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Geotechnical Investigation and Hydrogeological Report

for

Proposed Legacy Village Redevelopment Project

at

51 Masons Parade, Point Frederick, NSW 2250

Prepared for

Brisbane Waters Legacy (BWL),

C/o Grindley Construction

14 September 2021

Report No: 10827-GR-1-1 Rev B

We give you the right information to make the right decisions

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DOCUMENT CONTROL

Revision	Date	Description	Author	Reviewer
0	9 July 2020	Issued to the client	SM	TM
A	19 March 2021	Revised based on removing the basement level	SM	MAG
B	14 September 2021	Revised based on updated architectural drawings	SM	MAG

	Author	Reviewer
Signature		
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APPENDICES

1. INTRODUCTION

This revised report presents the findings of a geotechnical investigation undertaken by Alliance Geotechnical Pty Ltd (Alliance) for Brisbane Waters Legacy (BWL) (the Client) for a proposed multi-storey residential development at 51 Masons Parade, Point Frederick, NSW 2250 (the site). The investigation was undertaken in accordance with the scope of works requested by Grindley Construction on behalf of the client, outlined in Alliance's proposal, Estimate No. 3470, dated 21st April 2020. The findings of the geotechnical investigation were initially presented in July 2020 and the recommendations were provided for a proposed five-storey building over a single level of basement. Following a complicated hydrogeological condition, the client removed the basement level and this revised report is prepared to update the geotechnical recommendations and comments based on the latest architectural drawings.

It is understood that the proposed development comprises the demolition of some of the existing buildings on the site to enable the construction of the proposed new buildings. The new buildings comprise a seven-storey building at the Masons Parade frontage.

This geotechnical investigation was requested to provide geotechnical design parameters for the foundation and retaining structure design and provide recommendations regarding:

- Geotechnical subsurface conditions and groundwater;
- Suitable footings system and competent foundation depth;
- Geotechnical design parameters for shallow and deep foundations;
- Soil aggressivity to concrete and steel;
- Site sub-soil class in accordance with AS 1170.4;
- Design parameters for piled footings;
- Comment on the suitability of existing material to either be reused on site or exported from the site.

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

- Review of the geological maps and the provided architectural drawings;
- Site walkover inspection by a geotechnical engineer;
- Three boreholes to a maximum depth of 26.4m below the existing surface level (ESL);
- Two boreholes to 6m depth;
- Installation of four monitoring wells;
- Undertaking rising heads test in three monitoring wells;
- Laboratory tests on the recovered soil and rock samples.

1.1. Proposed Development

For the preparation of this report, Alliance has referred to the following documents listed below:

- A set of preliminary Architectural drawings, prepared by Integrated Design Group, dated September 2021.
- Site Survey Plan, Ref. 16195, prepared by Bannister & Hunter, dated 21st July 2020.

Based on the provided information, it is understood that construction activities associated with the proposed development include:

- Demolition of the existing double buildings located within the site area (shown in Figure 1);
- Construction of a seven-storey residential building at the western side of the site, and carparks;
- Garbage room and maintenance room at the rear side;
- The ground floor is proposed to be constructed at RL 2.78m AHD. Therefore, the site levels should be raised up between 0.5m and 1m above the existing ground surface.

2. SITE DESCRIPTION AND REGIONAL GEOLOGY

2.1. Site Location and Description

The site is located at the northern half of Brisbane Waters (NSW) Legacy Village (located at 51 Masons Parade), is within a residential area of Point Fredrick. The site area is approximately 5200 m^2 (52m x 100m). It is located approximately 100m east of Brisbane Waters.

The site location in relation to the surrounding features is shown in Figure 1.

Figure 1- General Site Location

At the time of this geotechnical investigation, the site was occupied by double-storey residential buildings (which operate under the NSW Retirement Village Act) and car park.

The site is bounded by Masons Parade to the west, a creek to the north and residential developments to the east and west. A multi-storey development over a single level of basement is under construction at the northern side of the site at No. 65 Masons Parade. At the time of this investigation, dewatering pumps were still running to drawdown the groundwater level in the excavation.

The provided survey plan indicates that the site is relatively flat with an approximate gradient of 1 degree to the northwest and ranges in elevations from RL 2.3m (AHD) at the eastern side to RL 1.5m (AHD) at the northwestern corner.

2.2. Regional Geology

The 1:100,000 scale Geological Map (Gosford – Lake Macquarie, Sheet 9131, part sheet 9231) indicates that the site is underlain by Quaternary Deposits (Qa) and underlain by the Gosford Subgroup Terrigal Formation (Rnt). The alluvial deposits are described as *gravel and sand.* The Terrigal Formation (Rnt) is described as *interbedded laminate, shale and fine- to coarse-grained quartz- to quartz-lithic sandstone; minor red claystone.*

The investigation confirmed that the site is underlain by alluvial soils with sandstone bedrock.

3. GEOTECHNICAL INVESTIGATION

3.1. Methods

This geotechnical site investigation was carried out over four days between 3rd and 12th June 2020. Selected site photos taken during the fieldwork are presented in Appendix A.

The investigation comprised the initial scanning of underground utilities and setting out test locations, followed by:

- The drilling of three boreholes (BH1 to BH3) to a maximum depth of 26.3m;
- The drilling of two boreholes (BH4 & BH5) to a maximum depth of 6m;
- The drilling of additional 3No boreholes to a 3.5m depth for the installation of monitoring wells (MW1 to MW3) and also installation of a well in BH5 referred to as MW4.

The boreholes were drilled using a drilling rig operated by Alliance's nominated accredited drilling subcontractor and were advanced through soil profile using wash boring techniques with casing advance. A combination of wash boring and core drilling with an NMLC core barrel was used to advance the boreholes. Standard Penetration Tests (SPTs) have been undertaken in 1.5m vertical intervals to assess the soil consistency/density in the drilled boreholes. Perth Sand Penetrometer (PSP) tests have been undertaken at three locations to assess near surfaces soil density at within the proposed single-storey building footprint.

The wells' construction details are illustrated on the attached borehole logs. A screen was installed in the bottom 3m and the remainder was a solid pipe with sand backfill. Data loggers were installed in the monitoring wells to monitor the groundwater fluctuations from 3rd June to 11th June 2020. The

rising head test has been undertaken in three of the monitoring wells (MW1 to MW3) on 11th June 2020.

The soil/rock profile have been logged by Alliance's geotechnical engineer. Soil and rock samples were recovered and transported to Alliance's NATA accredited materials testing laboratory for further testing and storage.

The approximate locations of the boreholes (BH1 to BH5) and monitoring well (MW1 to MW4) are shown on the Borehole Location Plan (Drawing 10827-GR-1-A) presented in Appendix B.

The borehole logs and core photographs are attached in Appendix C. These logs should be read in conjunction with the attached Explanatory Notes, which explain the terms, abbreviations and symbols used, together with the interpretation and limitation of the logging procedure.

Levels provided in this report and the borehole logs are estimated based on the site survey plan.

3.2. Results

Reference to the individual borehole logs attached in Appendix C should be made for a full description of the subsurface conditions encountered at each borehole location. The summarised descriptions of the encountered subsurface geotechnical profile (soil and rock) are provided in Table 1 and Table 2.

Table 1 - Summary of Subsurface Profile (Soil & Rock)

Borehole	BH1	BH2	BH3	BH4	BH5/MW4
Surface Level (m) *	RL 1.25	RL 1.8	RL 2.1	RL 2.0	RL 2.0
Geotechnical Units	**Depth below the ground surface (m)**				
Pavement	0.0 – 0.05	-	-	-	-
Fill: Sandy Gravel/ Silty sand, appear poorly to moderately compacted	0.05 – 1.0	0.0 – 2.0	0.0 – 2.0	0.0 – 0.4	0.0 – 0.2
Quaternary Deposits: Clayey sand/sand, loose to medium dense	-	-	-	0.4 – 2.0	0.0 – 2.0
Quaternary Deposits: Clayey sand/sand, very loose	0.1 – 6.0	0.2 - 5.5	2.0 – 5.5	0.4 – 6.0	0.2 – 6.0
Quaternary Deposits: Silty clay, very soft to firm	6.0 – 9.0	5.5 – 16.0	5.5 – 15.0	-	-
Quaternary Deposits: Silty clay, stiff to very stiff	9.0 – 13.0	16.0 – 21.3	15.0 – 21.75	-	-
Bedrock: Sandstone, medium strength, slightly weathered.	13.0 – 16.0 (a) (RL -11.75 m)**	21.3 – 21.8 (RL -19.5 m)	-	-	-
Bedrock: Sandstone, high strength, slightly weathered/fresh	16.0 – 17.9 (RL -14.75 m)	21.8 – 25.4 (RL -20 m)	21.75 – 26.35 (RL -19.65 m)	-	-
Termination depth	17.9 (RL -16.65 m)	25.4 (RL -23.6 m)	26.35 (RL -24.25 m)	6.0 (RL -4 m)	6.0 (RL -4 m)

(a) Including a clayey band with a thickness of 630mm and medium strength sandstone with fracture spacing less than 100mm.

* The levels are estimated based on the site survey plan and the site's condition at the time of this investigation.

** The reduced level at the top of the layer.

Table 2 - Summary of Subsurface Profile in Monitoring Wells

Borehole	MW1	MW2	MW3
Surface Level (m) *	RL 1.2	RL 1.8	RL 2.0
Geotechnical Units	**Depth below the ground surface (m)**		
Fill: Sandy Gravel/ Silty sand, appear poorly to moderately compacted	0.0 – 0.7	0.0 – 2.0	0.0 – 2.0
Quaternary Deposits: Clayey sand, very loose	0.7 – 3.5	2.0 – 3.5	2.0 – 3.5
Termination depth	3.5 (RL -2.3 m)	3.5 (RL -1.7 m)	3.5 (RL -1.5 m)
* The reduced level at the top of the layer.			

The stratigraphy of the site comprises 0.4m to 2m of inferred poorly to moderately compacted sandy gravel/ silty sand fill overlying alluvial soils. The alluvial soils comprised loose to medium dense clayey sand in the upper 2m, very loose clayey sand and sand to an approximate depth of 6m, overlying very soft to firm silty clay extending to a 9m depth in BH1 and 16m in BH2. A layer of stiff to very stiff silty clay was encountered below the very soft to firm silty clay which extends to the depth of bedrock.

