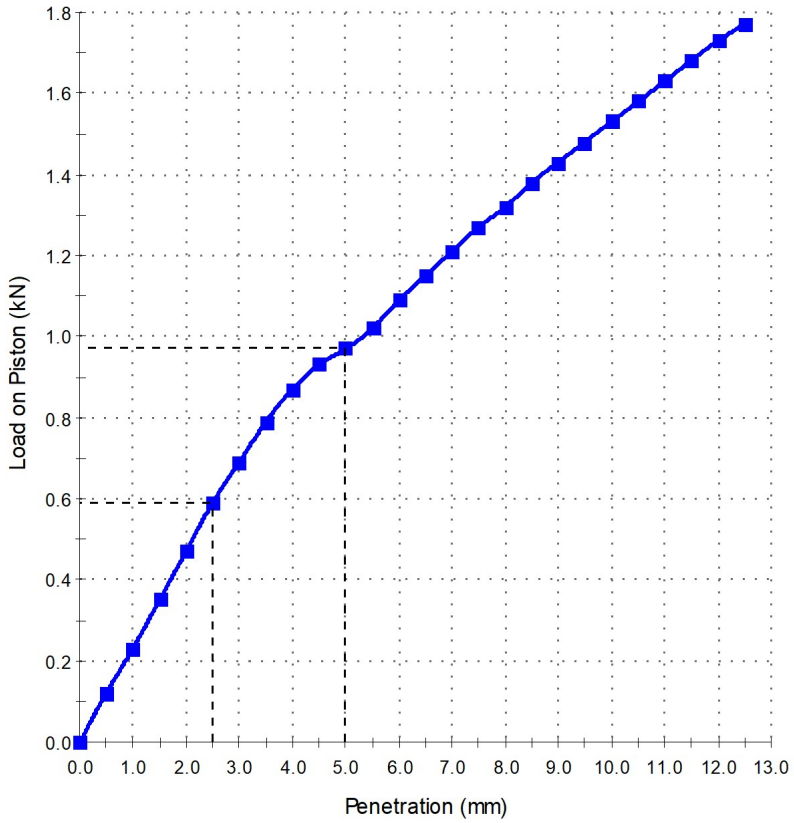
Client: Alliance Geotechnical Pty Ltd
10 Welder Road, Seven Hills NSW 2147
Project: DD Investigations
Project No: P191275
Location: 290-308 Aldington Road, Kemps Creek NSW

NATA Accreditation: 15100
Approved Signatory: Paul Haslam
Accredited for compliance with ISO/IEC 17025-Testing

Sample Details

Sample Location: BH 4 (0.3m-0.7m)
Sample Description: Refer to Borehole Log
Date Sampled: 4/10/2019
Date Tested: 21/10/2019

Load vs Penetration



Test Results

	AS 1289.6.1.1
CBR at 5.0mm (%):	5.0
Maximun Dry Density(t/m³):	1.83
Optimum Moisture Content(%):	15.8
Dry Density before Soaking (t/m³):	1.82
Density Ratio before Soaking (%):	99.5
Moisture Content before Soaking (%):	16.0
Moisture Ratio before Soaking (%):	101.5
Dry Density after Soaking (t/m³):	1.79
Density Ratio after Soaking (%):	97.5
Swell (%):	2.0
Moisture Content of Top 30mm (%):	19.9
Moisture Content of Remaining Depth (%):	17.1
Compaction Hammer Used:	Standard AS 1289.5.1.1
Surcharge Mass (kg):	4.50
Period of Soaking (Days):	4
Retained on 19 mm Sieve (%):	0
CBR Moisture Content Method:	AS 1289.2.1.1
Sample Curing Time (h):	146
Plasticity Determination Method:	Visual/Tactile
——— AS 1289.2.1.1 ———	
In Situ (Field) Moisture Content (%):	12.2

Comments

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California Bearing Ratio Test Report

