
Report on Geotechnical Investigation

**Kogarah Golf Club Redevelopment -
Concept & Early Works SSDA (SSD-
84467726)**

19-19A Marsh Street, Arncliffe NSW

**Prepared for Stockland Development Pty
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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

Signature

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Report on Geotechnical Investigation

Kogarah Golf Club Redevelopment - Concept & Early Works SSDA (SSD-84467726)

19-19A Marsh Street, Arncliffe NSW

1. Introduction

This geotechnical investigation report has been prepared by Douglas Partners Pty Ltd (Douglas) for the Stockland and John Boyd Properties Joint Venture (JV) to accompany a State Significant Development Application (SSDA) (SSD-84467726) for a Concept Masterplan and Early Works associated with the Kogarah Golf Club Redevelopment located on land identified as 13-19A Marsh Street, Arncliffe NSW (the overall site). It is noted that this investigation specifically applies to the land at 19 and 19A Marsh Street, Arncliffe NSW (the site).

The vision for the Kogarah Golf Club Redevelopment is to create a world-class precinct that leverages the site's strategic location adjacent to Sydney Airport and strong transport connections by delivering multi-level logistics development, trade-related enterprise and supporting uses with publicly accessible open space. It seeks to deliver state-of-the-art facilities that will redefine the logistics landscape in Australia, setting new benchmarks for scale, efficiency, sustainability and innovation.

The Concept & Early Works SSDA seeks consent for an overarching Concept Masterplan that establishes maximum building envelopes, Gross Floor Area (GFA), land uses, and other parameters through Urban Design Guidelines and technical reporting. It also seeks consent for the carrying out of Early Works to facilitate the initial site preparation and infrastructure works required to support future development and publicly accessible open space.

The investigation was commissioned by Stockland Development Pty Limited and was undertaken in accordance with Douglas' proposals 223528.01.P.001 and 223528.01.P.002.

It is understood that the existing golf course at the site will be closed and redeveloped into a warehouse distribution and office facility. The proposed redevelopment will include bulk earthworks for levelling of the site, and construction of multi-storey warehouse and office buildings, car parking and hardstand, as well as landscaping, footpaths and other ancillary works.

The aim of the investigation was to assess the subsurface conditions across the site to inform the planning and preliminary design of the proposed development. The initial investigation in 2024 included cone penetration testing with pore pressure measurement and pore pressure dissipation testing of the compressible soils underlying the site. The recent investigation included the drilling of geotechnical boreholes, groundwater well installations, groundwater level monitoring, and laboratory testing of selected soil and rock samples. The details of the field work for the investigations are presented in this report, together with comments and recommendations relevant to the proposed development.

The 2024 geotechnical investigation was carried out in conjunction with a contamination investigation, which included field work comprising the drilling of boreholes and excavation of test pits. The results of field work undertaken for the contamination investigation have not been

included in this report and reference should be made to Douglas' report on contamination data gap investigation (ref: 92400.01.R.001.Rev0, dated 14 November 2024). Relevant field work results from the contamination investigation have been used to inform the geotechnical model for the site.

This report must be read in conjunction with all appendices including the notes provided in Appendix A.

2. Site Description

The overall site is identified as 13-19A Marsh Street, Arncliffe NSW within the Bayside Local Government Area (LGA). It is situated to the immediate west of the Cooks River and Sydney Airport, located approximately 6 km west of Port Botany and 10 km south of the Sydney Central Business District (CBD). It includes frontages to Marsh Street, providing direct access to the M5 Motorway, Sydney Airport and St Peter's Interchange (via the Sydney Gateway).

The overall site includes land associated with nine (9) allotments and a total area of approximately 32 hectares. The existing uses include the previous Kogarah Golf Club (vacated in March 2025) accessed via Levey Street and the temporary M6 Motorway Stage 1 construction compound accessed directly from Marsh Street.

The development area represents Lot 31 DP1231486 and Lot 100 DP1231954, excluding land subject to future dedication to Bayside Council. It comprises an area of approximately 16.7 hectares and is zoned SP4 Enterprise and C2 Environmental Conservation under the Bayside LEP 2021.

The overall site is described in Table 1 below and depicted in Figure 1.

Table 1: Overall Site Description

Lot & DP	Address	Ownership
Lot 31 DP1231486	19 Marsh Street, Arncliffe	Cook Cove Nominees No 1 Pty Ltd as trustee of Cook Cove Property Trust 1
Lot 100 DP1231954	19A Marsh Street, Arncliffe	Cook Cove Nominees No 2 Pty Ltd as trustee of Cook Cove Property Trust 2
Lot 60 DP1301057	13 Marsh Street, Arncliffe	Bayside Council
Lot 61 DP1301057	19 Marsh Street, Arncliffe	
Lot 62 DP1301057	Marsh Street, Arncliffe	Transport for NSW
Lot 63 DP1301057	Marsh Street, Arncliffe	
Lot 12 DP570900	Marsh Street, Arncliffe	
Lot 102 DP1231954	Marsh Street, Arncliffe	
Lot 103 DP1231954	Marsh Street, Arncliffe	



Figure 1: Overall Site Aerial Map (Source: Nearmap, edited by Ethos Urban)

The site for this investigation (Items 1 and 2 in Table 1, the Development Area in Figure 1 and shown in Figure 2) is located off Marsh Street at Arncliffe and has an irregular shape with an approximate area of 18 Ha. The site was formerly occupied by Kogarah Golf Club, which has now been vacated and includes low-rise clubhouse and maintenance buildings, on-grade car parking, and extensive grassed areas for the fairways and rough. There are localised excavated areas for bunkers, as well as mounded areas across the site and two water-filled basins in the southern portion of the site. The Sydney Desalination pipeline runs through the central-eastern part of the site in a north-south direction within a shallow trench and mound in the southern portion of the site and within a deeper under-bored alignment in the north. The Moomba to Sydney ethane (gas) pipeline operated by APA Group (APA) also runs through the site in a north-south direction, through the eastern portion of the site. The approximate locations of the pipelines are shown in Figure 2.

The site is bounded by Marsh Street to the north, Cooks River to the east, the M5 motorway to the south and an M6 motorway construction facility to the west with a temporary M6 dive structure running adjacent to the north-west boundary of the site. Below ground level, the existing M8

motorway tunnels run beneath the M6 motorway construction facility and Marsh Street. The former golf course extends outside of the lot boundary to the west and south.

The site is located on relatively flat terrain with surface levels generally varying between about RL 1 m and RL 3 m relative to Australian height datum (AHD) with elevated areas up to RL 6 m AHD at the clubhouse and small, localised elevated areas, as shown in Figure 2.

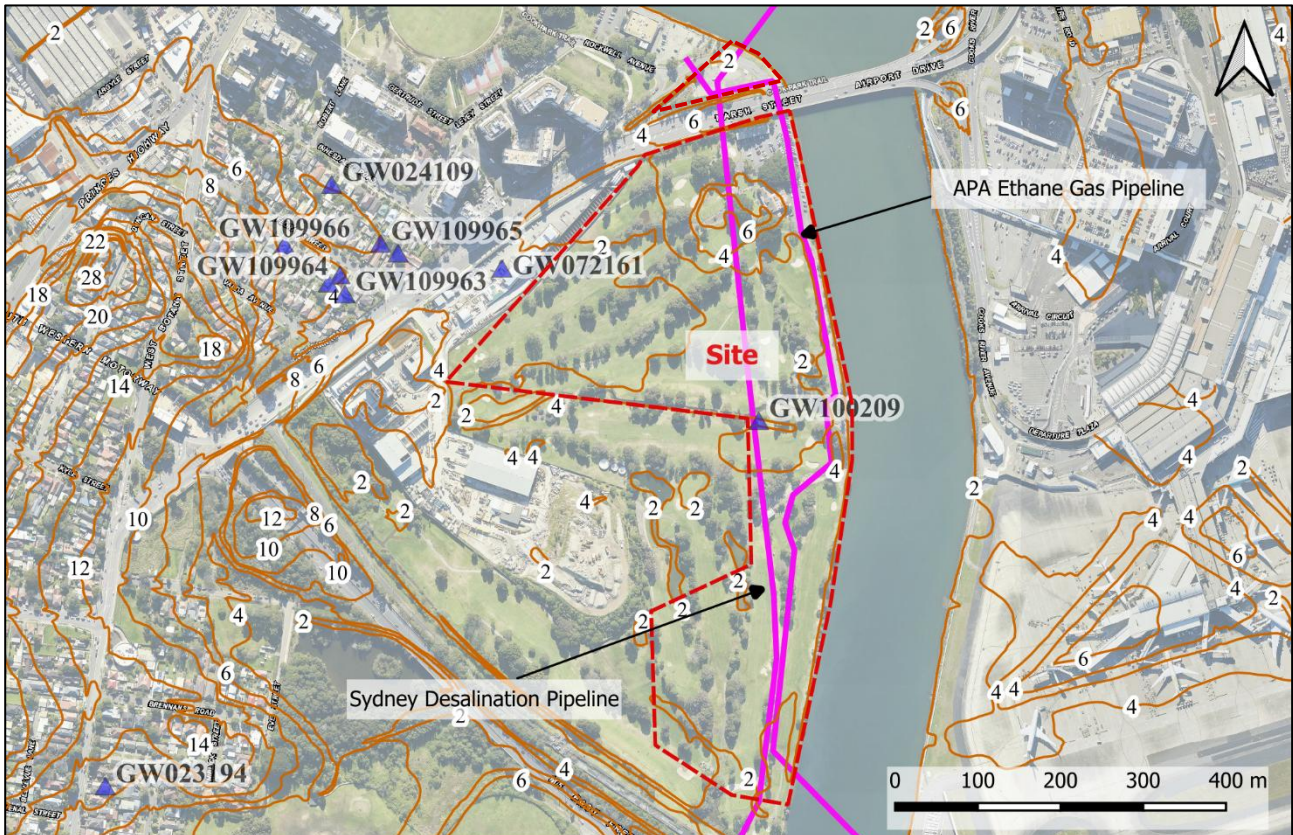


Figure 2: Aerial image of site overlain by 2 m surface contours to AHD

3. Project Description

The Concept & Early Works SSDA seeks consent for the following:

- Concept Masterplan to support the staged delivery of the Kogarah Golf Club Redevelopment, including:
 - o Maximum building envelopes, including maximum building heights and minimum setbacks;
 - o Maximum Gross Floor Area (GFA) up to 343,250 m², comprising up to:
 - 3,250 m² of GFA (FSR of 1.25:1) on Lot 31 DP 1231486; and
 - 340,000 m² of GFA on Lot 100 DP 1231954.
 - o Conceptual primary land uses, including:
 - Block 1 – Mixed use and advertising structures;

- Block 2 – Logistics and mixed-use;
 - Block 3A – Logistics;
 - Block 3B – Logistics; and
 - Block 3C – Logistics and Data centre.
- o Urban Design Guidelines to guide future development of the built form and public domain; and
- o Strategies and mitigation measures to manage potential environmental impacts.
- Early Works to support future delivery of built form and publicly accessible open space, including:
 - o Site preparation works, comprising:
 - Demolition of existing structures;
 - Clearing of existing vegetation;
 - Remediation works; and
 - Bulk earthworks, including ground improvement and flood mitigation works.
 - o Site servicing and infrastructure works, including:
 - Construction of the Flora Street East extension consistent with Item 3 of the executed Voluntary Planning Agreement with Bayside Council;
 - Construction of stormwater infrastructure; and
 - Construction and augmentation of service and utility infrastructure as necessary.

For a detailed description, refer to the Environmental Impact Statement prepared by Colliers Urban Planning.

The Concept Masterplan is supported by Indicative Reference Schemes that present as ‘proof of concepts’ within the proposed framework. The schemes demonstrate suitable primary land use, built form and public domain outcomes that align with the vision for a world-class precinct that leverages the site’s strategic location adjacent to Sydney Airport and strong transport connections

The Indicative Reference Schemes consider different potential development outcomes enabled by the Concept Masterplan to support the delivery of the highest and best use at the time of redevelopment. This includes a Logistics scheme and Alternative Uses scheme, which facilitate the potential for four (4) different primary land use outcomes across the Site. The alternative land use outcomes enabled by the Concept Masterplan include an alternative mixed-use outcome on Block 2 and alternative data centre outcome on Block 3C.

The Indicative Reference Schemes are established in Figure 3, with the Logistics scheme and Alternative Uses scheme prepared by Grimshaw depicted in Figure 4 and Figure 5.

It is noted that the Indicative Reference Schemes are indicative only and the development of future built form and publicly accessible open space will be subject to future Development Applications. The Indicative Reference Schemes demonstrate the ability to support different

potential outcomes, consistent with the proposed framework under the Concept Masterplan including Urban Design Guidelines.

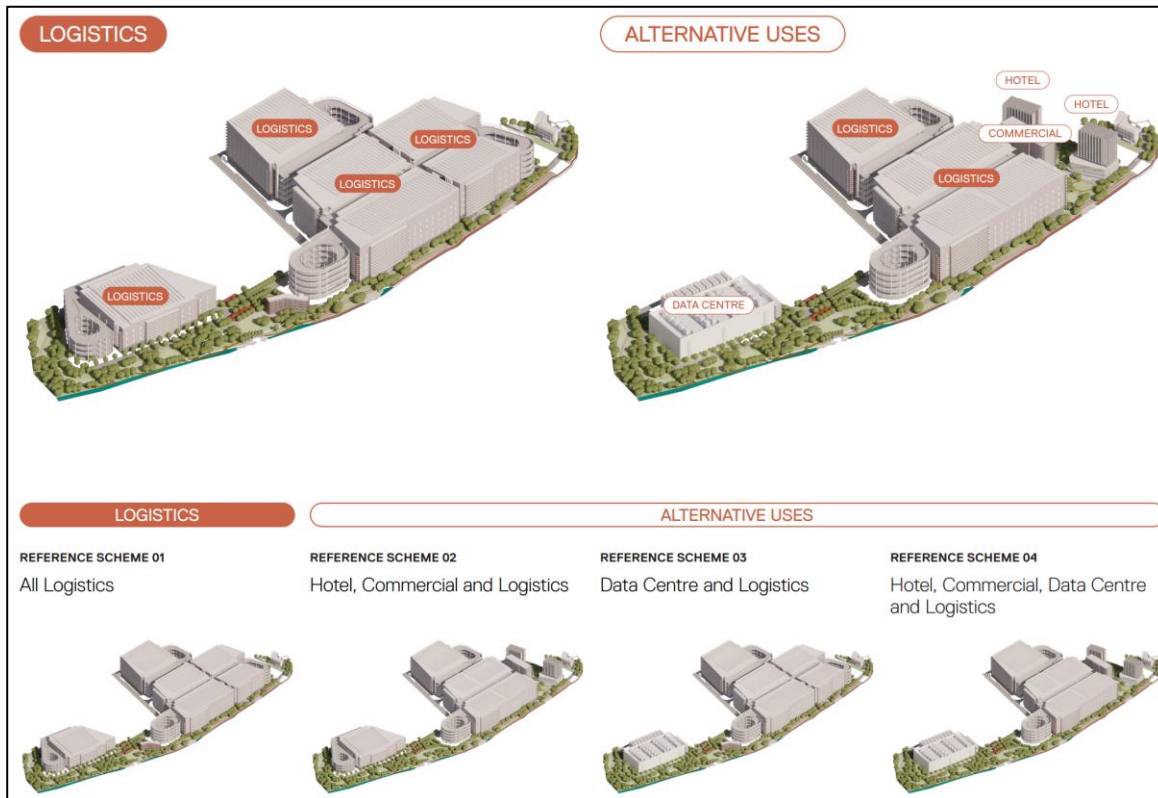


Figure 3: Indicative Reference Schemes (Source: Grimshaw)



Figure 4: Indicative Reference Scheme – Logistics Scheme (Source: Grimshaw)



Figure 5: Indicative Reference Scheme – Alternative Uses Scheme (Source: Grimshaw)

4. Published Data

4.1 Geology

Reference to the Sydney 1:100 000 Geological Series Map and NSW Seamless Geology database indicates that the site is mostly underlain by freshwater swamp material (Clastic sediment) comprising estuarine and marine deposits of the Quaternary period. The deposits are estuarine tidal-delta flat material deposited in a transitional environment (marine to terrestrial), typically comprising fine- to medium-grained lithic-carbonate-quartz sand (marine-deposited), silt, clay, shell material, polymictic gravel.

The geology mapping indicates that a northern portion of the site is underlain by Hawkesbury Sandstone. Hawkesbury Sandstone comprises medium to coarse grained quartz sandstone, with very minor shale and laminite lenses. An extract from the geological map is shown in Figure 6.

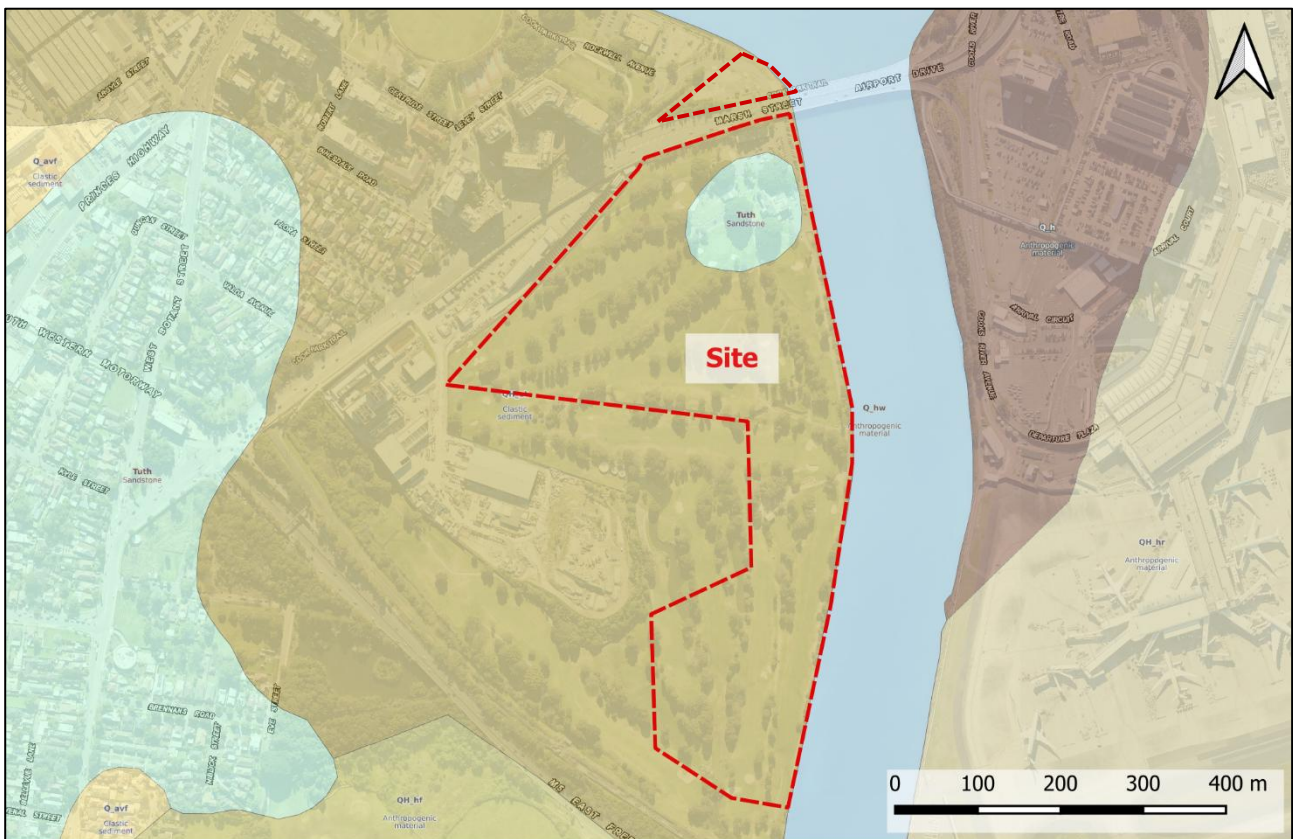


Figure 6: Extract from NSW Seamless Geology Map

4.2 Hydrogeology

One registered groundwater well (GW100209) is located on the site, as shown in Figure 2, which was installed in 1993 and abandoned in 1997.

The proximity of the Cooks River and previous groundwater measurements by Douglas, and others, on the site suggest groundwater levels beneath the site generally between 0.5 m and 2 m depth (RL -0.5 m to RL 2.0 m AHD).

4.3 Soil Landscape

Reference to the Sydney 1:100 000 Soil Landscape Series map indicates that the site is underlain by disturbed terrain.

Disturbed terrain sites are characterised by level plain to hummocky terrain, extensively disturbed by human activity, including complete disturbance, removal or burial of soil. Local relief is typically less than 10 m, slopes are less than 30% and the fill material can comprise soil, rock, building and waste material.

4.4 Acid Sulfate Soils

Reference to the 1:25 000 Acid Sulfate Soils (ASS) Risk map indicates that the site is in an area of high probability of occurrence of acid sulfate soils from depths of between 1 m and 3 m below the ground surface. An extract from the ASS Risk map is shown in Figure 7.

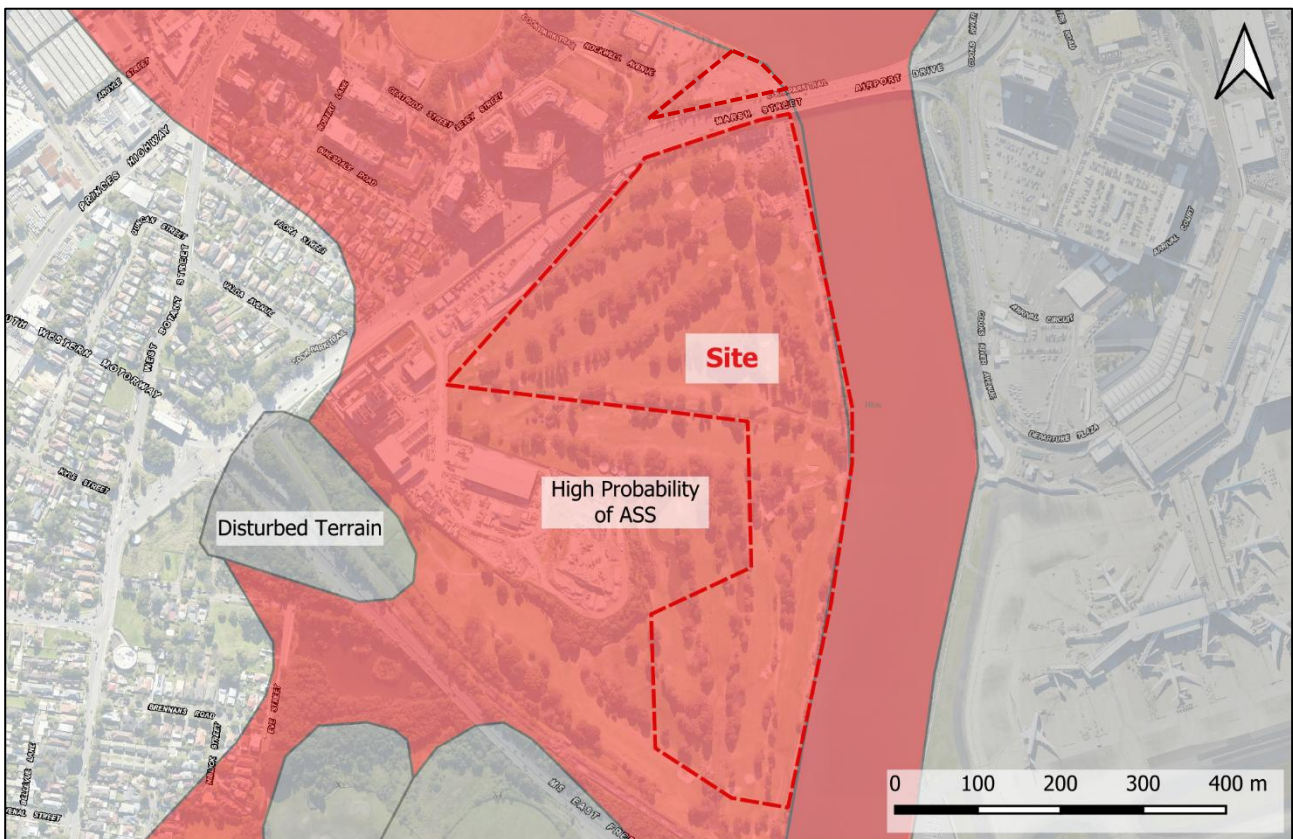


Figure 7: Extract from 1:25 000 Acid Sulfate Soils Risk Map

4.5 Salinity

Dryland salinity risk and hazard mapping was undertaken in 2000 by the former NSW Government Departments of Land and Water Conservation to show the broad distribution of areas considered as having either a high salinity risk or a high salinity hazard.

The site is not located within, or close to, mapped areas with high salinity risk or high salinity hazard. The nearest areas mapped as having high salinity risk/hazard are in Western Sydney.

4.6 Site History

A brief review of historical aerial photographs between 1943 and 2024 was undertaken using MetroMap and Historical Imagery (NSW Government, Spatial Services), accompanied by observations recorded in previous Douglas reports and other available documents.

In the 1880's and 1890's, Shea's Creek was dredged as part of the construction of Alexandra Canal and the dredged material was used to reclaim the surrounding low-lying land. The 1943 aerial images indicate the site comprised agricultural farmland, with the southern portion of the site flooded. By 2000, the site had been developed into the Kogarah Golf Course, indicating that bulk filling of the site had been undertaken. The historical aerial images of the site from 1943 and 2000 are shown in Figure 8.

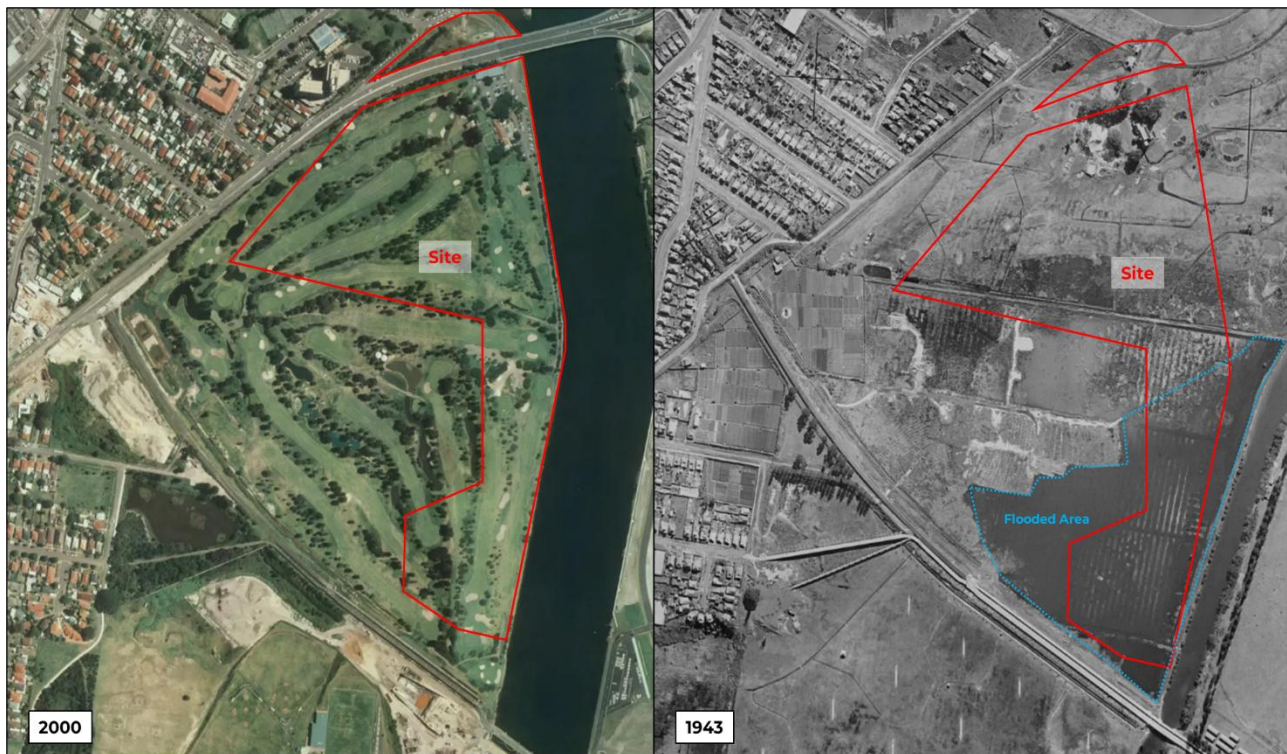


Figure 8: Historical Site Aerial Imagery

5. Previous Investigations

5.1 JK Geotechnical Investigation (2008)

Jeffery and Katauskas Pty Ltd (JK) undertook geotechnical investigation at the site in 2008, which included the drilling of four rock-cored boreholes and ten cone penetration tests with pore pressure measurements (CPTs). The results of the JK investigation (ref: Report on Preliminary Geotechnical Investigation, 22468VTrpt, dated 9 December 2008) have been provided by Stockland and have been used to assist in the development of the geotechnical model for the site (refer to Section 7). Relevant summary plots have been included in the interpreted geotechnical cross sections (Drawings 2-4 in Appendix B) and the encountered rock depths in the boreholes, as well as the inferred rock depths in the CPTs, have been used to develop the interpolated rock contour plan (Drawing 5 in Appendix B).

5.2 CES Contamination Investigation (2008)

Consulting Earth Scientists (CES) undertook contamination investigation at the site in 2008, which included the drilling of approximately 180 boreholes. The results of the CES contamination investigation (latest report revision, ref: Environmental Site Assessment, CES130608-BP-AR, Rev 03, dated 31 March 2023) were provided by Stockland. Relevant information from the CES investigation has been used to inform the geotechnical model for the site, however, the information is limited for geotechnical applications as the boreholes were typically drilled to only shallow depths and did not include in-situ testing for soil consistency.

6. Field Work – Current Investigation

6.1 Field work methods

The field work for the geotechnical investigation included the following:

- Cone penetration tests with pore pressure measurements (i.e. piezocone penetration tests, CPT_us) at ten (10) locations (CPT201 to CPT207, including CPT201A, CPT201B and CPT206A) to depths of between 0.9 m and 25.2 m, undertaken between 23 and 25 September 2024. A CPT_u involves pushing an instrumented cone and friction sleeve into the ground using hydraulic thrust from a ballasted truck-mounted testing rig. Measurements of cone resistance, sleeve friction and pore pressure are made at 20 mm depth intervals and are stored on a computer for subsequent interpretation. Further information is available in the explanatory notes on cone penetration testing in Appendix A.

The CPTs were terminated due to cone refusal in fill, very dense sand and inferred bedrock. Three tests were attempted at CPT201 (CPT201, CPT201A and CPT201B) but it was not possible to penetrate buried obstructions at shallow depths and the CPTs were terminated at depths of 0.9 m to 1.1 m. Two tests were undertaken at CPT206 (CPT206 and CPT206A) to confirm cone refusal at 8.1 m to 8.4 m depth;

- Pore pressure dissipation tests in CPT203, CPT205 and CPT207 at depths of 11.1 m, 4.0 m and 4.0 m, respectively. Dissipation tests were undertaken using the piezocone penetrometer. Each test involved stopping the piezocone at the required depth and measuring the rate of pore pressure dissipation to assess the compressibility/consolidation characteristics of the soils. The data is stored on a computer for subsequent interpretation, plotting and analysis;
- Drilling ten boreholes (BH401 to BH410) to depths between 8.0 m and 24.7 m using a track-mounted drilling rig between 29 September and 9 October 2025. All boreholes were drilled using solid flight augers and rotary wash boring drilling techniques through the fill and soils beneath the site. Boreholes BH402, BH404, BH405, BH408, BH409, and BH410 were drilled to the top of weathered rock, and then extended to their target depths within bedrock using NMLC diamond coring;
- Standard Penetration Tests (SPT) were carried out in soil and weathered rock in the boreholes at regular depth intervals to determine soil consistency / density. It should be noted that SPT testing can underestimate soil consistency / density in soft and loose soils due to the added weight of drill rods and SPT hammer contributing to further penetration;
- Point Load Index strength tests were undertaken at regular intervals along the rock core;
- Groundwater monitoring wells were installed in boreholes BH402, BH404, BH406, BH408, and BH409 to depths of 11.4 m, 11.5 m, 8.0 m, 7.4 m, and 7.8 m, respectively. Following installation, the wells were developed to remove drilling fluid and dataloggers were installed for ongoing groundwater level monitoring;
- Supervision of the CPTs, drilling, sampling and logging of boreholes by an experienced engineer.

Coordinates and surface levels for the test locations were determined using a differential Global Positioning System (dGPS) receiver, which has an accuracy of 0.1 m. Coordinates are in GDA2020/MGA Zone 56 format (Geocentric Datum of Australia 2020 base with Map Grid of Australia projection) and levels are relative to Australian Height Datum (AHD). The test locations are shown on Drawing 1 in Appendix B.

6.2 Field work results

The detailed subsurface conditions encountered are presented in the borehole logs, and the CPT_us results provided in Appendix C, along with notes defining descriptive terms and classification methods. Explanatory notes on the test method and interpretation of the results are included in Appendix A.

The interpreted subsurface conditions encountered at the CPT locations are shown on the CPT plots including the soil stratification based on the measured cone tip pressure, sleeve resistance and pore pressure.

The general subsurface profile encountered at the test locations may be summarised as follows:

- **FILL:** Fill was encountered at all CPT locations and boreholes BH401 and BH407 from the ground surface to depths of between 0.3 m and 3.6 m. At most boreholes locations the upper 0.1 m to 0.4 m of the fill comprised heavily root affected sandy clay similar to a topsoil type material. The test results indicated generally sandy silt and silty sand fill of variable consistency. The fill appeared generally consistent with very loose and loose sand material with some denser layers. Buried obstructions were encountered within the fill at CPT201, CPT201A and CPT201B, which were unable to be penetrated and the CPTs were terminated within the fill in these locations; overlying
- **CLAY and SILT (very soft to firm):** Very soft, soft, soft to firm and firm clay, silty clay, and sandy silt with trace shell fragments and sulphurous odour to depths of between 1.7 m and 7.8 m; overlying
- **SAND (very loose, loose & medium dense):** Very loose, loose and medium dense sand and silty sand to depths between 3.8 m and 8.0 m; followed by
- **INTERBEDDED CLAY & SAND:** Alternating layers of clay and sand to depths of between 8.0 m and 25.2 m. The clay ranged between stiff and hard, and the sand ranged between loose and very dense.

CPT204 was terminated within very dense sand in this unit due to cone refusal. It is possible that cone refusal was due to either very dense sand or bedrock preventing further penetration, but it was interpreted that refusal was due to very dense sand in CPT204; overlying

- **SANDSTONE BEDROCK:** Generally low and medium strength, fresh to moderately weathered, pale grey, fine to medium grained sandstone (Hawkesbury Sandstone) to the termination depth of boreholes. Very low and low strength, highly to moderately weathered sandstone was noted within the upper portion of the bedrock in BH405 and BH410, which then graded to low and medium strength sandstone, except at BH405, where the rock strength increased to high and medium to high strength rock from 18.7 m depth to the base of the borehole.

Highly weathered, very low strength bands were noted in most rock-cored boreholes at depths between 8.5 m and 19.0 m.

Clay seams ranging in thickness between 40 mm and 160 mm were noted in all rock-cored boreholes at depths between 6.9 m and 13.1 m.

The rock was typically slightly fractured in the rock-cored boreholes with zones of fractured and unbroken rock at variable depths.

Bedrock was inferred at CPT test locations where there was a sudden, high pressure on the cone tip and resultant refusal. Bedrock was inferred at the base of the tests at CPT202, CPT203 and CPT205 to CPT207 at depths of between 7.9 m and 21.1 m. CPT204 extended to 25.2 m depth at cone refusal, which was interpreted to be due to very dense sand rather than bedrock.

Table 2 summarises the levels at which different materials were encountered in the boreholes.

Table 3 summarises the levels at which different materials were encountered in the CPTs.

