Wu Properties

# Geotechnical Assessment – 4 Minna Close, Belrose, NSW

P2208709JR01V01
August 2022

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

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**All enquiries regarding this project are to be directed to the Project Manager.**

# Contents

# Abbreviations

ABC – Allowable bearing capacity

BH – Borehole

DBYD – Dial before you dig

DCP – Dynamic cone penetrometer

DP – Deposited plan

kN – kilo Newtons

$kN/m^3$ – kilo Newtons per cubic metre

kPa – kilo Pascal

LGA – Local government area

MA – Martens & Associates Pty Ltd

mAHD – metres Australian height datum

mbgl – metres below ground level

MDD – Maximum dry density

MPa – Mega pascal

# 1 Proposed Development and Investigation Scope

Proposed development details and the investigation scope are summarised in Table 1.

**Table 1:** Summary of proposed development.

| Item | Details |
|---|---|
| Property Address | 4 Minna Close, Belrose, NSW 2085 ('the site'). |
| Lot / DP | Lot 502 in DP875858 (Land and Property Information, 2022). |
| Site Area | Approximately 5,581 $m^2$ (Bureau SRH, 2022). |
| LGA | Northern Beaches Council ('Council'). |
| Proposed Development | We understand from the concept plans (Bureau SRH, 2022) and client provided information that the development will include a new two – storey warehousing building with one basement level.<br>Bulk excavation up to a depth of approximately 5 metres below ground level (mbgl) is anticipated to be required to achieve bulk excavation levels. The proposal plans have been provided in Attachment D. |
| Assessment Purpose | A preliminary geotechnical investigation to support the Development Application (DA) for the proposed development. |
| Investigation Scope of Work | Field investigations conducted on 11 July 2022 included:<br>o A site walkover inspection.<br>o Review of DBYD plans and underground service location.<br>o Drilling of seven boreholes up to 3.4 mbgl.<br>o Eight Dynamic Cone Penetrometer (DCP) tests up to 2.4 mbgl.<br>o Collection of soil samples for future reference.<br>Investigation locations are shown in Figure 1, Attachment A. |

# 2 General Site Details and Investigation Findings

## 2.1 General Site Details

General site details are summarised in Table 2.

**Table 2:** Summary of general site details.

| Item | Comment |
|---|---|
| Topography | The general site topography comprised:<br>o Undulating to rolling rises on Hawkesbury sandstone.<br>o Dense forest and bushland.<br>o Slopes generally < 10 %, but steeper along slope cuttings near the eastern and western boundaries. |
| Typical Slopes | Approximately 5 – 10 % across the site. |
| Site Aspect | North east aspect in the northern portion and south west aspect in the southern portion of the site. |
| Site Elevation | Ranging between 189.63 mAHD in the north east corner and 181.5 mAHD in the south east corner (Bureau SRH, 2022). |
| Expected geology | The geological map (Sydney 1:100 000 Geological Sheet 9130) indicates the site is underlain by shale, laminite (Rhs) but close to the geological boundary of Hawkesbury sandstone (Rh) (Herbert C., 1983). |
| Expected soil landscape | The NSW Office of Environment and Heritage's (OEH) information system (eSPADE) indicates the site to be located at the transition between the Lambert, Hawkesbury and Blacktown soil landscapes. The Lambert and Hawkesbury soil landscapes generally comprise a shallow to moderately deep (50 – 150 cm) soil profile overlying Hawkesbury sandstone.<br>The Blacktown soil landscape encompassing the eastern portion of the site comprises shallow to moderately (< 100 cm) soils in upper slopes / well drained areas and deep (150 – 300 cm) soils in areas of poor drainage, overlying Wianamatta Group shales and Hawkesbury shales. |
| Vegetation | Grass, shrubs and mature trees. |
| Existing development | The existing site area is currently un-developed.<br>An approximately 1.5 – 2 m high retaining wall is present along the western site boundary, as part of the neighbouring development. |
| Neighbouring environment | At the time of the geotechnical investigation, the site was bounded by:<br>o Industrial properties on the eastern and western boundaries.<br>o Mona Vale Road, followed by bushland to the north<br>o Minna Close, followed by industrial development to the south. |
| Drainage | Via overland flow and into Council's stormwater network on Minna Close. |

## 2.2 Subsurface Conditions

Investigation revealed the following generalised subsurface units likely underlie the site below ground surface level:

Unit A: Inferred poorly compacted uncontrolled fill comprising silty clay / silty clayey sand, trace gravels and cobbles, up to 0.6 mbgl (BH102). Some plastic pieces were encountered in this fill.

Unit B: Topsoil comprising silty sandy clay, trace gravels, up to 0.5 mbgl (BH103).

Unit C: Residual soil comprising:

Unit C1: Silty sandy clay; firm to stiff, with iron indurated bands, up to 1.1 mbgl (BH108).

Unit C2: Silty sandy clay; very stiff, up to 2.7 mbgl (BH108).

Unit D: Residual silty clayey sand; dense to very dense, up to 1.2 mbgl (BH107).

Unit E: Highly weathered rock comprising:

Unit E1: Inferred very low to low strength shale, up to 3.3 mbgl, observed in BH108 only.

Unit E2: Inferred very low to low strength sandstone, up to a maximum TC-bit refusal depth 3.4 mbgl (BH108).

Given the geological setting and site topography, it is likely that low to medium (or higher) strength sandstone bedrock underlies TC-bit refusal depths.

DCP tests encountered hammer bounce in six tests, which may indicate the presence of bedrock or possibly boulders. DCP102 and DCP104 (as shown in Attachment A) are likely to have refused on boulders.

Encountered conditions are described in further detail in the borehole logs provided in Attachment B and associated explanatory notes in Attachment F. For DCP test results in Attachment C.

## 2.3 Groundwater Conditions

Groundwater inflow was encountered at 0.4 mbgl in BH101 and 0.7 mbgl in BH105. Given the heavy precipitation preceding and during the time of geotechnical investigation, inflow is considered likely the result of ephemeral perched groundwater within the soil profile and / or at the soil / rock interface.

If further information of the permanent groundwater levels are required, groundwater monitoring wells are recommended to be adopted.

# 3 Geotechnical Assessment

## 3.1 Preliminary Material Properties

Material properties inferred from observations during borehole drilling, such as auger penetration resistance, DCP and laboratory test results as well as engineering judgement are summarised in Table 3.

**Table 3:** Soil and rock strength properties.

| Layer | $\gamma_{in\text{-}situ}$ [1] (kN/m³) | Cu [2] (kPa) | C' [3] (kPa) | Ø' [4] (deg) | E' [5] (MPa) | $K_0$ [6] | $K_a$ [6] | $K_p$ [6] |
|---|---|---|---|---|---|---|---|---|
| Unit A – Uncontrolled FILL: Silty CLAY / Silty Clayey Sand (inferred poorly compacted) | 17 | NA [7] | 0 | 26 | 3 | 0.56 | 0.39 | 2.56 |
| Unit B – TOPSOIL : Silty Sandy CLAY | 17 | 15 | 0 | 26 | 2 | 0.56 | 0.39 | 2.56 |
| Unit C1 – RESIDUAL : Silty Sandy CLAY (firm to stiff) | 20 | 40 | 1 | 26 | 6 | 0.56 | 0.39 | 2.56 |
| Unit C2 – RESIDUAL : Silty Sandy CLAY (very stiff) | 20 | 100 | 5 | 26 | 12 | 0.56 | 0.39 | 2.56 |
| Unit D – RESIDUAL : Silty Clayey SAND (dense to very dense) | 19 | NA [7] | 0 | 33 | 18 | 0.46 | 0.29 | 3.39 |
| Unit E 1 – SHALE (inferred very low to low strength) | 22 | NA [7] | 25 | 28 | 75 | 0.50 | 0.33 | 3.00 |
| Unit E2 – SANDSTONE (inferred very low to low strength) | 22 | NA [7] | 40 | 30 | 80 | 0.50 | 0.33 | 3.00 |

**Notes:**

1. Inferred material in-situ unit weight, based on visual assessment and DCP testing.
2. Average undrained shear strength estimate assuming normally consolidated clay.
3. Average drained cohesion estimate.
4. Average effective internal friction angle estimate assuming drained conditions.
5. Average effective elastic modulus estimate.
6. $k_a$ = Coefficient of active earth pressure; $k_p$ = Coefficient of passive earth pressure; $k_0$ = Coefficient of earth pressure at rest. Assuming horizontal ground surface. Higher earth pressures will apply for sloping ground.
7. Not applicable.

## 3.2 Risk of Slope Instability

A moderate slope (15 – 20%) is present at the front of the property along the south eastern site boundary (near Minna Close). The south western boundary comprises a near vertical retaining wall and the north eastern boundary a steep slope likely constructed as part of the neighbouring property developments. However, the majority of the site area generally comprises gentle gradients ranging between 5 % – 10 %.

No evidence of former or current slope movement was observed at the site. We consider the risk to property and loss of life by potential slope instability, such as landslide or soil creep, to be low subject to the recommendations in this report and adoption of relevant engineering standards and guidelines.

A detailed slope risk assessment in accordance with Australian Geomechanics Society's Landslide Risk Management Guidelines (2007) was not undertaken.

# 4 Geotechnical Recommendations

## 4.1 Recommendations

The following specific recommendations are provided for the proposed development. General geotechnical recommendations are provided in Attachment E.

## 4.2 Excavatability

The proposed 5 m deep excavation is anticipated to mainly encounter soils and highly weathered very low to low strength rock, followed by low to medium (or higher) strength bedrock. Soils and very low to low strength rock should be readily excavated using conventional earthmoving equipment. Low strength rock and iron indurated bands may require a 'toothed' bucket or a ripping tyne (or similar) and progress may be slower. Low to medium (or higher) strength rock will require the use of hydraulic earthmoving equipment with a rock hammer attachment. Loose sandstone boulders / blocks are also likely to be encountered.

If low to medium or higher strength rock is to be excavated using a rock hammer, vibration management will be required in accordance with AS2187.2 (2006).

## 4.3 Temporary Batters and Excavation Support (Shoring)

Excavations must be temporarily and permanently battered back / supported / retained to maintain excavation stability and limit potential adverse impacts on surrounding structures / neighbouring properties. Appropriate support methodologies should be adopted by the excavation contractor and design engineer and approved by a geotechnical engineer.

Where there is sufficient setback between the basement and the site boundaries, the excavation may be temporarily battered back at:

- 1V:2H in soil.
- 1V:1H in highly weathered, very low to low strength sandstone.
- Vertical excavation in low to medium strength sandstone (if encountered) subject to inspection by a geotechnical engineer to assess stability of the rock face.

Batter slopes may not be suitable in some areas such as along the south western boundary, due to the adjacent retaining structure. The above batter slopes are also not suitable in areas of sloping ground, which would require structural support.

Temporary excavation batters are assumed to remain unsupported for no more than two months. Recommended batters are subject to inspection and approval by an experienced geotechnical engineer on site and should be followed by construction of permanent retaining structures.

Where there is insufficient setback between the basement and site boundaries or due to sloping ground, structural support should be provided (e.g. soldier pile or contiguous pile walls). Where excavation is greater than approximately 3 m or to minimise shoring wall deflection, consideration should be given to additional structural support such as ground anchors socketed into the bedrock or internal propping / bracing.

Shoring wall design should consider additional surcharge loading from live loads, new and existing structures, construction equipment, backfill compaction, sloping ground and hydrostatic pressures behind retaining walls. Retaining walls may be designed using the preliminary material properties provided in Table 3.

## 4.4 Rock Support

For unsupported vertical rock faces in low to medium strength bedrock, the presence of clay seams, steeply dipping joints and other rock defects, may have an adverse effect on unsupported rock face stability and construction safety. Geotechnical mapping of the excavation should be conducted in 1.0 m height increments to identify such features and allow early mitigation of risks of rock movement, such as by installation of rock bolts and / or sprayed shotcrete surfacing over fractured zones.

## 4.5 Foundation Recommendations

Bulk excavation is likely to expose variable strength bedrock (sandstone and shale) with potential for residual clay soils particularly along the south eastern boundary. Suitable foundations are likely to comprise pad footings founding in at least very low to low strength bedrock. An allowable bearing capacity of 500 kPa may be adopted for the very low to low strength bedrock. All footings should be founded in consistent material to minimise the risk of long term differential settlement.

For high level footings or where clay is exposed at bulk excavation level, deepened foundations such as bored piles socketed at least 1.0 m into very low to low strength sandstone bedrock may be adopted. An allowable bearing capacity and shaft friction of 600 kPa and 25 kPa respectively, may be adopted for the very low to low strength bedrock. Where higher bearing capacities are required, additional cored boreholes should carried out to confirm design parameters and shaft friction in higher strength bedrock.

All foundations should be located outside the zone of influence of adjacent structures.

We recommend that all foundations are inspected by an experienced geotechnical engineer to check adequacy of cleanliness of the base of excavation and to confirm adequate embedment / socket depth into design strata during construction.

