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GEOTECHNICAL INVESTIGATION

for

NEW RESIDENTIAL DEVELOPMENT

at

53A & 53B WARRIEWOOD ROAD, WARRIEWOOD, NSW

Prepared For

Sekisui House

Project No.: 2023-108

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GEOTECHNICAL REPORT FOR PROPOSED NEW RESIDENTIAL DEVELOPMENT
53A & 53B WARRIEWOOD ROAD, WARRIEWOOD, NSW

1. INTRODUCTION:

This report details the results of a geotechnical investigation and assessment carried out for a proposed new residential development at No. 53a and 53b Warriewood Road, Warriewood, NSW. The investigation was undertaken by Crozier Geotechnical Consultants (CGC) at the written request of Willow Tree Planning on behalf of the client Sekisui House.

It is understood that the proposed works involve the community title sub-division of 53A and 53B Warriewood Road into 29 Residential properties and 1 community property lot. The proposed works will also include the construction of new roads to connect Lorikeet Grove and provide access to northern properties. Bulk excavation will be required to varying depths across the proposed development zone however is not anticipated to exceed 2.00m depth below existing ground levels.

Geotechnical investigation is for preliminary design and construction purposes only. This report includes a description of site and sub-surface conditions including a geotechnical assessment of the development, a site plan, a geological model and broadscale recommendations for design and construction purposes.

The geotechnical investigation included:

a) DBYD request, onsite review and clearing of locations by an accredited service locator.
b) Drilling of four boreholes using a restricted access drill rig employing solid stem spiral flighted augers and one using hand augers along with Dynamic Cone Penetrometer (DCP) tests at five locations to determine the subsurface geology, depth to bedrock, indication of underlying boulders and identification of groundwater,
c) Detailed geotechnical mapping of the entire site and adjacent land, with identification of geotechnical conditions and hazards including landslip related to the existing site and surroundings,
d) A photographic record of site conditions,
e) Laboratory test soil samples were sent to a NATA registered chemistry laboratory for confirmation of field assessment.

f) All fieldwork was conducted under the full-time supervision of an experienced Geotechnical Professional.

The following documents have been supplied by the Architect and relied upon for the investigation and reporting:

- Subdivision Plan Drawing – YSCO Geomatics, Reference No.: 6321/15B, 6321/16C, Dated: 27/04/2024

2. SITE FEATURES:

2.1. Description and Observations:

The combined site is a broadly trapezoidal shaped block on the southern side of Warriewood Road situated within gentle south to south west dipping topography that extends down to Narrabeen Creek which forms the southern site boundary. The site currently contains a two storey masonry dwelling towards the northern end of No. 53b, a single storey timber and weatherboard dwelling situated towards the northern end of 53a and a warehouse situated within the middle portion of No. 53b. A photograph of the site and surrounds is shown below in Photograph 1 with boundary designations.

Photograph 1: Aerial view of the site and surrounds (NSW Gov't Six Map Spatial Data)

Warriewood Road comprises a relatively flat dipping bituminous sealed pavement with no engineered drainage structure separating it from the site. The roadway did not exhibit any obvious signs of cracking or excessive settlement to indicate any underlying geotechnical concerns.

No. 53a, which comprises the western portion of the site contains a single storey timber and weatherboard dwelling situated towards the front northern end of the site and accessed by a gentle to moderate south west dipping driveway. The remainder of the site, with the exception of a few minor ancillary structures, is vacant and typically comprises an open, gentle south west dipping field. The western edge of the property adjacent to the western site boundary is slightly elevated with respect to the rest of the site, understood to be as a result of placed fill soils associated with the neighbouring development. Photograph 2 below provides a view of No. 53a.

Photograph 2: View of No. 53a, looking broadly south

No. 53b, which comprises the eastern portion of the site contains a two storey masonry residential dwelling situated towards the northern end of the site with an in ground pool situated adjacent to the rear southern edge of the dwelling. A gently south west dipping driveway extends along the eastern site boundary and provides access to the rear portion of the site where a warehouse structure is situated along with a relatively flat cleared area, understood to have previously been used for vehicle storage. Photograph 3 below provides a view of No. 53b.

Photograph 3: View of No. 53b, looking broadly north from the rear portion of the property

To the west of the site six separate properties (No. 4, 6, 8 & 10 Ibis Place, No. 21 Lorikeet Grove & No. 99 Warriewood Road) as well as a roadway (Lorikeet Grove) share a common boundary with the site. The residential properties all contain two storey masonry dwellings understood to be of relatively recent construction (<15 years) and appear to be in good condition with no signs of excessive settlement or cracking to indicate any impending geotechnical concern. The roadway comprises a bituminous sealed pavement of similar construction age to the adjacent dwellings and did not exhibit any signs of impending geotechnical concern. Ground levels were relatively similar to the site along the shared boundary.

To the east of the site, the roadway of Pheasant Place is situated adjacent to the shared boundary following a parallel alignment. The roadway is generally at similar levels to the site along the shared boundary however features some portions retained up to a maximum of 0.70m (approx..) above adjacent site levels via a concrete block retaining wall. There were no signs of impending instability observe within the roadway and boundary structure to indicate any large scale geotechnical concern.

2.2. Geology:

Reference to the Sydney 1: 100,000 Geological Series sheet (9130) indicates that the site is situated near the boundary of The Newport Formation (Upper Narrabeen Group) rock (Rnn) and Quaternary Sands (Qha). The rock unit is of middle Triassic age and typically comprises interbedded laminite, shale and quartz to lithic quartz sandstones and pink clay pellet sandstones and tends to weather to a significant depth. The sands typically comprise silty to peaty quartz sand silt and clay.

Extract 1: Sydney (9130 Geology Series Map): 1: 100000 – Geology underlying the site

3. FIELD WORK:

3.1. Methods:

The field investigation comprised a walk over inspection and mapping of the site on 25th March 2024 by a Geotechnical Engineer. It included a photographic record of site conditions as well as geological/geomorphological mapping of the site and limited inspection of adjacent land with examination of existing features and ground conditions.

It also included the drilling of four auger boreholes using a restricted access drill rig operating solid stem, spiral flighted augers and a tungsten carbide blade bit and one borehole using hand tools due to access limitations to investigate sub-surface geology.

Geotechnical logging of the subsurface conditions was undertaken by a Geotechnical Engineer by inspection of disturbed soil recovered from the augers. Logging was undertaken in accordance with AS1726:2017 'Geotechnical Site Investigations'. Soil samples were collected from the boreholes and directly transferred to sterile glass jars for submission to a NATA accredited laboratory for Acid Sulphate Soils testing.

DCP testing was carried out from the ground surface adjacent to all boreholes in accordance with AS1289.6.3.2 – 1997, "Determination of the penetration resistance of a soil – 9kg Dynamic Cone Penetrometer" to estimate near surface soil conditions.

Explanatory notes are included in Appendix: 1. Mapping information and test locations are shown on Figure: 1, along with detailed borehole log and DCP sheets in Appendix: 2, geological models/sections are provided as Figure: 2 & 3, Appendix: 2.

3.2. Ground Conditions:

The boreholes (BH1 - BH5) were drilled across the site broadly within the anticipated footprint of the proposed works with all extending initially through a variable layer of topsoil/fill prior to intersection of natural soils. Within the front northern portion of the site boreholes BH1 & BH4 intersected residual clay soils underlying the topsoil/fill interpreted as corresponding to the Newport formation bedrock unit (Rnn). These soils extended to a maximum drilled depth of 4.00m depth with no bedrock intersected. The test locations undertaken from the mid to rear southern portion of the site (BH2, BH3, BH5) intersected alluvial/fluvially deposited natural soils which varied in sand silt and clay composition and extended to the maximum investigation depth of 7.00m.

Dynamic Cone Penetrometer (DCP) testing was undertaken from surface level adjacent to the boreholes with all extending through the fill soils and intersecting residual/alluvial soils with the natural soils grading from stiff to hard by a maximum depth of 2.60m below existing ground levels.

For a description of the ground conditions encountered at the borehole/DCP test locations, the Borehole Log and DCP results sheets should be consulted however a very broad summary of the subsurface conditions encountered is provided below.

- **TOPSOIL/FILL** – This layer was encountered in all boreholes and extended from ground level to a maximum depth of 2.00m (BH2). Along the western site boundary (BH1 & BH2) as well as within the rear portion of No. 53b (BH5) it initially comprised a compacted silty/clayey sand with sandstone gravels and building refuse, considered uncontrolled. This uncontrolled fill extended to depths of 1.50m, 1.00m and 1.20m in BH1, BH2 & BH5 respectively. From 1.00m depth to within BH2 the fill transitioned to a clay fill with some sandstone gravels of relatively uniform density/consistency, considered potentially controlled. Only a relatively shallow layer (<1.00m) of fill soils was encountered within BH3 and BH4, typically comprising a silty sand with roots and intermittent building refuse.