Table 2: Summary of Interpreted Material Strata Levels (Boreholes)

Stratum	Depth (m) [RL (m, AHD)] of Top of Stratum									
	BH401	BH402	BH403	BH404	BH405	BH406	BH407	BH408	BH409	BH410
Ground Surface / Topsoil / Fill	[1.6]	[1.2]	[1.2]	[0.7]	[1.2]	[1.1]	[1.7]	[1.5]	[1.5]	[1.3]
Clay & Silt: very soft to firm	1.5 [0.1]	NE	NE	0.6 [0.1]	1.6 [-0.4]	2.4 [-1.3]	3.6 [-1.9]	0.7 [0.8]	2.9 [-1.4]	2.8 [-1.5]
Sand: very loose, loose, & medium dense	2.9 [-1.3]	0.7 [0.5]	0.1 [1.1]	2.6 [-1.9]	3.3 [-2.1]	3.8 [-2.7]	6.4 [-4.7]	6.0 [-4.5]	NE	5.5 [-4.2]
Interbedded Clay & Sand	6.9 [-5.3]	NE	6.3 [-5.1]	NE	6.9 [-5.7]	7.1 [-6.0]	NE	7.9 [-6.4]	7.8 [-6.3]	7.8 [-6.5]
Low Strength Sandstone	21.1* [-19.5]	5.6 [-4.4]	NE	NE	16.9 [-15.7]	NE	NE	10.5 [-9.0]	13.9 [-12.4]	10.5 [-9.2]
Medium Strength Sandstone	NE	6.2 [-5.0]	NE	4.0 [-3.3]	NE	NE	NE	13.1 [-11.6]	15.0 [-13.5]	16.1 [-14.8]
High Strength Sandstone	NE	NE	NE	NE	18.7 [-17.5]	NE	NE	NE	NE	NE
Termination Depth	21.1 [-19.5]	11.4 [-10.2]	8.5 [-7.3]	11.5 [-10.8]	24.7 [-23.5]	8.5 [-7.4]	8.5 [-6.8]	18.8 [-17.3]	20.0 [-18.5]	17.5 [-16.2]

Notes: NE = Not Encountered. *Inferred based on rotary wash bore refusal.

Table 3: Summary of Interpreted Material Strata Levels (CPTs)

Stratum	Depth (m) [RL (m, AHD)] of Top of Stratum									
	CPT201	CPT201A	CPT201B	CPT202	CPT203	CPT204	CPT205	CPT206	CPT206A	CPT207
Ground Surface / Fill	[2.2]	[2.1]	[2.3]	[1.0]	[1.1]	[1.5]	[1.6]	[1.9]	[1.4]	[1.6]
Clay & Silt: very soft & firm	NE	NE	NE	1.0 [0.0]	1.0 [0.1]	1.5 [0.0]	0.6 [1.0]	2.4 [-0.5]	0.5 [0.9]	1.5 [0.1]
Sand: very loose, loose, medium dense	NE	NE	NE	1.7 [-0.7]	2.6 [-1.5]	4.2 [-2.7]	NE	NE	NE	NE
Interbedded Clay & Sand	NE	NE	NE	5.0 [-4.0]	3.8 [-2.7]	5.0 [-3.5]	8.0 [-6.4]	NE	NE	8.6 [-7.0]
Inferred Bedrock	NE	NE	NE	21.1 [-20.1]	17.4 [-16.3]	NE	18.5 [-16.9]	8.4 [-6.5]	7.9 [-6.5]	12.0 [-10.4]
Base of CPT	0.9 [1.3]	0.9 [1.3]	1.1 [1.2]	21.2 [-20.2]	17.4 [-16.3]	25.2 [-23.7]	18.6 [-17.0]	8.4 [-6.5]	8.1 [-6.7]	12.0 [-10.4]

Notes: NE = not encountered

Groundwater was observed in all boreholes during drilling at depths between 0.4 m and 2.5 m, with the exception of BH409 in which groundwater was not observed whilst augering to only a shallow depth.

Groundwater monitoring wells were installed in BH402, BH404, BH406, BH408, and BH409, with the screened depths and material summarised in Table 4 below. All wells were purged (removal of water from well) on 10/10/2025 and groundwater level monitoring is ongoing with dataloggers. Groundwater observations from the ongoing monitoring will be reported separately.

Table 4: Summary of Well Installation and Initial Groundwater Level Measurements

Location	Screened Depth (m)	Material
BH402	6.0 – 11.4	SANDSTONE
BH404	5.0 – 11.5	SANDSTONE
BH406	1.5 – 8.0	SAND
BH408	0.2 – 7.5	CLAY & SAND
BH409	1.5 – 8.0	CLAY & SAND

Groundwater level measurements were attempted in the CPT holes after the withdrawal of the rods and the groundwater observations are summarised in Table 5.

Table 5: Groundwater Level Observations in CPT holes (Depth, m and [RL, m AHD])

CPT	Groundwater Measurement	Comments
CPT201	-	Shallow tests, groundwater not observed to termination depth.
CPT201A	-	
CPT201B	-	
CPT202	1.2 [-0.2]	Groundwater measured.
CPT203	1.1 [0.0]	Groundwater measured.
CPT204	-	Hole collapse measured at 1.4 m depth [RL 0.1 m], which may indicate the groundwater level at this location.
CPT205	0.8 [0.8]	Groundwater measured.
CPT206	-	Hole collapse measured at 0.7 m depth [RL 1.2 m]. Groundwater is likely to be at a similar level to nearby test, CPT206A, at approximately 1.4 m depth [RL 0.5 m].
CPT206A	0.9 [0.5]	Groundwater measured.
CPT207	0.9 [0.7]	Groundwater measured.

The results of the pore pressure dissipation tests are summarised in Table 6 and the detailed results are included in Appendix D.

Table 6: Results of Pore Pressure Dissipation Testing

CPT	Test Depth (m)	Material	Horizontal Coefficient of Consolidation (c_h , m ² /year)
CPT203	11.1 m	Clay & Silty Clay: stiff with sand layers	109
CPT205	4.0 m	Clay & Silty Clay: soft to firm with sand layers	26
CPT207	4.0 m	Clay & Silty Clay: soft	12

7. Geotechnical Model

The geotechnical model is illustrated in the Interpreted Geotechnical Cross-Sections A-A', B-B' and C-C' in Drawings 2 to 4, in Appendix B. The interpreted geotechnical boundaries between units or layers are shown for illustrative purposes only and it must be noted that variations in the soil profile may vary away from the borehole/CPT locations and from that shown on the sections.

The interpreted geotechnical model can be summarised as follows:

- **Unit 1 – Fill:** typically sandy/granular, including surficial grass cover, topsoil material and rubble material (JK boreholes noted inclusions of gravel and bricks), over possible fill comprising sandy silt assessed to be historic dredged material during initial construction of the golf course. The testing at CPT201 indicated possibly large pieces of buried rubble within the fill, which is expected to be more widespread within the northern, more developed portion of the site;
- **Unit 2 – Clayey material:** estuarine deposits comprising soft, soft to firm and firm clay, sandy silt, and silty clay with occasional sand bands. This unit is typically deeper in the southern portion of the site (up to about 7 m thick) and reducing to a thin or absent layer in the north and north-west parts of the site;
- **Unit 3 – Sandy soil:** alluvial deposits comprising very loose and loose sand and silty sand;
- **Unit 4 – Interbedded sand & clay:** alluvial deposits comprising alternating layers of stiff to hard clay and medium dense to very dense sand with some loose to medium dense bands; and
- **Units 5a to 5c – Sandstone Bedrock:** low, low to medium (Unit 5a), and medium strength (Unit 5b), moderately weathered to slightly weathered, grading to fresh medium to high and high strength (Unit 5c), pale grey, medium to coarse grained sandstone. Highly weathered very low strength bands were noted in BH410 at 12.8 m depth, and medium to high and high strength rock was noted in BH402 and BH405 at depths of 10.2 m and 18.7 m.

Clay seams ranging in thickness between 40 mm and 160 mm were noted in most rock-cored boreholes at depths between 6.9 m and 14.5 m.

Sandstone bedrock was also inferred based on CPT results and previous (borehole) investigations at the site.

An interpolated contour plan has been generated showing the RL of the top of rock (Unit 5) to assist with planning, which is shown on Drawing 5 in Appendix B. It is noted that this plan has been generated based on the CPT and borehole information (current and previous investigations) at discrete points and may not represent the actual ground conditions between the test locations. It is further noted that top of rock levels may only be inferred from CPTs and it is possible that the actual depth to rock may be greater than indicated by the CPT refusal depth. As shown in Cross-sections A-A' and B-B' rock levels appear to vary relatively suddenly in some areas. It is possible that rock levels are not gradual, but rather step down in a series of small cliff lines and benches. The higher elevation hill located in the northern portion of the site is inferred to be a previous sandstone outcrop now covered with surficial fill, interpreted from the shallow refusal depths in previous CES boreholes. The contour plan is approximate and to be used as a high-level guide, only.

Groundwater was measured at depths of between 0.6 m and 1.9 m (RL -0.7 m to 0.8 m AHD) during the field work. These groundwater measurements are consistent with the location of the site and its proximity to the Cooks River and Botany Bay. It is expected that groundwater levels at the site will vary between approximately RL -1.0 m and RL 2.0 m AHD and may rise above the current ground surface during flooding events.

It is noted that groundwater levels will fluctuate with weather, climactic conditions and tidal influences, and may temporarily rise following periods of prolonged rainfall. Groundwater levels may also be impacted by human activities such as dewatering in the area surrounding the site.

8. Proposed Development

It is understood that the proposed redevelopment will include the demolition of the existing golf course buildings and removal of golf course infrastructure followed by bulk earthworks for raising and levelling of the site, construction of multi-storey warehouse and office buildings, car parking and hardstand areas, as well as landscaping, footpaths and other ancillary works.

The bulk earthworks plans indicate a bulk earthworks level (BEL) of RL 3.1 m for roads, hardstands and pads, and a BEL of RL 1.6 m within building footprints with a finished floor level of RL 3.6 m. Filling will be required across much of the site to a maximum fill height of 3 m and cutting will be required in elevated areas, up to 4.5 m depth.

9. Comments

9.1 General

The placement of fill over the site will cause consolidation of the soft and firm clays, which has the potential to cause excessive settlements if it is not managed appropriately. Some form of soft soil (ground) improvement will be required within areas of the site where loads will not be supported by deep foundations and where significant zones of soft and firm clayey soil (Unit 2) are present. This could be undertaken by pre-loading or surcharging the ground with fill to allow the consolidation settlement to occur in a controlled manner, possibly with the aid of wick drains to

hasten the process. The time taken to achieve adequate consolidation is dependent on the thickness of soft soil, the consolidation characteristics of the soil, drainage characteristics of the soils above and below the compressible soil and the proposed load to be applied. The southern portion of the site has deep deposits of soft and firm clay, with the thickness of the deposits tending to reduce towards the north and north-west. The extent of required soft soil improvement will vary across the site.

Ground improvement by installing controlled-modulus columns (CMCs) with transfer platforms may be considered to support building loads and in areas with deep soft and firm clay. This technique involves installing columns of stiffer material (e.g. concrete, grout) within the weaker profile, effectively increasing the modulus of the weaker material to reduce overall settlements to tolerable levels. This process is not time-dependent and is likely to produce results more rapidly when compared with soft soil improvement such as pre-loading or surcharging.

Another ground improvement method that could be considered is the installation of stone columns, which has a similar soil stiffening effect to CMCs with an added benefit of providing a short, horizontal drainage pathway for consolidating soils. This can substantially reduce the time for primary consolidation of clayey soil. However, the installation of stone columns can cause significant vibrations, depending on the installation method, and it may not be suitable for the site.

It is understood that the preferred ground improvement method beneath buildings and car park areas is to use CMCs and transfer platforms. Menard Oceania Pty Ltd (Menard) has prepared an indicative CMC and platform scheme, which is attached in Appendix E for reference.

Deep piled foundations to rock could also be considered to support high loads.

Approach slabs may be necessary between filled areas with expected ongoing settlements and areas supported by deep foundations or CMCs (with limited settlements) to maintain an acceptable grades between areas with differing settlements.

It will also be necessary to consider the potential impacts of settlement, lateral spreading and applied pressures on the major pipelines traversing the eastern part of the site (Sydney Desalination and APA ethane gas pipelines).

The following sections provide comments for geotechnical design and construction relevant to the proposed development. It is noted that the project is at an early planning and approvals stage, and further comments/advice may be necessary throughout design development.

9.2 Site Preparation

9.2.1 Subgrade Preparation and Fill Placement

The existing fill at the site is assumed to be uncontrolled and will generally require subgrade preparation to provide a uniform bearing layer and reduce the potential for differential settlement of the fill. The least risk approach for subgrade preparation at sites with existing uncontrolled fill is for complete removal and replacement of all uncontrolled fill. However, due to the shallow groundwater table, depth of fill and underlying soils at the site, complete removal and replacement of existing uncontrolled fill is unlikely to be a feasible option.

A suggested general earthworks methodology for bulk filling works on the site is summarised below. As uncontrolled fill may remain below new engineered fill, as well as soft compressible soils in some areas, this subgrade preparation will not eliminate the risk of differential settlement, but will help to reduce the risk, and may require more specific geotechnical assessment in all or parts of the site.

- Strip topsoil, root affected, and organic soils, as well as any other deleterious materials (refer to Section 9.2.2 for further comments on topsoil, root affected and organic soils);
- For shallow fill or cut areas, remove fill to at least 0.6 m below the design bulk earthworks level. Removal to greater depths may be necessary in areas with deeper and looser fill, subject to geotechnical assessment;
- Prepare the subgrade by compacting the exposed material, then test roll the exposed surface using at least six passes of a minimum 12-tonne roller in non-vibration mode. The final pass should be witnessed by an experienced geotechnical engineer to detect any weak zones;
- Any weak zones identified during test rolling should be rectified as directed by the geotechnical engineer. A bridging layer may be required where there is insufficient fill above the soft and firm clays or in low-lying areas close to the groundwater table;
- Replacement fill should be free of oversize particles (>100 mm) and deleterious material, and should be placed in loose layers of thickness not greater than 250 mm (dependent upon the size of compaction machinery) and compacted to a dry density ratio of at least 98% relative to Standard compaction, with moisture contents maintained within 2% of Standard optimum moisture content if the fill exhibits clay-like properties. Compaction should be increased to a dry density ratio of 100% relative to Standard compaction for the upper layer of the subgrade. If the replacement fill used is sand, compact to a minimum Density Index of 75%;
- Moisture conditioning (i.e. drying or wetting) may be required for compaction of fill; and
- All fill should be placed in accordance with AS 3798 – 2007 “Guidelines on earthworks for commercial and residential developments” with earthworks quality control testing undertaken to verify that the required compaction/moisture criteria are achieved.

Piling rigs and other large machinery will generally require a suitable working platform for safety and operational reasons. An assessment of the required platform capacity (and design) should be made once piling equipment has been selected. Experience on sites with similar subsurface profiles suggests that some form of rockfill working platform will be required, possibly incorporating geogrid reinforcement. Where large rigs are to be used this working platform may be relatively thick.

Trafficability on the sandy fill may be difficult for heavy plant, particularly in low-lying areas close to the groundwater table where wet, ‘boggy’ conditions could be expected. A running layer of good quality granular material (e.g. DGB, DGS, crushed concrete) could be placed where heavy plant will operate (e.g. for dump trucks) to improve trafficability. The minimum thickness of the running layer will depend on the moisture content, consistency of the material and type/weight of plant, but typically a running layer with thickness of at least 150 mm would be required. The running layer could be incorporated into the design of working platforms, such as for piling plant and mobile cranes.

The CPT results from the current investigation, combined with previous experience, suggest that a preliminary design subgrade CBR of 5% would be appropriate for the existing predominantly silty sand fill materials on the site. The CBR of imported fill will probably govern the design of

pavements in areas that are to be raised by 1 m or more. CBR values should be confirmed by a geotechnical engineer following a suitable programme of laboratory testing during the earthworks phase or further geotechnical investigation works, once the pavement areas have been finalised.

The existing concrete slabs and pavements could be removed and crushed for re-use on site as fill, bridging material or as roadbase for temporary access roads/working platforms. If existing pavements or slabs are to remain in place then they should be broken-up to ensure that they do not act as a drainage barrier across the site.

From a geotechnical perspective, the predominantly sandy fill is likely to be suitable for re-use as engineered fill, provided that it is free of oversize particles (>100 mm) and deleterious material. The suitability of re-using site-won fill and natural soil should also be considered from a contamination perspective.

9.2.2 Topsoil, root affected, and organic soils

The findings from the geotechnical boreholes drilled during the recent investigation indicate a root affected organic topsoil fill depth of between 0.1 m and 0.4 m across the site. With reference to the previous borehole investigations by JK and CES, and Douglas' 2024 contamination investigation, an average root affected, organic topsoil depth of approximately 0.15 m is suggested as the design depth for the upper organic part of the topsoil. An underlying, generally inorganic, component of the topsoil was present across parts of the site and an initial design thickness of 0.1 m to 0.15 m for this layer (below the root-affected surface layer of topsoil) is suggested. It is noted that the field work results from the recent and previous investigations indicated substantial variation across the site, ranging from no topsoil, root affected or organic soil to about 0.5 m deep topsoil material.

From a geotechnical viewpoint, the upper organic part of all topsoil should be disposed offsite or used as 'non-structural' fill (i.e. material that is not required to provide support to structures or pavements, such as for garden beds and landscaping). Inorganic components of the topsoil beneath the upper organic, root affected zone may be excavated and blended with suitable fill, to be used as general fill on the site. The blending ratio will depend on the requirements of the project earthworks specification, but a maximum blend ratio of 1-part inorganic topsoil to 10-parts suitable fill (i.e. maximum of 10% inorganic topsoil) is suggested for preliminary design and planning purposes. Blended material would generally be unsuitable for the upper layer of subgrade.

The suitability of re-using the material should also be considered from a contamination perspective.

It is noted that investigation of the topsoil thickness and organic contents during previous and current investigations was not a focus for those investigations, which were predominantly contamination-focussed investigations. Further site inspection and laboratory testing will be necessary during design development to refine topsoil depth estimates and determine the topsoil composition, including organic content, and its suitability for incorporation into fill materials for the development.

9.2.3 Settlement

Preliminary settlement analyses were undertaken for the cases where 1 m and 2 m of fill is placed on the site to determine the orders of magnitude of settlements. Further, more detailed, analyses will be required following feedback from the design team regarding the time that fill can be left in place, additional loads, tolerable settlements, and other options to consider (e.g. surcharge loads, use of wick drains or stone columns).

For the purposes of the preliminary settlement analyses, the site was partitioned into three areas, as follows:

- Northern & NW Area: northern and north-western portion of the site with no Unit 2 soft and firm clay material;
- Central Area: central portion of the site with a 2 m thick layer of Unit 2 material; and
- Southern Area: southern portion of the site with a 7 m thick layer of Unit 2 material.

It is assumed that the 1 m and 2 m of fill can be placed and left for 9 months prior to construction of pavements, hardstands, etc. and that a design life of 50 years will be adopted for the proposed development. The preliminary settlement estimates for the initial period (0 to 9 months) due to primary consolidation and residual settlements from the reference point of 9 months to 50 years due to primary and secondary consolidation are summarised in Table 7. The 'post-construction' settlement (i.e. 9 months to 50 years) will be critical for the design as this is the settlement that will be experienced by the finished pavements and slabs, which cannot be rectified easily. Immediate settlements have not been included here as we have assumed that these will be 'built out' during initial fill placement.

Table 7: Preliminary Settlement Estimation due to Primary and Secondary Consolidation

Area	1m Fill Placed		2m Fill Placed	
	0 to 9mo	9mo to 50yr	0 to 9mo	9mo to 50yr
Northern & NW Area	<20 mm	<20 mm	<30 mm	<20 mm
Central Area	20-50 mm	10-30 mm	40-90 mm	10-30 mm
Southern Area	30-80 mm	50-100 mm	70-150 mm	80-150 mm

Notes: **bold** = estimated 'post-construction' settlement range

Consideration could be given to treating the soft soils with additional surcharge preload and/or the use of wick drains. Surcharge preload is additional material that is placed above design earthworks levels to increase the effective stress in the compressible soil during the pre-construction period, which is then removed prior to the construction of pavements and slab. This has the effect of reducing or eliminating post-construction primary consolidation, as well as reducing the rate of secondary consolidation (creep). Wick drains provide a shorter drainage path for soils, which can significantly reduce the time for primary consolidation.

Detailed analysis would be necessary for surcharge preload and wick drain design, however, high-level calculations indicate that post-construction (i.e. 9 months to 50 years) maximum settlements for the southern area with 2 m of fill placed are:

- 1 m of additional surcharge preload: less than 100 mm post-construction settlement;

- 2 m of additional surcharge preload: less than 70 mm post-construction settlement; and
- Wick drains at a suitable spacing for all primary consolidation to occur pre-construction: less than 50 mm post-construction settlement.

The settlement estimates in this report have not considered additional surcharge loads due to traffic, equipment storage, or building loads, which could result in substantial increases to the above settlement estimates. Heavily loaded slabs for buildings will be associated with high settlements and will require ground improvement or piled structures. Furthermore, detailed settlement estimates should be commissioned once the final development details, in particular potential loads and settlement tolerances, are known.

9.2.4 **Controlled-Modulus Columns**

Ground improvement with CMCs would typically involve the installation of closely spaced rigid inclusions extending down to stiffer material (e.g. Unit 4, interbedded clay and sand). The spacing of CMCs is typically in the order of 1-3 m and is dependent on the ground conditions, CMC type, proposed loads, tolerable total and differential settlements, as well as the type of load transfer platform at the surface.

The load transfer platform usually includes high tensile capacity geogrid with good quality crushed rock (e.g. DGB20) with a typical thickness of 0.4-1.5 m. Alternatively, a post-tensioned concrete slab may also be feasible and can result in wider spaced CMCs.

Stone columns may also be considered and have a similar design process to CMCs, although can expedite consolidation, particularly when used in conjunction with a surcharge, such as a temporary earthfill embankment.

Menard's indicative CMC and platform analysis and sequencing (attached in Appendix E) show typically 280 mm to 360 mm diameter CMCs at 1.5 m to 2.5 m spacing with a 0.4 m thick transfer platform, overlain by additional engineered fill and a raft slab.

9.3 **Excavation Conditions**

Excavation for bulk earthworks is anticipated to be up to approximately 2 m depth across most of the site, and down to a maximum of 4.5 m depth in localised elevated areas. Excavations across most of the site is likely to be through fill and natural soils. Sandstone bedrock is likely to be present at shallow depths in the elevated northern area, based on the interpreted geotechnical model of the site. Excavation of fill and natural soil materials should be readily achievable using conventional earthmoving equipment, such as hydraulic excavators and bulldozers. Pavements, slabs and large, buried obstructions may require the use of hydraulic hammers (i.e. impact breakers). Excavations in medium strength or stronger rock is likely to require the use of heavy ripping, rock hammers, etc. for effective removal.

Excavations are expected to be predominantly above the groundwater table. For any excavation below the groundwater table, temporary dewatering will be required to lower groundwater levels within the excavation footprint. Suitable dewatering methods will depend on the depth of proposed excavation and the soil profile and may include sump-and-pump methods within a confined or localised excavation, or spearpoint wells connected to an extraction pump. Further advice can be provided if excavations below groundwater are included in the proposed development.

All excavated materials to be disposed off-site must be moved in accordance with the provisions of the current legislation and guidelines including the Waste Classification Guidelines (NSW EPA, 2014).

9.4 **Ground Vibrations**

During construction, it will be necessary to use appropriate methods and equipment to keep ground vibrations at adjacent infrastructure and structures within acceptable limits. In particular, it is expected that consideration of vibrations to the Marsh Street bridge, M6 temporary dive site, Sydney Desalination pipeline and APA ethane gas pipeline may be necessary.

Based on previous experience and with reference to Australian Standard AS 2670.2-1990 "Evaluation of human exposure to whole-body vibrations – continuous and shock induced vibrations in buildings (1-80 Hz)", an initial vibration limit of 8 mm/sec vector sum peak particle velocity (VSPPV) at the foundation level of adjacent buildings for human comfort consideration is suggested. This vibration limit may need to be reduced if there are vibration-sensitive buildings, utilities or equipment in the area. As a guide, a reduced vibration limit of 3-5 mm/s may be required for any structures on loose sands. It will be necessary to confirm the acceptable vibration criteria for the major pipeline infrastructure and other utilities/structures at and nearby the site.

As the magnitude of vibration transmission is site specific, it is recommended that a vibration trial be undertaken at the commencement of earthworks. The trial may indicate that smaller or different types of plant should be used.

9.5 **Excavation Support**

9.5.1 **Batter Slopes**

Steep or vertical excavations in fill and soil are not expected to be stable for any period of time. Temporary batters above the groundwater table, with no surcharge loading, should be feasible for minor excavations on the site and should be cut no steeper than 1.5H:1V (Horizontal:Vertical) for depths of up to 3 m. Permanent or semi-permanent batters for embankments should be no steeper than 2H:1V and may need to be flatter or incorporate intermediate benches if greater than 3 m in height. Permanent batters should be vegetated and at no steeper than 3H:1V to allow maintenance and vegetation.

Batters would generally not be appropriate to support excavations below the groundwater table.

Care should be taken where any loads are planned at the crest of batter slopes (e.g. stockpiles and mobile plant). Groundwater levels can also affect batter stability. A slope stability analysis should be undertaken for batters subjected to surcharge loads on a case-by-case basis following inspection and testing by a geotechnical engineer.

9.5.2 **Earth Pressures**

Excavations may need to be retained either temporarily or permanently where it is not practical to construct batters. Retaining structures and shoring walls will be subjected to earth pressures. Table 8 outlines material and strength parameters that could be used for the design of excavation support (i.e. retaining/shoring) structures.

A triangular lateral earth pressure distribution could be assumed for cantilevered shoring systems and systems with one row of support (increasing linearly with depth).

Table 8: Material and Strength Parameters for Excavation Support Structures

Material	Bulk Unit Weight (kN/m ³)	Coefficient of Active Earth Pressure (K_a)	Coefficient of Earth Pressure at Rest (K_0)	Coefficient of Passive Earth Pressure ¹ (K_p)
Fill & Sandy Soil (Units 1 & 3)	20	0.35	0.55	2.5
Clayey Soil (Unit 2)	Determine using parameters provided in Table 11 (Section 9.7.5)			
Interbedded Clay & Sand (Unit 4)	20	0.3	0.5	3.0

Notes: ¹Only from 0.5 m below excavation level

A rectangular lateral earth pressure distribution could be assumed for shoring/retaining walls fully propped such as trench boxes and shoring shields, braced by two or more rows of props. Where there are no movement sensitive structures or services in close proximity to the excavation, the maximum pressure (in kPa) could be calculated using $4H$ (where H equals the depth to the bulk excavation level). Where the wall movement is to be minimised, the maximum pressure could be calculated using $6H$ to $8H$ (in kPa).

Lateral pressures due to surcharge loads from construction machinery and traffic should be included where relevant. Hydrostatic pressure should also be included in the design to cater for groundwater rise, in flooding and prolonged wet weather situations.

9.6 Groundwater

The groundwater level has been measured within about 1 m of the existing ground surface and will fluctuate over time. It is understood that excavation will probably be limited to levelling localised elevated areas, and possibly works related to the construction of pile caps, slab thickenings and installation of services. Excavation below the groundwater table, is possible, but is expected to prove problematic and should be avoided where possible.

It will be necessary to undertake localised dewatering if excavation below the groundwater table is required. This would typically involve shoring structures (e.g. sheet piles) and dewatering spears to allow for localised drawdown of groundwater in the area of interest. Further advice can be provided if excavation below the water table is included in the proposed development.

9.7 Foundations

9.7.1 General

Spread or high-level footings (e.g. pad and strip footings) will generally not be appropriate for the site due to the weak and variable material encountered during the investigation. Raft or a stiffened raft slabs may be considered for buildings in the northern and north-western portion of the site where Units 2 and 3 are not present or are only thin, however, it is expected that raft slabs

are generally unsuitable for the buildings at this site due to the soft and loose soils and variable nature of the soil conditions. The general design parameters in Section 9.7.5 may be used for preliminary design consideration of raft slabs. However, time dependent consolidation settlements will need careful consideration in the clayey soils. It is expected that all significant building loads will need to be supported on piled foundations or following significant ground improvement, such as using CMCs or stone columns with load transfer platforms.

Suitable pile types to support the main superstructure of buildings include:

- Drilled non-displacement (i.e. “replacement”) piles, such as cased bored piles and continuous flight auger (CFA) piles; and
- Displacement piles, such as concrete-injected screw-type piles, driven precast concrete piles and driven steel piles.

Heavily loaded columns would generally need to be supported on drilled, non-displacement, cased bored or CFA piles socketed within the sandstone bedrock underlying the site.

Moderately loaded columns may be supported on displacement piles, which typically extend to the top of rock only and cannot achieve a rock socket. An advantage of these pile types is that there is only very limited (or no) spoil generated during piling. However, vibrations caused by the installation of driven piles would need to be considered for the site.

Lightly loaded structures could also be supported using these pile types, and possibly steel screw piles in areas of the site where the stronger alluvium is at relatively shallow depth and where corrosion protection measures are provided.

9.7.2 Drilled, Non-displacement Piles

CFA piles are constructed by drilling a hollow-stem auger into the ground to a nominated depth. Concrete or grout is injected through the stem of the auger as the auger is withdrawn. A column of concrete or grout is then formed upon complete auger withdrawal and a steel reinforcing cage is lowered into the column to complete the pile.

Bored piles would need to be drilled with bentonite or polymer mud support through the soils followed by the installation of casing (temporary or permanent) to the top of rock as the soils at the site are not expected to be self-supporting. Drilling could then be undertaken through the casing with a small diameter auger or rock coring barrel to achieve the rock socket.

CFA and bored piles could be designed using the parameters provided in Table 9. Parameters for both the working stress and limit-state design approaches have been provided. The quality of the rock varies across the site, and the parameters will need to be reviewed following design development and possibly further detailed investigations. A range has been included for the medium strength rock (Unit 5b) due to the presence of weak seams at some locations which, if present within the zone of influence of the pile toe, may warrant use of the lower bound parameters. The Unit 5c has not been well defined and will require further investigation with deeper cored boreholes if this is to be used for foundations. An interpolated top of rock contour plan has been prepared (Drawing 5 in Appendix B) to assist with planning, which is based on the rock-cored boreholes and inferred top of rock depths from CPTs.

Table 9: Preliminary Design Parameters for Bored and CFA Piles

Material Description	Allowable End-Bearing Pressure (kPa)	Allowable Shaft Adhesion (kPa)¹	Ultimate End-Bearing Pressure (kPa)	Ultimate Shaft Adhesion (kPa)¹	Elastic Modulus (MPa)
Unit 5a – LS Sandstone Rock	2,000	100	10,000	250	150
Unit 5b - MS Sandstone Rock ³	3,500-6,000	200-350	15,000-30,000	600-1,200	200-400
Unit 5c - HS Sandstone Rock ²	8,000	600	60,000	2,000	1,200

Notes: LS = low strength; MS = medium strength; HS = high strength;

¹Reduce by 50% for uplift loads and ensure cone-pullout criteria are met;

²Additional rock-cored boreholes will be required at pile locations to confirm HS sandstone rock

³ Range included for Unit 5b due to presence of seams at varying depths

It should be noted that the serviceability limit-state is likely to govern the design of the piles and the ultimate bearing pressures provided in Table 9 are unlikely to be achieved within the limits of serviceability. An appropriate geotechnical strength reduction factor should be applied when using the limit-state approach as outlined in AS 2159 – 2009 *Piling – Design and installation*.

Settlement of a pile is dependent on the loads applied to the pile and the foundation conditions in the socket zone and below the pile toe. The total settlement of a CFA or bored concrete pile designed using the 'allowable' parameters provided in Table 9 should be less than 1% of the pile diameter upon application of the design load.

Soil decompression can occur during CFA piling when a strong stratum is encountered. In this case, the augers continue to rotate but the rate of auger progression decreases and soil from around the auger is displaced upwards towards the surface. Decompression can cause weakening and settlement of the soils adjacent to the pile and should be avoided by monitoring auger speed and progression closely. Also, only skilled operators with high powered CFA rigs should be used for the piling works at this site.

9.7.3 Displacement Piles

Concrete screw-type piles are constructed using a similar process to a CFA pile except that the auger is inserted and withdrawn at the pitch of the auger so that pile spoil is not produced. This forms a full-displacement pile which allows for increased shaft capacities in soils. The downside of this piling technique is that refusal occurs on the top of rock and therefore lower end-bearing pressures usually result and rock sockets are not achievable. Table 10 provides suggested preliminary design parameters for displacement piles.

Driven precast concrete or steel-tube piles could also be used to support the proposed building loads and have an advantage in that they are also full-displacement piles (i.e. no pile spoil produced) and can usually support higher loads than piles cast in place, for the same size and end bearing conditions. The capacity of a pile driven to rock is likely to be governed by the structural capacity of the pile and the efficiency of the driving equipment. Driven piles could

initially be designed on the basis of the ‘ultimate’ design parameters provided in Table 10 although are usually governed by the structural capacity of the pile rather than the geotechnical capacity. Unit 4 materials will provide shaft resistance to concrete screw-type piles and driven piles. The installation of test piles and pile load testing should then be undertaken to confirm driving conditions, pile set, pile capacity and an appropriate geotechnical strength reduction factor. Settlement of a driven pile should be estimated using load test data obtained during the design confirmation stage of the piling process.

Steel screw piles for lightly loaded structures would need to extend into Unit 4 and could be designed using the generalised end-bearing parameters for the Unit 4 interbedded clay and sand shown in Table 10. Alternatively, a more detailed analysis for location-specific Unit 4 strata could be undertaken using the general design parameters in Section 9.7.5. Given the variability of material types within Unit 4, careful consideration of differential settlements would be required for structures spanning between piles founded in Unit 4 material.

Table 10: Preliminary Design Parameters for Displacement Piles

Material Description	Allowable End-Bearing Pressure (kPa)	Allowable Shaft Adhesion (kPa)	Ultimate End-Bearing Pressure (kPa)	Ultimate Shaft Adhesion (kPa)	Elastic Modulus (MPa)
Unit 4 – Interbedded Clay & Sand ¹	250	25	500	50	25
Unit 5a – LS Sandstone Rock	2,000	NA	10,000	NA	150

Notes: LS = low strength NA = shaft adhesion in rock not applicable for driven piles

¹Assumes minimum founding depth of 5 m and shaft adhesion only applicable below 5 m depth.

As per the previous section, serviceability limit-state is likely to govern the design of the piles and the ultimate bearing pressures provided are unlikely to be achieved within the limits of serviceability. An appropriate geotechnical strength reduction factor should be applied when using the limit-state approach as outlined in AS 2159 – 2009 *Piling – Design and installation*.

9.7.4 Negative Skin Friction

Negative skin friction or ‘downdrag’ describes the additional load applied to a pile as a result of consolidation or settlement of a compressible soil in contact with the pile shaft. The structural capacity of the pile should be designed to include a negative skin friction allowance in the Unit 2 soft and firm clayey soil and overlying fill.

9.7.5 General Design Parameters

Suggested preliminary general design parameters for the geological units encountered at the site are provided in Table 11. These parameters are based on the boreholes undertaken during the current investigation, and information from Douglas’ and JK’s investigations on the site, together with consideration of a range of published data and empirical correlations.

Parameters are provided for crushed sandstone fill placed as engineered fill, which has been assumed at this stage as a guide. These parameters may be used to assess bearing capacities of various strata, lateral resistance for single piles and other relevant applications. Caution is required for the use of the drained modulus values, E' , for the assessment of settlements as the parameter does not include secondary consolidation, which may be substantial for Unit 2 materials in particular. As discussed previously, consolidation (primary and secondary) of compressible clay layers occurs over significant timeframes, which needs to be considered and managed appropriately.