### 4.6 Dilapidation Surveys

Dilapidation surveys of adjacent structures / infrastructure / properties should be carried out prior to excavation and following completion of the development.

### 4.7 Groundwater / Drainage Requirements

Groundwater inflow, if encountered during excavation, is anticipated to be managed by sump and pump methods. However the expected rate of groundwater inflow is currently unknown. Appropriate surface and sub-surface drainage should be provided to divert overland flows and limit ponding of water near footings and foundations.

All site discharges should be passed through a filter material prior to release. Collected flows should be directed (where possible) to a suitable stormwater system so as to prevent water accumulating in areas surrounding footings and pavements.

### 4.8 Preliminary Site Classification

The site is classified as Class "P" in accordance with AS 2870 (2011), due to the presence of uncontrolled clay fill up to 0.6 mbgl (BH102). A reclassification to Class “A” may be possible subject to all foundation founding on bedrock.

# 5 Works Prior to Construction

We recommend the following additional geotechnical works are carried out prior to construction:

1. Additional geotechnical investigation is required to confirm the depth to bedrock including rock coring and point load testing of collected rock samples to assess rock strength. Monitoring wells should also be installed to assess groundwater.

2. Prepare a geotechnical monitoring plan.

3. Review of the detailed design by a senior geotechnical engineer to confirm adequate consideration of the geotechnical risks and adoption of the recommendations provided in this report.

# 6 References


Bureau SRH (2022), *4 Minna Close Belrose, NSW 2085 Concept Design* Drawing No: SK100 – SK102, SK200 – SK201, SK500 – SK5005, revision 01, dated 21.12.2021 (Bureau SRH, 2022),

NSW Department of Environment & Heritage (2020) eSPADE, NSW soil and land information, www.environment.nsw.gov.au, accessed 7.07.2022.

Standards Australia Limited (2004) AS 1289.6.3.1:2004, *Determination of the penetration resistance of a soil – Standard penetration test (SPT)*, SAI Global Limited.

Standards Australia Limited (2017) AS 1726:2017, *Geotechnical site investigations*, SAI Global Limited.

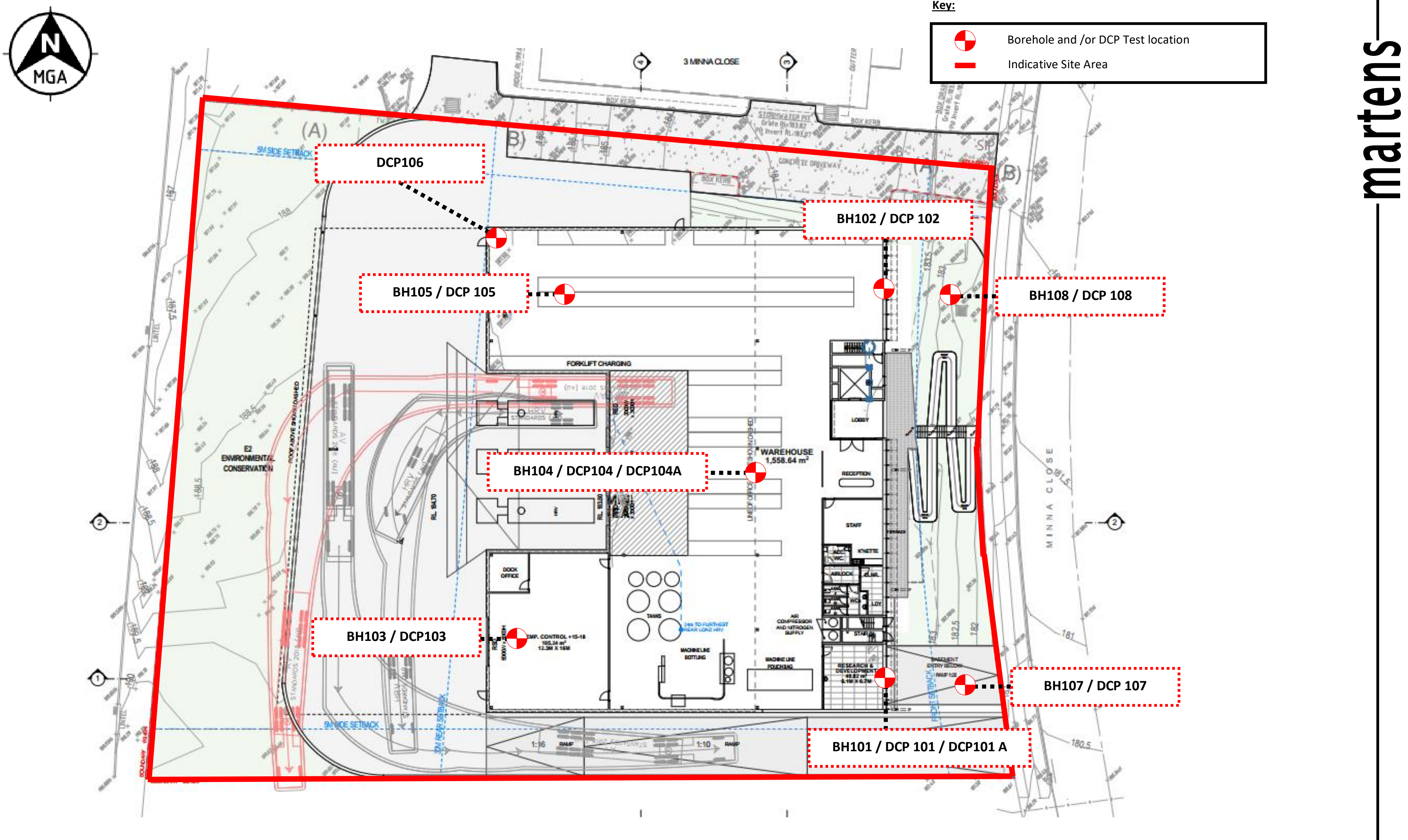
Standards Australia Limited (2009) AS 2159:2009, *Piling – Design and installation*, SAI Global Limited.

Standards Australia Limited (2011) AS 2870:2011, *Residential slabs and footings*, SAI Global Limited.

Standards Australia Limited (2018) AS 3600:2018, *Concrete Structures*, SAI Global Limited.

Standards Australia Limited (2007) AS 3798:2007, *Guidelines on earthworks for commercial and residential developments*, SAI Global Limited.

# 7 Attachment A – Geotechnical Testing Plan




| Martens & Associates Pty Ltd ABN 85 070 240 890 | | Environment \| Water \| Wastewater \| Geotechnical \| Civil \| Management | |
|---|---|---|---|
| Drawn: | MH | GEOTECHNICAL TESTING PLAN<br>4 MINNA CLOSE BELROSE, NSW<br>(Source: Bureau SRH, 2022) | Drawing No: FIGURE 1 |
| Approved: | KB | | |
| Date: | 15.07.2022 | | |
| Scale: | NA | | Job No: P2208709JR01V01 |

# 8 Attachment B – Test Borehole Logs

| CLIENT | Wu Properties | COMMENCED | 11/07/2022 | COMPLETED | 11/07/2022 | REF BH101 |
|---|---|---|---|---|---|---|
| PROJECT | Geotechnical Assessment | LOGGED | MH | CHECKED | KB | Sheet 1 OF 1 |
| SITE | 4 Minna Close, Belrose, NSW | GEOLOGY | Shale laminite | VEGETATION | Grass | PROJECT NO. P2208709 |
| EQUIPMENT | Hand Auger | LONGITUDE | 151.208006 | RL SURFACE | 183 m | DATUM AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 0.50 m depth | LATITUDE | -33.703853 | ASPECT | South East | SLOPE <5% |

| Drilling | | | | | Sampling | | Field Material Description | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | PENETRATION RESISTANCE | WATER | DEPTH (metres) | DEPTH RL | SAMPLE OR FIELD TEST | RECOVERED | GRAPHIC LOG | USCS / ASCS CLASSIFICATION | SOIL/ROCK MATERIAL DESCRIPTION | MOISTURE CONDITION | CONSISTENCY DENSITY | STRUCTURE AND ADDITIONAL OBSERVATIONS |
| HA | L | | | 183.00 | | | | CL-CI | FILL: Silty CLAY; low to medium plasticity; brown, black; trace gravels. | W | | FILL |
| | | | | 0.40 | 0.3-0.5/S/1 D 0.30-0.50 m | | | | | | | 0.30: 0.3m: Plastic pieces encountered. |
| | L-M | Inflow | 0.5 | 182.60 0.50 | | | | CI | Silty Sandy CLAY; medium plasticity; reddish brown, pale brown; trace iron indurated bands. | M (>PL) | VSt | RESIDUAL SOIL |
| | | | | | | | | | Hole Terminated at 0.50 m | | | 0.50: Hand auger refusal. |

1.0

1.5

2.0

2.5

3.0

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

martens



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**Engineering Log - BOREHOLE**

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P2208709BH101-109V01.GPJ <<DrawingFile>> 25/07/2022 15:36 10.02.00.04 Datgel Lab and In Situ Tool - DGD | Lib: Martens 2.00 2016-11-13 Prj: Martens 2.00 2016-11-13

| CLIENT | Wu Properties | COMMENCED | 11/07/2022 | COMPLETED | 11/07/2022 | REF BH102 |
|---|---|---|---|---|---|---|
| PROJECT | Geotechnical Assessment | LOGGED | MH | CHECKED | KB | Sheet 1 OF 1 |
| SITE | 4 Minna Close, Belrose, NSW | GEOLOGY | Shale laminite | VEGETATION | Grass | PROJECT NO. P2208709 |
| EQUIPMENT | 4WD ute-mounted hydraulic dril rig | LONGITUDE | 151.208334 | RL SURFACE | 183 m | DATUM AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 0.90 m depth | LATITUDE | -33.703697 | ASPECT | South East | SLOPE <5% |

| METHOD | PENETRATION RESISTANCE | WATER | DEPTH (metres) | DEPTH RL | SAMPLE OR FIELD TEST | RECOVERED | GRAPHIC LOG | USCS / ASCS CLASSIFICATION | SOIL/ROCK MATERIAL DESCRIPTION | MOISTURE CONDITION | CONSISTENCY DENSITY | STRUCTURE AND ADDITIONAL OBSERVATIONS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PT | L | Not Encountered | 0.5 | 183.00 | 0.3-0.5/S/1 D<br>0.30-0.50 m<br>0.5-0.7/S/1 D<br>0.50-0.70 m | | | CI | FILL: Silty CLAY; medium plasticity; brown, olive; trace rootlets. | M (>PL) | | FILL |
| | M-H<br>H | | | *0.60*<br>182.40 | | | | CL-CI | Silty Sandy CLAY; low to medium plasticity; pale brown, yellow, reddish brown; trace iron indurated bands. | M (<PL) | | RESIDUAL SOIL |
| | | | 1.0<br>1.5<br>2.0<br>2.5<br>3.0 | *0.90* | | | | | Hole Terminated at 0.90 m | | | 0.90: Push tube refusal. |

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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**Engineering Log - BOREHOLE**

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P2208709BH101-109V01.GPJ <<DrawingFile>> 25/07/2022 15:36 10.02.00.04 Datgel Lab and In Situ Tool - DGD | Lib: Martens 2.00 2016-11-13 Prj: Martens 2.00 2016-11-13

| | | | | | | |
|---|---|---|---|---|---|---|
| CLIENT | Wu Properties | COMMENCED | 11/07/2022 | COMPLETED | 11/07/2022 | **REF BH103** |
| PROJECT | Geotechnical Assessment | LOGGED | MH | CHECKED | KB | Sheet 1 OF 1 |
| SITE | 4 Minna Close, Belrose, NSW | GEOLOGY | Shale laminite | VEGETATION | Grass and Trees | PROJECT NO. P2208709 |
| EQUIPMENT | Hand Auger | LONGITUDE | 151.207775 | RL SURFACE | 188 m | DATUM AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 0.70 m depth | LATITUDE | -33.703555 | ASPECT | South East | SLOPE <5% |

| Drilling | | | | | Sampling | | Field Material Description | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | PENETRATION RESISTANCE | WATER | DEPTH (metres) | DEPTH RL | SAMPLE OR FIELD TEST | RECOVERED | GRAPHIC LOG | USCS / ASCS CLASSIFICATION | SOIL/ROCK MATERIAL DESCRIPTION | MOISTURE CONDITION | CONSISTENCY DENSITY | STRUCTURE AND ADDITIONAL OBSERVATIONS |
| HA | L | Not Encountered | | 188.00 | | | | CI | TOPSOIL: Silty Sandy CLAY; medium plasticity; brown, brown; trace gravels. | M (<PL) | | TOPSOIL |
| | M-H | | 0.5 | 0.50 187.50 | | | | CL-CI | Silty Sandy CLAY; low to medium plasticity; pale brown, yellow, reddish brown; trace iron indurated bands. | | VSt | RESIDUAL SOIL |
| | | | | 0.70 | | | | | Hole Terminated at 0.70 m | | | 0.70: Hand auger refusal. |
| | | | 1.0 | | | | | | | | | |
| | | | 1.5 | | | | | | | | | |
| | | | 2.0 | | | | | | | | | |
| | | | 2.5 | | | | | | | | | |
| | | | 3.0 | | | | | | | | | |