The top of the sandstone bedrock was encountered at a depth of 13m (RL -11.7m) in BH1 and dipped to a depth of 23.7m (RL -19.6m) in BH3. The upper 2.5m of the encountered bedrock in BH1 was slightly weathered medium strength sandstone but included a band of clay with a thickness of 630mm, very low strength sandstone and fractures with less than 100mm spacing. Below a depth of 16m in BH1, the sandstone was predominantly slightly weathered and high strength. In BH2 and BH3 the bedrock was predominantly high strength.

Bedrock defects and seams are recorded in the attached logs. There were clayey seams with a thickness of 10mm to 20mm within medium to high strength sandstone. The majority of the joints have dip at an angle of 5 to 10 degrees with a maximum angle of 70 degrees in BH3.

3.3. Groundwater and Rising Head Test Results

Groundwater was encountered during augering in all of the drilled boreholes at the depths provided in Table 3. Data loggers were installed in the monitoring wells to record the groundwater level over 9 days (from 3rd to 11th of June). The recorded groundwater level in the monitoring wells prior to conducting the rising head tests on 11th June is presented in Table 3. It should be noted that groundwater levels may fluctuate due to climatic and seasonal variations.

Table 3- Groundwater Water Levels (m)

Borehole/ Well	Borehole Elevation RL (m)	Well solid Depth (m)	Well Screen Depth (m)	Groundwater Depth (m)		
				Site investigation	Highest groundwater level during monitoring	11th June 2020
BH1	1.25	N/A	N/A	0.7 (RL 0.55m)	N/A	N/A
BH2	1.8	N/A	N/A	2.0 (RL -0.2m)	N/A	N/A
BH3	2.1	N/A	N/A	2.3 (RL -0.2m)	N/A	N/A
BH4	2	N/A	N/A	2.3 (RL -0.3m)	N/A	N/A
BH5/MW4	2	0.0 – 0.7	0.7 – 3.2	2.3 (RL -0.3m)	N/A	2.3 (RL -0.3m)
MW1	1.2	0.0 – 0.5	0.5 - 3.5	0.7 (RL 0.5m)	0.3 (RL 0.9m)	0.4 (RL 0.8m)
MW2	1.8	0.0 – 1.0	1.0- 3.5	2.3 (RL -0.5m)	2.0m (RL -0.2m)	2.1 (RL -0.3m)
MW3	2	0.0 – 1.0	1.0- 3.5	2.3 (RL -0.3m)	2.1 (RL -0.2m)	2.4 (RL -0.4m)

The groundwater level changes in three of the monitoring wells (MW 1 to MW3) are shown in Figure 2. The groundwater in MW1 is at a shallower depth compared to the other wells.

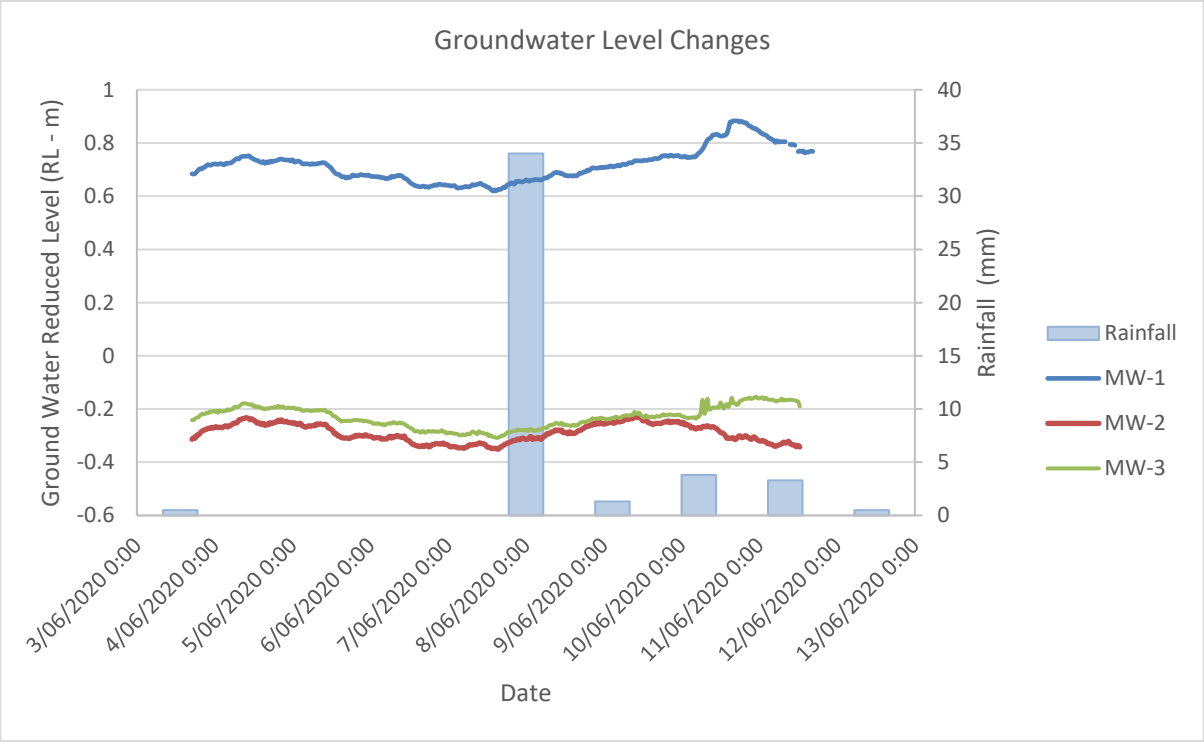

Figure 2 - Groundwater Level Changes in the Monitoring Wells

The well construction details are illustrated on the attached borehole logs. Rising head tests were undertaken in three of the monitoring wells (MW1 to MW3). The test comprised the pumping out all of the water in the monitoring well and recording the groundwater discharge rate by the installation

of data loggers in the wells. Data logger installation was not possible in MW1 since groundwater pumping was not possible due to the groundwater immediately recovering.

The tests results are presented in Appendix D. The soil permeability values have been calculated using the rising head test results in accordance with the Hvorslev (1951) method as provided in Table 4.

Table 4- The Groundwater Water Levels (m) and Rising Head Test Result

Monitoring Well	Test duration (min)	Discharge rate measured in the monitoring wells (L/sec/m²)	Calculated Hydraulic Conductivity (m/day)
MW1	The test was not conducted due to high recovery discharge. Pumping out the water was not possible.		
MW2	210	2.8E-4	0.7
MW3	230	6E-5	0.002

Given the pumps installed to drawdown the groundwater level in the basement excavation of No. 65 Masons Parade, the groundwater data collected in the wells are likely, not representative of the usual long-term conditions and it is advisable to undertake further groundwater monitoring following cessation of the adjacent site's dewatering activities.

4. LABORATORY TESTING

Laboratory tests were carried out on selected soil and rock samples collected during the drilling of the boreholes including:

- Point Load Strength Index (Is_{50}) tests;
- Three CBR tests;
- Four Soil Aggressivity tests.

4.1. Point Load Strength Index (Is_{50}) Test

The Point Load Strength Index (Is_{50}) tests were undertaken on rock core samples obtained from the boreholes and are recorded on the core log sheets presented in Appendix C. The test was carried out in Alliance's NATA-certified soil and rock laboratory.

4.2. California Bearing Ratio (CBR) Test

CBR testing was carried out on three bulk soil samples collected from the locations of MW2, MW3 and MW4, which are close to the proposed pavement area. The CBR tests were conducted in a NATA-certified soils laboratory in accordance with AS 1289 -2006 test methods on the soil samples which have been soaked for four days. The results of the laboratory are summarised in Table 5 and the test certificates are presented in Appendix D.

Table 5 - Summary of CBR Testing

Location	Depth (m)	Material Type	OMC (%)	MDD (t/m^3)	CBR (%)
MW2	**1.0 – 2.0**	**Sand**	**12.5**	**1.92**	**9**
MW3	**1.0 – 2.0**	**Sand**	**9.5**	**2.02**	**12**
MW4	**1.0 – 2.0**	**Clayey Sand**	**10.5**	**1.98**	**20**

Legend:
MDD: Maximum Dry Density **OMC: Optimum Moisture Content** **CBR: California Bearing Ratio**

4.3. Soil Aggressivity Tests

Soil aggressivity testing was performed on selected soil samples to the design of durable concrete and steel materials in contact with the site soils. Table 6 presents the results of the soil aggressivity tests.

Table 6 - Aggressivity Test Results

Test	Unit	BH1 2m Sand	BH1 7m Clay	BH3 2m Sand	BH3 3m Sand
Chloride	mg/kg	23	23	350	260
pH	--	4.5	4.2	6.7	7.6
Sulfate (SO_4)	mg/kg (ppm)	120	140	160	21
Conductivity	uS/cm	94	120	330	240
Resistivity	Ohm.cm	53000	41000	15000	21000
Moisture	%	18	19	24	27
Results and Assessment *	In relation to Concrete	Moderate	Moderate	Mild	
	In relation to Steel	Mild	Non-aggressive		

** Assessed in accordance with AS 2159 – 2009, Table 6.4.2 (C) & Table 6.5.2 (C)*

5. COMMENTS AND RECOMMENDATIONS

5.1. Groundwater Control Recommendations

Groundwater was measured at a depth of 0.3m (RL 0.9m AHD) in MW1 and 2.1m (RL -0.3m AHD) in the rest of the wells (MW2 to MW4). The groundwater level may fluctuate following the seasonal rainfall and the tides. Given the average maximum daily tide level is RL 0.9m and the average minimum tide level is RL 0.1m, it is recommended to use the maximum mean tide level of RL 0.9m for the purpose of any permanent retaining wall design.

Since the proposed development does not include any significant excavation activities, it is not anticipated that any dewatering activity be required during the construction. If at any stage, it would

be required to undertake any dewatering, the project geotechnical engineer should be notified before any dewatering activity.