Table 11: Suggested Preliminary General Parameters for Geological Units

Unit	Unit Weight (kN/m ³)	Drained Poisson's Ratio	Friction Angle (°)	Effective Cohesion (kPa)	Undrained Shear Strength, c _u (kPa)	Drained Modulus, E' (MPa)	Parameters for Lateral Resistance for Single Piles	
							Horizontal Modulus of Subgrade Reaction, K _h ⁽¹⁾ (kN/m ³)	Ultimate Lateral Resistance (MPa)
FILL – Engineered Fill (Sandstone)	20	0.3	35	2	50	25	17,500/d	0.1
UNIT 1 – Existing Fill	18	0.3	28	0	-	5	3,500/d	-
UNIT 2 – s clay	17	0.3	20	2	17	3	2,100/d	-
UNIT 2 – s-f clay	17	0.3	20	3	25	4	2,800/d	-
UNIT 2 – f clay	18	0.3	20	4	35	5	3,500/d	-
UNIT 3 – vl sand	18	0.3	28	0	-	5	3,500/d	-
UNIT 3 – l sand	18	0.3	30	0	-	10	7,000/d	-
UNIT 4 – md sand	18	0.3	33	0	-	35	24,500/d	Varies with depth

Unit	Unit Weight (kN/m ³)	Drained Poisson's Ratio	Friction Angle (°)	Effective Cohesion (kPa)	Undrained Shear Strength, c_u (kPa)	Drained Modulus, E' (MPa)	Parameters for Lateral Resistance for Single Piles	
							Horizontal Modulus of Subgrade Reaction, $K_h^{(1)}$ (kN/m ³)	Ultimate Lateral Resistance (MPa)
UNIT 4 - d-vd sand	19	0.3	37	0	-	75	52,500/d	Varies with depth
UNIT 4 - st clay	19	0.3	25	7	75	15	10,500/d	0.1
UNIT 4 - vst-h clay	20	0.25	25	10	200	30	21,000/d	0.4
UNIT 5a – LS Sandstone	23	0.25	32	40	-	150	70,000/d	1
UNIT 5b – MS Sandstone	24	0.25	34	200	-	400	280,000/d	9
UNIT 5c – HS Sandstone	24	0.25	36	450	-	1200	840,000/d	18

Notes: (1) d = pile diameter in metres, sensitivity analysis should be undertaken using values at least $\pm 20\%$ of these values. The K_h values are based on the relationship of $K_h = 0.7E_v/d$.

s = soft; f = firm; st = stiff, vst = very stiff; h = hard;

vl = very loose; l = loose; md = medium dense; d = dense; vd = very dense;

LS = low strength; MS = medium strength; HS = high strength.

9.8 Acid Sulfate Soils

Mapping indicates the sites are in an area with high probability of ASS below 1-3 m depth. It is recommended that all material that is disturbed or brought to the surface from below the groundwater table should be treated as acid sulfate soil until proven otherwise. Reference should be made to Douglas' Acid Sulfate Soil Assessment and Management Plan (ref.: 223528.01.R.003) undertaken on the site for further comments and recommendations on the presence, treatment, and mitigation strategies involved with ASS. The effect of ASS on the durability of structural elements (e.g. piles) will need to be taken into account by the designers.

9.9 Soil Aggressivity

Reference should be made to Douglas' Salinity and Erosion Investigation and Management Plan (ref.: 223528.01.R.002) for detailed results of aggressivity testing and exposure classification for steel and concrete elements. Compared with Australian Standard 2159 – 2009 Tables 6.4.2(C): "Exposure Classification for Concrete Piles – Piles in Soil" and 6.5.2(C): "Exposure Classification for Steel Piles – Piles in Soil", the results of the testing indicated that the site soils are 'non-aggressive to severe' with respect to steel, and 'non-aggressive to moderate' with respect to concrete. Based on the results, an exposure classification of 'moderate' and 'severe' should be adopted for concrete and steel elements, respectively.

9.10 Seismic Design

Based on the sub-surface conditions encountered and in accordance with the requirements of AS1170.4-2007 Structural Design Actions Part 4 – Earthquake Actions in Australia, the site sub-soil is considered to correlate to Class D_e (shallow soil site). For Sydney, AS 1170.4 nominates a Hazard Factor (z) of 0.08. It may be possible to revise this classification to a less severe C_e, particularly where the soft soil layer is thinner or absent, with further testing and analysis of the site period, including by undertaking seismic CPTs.

9.11 Impacts on Infrastructure

There is significant infrastructure surrounding and within the site, including the Marsh Street bridge to the north, M6 temporary dive structure to the north-west (which may be backfilled before development works begin at the site), M8 motorway tunnels, and the Sydney Desalination pipeline and APA ethane gas pipeline that run through the site.

A design solution will be required to limit movements and pressures applied to the pipelines running through the site, particularly in areas underlain by deep soft and firm clayey soil. This may include piles or CMCs running adjacent to the pipelines with suspended slabs spanning the pipelines. Sydney Water will require a Specialist Engineering Assessment (SEA) to be undertaken for the Sydney Desalination pipelines, as well as for any other major buried assets close to the site, to assess the potential impact of the proposed development on the assets. It is expected that APA may also require an engineering assessment for impacts to their pipeline.

Similarly, Transport for NSW may require an assessment of the impact of the proposed development on the M6 temporary dive structure, M8 tunnels or Marsh Street bridge.

Where possible, dilapidation surveys may be necessary before construction commences in order to document any existing defects, so that any claims for damage due to construction related activities can be accurately assessed.

10. Limitations

Douglas Partners Pty Ltd (Douglas) has prepared this report for this project at 19-19A Marsh Street, Arncliffe NSW in line with Douglas' proposals 223528.01.P.001 and 223528.01.P.002 and acceptance received from Stockland Development Pty Limited. The work was carried out under the Standing Offer Deed between Douglas and Stockland, dated February 2025. This report is provided for the exclusive use of Stockland Development Pty Limited for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of Douglas, does so entirely at its own risk and without recourse to Douglas for any loss or damage. In preparing this report Douglas has necessarily relied upon information provided by the client and their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after Douglas' field testing has been completed.

Douglas' advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by Douglas in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

The assessment of atypical safety hazards arising from this advice is restricted to the geotechnical components set out in this report and based on known project conditions and stated design advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this report and requires additional project data and assessment.

The scope of work for this investigation did not include the assessment of surface or sub-surface materials or groundwater for contaminants, within or adjacent to the site. Refer to the accompanying report on contamination for further information about contamination at the site.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. Douglas cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by Douglas. This is because this report has been written as advice and opinion rather than instructions for construction.

The scope of work for this report did not include the assessment of surface or sub-surface materials or groundwater for contaminants, within or adjacent to the site. Should evidence of fill of unknown origin be noted in the report, and in particular the presence of building demolition materials, it should be recognised that there may be some risk that such fill may contain contaminants and hazardous building materials.

Appendix A

About this Report

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

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

Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

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

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

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at

the time of construction as are indicated in the report; and

- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements 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.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

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

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

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

continued next page

About this Report

Site Anomalies

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

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

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

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Introduction to Terminology, Symbols and Abbreviations

Douglas Partners' reports, investigation logs, and other correspondence may use terminology which has quantitative or qualitative connotations. To remove ambiguity or uncertainty surrounding the use of such terms, the following sets of notes pages may be attached Douglas Partners' reports, depending on the work performed and conditions encountered:

- Soil Descriptions;
- Rock Descriptions; and
- Sampling, insitu testing, and drilling methodologies

In addition to these pages, the following notes generally apply to most documents.

Abbreviation Codes

Site conditions may also be presented in a number of different formats, such as investigation logs, field mapping, or as a written summary. In some of these formats textual or symbolic terminology may be presented using textual abbreviation codes or graphic symbols, and, where commonly used, these are listed alongside the terminology definition. For ease of identification in these note pages, textual codes are presented in these notes in the following style **XW**. Code usage conforms with the following guidelines:

- Textual codes are case insensitive, although herein they are generally presented in upper case; and
- Textual codes are contextual (i.e. the same or similar combinations of characters may be used in different contexts with different meanings (for example `PL` is used for plastic limit in the context of soil moisture condition, as well as in `PL(A)` for point load test result in the testing results column)).

Data Integrity Codes

Subsurface investigation data recorded by Douglas Partners is generally managed in a highly structured database environment, where records "span" between a top and bottom depth interval. Depth interval "gaps" between records are considered to introduce ambiguity, and, where appropriate, our practice guidelines may require contiguous data sets. Recording meaningful data is not always appropriate (for example assigning a "strength" to a concrete pavement) and the following codes may be used to maintain contiguity in such circumstances.

Term	Description	Abbreviation Code
Core loss	No core recovery	KL
Unknown	Information was not available to allow classification of the property. For example, when auguring in loose, saturated sand auger cuttings may not be returned.	UK
No data	Information required to allow classification of the property was not available. For example, if drilling is commenced from the base of a hole predrilled by others	ND
Not Applicable	Derivation of the properties not appropriate or beyond the scope of the investigation. For example, providing a description of the strength of a concrete pavement	NA

Graphic Symbols

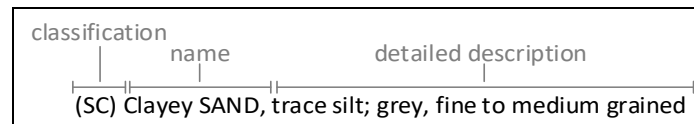
Douglas Partners' logs contain a "graphic" column which provides a pictorial representation of the basic composition of the material. The symbols used are directly representing the material name stated in the adjacent "Description of Strata" column, and as such no specific graphic symbology legend has been provided in these notes.

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Introduction

All materials which are not considered to be “in-situ rock” are described in general accordance with the soil description model of AS 1726-2017 Part 6.1.3, and can be broken down into the following description structure:



The “classification” comprises a two character “group symbol” providing a general summary of dominant soil characteristics. The “name” summarises the particle sizes within the soil which most influence its behaviour. The detailed description presents more information about composition, condition, structure, and origin of the soil.

Classification, naming and description of soils require the relative proportion of particles of different sizes within the whole soil mixture to be considered.

Particle size designation and Behaviour Model

Solid particles within a soil are differentiated on the basis of size.

The engineering behaviour properties of a soil can subsequently be modelled to be either “fine grained” (also known as “cohesive” behaviour) or “coarse grained” (“non cohesive” behaviour), depending on the relative proportion of fine or coarse fractions in the soil mixture.

Particle Size Designation	Particle Size (mm)	Behaviour Model	
		Behaviour	Approximate Dry Mass
Boulder	>200	Excluded from particle behaviour model as “oversize”	
Cobble	63 - 200		
Gravel ¹	2.36 - 63	Coarse	>65%
Sand ¹	0.075 - 2.36		
Silt	0.002 - 0.075	Fine	>35%
Clay	<0.002		

¹ – refer grain size subdivision descriptions below

The behaviour model boundaries defined above are not precise, and the material behaviour should be assumed from the name given to the material (which considers the particle fraction which dominates the behaviour, refer “component proportions” below), rather than strict observance of the proportions of particle sizes. For example, if a material is named a “Sandy CLAY”, this is indicative that the material exhibits fine grained behaviour, even if the dry mass of coarse grained material may exceed 65%.

Component proportions

The relative proportion of the dry mass of each particle size fraction is assessed to be a “primary”, “secondary”, or “minor” component of the soil mixture, depending on its influence over the soil behaviour.

Component Proportion Designation	Definition ¹	Relative Proportion	
		In Fine Grained Soil	In Coarse Grained Soil
Primary	The component (particle size designation, refer above) which dominates the engineering behaviour of the soil	The clay/silt component with the greater proportion	The sand/gravel component with the greater proportion
Secondary	Any component which is not the primary, but is significant to the engineering properties of the soil	Any component with greater than 30% proportion	Any granular component with greater than 30%; or Any fine component with greater than 12%
Minor ²	Present in the soil, but not significant to its engineering properties	All other components	All other components

¹ As defined in AS1726-2017 6.1.4.4

² In the detailed material description, minor components are split into two further sub-categories. Refer “identification of minor components” below.

Composite Materials

In certain situations, a lithology description may describe more than one material, for example, collectively describing a layer of interbedded sand and clay. In such a scenario, the two materials would be described independently, with the names preceded or followed by a statement describing the arrangement by which the materials co-exist. For example, “INTERBEDDED Silty CLAY AND SAND”.

Classification

The soil classification comprises a two character group symbol. The first character identifies the primary component. The second character identifies either the grading or presence of fines in a coarse grained soil, or the plasticity in a fine grained soil. Refer AS1726-2017 6.1.6 for further clarification.

Soil Name

For most soils, the name is derived with the primary component included as the noun (in upper case), preceded by any secondary components stated in an adjective form. In this way, the soil name also describes the general composition and indicates the dominant behaviour of the material.

Component ¹	Prominence in Soil Name
Primary	Noun (eg "CLAY")
Secondary	Adjective modifier (eg "Sandy")
Minor	No influence

¹ – for determination of component proportions, refer component proportions on previous page

For materials which cannot be disaggregated, or which are not comprised of rock or mineral fragments, the names "ORGANIC MATTER" or "ARTIFICIAL MATERIAL" may be used, in accordance with AS1726-2017 Table 14.

Commercial or colloquial names are not used for the soil name where a component derived name is possible (for example "Gravelly SAND" rather than "CRACKER DUST").

Materials of "fill" or "topsoil" origin are generally assigned a name derived from the primary/secondary component (where appropriate). In log descriptions this is preceded by uppercase "FILL" or "TOPSOIL". Origin uncertainty is indicated in the description by the characters (?), with the degree of uncertainty described (using the terms "probably" or "possibly" in the origin column, or at the end of the description).

Identification of minor components

Minor components are identified in the soil description immediately following the soil name. The minor component fraction is usually preceded with a term indicating the relative proportion of the component.

Minor Component Proportion Term	Relative Proportion	
	In Fine Grained Soil	In Coarse Grained Soil
With	All fractions: 15-30%	Clay/silt: 5-12% sand/gravel: 15-30%
Trace	All fractions: 0-15%	Clay/silt: 0-5% sand/gravel: 0-15%

The terms "with" and "trace" generally apply only to gravel or fine particle fractions. Where cobbles/boulders are encountered in minor proportions (generally less than about 12%) the term "occasional" may be used. This term describes the sporadic distribution of the material within the confines of the investigation excavation only, and there may be considerable variation in proportion over a wider area which is difficult to factually characterise due to the relative size of the particles and the investigation methods.

Soil Composition

Plasticity

Descriptive Term	Laboratory liquid limit range	
	Silt	Clay
Non-plastic materials	Not applicable	Not applicable
Low plasticity	≤50	≤35
Medium plasticity	Not applicable	>35 and ≤50
High plasticity	>50	>50

Note, Plasticity descriptions generally describe the plasticity behaviour of the whole of the fine grained soil, not individual fine grained fractions.

Grain Size

Type	Particle size (mm)	
	Coarse	Fine
Gravel	19 - 63	6.7 - 19
	Medium	2.36 - 6.7
	Fine	0.6 - 2.36
Sand	0.21 - 0.6	0.075 - 0.21

Grading

Grading Term	Particle size (mm)
Well	A good representation of all particle sizes
Poorly	An excess or deficiency of particular sizes within the specified range
Uniformly	Essentially of one size
Gap	A deficiency of a particular size or size range within the total range

Note, AS1726-2017 provides terminology for additional attributes not listed here.

Soil Condition

Moisture

The moisture condition of soils is assessed relative to the plastic limit for fine grained soils, while for coarse grained soils it is assessed based on the appearance and feel of the material. The moisture condition of a material is considered to be independent of stratigraphy (although commonly these are related), and this data is presented in its own column on logs.

Applicability	Term	Tactile Assessment	Abbreviation code
Fine	Dry of plastic limit	Hard and friable or powdery	w<PL
	Near plastic limit	Can be moulded	w=PL
	Wet of plastic limit	Water residue remains on hands when handling	w>PL
	Near liquid limit	"oozes" when agitated	w=LL
	Wet of liquid limit	"oozes"	w>LL
Coarse	Dry	Non-cohesive and free running	D
	Moist	Feels cool, darkened in colour, particles may stick together	M
	Wet	Feels cool, darkened in colour, particles may stick together, free water forms when handling	W

The abbreviation code **NDF**, meaning "not-assessable due to drilling fluid use" may also be used.

Note, observations relating to free ground water or drilling fluids are provided independent of soil moisture condition.

Consistency/Density/Compaction/Cementation/Extremely Weathered Material

These concepts give an indication of how the material may respond to applied forces (when considered in conjunction with other attributes of the soil). This behaviour can vary independent of the composition of the material, and on logs these are described in an independent column and are generally mutually exclusive (i.e it is inappropriate to describe both consistency and compaction at the same time). The method by which the behaviour is described depends on the behaviour model and other characteristics of the soil as follows:

- In fine grained soils, the "consistency" describes the ease with which the soil can be remoulded, and is generally correlated against the materials undrained shear strength;
- In granular materials, the relative density describes how tightly packed the particles are, and is generally correlated against the density index;
- In anthropogenically modified materials, the compaction of the material is described qualitatively;
- In cemented soils (both natural and anthropogenic), the cemented "strength" is described qualitatively, relative to the difficulty with which the material is disaggregated; and
- In soils of extremely weathered material origin, the engineering behaviour may be governed by relic rock features, and expected behaviour needs to be assessed based the overall material description.

Quantitative engineering performance of these materials may be determined by laboratory testing or estimated by correlated field tests (for example penetration or shear vane testing). In some cases, performance may be assessed by tactile or other subjective methods, in which case investigation logs will show the estimated value enclosed in round brackets, for example (VS).

Consistency (fine grained soils)

Consistency Term	Tactile Assessment	Undrained Shear Strength (kPa)	Abbreviation Code
Very soft	Extrudes between fingers when squeezed	<12	VS
Soft	Mouldable with light finger pressure	>12 - ≤25	S
Firm	Mouldable with strong finger pressure	>25 - ≤50	F
Stiff	Cannot be moulded by fingers	>50 - ≤100	St
Very stiff	Indented by thumbnail	>100 - ≤200	VSt
Hard	Indented by thumbnail with difficulty	>200	H
Friable	Easily crumbled or broken into small pieces by hand	-	Fr

Relative Density (coarse grained soils)

Relative Density Term	Density Index	Abbreviation Code
Very loose	<15	VL
Loose	>15 - ≤35	L
Medium dense	>35 - ≤65	MD
Dense	>65 - ≤85	D
Very dense	>85	VD

Note, tactile assessment of relative density is difficult, and generally requires penetration testing, hence a tactile assessment guide is not provided.

Soil Descriptions

Terminology
Symbols
Abbreviations

Compaction (anthropogenically modified soil)

Compaction Term	Abbreviation Code
Well compacted	WC
Poorly compacted	PC
Moderately compacted	MC
Variably compacted	VC

Cementation (natural and anthropogenic)

Cementation Term	Abbreviation Code
Moderately cemented	MOD
Weakly cemented	WEK

Extremely Weathered Material

AS1726-2017 considers weathered material to be soil if the unconfined compressive strength is less than 0.6 MPa (i.e. less than very low strength rock). These materials may be identified as “extremely weathered material” in reports and by the abbreviation code **XWM** on log sheets. This identification is not correlated to any specific qualitative or quantitative behaviour, and the engineering properties of this material must therefore be assessed according to engineering principles with reference to any relic rock structure, fabric, or texture described in the description.

Soil Origin

Term	Description	Abbreviation Code
Residual	Derived from in-situ weathering of the underlying rock	RS
Extremely weathered material	Formed from in-situ weathering of geological formations. Has strength of less than ‘very low’ as per as1726 but retains the structure or fabric of the parent rock.	XWM
Alluvial	Deposited by streams and rivers	ALV
Estuarine	Deposited in coastal estuaries	EST
Marine	Deposited in a marine environment	MAR
Lacustrine	Deposited in freshwater lakes	LAC
Aeolian	Carried and deposited by wind	AEO
Colluvial	Soil and rock debris transported down slopes by gravity	COL
Slopewash	Thin layers of soil and rock debris gradually and slowly deposited by gravity and possibly water	SW
Topsoil	Mantle of surface soil, often with high levels of organic material	TOP
Fill	Any material which has been moved by man	FILL
Littoral	Deposited on the lake or seashore	LIT
Unidentifiable	Not able to be identified	UID

Cobbles and Boulders

The presence of particles considered to be “oversize” may be described using one of the following strategies:

- Oversize encountered in a minor proportion (when considered relative to the wider area) are noted in the soil description; or
- Where a significant proportion of oversize is encountered, the cobbles/boulders are described independent of the soil description, in a similar manner to composite soils (described above) but qualified with “MIXTURE OF”.

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Rock Strength

Rock strength is defined by the unconfined compressive strength, and it refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects.

The Point Load Strength Index $I_{s(50)}$ is commonly used to provide an estimate of the rock strength and site specific correlations should be developed to allow UCS values to be determined. The point load strength test procedure is described by Australian Standard AS4133.4.1-2007. The terms used to describe rock strength are as follows:

Strength Term	Unconfined Compressive Strength (MPa)	Point Load Index ¹ $I_{s(50)}$ MPa	Abbreviation Code
Very low	0.6 - 2	0.03 - 0.1	VL
Low	2 - 6	0.1 - 0.3	L
Medium	6 - 20	0.3 - 1.0	M
High	20 - 60	1 - 3	H
Very high	60 - 200	3 - 10	VH
Extremely high	>200	>10	EH

¹ Rock strength classification is based on UCS. The UCS to $I_{s(50)}$ ratio varies significantly for different rock types and specific ratios may be required for each site. The point load Index ranges shown above are as suggested in AS1726 and should not be relied upon without supporting evidence.

The following abbreviation codes are used for soil layers or seams of material “within rock” but for which the equivalent UCS strength is less than 0.6 MPa.

Scenario	Abbreviation Code
The material encountered has an equivalent UCS strength of less than 0.6 MPa, and therefore is considered to be soil (as per Note 1 of Table 20 of AS 1726-2017). The properties of the material encountered over this interval are described in the “Description of Strata” and soil properties columns.	SOIL
The material encountered has an equivalent UCS strength of less than 0.6 MPa, and therefore is considered to be soil (as per Note 1 of Table 20 of AS 1726-2017). The prominence of the material is such that it can be considered to be a seam (as defined in Table 22 of AS1726-2017) and the properties of the material are described in the defect column.	SEAM

Degree of Weathering

The degree of weathering of rock is classified as follows:

Weathering Term	Description	Abbreviation Code
Residual Soil ¹	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.	RS
Extremely weathered ¹	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible	XW
Highly weathered	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original 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.	HW
Moderately weathered	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable but shows little or no change of strength from fresh rock.	MW
Slightly weathered	Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.	SW
Fresh	No signs of decomposition or staining.	FR
Note: If HW and MW cannot be differentiated use DW (see below)		
Distinctly weathered	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching or may be decreased due to deposition of weathered products in pores.	DW

¹ The parent rock type, of which the residual/extremely weathered material is a derivative, will be stated in the description (where discernible).

Degree of Alteration

The degree of alteration of the rock material (physical or chemical changes caused by hot gasses or liquids at depth) is classified as follows:

Term	Description	Abbreviation Code
Extremely altered	Material is altered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible.	XA
Highly altered	The whole of the rock material is discoloured, usually by staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is changed by alteration. Some primary minerals are altered to clay minerals. Porosity may be increased by leaching or may be decreased due to precipitation of secondary materials in pores.	HA
Moderately altered	The whole of the rock material is discoloured, usually by staining or bleaching to the extent that the colour of the original rock is not recognisable but shows little or no change of strength from fresh rock.	MA
Slightly altered	Rock is slightly discoloured but shows little or no change of strength from fresh rock	SA
Note: If HA and MA cannot be differentiated use DA (see below)		
Distinctly altered	Rock strength usually changed by alteration. The rock may be highly discoloured, usually by staining or bleaching. Porosity may be increased by leaching or may be decreased due to precipitation of secondary minerals in pores.	DA

Degree of Fracturing

The following descriptive classification apply to the spacing of natural occurring fractures in the rock mass. It includes bedding plane partings, joints and other defects, but excludes drilling breaks. These terms are generally not required on investigation logs where fracture spacing is presented as a histogram, and where used are presented in an unabbreviated format.

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with occasional fragments
Fractured	Core lengths of 30-100 mm with occasional shorter and longer sections
Slightly Fractured	Core lengths of 300 mm or longer with occasional sections of 100-300 mm
Unbroken	Core contains very few fractures

Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$RQD \% = \frac{\text{cumulative length of 'sound' core sections} > 100 \text{ mm long}}{\text{total drilled length of section being assessed}}$$

where 'sound' rock is assessed to be rock of low strength or stronger. The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e., drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

Stratification Spacing

These terms may be used to describe the spacing of bedding partings in sedimentary rocks. Where used, these terms are generally presented in an unabbreviated format

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

Rock Descriptions

Terminology
Symbols
Abbreviations

Defect Descriptions

Defect Type

Term	Abbreviation Code
Bedding plane	B
Infilled seam	IS
Cleavage	CV
Crushed zone	CZ
Decomposed seam	DS
Fault	F
Joint	JT
Lamination	LAM
Parting	P
Shear zone	SZ
Vein	VN
Drilling/handling break	DB , HB
Fracture	FC

Rock Defect Orientation

Term	Abbreviation Code
Horizontal	H
Vertical	V
Sub-horizontal	SH
Sub-vertical	SV

Rock Defect Coating

Term	Abbreviation Code
Clean	CN
Coating	CT
Healed	HE
Infilled	INF
Stained	SN
Tight	TI
Veneer	VNR

Rock Defect Infill

Term	Abbreviation Code
Calcite	CA
Carbonaceous	CBS
Clay	CLAY
Iron oxide	FE
Manganese	MN

intentionally blank

Rock Defect Shape/Planarity

Term	Abbreviation Code
Curved	CU
Irregular	IR
Planar	PR
Stepped	ST
Undulating	UN

Rock Defect Roughness

Term	Abbreviation Code
Polished	PO
Rough	RF
Slickensided	SL
Smooth	SM
Very rough	VR

Defect Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

intentionally blank

Sampling and Testing

A record of samples retained, and field testing performed is usually shown on a Douglas Partners' log with samples appearing to the left of a depth scale, and selected field and laboratory testing (including results, where relevant) appearing to the right of the scale, as illustrated below:

SAMPLE			DEPTH (m)	TESTING	
SAMPLE REMARKS	TYPE	INTERVAL		TEST TYPE	RESULTS AND REMARKS
	SPT		1.0 1.45	SPT	4,9,11 N=20

Sampling

The type or intended purpose for which a sample was taken is indicated by the following abbreviation codes.

Sample Type	Code
Auger sample	A
Bulk sample	B
Core sample	C
Disturbed sample	D
Sample from SPT test	SPT
Environmental sample	ES
Gas sample	G
Undisturbed tube sample	U ¹
Water sample	W
Piston sample	P
Core sample for unconfined compressive strength testing	UCS
Material Sample	MT

¹ – numeric suffixes indicate tube diameter/width in mm

The above codes only indicate that a sample was retained, and not that testing was scheduled or performed.

Field and Laboratory Testing

A record that field and laboratory testing was performed is indicated by the following abbreviation codes.

Test Type	Code
Pocket penetrometer (kPa)	PP
Photo ionisation detector (ppm)	PID
Standard Penetration Test x/y = x blows for y mm penetration HB = hammer bouncing HW = fell under weight of hammer	SPT
Shear vane (kPa)	V
Unconfined compressive strength, (MPa)	UCS

Field and laboratory testing (continued)

Test Type	Code
Point load test, (MPa), axial (A), diametric (D), irregular (I)	PLT(L)
Dynamic cone penetrometer, followed by blow count penetration increment in mm (cone tip, generally in accordance with AS1289.6.3.2)	DCP/150
Perth sand penetrometer, followed by blow count penetration increment in mm (flat tip, generally in accordance with AS1289.6.3.3)	PSP/150

Groundwater Observations

▷	seepage/inflow
▽	standing or observed water level
NFGWO	no free groundwater observed
OBS	observations obscured by drilling fluids

Drilling or Excavation Methods/Tools

The drilling/excavation methods used to perform the investigation may be shown either in a dedicated column down the left-hand edge of the log, or stated in the log footer. In some circumstances abbreviation codes may be used.

Method	Abbreviation Code
Toothed bucket	TB ¹
Mud/blade bucket	MB ¹
Ripping tyne/ripper	R
Rock breaker/hydraulic hammer	RB
Hand auger	HA ¹
NMLC series coring	NMLC
HMLC series coring	HMLC
NQ coring	NQ3
HQ coring	HQ3
PQ coring	PQ3
Push tube	PT ¹
Rock roller	RR ¹
Solid flight auger. Suffixes: /T = tungsten carbide tip, /V = v-shaped tip	AD ¹
Sonic drilling	SON ¹
Vibrocore	VC ¹
Wash bore (unspecified bit type)	WB ¹
Existing exposure	X
Hand tools (unspecified)	HAND
Predrilled	PD
Diatube	DT ¹
Hollow flight auger	HSA ¹
Vacuum excavation	VE

¹ – numeric suffixes indicate tool diameter/width in mm

Introduction

The Cone Penetration Test (CPT) is a sophisticated soil profiling test carried out in-situ. A special cone shaped probe is used which is connected to a digital data acquisition system. The cone and adjoining sleeve section contain a series of strain gauges and other transducers which continuously monitor and record various soil parameters as the cone penetrates the soils.

The soil parameters measured depend on the type of cone being used, however they always include the following basic measurements

- Cone tip resistance q_c
- Sleeve friction f_s
- Inclination (from vertical) i
- Depth below ground z

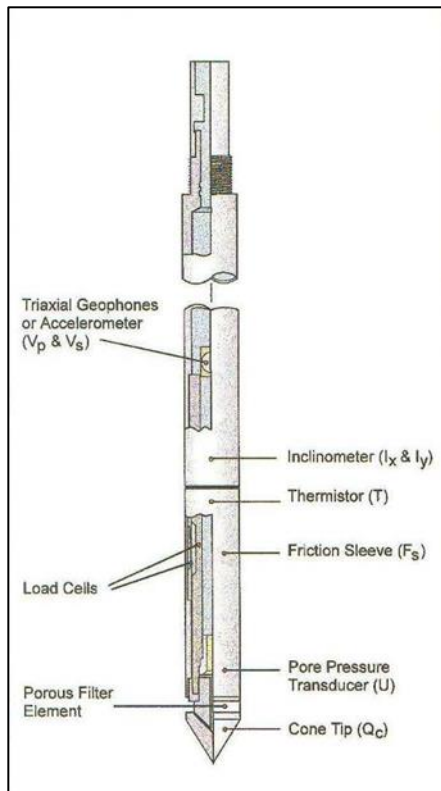


Figure 1: Cone Diagram

The inclinometer in the cone enables the verticality of the test to be confirmed and, if required, the vertical depth can be corrected.

The cone is thrust into the ground at a steady rate of about 20 mm/sec, usually using the hydraulic rams of a purpose built CPT rig, or a drilling rig. The testing is carried out in accordance with the Australian Standard AS1289 Test 6.5.1.



Figure 2: Purpose built CPT rig

The CPT can penetrate most soil types and is particularly suited to alluvial soils, being able to detect fine layering and strength variations. With sufficient thrust the cone can often penetrate a short distance into weathered rock. The cone will usually reach refusal in coarse filling, medium to coarse gravel and on very low strength or better rock. Tests have been successfully completed to more than 60 m.

Types of CPTs

Douglas Partners (and its subsidiary GroundTest) owns and operates the following types of CPT cones:

Type	Measures
Standard	Basic parameters (q_c , f_s , i & z)
Piezocone	Dynamic pore pressure (u) plus basic parameters. Dissipation tests estimate consolidation parameters
Conductivity	Bulk soil electrical conductivity ($\square$) plus basic parameters
Seismic	Shear wave velocity (V_s), compression wave velocity (V_p), plus basic parameters

Strata Interpretation

The CPT parameters can be used to infer the Soil Behaviour Type (SBT), based on normalised values of cone resistance (Q_t) and friction ratio (Fr). These are used in conjunction with soil classification charts, such as the one below (after Robertson 1990)

Cone Penetration testing

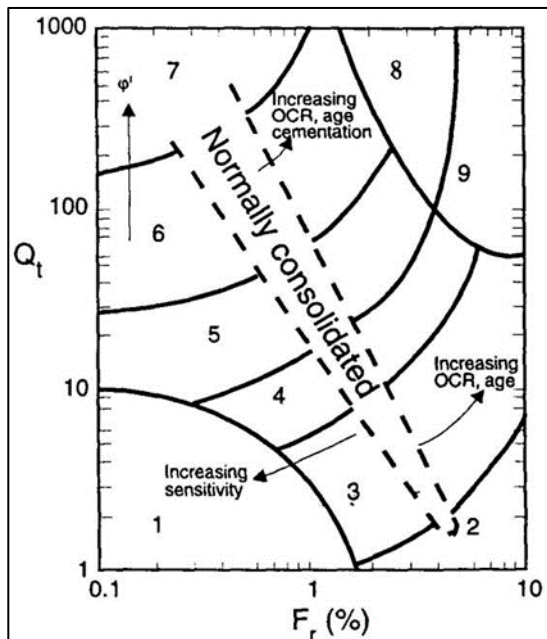


Figure 3: Soil Classification Chart

DP's in-house CPT software provides computer aided interpretation of soil strata, generating soil descriptions and strengths for each layer. The software can also produce plots of estimated soil parameters, including modulus, friction angle, relative density, shear strength and over consolidation ratio.

DP's CPT software helps our engineers quickly evaluate the critical soil layers and then focus on developing practical solutions for the client's project.

Engineering Applications

There are many uses for CPT data. The main applications are briefly introduced below:

Settlement

CPT provides a continuous profile of soil type and strength, providing an excellent basis for settlement analysis. Soil compressibility can be estimated from cone derived moduli, or known consolidation parameters for the critical layers (eg. from laboratory testing). Further, if pore pressure dissipation tests are undertaken using a piezocone, in-situ consolidation coefficients can be estimated to aid analysis.

Pile Capacity

The cone is, in effect, a small scale pile and, therefore, ideal for direct estimation of pile capacity. DP's in-house program ConePile can analyse most pile types and produces pile capacity versus depth plots. The analysis methods are based on proven static theory and empirical studies, taking account of scale effects, pile materials and method of installation.

The results are expressed in limit state format, consistent with the Piling Code AS2159.

Dynamic or Earthquake Analysis

CPT and, in particular, Seismic CPT are suitable for dynamic foundation studies and earthquake response analyses, by profiling the low strain shear modulus G_0 . Techniques have also been developed relating CPT results to the risk of soil liquefaction.

Other Applications

Other applications of CPT include ground improvement monitoring (testing before and after works), salinity and contaminant plume mapping (conductivity cone), preloading studies and verification of strength gain.