Report No: CBR:19-1226-S03
Date of Issue: 22/10/2019
Issue Number: 1

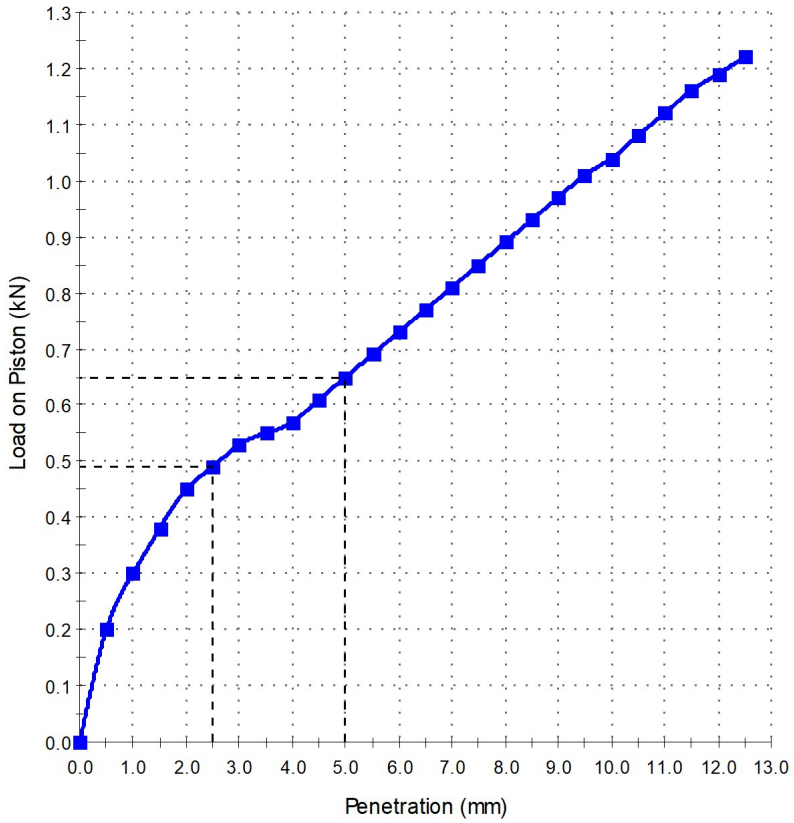
Client: Alliance Geotechnical Pty Ltd
10 Welder Road, Seven Hills NSW 2147
Project: DD Investigations
Project No: P191275
Location: 290-308 Aldington Road, Kemps Creek NSW

NATA Accreditation: 15100
Approved Signatory: Paul Haslam
Accredited for compliance with ISO/IEC 17025-Testing

Sample Details

Sample Location: BH 5 (1.0m-1.5m)
Sample Description: Refer to Borehole Log attached
Date Sampled: 4/10/2019
Date Tested: 21/10/2019

Load vs Penetration



Test Results

	AS 1289.6.1.1
CBR at 2.5mm (%):	3.5
Maximun Dry Density(t/m³):	1.58
Optimum Moisture Content(%):	23.4
Dry Density before Soaking (t/m³):	1.58
Density Ratio before Soaking (%):	100.0
Moisture Content before Soaking (%):	23.6
Moisture Ratio before Soaking (%):	100.5
Dry Density after Soaking (t/m³):	1.54
Density Ratio after Soaking (%):	97.5
Swell (%):	2.5
Moisture Content of Top 30mm (%):	29.2
Moisture Content of Remaining Depth (%):	24.6
Compaction Hammer Used:	Standard
	AS 1289.5.1.1
Surcharge Mass (kg):	4.50
Period of Soaking (Days):	4
Retained on 19 mm Sieve (%):	0
CBR Moisture Content Method:	AS 1289.2.1.1
Sample Curing Time (h):	148
Plasticity Determination Method:	Visual/Tactile
——— AS 1289.2.1.1 ———	
In Situ (Field) Moisture Content (%):	21.9