5.2. Earthworks

It is proposed to place fill material to raise the ground floor slab to a level of RL 2.78m AHD. The fill should be placed after removing the upper 1m of uncontrolled fill and very loose sand layers. The fill should be placed in accordance with Australian Standard "AS 3798 -2007 Earthworks for Residential and Commercial Developments". It is recommended that all compaction control testing in areas that will support structures and pavements be undertaken under appropriate supervision by an approved Geotechnical Inspection and Testing Authority (GITA).

The site won soils excavated from the cut area, may be considered suitable to be reused as fill material.

Fill material should not contain vegetation, organic matter, high plasticity clayey soils or particles greater than 75mm. Plasticity Index should be limited to 30%. If it is intended to import fill material, granular fill is preferred for general filling provided the fill material is of low to medium plasticity.

Filling material should be placed with density ratio and moisture content specified in Table 4.

Table 4 - Compaction specifications

Fill Material	Loose layer thickness (mm)	Minimum compaction ratio (for Clayey fill)	Minimum density index ratio (for granular fill)	Moisture Content
General fill	250	95%	70%	$\pm$ 2 % OMC
Engineering fill to support pavement, subgrades and structures	250	98%	75%	$\pm$ 2 % OMC

Legend:

OMC – Optimum Moisture Content (for compaction)

General fill (with a compaction ratio of 95%) cannot be relied on appropriate foundation strata for the shallow footings, to support pavement and subgrades. Placement of fill will require strict moisture control to minimise post-compaction shrink-swell movement, especially for clayey fill materials.

It is recommended to place a final layer of compacted granular fill with a thickness of 150mm, to finish the construction platform to protect the subgrade from soil moisture changes.

During earthworks operations, installation of silt fences, hay bales or equivalent sediment erosion controls should be undertaken where runoff will exit the site, to limit sediment runoff from the site during construction. The earthworks plan, sediment control and drainage plan should be prepared by a civil engineer.

5.3. Lateral Earth Pressure Coefficients

To support the new fill material which will be required for build up the building platform, earth retaining structures should be designed to withstand the applied lateral pressures of the subsurface soil layers, hydrostatic pressure and the existing live surcharge loads within the zone of influence of the structure. For the preliminary 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, an earth pressure coefficient 'at rest' (k_o) should be considered.

Given the car park areas, it is assumed that the fill would be an engineering fill (well compacted clayey or sandy fill) in accordance with Australian Standard "AS 3798 -2007 Earthworks for Residential and Commercial Developments".

The recommended design parameters as summarised in Table 7 is recommended.

Table 7 - Typical Material Properties for Retaining wall Design

Geotechnical Units	c' (kPa)	∅′ (degrees)	γ (KN/m^3)	K_a	K_p	K_o	E' (MPa)	ϑ'
Well compacted sandy fill	0	30	18	0.3	3.0	0.5	15	0.35
Well compacted clayey fill	0	26	18	0.39	2.56	0.56	10	0.35
Very loose sand	0	28	17	0.39	2.56	0.56	8	0.3
Very soft to firm silty clay	2	22	16	0.45	2.20	0.63	5	0.35
Stiff to very stiff silty clay	4	26	18	0.39	2.56	0.56	20	0.35

Legend:
∅′ : Effective Friction Angle
c': Effective Cohesion
γ : Bulk Unit Weight
K_a: Active earth pressure
K_o: Earth pressure at rest
Kp: Passive earth pressure
E': Elasticity Modulus
ϑ': Poisson's Ratio

5.4. Foundations

5.4.1. Multi-storey Residential Building

The strength of the encountered soil layers is not adequate to support a seven-storey building on shallow foundations. Significant differential foundation settlement would be expected if the building were to be founded on a raft footing or other shallow foundations at the ground floor level.

Based on the subsurface geotechnical condition encountered and the anticipated loads, it is expected that all structural loads would be taken to the bedrock.

Considering the shallow groundwater level and collapsible soil layers, grouted Continuous Flight Auger (CFA) piles may be feasible provided that the reinforcement cage installation can be undertaken. Consideration should be given to the pile boring into the bedrock to prevent excessive "draw-in" of surrounding granular material due to the relatively slow penetration of the auger per revolution in the sandstone bedrock. Therefore, cased bored piles are recommended. If cased bored piles are adopted,

pumps may be required to remove water from the bored pile holes for inspection prior to the placement of concrete. Alternatively, tremie concrete placement method could be adopted for the concrete placement soon after inspection.

The pilling method should not cause any vibrations or impulses and open-cut excavation resulting in soil decompression. The design parameters for the foundations are presented in Table 8.

Table 8 – Geotechnical Design Parameters for Deep Foundation

Description	Approximate Depth (m)	Ultimate End Bearing (MPa)	Allowable End Bearing Pressure (MPa)	Ultimate Shaft Adhesion (kPa)	Allowable Shaft Adhesion (kPa)	Elasticity Modulus (MPa)
Sandstone, medium to high strength, slightly weathered	16m at the north 22m at the south	60	10	2000	1000	2000

These values are applicable where a minimum three pile diameters of the rock have been proved below the pile toe. Additional boreholes could be drilled prior to pile construction if needed.

The pile foundations should be designed in accordance with AS 2159-2009 Piling – Design and Installation using the appropriate geotechnical reduction factors. The pile length should be based on the applied loads.

Large settlements (more than 5% of minimum footing dimensions) are required in order to mobilise the ultimate end bearing resistance. This level of a settlement could be excessive for the building structure.

The settlement at the footings level is to be calculated based on the footings dimension and applied loads. The serviceability end bearing pressure is to be assessed based on the tolerable settlements. .

5.4.2. Single Storey Maintenance Building

The site has been assessed as Class P in accordance with AS 2870-2011 due to the existing uncontrolled fill material and underlain material with loose and soft consistency.

Currently, there are double-storey buildings at the rear side of the site which are to be demolished and be replaced with a active green, single storey buildings accommodating maintenance and garbage rooms. At the time of Alliance's site investigation, the buildings appeared to be in a good condition (based on visual inspection from outside) and there was no visible sign of crack or settlement.

Based on the boreholes drilled at the location of BH4 and BH5/MW4 and PSP tests, the upper 200mm fill is not suitable for the foundation. Shallow pad footings can be founded on natural loose to medium dense clayey sand encountered below a 0.2m depth. However, since the material underneath (below 2m depth) is still of very loose density, the footings are recommended to be founded with a maximum embedment depth of 300mm to avoid excessive additional pressure on the very loose and soft

material underneath. The recommended allowable bearing capacities for different footing widths are provided in Table 9.

Table 9 – Geotechnical Design Parameters for Shallow Strip/Square Footings

Description/ Consistency	Footing type	Width (m)	Maximum Embedment Depth (m)	Allowable Bearing Capacity (kPa)
Loose to medium dense clayey sand	Square/strip	0.3	0.3	55
		0.5	0.3	70
		1.0	0.3	100

If it is proposed to found the building on raft footing then the allowable bearing capacity and corresponding settlement should be assessed based on the design loads.

5.5. Construction Inspection

The piled footings will need to be inspected during boring to confirm the bedrock strength. An experienced geotechnical engineer is to confirm the capacity of the design socket depths and also confirm that the bases of the piles are clean and free of soft, loose, wet or disturbed soils.

5.6. Earthquake Loading Factors

Based on the observed subsurface condition, the maximum depth of the soil is ~ 22m. Referring to Australian Standard AS1170.4 – 2007, Part 4, Table 4.1, the maximum depth of the soil is less than 40m (assuming stiff clay). Therefore, the site subsoil is classified as Class C_e. Referring to Table 3.2 of the above standard, hazard factor is 0.09 for Gosford.

5.7. CBR Value for Pavement Design

The pavement subgrade will be constructed over alluvial medium dense sandy material. Therefore, it is recommended to design the pavement thickness using the following parameters:

- CBR: 10%
- Subgrade Modulus: 100MPa

The civil contractor should minimise disturbance to the subgrade given the shallow water table. It is recommended to enlist a civil contractor that has proven experience working in sandy subgrades.

Following trimming to the final subgrade level, over excavate top 0.5m. Localised dewatering might be required to provide dry platform. The exposed subgrade should then be compacted and proof rolled with a 10-tonne roller with minimum 6 passes to detect any loose or compressible zones that may require removal or further treatment. The proof rolling should be observed by an experienced geotechnical engineer.

If the significant movement of the subgrade is observed, then further treatment should be recommended by the geotechnical engineer and this may require over-excavation of the 0.5m depth

of existing soil and replacement with controlled fill comprising ripped sandstone or other suitable granular materials.

Where levels are to be raised to form the platform levels, controlled fill material should be placed in uniform layers of 300mm maximum (loose) thickness and compacted to a minimum density index of at 98% maximum dry density with moisture content within 2% of the Standard Optimum Moisture Content (SOMC).

The site won material, comprising sandy soils, may be re-used as a fill.

6. LIMITATIONS

Alliance Geotechnical Pty Ltd (Alliance) has prepared this report for the site located at 51 Masons Parade, Point Frederick, NSW 2250 in accordance with Alliance's fee proposal and Terms of Engagement. This geotechnical report has been prepared for Brisbane Waters Legacy (BWL) for this project and for the purposes outlined in this report. This report cannot be relied upon for other projects, other parties on this site or any other site. The comments and recommendations provided in this report are based on the assumption that the geotechnical recommendations contained in this report will be fully complied with during the design and construction of the proposed site development.

The borehole investigation and laboratory testing results provided in this report are indicative of the subsurface conditions at the site only at the specific sampling and testing locations, and to the depths drilled at the time of the investigation. Subsurface conditions can change significantly due to geological and human processes. Where variations in conditions are encountered further geotechnical advice should be sought from Alliance.