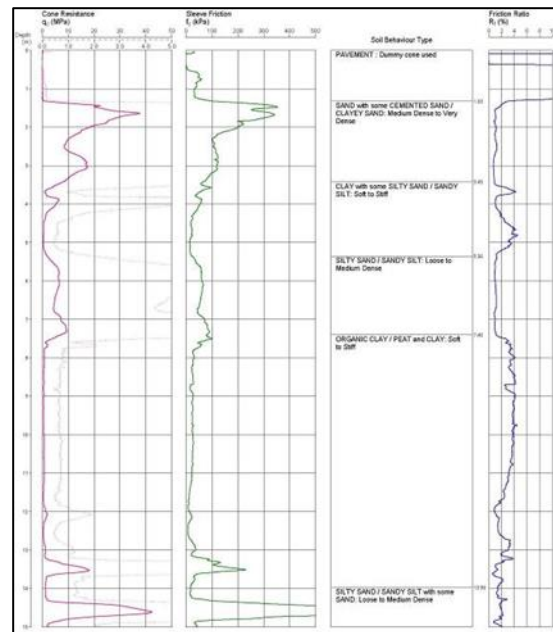
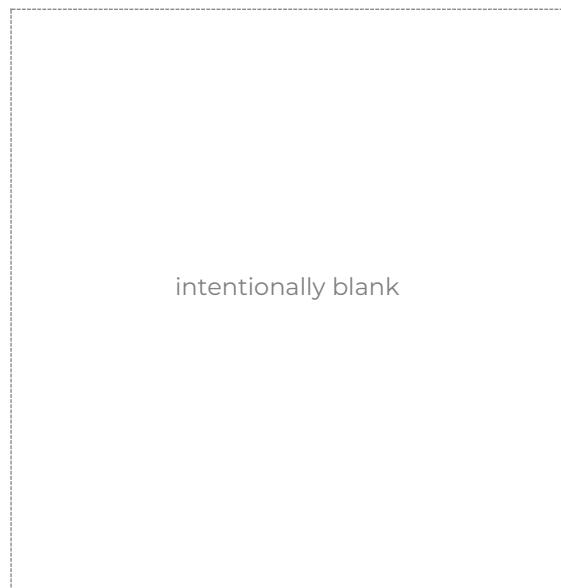
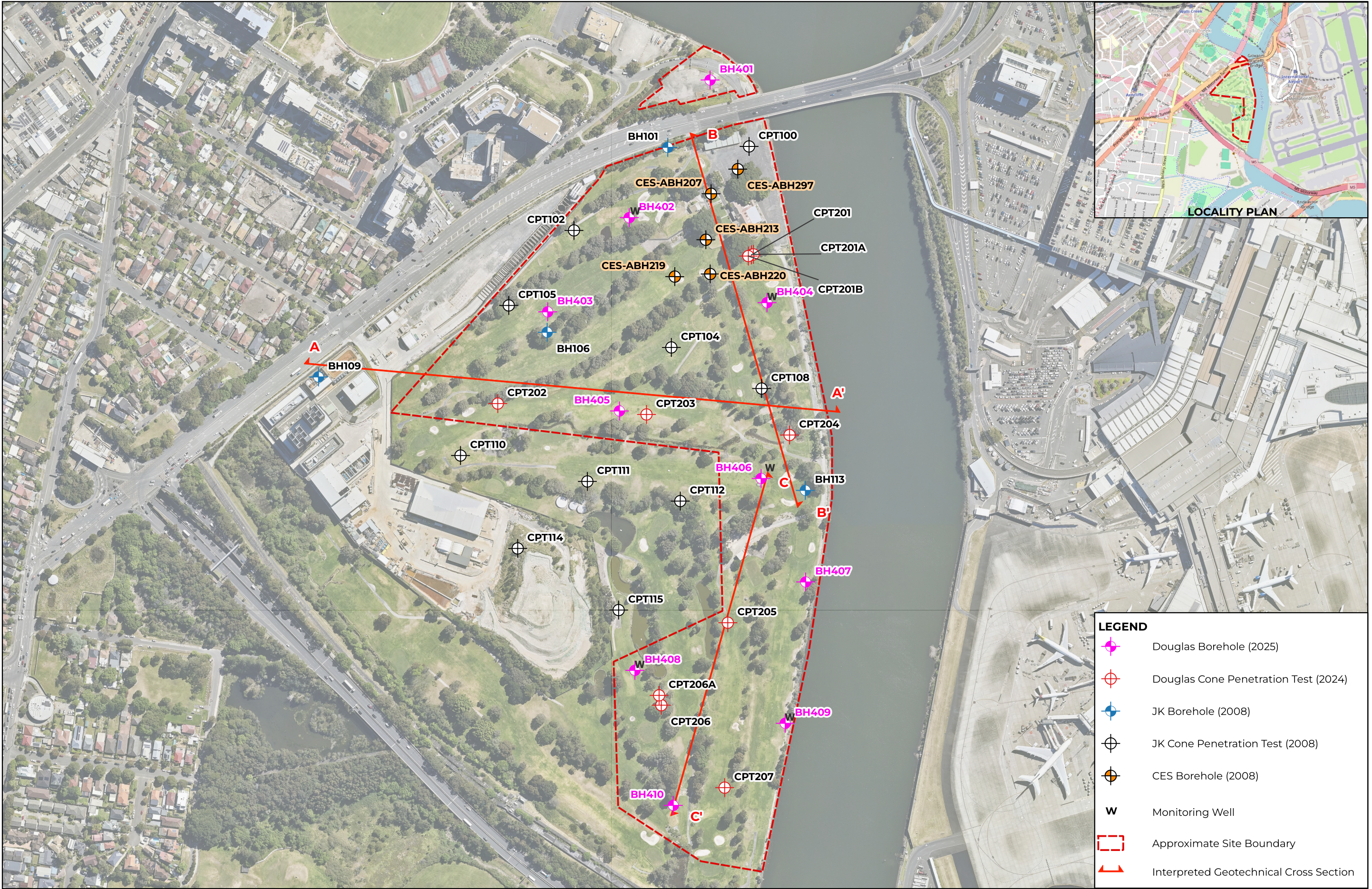


Figure 4: Sample Cone Plot



Appendix B

Drawings



LEGEND

Douglas Borehole (2025)

Douglas Cone Penetration Test (2024)

JK Borehole (2008)

JK Cone Penetration Test (2008)

CES Borehole (2008)

Monitoring Well

Approximate Site Boundary

Interpreted Geotechnical Cross Section

REV	DESCRIPTION/COMMENT	DATE	DRAWN BY
0	Issued for Information	06.11.2025	MN

SCALE:

0

50

100

150

200 m

1:4000 @ A3

N

PARTNERS

OFFICE: SYDNEY
96-98 Hermitage Rd, West Ryde NSW 2114
(02)9809 0666

CLIENT:

Stockland Development Pty Limited

NOTE:

1: Basemap from Metromap (Dated 04.09.2025)

COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 56

PROJECT NAME:

Proposed Commercial-Industrial Development

PROJECT ADDRESS:

Kogarah Golf Course, Cooks Cove, Arncliffe NSW

DRAWING TITLE:

Test Location Plan

PROJECT NO:

223528.01

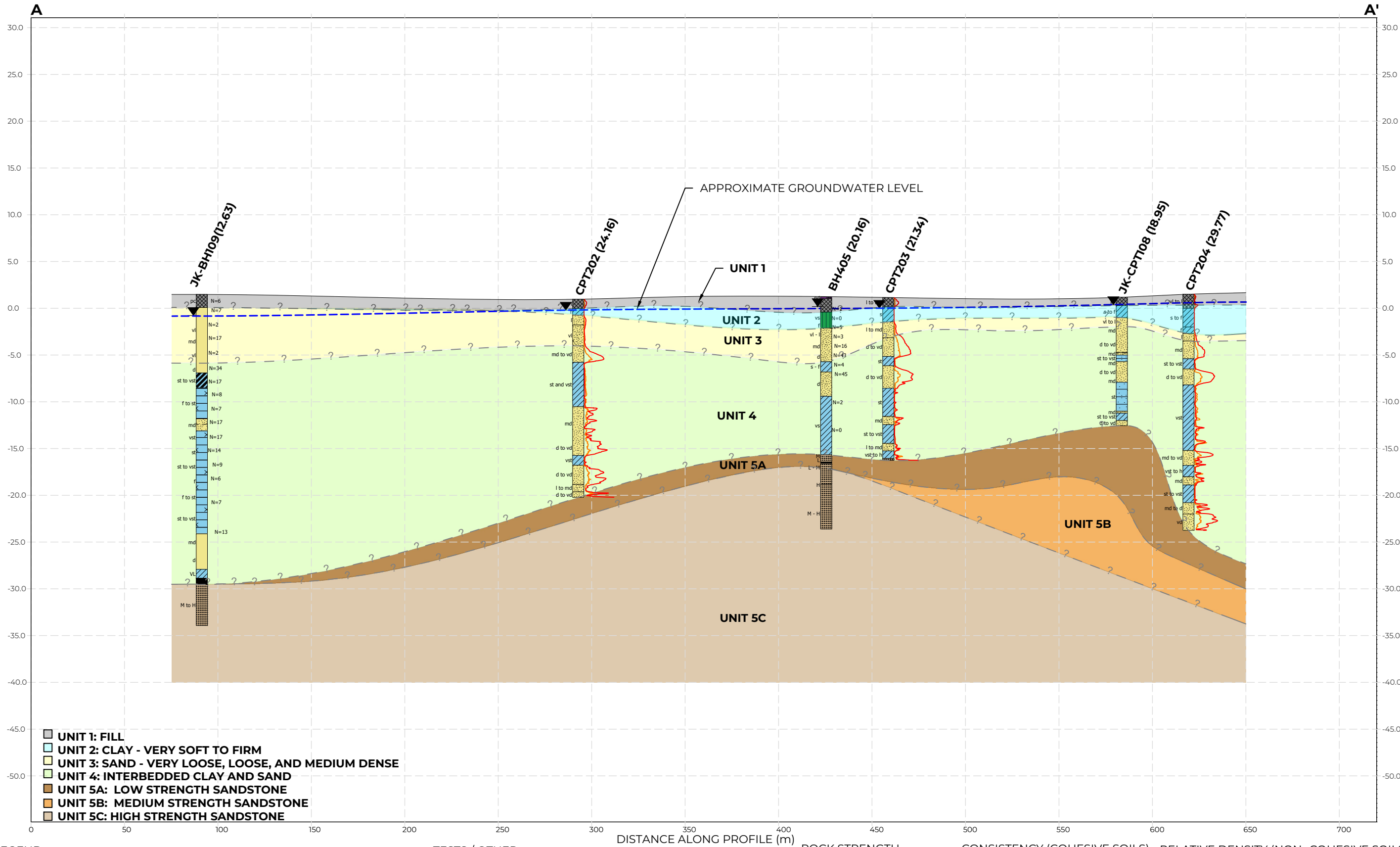
DRAWING NO:

1

REVISION:

0

P:\223528.01 - ARNCLIFFE, Kogarah Golf Course Redevelop\7.0 Drawings\7.2 Out\223528.01.D.002.004.Rev0_Cross Sections A-A.dwg



- UNIT 1: FILL
UNIT 2: CLAY - VERY SOFT TO FIRM
UNIT 3: SAND - VERY LOOSE, LOOSE, AND MEDIUM DENSE
UNIT 4: INTERBEDDED CLAY AND SAND
UNIT 5A: LOW STRENGTH SANDSTONE
UNIT 5B: MEDIUM STRENGTH SANDSTONE
UNIT 5C: HIGH STRENGTH SANDSTONE

CH - High Plasticity CLAY	Sandy CLAY	FILL	Silty SAND	SANDSTONE
CI - Medium Plasticity CLAY	Silty CLAY	Clayey SAND	Silty clayey SAND	ML - Low Plasticity SILT
CLAY	NO CORE	Clayey silty SAND	Some/scattered Sand	

TESTS / OTHER
N - Standard penetration test value
- ? - Interpreted geotechnical boundary
- Water Level

ROCK STRENGTH
VL - Very Low
L - Low
M - Medium
H - High
VH - Very High
EH - Extremely High

CONSISTENCY (COHESIVE SOILS)
vs - Very Soft
s - Soft
f - Firm
st - Stiff
vst - Very Stiff
h - Hard

RELATIVE DENSITY (NON-COHESIVE SOILS)
vl - Very Loose
l - Loose
md - Medium Dense
d - Dense
vd - Very Dense

REV	DESCRIPTION/COMMENT	DATE	DRAWN BY
0	INITIAL ISSUE	06.11.2024	EC
1	UPDATES	17.11.2025	MN

SCALE: 0 10 20 30 40 60 80 100
1:2000 @ A3
Vertical Exaggeration = 5.0

Douglas
PARTNERS
OFFICE: SYDNEY
96-98 Hermitage Rd, West Ryde NSW 2114
(02) 9809 0666

CLIENT:
Stockland Development Pty Limited

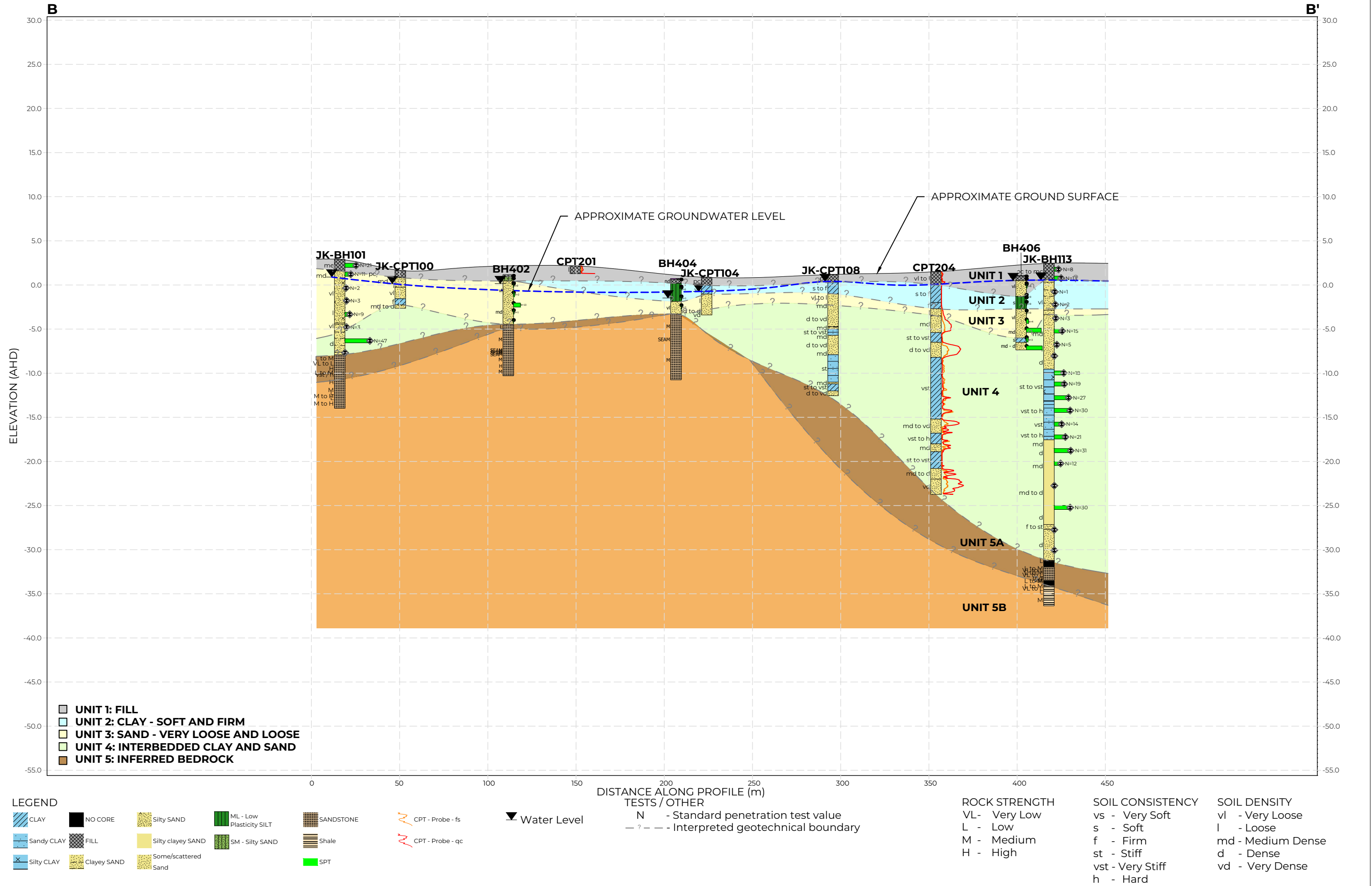
NOTES
1. Subsurface conditions are accurate at the borehole locations only.
Variations in subsurface conditions may occur between borehole locations.
Interpreted strata boundaries are approximate and should be used as a guide only.
2. Summary logs only and should be read in conjunction with detailed logs.
3. Horizontal and vertical scales are not equal.

PROJECT NAME:
Proposed Commercial - Industrial Development
PROJECT ADDRESS:
Kogarah Golf Course, Cooks Cove Arncliffe NSW

DRAWING TITLE:
INTERPRETED GEOTECHNICAL CROSS SECTION A-A'

PROJECT No:
223528.01
DRAWING No:
2
REVISION:
1

\\psdpsdhas02\Projects\223528.01 - ARNCLIFFE, Kogarah Golf Course Redevelop\7.0 Drawings\7.2 Out\223528.01 D002-004 Rev0_Cross Sections A-C.dwg



REV	DESCRIPTION/COMMENT	DATE	DRAWN BY
0	INITIAL ISSUE	24.10.2024	EC/MN

SCALE:

0102030406080100

1:2000 @ A3

Vertical Exaggeration = 5.0

OFFICE: SYDNEY

96-98 Hermitage Rd, West Ryde NSW 2114

(02) 9809 0666

CLIENT:

Stockland Development Pty Limited

PROJECT NAME:

Proposed Commercial - Industrial Development

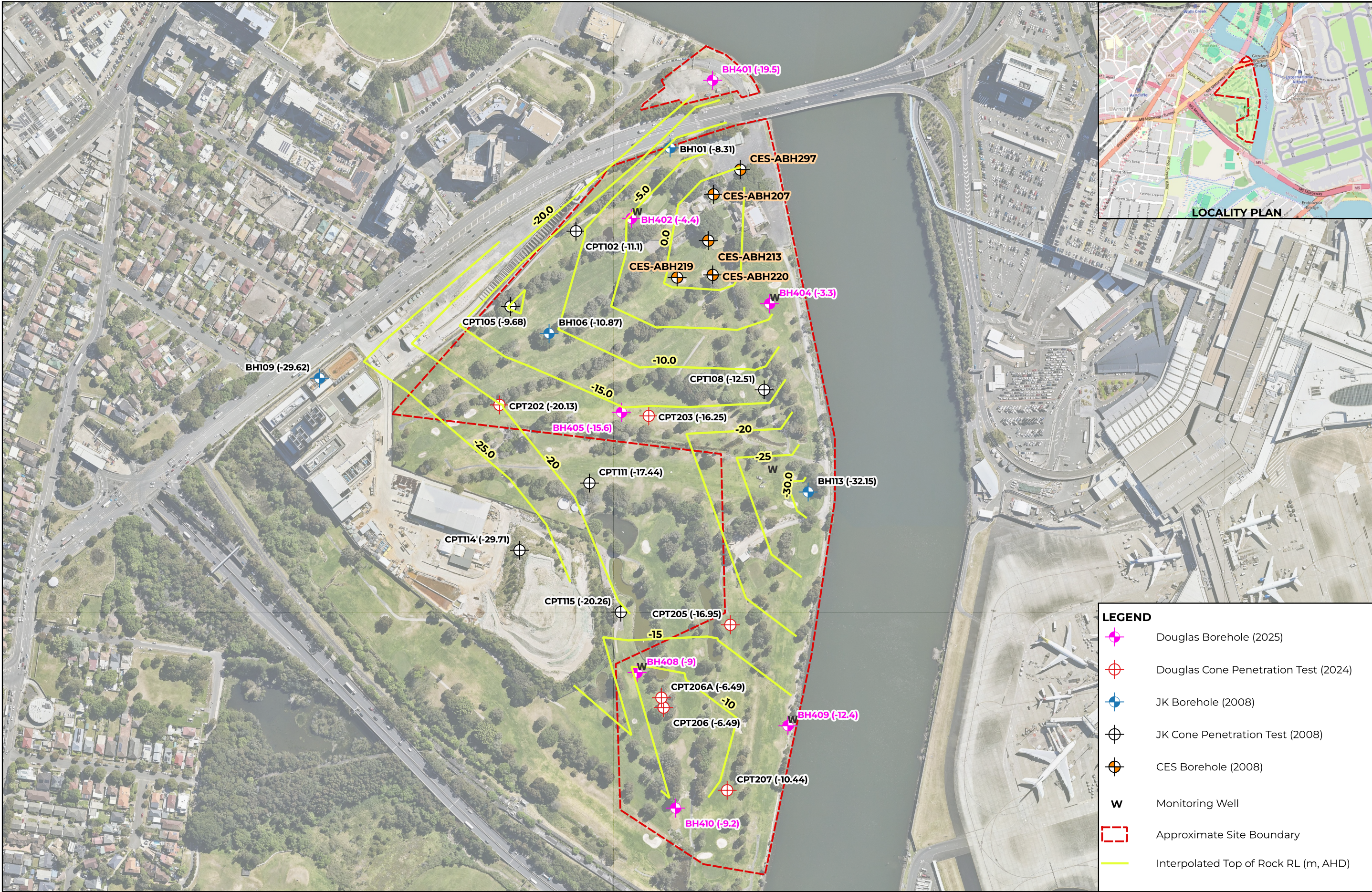
PROJECT ADDRESS:

Kogarah Golf Course, Cooks Cove Arncliffe NSW

DRAWING TITLE:

INTERPRETED GEOTECHNICAL CROSS SECTION B-B'

PROJECT No:	223528.01
DRAWING No:	3
REVISION:	0



LEGEND

Douglas Borehole (2025)

Douglas Cone Penetration Test (2024)

JK Borehole (2008)

JK Cone Penetration Test (2008)

CES Borehole (2008)

Monitoring Well

Approximate Site Boundary

Interpolated Top of Rock RL (m, AHD)

REV	DESCRIPTION/COMMENT	DATE	DRAWN BY
0	Issued for information	12.11.2025	MAB/MN

SCALE:

0

50

100

150

200 m

1:4000 @ A3

N

PARTNERS

OFFICE: SYDNEY

96-98 Hermitage Rd, West Ryde NSW 2114

(02)9809 0666

CLIENT:

Stockland Development Pty Limited

NOTE:

1: Basemap from Metromap (Dated 04.09.2022)

2: Suffix to test name indicates the inferred top of rock level at the test location

3: Surface RLs at JK test locations estimated using Lidar data (NSW Spatial Services, Apr 2013)

4: Inferred top of rock levels indicated by CPTs must be confirmed with rock-cored boreholes

5: This drawing should be used for high-level planning purposes only. Variations in subsurface conditions may occur between test locations.

COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 56

PROJECT NAME:

Proposed Commercial-Industrial Development

PROJECT ADDRESS:

Kogarah Golf Course, Cooks Cove, Arncliffe NSW

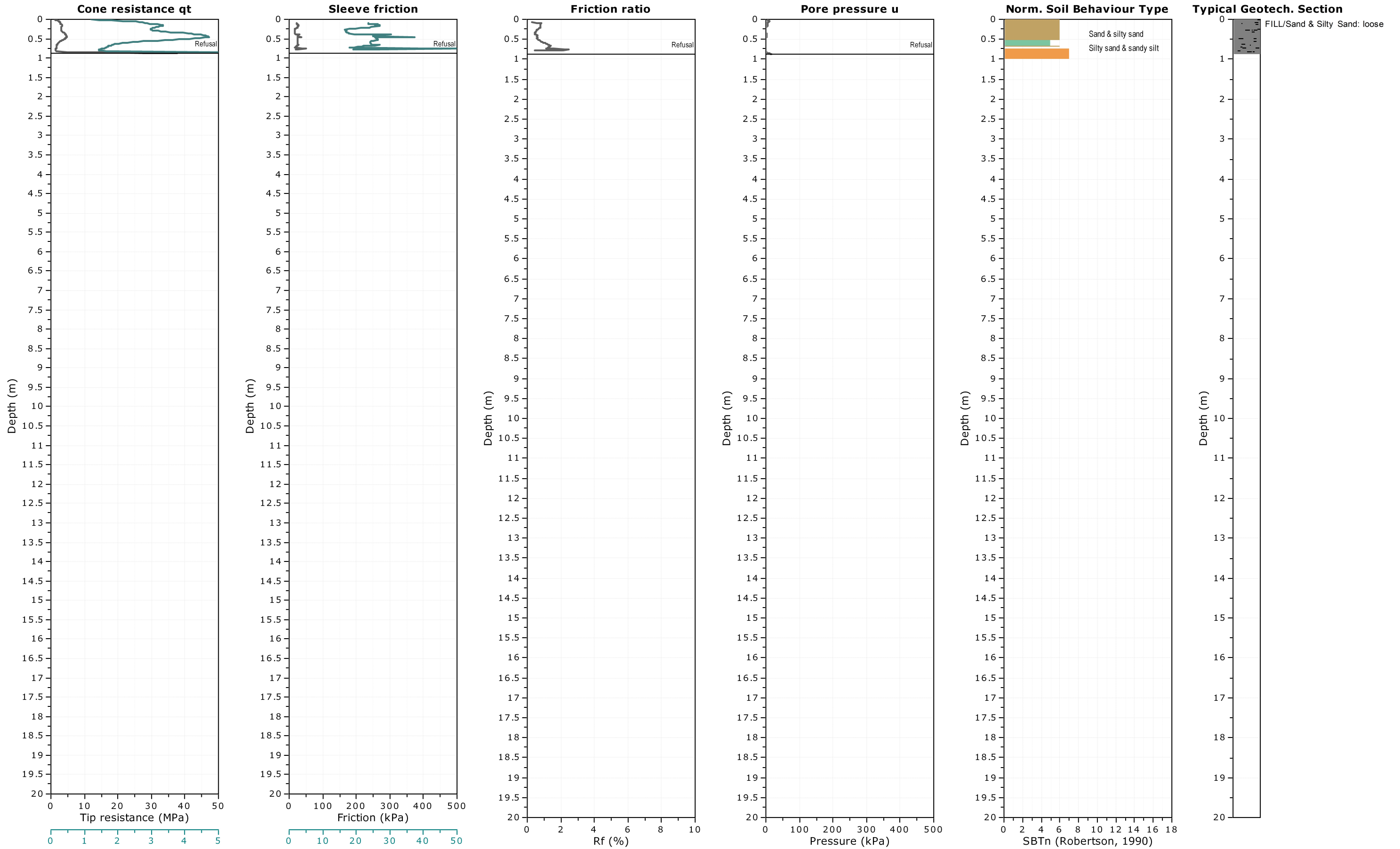
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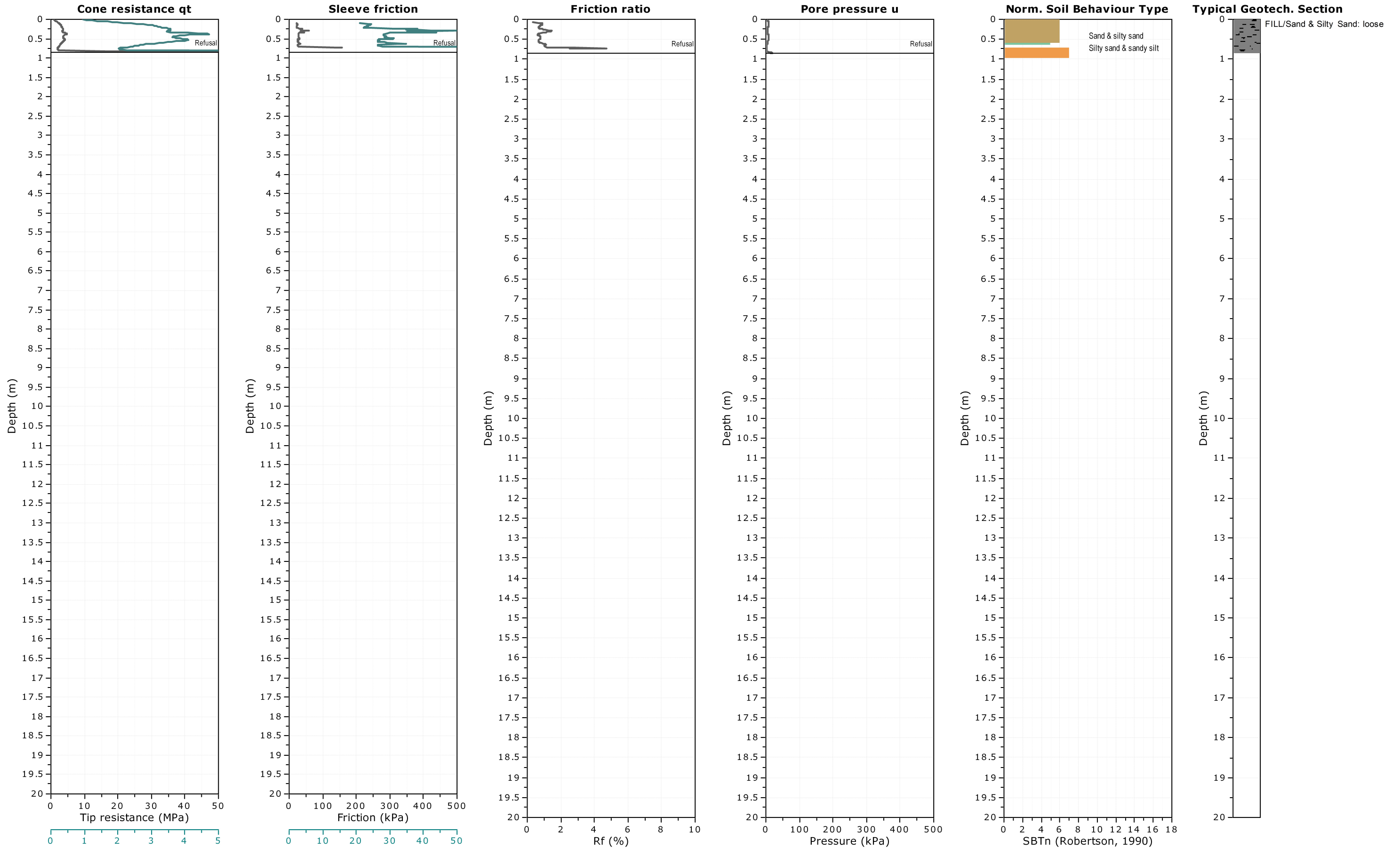
Interpolated Top of Rock Contour Plan

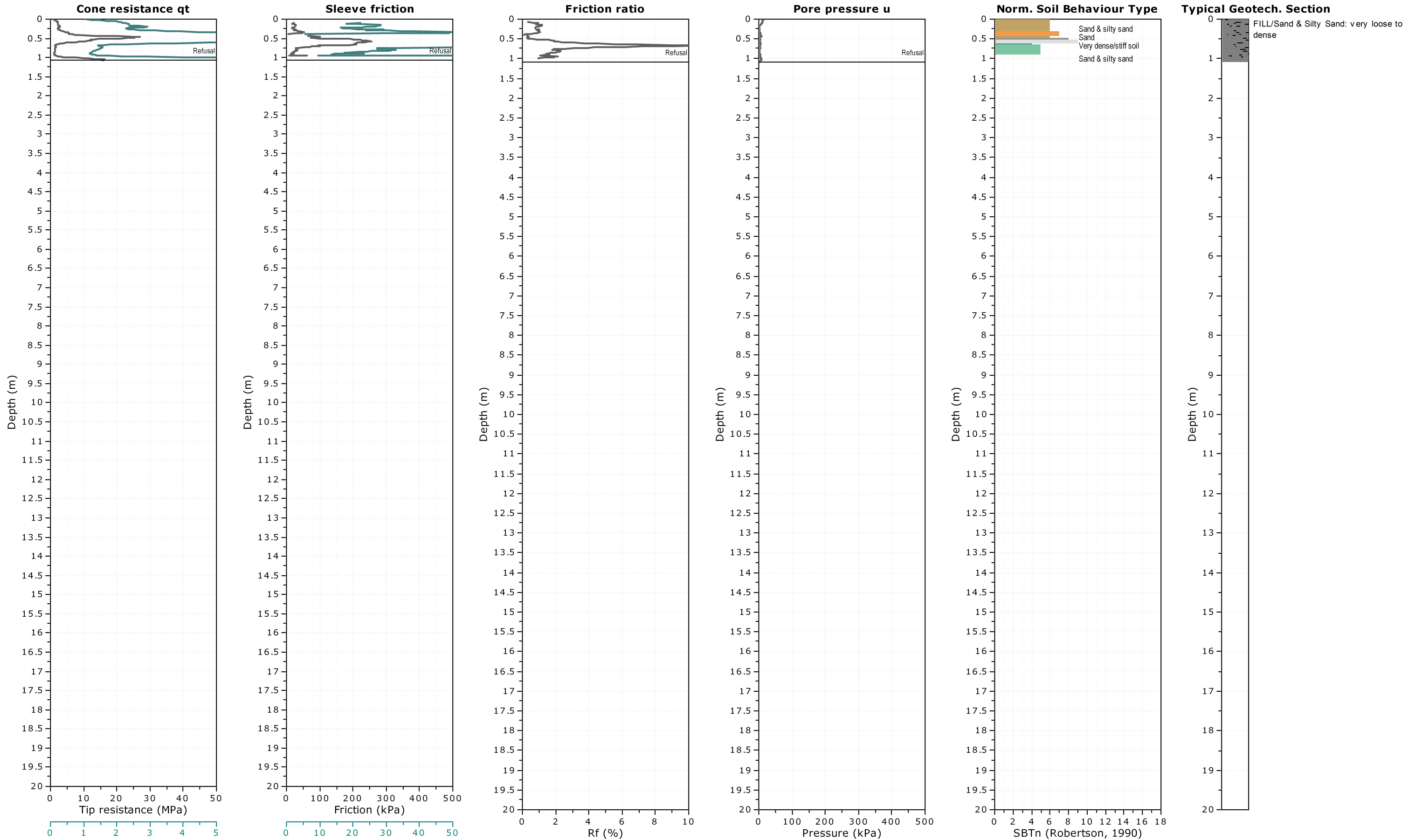
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REVISION:	0