- **ALLUVIAL SOILS –** This layer was encountered underlying the topsoil and fill in BH2, BH3 and BH5 at depths of 2.00m, 0.50m and 1.20m respectively. The composition of these fluvially deposited soils generally varied with both depth and location across site, a characteristic inherent to alluvial soils.
    - Within BH2 the clay was initially intersected as a hard, grey, medium plasticity silty clay with red mottle with effective DCP refusal encountered below 2.80m depth. Below 3.00m the deposit temporarily transitioned to a yellow brown, silty clay prior to intersection of a similar grey clay below 3.50m and subsequently a wet grey sandy clay below 4.00m which continued for the remainder of the investigation depth of 7.00m.
    - Within BH3 the clay was initially intersected as a hard, yellow/brown, medium plasticity, moist/dry silty clay with red mottle with effective DCP refusal intersected below 1.20m depth. Below 2.00m the deposit transitioned to a grey, medium plasticity, moist silty clay with red mottle becoming wet below 3.00m which continued until borehole termination at 4.00m depth.
    - Within BH5 the clay was initially intersected as a stiff, dark grey, peaty clay, becoming very stiff below 1.50m depth. From 2.20m depth a hard, grey, medium plasticity, moist silty clay was intersected, with effective DCP refusal encountered below 2.70m and the soil becoming wet below 3.00m depth. Below 4.00m depth a grey, wet sandy clay was intersected and continued to the maximum investigation depth of 7.00m.
- **RESIDUAL SOILS –** This layer was intersected underlying the topsoil/fill within the test locations in the front (northern) end of site (BH1 & BH4) at depths of 1.50m and 1.20m respectively. In both locations this material was initially intersected as a very stiff to hard, yellow/brown, medium plasticity, moist-dry, silty clay with red mottle and ironstone gravels. In both locations this material graded to a red-brown silty clay and subsequently a grey silty clay with red mottle and ironstone gravels which extended to the maximum investigation depth in the northern end of site of 4.00m. Effective DCP refusal was encountered in BH1 and BH4 at depths of 2.90m and 2.60m respectively.

A freestanding ground water table was intersected in both BH2 and BH5 within the alluvial soils with the wet/saturated soils typically corresponding with the intersection of the grey sandy clay below 4.00m depth in BH2 and BH5 at 4.00m depth, following which standing water rose in the holes and remained stable at approximately 3.00m depth. Additionally, some seepage was observed below the fill soils overlying the clayey natural soils.

3.3. Laboratory Testing

3.3.1 Acid Sulfate Soils Testing

Soil samples collected from the boreholes were sent to a NATA accredited laboratory for chemical testing (Envirolab).

Five samples were tested at Envirolab to via the pH, pHFOX methods with two sample analysed by using the Chromium method to provide quantitative data on ASS based on the recommendations of the Acid Sulphate Soils Laboratory Methods Guidelines, Version.2.1, June 2004 and National Acid Sulphate Soils Guidance (June 2018). The results are summarised in Table 1 and Table 2 below and the certificates of analysis are included in Appendix 3.

Table 1: Summary of Laboratory Test Results (pH and pH_{FOX})

Borehole:	Depth (m)	pH	pH_{FOX}	Reaction Rate
BH5	2.50	5.0	2.7	High
BH5	3.50	6.2	3.6	Medium
BH5	5.00	6.1	3.0	Medium
BH2	5.50	5.5	3.9	Medium
BH1	2.00	5.0	3.0	Medium

Table 2: Chromium Suite Laboratory Test Results +%S w/w yellow indicates partial exceedance of action criteria

Borehole:	Depth	pH (KCL)	Titratable Actual Acidity %w/w S	Chromium Reducible Sulphur – Scr) % w/w	Net Acidity * moles H^+/t	Calculated Liming Rate (kg CaCO3/t)
BH5	2.50	4.4	0.05	0.04	25	5
BH5	5.00	4.7	0.02	0.03	17	2

All excavated soils were either shallow topsoil/fill, alluvial/fluvial clays and residual clays with none exhibiting significant characteristics inherent to ASS, with the majority of the action criteria outlined in Table 4.4 of the NSW Acid Sulfate Soil Manual not exceeded. However, within BH5 from approximately 2.00m - 3.50m depth the net acidity and Sulfur Trail exceeds the action criteria outlined if >1000 tonnes of material are disturbed. Additionally, the Sulfur trail below 5.00m depth also exceeds the action criteria for >1000 tonnes of disturbed material.

Therefore, the requirement of an Acid Sulphate Soils Management Plan will be based on the confirmed scope of proposed works.

3.3.2 Soil Aggressivity Tests

Two samples collected from the investigation were tested at Envirolab to determine the aggressivity and salinity of the soils below the site to provide durability classification for new concrete/steel structures as per AS2159. The samples were tested after preparing a 1:5 soil:water suspension. The results are summarised in Table 3.

Table 3 - Summary of Envirolab Aggressivity Laboratory Test Results

Borehole:	Depth (m)	pH	Chloride, Cl (mg/kg)	Sulphate, SO4 (mg/kg)	Electrical Conductivity, (µS/cm)
BH5	1.00	6.4	36	40	100
BH5	2.00	6.2	54	20	86

These results correspond to a "Non-Aggressive" classification for steel piling according to AS2159 - Piling Table 6.5.2(C) and corresponds to a "Non-Aggressive" classification for concrete piling according to AS2159 - Piling Table 6.4.2 (C).

3.3.3 Moisture Content

Seven soil samples were sent for measurement of moisture content and the results are summarised in Table 4 below.

Table 4: Summary of Reported Moisture Content Results

Location	Laboratory Description	Moisture Content (%)
BH1, 1.50m	Silty CLAY	19.4
BH1, 2.50m	Silty Sandy CLAY	15.0
BH1, 3.70m	Silty CLAY	20.9
BH2, 2.00m	Silty CLAY	16.3
BH2, 3.50m	Silty CLAY	25.7
BH2, 4.00m	Silty CLAY	21.1
BH2, 5.00m	Silty Sandy CLAY	22.4

3.3.4 Shrink Swell Index

Two samples of undisturbed cohesive soil recovered from BH3 and BH4 were tested to determine shrink swell index (I_{ss}) using the methods given in Australian Standard AS1289.7.1.1 – 1992. The test results are summarised in Table 1 and indicate that the sample tested displayed a moderate to high potential for shrink-swell movement associated with soil moisture content/suction changes.

Table 5: Summary of Reported Shrink-Swell Index Test Results

Sample Location	Sample Description	Sample Moisture Content (%)	Shrinkage (%)	Swell (%)	I_{ss} (% per pF)
BH3, 0.50m	Silty Clay	19.1	2.4	0.0	1.3
BH4, 0.70m	Silty Sandy Clay	10.3	0.4	0.0	0.2

An estimation of characteristic surface movement was undertaken using the methods as defined in AS2870-2011 and using the depth of design suction change (Hs) of 1.8m as per AS2870. Estimated surface movements of < 20mm have been calculated for both locations indicating a site classification of Class 'S'.

3.3.5 Plasticity

One soil sample was tested for measurement of plasticity using Atterberg limit and linear shrinkage test methods. The reported test results are summarised in the table below, together with the soil classification. The test results indicate that the silty clay samples tested were of medium to high plasticity.

Table 6: Summary of reported Plasticity Results

Sample Location	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Sample Classification*1
BH2 2.50m	38	10	28	CL

*1 Australian Standard AS1726 – 2017 *Geotechnical site investigations*

3.3.6 Moisture Density Relationship

One bulk soil sample was tested to determine laboratory moisture density relationship (Standard) for assessment of maximum dry density (MMD) and the optimum moisture content. The results of the testing are summarised in the table below.

Table 7: Summary of Reported Moisture Density Relationship Results

Sample Location	Description	Maximum Dry Density (t/m^3)	Optimum Moisture Content (%)
BH3a, 0.50m	Sandy Silty Clay	1.81	16.3

3.3.7 California Bearing Ratio

A disturbed sample of clay soil recovered from BH3a was re-compacted using Standard compactive effort at estimated Standard optimum moisture content, soaked for four days under a surcharge load of 4.5 kg, then tested to determine the California bearing ratio (CBR) and the results of the testing are summarised in Table 8.

Table 8: Summary of reported Chemical Analysis

Sample Location	Swell during Soaking (%)	CBR (%)
BH3a, 0.50m	0.7	4.5

4. COMMENTS:

4.1. Geotechnical Assessment:

The site investigation identified the presence of a variable layer of anthropogenic fill soils across site, with increased depth of fill material noted adjacent to the western site boundary and within the south eastern portion of the site. This material was relatively compacted however was considered to be uncontrolled, particularly towards existing ground surface levels. Underlying the fill soils, residual clay soils were intersected towards the front northern portion of site with alluvial clayey soils intersected in the rear southern portion of site in line with the natural topography and location of the site adjacent to a natural drainage channel. The water table was intersected within the rear portion of the site at depths ranging between 2.50m and 3.00m below existing ground levels however may be considerably shallower towards the southern site boundary, particularly as the topography drops away.

It is understood that the proposed works involve the community title sub-division of 53A and 53B Warriewood Road into 29 Residential properties and 1 community property lot. The proposed works will also include the construction of new roads to connect Lorikeet Grove and provide access to northern properties. Bulk excavation will be required to varying depths across the proposed development zone however is not anticipated to exceed 2.00m depth below existing ground levels.

Where safe batter slopes, as outlined in Section 4.2, are unachievable within the confines of the site, then pre-excavation support will be required to maintain stability with respect to neighbouring properties. Excavation support would be effectively achieved via a bored pile wall founded below the base excavation level.

Due to the depth of relatively inconsistent fill encountered across site towards existing ground surface levels, particularly in the vicinity of neighbouring boundaries, the bored pile wall will need to be closely spaced to contiguous to account for potential erosion of fill soils between piles. Any gaps between piles would need to be filles at the earliest opportunity.

Additionally, any bored piers undertaken within the rear portion of the site will likely encounter a freestanding groundwater table, precluding conventional open bored methods. Where this occurs, CFA methods or similar will be required.