APPENDIX A – Site Photographs

Photo 1 – A Creek Located at the Northern Side of the Site

Photo 2 – General Site Overview – Looking south

APPENDIX B – Borehole Location Plan (Drawing: 10827-GR-1-A)

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Site Plan 1:500 Scale on A3

Client Name:	Brisbane Waters Legacy	Figure Number:	10827-GR-1-A
Project Name:	Proposed Legacy Village Redevelopment Project	Figure/Drawing Date:	23/06/2020
Project Location	51 Masons Parade, Point Frederick, NSW 2250	Report Number:	10827-GR-1-1

N 0 100 200 Meters

APPENDIX C –Boreholes and Monitoring Wells Logs

(BH1 to BH4 & MW1 to MW4/BH5)

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BH No: BH01
PAGE 1 OF 4
Job No: 10827

Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW
Started: 11/06/2020
Finished: 11/06/2020
Borehole Size 110 mm

Rig Type: Hanjin D&B 8D | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** EC | **Logged:** KT
RL Surface: 1.25m | **Contractor:** Rockwell 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		1	1		- -	ASPHALTIC CONCRETE, 50mm thickness.		- -	- -	PAVEMENT
					- -	FILL: Sandy GRAVEL, medium to coarse gravel, grey and brown, fine to medium grained sand, appears moderately compacted.		M	- -	FILL
	11/06/2020				- -	FILL: SAND, fine to medium grained, grey and pale brown.		M	- -	
		0	2		SC	Clayey SAND, fine to medium grained, grey, trace shell fragments, appears poorly graded.	SPT 2, 0, 1 N=1	W	VL	QUATERNARY DEPOSITS
		-1	3				SPT 0, 0, 1 N=1			
						3.00m: as above but fine grained.			VL	
		-2	4							
WB		-3	5		SP	SAND, fine to medium grained, dark grey, appears poorly graded.	SPT 2, 2, 1 N=3	W	VL	
		-4	6							
		-5	7		CI-CH	Silty CLAY, medium to high plasticity, grey, trace fine grained sand.		W	S	
		-6					SPT 0, 1, 3 N=4			
			8							

2. NON CORED BOREHOLE (NO COORD/RL) 10827 GINT.GPJ GINT STD AUSTRALIA.GDT 25/6/20

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Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW

Started: 11/06/2020
Finished: 11/06/2020
Borehole Size 110 mm

Rig Type: Hanjin D&B 8D | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** EC | **Logged:** KT
RL Surface: 1.25m | **Contractor:** Rockwell 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
WB		-7	9		CI-CH	Silty CLAY, medium to high plasticity, grey, trace fine grained sand. *(continued)*		W	S	
		-8			CI-CH	Silty CLAY, medium to high plasticity, pale grey, trace fine grained sand.			VSt	
		-9	10				SPT 4, 9, 14 N=23			
		-10	11							
		-11	12							
			13							
		-12	14			Borehole BH01 continued as cored hole				
		-13	15							
		-14	16							

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Cored Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW

Started: 11/06/2020
Finished: 11/06/2020
Borehole Size 110 mm

Rig Type: Hanjin D&B 8D | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** EC | **Logged:** KT
RL Surface: 1.25m | **Contractor:** Rockwell Drilling Pty Ltd | **Bearing:** --- | **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL -0.03, VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	$Is_{(50)}$ MPa D- diametral A- axial	RQD %	Defect Spacing mm (30, 100, 300, 1000, 3000)	Additional Data
		-7	9								
		-8	10								
		-9	11								
		-10	12								
		-11	13		Continued from non-cored borehole						
NMLC	Partial Water Loss	-12	14		SANDSTONE, fine to medium grained, grey and pale brown, with red bands.	SW		D 0.23 A 0.33 D 0.16 A 0.46	67		13.2 - JT, 5°, Planar, Rough, 13.59 - JT, 50°, Planar, Rough,
		-13						D 0.21 A 0.52			14.17 - Clay SM, 20mm 14.2 - Clay SM, 500mm
		-14	15		SANDSTONE, fine to medium grained, grey.			D 0.47 A 0.63 D 0.63 A 0.74	93		14.7 - Clay SM, 20mm 14.78 - Clay SM, 20mm 14.92 - Clay SM, 10mm 14.94 - JT, 10°, Planar, Rough, 15.15 - JT, 5°, Planar, Rough, 15.26 - JT, 10-15°, Planar, Rough, 15.31 - JT, 10-15°, Planar, Rough, 15.32 - JT, 10-15°, Planar, Rough, 15.35 - JT, 10-15°, Planar, Rough,
			16					D A			15.96 - JT, 15°, Planar, Rough,

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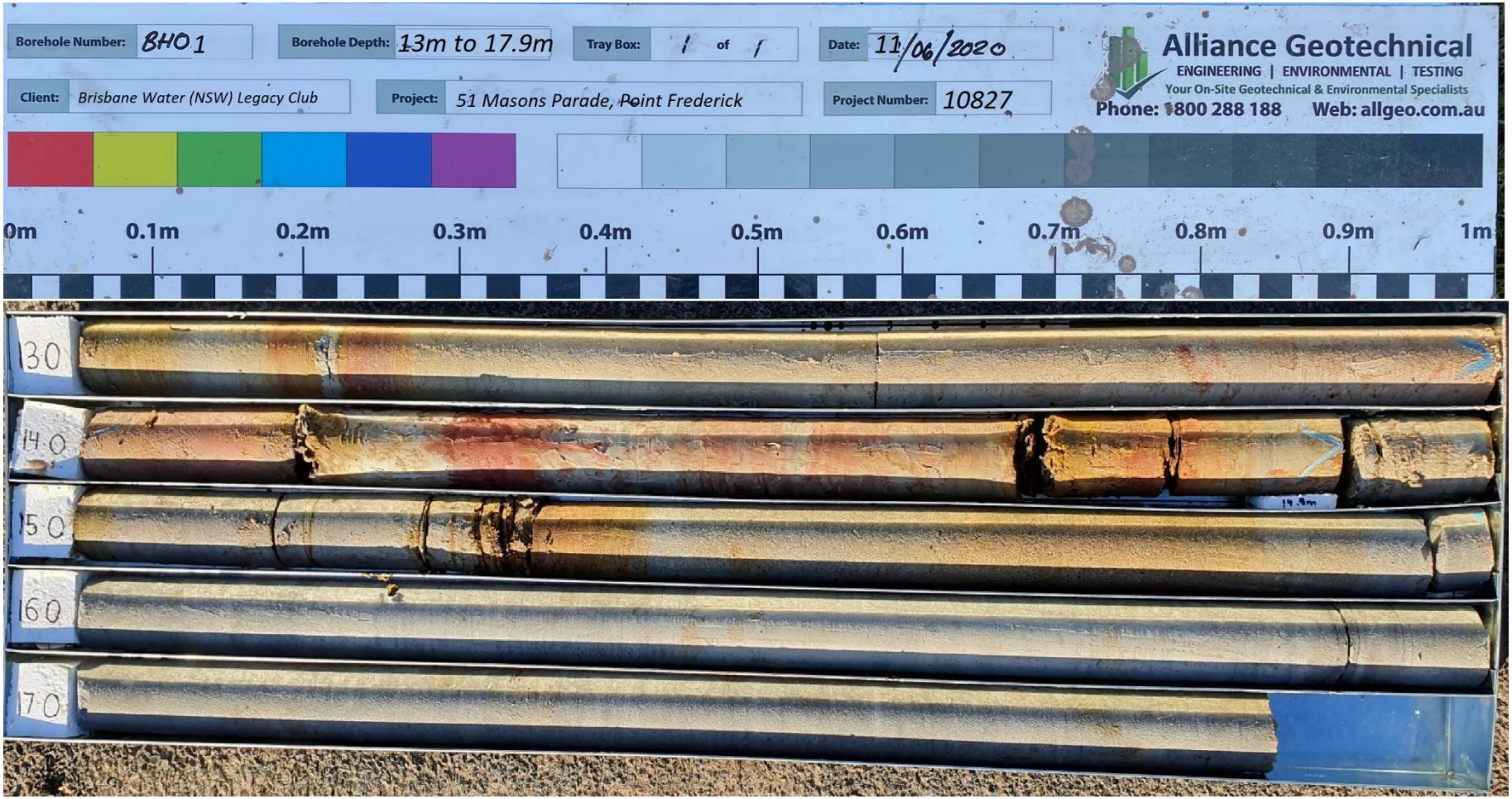
Cored Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW
Started: 11/06/2020
Finished: 11/06/2020
Borehole Size 110 mm

Rig Type: Hanjin D&B 8D | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** EC | **Logged:** KT
RL Surface: 1.25m | **Contractor:** Rockwell Drilling Pty Ltd | **Bearing:** --- | **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL -0.03, VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	$Is_{(50)}$ MPa D- diametral A- axial	RQD %	Defect Spacing mm (30, 100, 300, 1000, 3000)	Additional Data
NMLC	Partial Water Loss	-15	17		SANDSTONE, fine to medium grained, pale grey, with dark grey laminations. *(continued)*	SW		1.32 1.69 D 1.4 A 1.31 D 1.6 A 1.84 D 1.73 A 1.79 D 1.41 A 1.86	93		16.95 - JT, 10°, Planar, Rough,
		-16									
		-17	18		BH01 terminated at 17.9m						End of Borehole
		-18	19								
		-19	20								
		-20	21								
		-21	22								
		-22	23								
			24								



Core Box Photo – BH1

Client Name:	Brisbane Waters Legacy BWL	Figure / Drawing Number:	10827-GR-1-A
Project Name:	Proposed Legacy Village Redevelopment Project	Figure / Drawing Date:	03/07/2020
Project Location:	51 Masons Parade, Point Frederick, NSW 2250	Report Number:	10827-GR-1-1

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BH No: BH02
PAGE 1 OF 5
Job No: 10827

Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW

Started: 12/06/2020
Finished: 12/06/2020
Borehole Size 110 mm

Rig Type: Hanjin D&B 8D | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** EC | **Logged:** JA
RL Surface: 1.80m | **Contractor:** Rockwell 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		1	1		- -	FILL: Mixture of Silty Clay and Sand, brown orange, appears poorly compacted.	SPT 0, 0, 0 N=0	M	- -	FILL
		0	2							
WB	12/06/2020	-1	3		SC	Clayey SAND, fine to medium grained, grey, trace shell fragments, appears poorly graded.	SPT 1, 2, 1 N=3	W	VL	QUATERNARY DEPOSITS
		-2	4		SP	SAND, fine to medium grained, dark grey, appears poorly graded.	SPT 1, 0, 1 N=1	W	VL	
		-3	5							
		-4	6		CI-CH	Silty CLAY, medium to high plasticity, grey, trace fine grained sand.		W	S	
		-5	7							
		-6	8				SPT 0, 1, 2 N=3			

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Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW