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**Engineering Log - BOREHOLE**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CLIENT | Wu Properties | COMMENCED | 11/07/2022 | COMPLETED | 11/07/2022 | **REF BH104** | |
| PROJECT | Geotechnical Assessment | LOGGED | MH | CHECKED | KB | Sheet 1 OF 1 | |
| SITE | 4 Minna Close, Belrose, NSW | GEOLOGY | Shale laminite | VEGETATION | Grass and Trees | PROJECT NO. P2208709 | |
| EQUIPMENT | Hand Auger | LONGITUDE | 150.208073 | RL SURFACE | 185 m | DATUM | AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 0.80 m depth | LATITUDE | -33.7034 | ASPECT | South East | SLOPE | <5% |

| Drilling | | | | | Sampling | | Field Material Description | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | PENETRATION RESISTANCE | WATER | DEPTH (metres) | DEPTH RL | SAMPLE OR FIELD TEST | RECOVERED | GRAPHIC LOG | USCS / ASCS CLASSIFICATION | SOIL/ROCK MATERIAL DESCRIPTION | MOISTURE CONDITION | CONSISTENCY DENSITY | STRUCTURE AND ADDITIONAL OBSERVATIONS |
| HA | L | Not Encountered | | 185.00 | | | | CI | TOPSOIL: Silty CLAY; medium plasticity; brown, pale brown; trace gravels. | M (<PL) | | TOPSOIL |
| | M-H | | 0.5 | 0.50<br>184.50 | | | | CI | Silty CLAY; medium plasticity; pale brown; trace gravels. | | VSt | RESIDUAL SOIL<br>0.70: Hand auger refusal. |
| | | | | 0.80 | | | | | Hole Terminated at 0.80 m | | | |
| | | | 1.0 | | | | | | | | | |
| | | | 1.5 | | | | | | | | | |
| | | | 2.0 | | | | | | | | | |
| | | | 2.5 | | | | | | | | | |
| | | | 3.0 | | | | | | | | | |

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**Engineering Log - BOREHOLE**

| CLIENT | Wu Properties | COMMENCED | 11/07/2022 | COMPLETED | 11/07/2022 | REF BH105 |
|---|---|---|---|---|---|---|
| PROJECT | Geotechnical Assessment | LOGGED | MH | CHECKED | KB | Sheet 1 OF 1 |
| SITE | 4 Minna Close, Belrose, NSW | GEOLOGY | Shale laminite | VEGETATION | Grass and Trees | PROJECT NO. P2208709 |
| EQUIPMENT | Hand Auger | LONGITUDE | 151.208121 | RL SURFACE | 187 m | DATUM AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 0.80 m depth | LATITUDE | -33.703386 | ASPECT | South East | SLOPE <5% |

| Drilling | | | | | Sampling | | Field Material Description | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | PENETRATION RESISTANCE | WATER | DEPTH (metres) | DEPTH RL | SAMPLE OR FIELD TEST | RECOVERED | GRAPHIC LOG | USCS / ASCS CLASSIFICATION | SOIL/ROCK MATERIAL DESCRIPTION | MOISTURE CONDITION | CONSISTENCY DENSITY | STRUCTURE AND ADDITIONAL OBSERVATIONS |
| HA | | | | 187.00 | | | | CI | TOPSOIL: Silty Sandy CLAY; medium plasticity; brown, brown; trace gravels. | M (>PL) | | TOPSOIL |
| HA | | Inflow | 0.5 | 0.50 186.50 | | | | CL-CI | Silty Sandy CLAY; low to medium plasticity; pale brown, yellow, reddish brown; trace iron indurated bands; trace gravels. | M (>PL) / W | F - St | RESIDUAL SOIL |
| | | | | 0.80 | | | | | Hole Terminated at 0.80 m | | | 0.80: Hand auger refusal. |
| | | | 1.0 | | | | | | | | | |
| | | | 1.5 | | | | | | | | | |
| | | | 2.0 | | | | | | | | | |
| | | | 2.5 | | | | | | | | | |
| | | | 3.0 | | | | | | | | | |

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS



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**Engineering Log - BOREHOLE**

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P2208709BH101-109V01.GPJ <<DrawingFile>> 25/07/2022 15:36 10.02.00.04 Datgel Lab and In Situ Tool - DGD | Lib: Martens 2.00 2016-11-13 Prj: Martens 2.00 2016-11-13

| CLIENT | Wu Properties | COMMENCED | 11/07/2022 | COMPLETED | 11/07/2022 | REF BH107 |
|---|---|---|---|---|---|---|
| PROJECT | Geotechnical Assessment | LOGGED | MH | CHECKED | KB | Sheet 1 OF 1 |
| SITE | 4 Minna Close, Belrose, NSW | GEOLOGY | Shale laminite | VEGETATION | Grass | PROJECT NO. P2208709 |
| EQUIPMENT | 4WD ute-mounted hydraulic dril rig | LONGITUDE | 151.208049 | RL SURFACE | 181 m | DATUM: AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 2.00 m depth | LATITUDE | -33.703931 | ASPECT | South East | SLOPE: <5% |

| METHOD | PENETRATION RESISTANCE | WATER | DEPTH (metres) | DEPTH RL | SAMPLE OR FIELD TEST | USCS / ASCS CLASSIFICATION | SOIL/ROCK MATERIAL DESCRIPTION | MOISTURE CONDITION | CONSISTENCY DENSITY | STRUCTURE AND ADDITIONAL OBSERVATIONS |
|---|---|---|---|---|---|---|---|---|---|---|
| AD/V | L | Not Encountered | | 181.00 | 0.3-0.5/S/1 D 0.30-0.50 m | SM-SC | FILL: Silty Clayey SAND; fine to medium grain; grey, pale grey; with gravels. | M | | FILL |
| AD/V | L | Not Encountered | 0.5 | 0.45 / 180.55 | 0.5-0.8/S/1 D 0.50-0.80 m | SM-SC | Silty Clayey SAND; fine to medium grain; grey, pale grey; trace gravels. | D | D / VD | RESIDUAL SOIL |
| AD/T | M | Not Encountered | 1.0 | 1.20 / 179.80 | 1.2-1.4/S/1 D 1.20-1.40 m | | SANDSTONE; highly weathered; grey, pale grey; inferred very low strength. | | | WEATHERED ROCK<br>1.20: V-bit refusal. |
| AD/T | M-H | Not Encountered | 1.5 | 1.50 / 179.50 | | | SANDSTONE; highly weathered; reddish brown, red; inferred very low to low strength. | | | |
| | | | 2.0 | 2.00 | | | Hole Terminated at 2.00 m | | | 2.00: TC-bit refusal on inferred low strength sandstone. |
| | | | 2.5 | | | | | | | |
| | | | 3.0 | | | | | | | |

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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**Engineering Log - BOREHOLE**

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P2208709BH101-109V01.GPJ <<DrawingFile>> 25/07/2022 15:36 10.02.00.04 Datgel Lab and In Situ Tool - DGD | Lib: Martens 2.00 2016-11-13 Prj: Martens 2.00 2016-11-13

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CLIENT | Wu Properties | COMMENCED | 11/07/2022 | COMPLETED | 11/07/2022 | **REF BH108** | |
| PROJECT | Geotechnical Assessment | LOGGED | MH | CHECKED | KB | Sheet 1 OF 1 | |
| SITE | 4 Minna Close, Belrose, NSW | GEOLOGY | Shale laminite | VEGETATION | Grass | PROJECT NO. P2208709 | |
| EQUIPMENT | 4WD ute-mounted hydraulic dril rig | LONGITUDE | 151.208363 | RL SURFACE | 181 m | DATUM | AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 3.40 m depth | LATITUDE | -33.703732 | ASPECT | South East | SLOPE | <5% |

| Drilling | | | | | Sampling | | Field Material Description | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | PENETRATION RESISTANCE | WATER | DEPTH (metres) | DEPTH RL | SAMPLE OR FIELD TEST | RECOVERED | GRAPHIC LOG | USCS / ASCS CLASSIFICATION | SOIL/ROCK MATERIAL DESCRIPTION | MOISTURE CONDITION | CONSISTENCY DENSITY | STRUCTURE AND ADDITIONAL OBSERVATIONS |
| AD/V | L | Not Encountered | | 181.00 | 0.2-0.3/S/1 D 0.20-0.30 m | | | CI-CH | TOPSOIL: Silty CLAY; medium to high plasticity; trace boulders. | M (>PL) | | TOPSOIL |
| | | | 0.5 | 0.45 180.55 | 0.6-0.7/S/1 D 0.60-0.70 m | | | CI-CH | Silty CLAY; medium to high plasticity; pale brown, brown, grey. | | VSt | RESIDUAL SOIL |
| | M | | 1.0 | 1.00 180.00 | 1.0-1.1/S/1 D 1.00-1.10 m | | | | Becoming grey, pale grey. | | St | |
| | | | 1.5 | | | | | | | | | |
| | | | 2.0 | | | | | | | | VSt | |
| | | | 2.5 | | 2.3-2.5/S/1 D 2.30-2.50 m | | | | | | | |
| | M-H | | | 2.70 178.30 | | | | | SHALE; highly weathered; dark grey, grey; inferred very low strength. | | | WEATHERED ROCK |
| AD/T | H | | 3.0 | 3.00 178.00 | | | | | SHALE; highly weathered; dark grey; inferred very low to low strength. | | | 3.00: V-bit refusal. |
| | | | | 3.30 177.70 | | | | | SANDSTONE; highly weathered; grey, white; inferred very low to low strength. | | | |
| | | | | 3.40 | | | | | Hole Terminated at 3.40 m | | | 3.40: TC-bit refusal on inferred low strength sandstone. |

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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**Engineering Log - BOREHOLE**

# 9 Attachment C – DCP ‘N’ Counts

# Dynamic Cone Penetrometer Test Log Summary

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| | | | |
|---|---|---|---|
| **Site** | 4 Minna Close, Belrose, NSW | **DCP Group Reference** | P2208709JS01V01 |
| **Client** | Wu Properties | **Log Date** | 11.07.2022 |
| **Logged by** | MH | | |
| **Checked by** | KB | | |
| **Comments** | DCPs commenced at 50 mm bgl. | | |

**TEST DATA**

| Depth Interval (m) | DCP101 | DCP101 A | DCP102 | DCP103 | DCP104 | DCP104 A | DCP105 | DCP106 |
|---|---|---|---|---|---|---|---|---|
| **0.15** | 1 | 1 | 3 | 3 | 1 | 1 | 1 | 2 |
| **0.30** | 2 | 2 | 5 | 2 | 13 | 2 | 2 | 2 |
| **0.45** | 14 | 22 | Terminated @ 0.3 mbgl due to hammer bounce. | 6 | Terminated @ 0.3 mbgl due to hammer bounce. | 4 | 2 | 2 |
| **0.60** | 22 | 14 | | 11 | | 10 | 3 | 9 |
| **0.75** | 9 | 9 | | 15 | | 14 | 4 | 18 |
| **0.90** | 10 | 8 | | 10 | | Terminated @ 0.75 mbgl due to hammer bounce. | 5 | 9 |
| **1.05** | 11 | 8 | | 12 | | | Terminated @ 0.75 mbgl due to hammer bounce. | 7 |
| **1.20** | 12 | 14 | | 15 | | | | 9 |
| **1.35** | 14 | 22 | | 23 | | | | 10 |
| **1.50** | 14 | 14 | | 13 | | | | Terminated @ 1.35 mbgl due to hammer bounce. |
| **1.65** | 16 | 19 | | 27 | | | | |
| **1.80** | 17 | Terminated @ 1.65 mbgl. Target Depth Reached. | | Terminated @ 1.65 mbgl due to hammer bounce. | | | | |
| **1.95** | 18 | | | | | | | |
| **2.10** | 22 | | | | | | | |
| **2.25** | 30 | | | | | | | |
| **2.40** | 30 | | | | | | | |
| **2.55** | Terminated @ 2.4 mbgl due to high blow counts. | | | | | | | |
| **2.70** | | | | | | | | |
| **2.85** | | | | | | | | |
| **3.00** | | | | | | | | |
| **3.15** | | | | | | | | |
| **3.30** | | | | | | | | |
| **3.45** | | | | | | | | |
| **3.60** | | | | | | | | |
| **3.75** | | | | | | | | |
| **3.90** | | | | | | | | |
| **4.05** | | | | | | | | |
| **4.20** | | | | | | | | |
| **4.35** | | | | | | | | |
| **4.50** | | | | | | | | |
| **4.65** | | | | | | | | |
| **4.80** | | | | | | | | |

# Dynamic Cone Penetrometer Test Log Summary

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| | | | |
|---|---|---|---|
| **Site** | 4 Minna Close, Belrose, NSW | **DCP Group Reference** | P2208709JS01V01 |
| **Client** | Wu Properties | **Log Date** | 11.07.2022 |
| **Logged by** | MH | | |
| **Checked by** | KB | | |
| **Comments** | DCPs commenced at 50 mm bgl. | | |