Driven style support systems (i.e. sheet piling, concrete/timber piles) are not suitable for use on this site due to ground vibration compaction in the adjacent sands and subsequent risk of damage to nearby structures. Also, care will need to be exercised during demolition of any existing structures and large scale breakers should be avoided to prevent damage to neighbouring structures.

If excavation support is proposed to extend to within 0.50m of neighbouring boundaries, it is assumed that no deflection will be tolerated. As such, provisions should be made to incorporate temporary bracing until installation of permanent bracing (in the form of the proposed structure) has been successfully implemented, and at rest pressure coefficients should be used in design.

All excavation works related to the proposed works are anticipated to extend through topsoil/fill and natural residual and alluvial soils with no bedrock rock excavation anticipated. Excavation of these natural soils will be readily achievable with conventional earth moving equipment. Therefore, there will be no requirement for rock breaking equipment or any vibration monitoring.

All new footings should be founded off natural material of similar strength in order to avoid differential settlement.

The fill soils must be considered uncontrolled though they are generally at least medium dense. As such, pending load requirements, ancillary structured could be founded in the fill using an allowable bearing pressure of ≤150kPa with the expectation that some differential settlement could occur over time.

All new footings must be inspected by an experienced geotechnical professional before concrete or steel are placed to verify their bearing capacity and the in-situ nature of the founding strata. This is mandatory to allow them to be 'certified' at the end of the project. If continual flight auger (CFA) methods are chosen then geotechnical inspection of the founding conditions is not possible as it is an essentially "blind" method.

Based on the laboratory test results, Actual or Potential Acid Sulfate Soils were intersected within BH5 below 2.50m depth. These soils will not require an action plan provided less that 1000 tonnes of material are disturbed. However, if the proposed works involve excavation of >1000 tonnes of natural an Acid Sulfate Soils Management Plan will be required for the proposed development.

The laboratory test results indicate that the soils underlying the site fall under the "Non-Aggressive" classifications for steel and concrete piles as per AS2159.

The inspection and assessment identified no obvious credible geotechnical hazards within the site or adjacent properties. The site shows no signs of any instability or problematic ground movement. No obvious surface stormwater flow or excess seepage/wet areas were identified.

The proposed works are considered suitable for the site and may be completed with negligible impact to neighbouring properties provided the recommendations of this report are implemented in the design and construction phases.

The recommendations and conclusions in this report are based on an investigation utilising only surface observations and isolated boreholes and DCP testing. This test equipment provides limited data from small isolated test points across the entire site. Therefore, some minor variation to the interpreted sub-surface conditions is possible, especially between test locations. However, the results of the investigation provide a reasonable basis for subsequent preliminary design of the proposed works.

4.2. Design & Construction Recommendations:

Design and the construction recommendations are tabulated below:

4.2.1. New Footings:	
Site Classification as per AS2870 – 2011 for new footing design	Class 'P' due to prevalence of Fill soils Class 'S' where fill soils cleared and footings situated atop natural clays at base of excavation
Type of Footing	Strip/Pad/Piles
Sub-grade material and Maximum Allowable Bearing Capacity	- Very Stiff Alluvial/Residual Soils: 200kPa - Hard Alluvial/Residual Soils: 400kPa
Site sub-soil classification as per *Structural design actions AS1170.4 – 2007, Part 4: Earthquake actions in Australia*	C_e – Shallow Soil site (interpreted)
Remarks: All footings for the proposed structure should be founded off material of similar strength to prevent differential settlement. All new footings must be inspected by an experienced geotechnical professional before concrete or steel are placed to verify their bearing capacity and the in-situ nature of the founding strata. This is mandatory to allow them to be 'certified' at the end of the project.	

4.2.2. Excavation:		
Depth of Excavation	Up to 2.00m depth	
Property Separation	Excavation may potentially extend to within 0.50m of site boundaries	
Type of Material to be Excavated	Up to 2.00m	Fill soils
	From minimum of 0.50m	Alluvial and residual soils

Guidelines for <u>un-surcharged</u> batter slopes for this site are tabulated below:

Material	Safe Batter Slope (H:V)	
	Short Term/Temporary	Long Term/Permanent
Fill and natural soils	1.5:1	2.0:1

Remarks:

If surface or groundwater flow is encountered during excavation, a significant reduction of the batter angles provided above may occur and geotechnical inspection of batters will be required at regular intervals to assess their stability, especially for permanent batters.		
Equipment for Excavation	Fill/natural soils	Bucket
Geotechnical Inspection Requirement	Yes, recommended that these inspections be undertaken as per below mentioned sequence: • During installation of pre-excavation support • Where ground conditions are exposed that differ to those than expected	
Dilapidation Surveys Requirement	Recommended for all structures within 10.0m of any excavation edge to avoid spurious claims of damage	

4.2.3. Retaining Structures:

Types	Bored Pile wall where pre-excavation support is required or Steel reinforced concrete walls or conventional gravity walls. Designed in accordance with Australian Standard AS 4678-2002 Earth Retaining Structures.

Parameters for calculating unsurcharged pressures acting on retaining walls for the materials likely to be retained:

Material	Unit Weight (kN/m3)	Long Term (Drained)	Earth Pressure Coefficients		Passive Earth Pressure Coefficient *
			Active (Ka)	At Rest (K_0)	
Fill and Loose/firm alluvial soils	18	ϕ' = 28°	0.35	0.52	N/A
Dense/very dense and Very Stiff/Hard Alluvial/Residual Soils	22	ϕ' = 35°	0.27	0.43	3.69

Remarks:

In suggesting these parameters, it is assumed that the retaining walls will be fully drained with suitable subsoil drains provided at the rear of the wall footings. If this is not done, then the walls should be designed to support full hydrostatic pressure in addition to pressures due to the soil backfill. It is suggested that the retaining walls should be back filled with free-draining granular material (preferably not recycled concrete) which is only lightly compacted in order to minimize horizontal stresses. The retaining walls should be designed using a triangular stress distribution.

Retaining structures near site boundaries or existing structures should be designed with the use of at rest (K_0) earth pressure coefficients to reduce the risk of movement in the excavation support and resulting surface movement in adjoining areas. Backfilled retaining walls within the site, away from site boundaries or existing structures, that may deflect can utilise active earth pressure coefficients (Ka).

4.2.4. Drainage and Hydrogeology		
Groundwater Table or Seepage identified in Investigation		Yes – freestanding groundwater table encountered broadly 2.50m-3.00m below existing ground levels within the rear of site with minor seepage also observed at geological interfaces
Excavation likely to intersect	Water Table	No – Pending excavation depth
	Seepage	Negligible
Site Location and Topography		On the southern side of the road within gentle south west dipping topography
Impact of development on local hydrogeology		Negligible, provided the recommendations of this report are implemented
Onsite Stormwater Disposal		Not possible
Remarks: Trenches, as well as all new building gutters, down pipes and stormwater intercept trenches should be connected to a stormwater system designed by a Hydraulic Engineer.		

4.3. Conditions Relating to Design and Construction Monitoring:

To allow certification as part of construction, building and post-construction activity for this project, it will be necessary for the geotechnical engineer to:

1. Review structural design against the recommendations of this report.
2. During installation of pre-excavation support where deemed necessary
3. Inspect all new footings to confirm compliance to design assumptions with respect to allowable bearing pressure and stability prior to the placement of steel or concrete.
4. Where ground conditions vary from those anticipated and outlined in this report are encountered.

The client and builder should make themselves familiar with the requirements spelled out in this report for inspections during the construction phase. Crozier Geotechnical Consultants cannot provide certification for the Occupation Certificate if it has not been called to site to undertake the required inspections.

5. CONCLUSION:

The site investigation identified the presence of a relatively shallow layer of topsoil fill overlying alluvial sands and clays across the lower southern portion of site that, whilst somewhat variable in composition between test points, graded relatively consistently with depth from loose/firm to very dense/hard broadly within 3.00m depth. The alluvial soils extended to the maximum investigation depth of 7.00m. Across the higher portion of the site residual clayey soils were encountered to the a maximum investigated depth of 4.00m.

The water table was intersected within the rear portion of the site at depths ranging between 2.50m and 3.00m below existing ground levels however may be considerably shallower towards the southern site boundary, particularly as the topography drops away.

It is understood that the proposed works involve the community title sub-division of 53A and 53B Warriewood Road into 29 Residential properties and 1 community property lot. The proposed works will also include the construction of new roads to connect Lorikeet Grove and provide access to northern properties. Bulk excavation will be required to varying depths across the proposed development zone however is not anticipated to exceed 2.00m depth below existing ground levels.

If excavation support is proposed to extend to within 0.50m of neighbouring boundaries, it is assumed that no deflection will be tolerated. As such, provisions should be made to incorporate temporary bracing until installation of permanent bracing (in the form of the proposed structure) has been successfully implemented.

All excavation works will extend through fill and surficial alluvial and residual soils with no intersection of bedrock anticipated. Therefore, pending demolition methodology, vibrations level associated with the proposed works should not be in issue with regards to neighbouring structures and vibration monitoring.

All new footings should bear within material of similar strength/density in order to minimise the risk of differential settlement.

The fill soils must be considered uncontrolled though they are generally at least medium dense. As such, pending load requirements, ancillary structured could be founded in the fill using an allowable bearing pressure of ≤150kPa with the expectation that some differential settlement could occur over time.