Started: 12/06/2020
Finished: 12/06/2020
Borehole Size 110 mm

Rig Type: Hanjin D&B 8D | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** EC | **Logged:** JA
RL Surface: 1.80m | **Contractor:** Rockwell 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
WB		-7	9		CI-CH	Silty CLAY, medium to high plasticity, grey, trace fine grained sand. *(continued)*		W	S	
					CI-CH	Silty CLAY, medium to high plasticity, pale grey, trace fine grained sand.		W	S	
		-8	10							
		-9	11				SPT 0, 0, 1 N=1			
		-10	12							
		-11	13							
		-12	14				SPT 3, 4, 3 N=7		F	
		-13	15							
		-14	16							

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Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW
Started: 12/06/2020
Finished: 12/06/2020
Borehole Size 110 mm

Rig Type: Hanjin D&B 8D | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** EC | **Logged:** JA
RL Surface: 1.80m | **Contractor:** Rockwell 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
WB		-15	17		CI-CH	Silty CLAY, medium to high plasticity, pale grey, trace fine grained sand. *(continued)*	SPT 6, 9, 9 N=18	W	S VSt	
		-16	18		CI-CH	Silty CLAY, medium to high plasticity, pale grey,with fine grained sand, with fine sandstone gravel.		W	St - VSt	
		-17	19							
		-18	20				SPT 9, 8, 8 N=16			
		-19	21							
		-20	22			Borehole BH02 continued as cored hole				
		-21	23							
		-22	24							

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Cored Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW

Started: 12/06/2020
Finished: 12/06/2020
Borehole Size 110 mm

Rig Type: Hanjin D&B 8D | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** EC | **Logged:** JA
RL Surface: 1.80m | **Contractor:** Rockwell Drilling Pty Ltd | **Bearing:** --- | **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL -0.03, VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	$Is_{(50)}$ MPa D- diametral A- axial	RQD %	Defect Spacing mm (30, 100, 300, 1000, 3000)	Additional Data
		-15	17								
		-16	18								
		-17	19								
		-18	20								
		-19	21		Continued from non-cored borehole						
NMLC		-20	22		SANDSTONE, fine to medium grained, pale grey, massive.	MW/SW		D 0.54 A 0.61 D 0.41 A 1.14	96		21.6 - JT, 60°, Irregular, Rough, 21.72 - JT, 30°, Irregular, Rough,
		-21	23					D 1.21 A 1.44 D 1.27 A 1.34			
		-22	24					D 2.62 A 3.18	93		

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Cored Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW
Started: 12/06/2020
Finished: 12/06/2020
Borehole Size 110 mm

Rig Type: Hanjin D&B 8D | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** EC | **Logged:** JA
RL Surface: 1.80m | **Contractor:** Rockwell Drilling Pty Ltd | **Bearing:** --- | **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL -0.03, VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	Is(50) MPa D- diametral A- axial	RQD %	Defect Spacing mm (30, 100, 300, 1000, 3000)	Additional Data
NMLC		-23	25		SANDSTONE, fine to medium grained, pale grey, massive. *(continued)*	MW/SW		D 0.79 A 2.45	93		24.1 - Clay SM, 10mm 24.55 - Clay SM, 10mm 24.65 - Clay SM, 10mm 24.66 - JT, 20°, Planar, Rough,
					SANDSTONE, fine grained, interbedded with shale.			D 0.04 A 1.5			25.1 - Clay SM, 10mm 25.12 - Clay SM, 10mm
		-24	26		BH02 terminated at 25.37m						End of Borehole
		-25	27								
		-26	28								
		-27	29								
		-28	30								
		-29	31								
		-30	32								

Alliance Geotechnical ENGINEERING | ENVIRONMENTAL | TESTING Manage the earth, eliminate the risk	Core Box Photo – BH2				
	Client Name:	Brisbane Waters Legacy (BWL)		Figure / Drawing Number:	10827-GR-1-A
	Project Name:	Proposed Legacy Village Redevelopment Project		Figure / Drawing Date:	03/07/2020
	Project Location:	51 Masons Parade, Point Frederick, NSW 2250		Report Number:	10827-GR-1-1

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Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW
Started: 12/06/2020
Finished: 12/06/2020
Borehole Size 110 mm

Rig Type: Hanjin D&B 8D | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** EC | **Logged:** JA
RL Surface: 2.10m | **Contractor:** Rockwell 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		2	1		- -	FILL: Silty Clay, brown and orange, with sand, appears poorly compacted.		M	- -	FILL
		1								
		0	2		SC	Clayey SAND, fine to medium grained, grey, trace shell fragments, poorly graded.		M	VL	QUATERNARY DEPOSITS
WB	12/03/2020	-1	3							
					SP	SAND, fine to medium grained, dark grey, poorly graded.		W	VL	
		-2	4							
		-3	5							
					CI-CH	Silty CLAY, medium to high plasticity, grey, trace fine grained sand.		W	VS	
		-4	6				SPT 0, 0, 1 N=1			
		-5	7							
			8							

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Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW
Started: 12/06/2020
Finished: 12/06/2020
Borehole Size 110 mm

Rig Type: Hanjin D&B 8D | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** EC | **Logged:** JA
RL Surface: 2.10m | **Contractor:** Rockwell 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
WB		-6			CI-CH	Silty CLAY, medium to high plasticity, grey, trace fine grained sand. *(continued)*		W	VS	
			9							
		-7					SPT 0, 0, 1 N=1			
						9.5m: as above but pale grey.			VS	
			10							
		-8								
			11							
		-9								
			12							
		-10					SPT 0, 0, 2 N=2		VS	
			13							
		-11								
			14							
		-12								
			15							
		-13					SPT 2, 5, 7 N=12		St	
			16							

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Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW
Started: 12/06/2020
Finished: 12/06/2020
Borehole Size 110 mm

Rig Type: Hanjin D&B 8D | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** EC | **Logged:** JA
RL Surface: 2.10m | **Contractor:** Rockwell 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
WB		-14			CI-CH	Silty CLAY, medium to high plasticity, grey, trace fine grained sand. *(continued)*		W	VS	
			17							
		-15								
			18							
		-16				18.0m: as above but with sandstone gravel.	SPT 5, 9, 9 N=18		VSt	
			19							
		-17								
			20							
		-18								
			21							
		-19								
			22			Borehole BH03 continued as cored hole				
		-20								
			23							
		-21								
			24							

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Cored Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW
Started: 12/06/2020
Finished: 12/06/2020
Borehole Size 110 mm

Rig Type: Hanjin D&B 8D | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** EC | **Logged:** JA
RL Surface: 2.10m | **Contractor:** Rockwell Drilling Pty Ltd | **Bearing:** --- | **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL -0.03, VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	$Is_{(50)}$ MPa D- diametral A- axial	RQD %	Defect Spacing mm (30, 100, 300, 1000, 3000)	Additional Data
		-14	17								
		-15									
			18								
		-16									
			19								
		-17									
			20								
		-18									
			21								
		-19			Continued from non-cored borehole						
NMLC			22		SANDSTONE, fine to medium grained, pale grey, massive.	SW		D 1.16 A 1.38	95		21.88 - HB, °, Planar, Rough, 21.95 - FZ, 50mm 22.16 - JT, 70°, Planar, Rough, 22.47 - JT, 70°, Planar, Rough,
		-20									
			23					D 1.57 A 1.42			
		-21						D 1.48 A 1.66	90		23.3 - HB, °, Planar, Rough, 23.45 - BP, 0°, Planar, Rough,
			24					D 1 A 1.18			23.8 - Clay CS, 20mm 23.9 - BP, 0°, Planar, Rough,

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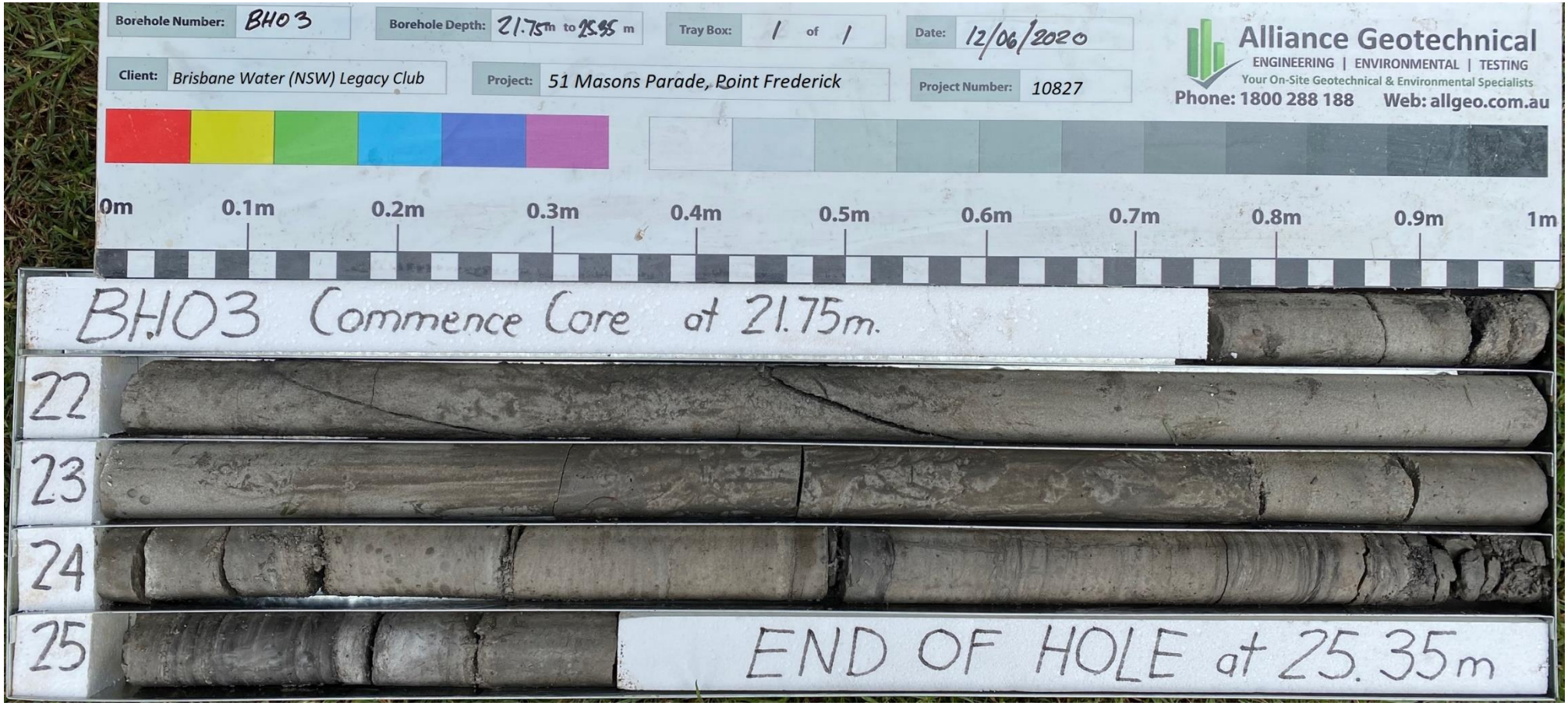
Cored Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW
Started: 12/06/2020
Finished: 12/06/2020
Borehole Size 110 mm