**TEST DATA**

| Depth Interval (m) | DCP107 | DCP108 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **0.15** | 3 | 1 | | | | | | |
| **0.30** | 11 | 2 | | | | | | |
| **0.45** | 11 | 3 | | | | | | |
| **0.60** | 6 | 8 | | | | | | |
| **0.75** | 12 | 13 | | | | | | |
| **0.90** | 20 | 16 | | | | | | |
| **1.05** | 17 | 6 | | | | | | |
| **1.20** | 24 | 5 | | | | | | |
| **1.35** | Terminated @ 1.2 mbgl due to hammer bounce. | 8 | | | | | | |
| **1.50** | | 9 | | | | | | |
| **1.65** | | 12 | | | | | | |
| **1.80** | | 15 | | | | | | |
| **1.95** | | 30 | | | | | | |
| **2.10** | | 27 | | | | | | |
| **2.25** | | 22 | | | | | | |
| **2.40** | | 24 | | | | | | |
| **2.55** | | Terminated @ 2.4 mbgl due to high blow counts | | | | | | |
| **2.70** | | | | | | | | |
| **2.85** | | | | | | | | |
| **3.00** | | | | | | | | |
| **3.15** | | | | | | | | |
| **3.30** | | | | | | | | |
| **3.45** | | | | | | | | |
| **3.60** | | | | | | | | |
| **3.75** | | | | | | | | |
| **3.90** | | | | | | | | |
| **4.05** | | | | | | | | |
| **4.20** | | | | | | | | |
| **4.35** | | | | | | | | |
| **4.50** | | | | | | | | |
| **4.65** | | | | | | | | |
| **4.80** | | | | | | | | |

# 10 Attachment D – Proposed Development Plans

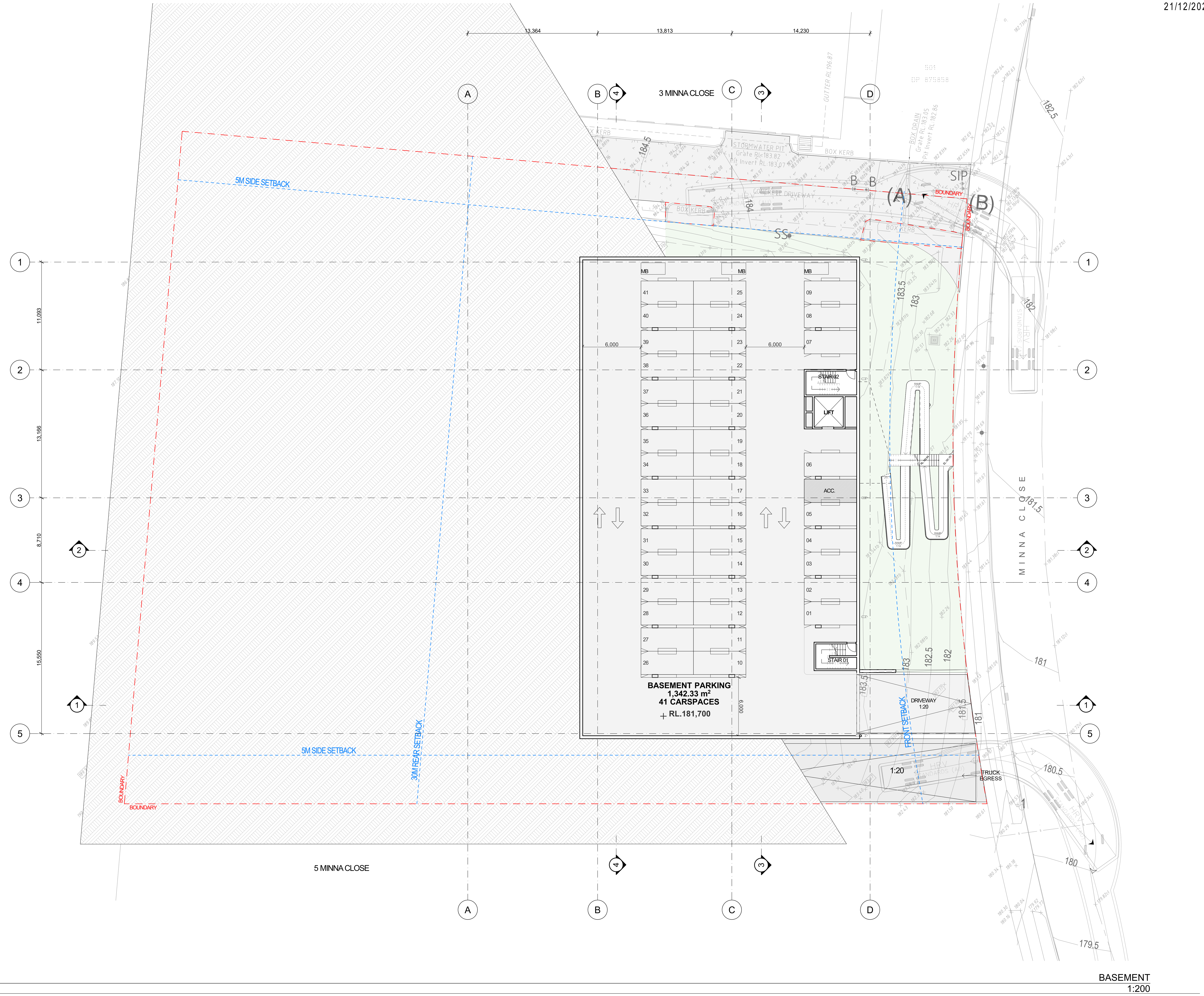
# PRELIMINARY PLANS
## BASEMENT
## 1:200

/ SEPARATE HEAVY/ STAFF VEHICLE ENTRIES

/ EAST ACCESS SHARED WITH EXISTING DRIVEWAY

/ ON-GRADE STAFF PARKING ACCESS

/ 41 CARSPACES




WU PROPERTIES

BUREAU SRH
architecture

# PRELIMINARY PLANS
## GROUND
## 1:200

/ HIGH CLEARANCE WAREHOUSE (UP TO 13.5m)

/ PRODUCTION ZONE 5M CLEARANCE

/ HRV LOADING BAY + HARDSTAND

/ OFFICE LOBBY & PRODUCTION VIEWING

/ 15/16m x 14m STRUCTURAL GRID

/ PALLET CAPACITY: APPROX. 1,300 (TBC)