The laboratory test results indicate that the soils underlying the site fall under the "Non-Aggressive" classification for steel and concrete piles respectively as per AS2159.

The laboratory test results indicate that potential Acid Sulfate soils (PASS) are present within the site with any disturbance of natural soils in excess of 1000 tonnes triggering the requirement of a detailed ASS management plan.

There were no existing/credible landslip hazards identified and the proposed works are relatively minor from a geotechnical perspective and should not create any new instability provided the recommendations of this report are implemented.

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6. REFERENCES:

1. Geological Society Engineering Group Working Party 1972, "The preparation of maps and plans in terms of engineering geology" Quarterly Journal Engineering Geology, Volume 5, Pages 295 - 382.
2. C. W. Fetter 1995, "Applied Hydrology" by Prentice Hall. V. Gardiner & R. Dackombe 1983, "Geomorphological Field Manual" by George Allen & Unwin
3. Australian Standard AS 2870 – 2011, Residential Slabs and Footings
4. Australian Standard AS 1726 – 2017, Geotechnical Site Investigations
5. Australian Standard AS 1289 – 2000, Method of Testing Soils for Engineering Purposes
6. Australian Standards AS4678-2002, Earth Retaining Structures

Appendix 1

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Brookvale NSW 2100 Email: info@croziergeotech.com.au
Crozier Geotechnical Consultants, a division of PJC Geo-Engineering Pty Ltd

NOTES RELATING TO THIS REPORT

Introduction

These notes have been provided to amplify the geotechnical report in regard to classification methods, specialist field procedures and certain matters relating to the Discussion and Comments section. Not all, of course, are necessarily relevant to all reports.

Geotechnical reports are based on information gained from limited subsurface test boring and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Description and classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, Geotechnical Site Investigation Code. In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. Sandy clay) on the following bases:

Soil Classification	Particle Size
Clay	less than 0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.06 to 2.00 mm
Gravel	2.00 to 60.00mm

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

Classification	Undrained Shear Strength kPa
Very soft	Less than 12
Soft	12 - 25
Firm	25 – 50
Stiff	50 – 100
Very stiff	100 - 200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	SPT “N” Value (blows/300mm)	CPT Cone Value (Qc – MPa)
Very loose	less than 5	less than 2
Loose	5 – 10	2 – 5
Medium dense	10 – 30	5 -15
Dense	30 – 50	15 – 25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

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

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

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Drilling Methods

The following is a brief summary of drilling methods currently adopted by the company and some comments on their use and application.

Test Pits – these are excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descent into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) – the hole is advanced by a rotating plate or short spiral auger, generally 300mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

Continuous Sample Drilling – the hole is advanced by pushing a 100mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

Continuous Spiral Flight Augers – the hole is advanced using 90 – 115mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPT's or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling - the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling – similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. From SPT).

Continuous Core Drilling – a continuous core sample is obtained using a diamond-tipped core barrel, usually 50mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedures is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" – Test 6.3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube under the impact of a 63kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150mm of say 4, 6 and 7 as 4, 6, 7 then N = 13
- In the case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm then as 15, 30/40mm.

The results of the test can be related empirically to the engineering properties of the soil. Occasionally, the test method is used to obtain samples in 50mm diameter thin wall sample tubes in clay. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch Cone – abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australia Standard 1289, Test 6.4.1.

In tests, a 35mm diameter rod with a cone-tipped end is pushed continually into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separte 130mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected buy electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) their information is plotted on a computer screen and at the end of the test is stored on the computer for later plotting of the results.

The information provided on the plotted results comprises: -

- Cone resistance – the actual end bearing force divided by the cross-sectional area of the cone – expressed in MPa.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio - the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower scale (0 – 5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main scale (0 – 50 MPa) is less sensitive and is shown as a full line. The ratios of the sleeve friction to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios 1% - 2% are commonly encountered in sands and very soft clays rising to 4% - 10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range: -

Q_c (MPa) = (0.4 to 0.6) N blows (blows per 300mm)

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range: -

$Q_c = (12 \text{ to } 18)\, C_u$

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculations of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Dynamic Penetrometers

Dynamic penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150mm increments of penetration. Normally, there is a depth limitation of 1.2m but this may be extended in certain conditions by the use of extension rods.

Two relatively similar tests are used.

- Perth sand penetrometer – a 16mm diameter flattened rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test 6.3.3). The test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS 1289, Test 6.3.2). The test was developed initially for pavement sub-grade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

Laboratory testing is generally carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms.

Borehole Logs

The bore logs presented herein are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable, or possible to justify on economic grounds. In any case, the boreholes represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes, the frequency of sampling and the possibility of other than 'straight line' variations between the boreholes.

Details of the type and method of sampling are given in the report and the following sample codes are on the borehole logs where applicable:

D	Disturbed Sample	E	Environmental sample	DT	Diatube
B	Bulk Sample	PP	Pocket Penetrometer Test		
U50	50mm Undisturbed Tube Sample	SPT	Standard Penetration Test		
U63	63mm " " " " "	C	Core		

Ground Water

Where ground water levels are measured in boreholes there are several potential problems:

- In low permeability soils, ground water although present, may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations are to be made. More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be interference from a perched water table.

Engineering Reports

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. A three-storey building), the information and interpretation may not be relevant if the design proposal is changed (eg. to a twenty-storey building). If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface condition, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- unexpected variations in ground conditions – the potential for this will depend partly on bore spacing and sampling frequency,
- changes in policy or interpretation of policy by statutory authorities,
- the actions of contractors responding to commercial pressures,

If these occur, the Company will be pleased to assist with investigation or advice to resolve the matter.

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some later stage, well after the event.

Reproduction of Information for Contractual Purposes

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institution of Engineers Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a special ally edited document. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

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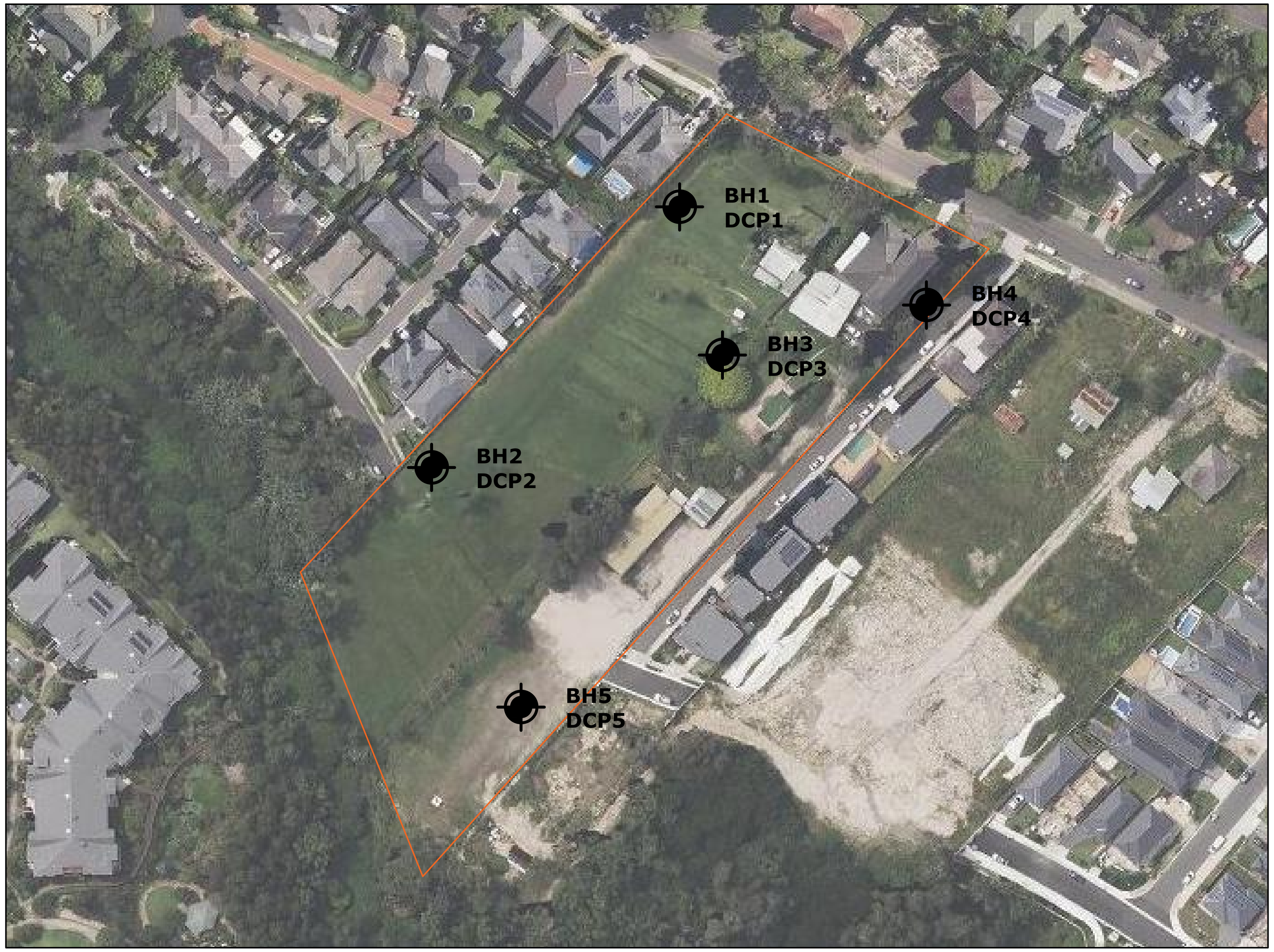
GEOTECHNICAL CONSULTANTS

Appendix 2



SITE PLAN & TEST LOCATIONS

FIGURE 1.