Rig Type: Hanjin D&B 8D | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** EC | **Logged:** JA
RL Surface: 2.10m | **Contractor:** Rockwell Drilling Pty Ltd | **Bearing:** --- | **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL -0.03, VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	$Is_{(50)}$ MPa D- diametral A- axial	RQD %	Defect Spacing mm (30, 100, 300, 1000, 3000)	Additional Data
		-22			SANDSTONE, fine to medium grained, pale grey, massive. *(continued)*	SW		D 2.57 A 2.64			24.05 - BP, 0°, Planar, Rough, 24.1 - BP, 0°, Planar, Rough, 24.15 - Clay CS, 20mm 24.3 - Clay CS, 20mm 24.5 - BP, 0°, Planar, Rough,
					24.6m: trace carbonaceous veins.			D 0.42 A 2.85	90		24.8 - HB, °, Planar, Rough, 24.85 - DB, °, Planar, Rough, 24.92 - JT, 60°, Planar, Rough,
		-23	25		25.0m: with shale/carbonaceous laminations.						25.15 - BP, 0°, Planar, Rough, 25.22 - Clay CS, 20mm
					BH03 terminated at 25.35m						End of Borehole
		-24	26								
		-25	27								
		-26	28								
		-27	29								
		-28	30								
		-29	31								
			32								



Alliance Geotechnical ENGINEERING | ENVIRONMENTAL | TESTING Manage the earth, eliminate the risk	**Core Box Photo – BH3**			
	Client Name:	Brisbane Waters Legacy (BWL)	Figure / Drawing Number:	10827-GR-1-A
	Project Name:	Proposed Legacy Village Redevelopment Project	Figure / Drawing Date:	03/07/2020
	Project Location:	51 Masons Parade, Point Frederick, NSW 2250	Report Number:	10827-GR-1-1

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BH No: BH04
Sheet: 1 of 1
Job No: 10827

Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW

Started: 3/06/2020
Finished: 3/06/2020
Borehole Size 110 mm

Rig Type: Geoprobe 6712DT | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** DC | **Logged:** JA
RL Surface: 2.00m | **Contractor:** Stratacore 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					- -	FILL: Silty Sand, fine to medium grained, dark brown.		M		FILL
	Tidal Sepage 3/06/2020 ▼				S	Clayey SAND, fine to medium grained, pale brown, with shell fragments, low to medium plasticity clay.		M	L	QUATERNARY DEPOSITS
		1	1							
						1.60m: as above, but grey.	SPT 3, 5, 5 N=10			
		0	2			2.00m: as above but grey green.		W		
						2.50m: as above but grey.				
		-1	3				SPT 0, 0, 0 N=0	VL		
		-2	4							
							SPT 0, 0, 0 N=0			
		-3	5							
		-4	6							
						Borehole BH04 terminated at 6m				
		-5	7							
		-6	8							

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BH No: MW01
Sheet: 1 of 1
Job No: 10827

Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW

Started: 3/06/2020
Finished: 3/06/2020
Borehole Size 110 mm

Rig Type: Geoprobe 6712DT | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** DC | **Logged:** JA
RL Surface: 1.20m | **Contractor:** Stratacore Pty Ltd | **Bearing:** --- | **Checked:** LM

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT			1			- -	FILL: Silty Sand, fine to medium grained, dark grey, with medium to high plasticity clay, trace fine rounded gravel.	ES 0.5	M	- -	FILL
	Tidal Seepage 3/06/2020		0	1		SC	Clayey SAND, fine to medium grained, grey, with shell fragments, low to medium plasticity clay.	ES 1.0	W	VL	QUATERNARY DEPOSITS
			-1	2		SC	Clayey SAND, fine to medium grained, brown and dark grey, low to medium plasticity clay, with shell fragments.	SPT 0, 0, 0 N=0 ES 1.5 ES 2.0 ES 2.5	W	VL	
			-2	3				SPT 0, 0, 0 N=0 ES 3.0 ES 3.5			
			-3	4			Borehole MW01 terminated at 3.5m				
			-4	5							
			-5	6							
			-6	7							
				8							

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BH No: MW02
Sheet: 1 of 1
Job No: 10827

Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW

Started: 3/06/2020
Finished: 3/06/2020
Borehole Size 110 mm

Rig Type: Geoprobe 6712DT | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** DC | **Logged:** JA
RL Surface: 1.80m | **Contractor:** Stratacore Pty Ltd | **Bearing:** --- | **Checked:** LM

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT			1	1		- -	FILL: Silty Sand, fine to medium grained, dark grey, with medium to high plasticity clay, trace fine rounded gravel.	ES 0.5	D	- -	FILL
						- -	SAND, fine to medium grained, pale brown.	ES 1.0	M	VL	POSSIBLE FILL
			0	2				SPT 0, 0, 0 N=0 ES 1.5			
						SC	Clayey SAND, fine to medium grained, grey, with shell fragments, low to medium plasticity clay.	ES 2.0	W	VL	QUATERNARY DEPOSITS
	Tidal Seepage 3/06/2020 ▼		-1	3		SC	Clayey SAND, fine to medium grained, brown and dark grey, low to medium plasticity clay, with shell fragments.	ES 2.5	W	VL	
								SPT 1, 1, 1 N=2 ES 3.0			
			-2	4			Borehole MW02 terminated at 3.5m	ES 3.5			
			-3	5							
			-4	6							
			-5	7							
			-6	8							

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BH No: MW03
Sheet: 1 of 1
Job No: 10827

Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW

Started: 3/06/2020
Finished: 3/06/2020
Borehole Size 110 mm

Rig Type: Geoprobe 6712DT | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** DC | **Logged:** JA
RL Surface: 2.00m | **Contractor:** Stratacore Pty Ltd | **Bearing:** --- | **Checked:** LM

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT			1	1		- -	FILL: Sandy Gravel, fine to medium, dark grey, fine to medium grained sand.	ES 0.5	D	- -	FILL
						- -	SAND, fine to medium grained, pale brown.	ES 1.0	M	L	POSSIBLE FILL
			0	2				SPT 3, 3, 3 N=6 ES 1.5			
	Tidal Seepage 3/06/2020					SC	Clayey SAND, fine to medium grained, grey, with shell fragments, low to medium plasticity clay.	ES 2.0	W	VL	QUATERNARY DEPOSITS
			-1	3		SC	Clayey SAND, fine to medium grained, brown and dark grey, low to medium plasticity clay, with shell fragments.	ES 2.5	W	VL	
								SPT 2, 1, 1 N=2 ES 3.0			
							Borehole MW03 terminated at 3.5m	ES 3.5			
			-2	4							
			-3	5							
			-4	6							
			-5	7							
			-6	8							

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BH No: MW04
Sheet: 1 of 1
Job No: 10827

Borehole Log

Client: Brisbane Waters NSW Legacy
Project: Legacy Redevelopment
Location: 51 Masons Parade, Point Frederick, NSW
Started: 3/06/2020
Finished: 3/06/2020
Borehole Size 110 mm

Rig Type: Geoprobe 6712DT | **Hole Location:** Refer Drawing 10827-GR-1-A | **Driller:** DC | **Logged:** JA
RL Surface: 2.00m | **Contractor:** Stratacore Pty Ltd | **Bearing:** --- | **Checked:** LM

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT						- -	FILL: Silty Sand, fine to medium grained, dark grey, with medium to high plasticity clay, trace fine fill rounded gravel.		D	- -	FILL
						SP	Clayey SAND, fine to medium grained, brown, with shell fragments, low to medium plasticity clay.	ES 0.5	M	L	QUATERNARY DEPOSITS
			1	1			1.00m: as above, but pale brown.	ES 1.0		VL - L	
								SPT 2, 4, 4 N=8 ES 1.5			
			0	2			2.00m: as above, but grey green.	ES 2.0	W		
								ES 2.5			
	Tidal Seepage 3/06/2020		-1	3			3.00m: as above, but dark grey.	SPT 0, 0, 0 N=0 ES 3.0		VL	
								ES 3.5			
			-2	4				ES 4.0			
								SPT 0, 0, 0 N=0 ES 4.5			
			-3	5				ES 5.0			
								ES 5.5			
			-4	6							
							Borehole MW04 terminated at 6m	ES 6.0			
			-5	7							
			-6	8							

2. NON CORED BOREHOLE (NO COORD/RL) 10827 GINT.GPJ GINT STD AUSTRALIA.GDT 25/6/20

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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.

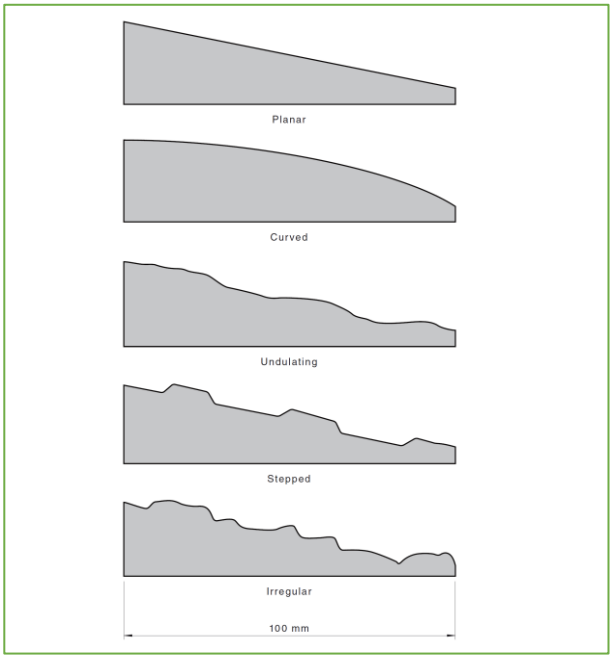
Defect Type – Defect abbreviations are as follows:

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.