Comments

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California Bearing Ratio Test Report

Report No: CBR:19-1226-S04
Date of Issue: 22/10/2019
Issue Number: 1

Client: Alliance Geotechnical Pty Ltd
10 Welder Road, Seven Hills NSW 2147
Project: DD Investigations
Project No: P191275
Location: 290-308 Aldington Road, Kemps Creek NSW

NATA Accreditation: 15100

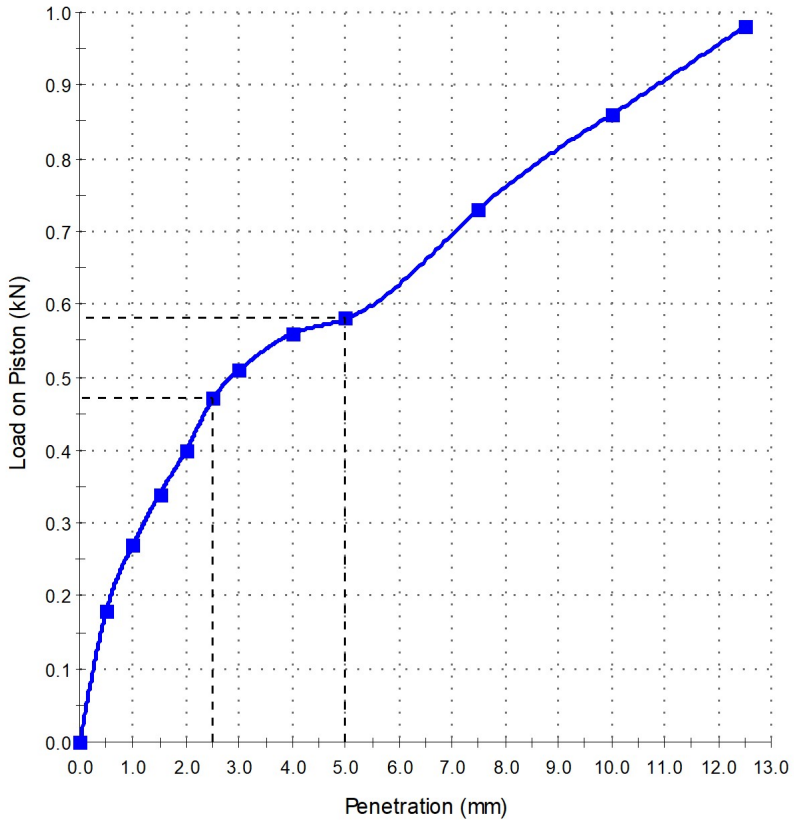
Approved Signatory: Paul Haslam

Accredited for compliance with ISO/IEC 17025-Testing

Sample Details

Sample Location: BH 6 (0.3m-0.7m)
Date Sampled: 4/10/2019
Date Tested: 21/10/2019

Load vs Penetration



Test Results

	AS 1289.6.1.1
CBR at 2.5mm (%):	3.5
Maximun Dry Density(t/m³):	1.63
Optimum Moisture Content(%):	21.5
Dry Density before Soaking (t/m³):	1.63
Density Ratio before Soaking (%):	100.0
Moisture Content before Soaking (%):	21.6
Moisture Ratio before Soaking (%):	100.5
Dry Density after Soaking (t/m³):	1.60
Density Ratio after Soaking (%):	97.5
Swell (%):	2.0
Moisture Content of Top 30mm (%):	27.7
Moisture Content of Remaining Depth (%):	23.3
Compaction Hammer Used:	Standard AS 1289.5.1.1
Surcharge Mass (kg):	4.50
Period of Soaking (Days):	4
Retained on 19 mm Sieve (%):	0
CBR Moisture Content Method:	AS 1289.2.1.1
Sample Curing Time (h):	148
Plasticity Determination Method:	Visual/Tactile
——— AS 1289.2.1.1 ———	
In Situ (Field) Moisture Content (%):	21.9

Comments