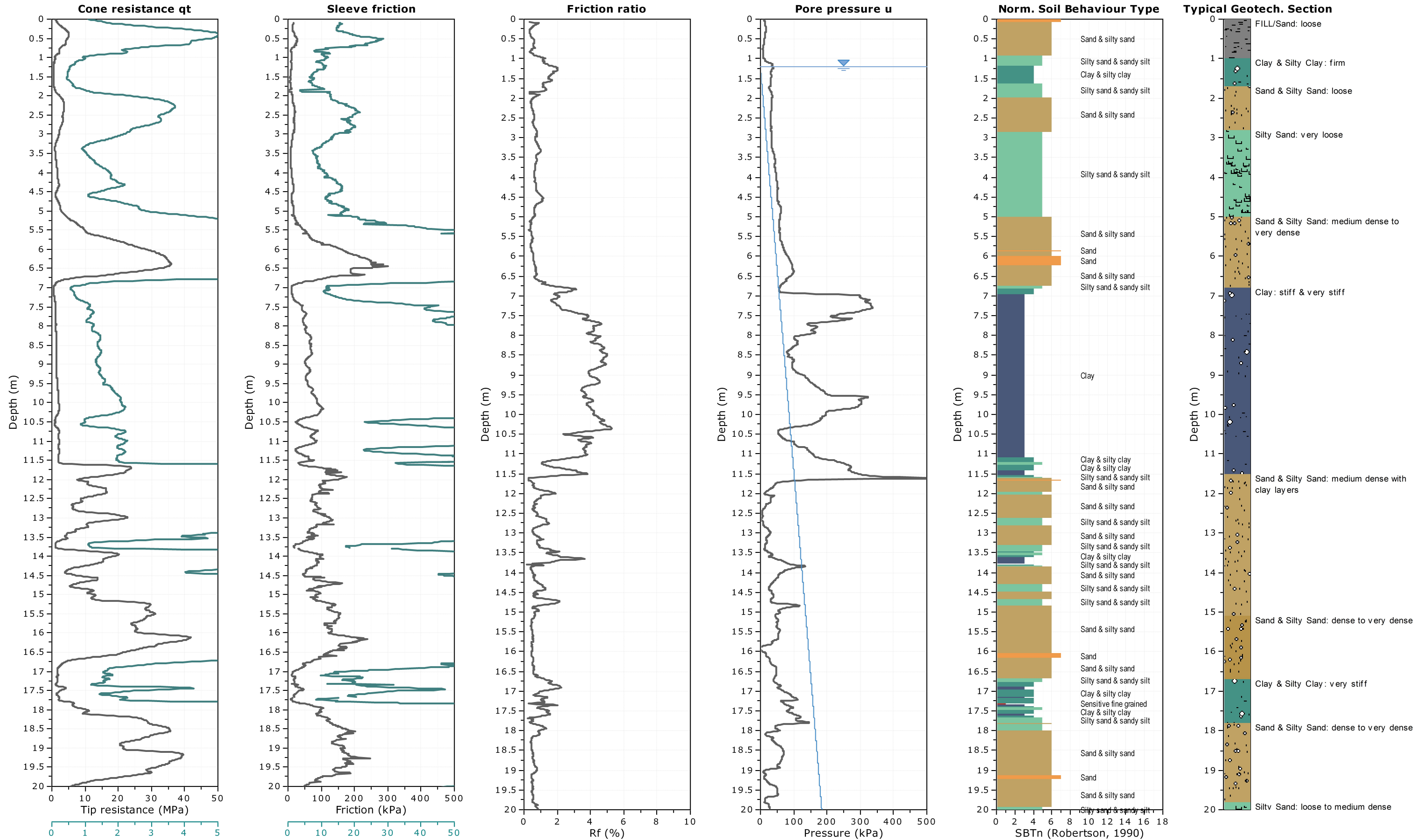
Appendix C

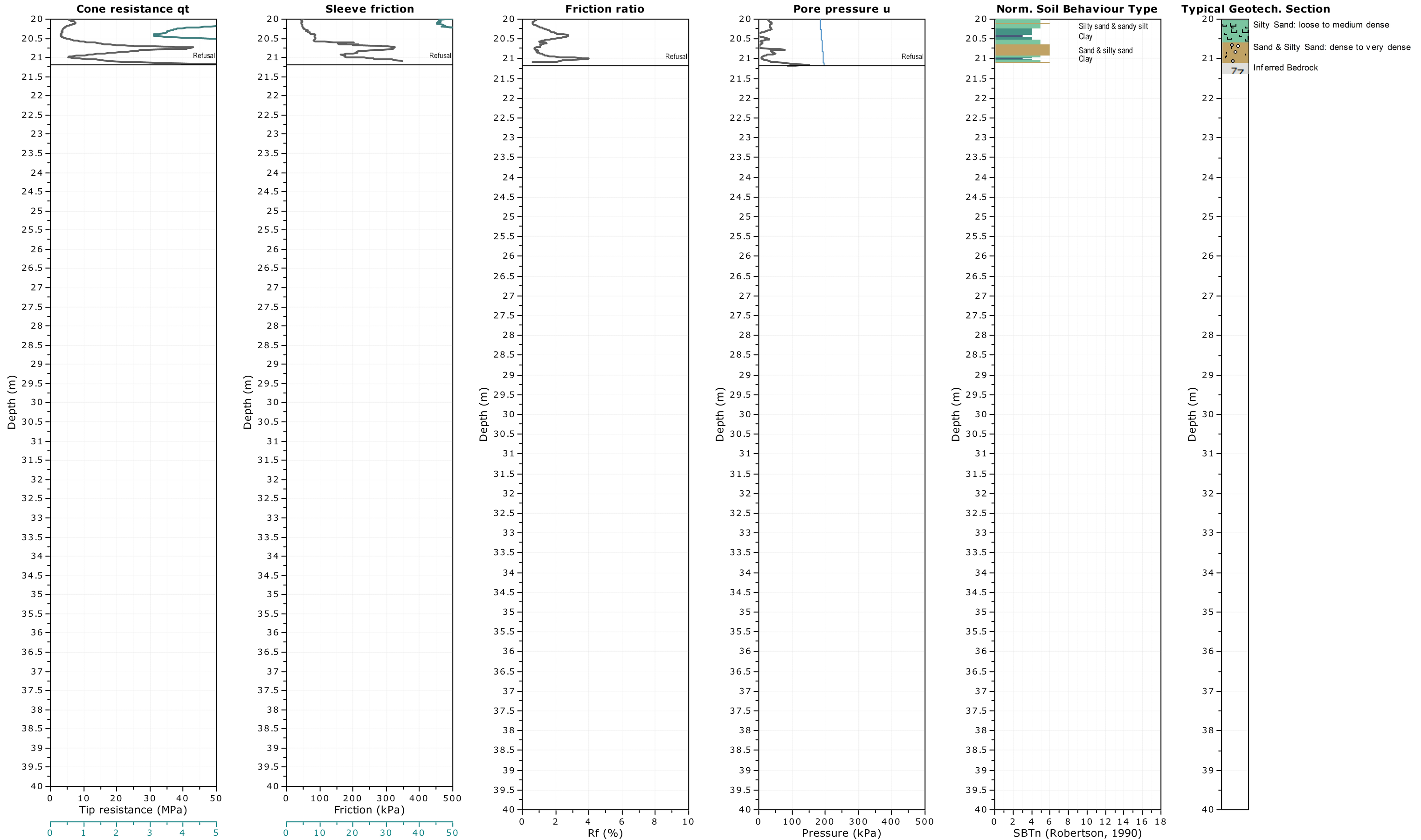
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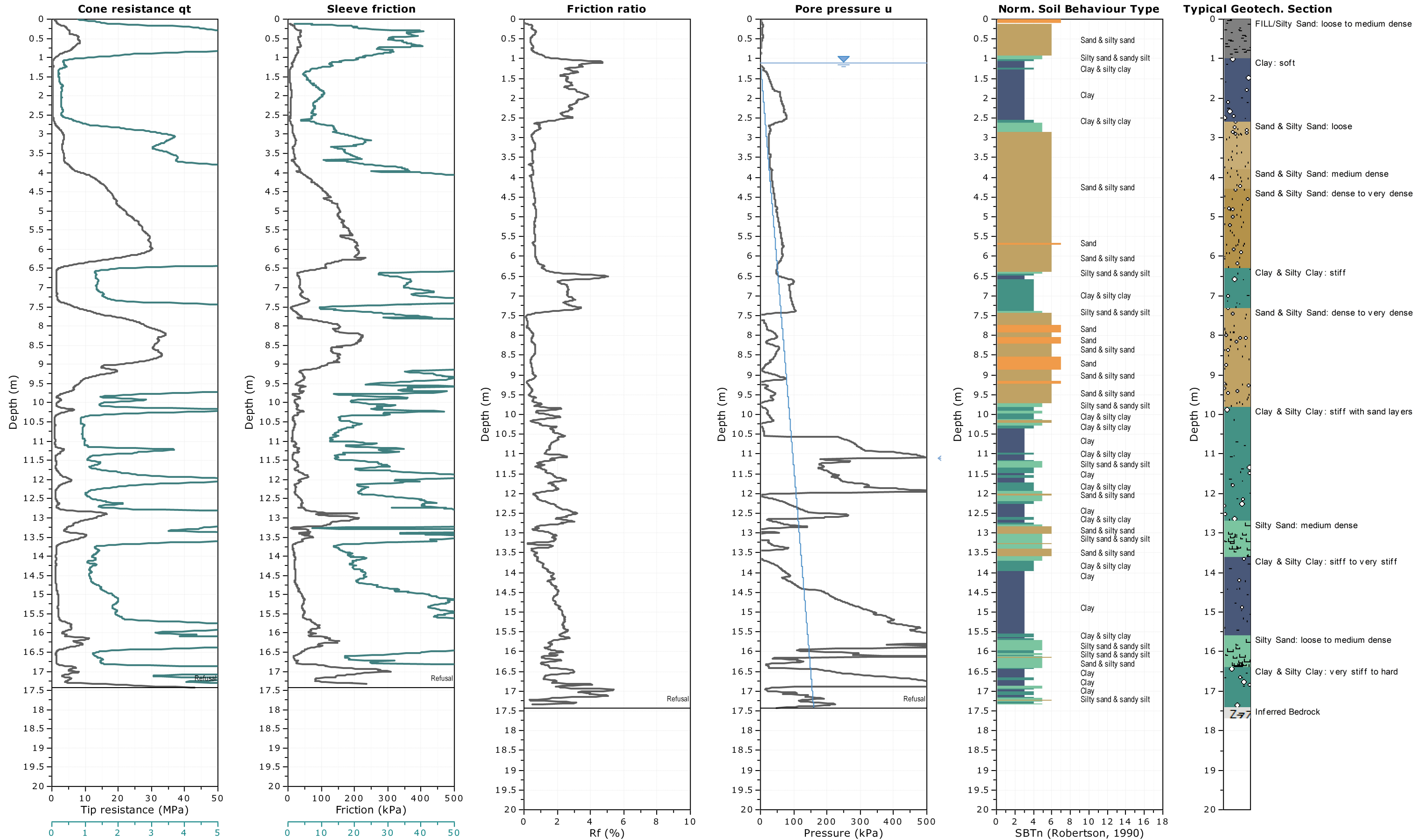


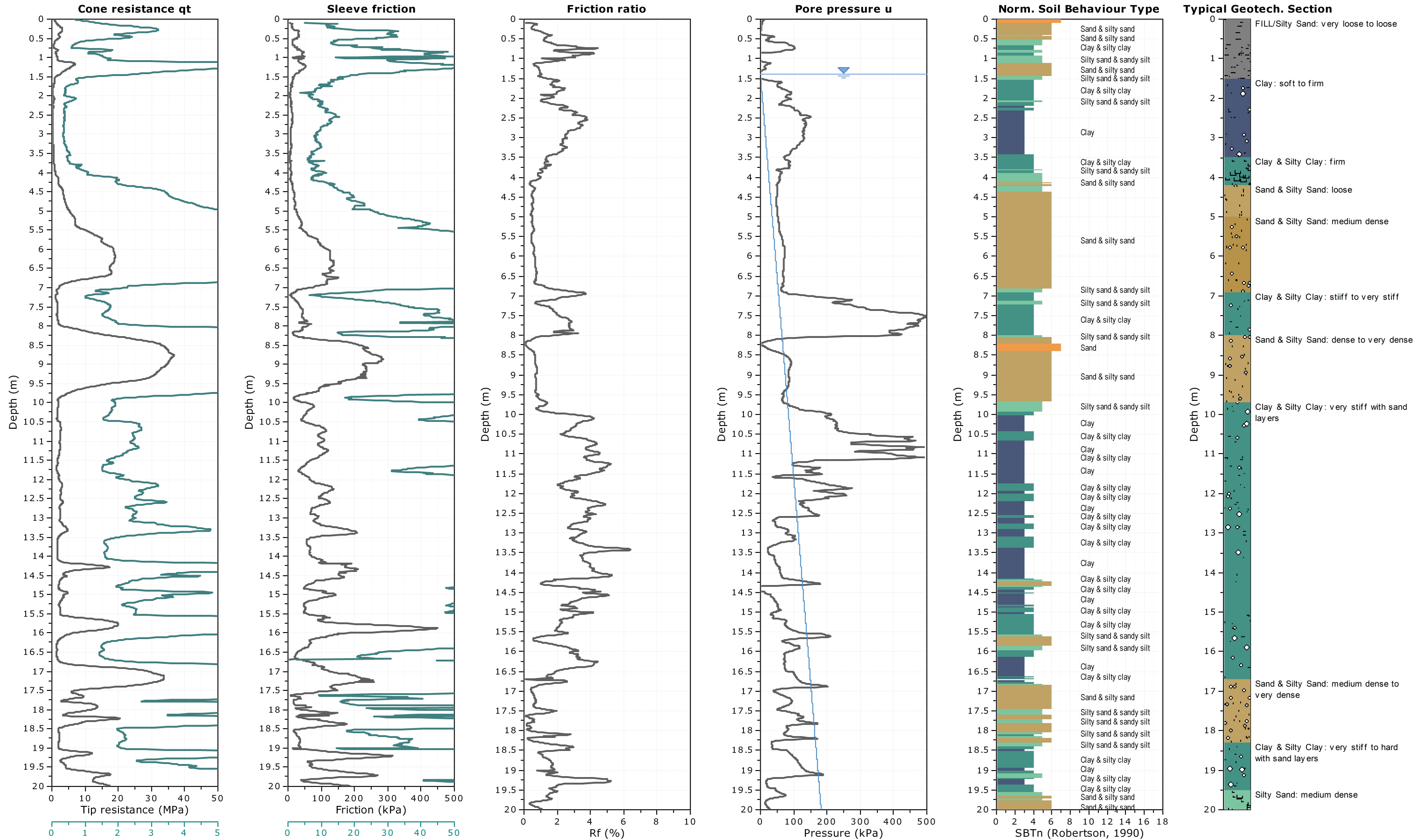






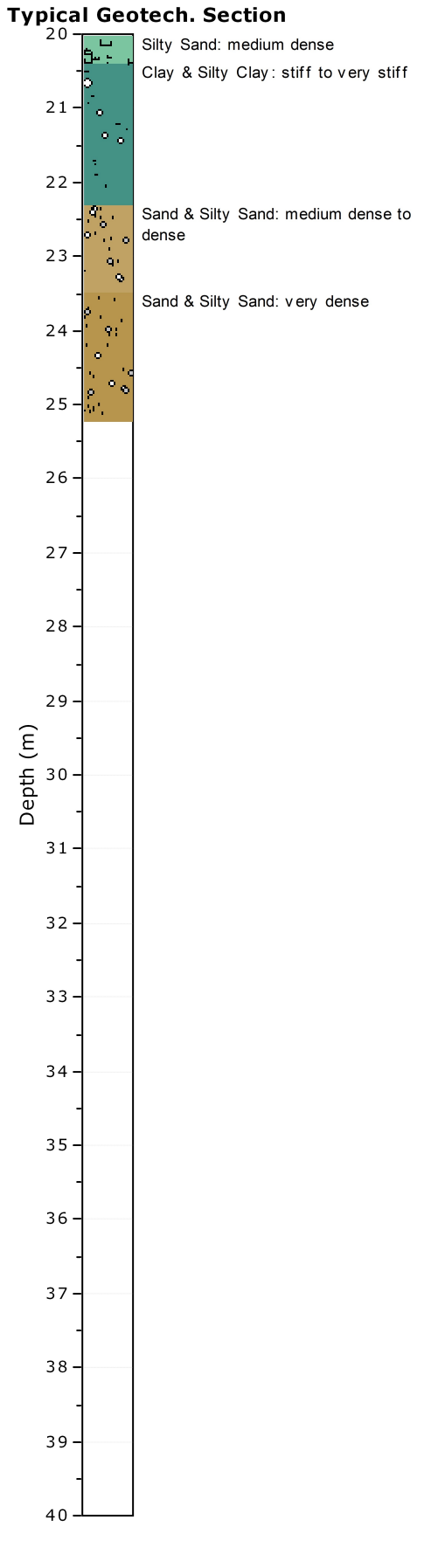
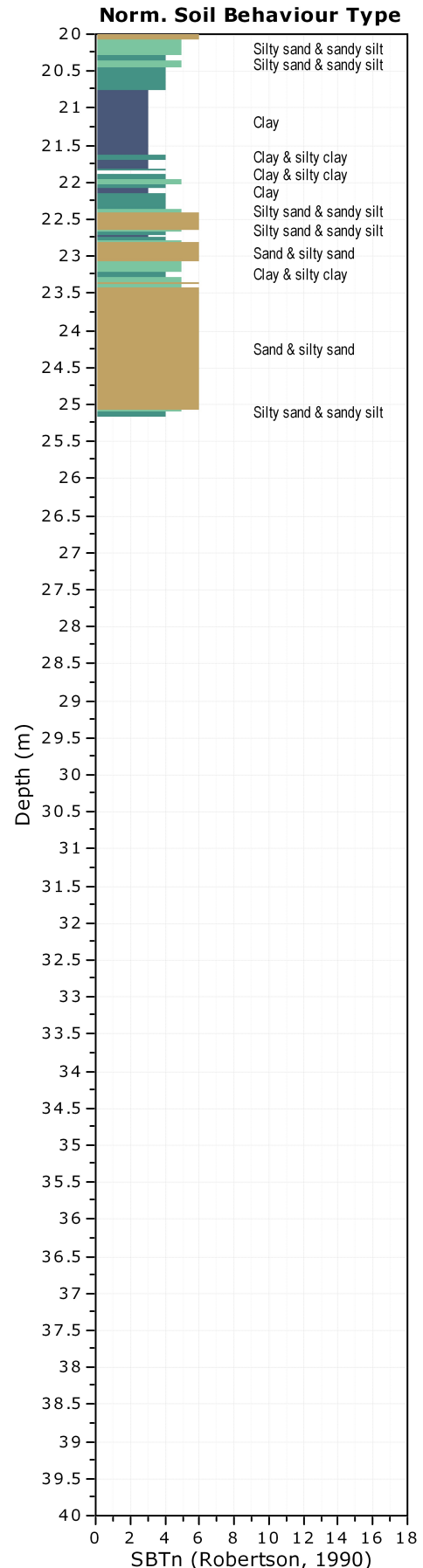
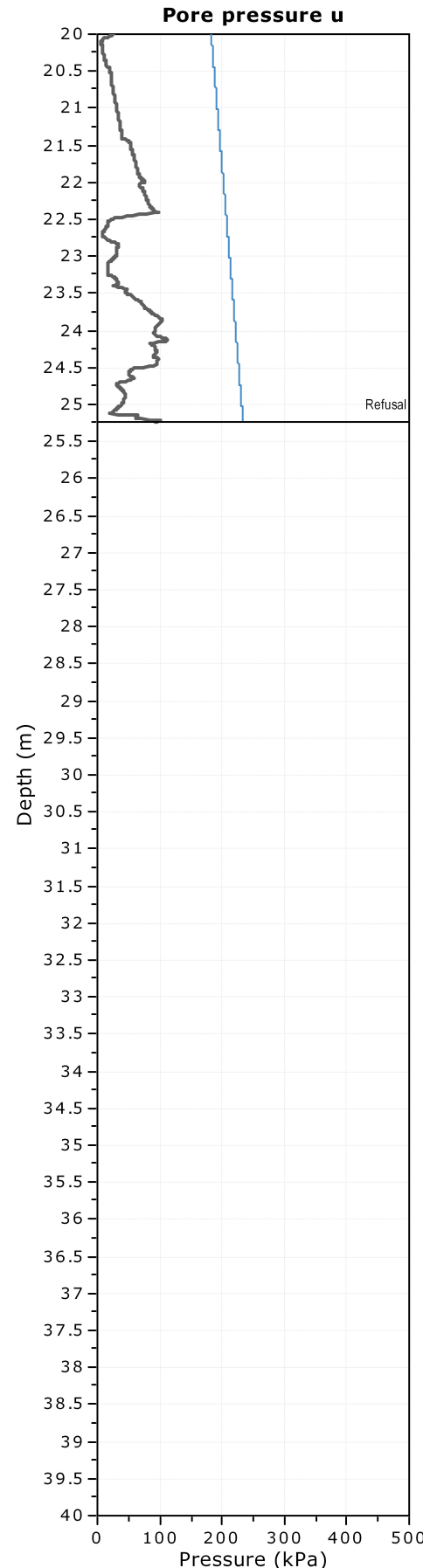
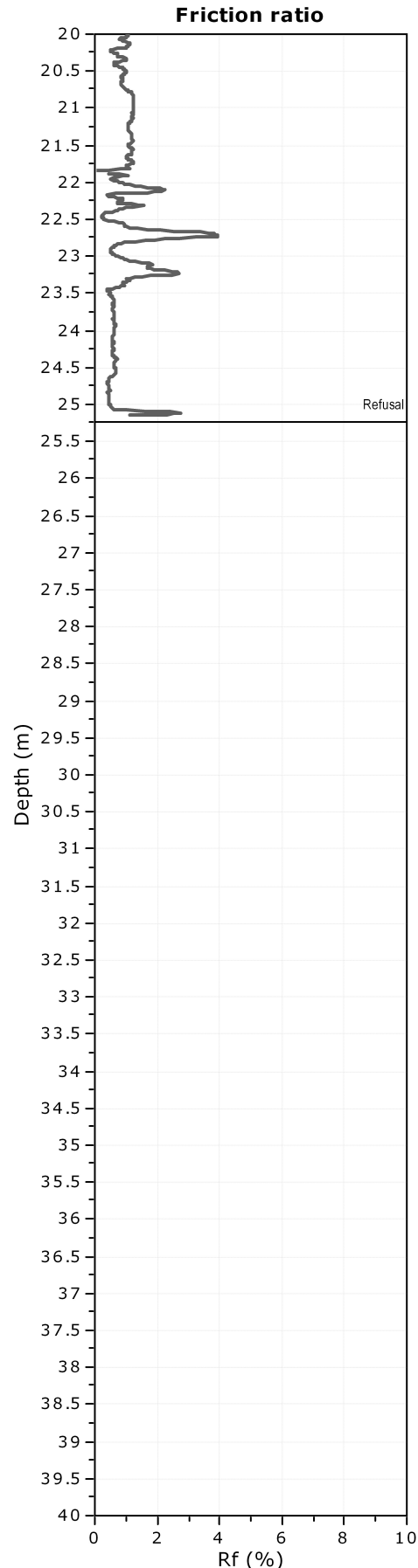
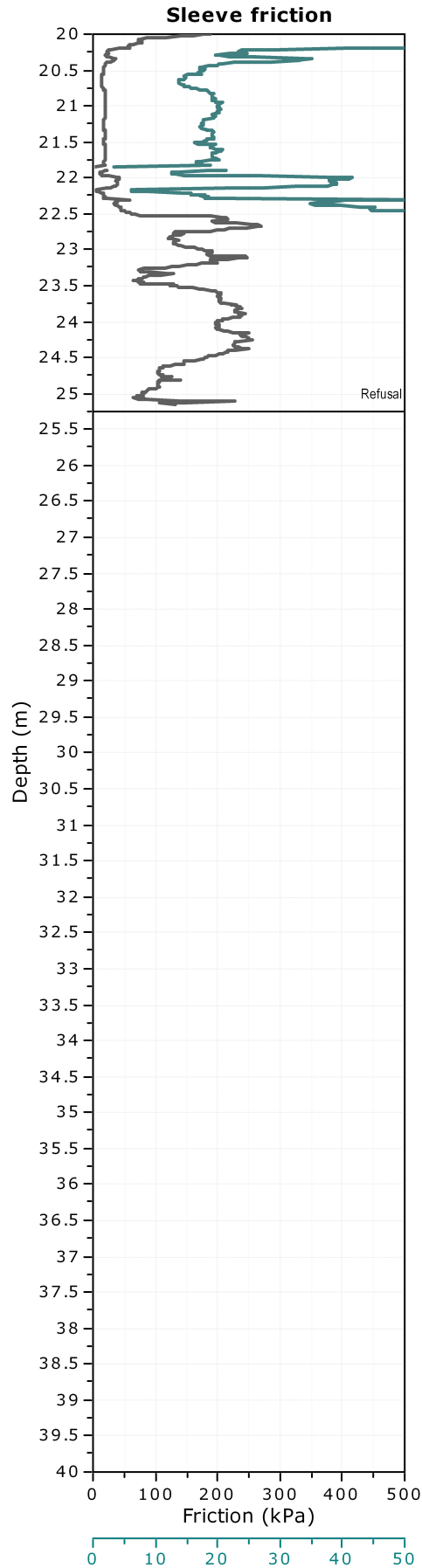
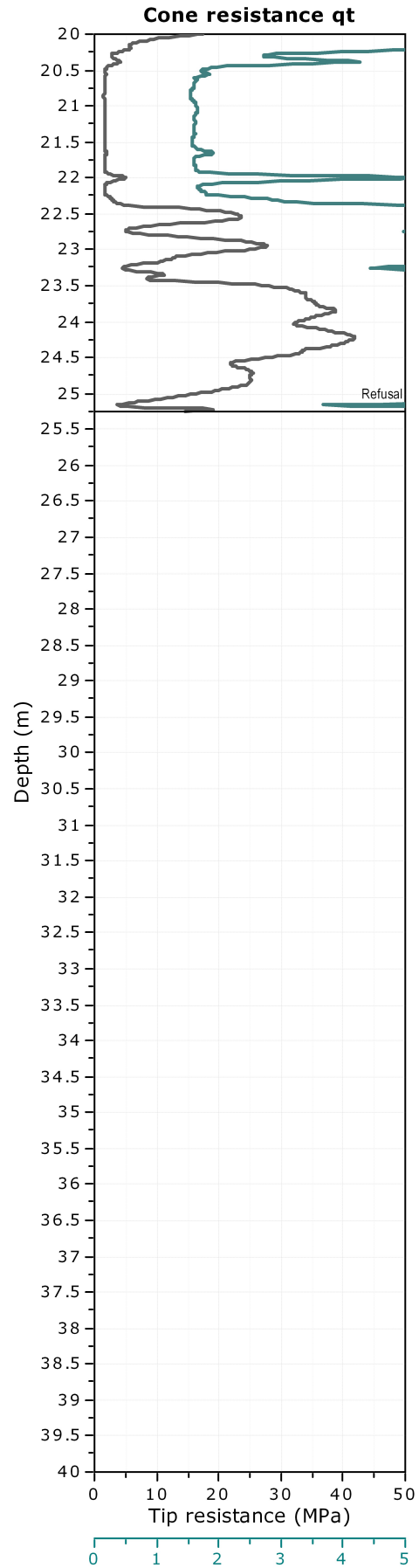


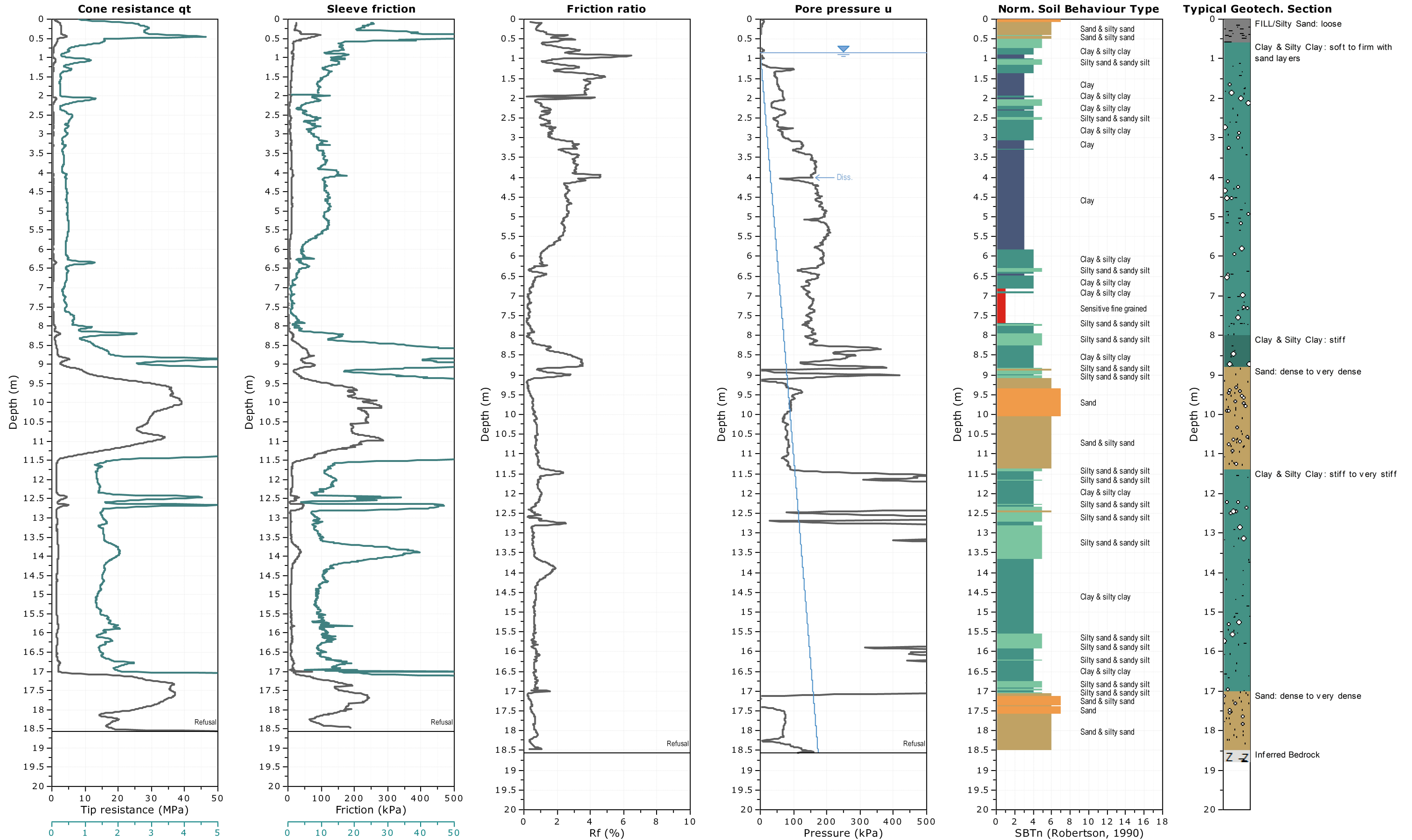


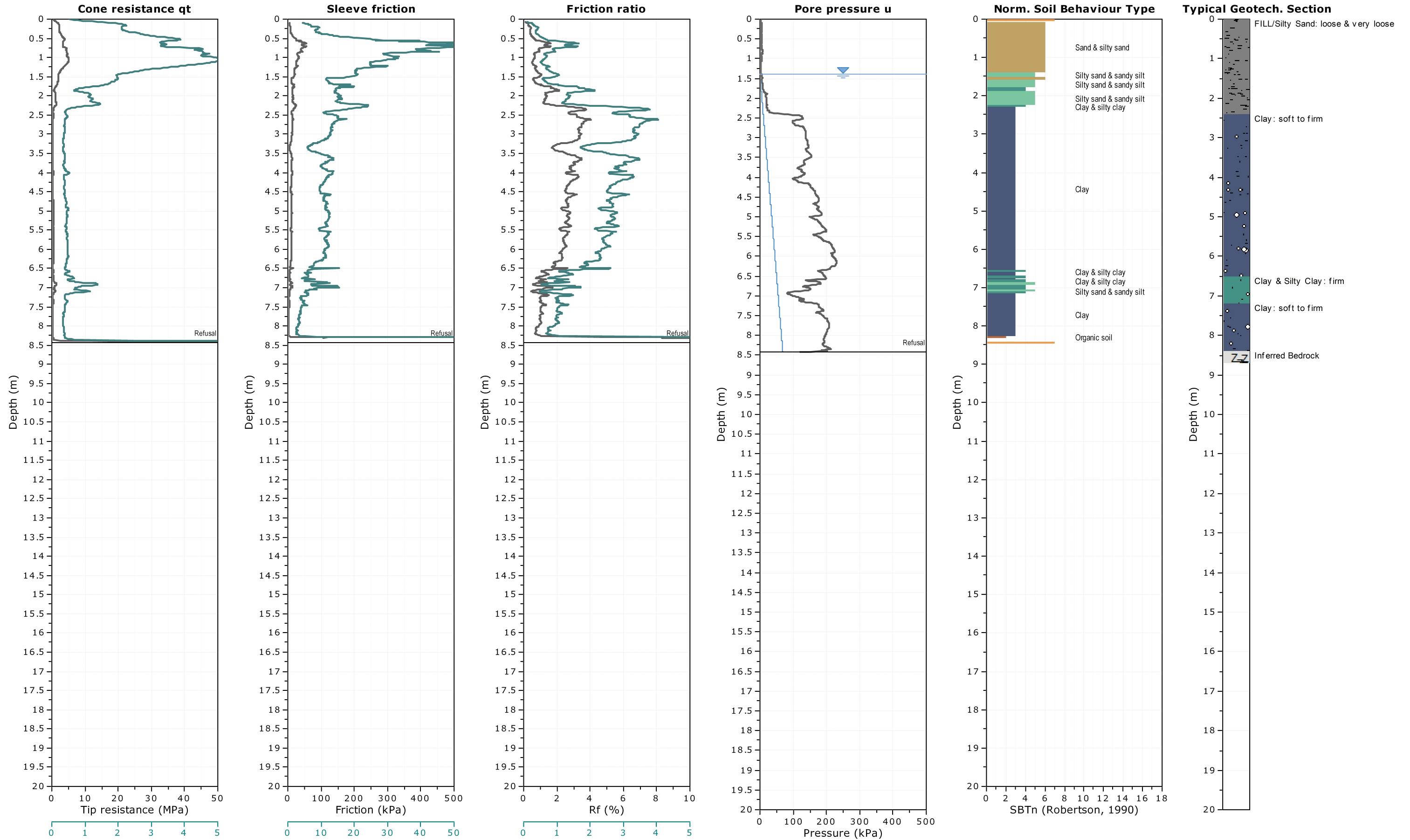


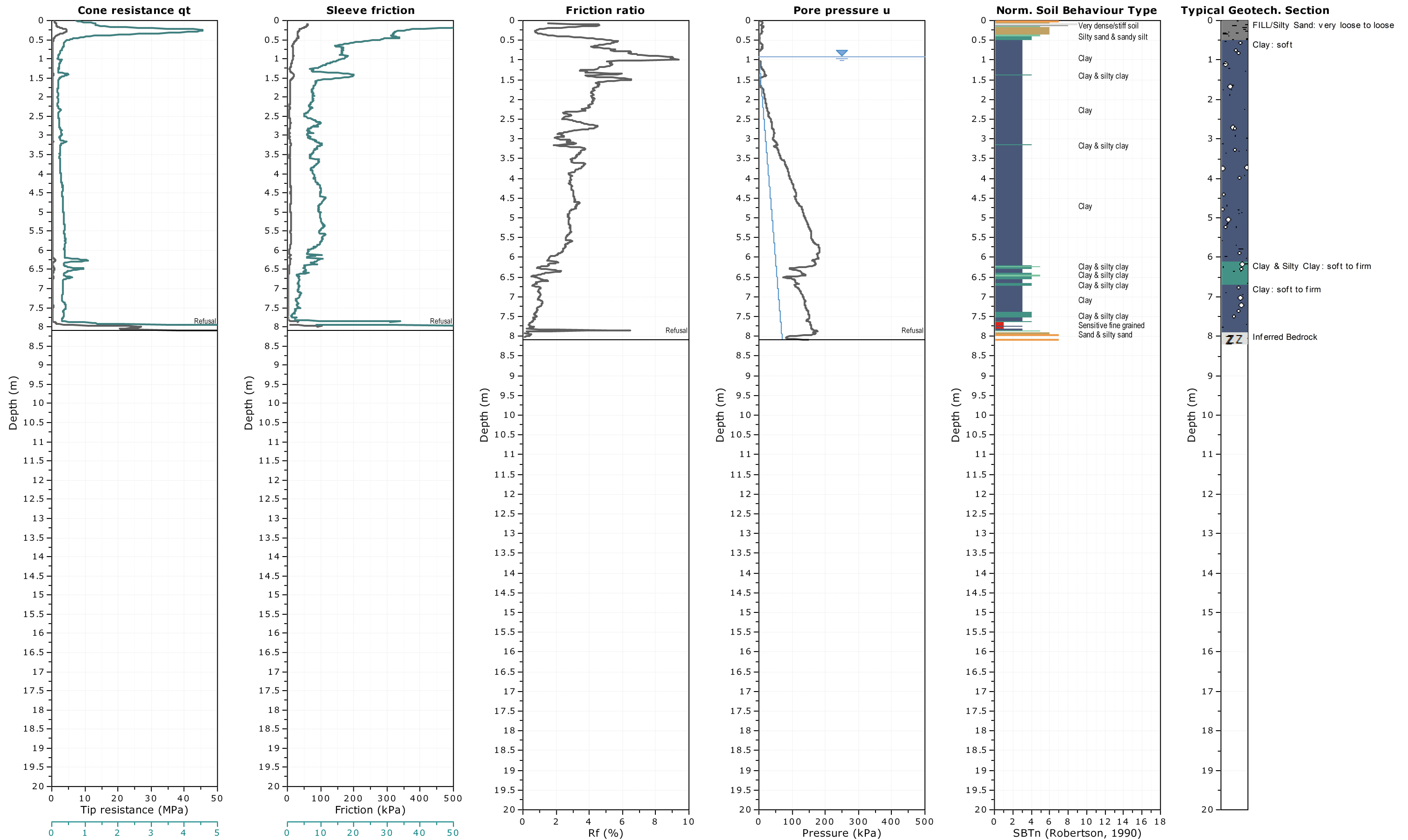
Project: PROPOSED COMMERCIAL-INDUSTRIAL DEVELOPMENT

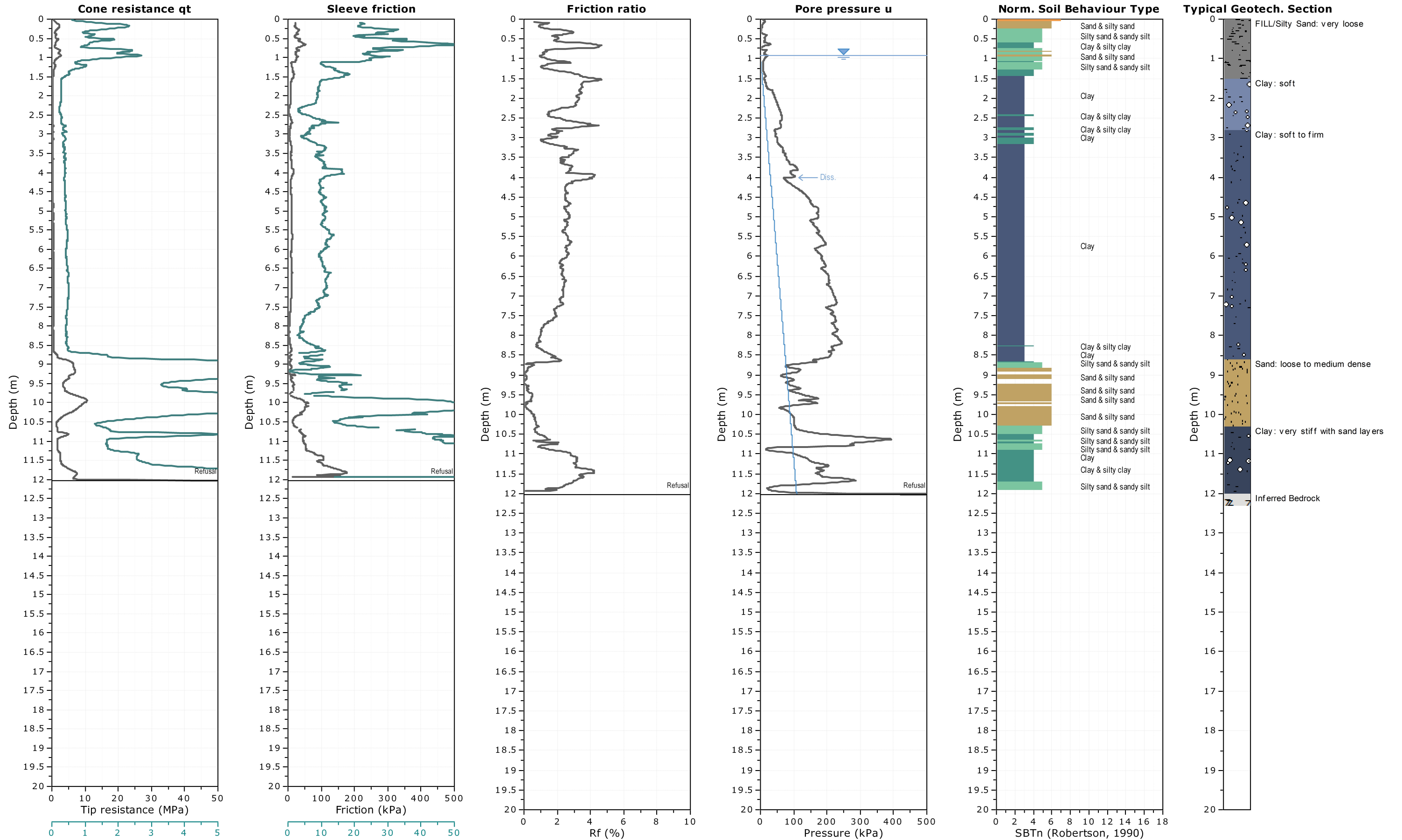
Location: KOGARAH GOLF COURSE, COOKS COVE, ARNCIFFE NSW











BOREHOLE LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.6 AHD
COORDINATE: E:329923.9, N:6243666.5
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH401
PROJECT No: 223528.01
DATE: 03/10/25
SHEET: 1 of 3

CONDITIONS ENCOUNTERED														SAMPLE				TESTING		
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK							SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
					ORIGIN ^(#)	CONSIS. ^(*)	DENSITY. ^(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY	(%)	RQD						
		0.10	FILL / Sandy GRAVEL: grey; fine to medium; medium to coarse sand.		FILL	ND									ASS	D	0.10			
		0.20			FILL										x2 ASS	D	0.40			
		0.60	FILL / SAND trace gravel: dark brown; medium; medium gravel.														0.50			
		1	FILL / SAND with silt: dark grey; medium.		FILL	(VL)									ASS	D	0.90			
		1.00													SPT		1.45	SPT	0,1,1 N=2	
		1.50	Sandy SILT (ML): dark grey; low plasticity; fine to medium sand; trace shells.														1.45			
		2			EST	VS	w=LL								ASS	D	2.00			
		2.00													no return	SPT	2.20	SPT	0,0,0 N=0 (HW)	
		2.45															2.45			
		2.90	SAND (SP) trace silt: grey; medium.												ASS	SPT	3.00	SPT	0,1,1 N=2	
		3.00															3.45			
		4				VL									ASS	SPT	4.00	SPT	1,0,1 N=1	
		4.00															4.45			
		5	From 4.80m: No silt, pale grey		EST		W										5			
		5.20													ASS	SPT	5.20	SPT	9,16,20 N=36	
		5.65															5.65			
		6				D									ASS	SPT	6.00	SPT	8,17,25 N=42	
		6.00															6.45			
		6.90	Silty CLAY (CH): grey; high plasticity.												ASS	SPT	7.00	SPT	1,2,1 N=3	
		7.00															7.45			
		8			EST	VS	w>PL								ASS	SPT	8.00	SPT	0,1,0 N=1	
		8.00															8.45			
		9															9			
		9.70			ALV	VSt														

NOTES: ^(#)Soil origin is "probable" unless otherwise stated. ^(*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

NOTES: ¹Soil origin is "probable" unless otherwise stated. ²Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Geo 305

OPERATOR: Ground Test (S. Stembridge)

LOGGED: I. Howsam

METHOD: AD/T to 4.0 m, WB to 21.1m

CASING: HWT to 5.1m

REMARKS:

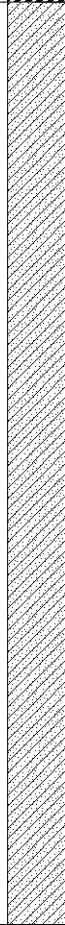
Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.6 AHD
COORDINATE: E:329923.9, N:6243666.5
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH401
PROJECT No: 223528.01
DATE: 03/10/25
SHEET: 2 of 3

CONDITIONS ENCOUNTERED														SAMPLE		TESTING				
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK							SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
					ORIGIN [#]	CONSIS. ¹ DENSITY. ¹	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS						
			Silty CLAY (CH): grey; high plasticity.																	
			Clayey SAND (SC): grey; medium.																	