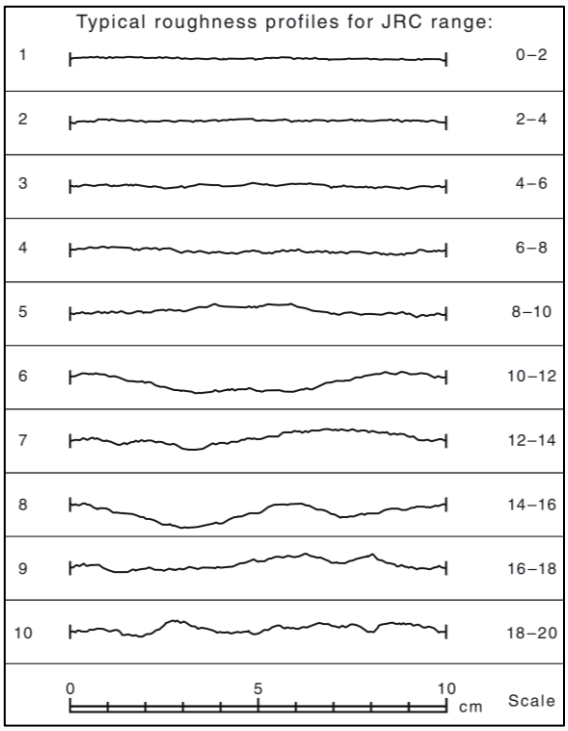
Defect spacing and length (sometimes called persistence), shall be described directly inmillimetres and metres.

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.

Perth Sand Penetrometer (PSP) Test Report

Client:	Brisbane Waters Legacy	Report Number:	10827-GR-1-1
Project Name:	Proposed Legacy Village Redevelopment	Project Number:	10827
Project Location:	51 Masons Parade, Point Frederick, NSW	Date Tested:	26/06/2020
Test Method:	AS 1289.6.3.3		

Test Number	**PSP01**	**PSP02**	**PSP03**
Test Locations	Refer to 10827-GR-1-A		
Surface Material	TOPSOIL/FILL: Silty Sand		
Surface Condition	Dry	Dry	Dry
Depth (metres)			
0.00 – 0.15	4	2	2
0.15 – 0.30	5	4	5
0.30 – 0.45	6	6	5
0.45 – 0.60	4	5	3
0.60 – 0.75	4	4	2
0.75 – 0.90	3	4	2
0.90 – 1.05	6	7	3
1.05 – 1.20	10	8	3
1.20 – 1.35	2	2	6
1.35 – 1.50	3	2	8
1.50 – 1.65	3	4	12
1.65 – 1.80	5	5	14
1.80 – 1.95	8	4	16
1.95 – 2.10	8	4	TD
2.10 – 2.25	12	7	
2.25 – 2.40	TD	8	
2.40 – 2.55		10	
2.55 – 2.70		TD	

APPENDIX D – Rising Head Test Results

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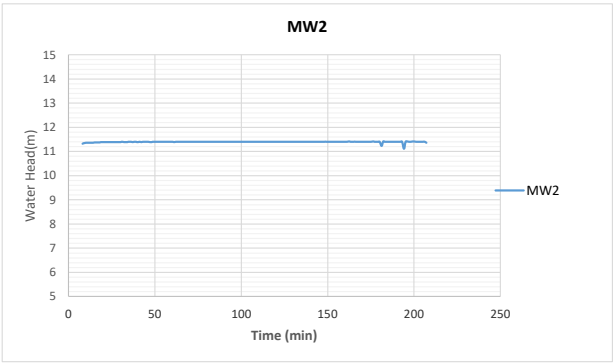
RISING HEAD PERMEAMEBILITY TEST REPORT

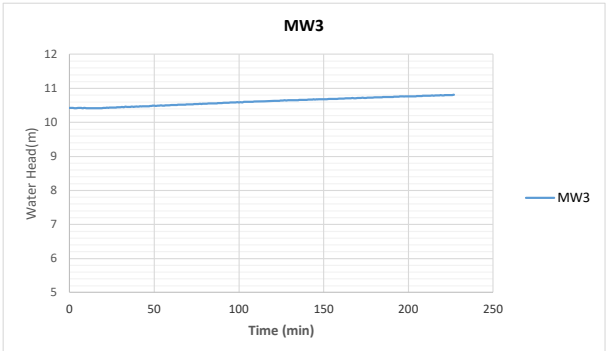
Client :	Brisbane Waters Legacy (BWL)	**Job Number :**	10827
Project :	Proposed Legacy Village Redevelopment Project	**Test Date :**	11/06/2020
Location:	51 Masons Parade, Point Frederick, NSW 2250	**Tested By :**	KT
Test Location:	(refer to drawing 10827-GR-1-A)		
Test Method :	Hvorslev's Method (1951)		

Test	**MW2**	
Bore Data	**Unit**	**Value**
Initial Ground Water Depth (bgs)	m	2
Groundwater Depthat t=0	m	0
Casing Radius (rc)	m	0.025
Bore Radius (rw)	m	0.05
Screened Length (Le)	m	2.5
Characteristic Time (t_0)	min	1
Hydraulic Conductivity (k)	m/day	**0.7042**
Discharge into the monitoring well	L/s/m2	2.8E-04

$$K = \frac{r_c^2 \cdot \ln\left(\frac{L_e}{r_w}\right)}{2 \cdot L_e \cdot t_0}$$



Test	**MW3**	
Bore Data	**Unit**	**Value**
Initial Ground Water Depth (bgs)	m	2.3
Groundwater Depthat t=0	m	0
Casing Radius (rc)	m	0.025
Bore Radius (rw)	m	0.05
Screened Length (Le)	m	2.5
Characteristic Time (t_0)	min	350
Hydraulic Conductivity (k)	m/day	**0.002**
Discharge into the monitoring well	L/s/m2	6.0E-05



APPENDIX E – Laboratory Tests Certificate

Material Test Report

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Alliance Geotechnical Pty Ltd
10 Welder Road Seven Hills NSW 2147
PO Box 275, Seven Hills NSW 1730
Phone: 1800 288 188
Fax: (02) 9838 8022
Email: brett@allgeo.com.au

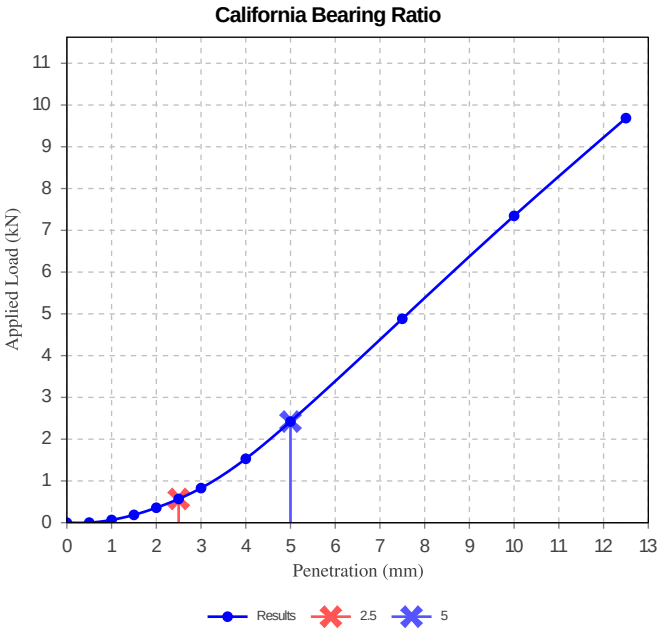
Accredited for compliance with ISO/IEC 17025 - Testing

NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Brett Bellingham
Projects Coordinator - Testing
NATA Accredited Laboratory Number: 15100

Report Number: **10827-1**
Issue Number: 1
Date Issued: 02/07/2020
Client: Alliance Geotechnical
10 Welder Road, Seven Hills NSW 2147
Contact: Jhan-Paule Arbizo
Project Number: 10827
Project Name: Legacy Redevelopment - Point Frederick 51
Project Location: Mason Parade - Point Frederick
Contractor: Grindley Constructions
Work Request: 5954
Sample Number: 20-5954A
Date Sampled: 23/06/2020
Dates Tested: 23/06/2020 - 30/06/2020
Sampling Method: Sampled by Client
The results apply to the sample as received
Sample Location: **MW 03 (1.0-2.0m)**
Material: SAND, fine to medium grained, pale brown.

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**12**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual		
Maximum Dry Density (t/m^3)	2.02		
Optimum Moisture Content (%)	9.5		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	101.0		
Dry Density after Soaking (t/m^3)	2.01		
Field Moisture Content (%)	20.8		
Moisture Content at Placement (%)	9.6		
Moisture Content Top 30mm (%)	10.4		
Moisture Content Rest of Sample (%)	10.0		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	49.6		
Swell (%)	0.0		
Oversize Material (mm)	19		
Oversize Material Included	N/A		
Oversize Material (%)	0		



Material Test Report

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Alliance Geotechnical Pty Ltd
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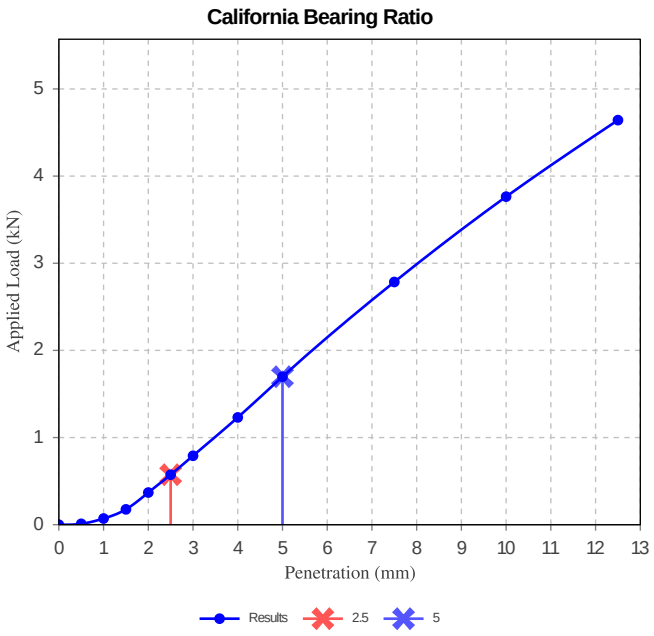
NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Brett Bellingham
Projects Coordinator - Testing
NATA Accredited Laboratory Number: 15100

Report Number: **10827-1**
Issue Number: 1
Date Issued: 02/07/2020
Client: Alliance Geotechnical
10 Welder Road, Seven Hills NSW 2147
Contact: Jhan-Paule Arbizo
Project Number: 10827
Project Name: Legacy Redevelopment - Point Frederick 51
Project Location: Mason Parade - Point Frederick
Contractor: Grindley Constructions
Work Request: 5954
Sample Number: 20-5954B
Date Sampled: 23/06/2020
Dates Tested: 23/06/2020 - 30/06/2020
Sampling Method: Sampled by Client
The results apply to the sample as received
Sample Location: **MW 02 (1.0-2.0m)**
Material: SAND, fine to medium grained, pale brown.