CROZIER GEOTECHNICAL CONSULTANTS

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Unit 12, 42-46 Wattle Road Phone: (02) 9939 1882
Brookvale NSW 2100 Fax: (02) 9939 1883
Crozier Geotechnical is a division of PJC Geo-Engineering Pty Ltd

LEGEND

PROPERTY BOUNDARY	BH / DCP AUGER / DYNAMIC CONE PENETROMETER LOCATION

SCALE:	1:800 @ A3
DRAWING:	FIGURE 1
DATE:	04 /2024
APPROVED BY:	TMC
DRAWN BY:	JD
PROJECT:	2023-108

PREPARED FOR:
Sekisui House

ADDRESS:
53a & 53b Warriewood Road, Warriewood

BOREHOLE LOG

CLIENT: Sekisui House **DATE:** 28/03/2024 **BORE No.:** 1

PROJECT: New Residential Development **PROJECT No.:** 2023-108 **SHEET:** 1 of 1

LOCATION: 53a & 53b Warriewood Road, Warriewood **SURFACE LEVEL:** Exst. GL

Depth (m)	Classification	Description of Strata PRIMARY SOIL - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
			Type	Tests	Type	Results
0.00		Fill: compacted gravelly sand with sandstone cobbles and building refuse				
1.50	CL	CLAY: very stiff, yellow/brown, medium palsticity, moist silty clay with ironstone gravels, interpreted to be residual				
2.00		… red brown				
2.40		… hard				
2.50		… red/brown with grey and yellow mottle				
3.50		… grey with red mottle and ironstone gravel bands				
4.10		End borehole @ 4.10m depth within hard residual clays				

RIG: Dingo - restricted access drill rig DRILLER: AC

METHOD: Solid Stem Spiral Flighted Augers with Tungsten Carbide Bit LOGGED: JD

GROUND WATER OBSERVATIONS: Not encountered

REMARKS: CHECKED: BT

BOREHOLE LOG

CLIENT: Sekisui House **DATE:** 28/03/2024 **BORE No.:** 2

PROJECT: New Residential Development **PROJECT No.:** 2023-108 **SHEET:** 1 of 2

LOCATION: 53a & 53b Warriewood Road, Warriewood **SURFACE LEVEL:** Exst. GL

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
0.00			Type	Tests	Type	Results
		Tospoil/Fill: compacted gravelly sand with miscelaneous building refuse				
1.00		… decrease in refuse, potentially controlled fill/disturbed natural material				
2.00	CL	CLAY: very stiff, yellow/brown with grey mottle, medium plasticity, moist silty				
2.60		… hard				
3.50		… grey with yellow mottle				
4.00	SC/CL	Sandy CLAY: hard (interpreted) grey, medium plasticity, wet/saturated, interpreted to be alluvial				

RIG: Dingo - restricted access drill rig DRILLER: AC

METHOD: Solid Stem Spiral Flighted Augers with Tungsten Carbide Bit LOGGED: JD

GROUND WATER OBSERVATIONS: Saturated soils encountered below 4.00m, water level in borehole rose to 2.50m below existing ground levels

REMARKS: CHECKED: BT

BOREHOLE LOG

CLIENT: Sekisui House **DATE:** 28/03/2024 **BORE No.:** 2

PROJECT: New Residential Development **PROJECT No.:** 2023-108 **SHEET:** 2 of 2

LOCATION: 53a & 53b Warriewood Road, Warriewood **SURFACE LEVEL:** Exst. GL

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
			Type	Tests	Type	Results
0.00		Sandy CLAY: hard (interpreted) grey, medium plasticity, wet/saturated				
7.00		End borehole @ 7.00m depth within saturated grey sandy clay				

RIG: Dingo - restricted access drill rig DRILLER: AC

METHOD: Solid Stem Spiral Flighted Augers with Tungsten Carbide Bit LOGGED: JD

GROUND WATER OBSERVATIONS: Saturated soils encountered below 4.00m, water level in borehole rose to 2.50m below existing ground levels

REMARKS: CHECKED: BT

BOREHOLE LOG

CLIENT: Sekisui House **DATE:** 28/03/2024 **BORE No.:** 3

PROJECT: New Residential Development **PROJECT No.:** 2023-108 **SHEET:** 1 of 1

LOCATION: 53a & 53b Warriewood Road, Warriewood **SURFACE LEVEL:** Exst. GL

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
5.00			Type	Tests	Type	Results
		Topsoil/Fill: loose, light brown sandy silt with roots, dry/moist				
0.50	CL	CLAY: hard, yellow/brown with red mottle , medium plasticity, moist/dry silty clay, interpreted to be alluvial				
1.50		… with red and grey mottle				
2.00		… grey with red and yellow mottle				
2.30		… grey with red mottle				
3.00		… moist/wet				
4.00		End borehlole @ 4.00m depth within hard (interpreted) alluvial clay soils				

RIG: Not applicable DRILLER: JD

METHOD: Hand Auger LOGGED: JD

GROUND WATER OBSERVATIONS: Wet soils encountered below 3.00m depth

REMARKS: CHECKED: BT

BOREHOLE LOG

CLIENT: Sekisui House **DATE:** 28/03/2024 **BORE No.:** 4

PROJECT: New Residential Development **PROJECT No.:** 2023-108 **SHEET:** 1 of 1

LOCATION: 53a & 53b Warriewood Road, Warriewood **SURFACE LEVEL:** Exst. GL

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
			Type	Tests	Type	Results
0.00		Fill: gravelly sand with building refuse				
1.20	CL	CLAY: very stiff, orange/brown, medium palsticity, moist silty clay with ironstone gravels, interpreted to be residual				
1.50		… hard				
2.00		… red brown with ironstone gravels				
4.10		End borehole @ 4.10m depth within hard residual clays				

RIG: Dingo - restricted access drill rig DRILLER: AC

METHOD: Solid Stem Spiral Flighted Augers with Tungsten Carbide Bit LOGGED: JD

GROUND WATER OBSERVATIONS: Not encountered

REMARKS: CHECKED: BT

BOREHOLE LOG

CLIENT: Sekisui House **DATE:** 28/03/2024 **BORE No.:** 5

PROJECT: New Residential Development **PROJECT No.:** 2023-108 **SHEET:** 1 of 2

LOCATION: 53a & 53b Warriewood Road, Warriewood **SURFACE LEVEL:** Exst. GL

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling: Type	Sampling: Tests	In Situ Testing: Type	In Situ Testing: Results
0.00		Fill: compacted gravelly sand with building refuse				
1.20	OL/CL	CLAY: stiff, dark grey (black) organic rich (peaty) medium to high palsticity, moist/wet with trace sand				
1.80		… very stiff				
2.20	CL	CLAY: hard, grey with yellow mottle, moist silty clay				
3.00		… wet				
3.80		… with some sand				
4.00		Sandy CLAY: hard (interpreted) grey with yellow mottle, medium plasticity, wet/saturated sandy clay				
4.50		… icrease in silt/decrease in sand				

RIG: Dingo - restricted access drill rig DRILLER: AC

METHOD: Solid Stem Spiral Flighted Augers with Tungsten Carbide Bit LOGGED: JD

GROUND WATER OBSERVATIONS: Saturated soils encountered below 4.00m, water level in borehole rose to 3.00m below existing ground levels

REMARKS: CHECKED: BT

BOREHOLE LOG

CLIENT: Sekisui House **DATE:** 28/03/2024 **BORE No.:** 5

PROJECT: New Residential Development **PROJECT No.:** 2023-108 **SHEET:** 2 of 2

LOCATION: 53a & 53b Warriewood Road, Warriewood **SURFACE LEVEL:** Exst. GL

Depth (m) 5.00	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
			Type	Tests	Type	Results
5.50		… increse in sand/decrease in silt				
7.00		End borehole @ 7.00m depth within saturated grey sandy clay				

RIG: Dingo - restricted access drill rig DRILLER: AC

METHOD: Solid Stem Spiral Flighted Augers with Tungsten Carbide Bit LOGGED: JD

GROUND WATER OBSERVATIONS: Saturated soils encountered below 4.00m, water level in borehole rose to 3.00m below existing ground levels

REMARKS: CHECKED: BT

DYNAMIC PENETROMETER TEST SHEET

CLIENT: Sekisui House **DATE:** 28/03/2024
PROJECT: New Residential Development **PROJECT No.:** 2023-108
LOCATION: 53a & 53b Warriewood Road, Warriewood **SHEET:** 1 of 1