NOTES: ¹Soil origin is "probable" unless otherwise stated. ²Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Geo 305

METHOD: AD/T to 4.0 m, WB to 21.1m

REMARKS:

OPERATOR: Ground Test (S. Stembridge)

LOGGED: I. Howsam

CASING: HWT to 5.1m

Refer to explanatory notes for symbol and abbreviation definitions

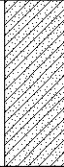


BOREHOLE LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.6 AHD
COORDINATE: E:329923.9, N:6243666.5
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH401
PROJECT No: 223528.01
DATE: 03/10/25
SHEET: 3 of 3

CONDITIONS ENCOUNTERED																			SAMPLE					TESTING	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK							SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS					
					ORIGIN (#)	CONSIS. (1) DENSITY (1)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH V/L M H V/H BH	RECOVERY (%)	RQD	FRACTURE SPACING (m) V/L M H V/H BH	DEFECTS & REMARKS											
	-19 21		[CONT] Clayey SAND (SC): grey; medium.		ALV	L	W										21								
		22	Borehole discontinued at 21.10m depth. WB Refusal on Inferred Sandstone Bedrock.																						
		23																							
		24																							
		25																							
		26																							
		27																							
		28																							
		29																							

NOTES: [#]Soil origin is "probable" unless otherwise stated. ¹Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

NOTES: ^HSoil origin is "probable" unless otherwise stated. ^VConsistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Geo 305
METHOD: AD/T to 4.0 m, WB to 21.1m
REMARKS:

OPERATOR: Ground Test (S. Stembridge)

LOGGED: I. Howsam
CASING: HWT to 5.1m

Refer to explanatory notes for symbol and abbreviation definitions



BOREHOLE LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.2 AHD
COORDINATE: E:329833.9, N:6243513.3
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH402
PROJECT No: 223528.01
DATE: 09/10/25
SHEET: 1 of 2

CONDITIONS ENCOUNTERED														SAMPLE		TESTING					
GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK							SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS	BACKFILL	WELL PIPE
				ORIGIN ^(#)	CONSIS. ⁽¹⁾ DENSITY ⁽²⁾	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS								
0.20	0.20	FILL / SAND trace silt: brown; fine; heavy roots to 0.06m, trace roots to 0.3m; Topsoil.		EST	ND	D									ASS	D	0.10 0.20				
0.70	0.70	Silty SAND (SM): dark brown; fine.				M									ASS	D	0.40 0.50				
1.00	1.00	SAND (SP): grey and orange-brown; fine to medium.													ASS	D	0.90 1.00				
1.45	1.45				VL										SPT		1.45	SPT	0,0,0 N=0 (HW)		
2.00	2.00				VL										ASS	SPT	2.00	SPT	1,1,1 N=2		
2.45	2.45																2.45				
3.00	3.00			EST		W									ASS	SPT	3.00	SPT	3,5,8 N=13		
3.65	3.65																3.65				
4.00	4.00				MD										ASS	SPT	4.00	SPT	3,1,0 N=1		
4.45	4.45																4.45				
5.00	5.00	From 4.20m-5.00m: Soft clay bed															5.00				
5.60	5.60														ASS	SPT	5.60	SPT	1,3,7/80m m (HB)		
6.00	6.00	SANDSTONE: pale grey, medium to coarse grained, cross bedded at 10°.															6.00	PLT	PL(A)=0.15MPa		
6.35	6.35																6.35				
6.71	6.71																6.71				
7.00	7.00																7.00	PLT	PL(A)=0.60MPa		
7.35	7.35																7.35				
7.71	7.71																7.71	PLT	PL(A)=0.40MPa		
8.00	8.00																8.00				
8.49	8.49																8.49				
8.58	8.58																8.58				
8.76	8.76																8.76	PLT	PL(A)=0.28MPa		
8.82	8.82																8.82				
8.96	8.96																8.96				
9.05	9.05																9.05				
9.47	9.47																9.47	PLT	PL(A)=0.44MPa		

NOTES: ^(#)Soil origin is "probable" unless otherwise stated. ⁽¹⁾Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

NOTES: [#]Soil origin is "probable" unless otherwise stated. [†]Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Geo 305

OPERATOR: Ground Test (S. Stemberge)

LOGGED: I. Howsam
CASING: HWT to 3.2m

METHOD: AD/T to 2.0 m, WB to 5.6 m, NMLC to 11.44 m

REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions



BOREHOLE LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.2 AHD
COORDINATE: E:329833.9, N:6243513.3
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH402
PROJECT No: 223528.01
DATE: 09/10/25
SHEET: 2 of 2

CONDITIONS ENCOUNTERED														SAMPLE				TESTING				
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK							SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS	BACKFILL	WELL PIPE
					ORIGIN (#)	CONSIS. ⁽¹⁾	DENSITY. ⁽¹⁾	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)								
	9		[CONT] SANDSTONE: pale grey, medium to coarse grained, cross bedded at 10°. Hawkesbury Sandstone.																			
	10		11.27m-11.31m: Siltstone bed						FR													
	11																					
	12		Borehole discontinued at 11.44m depth. Target Depth Reached.																			
	13																					
	14																					
	15																					
	16																					
	17																					
	18																					
	19																					

NOTES: [#]Soil origin is "probable" unless otherwise stated. ⁽¹⁾Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

NOTES: ° Soil origin is "probable" unless otherwise stated. ° Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Geo 305
METHOD: AD/T to 2.0 m, WB to 5.6 m, NMLC to 11.44 m
REMARKS:

OPERATOR: Ground Test (S. Stembridge)

LOGGED: I. Howsam
CASING: HWT to 3.2m

Refer to explanatory notes for symbol and abbreviation definitions



CORE PHOTO LOG

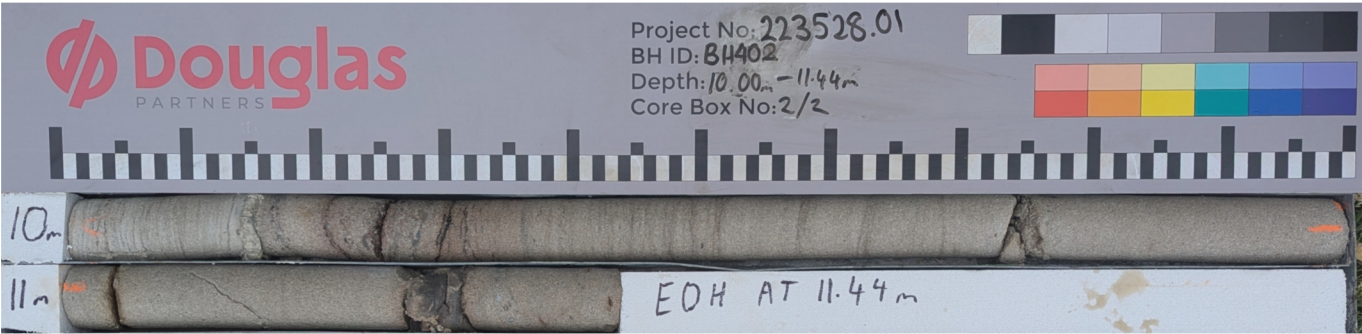
CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.2 AHD
COORDINATE: E:329833.9, N:6243513.3
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH402
PROJECT No: 223528.01
DATE: 09/10/25
SHEET: 1 of 1



5.60-10.00 m depth



10.00-11.44 m depth

BOREHOLE LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.2 AHD
COORDINATE: E:329743.2, N:6243408.5
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH403
PROJECT No: 223528.01
DATE: 08/10/25 - 09/10/25
SHEET: 1 of 1

CONDITIONS ENCOUNTERED														SAMPLE		TESTING				
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK							SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
					ORIGIN (#)	CONSIS. (%)	DENSITY (%)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)						
	0.10		FILL / SAND trace silt: grey; fine to medium; heavy roots to 0.08m, trace roots to 0.15m; Topsoil.																	
	0.20																			
	0.40																			
	0.50		SAND (SP) trace silt: brown; fine to medium.																	
	0.90		From 0.70m: with silt, dark grey-brown																	
	1.00																			
	1.45																			
	2.00				EST															
	2.20																			
	2.50					VL														
	2.95																			
	3.20																			
	3.65																			
	4.00		SAND (SP): pale grey and orange-brown; fine to medium.																	
	4.45																			
	5.00				ALV		MD													
	5.45																			
	6.00																			
	6.30																			
	6.45		CLAY (CH) trace sand: grey; high plasticity; fine to medium sand.																	
	7.00				ALV		VS	w>PL												
	7.45																			
	7.90																			
	8.00		SAND (SW): grey, pale grey and yellow-brown; fine to coarse.		ALV		MD	M												
	8.45																			
	8.45		Borehole discontinued at 8.45m depth. Target Depth Reached.																	
	9.00																			

NOTES: #Soil origin is "probable" unless otherwise stated. %Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

NOTES: ¹Soil origin is "probable" unless otherwise stated. ²Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Geo 305

OPERATOR: Ground Test (S. Stembridge)

LOGGED: I. Howsam

METHOD: AD/T to 2.5 m, WB to 8.0 m

CASING: HWT to 3.2m

REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions



BOREHOLE LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 0.7 AHD
COORDINATE: E:329987.2, N:6243418.7
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH404
PROJECT No: 223528.01
DATE: 02/10/25 - 03/10/25
SHEET: 1 of 2

CONDITIONS ENCOUNTERED																SAMPLE		TESTING				
GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK								SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS	BACKFILL	WELL PIPE
				ORIGIN ^(#)	CONSIS. ^(*) DENSITY. ^(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS									
RL (m)																						
0.10	0.10	TOPSOIL / SAND with silt: dark grey; fine to medium; Heavy roots to 0.03 m, trace roots to 0.2 m.	TS	TOP	ND	M									ASS	D	0.10					
0.55	0.55	FILL / SAND: grey; fine to medium.	FILL														0.20					
1	1	Sandy SILT (ML): grey and dark grey; low plasticity; fine to medium sand; faint sulphurous odour.					w>PL								ASS	D	0.90					
																SPT	1.00		0,0,0 N=0 (HW)			
				EST	(VS)		w=LL										1.45					
2	2																2.00					
															ASS	SPT	2.45		0,0,1 N=1			
2.60	2.60	SAND (SP): pale grey; fine to medium.															3.00					
3	3			EST	(VL)	W									ASS	SPT	3.45		1,0,1 N=1			
4.00	4.00	SANDSTONE: pale grey and yellow-brown, medium to coarse grained. Hawkesbury Sandstone.															4		PLT	PL(A)=0.46MPa		
										100	100											
5	5													5.04m: B, 5°, PR, INF Clay 10mm, SM			5					
														5.17m: B, 0°, PR, INF Clay 5mm, SM								
																		PLT	PL(A)=0.59MPa			
6	6													5.91m: B, 10°, PR, CN, SM			6					
														6.04m: B, 0°, PR, CN, SM								
														6.31m: B, 15°, PR, VNR Clay, SM				PLT	PL(A)=0.60MPa			
														6.59m: B, 10°, ST, CN, RF								
7	7													6.75m: B, 5°, PR, CN, RF			7					
														6.86m: EW, Clay 60mm								
																		PLT	PL(A)=0.50MPa			
8	8													7.84m: B, 20°, PR, VNR Clay, SM			8					
														8.18m: B, 5°, PR, VNR Clay, RF								
														8.44m: B, 0°, IR, CN, RF				PLT	PL(A)=0.68MPa			
9	9													8.86m: B, 10°, ST, CN, SM			9					
														9.67m: B, 15°, PR, CN, SM				PLT	PL(A)=0.32MPa			

NOTES: [#] Soil origin is "probable" unless otherwise stated. ^(*) Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Coo 305 OPERATOR: J. H. H. LOGGED: J. H. H.

PLANT: Geo 305
METHOD: AD/T to 2.0 m, WB to 4.0 m, NMLC to 11.48 m
REMARKS:

OPERATOR: Ground Test (S. Stemberge)

LOGGED: I. Howsam
CASING: HWT to 4m

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 0.7 AHD
COORDINATE: E:329987.2, N:6243418.7
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH404
PROJECT No: 223528.01
DATE: 02/10/25 - 03/10/25
SHEET: 2 of 2

CONDITIONS ENCOUNTERED															SAMPLE				TESTING																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK							SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS	BACKFILL	WELL PIPE																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
					ORIGIN(%)	CONSIS. (%)	DENSITY (%)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)									DEFECTS & REMARKS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
	-6	11	[CONT] SANDSTONE: pale grey and yellow-brown, medium to coarse grained. Hawkesbury Sandstone. From 10.14m: Pale grey					SW	10.14																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						

PLANT: Coo 305 OPERATOR: J. L. H. LOGGED:

PLANT: Geo 305
METHOD: AD/T to 2.0 m, WB to 4.0 m, NMLC to 11.48 m
REMARKS:

OPERATOR: Ground Test (S. Stemberge)

LOGGED: I. Howsam
CASING: HWT to 4m

Refer to explanatory notes for symbol and abbreviation definitions



CORE PHOTO LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 0.7 AHD
COORDINATE: E:329987.2, N:6243418.7
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH404
PROJECT No: 223528.01
DATE: 02/10/25 - 03/10/25
SHEET: 1 of 1



4.00-8.00 m depth



8.00-11.48 m depth

BOREHOLE LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.2 AHD
COORDINATE: E:329823.0, N:6243298.2
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH405
PROJECT No: 223528.01
DATE: 08/10/25
SHEET: 1 of 3

CONDITIONS ENCOUNTERED														SAMPLE		TESTING				
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK							SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
					ORIGIN(%)	CONSIS. (%)	DENSITY (%)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)						
		0.15	TOPSOIL / SAND trace silt: dark brown; fine to medium; heavy roots to 0.04m, trace roots to 0.15m.	TS	TOP	ND		D												
		1	FILL / SAND: brown; fine to medium. From 0.60m: pale grey From 0.80m: grey, trace silt	FILL	PC		M													
		1.60																		
		2	Sandy SILT (ML): grey; low plasticity; fine to medium sand; trace shell fragments; sulphurous odour.			VS														
		2.45		EST			W=LL													
		3				F														
		3.30	SAND (SP): brown; fine to medium; trace shell fragments.																	
		4				VL														
		5		EST		MD		W												
		6				D														
		6.90	CLAY (CI-CH) with sand: grey mottled yellow-brown; medium to high plasticity.		EST	S		W>PL												
		8.00	SAND (SP): grey; fine to medium.																	
		9		EST		D		W												
NOTES: #Soil origin is "probable" unless otherwise stated. %Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.																				

NOTES: ¹ Soil origin is "probable" unless otherwise stated. ² Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Geo 305

OPERATOR: Ground Test (S. Stembridge)

LOGGED: J. Flynn

METHOD: AD/T to 2.0 m, WB to 16.85 m, NMLC to 24.70 m

CASING: HWT to 3.2m

REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.2 AHD
COORDINATE: E:329823.0, N:6243298.2
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH405
PROJECT No: 223528.01
DATE: 08/10/25
SHEET: 2 of 3

CONDITIONS ENCOUNTERED													SAMPLE		TESTING			
GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK						SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
				ORIGIN (#)	CONSIS. (°)	DENSITY (t)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD						
	0	[CONT] SAND (SP): grey; fine to medium.		EST	D	W												
	10.60	Sandy CLAY (Cl): grey; medium plasticity; fine to medium sand.																
	11																	
	12																	
	13																	
	14			ALV	(VS)	w>PL												
	15																	
	16																	
	16.85	SANDSTONE: pale grey and orange-brown, fine to medium grained; crossbedded.																
	17						MW										PLT	PL(A)=0.49MPa
	17.20						SW										PLT	PL(A)=0.11MPa
	17.61																	
	17.79																	
	18						SW										PLT	PL(A)=0.11MPa
	18.70																	
	19						MW										PLT	PL(A)=1.1MPa
	19																	

NOTES: ° Soil origin is "probable" unless otherwise stated. ° Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Coo 305 OPERATOR: J. L. H. LOGGED: J. L. H.

PLANT: Geo 305

OPERATOR: Ground Test (S. Stembridge)

LOGGED: J. Flynn

METHOD: AD/T to 2.0 m, WB to 16.85 m, NMLC to 24.70 m

CASING: HWT to 3.2m

REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions



BOREHOLE LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.2 AHD
COORDINATE: E:329823.0, N:6243298.2
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH405
PROJECT No: 223528.01
DATE: 08/10/25
SHEET: 3 of 3

CONDITIONS ENCOUNTERED																			SAMPLE				TESTING																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK								SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
				ORIGIN ^(#)	CONSIS. ^(*)	DENSITY. ^(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
	20.00	[CONT] SANDSTONE: grey-orange brown, fine to medium grained, siltstone laminations, 0-10°.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					

NOTES: ⁽¹⁾ Soil origin is "probable" unless otherwise stated. ⁽²⁾ Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Geo 305
METHOD: AD/T to 2.0 m, WB to 16.85 m, NMLC to 24.70 m
REMARKS:

OPERATOR: Ground Test (S. Stembridge)

LOGGED: J. Flynn
CASING: HWT to 3.2m

Refer to explanatory notes for symbol and abbreviation definitions



CORE PHOTO LOG

CLIENT:

Stockland Development Pty Limited

PROJECT:

Kogarah Golf Course Redevelopment

LOCATION:

Marsh Street, Arncliffe, NSW

SURFACE LEVEL:

1.2 AHD

COORDINATE:

E:329823.0, N:6243298.2

DATUM/GRID:

MGA2020 Zone 56

DIP/AZIMUTH:

90°/---°

LOCATION ID:

BH405

PROJECT No:

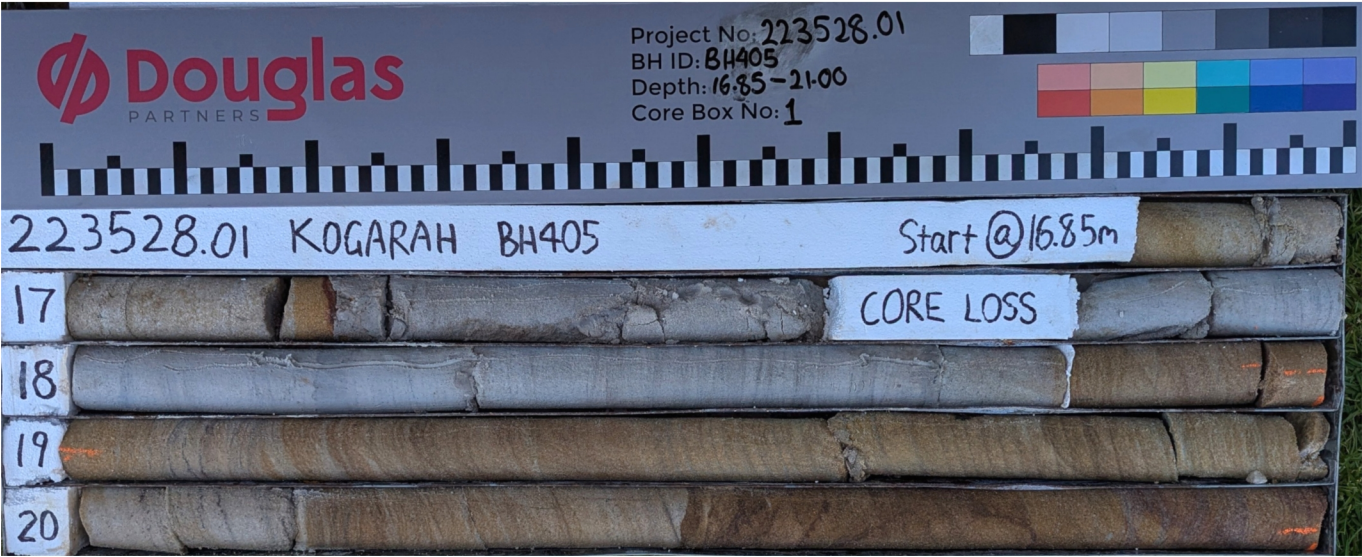
223528.01

DATE:

08/10/25

SHEET:

1 of 1



16.85-21.00 m depth



21.00-24.78 m depth

BOREHOLE LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.1 AHD
COORDINATE: E:329980.7, N:6243223.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH406
PROJECT No: 223528.01
DATE: 02/10/25
SHEET: 1 of 1

CONDITIONS ENCOUNTERED														SAMPLE		TESTING							
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK							SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS	BACKFILL	WELL PIPE	
					ORIGIN ^(*)	CONSIS. ^(*) DENSITY ^(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS									
02/10/25	1	0.10	FILL / SAND with silt: dark grey; fine to medium; Heavy roots to 0.05 m, trace roots to 0.2 m; Topsoil.		FILL	PC	M									ASS	D	0.10					
		0.60	FILL / SAND: grey mottled orange-brown; fine to medium; frequent shells.													x2 ASS	D	0.20					
		1	SAND (SP): grey and dark grey; fine to medium; faint sulphurous odour . From 0.60m: grey and dark grey, faint sulphur odour		EST. or possibly FILL	VL	W									ASS	D	0.40					
		2																0.50					
		2.40	Sandy SILT (ML): dark grey and black; low plasticity; fine to medium sand; frequent shells, sulphur odour.		EST	S	w=LL											0.90					
		3																1.00	SPT	0,1,0 N=1			
		3.80	SAND (SP): grey; fine to medium; trace shells.															1.45					
		4																2					
		5																2.20					
		6																2.50	SPT	1,0,0 N=0 (HW)			
		7	From 6.70m: With silt, dark grey															2.65					
		7.10	CLAY (CI) with sand: grey; medium plasticity; medium sand.															2.80					
		7.60	SAND (SP): pale grey and yellow-grey; medium.															3.00	SPT	0,0,0 N=0 (HW)			
		8																	3.45				
		9	Borehole discontinued at 8.45m depth. Target Depth Reached.															4.00	SPT	0,0,0 N=0			

NOTES: ^(*)Soil origin is "probable" unless otherwise stated. ^(*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

NOTES: ¹ Soil origin is "probable" unless otherwise stated. ² Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Geo 305

METHOD: AD/T to 1.0 m, WB to 8.45 m

REMARKS:

OPERATOR: Ground Test (L. Cooper / S. Stembridge)

LOGGED: I. Howsam
CASING: HWT to 2.2m

Refer to explanatory notes for symbol and abbreviation definitions



BOREHOLE LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.7 AHD
COORDINATE: E:330030.2, N:6243107.9
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH407
PROJECT No: 223528.01
DATE: 29/09/25
SHEET: 1 of 1

CONDITIONS ENCOUNTERED														SAMPLE		TESTING			
GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK							SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
				ORIGIN(%)	CONSIS. (%)	DENSITY (%)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)						
	0.20	FILL / SAND: grey; medium; trace charcoal, heavy roots to 0.01 m, trace roots to 0.2 m.		FILL	ND														
	1	FILL / SAND: pale grey and white; medium. From 0.60m: dark grey, trace silt		FILL															
	1.60																		
	2	Sandy SILT (ML): dark grey and black; fine to medium sand; trace shells, strong sulphur odour.			VL														
	2.55			EST. possibly FILL															
	3																		
	3.60																		
	4	Silty CLAY (OH): dark grey; high plasticity; strong sulphur odour, possibly peat.																	
	5			EST	VS	W=LL													
	6																		
	6.40																		
	7	Silty SAND (SM): grey; medium; trace shells, strong sulphur odour.																	
	7.45			EST	VL	W													
	8																		
	8.45																		
	9	Borehole discontinued at 8.45m depth. Target Depth Reached.																	

NOTES: [#]Soil origin is "probable" unless otherwise stated. [®]Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

NOTES: ¹ Soil origin is "probable" unless otherwise stated. ² Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Geo 305

OPERATOR: Ground Test (L. Cooper)

LOGGED: I. Howsam

METHOD: AD/T to 8.0 m

CASING: Uncased

REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.5 AHD
COORDINATE: E:329840.2, N:6243009.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH408
PROJECT No: 223528.01
DATE: 01/10/25
SHEET: 1 of 2

CONDITIONS ENCOUNTERED														SAMPLE		TESTING						
GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK							SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS	BACKFILL	WELL PIPE	
				ORIGIN(##)	CONSIS. (V) DENSITY. (C)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS									
0.0/10.25	0.10	FILL / Silty SAND: dark brown; fine to coarse; with rootlets.	TS	FILL	(PC) (MC)	M									D		0.10					
	0.70	FILL / SAND trace silt: grey, brown and orange - brown; fine to coarse; trace shell fragments.		FILL											D		0.40 0.50					
	1	Silty CLAY: dark grey; medium plasticity; trace shells, organic odour.													ASS	SPT	0.90 1.00	SPT	1,0,0 N=0			
	2														ASS	SPT	1.45 2.00 2.45	SPT	0,0,0 N=0 (HW)			
	3			EST	(VS) (S)	w>PL								no recovery	SPT	3.00 3.45	SPT	0,0,0 N=0 (HW)				
	4														ASS	SPT	4.00 4.45	SPT	0,0,0 N=0 (HW)			
	5														ASS	SPT	5.00 5.45	SPT	0,0,0 N=0 (HW)			
	6.00	Silty SAND: dark grey; fine to medium; trace shells, organic odour.													ASS	SPT	6.00 6.45	SPT	0,0,0 N=0 (HW)			
	7			EST	VL	W									ASS	SPT	7.00 7.45	SPT	0,0,0 N=0 (HW)			
	7.90	Sandy CLAY (CI-CH): grey; medium to high plasticity; fine to medium sand.		ALV	S	w>PL									ASS	SPT	8.00 8.45	SPT	2,1,1 N=2			
	9																					
	9.30	SAND (SP): grey; fine to medium.		ALV	D	W									ASS	SPT	9.00 9.45	SPT	2,4,19 N=23			

NOTES: "Soil origin is "probable" unless otherwise stated. "Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Geo 305
METHOD: AD/T to 2.0 m, WB to 10.5 m, NMLC to 18.78 m
REMARKS: grass overlay

OPERATOR: Ground Test (L. Cooper)
LOGGED: L. Straney/R. Taylor
CASING: HWT to 3.2m, then HQ to 10.45m

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.5 AHD
COORDINATE: E:329840.2, N:6243009.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH408
PROJECT No: 223528.01
DATE: 01/10/25
SHEET: 2 of 2

CONDITIONS ENCOUNTERED										SAMPLE		TESTING						
GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK						DEPTH (m)	TEST TYPE	RESULTS AND REMARKS	BACKFILL	WELL PIPE	
				ORIGIN (#)	CONSIS. (%)	DENSITY (%)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD						FRACTURE SPACING (m)
	10.20	[CONT] SAND (SP): grey; fine to medium.		ALV	D	W												
	10.50	Clayey SAND (SC): grey; fine to medium; low plasticity clay.		XWM														
	11	SANDSTONE: pale grey, medium to coarse grained, cross bedding, 5 to 10°. Hawkesbury sandstone.																
	11.19						FR						11.13m: B, 0°, PR, CN, RF					
	11.47						XW						11.19m: EW, 30mm					
	11.57						FR		100	84			11.47-11.57m: EW, 100mm					
	11.75						XW						11.75-11.81m: EW, 60mm					
	11.81																	
	12												12.31m: EW, 40mm					
	12.31																	
	13												13.05m: EW, 10mm					
	13.14												13.14m: B, 0°, PR, CT Clay, SM					
	13.70																	
	14																	
	14.00																	
	14.58						FR		100	96			14.58m: B, 0°, PR, MS, SM, sand					
	15																	
	15.55												15.55m: EW, 15mm					
	16																	
	16.66												16.66m: B, 0°, PR, CN, SM					
	17																	
	17.36								100	98			17.53m: EW, 35mm					
	17.66						SW						17.66m: B, 5°, PR, VNR Clay, SM					
	18																	
	18.30						FR						18.30m: B, 5°, PR, VNR Clay, SM					
	18.35																	
	18.78																	
	19	Borehole discontinued at 18.78m depth. Target Depth Reached.																

NOTES: #Soil origin is "probable" unless otherwise stated. %Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

NOTES: ¹Soil origin is "probable" unless otherwise stated. ²Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Geo 305

OPERATOR: Ground Test (L. Cooper)

LOGGED: L. Straney/R. Taylor

METHOD: AD/T to 2.0 m, WB to 10.5 m, NMLC to 18.78 m

CASING: HWT to 3.2m, then HQ to 10.45m

REMARKS: grass overlay

Refer to explanatory notes for symbol and abbreviation definitions



CORE PHOTO LOG

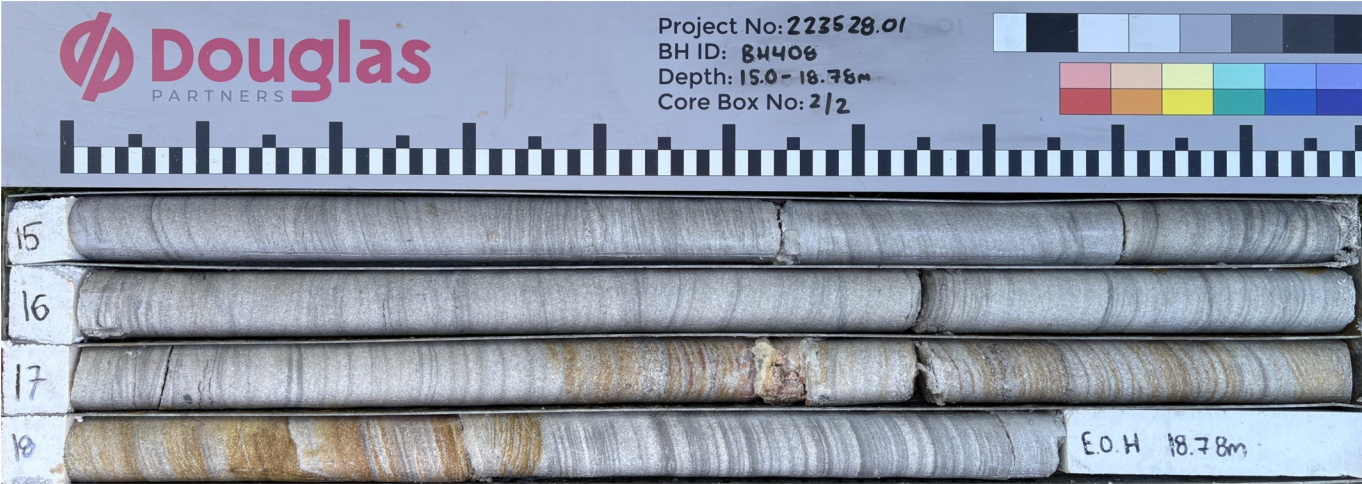
CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.5 AHD
COORDINATE: E:329840.2, N:6243009.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH408
PROJECT No: 223528.01
DATE: 01/10/25
SHEET: 1 of 1



10.50-15.00 m depth



15.00-18.78 m depth

BOREHOLE LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.5 AHD
COORDINATE: E:330007.5, N:6242950.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH409
PROJECT No: 223528.01
DATE: 29/09/25
SHEET: 1 of 2

CONDITIONS ENCOUNTERED														SAMPLE			TESTING						
GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK								SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS	BACKFILL	WELL PIPE	
				ORIGIN(1)	CONSIS. (1) DENSITY. (1)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS										
29/10/25 No Free Groundwater Observed Whilst Augering	0.30	FILL / SAND: brown; medium; trace wood chips, heavy roots to 0.01 m, trace roots to 0.3 m.		FILL		ND	M								ASS	D	0.10 0.20						
	0.80	FILL / SAND: yellow-brown; fine to medium.		FILL											ASS	D	0.40 0.50						
	1	Sandy SILT (ML): dark grey; low plasticity; fine to medium sand.													ASS	D	0.90 1.00						
	2			EST possibly FILL		S	w>PL										1.45	SPT	1,1,1 N=2				
	2.90																2						
	3	Silty CLAY (OH): dark grey; high plasticity; possibly peat, strong sulphur odour.													ASS	SPT	2.50	SPT	1,0,0 N=0				
	4														ASS	SPT	2.95	SPT	1,0,0 N=0				
	5																3.45						
	6														ASS	SPT	4.00	SPT	1,0,0 N=0				
	7																4.45						
	8			EST	(VS)	w=LL								no return	SPT	5.00	SPT	1,0,0 N=0					
	9																5.45						
	10														ASS	SPT	6.00	SPT	1,0,0 N=0				
	11																6.45						
	12														ASS	SPT	7.00	SPT	0,0,0 N=0 (HW)				
	13																7.45						
	14																8.00	SPT	1,4,7 N=11				
	15																8.45						
	16														ASS	SPT	9.00	SPT	3,3,7 N=10				
	17																9.45						
NOTES: (1) Soil origin is "probable" unless otherwise stated. (2) Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.																							