/ PACKAGING LINE WITH NITROGEN SUPPLY

/ PROVISION FOR 7 x OIL TANKS
AS PER SPEC. PROVIDED

/ R&D LAB WITH WASH BAY

/ COOLROOM APPROX 200m$^2$ to +15-18°C WITH
2 ACCESS POINTS

/ LOADING DOCK OFFICE
FOR QUALITY CONTROL

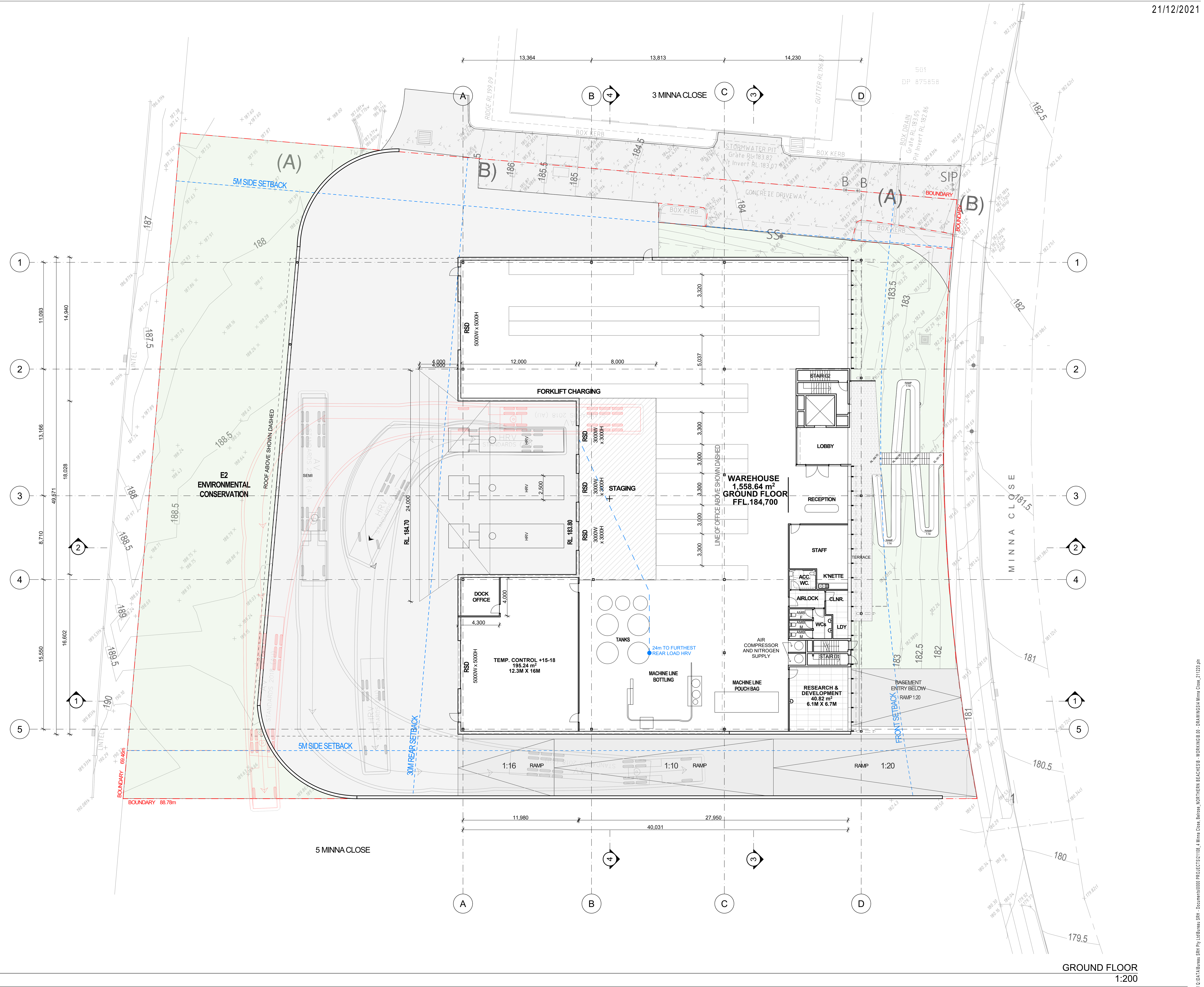
/ FORKLIFT CHARGING BAYS

/ END-OF-TRIP FACILITIES

/ LAUNDRY FACILITY

/ STAFF LUNCHROOM

/ PARKING SPACES




GROUND FLOOR
1:200

# PRELIMINARY PLANS
## LEVEL 01
## 1:200

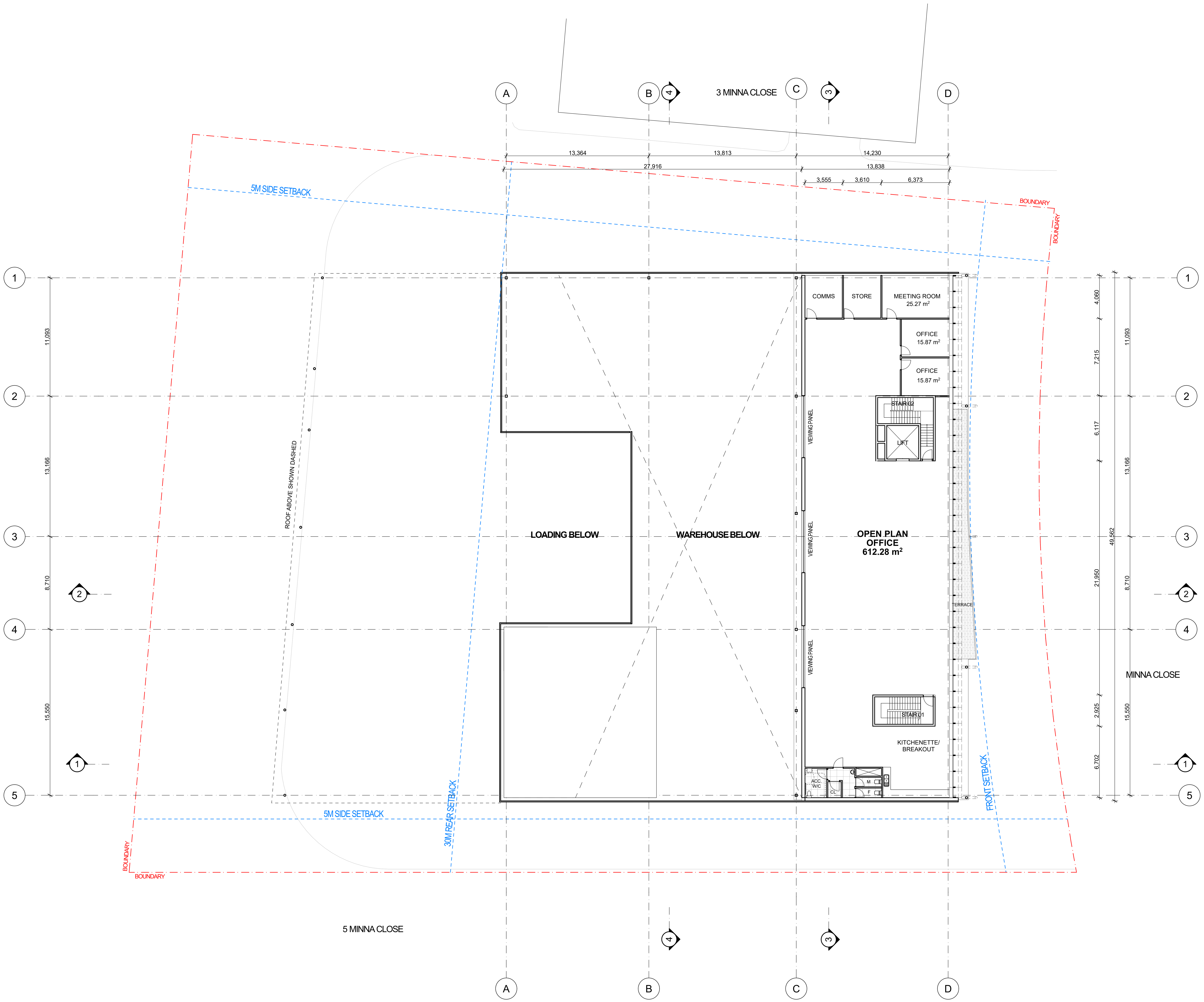
/ OFFICES & STAFF AMENITY

/ HIGHLY VISIBLE STREET PRESENCE

/ VIEWING PANELS THROUGH TO WAREHOUSE

/ MEETING ROOM

/ OPEN PLAN WORKSPACE




LEVEL 01
1:200

**WU PROPERTIES**

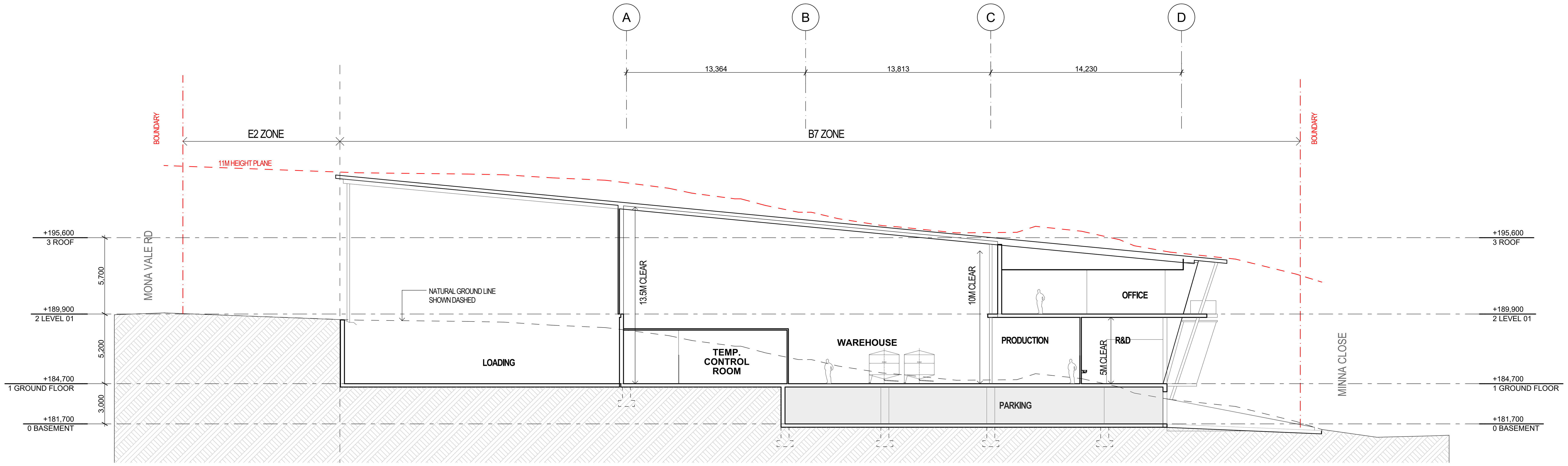
**BUREAU SRH**
architecture

# PRELIMINARY SECTIONS
## 1:200

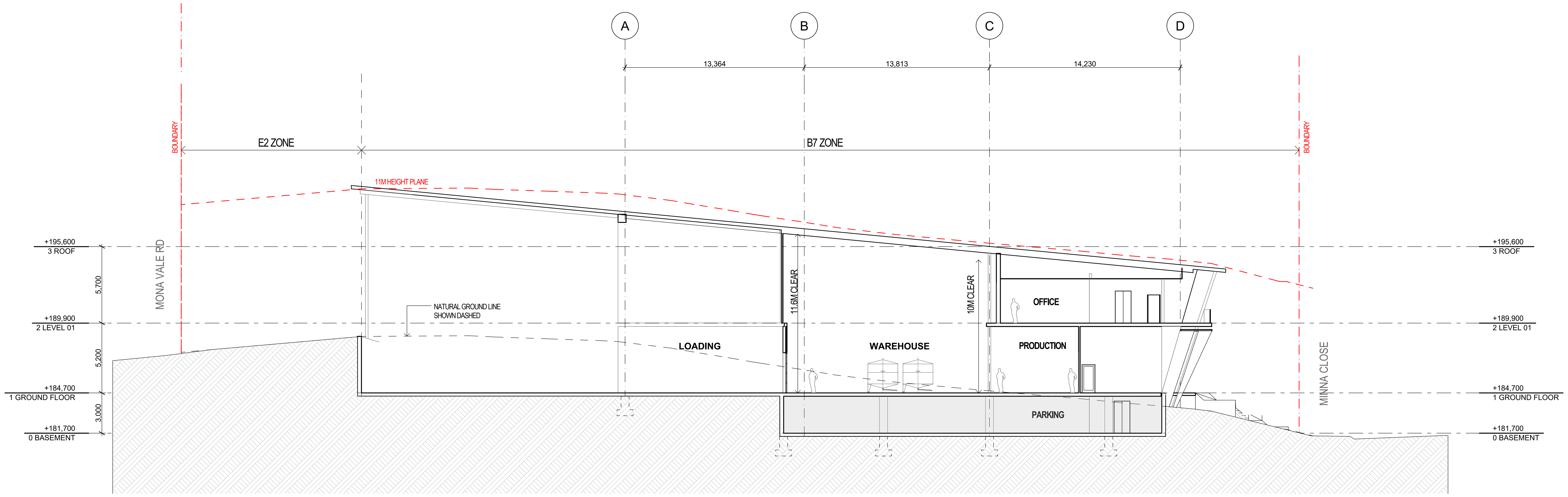
/ OFFICES & STAFF AMENITY

/ HIGHLY VISIBLE STREET PRESENCE

/ VIEWING PANELS THROUGH TO WAREHOUSE




1 SECTION 01
1:200




2 SECTION 02
1:200

WU PROPERTIES

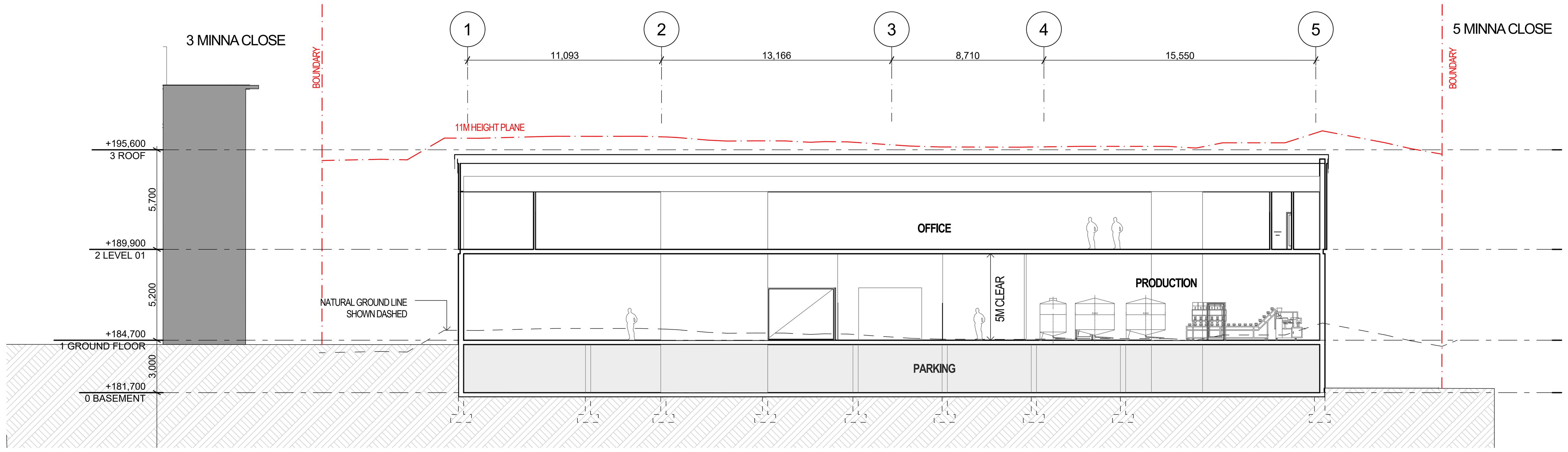
BUREAU SRH
architecture

# PRELIMINARY SECTIONS
## 1:200

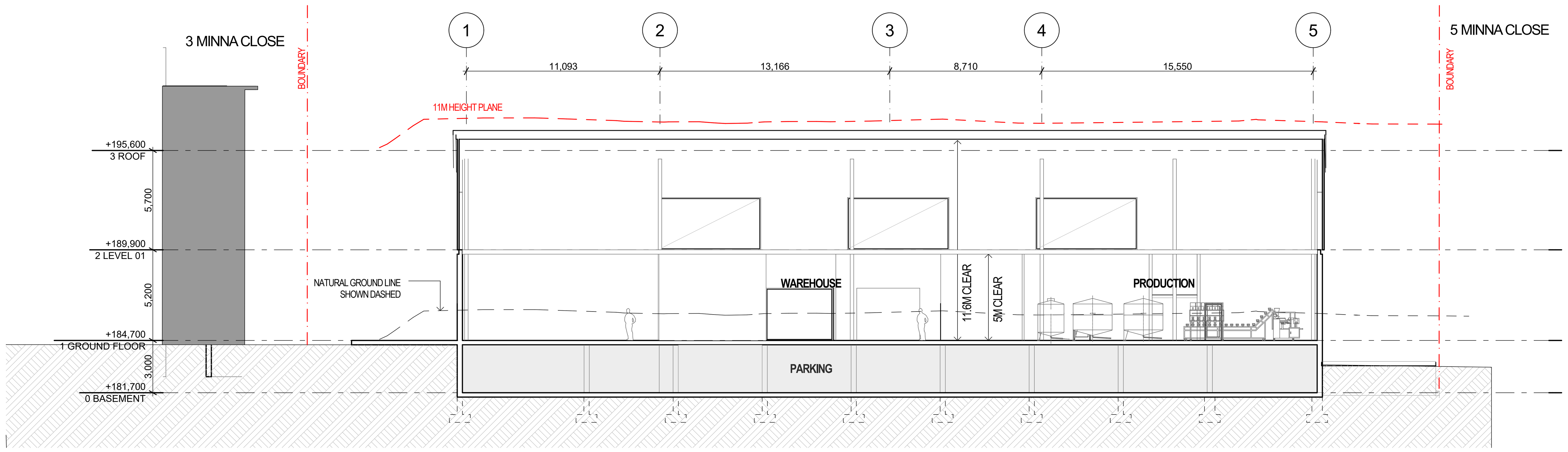
/ OFFICES & STAFF AMENITY

/ HIGHLY VISIBLE STREET PRESENCE

/ VIEWING PANELS THROUGH TO WAREHOUSE




4 SECTION 03
1:200




3 SECTION 04
1:200

# 11 Attachment E – General Geotechnical Recommendations

# Geotechnical Recommendations



martens consulting engineers

*These general geotechnical recommendations have been prepared by Martens to help you deliver a safe work site, to comply with your obligations, and to deliver your project. Not all are necessarily relevant to this report but are included as general reference. Any specific recommendations made in the report will override these recommendations.*

**Batter Slopes**

Excavations in soil and extremely low to very low strength rock exceeding 0.75 m depth should be battered back at grades of no greater than 1 Vertical (V) : 2 Horizontal (H) for temporary slopes (unsupported for less than 1 month) and 1 V : 3 H for longer term unsupported slopes.

Vertical excavation may be carried out in medium or higher strength rock, where encountered, subject to inspection and confirmation by a geotechnical engineer. Long term and short term unsupported batters should be protected against erosion and rock weathering due to, for example, stormwater run-off.