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**9**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual		
Maximum Dry Density (t/m^3)	1.92		
Optimum Moisture Content (%)	12.5		
Laboratory Density Ratio (%)	99.5		
Laboratory Moisture Ratio (%)	100.0		
Dry Density after Soaking (t/m^3)	1.91		
Field Moisture Content (%)	26.8		
Moisture Content at Placement (%)	12.7		
Moisture Content Top 30mm (%)	14.4		
Moisture Content Rest of Sample (%)	13.7		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	49.6		
Swell (%)	0.0		
Oversize Material (mm)	19		
Oversize Material Included	N/A		
Oversize Material (%)	0		



Material Test Report

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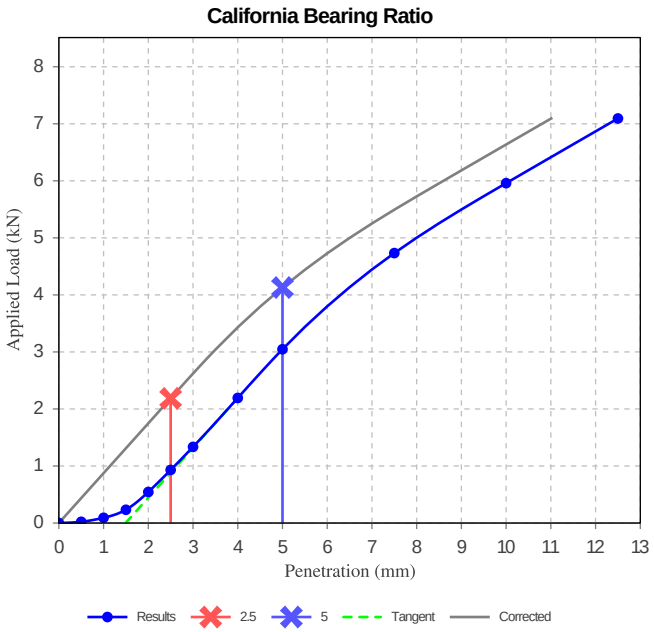
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Brett Bellingham
Projects Coordinator - Testing
NATA Accredited Laboratory Number: 15100

Report Number: **10827-1**
Issue Number: 1
Date Issued: 02/07/2020
Client: Alliance Geotechnical
10 Welder Road, Seven Hills NSW 2147
Contact: Jhan-Paule Arbizo
Project Number: 10827
Project Name: Legacy Redevelopment - Point Frederick
Project Location: 51 Mason Parade - Point Frederick
Contractor: Grindley Constructions
Work Request: 5954
Sample Number: 20-5954C
Date Sampled: 23/06/2020
Dates Tested: 23/06/2020 - 30/06/2020
Sampling Method: Sampled by Client
The results apply to the sample as received
Sample Location: **MW 04 (1.0-2.0m)**
Material: Clayey SAND, fine to medium grained, brown, with shell fragments, low to medium plasticity clay.

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**20**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual		
Maximum Dry Density (t/m^3)	1.98		
Optimum Moisture Content (%)	10.5		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	100.0		
Moisture Content at Placement (%)	10.7		
Moisture Content Top 30mm (%)	11.8		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	49.5		
Oversize Material (mm)	19		
Oversize Material Included	N/A		
Oversize Material (%)	0		



Alliance Geotechnical
10 Welder Road
Seven Hills
NSW 2147

NATA Accredited
Accreditation Number 1261
Site Number 18217

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Attention: **Sahar Mamouri**

Report **726336-S**
Project name BRISBANE WATER LEGACY CLUB
Project ID 10827
Received Date Jun 17, 2020

Client Sample ID			**BH03 3.0**	**BH03 2.0**	**BH01 2.0**	**BH01 7.0**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**S20-Jn29890**	**S20-Jn29891**	**S20-Jn29892**	**S20-Jn29893**
Date Sampled			**Jun 12, 2020**	**Jun 12, 2020**	**Jun 11, 2020**	**Jun 11, 2020**
Test/Reference	LOR	Unit				
Chloride	10	mg/kg	23	23	350	260
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	94	120	330	240
pH (1:5 Aqueous extract at 25°C as rec.)	0.1	pH Units	4.5	4.2	6.7	7.6
Resistivity*	0.5	ohm.m	530	410	150	210
Sulphate (as SO4)	10	mg/kg	120	140	160	21
% Moisture	1	%	18	19	24	27

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

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

Description	Testing Site	Extracted	Holding Time
Chloride	Sydney	Jun 24, 2020	28 Days
- Method: E045 /E047 Chloride			
Conductivity (1:5 aqueous extract at 25°C as rec.)	Sydney	Jun 24, 2020	7 Days
- Method: LTM-INO-4030 Conductivity			
pH (1:5 Aqueous extract at 25°C as rec.)	Sydney	Jun 24, 2020	7 Days
- Method: LTM-GEN-7090 pH in soil by ISE			
Sulphate (as SO4)	Sydney	Jun 24, 2020	28 Days
- Method: E045 Anions by Ion Chromatography			
% Moisture	Sydney	Jun 18, 2020	14 Days
- Method: LTM-GEN-7080 Moisture			

eurofins | Environment Testing

ABN – 50 005 085 521 web : www.eurofins.com.au e.mail : EnviroSales@eurofins.com

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Lane Cove West NSW 2066
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NATA # 1261 Site # 18217

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NATA # 1261 Site # 20794

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Kewdale WA 6105
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NATA # 1261
Site # 23736

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Penrose, Auckland 1061
Phone : +64 9 526 45 51
IANZ # 1327

Christchurch
43 Detroit Drive
Rolleston, Christchurch 7675
Phone : 0800 856 450
IANZ # 1290

Company Name: Alliance Geotechnical
Address: 10 Welder Road
Seven Hills
NSW 2147

Project Name: BRISBANE WATER LEGACY CLUB
Project ID: 10827

Order No.:
Report #: 726336
Phone: 1800 288 188
Fax: 02 9675 1888

Received: Jun 17, 2020 5:37 PM
Due: Jun 25, 2020
Priority: 5 Day
Contact Name: Sahar Mamouri

Eurofins Analytical Services Manager : Andrew Black

Sample Detail						Aggressivity Soil Set	Moisture Set
Melbourne Laboratory - NATA Site # 1254 & 14271							
Sydney Laboratory - NATA Site # 18217						X	X
Brisbane Laboratory - NATA Site # 20794							
Perth Laboratory - NATA Site # 23736							
External Laboratory							
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**		
1	BH03 3.0	Jun 12, 2020		Soil	S20-Jn29890	X	X
2	BH03 2.0	Jun 12, 2020		Soil	S20-Jn29891	X	X
3	BH01 2.0	Jun 11, 2020		Soil	S20-Jn29892	X	X
4	BH01 7.0	Jun 11, 2020		Soil	S20-Jn29893	X	X
Test Counts						4	4

Internal Quality Control Review and Glossary

General

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

Holding Times

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

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

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

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

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

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram

mg/L: milligrams per litre

ug/L: micrograms per litre

ppm: Parts per million

ppb: Parts per billion

%: Percentage

org/100mL: Organisms per 100 millilitres

NTU: Nephelometric Turbidity Units

MPN/100mL: Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

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

Results <10 times the LOR : No Limit

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

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

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test			Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank									
Chloride			mg/kg	< 10			10	Pass	
Conductivity (1:5 aqueous extract at 25°C as rec.)			uS/cm	< 10			10	Pass	
Sulphate (as SO4)			mg/kg	< 10			10	Pass	
LCS - % Recovery									
Chloride			%	90			70-130	Pass	
Conductivity (1:5 aqueous extract at 25°C as rec.)			%	99			70-130	Pass	
Resistivity*			%	99			70-130	Pass	
Sulphate (as SO4)			%	96			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Spike - % Recovery									
				Result 1					
Chloride	S20-Jn32354	NCP	%	97			70-130	Pass	
Sulphate (as SO4)	S20-Jn32354	NCP	%	101			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
				Result 1	Result 2	RPD			
Chloride	S20-Jn35864	NCP	mg/kg	< 10	< 10	<1	30%	Pass	
Conductivity (1:5 aqueous extract at 25°C as rec.)	S20-Jn35864	NCP	uS/cm	31	26	18	30%	Pass	
pH (1:5 Aqueous extract at 25°C as rec.)	S20-Jn35864	NCP	pH Units	5.9	5.8	Pass	30%	Pass	
Resistivity*	S20-Jn35864	NCP	ohm.m	1600	1900	18	30%	Pass	
Sulphate (as SO4)	S20-Jn35864	NCP	mg/kg	< 10	< 10	<1	30%	Pass	
% Moisture	S20-Jn32360	NCP	%	9.3	9.0	4.0	30%	Pass	

Comments

Sample Integrity

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

Authorised By

Andrew Black	Analytical Services Manager
Gabriele Cordero	Senior Analyst-Inorganic (NSW)

Glenn Jackson
General Manager

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

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

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