	Test Location									
Depth (m)	1	1a	2	2a	3	4	5	5a	5b	5c
0.00 - 0.10	8	-	5	-	1	4	12	2	11	-
0.10 - 0.20	8	-	6	-	2	1	8	12	8	-
0.20 - 0.30	17	-	5	-	4	4	16	8	10	-
0.30 - 0.40	end	12	5	-	4	6	10	4	18	-
0.40 - 0.50		14	9	-	3	4	9	9	end	-
0.50 - 0.60		6	7	-	4	2	8	2		-
0.60 - 0.70		6	10	-	9	6	8	4		-
0.70 - 0.80		6	13		9	8	5	b@0.70		-
0.80 - 0.90		7	end	5	10	12	9			-
0.90 - 1.00		6		12	13	11	b@0.85			-
1.00 - 1.10		5		8	10	13				11
1.10 - 1.20		4		8	12	11				5
1.20 - 1.30		5		13	16	6				3
1.30 - 1.40		5		6	end	7				4
1.40 - 1.50		7		14		8				4
1.50 - 1.60		8		10		9				6
1.60 - 1.70		8		10		8				5
1.70 - 1.80		10		7		9				5
1.80 - 1.90		7		7		9				5
1.90 - 2.00		7		7		10				6
2.00 - 2.10		8		7		9				6
2.10 - 2.20		9		10		9				7
2.20 - 2.30		9		9		10				8
2.30 - 2.40		9		8		10				8
2.40 - 2.50		9		9		11				9
2.50 - 2.60		9		9		11				10
2.60 - 2.70		10		10		end				10
2.70 - 2.80		10		11						11
2.80 - 2.90		13		12						end
2.90 - 3.00		end		end						
3.00 - 3.10										
3.10 - 3.20										
3.20 - 3.30										
3.30 - 3.40										
3.40 - 3.50										
3.50 - 3.60										
3.60 - 3.70										
3.70 - 3.80										
3.80 - 3.90										
3.90 - 4.00										

TEST METHOD: AS 1289. F3.2, CONE PENETROMETER

REMARKS:
(B) Test hammer bouncing upon refusal on solid object
-- No test undertaken at this level due to prior excavation of soils

CROZIER
GEOTECHNICAL CONSULTANTS

Appendix 3

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 347940

Client Details

Client	Crozier Geotechnical Consultants
Attention	Troy Crozier
Address	Unit 12/42-46 Wattle Rd, Brookvale, NSW, 2100

Sample Details

Your Reference	**2023-108, 53a & 53b Warriewood Road, Warriewood**
Number of Samples	6 Soil
Date samples received	03/04/2024
Date completed instructions received	03/04/2024

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	10/04/2024
Date of Issue	10/04/2024

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Jenny He, Senior Chemist

Authorised By
Nancy Zhang, Laboratory Manager

Misc Inorg - Soil			
Our Reference		347940-1	347940-3
Your Reference	UNITS	BH5	BH5
Depth		1.5	3.5
Type of sample		Soil	Soil
Date prepared	-	04/04/2024	04/04/2024
Date analysed	-	04/04/2024	04/04/2024
pH 1:5 soil:water	pH Units	6.4	6.2
Electrical Conductivity 1:5 soil:water	µS/cm	100	86
Chloride, Cl 1:5 soil:water	mg/kg	36	55
Sulphate, SO4 1:5 soil:water	mg/kg	40	20

sPOCAS field test						
Our Reference		347940-2	347940-3	347940-4	347940-5	347940-6
Your Reference	UNITS	BH5	BH5	BH5	BH2	BH1
Depth		2.5	3.5	5.0	5.5	2.0
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	03/04/2024	03/04/2024	03/04/2024	03/04/2024	03/04/2024
Date analysed	-	08/04/2024	08/04/2024	08/04/2024	08/04/2024	08/04/2024
pH_F (field pH test)	pH Units	5.0	6.2	6.1	5.5	5.0
pH_{FOX} (field peroxide test)	pH Units	2.7	3.6	3.0	3.9	3.0
Reaction Rate*	-	High reaction	Medium reaction	Medium reaction	Medium reaction	Medium reaction

Chromium Suite			
Our Reference		347940-2	347940-4
Your Reference	UNITS	BH5	BH5
Depth		2.5	5.0
Type of sample		Soil	Soil
Date prepared	-	03/04/2024	03/04/2024
Date analysed	-	04/04/2024	04/04/2024
pH_{kcl}	pH units	4.4	4.7
s-TAA pH 6.5	%w/w S	0.05	0.02
TAA pH 6.5	moles H^+/t	32	10
Chromium Reducible Sulfur	%w/w	0.04	0.03
a-Chromium Reducible Sulfur	moles H^+/t	25	17
S_{HCl}	%w/w S	0.012	[NT]
S_{KCl}	%w/w S	<0.005	[NT]
S_{NAS}	%w/w S	0.018	[NT]
ANC_{BT}	% $CaCO_3$	[NT]	[NT]
s-ANC_{BT}	%w/w S	[NT]	[NT]
s-Net Acidity	%w/w S	0.11	0.043
a-Net Acidity	moles H^+/t	66	27
Liming rate	kg $CaCO_3$/t	5	2
a-Net Acidity without ANCE	moles H^+/t	66	27
Liming rate without ANCE	kg $CaCO_3$/t	5.0	2.0
s-Net Acidity without ANCE	%w/w S	0.11	0.043

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell.
Inorg-063	pH- measured using pH meter and electrode. Soil is oxidised with Hydrogen Peroxide or extracted with water. To ensure accurate results these tests are recommended to be done in the field as pH may change with time thus these results may not be representative of true field conditions.
Inorg-068	Chromium Reducible Sulfur - Hydrogen Sulfide is quantified by iodometric titration after distillation to determine potential acidity. Net acidity including ANC has a safety factor of 1.5 applied. Neutralising value (NV) of 100% is assumed for liming rate. The recommendation that the SHCL concentration be multiplied by a factor of 2 to ensure retained acidity is not underestimated, has not been applied in the SHCL result. However, it has been applied in the SNAS calculation: SNAS % = (SHCL-SKCL)x2
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			04/04/2024	3	04/04/2024	04/04/2024		04/04/2024	[NT]
Date analysed	-			04/04/2024	3	04/04/2024	04/04/2024		04/04/2024	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	3	6.2	6.2	0	100	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	3	86	87	1	102	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	3	55	54	2	101	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	3	20	20	0	101	[NT]

QUALITY CONTROL: sPOCAS field test					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			03/04/2024	[NT]	[NT]	[NT]	[NT]	03/04/2024	[NT]
Date analysed	-			08/04/2024	[NT]	[NT]	[NT]	[NT]	08/04/2024	[NT]
pH_F (field pH test)	pH Units		Inorg-063	[NT]	[NT]	[NT]	[NT]	[NT]	100	[NT]
pH_{FOX} (field peroxide test)	pH Units		Inorg-063	[NT]	[NT]	[NT]	[NT]	[NT]	100	[NT]

QUALITY CONTROL: Chromium Suite					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			03/04/2024	2	03/04/2024	03/04/2024		03/04/2024	[NT]
Date analysed	-			04/04/2024	2	04/04/2024	04/04/2024		04/04/2024	[NT]
pH $_{kcl}$	pH units		Inorg-068	[NT]	2	4.4	4.4	0	96	[NT]
s-TAA pH 6.5	%w/w S	0.01	Inorg-068	<0.01	2	0.05	0.05	0	[NT]	[NT]
TAA pH 6.5	moles H^+/t	5	Inorg-068	<5	2	32	33	3	94	[NT]
Chromium Reducible Sulfur	%w/w	0.005	Inorg-068	<0.005	2	0.04	0.04	0	98	[NT]
a-Chromium Reducible Sulfur	moles H^+/t	3	Inorg-068	<3	2	25	25	0	[NT]	[NT]
S_{HCl}	%w/w S	0.005	Inorg-068	<0.005	2	0.012	0.012	0	[NT]	[NT]
S_{KCl}	%w/w S	0.005	Inorg-068	<0.005	2	<0.005	<0.005	0	[NT]	[NT]
S_{NAS}	%w/w S	0.005	Inorg-068	<0.005	2	0.018	0.017	6	[NT]	[NT]
ANC_{BT}	% $CaCO_3$	0.05	Inorg-068	<0.05	2	[NT]	[NT]		100	[NT]
s-ANC_{BT}	%w/w S	0.05	Inorg-068	<0.05	2	[NT]	[NT]		[NT]	[NT]
s-Net Acidity	%w/w S	0.005	Inorg-068	<0.005	2	0.11	0.11	0	[NT]	[NT]
a-Net Acidity	moles H^+/t	5	Inorg-068	<5	2	66	66	0	[NT]	[NT]
Liming rate	kg $CaCO_3$/t	0.75	Inorg-068	<0.75	2	5	5	0	[NT]	[NT]
a-Net Acidity without ANCE	moles H^+/t	5	Inorg-068	<5	2	66	66	0	[NT]	[NT]
Liming rate without ANCE	kg $CaCO_3$/t	0.75	Inorg-068	<0.75	2	5.0	5.0	0	[NT]	[NT]
s-Net Acidity without ANCE	%w/w S	0.005	Inorg-068	<0.005	2	0.11	0.11	0	[NT]	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Where matrix spike recoveries fall below the lower limit of the acceptance criteria (e.g. for non-labile or standard Organics <60%), positive result(s) in the parent sample will subsequently have a higher than typical estimated uncertainty (MU estimates supplied on request) and in these circumstances the sample result is likely biased significantly low.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