Batter angles may need to be revised depending on the presence of bedding partings or adversely oriented joints in the exposed rock, and are subject to on-site inspection and confirmation by a geotechnical engineer. Unsupported excavations deeper than 1.0 m should be assessed by a geotechnical engineer for slope instability risk.

Any excavated rock faces should be inspected during construction by a geotechnical engineer to determine whether any additional support, such as rock bolts or shotcrete, is required.

**Earthworks**

Earthworks should be carried out following removal of any unsuitable materials and in accordance with AS3798 (2007). A qualified geotechnical engineer should inspect the condition of prepared surfaces to assess suitability as foundation for future fill placement or load application.

Earthworks inspections and compliance testing should be carried out in accordance with Sections 5 and 8 of AS3798 (2007), with testing to be carried out by a National Association of Testing Authorities (NATA) accredited testing laboratory.

**Excavations**

All excavation work should be completed with reference to the *Work Health and Safety (Excavation Work) Code of Practice (2015)*, by Safe Work Australia. Excavations into rock may be undertaken as follows:

1. Extremely low to low strength rock - conventional hydraulic earthmoving equipment.

2. Medium strength or stronger rock - hydraulic earthmoving equipment with rock hammer or ripping tyne attachment.

Exposed rock faces and loose boulders should be monitored to assess risk of block / boulder movement, particularly as a result of excavation vibrations.

**Fill**

Subject to any specific recommendations provided in this report, any fill imported to site is to comprise approved material with maximum particle size of two thirds the final layer thickness. Fill should be placed in horizontal layers of not more than 300 mm loose thickness, however, the layer thickness should be appropriate for the adopted compaction plant.

**Foundations**

All exposed foundations should be inspected by a geotechnical engineer prior to footing construction to confirm encountered conditions satisfy design assumptions and that the base of all excavations is free from loose or softened material and water. Water that has ponded in the base of excavations and any resultant softened material is to be removed prior to footing construction.

Footings should be constructed with minimal delay following excavation. If a delay in construction is anticipated, we recommend placing a concrete blinding layer of at least 50 mm thickness in shallow footings or mass concrete in piers / piles to protect exposed foundations.

A geotechnical engineer should confirm any design bearing capacity values, by further assessment during construction, as necessary.

**Shoring - Anchors**

Where there is a requirement for either soil or rock anchors, or soil nailing, and these structures penetrate past a property boundary, appropriate permission from the adjoining land owner must be obtained prior to the installation of these structures.

**Shoring - Permanent**

Permanent shoring techniques may be used as an alternative to temporary shoring. The design of such structures should be in accordance with the findings of this report and any further testing recommended by this report. Permanent shoring may include [but not be limited to] reinforced block work walls, contiguous and semi contiguous pile walls, secant pile walls and soldier pile walls with or without reinforced shotcrete infill panels. The choice of shoring system will depend on the type of structure, project budget and site specific geotechnical conditions.

Permanent shoring systems are to be engineer designed and backfilled with suitable granular material and free-draining drainage material. Backfill should be placed in maximum 100 mm thick layers compacted using a hand operated compactor. Care should be taken to ensure excessive compaction stresses are not transferred to retaining walls.

Shoring design should consider any surcharge loading from sloping / raised ground behind shoring structures, live loads, new structures, construction equipment, backfill compaction and static water pressures. All shoring systems shall be provided with adequate foundation designs.

Suitable drainage measures, such as geotextile enclosed 100 mm agricultural pipes embedded in free-draining gravel, should be included to redirect water that may collect behind the shoring structure to a suitable discharge point.

### Shoring - Temporary

In the absence of providing acceptable excavation batters, excavations should be supported by suitably designed and installed temporary shoring / retaining structures to limit lateral deflection of excavation faces and associated ground surface settlements.

### Soil Erosion Control

Removal of any soil overburden should be performed in a manner that reduces the risk of sedimentation occurring in any formal stormwater drainage system, on neighbouring land and in receiving waters. Where possible, this may be achieved by one or more of the following means:

1. Maintain vegetation where possible
2. Disturb minimal areas during excavation
3. Revegetate disturbed areas if possible

All spoil on site should be properly controlled by erosion control measures to prevent transportation of sediments off-site. Appropriate soil erosion control methods in accordance with Landcom (2004) shall be required.

### Trafficability and Access

Consideration should be given to the impact of the proposed works and site subsurface conditions on trafficability within the site e.g. wet clay soils will lead to poor trafficability by tyred plant or vehicles.

Where site access is likely to be affected by any site works, construction staging should be organised such that any impacts on adequate access are minimised as best as possible.

### Vibration Management

Where excavation is to be extended into medium or higher strength rock, care will be required when using a rock hammer to limit potential structural distress from excavation-induced vibrations where nearby structures may be affected by the works.

To limit vibrations, we recommend limiting rock hammer size and set frequency, and setting the hammer parallel to bedding planes and along defect planes, where possible, or as advised by a geotechnical engineer. We recommend limiting vibration peak particle velocities (PPV) caused by construction equipment or resulting from excavation at the site to 5 mm/s (AS 2187.2, 2006, Appendix J).

### Waste – Spoil and Water

Soil to be disposed off-site should be classified in accordance with the relevant State Authority guidelines and requirements.

Any collected waste stormwater or groundwater should also be tested prior to discharge to ensure contaminant levels (where applicable) are appropriate for the nominated discharge location.

MA can complete the necessary classification and testing if required. Time allowance should be made for such testing in the construction program.

### Water Management - Groundwater

If the proposed works are likely to intersect ephemeral or permanent groundwater levels, the management of any potential acid soil drainage should be considered. If groundwater tables are likely to be lowered, this should be further discussed with the relevant State Government Agency.

### Water Management – Surface Water

All surface runoff should be diverted away from excavation areas during construction works and prevented from accumulating in areas surrounding any retaining structures, footings or the base of excavations.

Any collected surface water should be discharged into a suitable Council approved drainage system and not adversely impact downslope surface and subsurface conditions.

All site discharges should be passed through a filter material prior to release. Sump and pump methods will generally be suitable for collection and removal of accumulated surface water within any excavations.

### Contingency Plan

In the event that proposed development works cause an adverse impact on geotechnical hazards, overall site stability or adjacent properties, the following actions are to be undertaken:

1. Works shall cease immediately.
2. The nature of the impact shall be documented and the reason(s) for the adverse impact investigated.
3. A qualified geotechnical engineer should be consulted to provide further advice in relation to the issue.

# 12 Attachment F – Notes About This Report

# Information

## Important Information About Your Report (1 of 2)

*These notes have been prepared by Martens to help you interpret and understand the limitations of your report. Not all are necessarily relevant to all reports but are included as general reference.*

**Engineering Reports - Limitations**

The recommendations presented in this report are based on limited investigations and include specific issues to be addressed during various phases of the project. If the recommendations presented in this report are not implemented in full, the general recommendations may become inapplicable and Martens & Associates accept no responsibility whatsoever for the performance of the works undertaken.

Occasionally, sub-surface conditions between and below the completed boreholes or other tests may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact Martens & Associates.

Relative ground surface levels at borehole locations may not be accurate and should be verified by on-site survey.

**Engineering Reports – Project Specific Criteria**

Engineering reports are prepared by qualified personnel. They are based on information obtained, on current engineering standards of interpretation and analysis, and on the basis of your unique project specific requirements as understood by Martens. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the Client.

Where the report has been prepared for a specific design proposal (e.g. a three storey building), the information and interpretation may not be relevant if the design proposal is changed (e.g. to a twenty storey building). Your report should not be relied upon, if there are changes to the project, without first asking Martens to assess how factors, which changed subsequent to the date of the report, affect the report's recommendations. Martens will not accept responsibility for problems that may occur due to design changes, if not consulted.

**Engineering Reports – Recommendations**

Your report is based on the assumption that site conditions, as may be revealed through selective point sampling, are indicative of actual conditions throughout an area. This assumption often cannot be substantiated until project implementation has commenced. Therefore your site investigation report recommendations should only be regarded as preliminary.

Only Martens, who prepared the report, are fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report, there is a risk that the report will be misinterpreted and Martens cannot be held responsible for such misinterpretation.

**Engineering Reports – Use for Tendering Purposes**

Where information obtained from investigations is provided for tendering purposes, Martens recommend 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 specially edited document.

Martens would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

**Engineering Reports – Data**

The report as a whole presents the findings of a site assessment and should not be copied in part or altered in any way.

Logs, figures, drawings *etc* are customarily included in a Martens report and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel), desktop studies and laboratory evaluation of field samples. These data should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

**Engineering Reports – Other Projects**

To avoid misuse of the information contained in your report it is recommended that you confer with Martens before passing your report on to another party who may not be familiar with the background and purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

**Subsurface Conditions - General**

Every care is taken with the report in relation to interpretation of subsurface conditions, discussion of geotechnical aspects, relevant standards 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 will depend partly on test point (eg. excavation or borehole) spacing and sampling frequency, which are often limited by project imposed budgetary constraints.

- Changes in guidelines, standards and policy or interpretation of guidelines, standards and policy by statutory authorities.
- The actions of contractors responding to commercial pressures.
- Actual conditions differing somewhat from those inferred to exist, because no professional, no matter how qualified, can reveal precisely what is hidden by earth, rock and time.

  The actual interface between logged materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions.

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

**Subsurface Conditions - Changes**

Natural processes and the activity of man create subsurface conditions. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Reports are based on conditions which existed at the time of the subsurface exploration / assessment.

Decisions should not be based on a report whose adequacy may have been affected by time. If an extended period of time has elapsed since the report was prepared, consult Martens to be advised how time may have impacted on the project.

**Subsurface Conditions - Site Anomalies**

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

**Report Use by Other Design Professionals**

To avoid potentially costly misinterpretations when other design professionals develop their plans based on a Martens report, retain Martens to work with other project professionals affected by the report. This may involve Martens explaining the report design implications and then reviewing plans and specifications produced to see how they have incorporated the report findings.

**Subsurface Conditions – Geo-environmental Issues**

Your report generally does not relate to any findings, conclusions, or recommendations about the potential for hazardous or contaminated materials existing at the site unless specifically required to do so as part of Martens' proposal for works.

Specific sampling guidelines and specialist equipment, techniques and personnel are typically used to perform geo-environmental or site contamination assessments. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Martens for information relating to such matters.

**Responsibility**

Geo-environmental reporting relies on interpretation of factual information based on professional judgment and opinion and has an inherent level of uncertainty attached to it and is typically far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded.

To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Martens to other parties but are included to identify where Martens' responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Martens closely and do not hesitate to ask any questions you may have.

**Site Inspections**

Martens will always be pleased to provide engineering inspection services for aspects of work to which this report relates. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site. Martens is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction.

# Soil Data



## Definitions

In engineering terms, soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material does not exhibit any visible rock properties and can be remoulded or disintegrated by hand in its field condition or in water, it is described as a soil. Other materials are described using rock description terms.

The methods of description and classification of soils and rocks used in this report are typically based on Australian Standard 1726 and the Unified Soil Classification System (USCS) – refer Soil Data Explanation of Terms (2 of 3). In general, descriptions cover the following properties: strength or density, colour, moisture, structure, soil or rock type and inclusions.

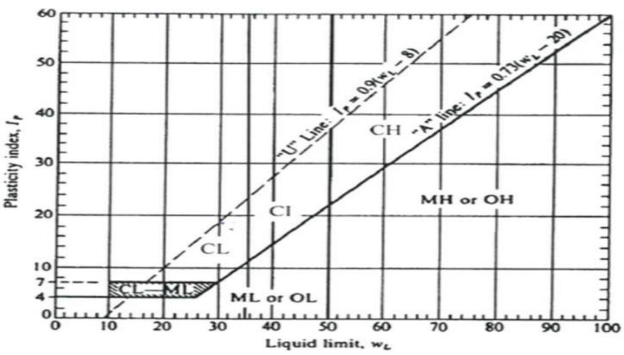
## Particle Size

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (e.g. sandy CLAY). Unless otherwise stated, particle size is described in accordance with the following table.

| Division | Subdivision | | Particle Size (mm) |
|---|---|---|---|
| Oversized | BOULDERS | | >200 |
| | COBBLES | | 63 to 200 |
| Coarse Grained Soil | GRAVEL | Coarse | 19 to 63 |
| | | Medium | 6.7 to 19 |
| | | Fine | 2.36 to 6.7 |
| | SAND | Coarse | 0.6 to 2.36 |
| | | Medium | 0.21 to 0.6 |
| | | Fine | 0.075 to 0.21 |
| Fine Grained Soil | SILT | | 0.002 to 0.075 |
| | CLAY | | < 0.002 |

## Plasticity Properties

Plasticity properties of cohesive soils can be assessed in the field by tactile properties or by laboratory procedures.