NOTES: ¹Soil origin is "probable" unless otherwise stated. ²Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Geo 305

OPERATOR: Ground Test (L. Cooper)

LOGGED: I. Howsam

METHOD: AD/T to 1.0 m, WB to 13.94 m, NMLC to 20.0 m

CASING: HWT to 2.6m, then HQ to 13.94m

REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Stockland Development Pty Limited

PROJECT: Kogarah Golf Course Redevelopment

LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.5 AHD

COORDINATE: E:330007.5, N:6242950.6

DATUM/GRID: MGA2020 Zone 56

DIP/AZIMUTH: 90°/---°

LOCATION ID: BH409

PROJECT No: 223528.01

DATE: 29/09/25

SHEET: 2 of 2

CONDITIONS ENCOUNTERED													SAMPLE		TESTING						
GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK							SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS	BACKFILL	WELL PIPE
				ORIGIN(%)	CONSIS. (1) DENSITY (2)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS								
RL (m)																					
5		[CONT] CLAY (CH): grey and yellow - brown; high plasticity; interbedded with bands of medium grained Sandy CLAY.																			
11				ALV	St	w>PL															
12																					
12.80																					
13		SAND (SP): pale grey; medium.		ALV	D	M															
13.94																					
13.94		SANDSTONE: pale grey - yellow, medium to coarse grained. Hawkesbury Sandstone.																			
14																					
14.42																					
14.48																					
14.92																					
15.00																					
15																					
16																					
17																					
17.23																					
17.23		SANDSTONE: pale grey, medium to coarse grained. Hawkesbury Sandstone.																			
18																					
19																					
19.94																					
19.94																					
20		Borehole discontinued at 20.00m depth. Target Depth Reached.																			
NOTES: (1) Soil origin is "probable" unless otherwise stated. (2) Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.																					

PLANT: Geo 305

OPERATOR: Ground Test (L. Cooper)

LOGGED: I. Howsam

METHOD: AD/T to 1.0 m, WB to 13.94 m, NMLC to 20.0 m

CASING: HWT to 2.6m, then HQ to 13.94m

REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions



CORE PHOTO LOG

CLIENT: Stockland Development Pty Limited

PROJECT: Kogarah Golf Course Redevelopment

LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.5 AHD

COORDINATE: E:330007.5, N:6242950.6

DATUM/GRID: MGA2020 Zone 56

DIP/AZIMUTH: 90°/---°

LOCATION ID: BH409

PROJECT No: 223528.01

DATE: 29/09/25

SHEET: 1 of 1



13.94-18.00 m depth



18.00-20.00 m depth

BOREHOLE LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.3 AHD
COORDINATE: E:329882.9, N:6242859.3
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH410
PROJECT No: 223528.01
DATE: 30/09/25
SHEET: 1 of 2

CONDITIONS ENCOUNTERED														SAMPLE		TESTING				
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK							SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
					ORIGIN ⁽¹⁾	CONSIS. ⁽¹⁾	DENSITY ⁽¹⁾	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)						
▼	30/10/25	0.40	FILL / SAND: brown; medium; heavy roots to 0.05 m, trace roots to 0.4 m.		FILL	ND	M													
		1	Sandy SILT (ML): dark grey; low plasticity; fine to medium sand; trace shell fragments, sulphur odour.		EST. possibly FILL	PC														
		2																		
		2.80	Silty CLAY (OH): dark grey; high plasticity; possibly peat, strong sulphur odour.				w=LL													
		3																		
		4			EST	VS														
		5																		
		5.50	Silty SAND (SM): dark grey; fine to medium; occasional shells, sulphur odour.																	
		6			EST	VL	W													
		7																		
		7.80	Sandy CLAY (CL-CI): grey; low to medium plasticity; fine to medium sand.																	
		8			EST	VS														
		9					w>PL													
		9.70	From 9.70m: orange-brown		RS	St														
NOTES: ⁽¹⁾ Soil origin is "probable" unless otherwise stated. ⁽²⁾ Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.																				

NOTES: ¹ Soil origin is "probable" unless otherwise stated. ² Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Geo 305

OPERATOR: Ground Test (L. Cooper)

LOGGED: I. Howsam

METHOD: AD/T to 2.0 m, WB to 10.48 m, NMLC to 17.45 m

CASING: HWT to 3.2m

REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Stockland Development Pty Limited
PROJECT: Kogarah Golf Course Redevelopment
LOCATION: Marsh Street, Arncliffe, NSW

SURFACE LEVEL: 1.3 AHD
COORDINATE: E:329882.9, N:6242859.3
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH410
PROJECT No: 223528.01
DATE: 30/09/25
SHEET: 2 of 2

CONDITIONS ENCOUNTERED														SAMPLE			TESTING				
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL			ROCK							SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS	
					ORIGIN (#)	CONSIS. (%) DENSITY (%)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS							
					RS	St	w>PL														
		10.48	SANDSTONE: orange - brown and grey, medium to coarse grained. Hawkesbury sandstone.					HW	10.48	VL									10.05	SPT	4,7,25/110mm (HB)
		10.46								10.77	SEAM								10.46		
		11						MW											11	PLT	PL(A)=0.29MPa
		12																			
		12						SW											12		
		12.85																			
		12.95						HW											13		
		13						XW													
		14						HW											14	PLT	PL(A)=0.13MPa
		15																			
		16																	16	PLT	PL(A)=0.33MPa
		17																			
		17.45		Borehole discontinued at 17.45m depth. Target Depth Reached.																	
		18																			
		19																			

NOTES: #Soil origin is "probable" unless otherwise stated. %Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

NOTES: ¹Soil origin is "probable" unless otherwise stated. ²Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Geo 305

OPERATOR: Ground Test (L. Cooper)

LOGGED: I. Howsam

METHOD: AD/T to 2.0 m, WB to 10.48 m, NMLC to 17.45 m

CASING: HWT to 3.2m

REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions



CORE PHOTO LOG

CLIENT:

Stockland Development Pty Limited

PROJECT:

Kogarah Golf Course Redevelopment

LOCATION:

Marsh Street, Arncliffe, NSW

SURFACE LEVEL:

1.3 AHD

COORDINATE:

E:329882.9, N:6242859.3

DATUM/GRID:

MGA2020 Zone 56

DIP/AZIMUTH:

90°/---°

LOCATION ID:

BH410

PROJECT No:

223528.01

DATE:

30/09/25

SHEET:

1 of 1



10.48-15.00 m depth



15.00-17.45 m depth

Appendix D

Results of Dissipation Tests

Project: PROPOSED COMMERCIAL-INDUSTRIAL DEVELOPMENT
Location: KOGARAH GOLF COURSE, COOKS COVE, ARNCLIFFE NSW

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50} , which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position

r: piezocone radius

I_r : stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).

t_{50} : time corresponding to 50% consolidation

Permeability estimates based on dissipation test

The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

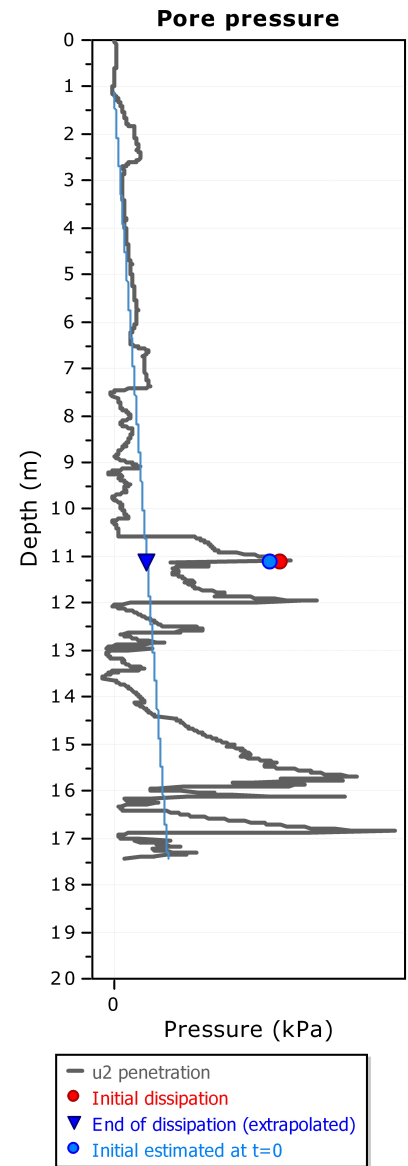
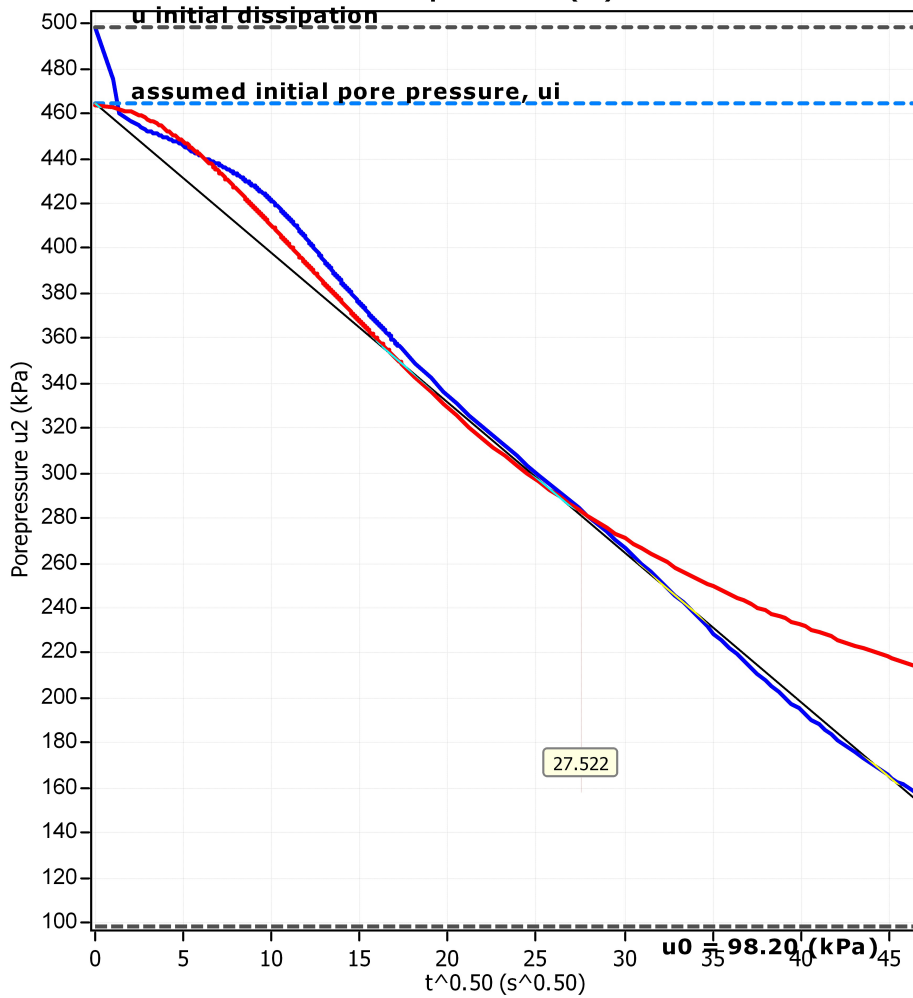
$$k_h = c_h \times \gamma_w / M$$

where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

Tabular results

CPTU Borehole	Depth (m)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/ S_u	c_h (m ² /s)	c_h (m ² /year)	M (MPa)	k_h (m/s)
CPT203	11.11	27.5	757	2.40E-005	485.37	3.45E-006	109	7.25	4.67E-009

Piezocone Dissipation Test: CPT203
Depth: 11.11 (m)



Project: PROPOSED COMMERCIAL-INDUSTRIAL DEVELOPMENT
Location: KOGARAH GOLF COURSE, COOKS COVE, ARNCLIFFE NSW

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50} , which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position

r: piezocone radius

I_r : stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).

t_{50} : time corresponding to 50% consolidation

Permeability estimates based on dissipation test

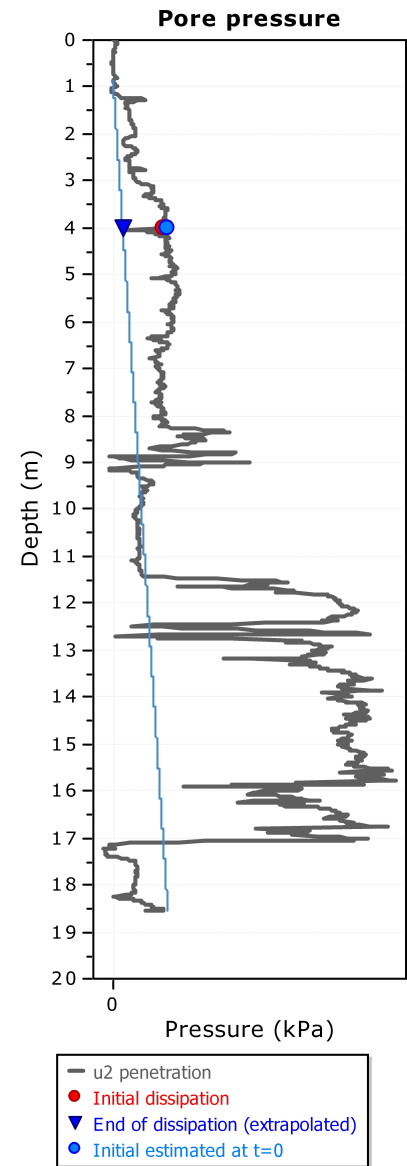
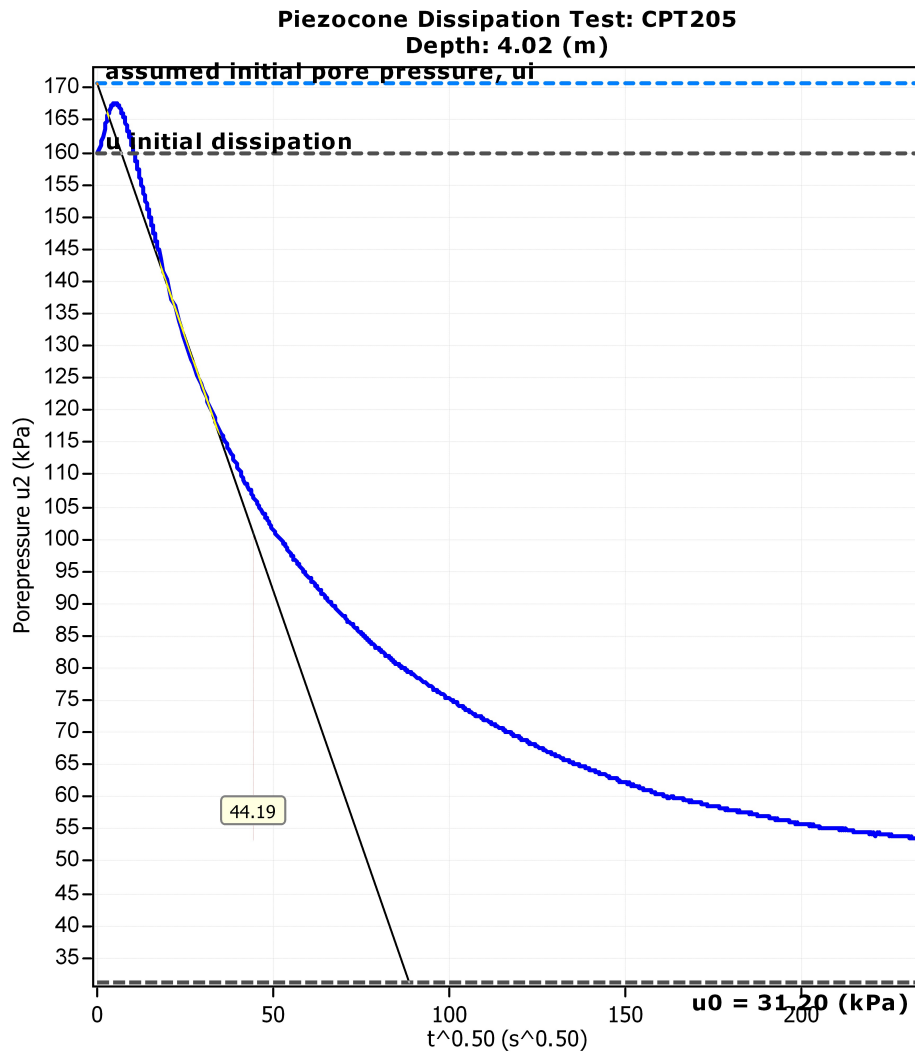
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

$$k_h = c_h \times \gamma_w / M$$

where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

Tabular results

CPTU Borehole	Depth (m)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/ S_u	c_h (m ² /s)	c_h (m ² /year)	M (MPa)	k_h (m/s)
CPT205	4.02	44.2	1953	6.19E-005	184.00	8.24E-007	26	2.30	3.51E-009



Project: PROPOSED COMMERCIAL-INDUSTRIAL DEVELOPMENT
Location: KOGARAH GOLF COURSE, COOKS COVE, ARNCLIFFE NSW

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50} , which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position

r: piezocone radius

I_r : stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).

t_{50} : time corresponding to 50% consolidation

Permeability estimates based on dissipation test

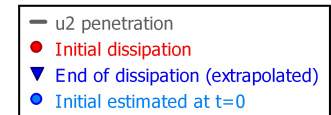
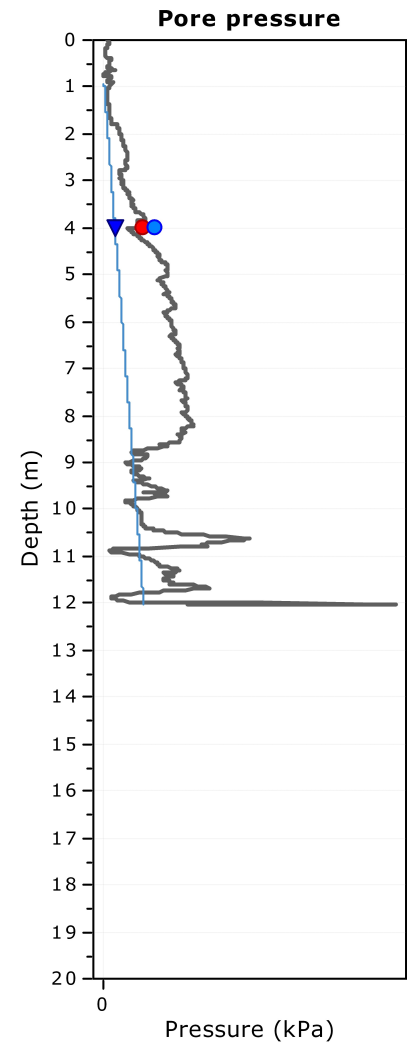
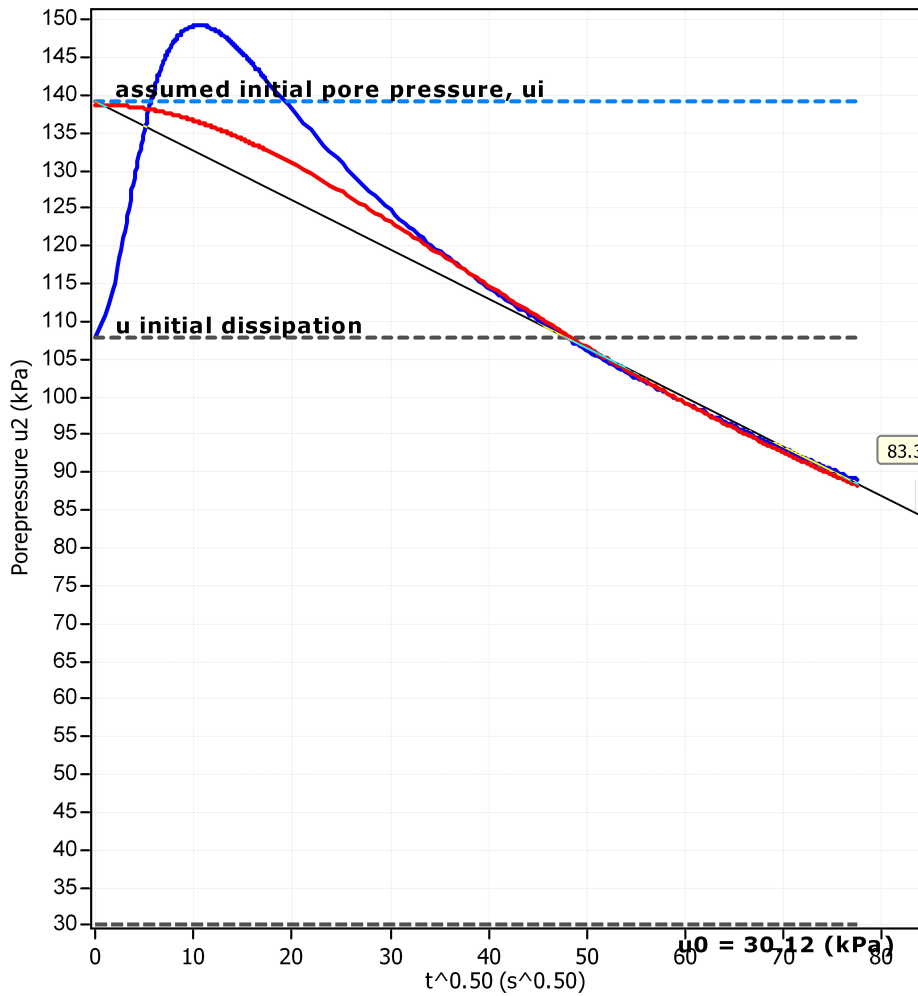
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

$$k_h = c_h \times \gamma_w / M$$

where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

Tabular results

CPTU Borehole	Depth (m)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/ S_u	c_h (m ² /s)	c_h (m ² /year)	M (MPa)	k_h (m/s)
CPT207	4.00	83.4	6953	2.20E-004	539.62	3.96E-007	12	3.58	1.09E-009

Piezocene Dissipation Test: CPT207
Depth: 4.00 (m)

Appendix E

Indicative Ground Improvement Scheme by
Menard



Cooks Cove

Philippe Vincent
Managing Director



Gary Webley
Operations Manager



Alex Hubaut
Design Manager



Jonathan Hale
MP BD Manager



Tin Le
Central Region
Manager



Adnan Sahyouni
Technical BD



Confidential Information

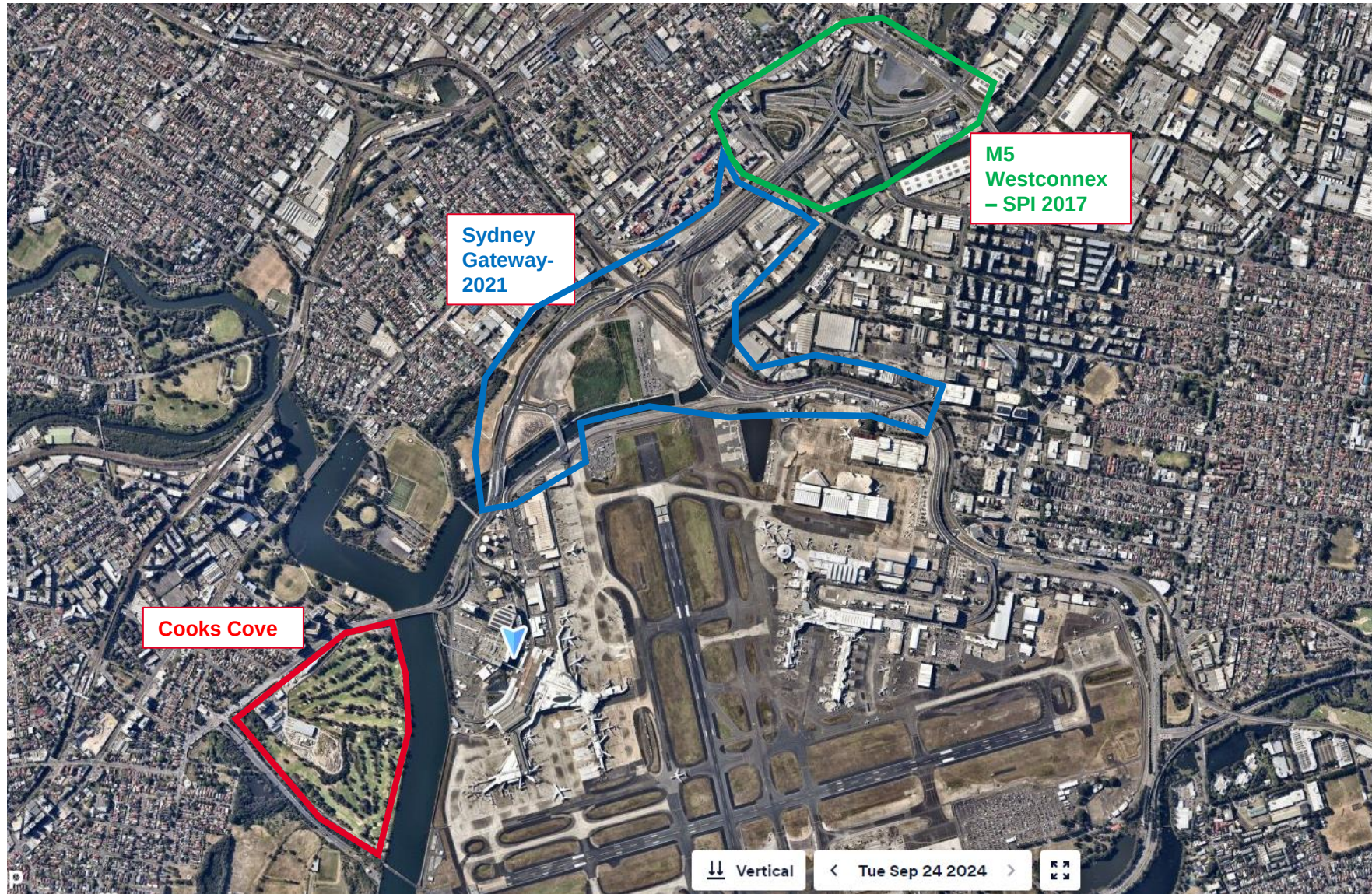




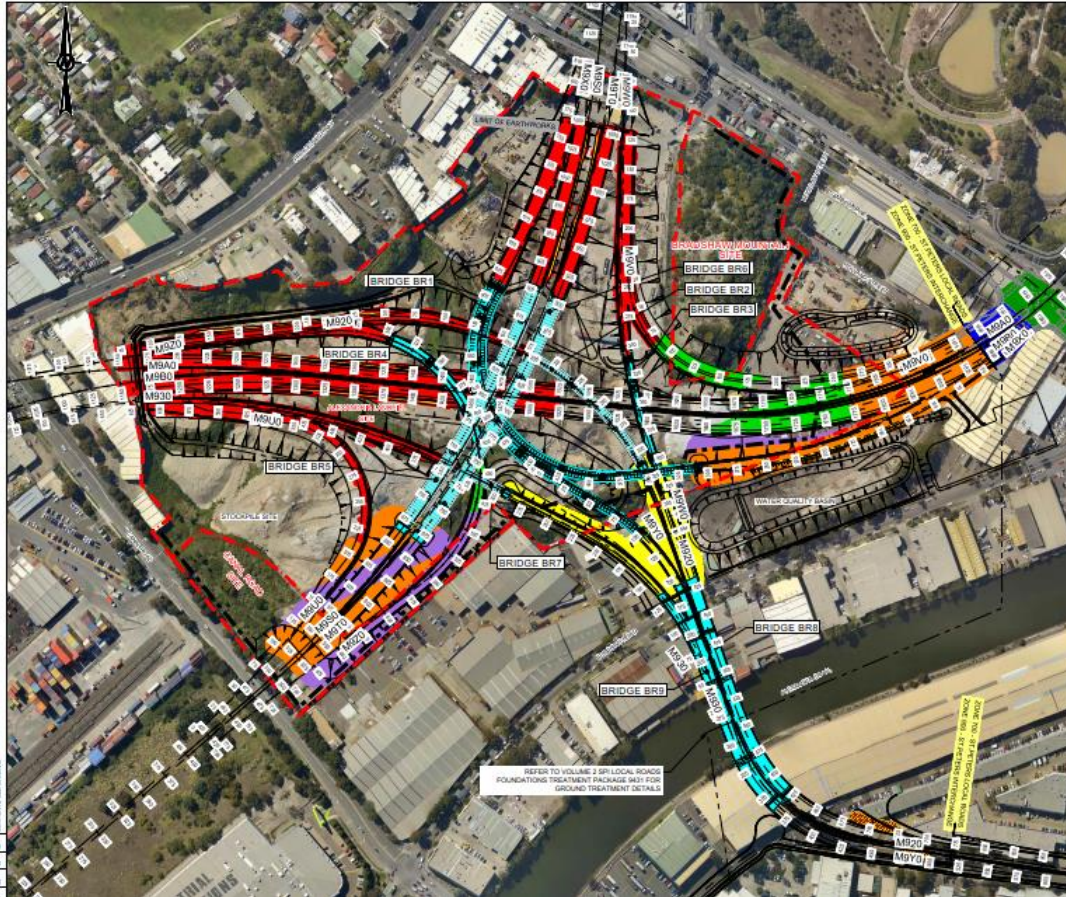
01 Desalination Pipeline interface

References

● Menard Nearby Projects

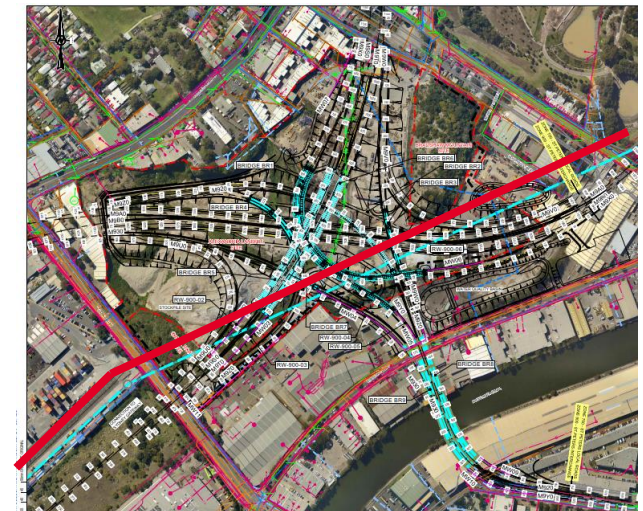


● M5 Westconnex – SPI 2017

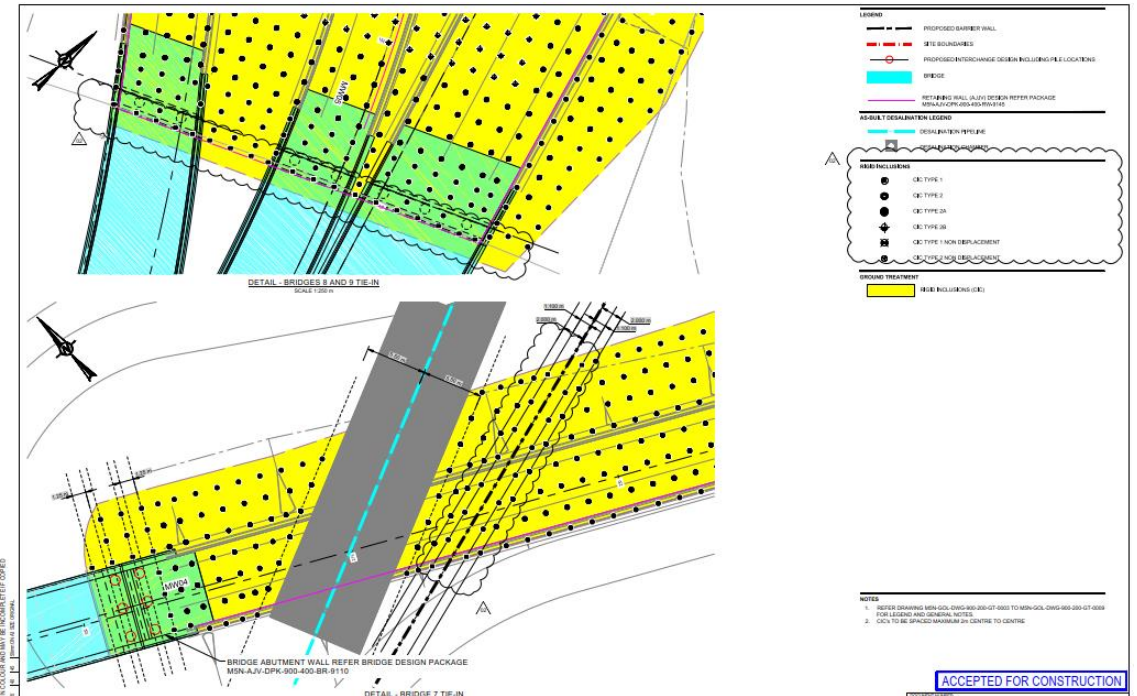
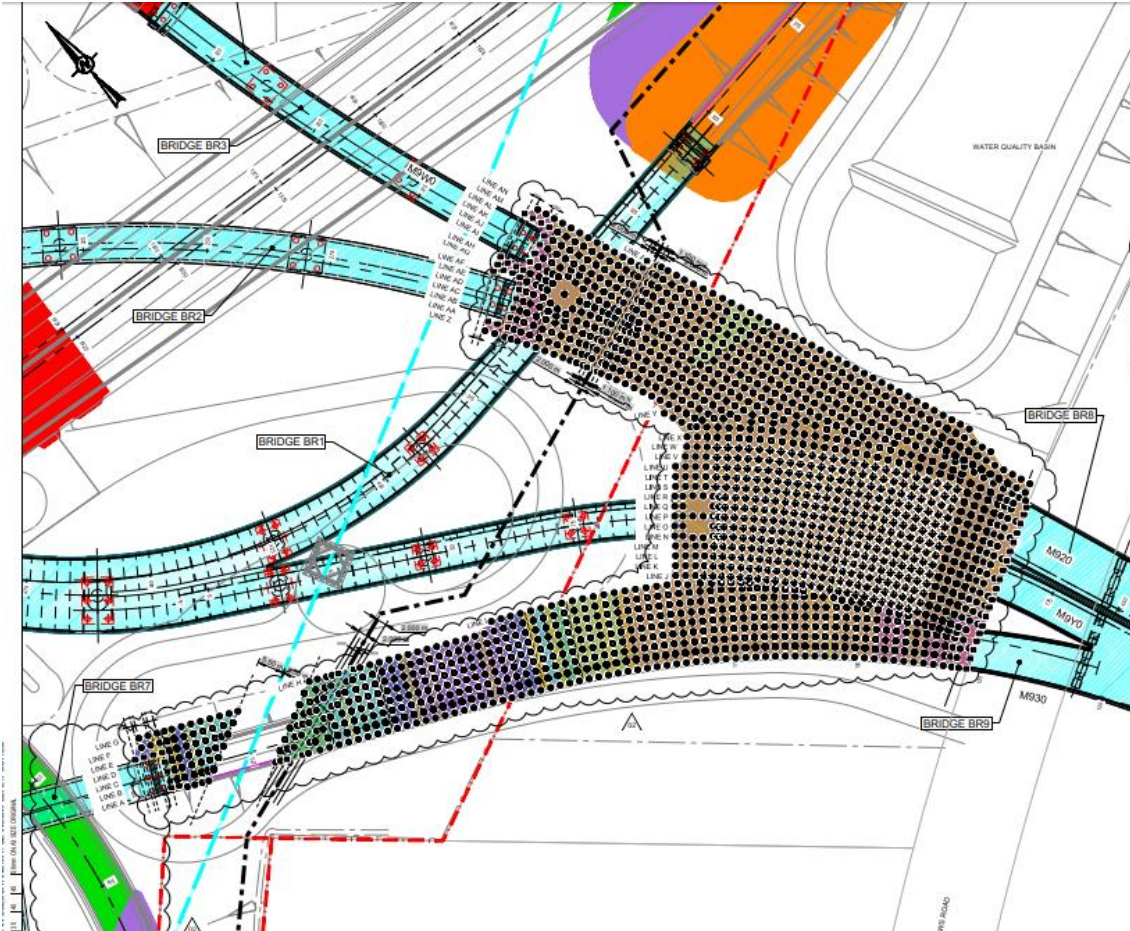