CALIFORNIA BEARING RATIO REPORT

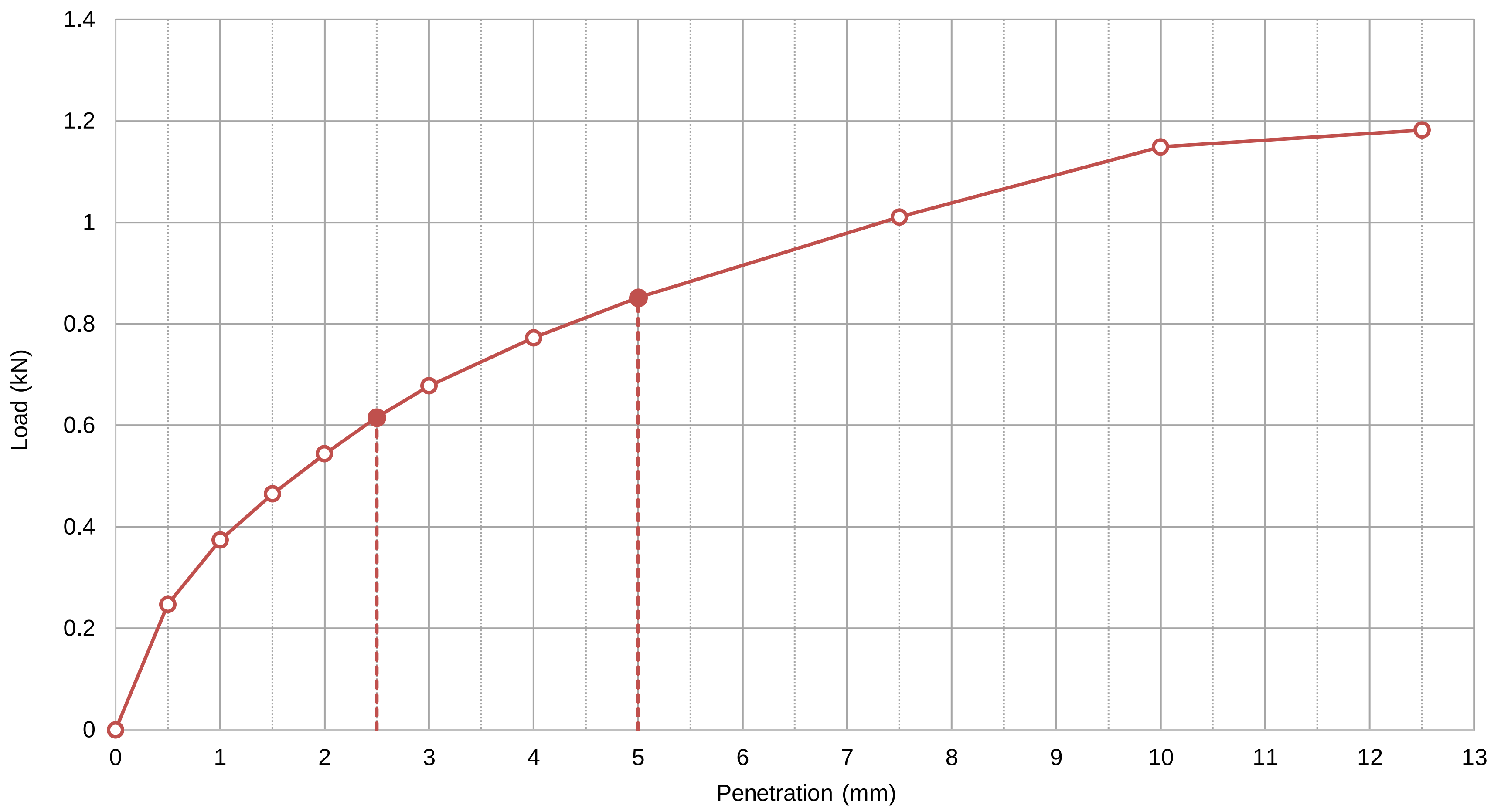
Client	Crozier Geotech	**Source**	BH3a 0.50m
Address	Unit 12/ 42-46 Wattle Street Brookvale NSW 2100	**Sample Description**	Silty Sandy CLAY
Project	53a & 53b Warriewood Road (2023-108)	**Report No.**	S95379-CBR
Job No.	S24155-1	**Sample No.**	S95379

Test Procedure

☑ AS 1289.6.1.1	☐ RMS T117	California Bearing Ratio
☑ AS 1289.5.1.1	☐ RMS T111	Dry Density / Moisture Content Relationship - Standard Compaction
☐ AS 1289.5.2.1	☐ RMS T112	Dry Density / Moisture Content Relationship - Modified Compaction
☑ AS 1289.2.1.1	☐ RMS T120	Moisture Content - Oven Drying Method (Standard Method)

Sampling Sampled by Client - results apply to the sample as received **Date Sampled** 28/03/2024

Preparation Prepared in accordance with the test method **Date Tested** 15/04/2024



Preparation & Specification		Density & Moisture	Achieved	Target
Retained on 19.0mm Sieve (%)	0	Lab Moisture Ratio - LMR (%)	101.5	100.0
Method of Establishing Plasticity Level	Technician Assessment	Lab Density Ratio - LDR (%)	95.0	95.0
Sample Curing Time (hrs)	49 hrs	Dry Density - At Compaction (t/m³)	1.72	1.72
Compaction Hammer Used	Standard	Dry Density - After Soaking (t/m³)	1.71	
Surcharge Mass Applied (kg)	4.5	Specimen Swell (%)	0.7	
Period of Soaking (Days)	4	Moisture Content - At Compaction (%)	16.6	
Maximum Dry Density - MDD (t/m³)	1.81	Moisture Content - Top 30mm (%)	19.0	
Optimum Moisture Content - OMC (%)	16.3	Moisture Content - Remainder (%)	18.4	

Material CBR Value (%): 4.5 at a penetration of 2.5 mm

Notes

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NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

Date: 17/04/2024

MACQUARIE GEOTECH

Macquarie Geotechnical
14 Carter St
Lidcombe NSW 2141

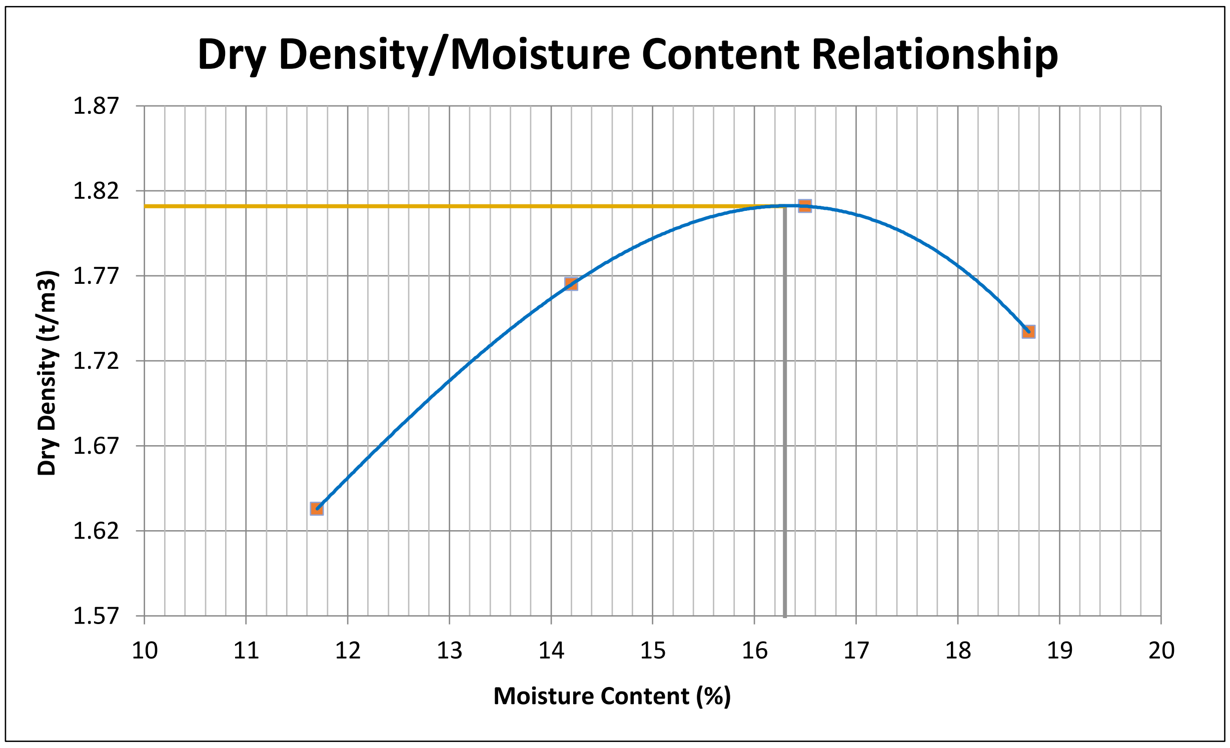
DRY DENSITY / OPTIMUM MOISTURE CONTENT REPORT

Client	Crozier Geotech	**Source**	BH3a 0.50m
Address	Unit 12/ 42-46 Wattle Street Brookvale NSW 2100	**Sample Description**	Sandy Silty CLAY
Project	53a & 53b Warriewood Road (2023-108)	**Report No**	S95379-MDD
Job No	S24155-1	**Sample No**	S95379

Test Procedure ☑ AS1289.5.1.1 Dry Density / Moisture Content Relationship - Standard Compaction
☑ AS1289.2.1.1 Moisture Content - Oven Drying Method (Standard Method)

Sampling Sampled by Client - results apply to the sample as received **Date Sampled** 28/03/2024

Preparation Prepared in accordance with the test method **Date Tested** 8/04/2024



Maximum Dry Density (t/m³)	1.81
Optimum Moisture Content (%)	16.3
Oversize Retained on 19mm sieve (%)	0
Oversize Retained on 37.5mm sieve (%)	0
Curing Time	69 hrs
Liquid Limit Determination	Technician Assessment