## Soil Moisture Condition

Coarse Grained (Granular) Soil:

| | |
|---|---|
| Dry (D): | Looks and feels dry. Cemented soils are hard, friable or powdery. Uncemented soils run freely through fingers. |
| Moist (M): | Feels cool and damp and is darkened in colour. Particles tend to cohere. |
| Wet (W): | As for moist but with free water forming on hands when handled. |

Fine Grained (Cohesive) Soil:

| | |
|---|---|
| Moist, dry of plastic limit[1] (w < PL): | Looks and feels dry. Hard, friable or powdery. |
| Moist, near plastic limit (w ≈ PL): | Can be moulded, feels cool and damp, is darkened in colour, at a moisture content approximately equal to the PL. |
| Moist, wet of plastic limit (w > PL): | Usually weakened and free water forms on hands when handled. |
| Wet, near liquid limit[2] (w ≈ LL) | |
| Wet, wet of liquid limit (w > LL) | |

[1] Plastic Limit (PL): Moisture content at which soil becomes too dry to be in a plastic condition.

[2] Liquid Limit (LL): Moisture content at which soil passes from plastic to liquid state.

## Consistency of Cohesive Soils

Cohesive soils refer to predominantly clay materials.
(Note: consistency is affected by soil moisture condition at time of measurement)

| Term | $C_u$ (kPa) | Field Guide |
|---|---|---|
| Very Soft (VS) | ≤12 | A finger can be pushed well into the soil with little effort. Sample exudes between fingers when squeezed in fist. |
| Soft (S) | >12 and ≤25 | A finger can be pushed into the soil to about 25mm depth. Easily moulded by light finger pressures. |
| Firm (F) | >25 and ≤50 | The soil can be indented about 5mm with the thumb, but not penetrated. Can be moulded by strong figure pressure. |
| Stiff (St) | >50 and ≤100 | The surface of the soil can be indented with the thumb, but not penetrated. Cannot be moulded by fingers. |
| Very Stiff (VSt) | >100 and ≤200 | The surface of the soil can be marked, but not indented with thumb pressure. Difficult to cut with a knife. Thumbnail can readily indent. |
| Hard (H) | > 200 | The surface of the soil can only be marked with the thumbnail. Brittle. Tends to break into fragments. |
| Friable (Fr) | - | Crumbles or powders when scraped by thumbnail. Can easily be crumbled or broken into small pieces by hand. |

## Density of Granular Soils

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

| Relative Density | % | SPT 'N' Value* (blows/300mm) | CPT Cone Value ($q_c$ MPa) |
|---|---|---|---|
| Very loose | ≤15 | < 5 | < 2 |
| Loose | >15 and ≤35 | 5 - 10 | 2 - 5 |
| Medium dense | >35 and ≤65 | 10 - 30 | 5 - 15 |
| Dense | >65 and ≤85 | 30 - 50 | 15 - 25 |
| Very dense | > 85 | > 50 | > 25 |

* Values may be subject to corrections for overburden pressures and equipment type and influenced by soil moisture condition at time of measurement.

## Minor Components

Minor components in soils may be present and readily detectable, but have little bearing on general geotechnical classification. Terms include:

| Description of components | Proportion of component in: | | | | | |
|---|---|---|---|---|---|---|
| | coarse grained soil | | | | fine grained soil | |
| | % Fines | Terminology | % Accessory coarse fraction | Terminology | % Sand/ gravel | Terminology |
| Minor | ≤5 | Trace clay / silt, as applicable | ≤15 | Trace sand / gravel, as applicable | ≤15 | Trace sand / gravel, as applicable |
| | >5,≤12 | With clay / silt, as applicable | >15,≤30 | With sand / gravel, as applicable | >5,≤30 | With sand / gravel, as applicable |
| Secondary | >12 | Prefix soil name as 'silty' or 'clayey', as applicable | >30 | Prefix soil name as 'sandy' or 'gravelly', as applicable | >30 | Prefix soil name as 'sandy' or 'gravelly', as applicable |

# Soil Data



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## Symbols for Soils and Other

| SOILS | | OTHER |
|---|---|---|
| COBBLES/BOULDERS | SILT (ML or MH) | FILL |
| GRAVEL (GP or GW) | ORGANIC SILT or CLAY (OH or OL) | TALUS |
| Silty GRAVEL (GM) | CLAY (CL, CI or CH) | ASPHALT |
| Clayey GRAVEL (GC) | Silty CLAY | CONCRETE |
| SAND (SP or SW) | Sandy CLAY | TOPSOIL |
| Silty SAND (SM) | PEAT (Pt) | |
| Clayey SAND (SC) | Gravelly CLAY | |

## Unified Soil Classification Scheme (USCS)

**FIELD IDENTIFICATION PROCEDURES** (Excluding particles larger than 63 mm and basing fractions on estimated mass)

(A 0.075 mm particle is about the smallest particle visible to the naked eye)

| | | | | USCS | Primary Name |
|---|---|---|---|---|---|
| COARSE GRAINED SOILS More than 65 % of material less than 63 mm is larger than 0.075 mm | GRAVELS More than half of coarse fraction is larger than 2.36 mm. | GRAVEL and GRAVEL-SAND Mixtures (≤ 5% fines) | Wide range in grain size and substantial amounts of all intermediate particle sizes; not enough fines to bind coarse grains; no dry strength | GW | GRAVEL |
| | | | Predominantly one size or a range of sizes with some intermediate sizes missing; not enough fines to bind coarse grains; no dry strength | GP | GRAVEL |
| | | GRAVEL-SILT and GRAVEL-SAND-SILT mixtures (≥12% fines) [1] | With excess non-plastic fines (for identification procedures see ML below); zero to medium dry strength; may also contain sand | GM | Silty GRAVEL |
| | | | With excess plastic fines (for identification procedures see CL below); medium to high dry strength; may also contain sand | GC | Clayey GRAVEL |
| | SANDS More than half of coarse fraction is smaller than 2.36 mm | SAND and GRAVEL-SAND mixtures (≤5% fines) | Wide range in grain sizes and substantial amounts of all intermediate sizes; not enough fines to bind coarse grains; no dry strength. | SW | SAND |
| | | | Predominantly one size or a range of sizes with some intermediate sizes missing; not enough fines to bind coarse grains; no dry strength | SP | SAND |
| | | SAND-SILT and SAND-CLAY mixtures (≥12% fines) [1] | With excess non-plastic fines (for identification procedures see ML below); zero to medium dry strength; | SM | Silty SAND |
| | | | With excess plastic fines (for identification procedures see CL below); medium to high dry strength | SC | Clayey SAND |

**IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM**

| | DRY STRENGTH (Crushing Characteristics) | DILATANCY | TOUGHNESS | DESCRIPTION | USCS | Primary Name |
|---|---|---|---|---|---|---|
| FINE GRAINED SOILS More than 35 % of material less than 63 mm is smaller than 0.075 mm | None to Low | Quick to Slow | Low | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or silt with low plasticity [2] | ML | SILT [3] |
| | Medium to High | None to Slow | Medium | Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays, lean clays | CL (or CI[4]) | CLAY |
| | Low to Medium | Slow | Low | Organic slits and organic silty clays of low plasticity | OL | Organic SILT or CLAY |
| | Low to Medium | None to Slow | Low to Medium | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts | MH | SILT [3] |
| | High to Very High | None | High | Inorganic clays of high plasticity, fat clays | CH | CLAY |
| | Medium to High | None to Very Slow | Low to Medium | Organic clays of medium to high plasticity, organic silt of high plasticity | OH | Organic SILT or CLAY |
| HIGHLY ORGANIC SOILS | Readily identified by colour, odour, spongy feel and frequently by fibrous texture | | | | Pt | PEAT |

**Notes:**

1. Between 5% and 12% - dual classification, e.g. GP-GM.
2. Low Plasticity Clay – Liquid Limit $W_L \le 35\%$; Medium Plasticity Clay – Liquid limit $W_L > 35\%, \le 50\%$; High Plasticity Clay - Liquid limit $W_L > 50\%$.
3. Low Plasticity Silt – Liquid Limit $W_L \le 50\%$; High Plasticity Silt - Liquid limit $W_L > 50\%$.
4. CI may be adopted for clay of medium plasticity to distinguish from clay of low plasticity.

## Soil Agricultural Classification Scheme

In some situations, such as where soils are to be used for effluent disposal purposes, soils are often more appropriately classified in terms of traditional agricultural classification schemes. Where a Martens report provides agricultural classifications, these are undertaken in accordance with descriptions by Northcote, K.H. (1979) *The factual key for the recognition of Australian Soils*, Rellim Technical Publications, NSW, p 26 - 28.

| Symbol | Field Texture Grade | Behaviour of moist bolus | Ribbon length | Clay content (%) |
|---|---|---|---|---|
| S | Sand | Coherence nil to very slight; cannot be moulded; single grains adhere to fingers | 0 mm | < 5 |
| LS | Loamy sand | Slight coherence; discolours fingers with dark organic stain | 6.35 mm | 5 |
| CLS | Clayey sand | Slight coherence; sticky when wet; many sand grains stick to fingers; discolours fingers with clay stain | 6.35mm - 1.3cm | 5 - 10 |
| SL | Sandy loam | Bolus just coherent but very sandy to touch; dominant sand grains are of medium size and are readily visible | 1.3 - 2.5 | 10 - 15 |
| FSL | Fine sandy loam | Bolus coherent; fine sand can be felt and heard | 1.3 - 2.5 | 10 - 20 |
| SCL- | Light sandy clay loam | Bolus strongly coherent but sandy to touch, sand grains dominantly medium size and easily visible | 2.0 | 15 - 20 |
| L | Loam | Bolus coherent and rather spongy; smooth feel when manipulated but no obvious sandiness or silkiness; may be somewhat greasy to the touch if much organic matter present | 2.5 | 25 |
| Lfsy | Loam, fine sandy | Bolus coherent and slightly spongy; fine sand can be felt and heard when manipulated | 2.5 | 25 |
| SiL | Silt loam | Coherent bolus, very smooth to silky when manipulated | 2.5 | 25 + > 25 silt |
| SCL | Sandy clay loam | Strongly coherent bolus sandy to touch; medium size sand grains visible in a finer matrix | 2.5 - 3.8 | 20 - 30 |
| CL | Clay loam | Coherent plastic bolus; smooth to manipulate | 3.8 - 5.0 | 30 - 35 |
| SiCL | Silty clay loam | Coherent smooth bolus; plastic and silky to touch | 3.8 - 5.0 | 30- 35 + > 25 silt |
| FSCL | Fine sandy clay loam | Coherent bolus; fine sand can be felt and heard | 3.8 - 5.0 | 30 - 35 |
| SC | Sandy clay | Plastic bolus; fine to medium sized sands can be seen, felt or heard in a clayey matrix | 5.0 - 7.5 | 35 - 40 |
| SiC | Silty clay | Plastic bolus; smooth and silky | 5.0 - 7.5 | 35 - 40 + > 25 silt |
| LC | Light clay | Plastic bolus; smooth to touch; slight resistance to shearing | 5.0 - 7.5 | 35 - 40 |
| LMC | Light medium clay | Plastic bolus; smooth to touch, slightly greater resistance to shearing than LC | 7.5 | 40 - 45 |
| MC | Medium clay | Smooth plastic bolus, handles like plasticine and can be moulded into rods without fracture, some resistance to shearing | > 7.5 | 45 - 55 |
| HC | Heavy clay | Smooth plastic bolus; handles like stiff plasticine; can be moulded into rods without fracture; firm resistance to shearing | > 7.5 | > 50 |

# Rock Data



## Symbols for Rock

**SEDIMENTARY ROCK**

- BRECCIA
- CONGLOMERATE
- CONGLOMERATIC SANDSTONE
- SANDSTONE/QUARTZITE
- SILTSTONE
- MUDSTONE/CLAYSTONE
- SHALE

- COAL
- LIMESTONE
- LITHIC TUFF

**IGNEOUS ROCK**

- GRANITE
- DOLERITE/BASALT

**METAMORPHIC ROCK**

- SLATE, PHYLLITE, SCHIST
- GNEISS
- METASANDSTONE
- METASILTSTONE
- METAMUDSTONE

## Definitions

Descriptive terms used for Rock by Martens are based on AS1726 and encompass rock substance, defects and mass.

| | |
|---|---|
| *Rock Material* | The intact rock that is bounded by defects. |
| *Rock Defect* | Discontinuity, fracture, break or void in the material or minerals across which there is little or no tensile strength. |
| *Rock Structure* | The nature and configuration of the different defects within the rock mass and their relationship to each other. |
| *Rock Mass* | The entirety of the system formed by all of the rock material and all of the defects that are present. |

## Degree of Weathering

Rock weathering is defined as the degree of decline in rock structure and grain property and can be determined in the field.

| Term | Symbol | Definition |
|---|---|---|
| Residual soil[1] | RS | Material is weathered to such an extent that it has soil properties. Mass structure, material texture, and fabric of original rock are no longer visible, but the soil has not been significantly transported. |
| Extremely weathered[1] | XW | Material is weathered to such an extent that it has soil properties - i.e. it can be remoulded and can be classified according to the Unified Classification System. Mass structure and material texture and fabric of original rock are still visible. |
| Highly weathered[2] | HW | The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the original colour of the rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores. |
| Moderately weathered[2] | MW | The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the rock is not recognisable. Rock strength shows little or no change from fresh rock. |
| Slightly weathered | SW | Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock. |
| Fresh | FR | Rock substance unaffected by weathering. No sign of decomposition of individual materials or colour changes. |

**Notes:**
1 RS and EW material is described using soil descriptive terms.
2. The term "Distinctly Weathered" (DW) may be used to cover the range of substance weathering between EW and SW

## Rock Strength

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

| Term (Strength) | $I_s$ (50) MPa | Uniaxial Compressive Strength MPa | Field Guide | Symbol |
|---|---|---|---|---|
| Very low | >0.03 ≤0.1 | 0.6 – 2 | May be crumbled in the hand. Sandstone is 'sugary' and friable. | VL |
| Low | >0.1 ≤0.3 | 2 – 6 | Core 150mm long x 50mm diameter may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling. | L |
| Medium | >0.3 ≤1.0 | 6 – 20 | Core 150mm long x 50mm diameter can be broken by hand with considerable difficulty. Readily scored with a knife. | M |
| High | >1 ≤3 | 20 – 60 | Core 150mm long x 50mm diameter cannot be broken by unaided hands, can be slightly scratched or scored with a knife. Breaks with single blow from pick. | H |
| Very high | >3 ≤10 | 60 – 200 | Core 150mm long x 50mm diameter, broken readily with hand held hammer. Cannot be scratched with knife. Breaks after more than one pick strike. | VH |
| Extremely high | >10 | >200 | A piece of core 150mm long x 50mm diameter is difficult to break with hand held hammer. Rings when struck with a hammer. | EH |

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## Degree of Fracturing

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

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

## Rock Core Recovery

TCR = Total Core Recovery

$$= \frac{\text{Length of core recovered}}{\text{Length of core run}} \times 100\,\%$$

SCR = Solid Core Recovery

$$= \frac{\sum \text{Length of cylindrical core recovered}}{\text{Length of core run}} \times 100\,\%$$

RQD = Rock Quality Designation

$$= \frac{\sum \text{Axial lengths of core} > 100 \text{ mm long}}{\text{Length of core run}} \times 100\,\%$$

## Rock Strength Tests

▼ Point load strength Index (Is50) - axial test (MPa)

▶ Point load strength Index (Is50) - diametral test (MPa)

● Uniaxial compressive strength (UCS) (MPa)

## Defect Type Abbreviations and Descriptions

**Defect Type (with inclination given)**

| | |
|---|---|
| BP | Bedding plane parting |
| FL | Foliation |
| CL | Cleavage |
| JT | Joint |
| FC | Fracture |
| SZ/SS | Sheared zone/ seam (Fault) |
| CZ/CS | Crushed zone/ seam |
| DZ/DS | Decomposed zone/ seam |
| FZ | Fractured Zone |
| IS | Infilled seam |
| VN | Vein |
| CO | Contact |
| HB | Handling break |
| DB | Drilling break |

**Planarity**

| | |
|---|---|
| Pl | Planar |
| Cu | Curved |
| Un | Undulating |
| St | Stepped |
| Ir | Irregular |
| Dis | Discontinuous |

**Roughness**

| | |
|---|---|
| Pol | Polished |
| Sl | Slickensided |
| Sm | Smooth |
| Ro | Rough |
| VR | Very rough |

**Thickness**

| | |
|---|---|
| Zone | > 100 mm |
| Seam | > 2 mm < 100 mm |
| Plane | < 2 mm |

**Coating or Filling**

| | |
|---|---|
| Cn | Clean |
| Sn | Stain |
| Ct | Coating |
| Vnr | Veneer |
| Fe | Iron Oxide |
| X | Carbonaceous |
| Qz | Quartzite |
| MU | Unidentified mineral |

**Inclination**

Inclination of defect is measured from perpendicular to and down the core axis.
Direction of defect is measured clockwise (looking down core) from magnetic north.

## Sampling

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

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

Undisturbed samples may be taken by pushing a thin-walled sampling tube, e.g. $U_{50}$ (50 mm internal diameter thin walled tube), into soils and withdrawing a soil sample 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. Other sampling methods may be used. Details of the type and method of sampling are given in the report.

## Drilling / Excavation Methods

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

Hand Excavation - in some situations, excavation using hand tools, such as mattock and spade, may be required due to limited site access or shallow soil profiles.

Hand Auger - the hole is advanced by pushing and rotating either a sand or clay auger, generally 75-100 mm in diameter, into the ground. The penetration depth is usually limited to the length of the auger pole; however extender pieces can be added to lengthen this.

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

Large Diameter Auger (e.g. Pengo) - the hole is advanced by a rotating plate or short spiral auger, generally 300 mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5 m) 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 (Push Tube) - the hole is advanced by pushing a 50 - 100 mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in 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 - 115 mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling or in-situ 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, 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 SPTs 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 of usually 50 mm internal diameter. Provided full core recovery is achieved (not always possible in very weak or fractured rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

## In-situ Testing and Interpretation

Cone Penetrometer Testing (CPT)

Cone penetrometer testing (sometimes referred to as Dutch Cone) described in this report has been carried out using an electrical friction cone penetrometer.

The test is described in AS 1289.6.5.1-1999 (R2013). In the test, a 35 mm diameter rod with a cone tipped end is pushed continuously 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 separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the push rod centre to an amplifier and recorder unit mounted on the control truck. As penetration occurs (at a rate of approximately 20 mm per second) the information is output on continuous chart recorders. The plotted results given in this report have been traced from the original records. The information provided on the charts comprises:

(i) Cone resistance ($q_c$) - the actual end bearing force divided by the cross sectional area of the cone, expressed in MPa.

(ii) Sleeve friction ($q_f$) - the frictional force of the sleeve divided by the surface area, expressed in kPa.

(iii) 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 (A) 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 (B) scale (0 - 50 MPa) is less sensitive and is shown as a full line.

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 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:

$$q_c \text{ (MPa)} = (0.4 \text{ to } 0.6)\ N \text{ (blows/300 mm)}$$

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 calculation 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.

Standard Penetration Testing (SPT)
Standard penetration tests 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 procedure is described in AS 1289.6.3.1-2004. The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm penetration depth increments and the 'N' value is taken as the number of blows for the last two 150 mm depth increments (300 mm total penetration). In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued. The test results are reported in the following form:

(i) Where full 450 mm penetration is obtained with successive blow counts for each 150 mm of say 4, 6 and 7 blows:

as 4, 6, 7
N = 13

(ii) Where the test is discontinued, short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm

as 15, 30/40 mm.

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

Dynamic Cone (Hand) Penetrometers
Hand 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 (PSP)** - a 16 mm diameter flat ended rod is driven with a 9 kg hammer, dropping 600 mm. The test, described in AS 1289.6.3.3-1997 (R2013), was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

**Cone penetrometer (DCP)** - sometimes known as the Scala Penetrometer, a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm. The test, described in AS 1289.6.3.2-1997 (R2013), was developed initially for pavement sub-grade investigations, with correlations of the test results with California Bearing Ratio published by various Road Authorities.

Pocket Penetrometers
The pocket (hand) penetrometer (PP) is typically a light weight spring hand operated device with a stainless steel loading piston, used to estimate unconfined compressive strength, $q_u$, (UCS in kPa) of a fine grained soil in field conditions. In use, the free end of the piston is pressed into the soil at a uniform penetration rate until a line, engraved near the piston tip, reaches the soil surface level. The reading is taken from a gradation scale, which is attached to the piston via a built-in spring mechanism and calibrated to kilograms per square centimetre (kPa) UCS. The UCS measurements are used to evaluate consistency of the soil in the field moisture condition. The results may be used to assess the undrained shear strength, $C_u$, of fine grained soil using the approximate relationship:

$q_u = 2 \times C_u$.

It should be noted that accuracy of the results may be influenced by condition variations at selected test surfaces. Also, the readings obtained from the PP test are based on a small area of penetration and could give misleading results. They should not replace laboratory test results. The use of the results from this test is typically limited to an assessment of consistency of the soil in the field and not used directly for design of foundations.

## Test Pit / Borehole Logs

Test pit / borehole log(s) presented herein are an engineering and / or geological interpretation of the subsurface conditions. Their reliability will depend to some extent on frequency of sampling and methods of excavation / drilling. Ideally, continuous undisturbed sampling or excavation / 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 test pit / borehole logs 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 test pits / boreholes, the frequency of sampling and the possibility of other than 'straight line' variation between the test pits / boreholes.

## Laboratory Testing

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

## 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 prior 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 advisable in low permeability soils or where there may be interference from a perched water table.

# Test, Drill and Excavation Methods

## Explanation of Terms (3 of 3)

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### DRILLING / EXCAVATION METHOD

| | | | | | |
|---|---|---|---|---|---|
| HA | Hand Auger | RD | Rotary Blade or Drag Bit | NQ | Diamond Core - 47 mm |
| AD/V | Auger Drilling with V-bit | RT | Rotary Tricone bit | NMLC | Diamond Core – 51.9 mm |
| AD/T | Auger Drilling with TC-Bit | RAB | Rotary Air Blast | HQ | Diamond Core – 63.5 mm |
| AS | Auger Screwing | RC | Reverse Circulation | HMLC | Diamond Core – 63.5 mm |
| HSA | Hollow Stem Auger | CT | Cable Tool Rig | DT | Diatube Coring |
| S | Excavated by Hand Spade | PT | Push Tube | NDD | Non-destructive digging |
| BH | Tractor Mounted Backhoe | PC | Percussion | PQ | Diamond Core - 83 mm |
| JET | Jetting | E | Tracked Hydraulic Excavator | X | Existing Excavation |

### SUPPORT

| | | | | | |
|---|---|---|---|---|---|
| Nil | No support | S | Shotcrete | RB | Rock Bolt |
| C | Casing | Sh | Shoring | SN | Soil Nail |
| WB | Wash bore with Blade or Bailer | WR | Wash bore with Roller | T | Timbering |

### WATER

| | |
|---|---|
| ▽ Water level at date shown | ◁ Partial water loss |
| ▷ Water inflow | ◀ Complete water loss |

| | |
|---|---|
| GROUNDWATER NOT OBSERVED (NO) | The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit. |
| GROUNDWATER NOT ENCOUNTERED (NX) | The borehole/test pit was dry soon after excavation. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period. |

### PENETRATION / EXCAVATION RESISTANCE

| | |
|---|---|
| L | Low resistance: Rapid penetration possible with little effort from the equipment used. |
| M | Medium resistance: Excavation possible at an acceptable rate with moderate effort from the equipment used. |
| H | High resistance: Further penetration possible at slow rate & requires significant effort equipment. |
| R | Refusal/ Practical Refusal. No further progress possible without risk of damage/ unacceptable wear to digging implement / machine. |

These assessments are subjective and dependent on many factors, including equipment power, weight, condition of excavation or drilling tools, and operator experience.

### SAMPLING

| | | | | | |
|---|---|---|---|---|---|
| D | Small disturbed sample | W | Water Sample | C | Core sample |
| B | Bulk disturbed sample | G | Gas Sample | CONC | Concrete Core |

U63 Thin walled tube sample - number indicates nominal undisturbed sample diameter in millimetres

### TESTING

| | |
|---|---|
| SPT | Standard Penetration Test to AS1289.6.3.1-2004 |
| 4,7,11 | 4,7,11 = Blows per 150mm. |
| N=18 | 'N' = Recorded blows per 300mm penetration following 150mm seating |
| DCP | Dynamic Cone Penetration test to AS1289.6.3.2-1997. 'n' = Recorded blows per 150mm penetration |

**Notes:**

| | |
|---|---|
| RW | Penetration occurred under rod weight only |
| HW | Penetration occurred under hammer and rod weight only |
| 20/100mm | Where practical refusal or hammer double bouncing occurred, blows and penetration for that interval are reported (e.g. 20 blows for 100 mm penetration) |

| | |
|---|---|
| CPT | Static cone penetration test |
| CPTu | CPT with pore pressure (u) measurement |
| PP | Pocket penetrometer test expressed as instrument reading (kPa) |
| FP | Field permeability test over section noted |
| VS | Field vane shear test expressed as uncorrected shear strength (sv = peak value, sr = residual value) |
| PM | Pressuremeter test over section noted |
| PID | Photoionisation Detector reading in ppm |
| WPT | Water pressure tests |

### SOIL DESCRIPTION

**Density**

| | |
|---|---|
| VL | Very loose |
| L | Loose |
| MD | Medium dense |
| D | Dense |
| VD | Very dense |

**Consistency**

| | |
|---|---|
| VS | Very soft |
| S | Soft |
| F | Firm |
| St | Stiff |
| VSt | Very stiff |
| H | Hard |

**Moisture**

| | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| Wp | Plastic limit |
| Wl | Liquid limit |

### ROCK DESCRIPTION

**Strength**

| | |
|---|---|
| VL | Very low |
| L | Low |
| M | Medium |
| H | High |
| VH | Very high |
| EH | Extremely high |

**Weathering**

| | |
|---|---|
| EW | Extremely weathered |
| HW | Highly weathered |
| MW | Moderately weathered |
| SW | Slightly weathered |
| FR | Fresh |