Notes

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Jacob Lloyd

Date: 9/04/2024

MACQUARIE GEOTECH

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Lidcombe NSW 2141

Shrink-Swell Index Report

Client	Crozier Geotech	**Source**	BH3 0.50m
Address	Unit 12/ 42-46 Wattle Street Brookvale NSW 2100	**Sample Description**	Silty CLAY
Project	53a & 53b Warriewood Road (2023-108)	**Report No**	S95380-SS
Job No	S24155-1	**Lab No**	S95380

Test Procedure	AS 1289.7.1.1 Soil reactivity tests - Determination of the shrinkage index of a soil - Shrink-swell index		
Sampling	Sampled by Client - results apply to the sample as received	**Date Sampled**	28/03/2024
Preparation	Prepared in accordance with the test method	**Date Tested**	8/04/2024

Sample Type	
Undisturbed	
Swell Test	
Swell on Saturation(E_{SW})	0.0
Moisture Content Before Test (%)	17.4
Moisture Content After Test (%)	18.3
Shrink Test	
Shrinkage on Drying (E_{SH}%)	2.4
Estimated Inert Material Present (%)	0.0
Extent of Crumbling During Shrinkage	Nil
Extent of Cracking During Shrinkage	Nil
Moisture Content (%)	19.1
Shrink-Swell Index	
I_{ss} (percentage vertical strain per pF change in total suction)	**1.3**

Notes

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Date: 9/04/2024

MACQUARIE GEOTECH

Macquarie Geotechnical

14 Carter Street Lidcombe NSW 2141

Shrink-Swell Index Report

Client	Crozier Geotech	**Source**	BH4 0.70m
Address	Unit 12/ 42-46 Wattle Street Brookvale NSW 2100	**Sample Description**	Silty Sandy CLAY, Trace of Gravel
Project	53a & 53b Warriewood Road (2023-108)	**Report No**	S95381-SS
Job No	S24155-1	**Lab No**	S95381

Test Procedure	AS 1289.7.1.1 Soil reactivity tests - Determination of the shrinkage index of a soil - Shrink-swell index		
Sampling	Sampled by Client - results apply to the sample as received	**Date Sampled**	28/03/2024
Preparation	Prepared in accordance with the test method	**Date Tested**	5/04/2024

Sample Type	
Undisturbed	
Swell Test	
Swell on Saturation(E_{SW})	0.0
Moisture Content Before Test (%)	14.0
Moisture Content After Test (%)	16.2
Shrink Test	
Shrinkage on Drying (E_{SH}%)	0.4
Estimated Inert Material Present (%)	13.0
Extent of Crumbling During Shrinkage	Mild
Extent of Cracking During Shrinkage	Mild
Moisture Content (%)	10.3
Shrink-Swell Index	
I_{ss} (percentage vertical strain per pF change in total suction)	**0.2**

Notes

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9/04/2024

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14 Carter Street Lidcombe NSW 2141

SOIL CLASSIFICATION REPORT

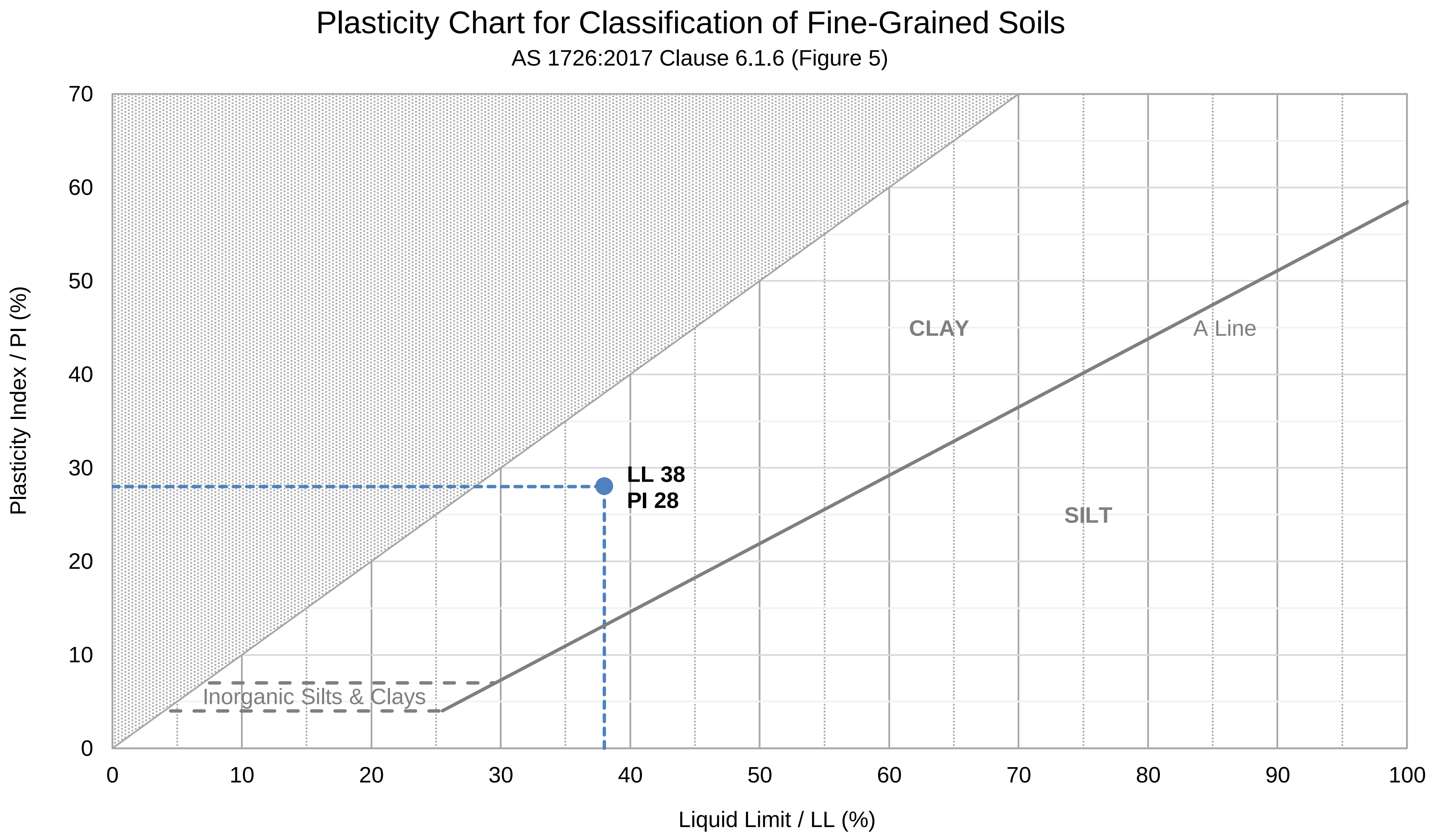
Client	Crozier Geotech	**Source**	BH2 2.50m
Address	Unit 12/ 42-46 Wattle Street Brookvale NSW 2100	**Sample Description**	Silty CLAY
Project	53a & 53b Warriewood Road (2023-108)	**Report No.**	S95382-PI
Job No.	S24155-1	**Lab No.**	S95382

Test Procedure

- ☐ AS1289 3.1.1 Liquid Limit - Four point Casagrande method
- ☐ AS1289 3.1.2 Liquid Limit - One point Casagrande method
- ☑ AS1289 3.2.1 Plastic Limit - Standard method
- ☑ AS1289 3.3.1 Calculation of the Plasticity Index
- ☐ AS1289 3.4.1 Linear Shrinkage - Standard method

Sampling Sampled by Client - results apply to the sample as received **Date Sampled** 28/03/2024

Preparation Prepared in accordance with the test method **Date Tested** 15/04/2024



Preparation

Method of Preparation	**Dry Sieved**
History of the Sample	**Air Dried**

Results

Liquid Limit / LL (%)	**38**
Plastic Limit (%)	**10**
Plasticity Index / PI (%)	**28**

Notes

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17/04/2024

Date:

MACQUARIE GEOTECH

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Lidcombe NSW 2141

MOISTURE CONTENT TEST REPORT

Client	Crozier Geotech	**Job #**	S24155-1
Address	Unit 12/ 42-46 Wattle Street Brookvale NSW 2100	**Report #**	S95383-MC
Project	53a & 53b Warriewood Road (2023-108)		

Test Procedure

- [x] AS 1289 2.1.1 Determination of the moisture content of a soil - Oven drying method (Standard method).
- [ ] AS4133 1.1.1 Determination of the moisture content of rock - Oven drying method (standard method)
- [ ] RMS T120 Moisture content of road construction materials (Standard method)
- [ ] RMS T262 Determination of moisture content of aggregates (Standard method)

Sampling Sampled by Client - results apply to the sample as received **Date Sampled** 28/03/2024

Preparation Prepared in accordance with the test method **Date Tested** 5/04/2024

Sample #	Source	Sample Description	Moisture Content %
S95383	BH2 2.00m	Silty CLAY	**16.3**
S95384	BH2 3.50m	Silty CLAY	**25.7**
S95385	BH2 4.00m	Silty CLAY	**21.1**
S95386	BH2 5.00m	Silty Sandy CLAY	**22.4**
S95387	BH1 1.50m	Silty CLAY	**19.4**
S95388	BH1 2.50m	Sandy Silty CLAY	**15.0**
S95389	BH1 3.70m	Silty CLAY	**20.9**

Notes

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Authorised Signatory:

Jacob Lloyd

8/04/2024

Date:

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