- + Controlled Modulus Columns - CMC
- + Rapid Impact Compaction
- + Rapid Impact Compaction + Surcharge

Desalination Pipe (in red) running across the site

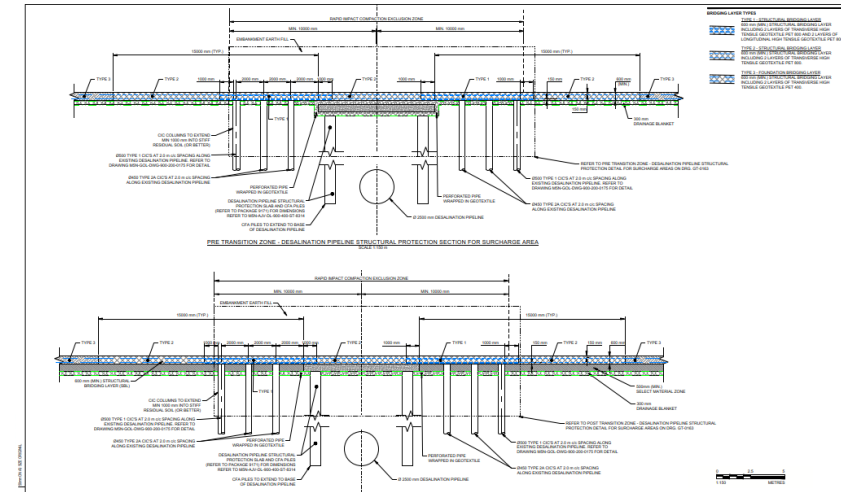
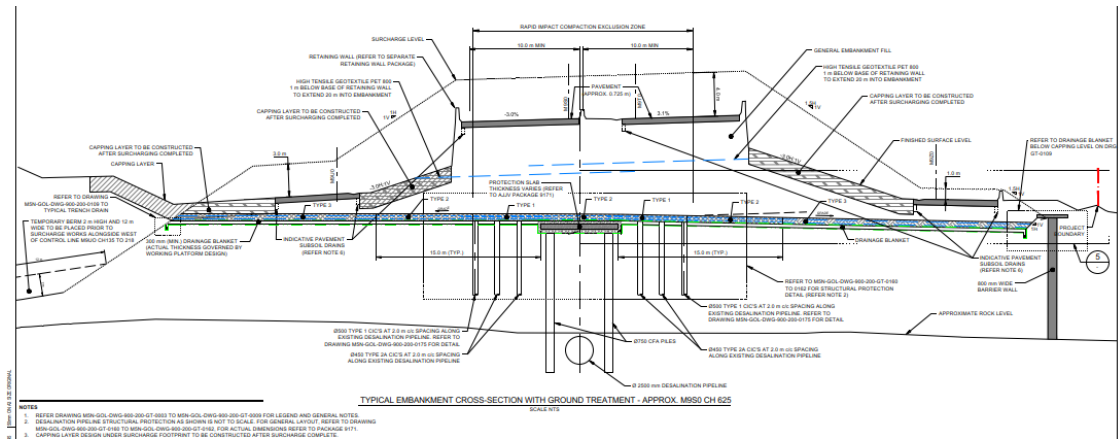
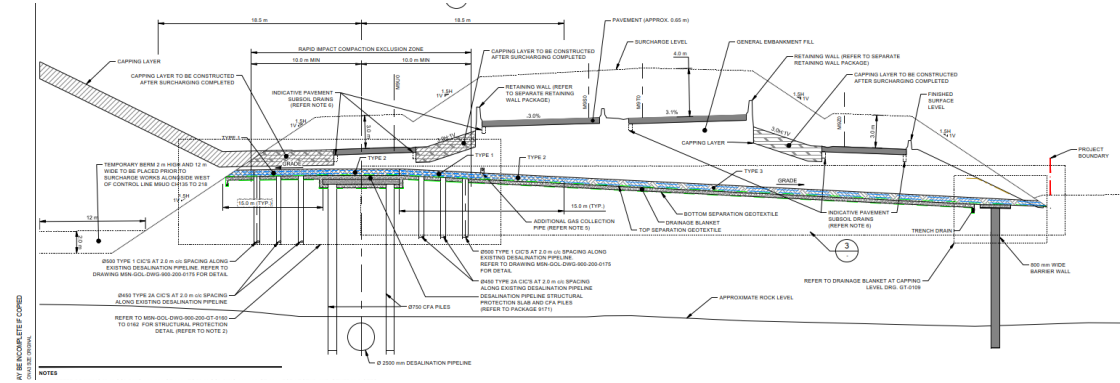


● M5 Westconnex – SPI 2017

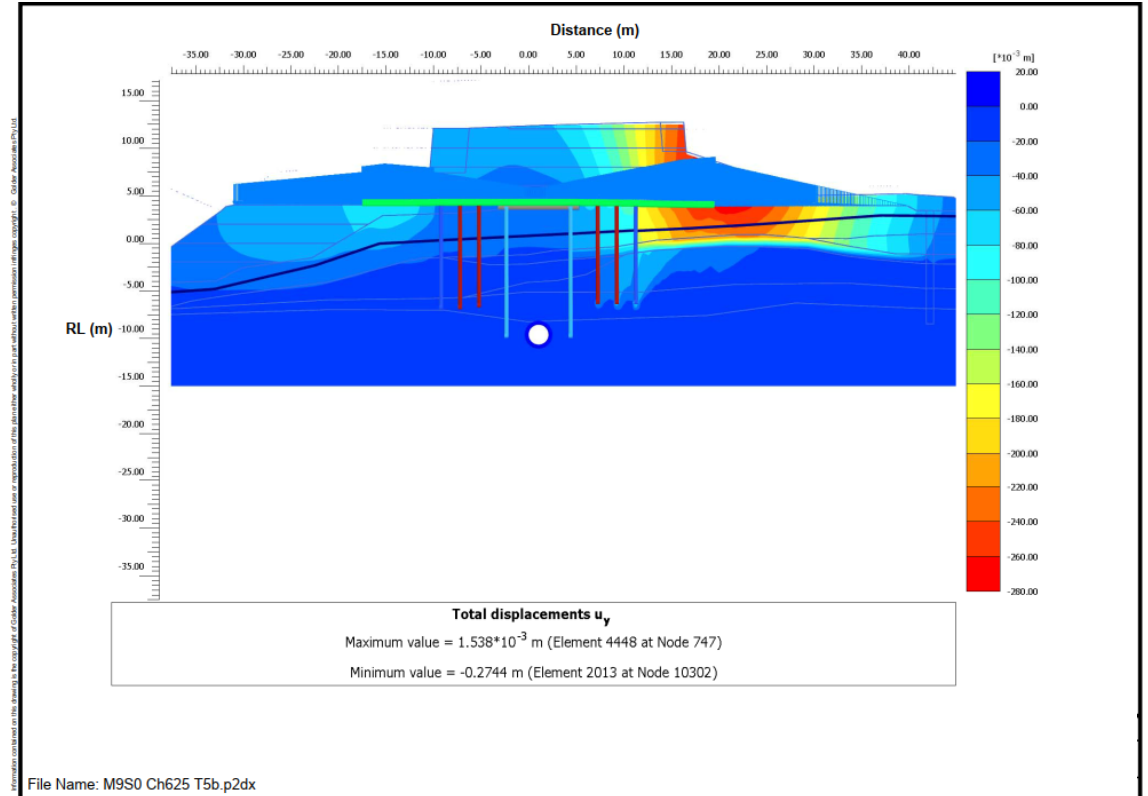
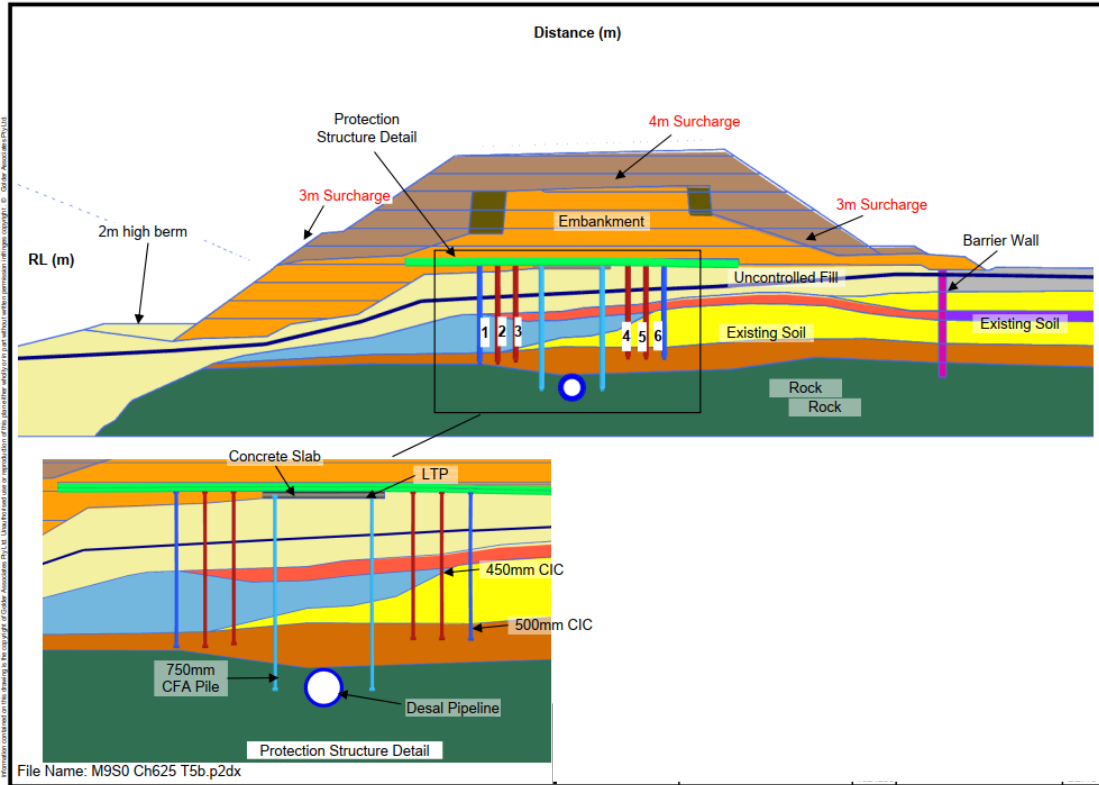


Part of the CMC installed

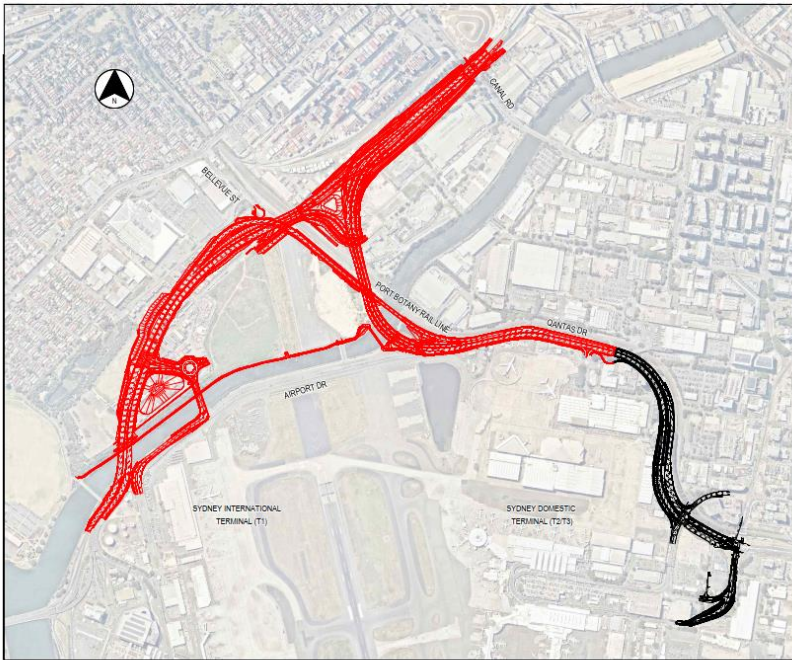
- **M5: Desalination Pipe (Bridging Design)**



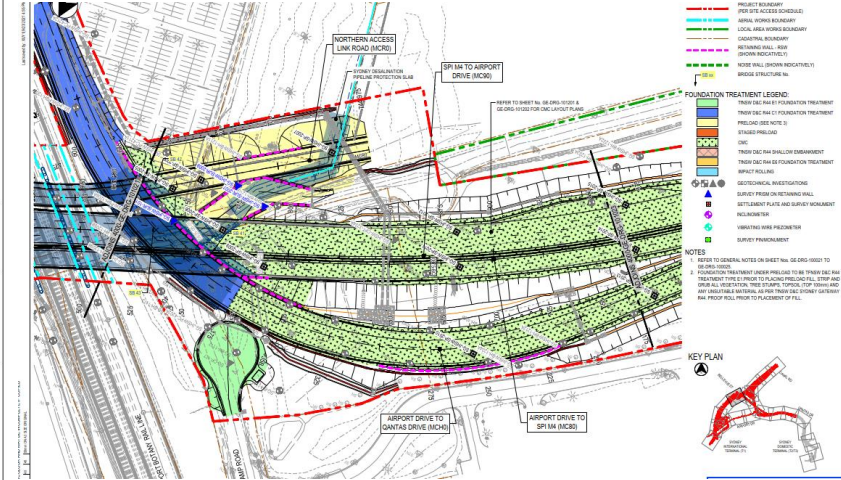
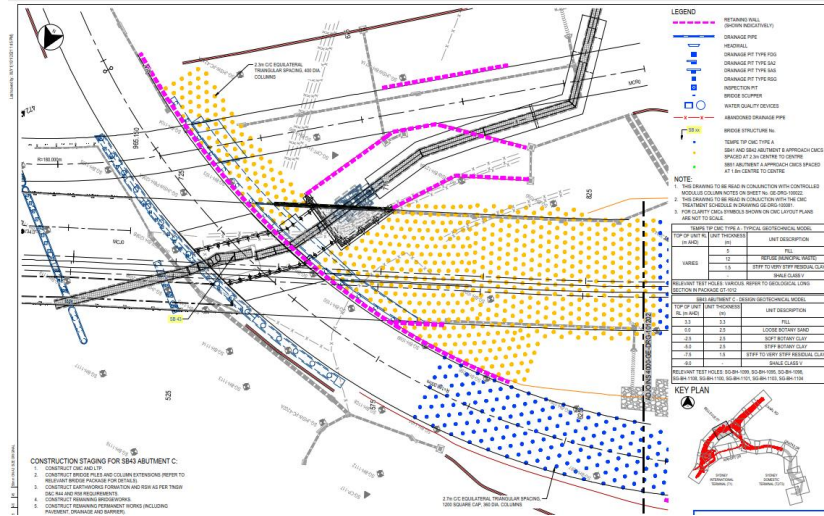
● M5: Desalination Pipe (Bridging Design)



- **Sydney Gateway (CMC + MSM)**



LOCALITY PLAN
NTS



Ground Improvement next to the Desalination Pipe



Desalination Pipe Monitoring

72	DCD	R.Karamihas	Sydney Desal	15/03/2021	3.4.5 Table 15	Reference to <u>Desalination</u> line in Table 15 is incomplete. It only discusses the pipe along the ATL path (above ground section of pipe). Update to include the full extent of the interface			Noted. Table 15 to be updated to include extent of <u>Desalination</u> Pipe interface with remaining project alignment at SDD	KL	C	Review at SDD	
73	DCD	R.Karamihas	Sydney Desal	15/03/2021	3.5.4.3	Detailed assessment to be undertaken at the SSD stage. How will that be presented? How will asset owners be engaged? 09/07/21: JHSW to present design.			Impact on adjacent <u>Desalination</u> Pipe shall be detailed in the report and presented on settlement contour plans developed from Commercially available RocScience Settle3D software. Additional finite element analysis (via PLAXIS 2D Software) will be carried out at critical sections (namely where embankment heights are greatest and/or where desal pipe line is closest to fill formations) 14/7 - Workshop arranged with SDP (KBR) on 29/7 to discuss report contents and SDP/KBR queries	KL	C	Review at SDD. Discuss with SDP need to bring in assessment by KBR 9/7 JHSW to present design 29/7/21 design presented by JHSW	
74	DCD	R.Karamihas	Sydney Desal	15/03/2021	4.2.4	Please clarify which design package protection slabs will be covered			Protection slabs are detailed in package MS-1625	KL	C	Noted	

REVIEWER						DESIGNER				REVIEWER			
Item	Stage	Reviewer	Organisation	Date	Document Reference	Reviewer Comments	Project Deed Ref.	Compliance Status	Comment Response	By	Response # Status	Close-out Response	New Comment
75	DCD	R.Karamihas	Sydney Desal	15/03/2021	3.9	What is the plan for instrumentation and monitoring in relation to the <u>desalination</u> pipeline and structures? How are the monitor and trigger levels determined? 09/07/21: JHSW designers to present the report.			Ground Movement Impact Assessment (GMIA) to be presented at SDD demonstrates negligible load conditions and movement imposed on adjacent buried above ground <u>Desalination</u> Pipe line. As such no monitoring is proposed. 14/7 - Workshop arranged with SDP (KBR) on 29/7 to discuss report contents and SDP/KBR queries	KL	C	Discuss with SDP 9/7 JHSW designers to present the report 29/7/21 design presented by JHSW	
	DCD	R.Karamihas	Sydney Desal	15/03/2021	4.1 Table 20 Utilities	For northern lands and interchange no limits for settlement of <u>desalination</u> pipe have yet been established. 09/07/21: JHSW designers to present the report.			Due to the depth and offsets from the project works there are negligible impacts on the <u>desalination</u> pipe due to the project works. Hence no specific monitoring/settlement limits are proposed. 14/7 - Workshop arranged with SDP (KBR) on 29/7 to discuss report contents and SDP/KBR queries		C	Discuss with SDP 9/7 JHSW designers to present the report 29/7/21 design presented by JHSW	
76	DCD	R.Karamihas	Sydney Desal	15/03/2021	5.1	Please confirm SDP and its operator/ops are to be included in CHAIR 2 and CHAIR 3. 09/07/21: JHSW designers to present the report.			As discussed in the SDP design coordination meeting on the 19/3/21, JHSW has held the Chair 2 SID workshop. JHSW will share the outcomes of the workshop with SDP, and invite SDP to the Chair 3 SID workshop.		C	Noted	
77	DCD	R.Karamihas	Sydney Desal	15/03/2021	7.2 table 25	In regards to settlement impacts along northern lands, assessment is also required for impacts on <u>desalination</u> pipeline. 09/07/21: JHSW designers to present the report.			Noted. Impacts on <u>desalination</u> pipe within Northern Lands to be discussed at SDD. 14/7 - Workshop arranged with SDP (KBR) on 29/7 to discuss report contents and SDP/KBR queries	KL	CS	Noted 9/7 JHSW designers to present the report 29/7/21 design presented by JHSW	
78	DCD	R.Karamihas	Sydney Desal	15/03/2021	7.2 table 25	In regards to settlement impacts along northern lands, assessment is also required for impacts on <u>desalination</u> pipeline. 09/07/21: JHSW designers to present the report.			Noted. Impacts on <u>desalination</u> pipe within Northern Lands to be discussed at SDD. 14/7 - Workshop arranged with SDP (KBR) on 29/7 to discuss report contents and SDP/KBR queries				

6.7.5. Desalination Pipeline

A GMIA has been undertaken for the desalination pipeline adjacent to the Stage 1 works, between the Port Botany Rail Line and Canal Road. The 100 year settlement profile at the depth of the pipe crown (approximately RL - 7.0 mAHd) is shown in Figure 25 for this section. To assess bending stresses in the pipe induced by ground movements, it is assumed ground movements are mirrored in the pipe. The pipeline chainage shown in the plots is the pipeline chainage in SDP drawings WMKE1-SS-2001 to 2003.

The Sydney Desalination Pipeline (SDP) Interface Agreement states the limiting allowable bending stress is limited by the concrete lining (typically 80 MPa) (Schedule 3 Item 3). Hence, if the pipe bending stresses due to embankment construction are less than 80 MPa, pipeline stresses are within allowable limits and there are no adverse load effects on the pipeline.

The settlement profile was used to assess the bending stress in the pipe. To calculate bending stress, firstly bending strains are needed to be calculated from the settlement profile.

Bending strain increase for each pipe length was calculated using the following equation:

$$\epsilon_b = \kappa R$$

Where:

ϵ_b = bending strain

R = pipe external radius (m)

κ = curvature

Bending stress at any point along the pipeline can be then calculated by the following equation:

$$M_b = E_{pipe} \epsilon_b$$

The following pipe parameters have been adopted in the assessment:

- Type: Circular
- Internal Diameter: 1800 mm
- Outer Diameter: 1824 mm
- Wall Thickness: 12 mm
- Young's Modulus, E_{pipe} : 200 GPa

The maximum bending stress induced in the pipe due to the settlement profile is 7.8 MPa, which is significantly under the allowable bending stress of 80 MPa. The settlement profile and calculated bending stress in the pipe are presented in Figure 25.

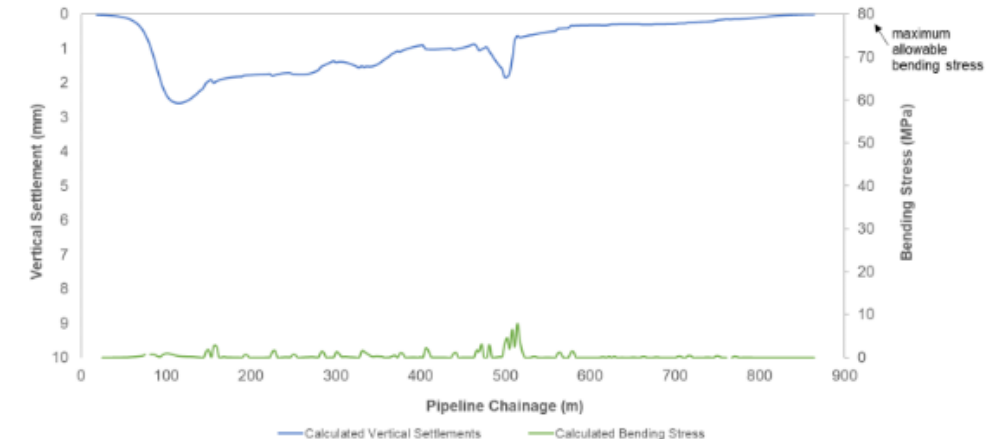


Figure 25: Predicted 100 year settlements and calculated bending stress along the Desalination Pipeline between the Port Botany Rail Line and Canal Road.

For the section of pipeline on the southern side of the Port Botany Rail Line, protection structures are proposed where the project works are being constructed over the pipeline. Desalination Pipe Protection Slab details are covered in design package no. MS-1625.

For the section of pipeline adjacent to the canal, the pipeline is above ground and founded on piles. The bridge abutments and embankments for SB51 and SB61 are founded piles and CMCs respectively. The bridge and embankment loads will be transferred to founding material at depth. As such, it is expected these works to have negligible impact on the pipeline.

An aerial architectural rendering of a large-scale development named 'Cooks Cove'. The main feature is a long, multi-story building with a series of interconnected, curved sections and a flat roof with visible structural ribs. To the left of this main building is a smaller, more compact structure. To the right, there's another large building with a similar curved design. The entire development is situated along a dark, winding body of water. The surrounding area includes landscaped grounds with numerous trees, pedestrian paths, and some smaller, more traditional buildings in the distance. The overall style is modern and urban.

02 Cooks Cove

Design & Construct CMC Solution

Available Geotechnical Information

LEGEND:

LEVELS DATUMS AND

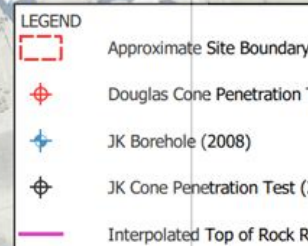
- DENOTES GROUND IMPROVEMENT
- DENOTES GROUND IMPROVEMENT
- DENOTES GROUND IMPROVEMENT



LEGEND

- Approximate Site Boundary
- Douglas Cone Penetration Test (2024)
- JK Borehole (2008)
- JK Cone Penetration Test (2008)
- Interpreted Geotechnical Cross Section

REV	DESCRIPTION/COMMENT	DATE	DRAWN BY
0	INITIAL ISSUE	04.10.2024	EC
SCALE: 0 50 100 150 200 m			
1:4000 @ A3			



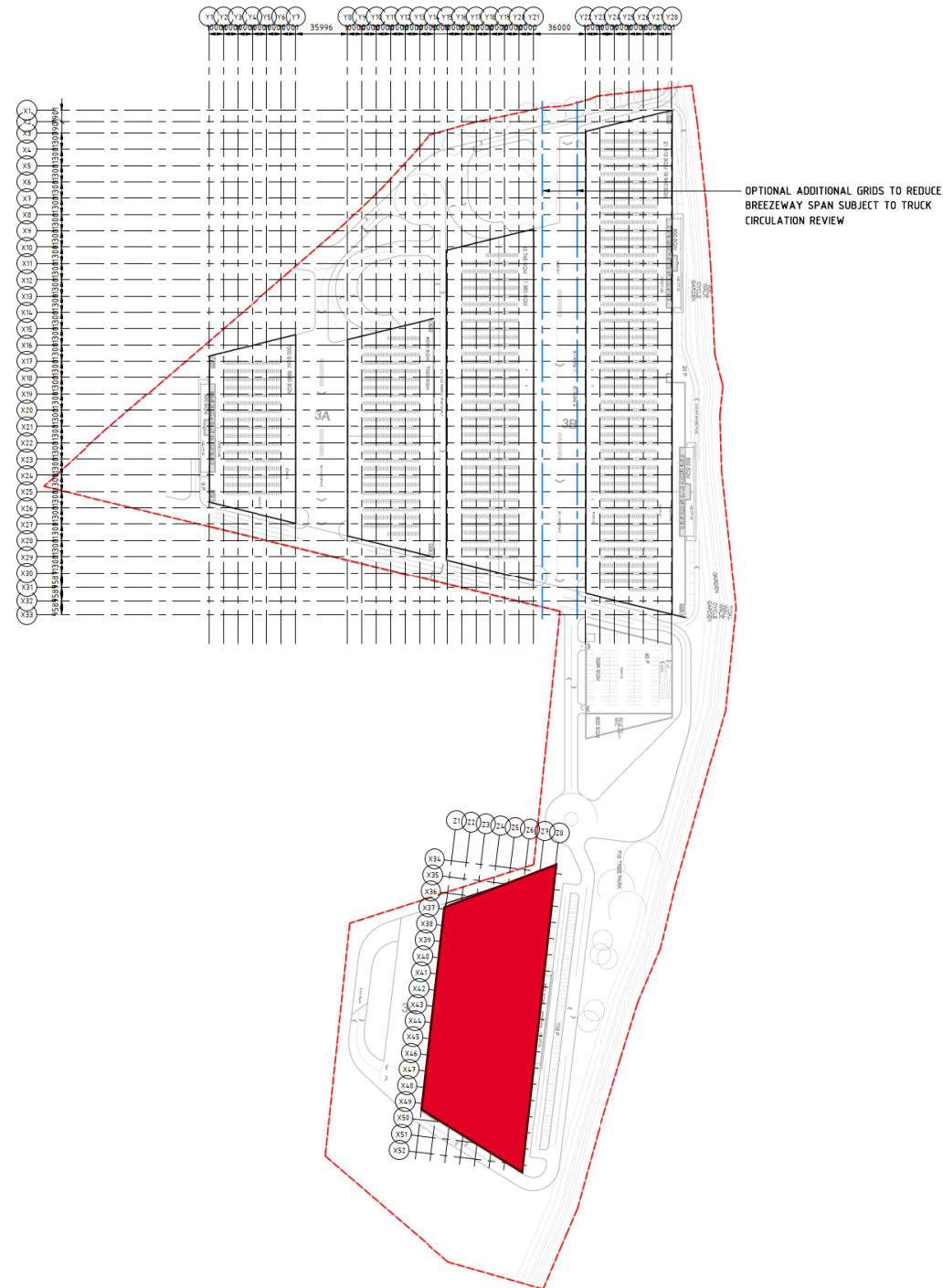


menARD

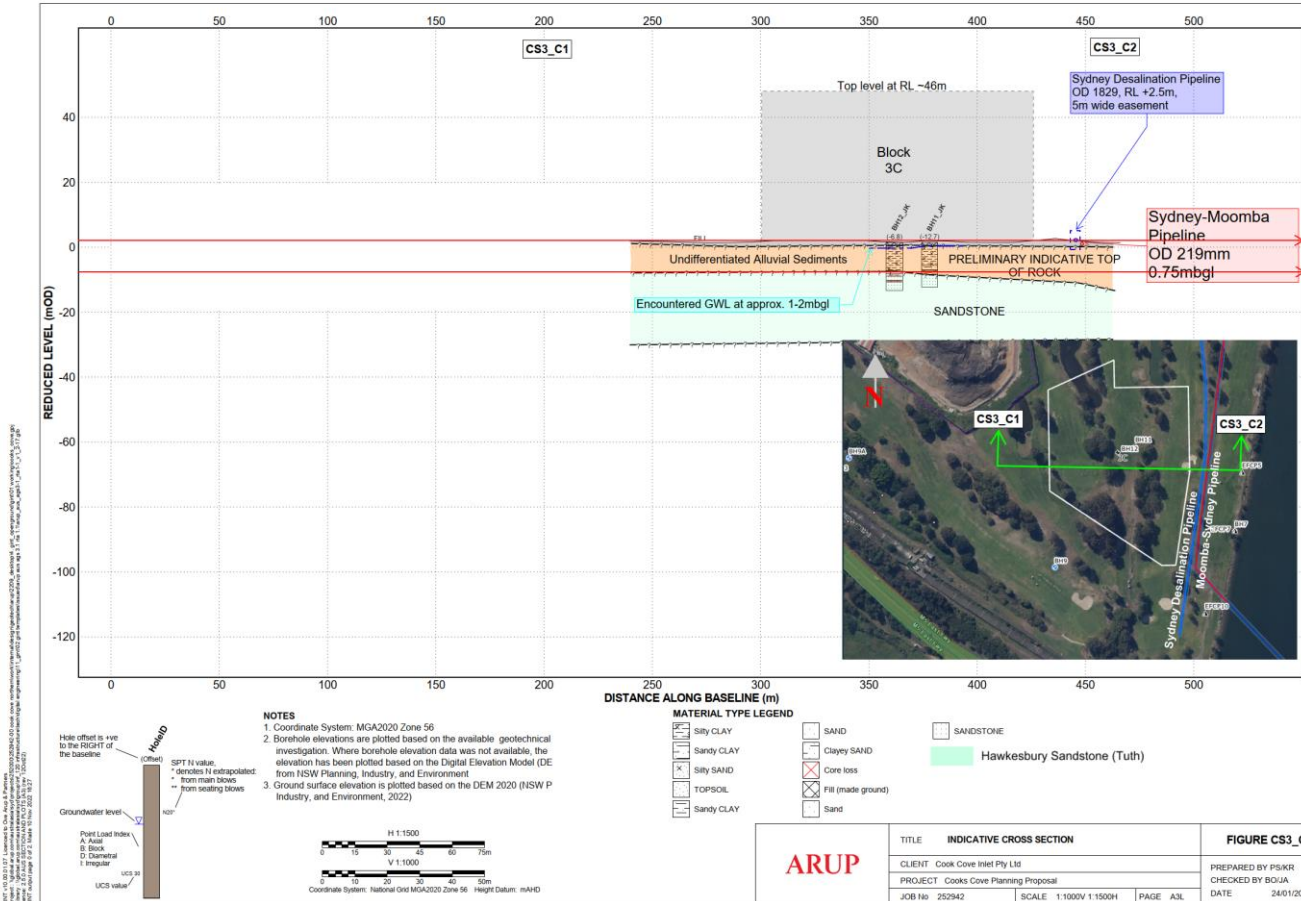
Building 3C

~13068 m²

CMC



● Building 3C

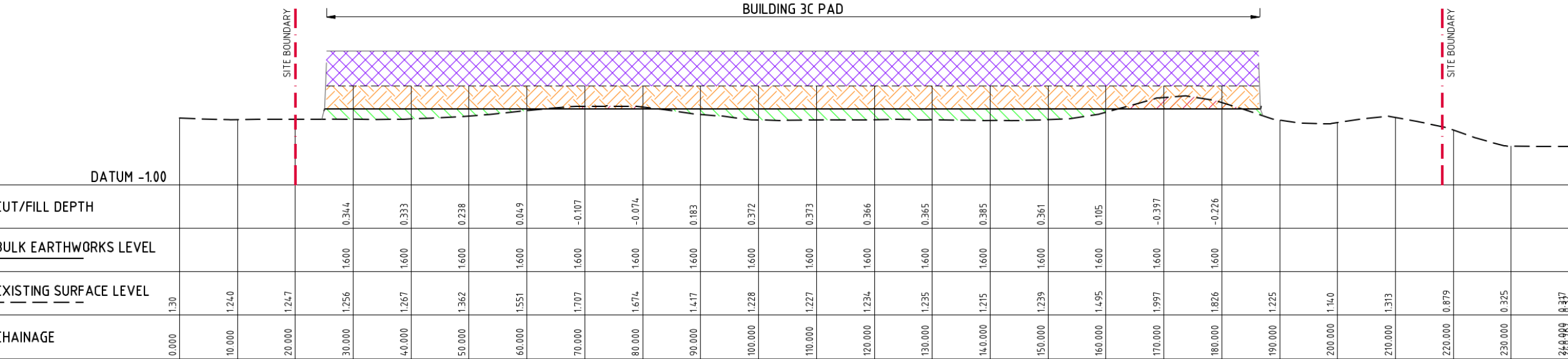
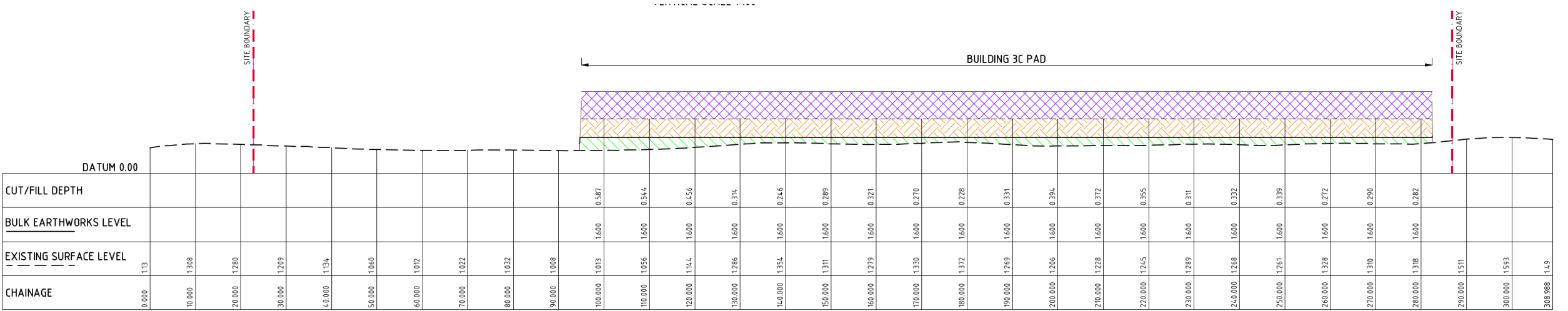


The desalination pipeline next to Building 3C is relatively shallow compared to other sections of the pipeline across the site.

Its design is currently outside the scope of our work.

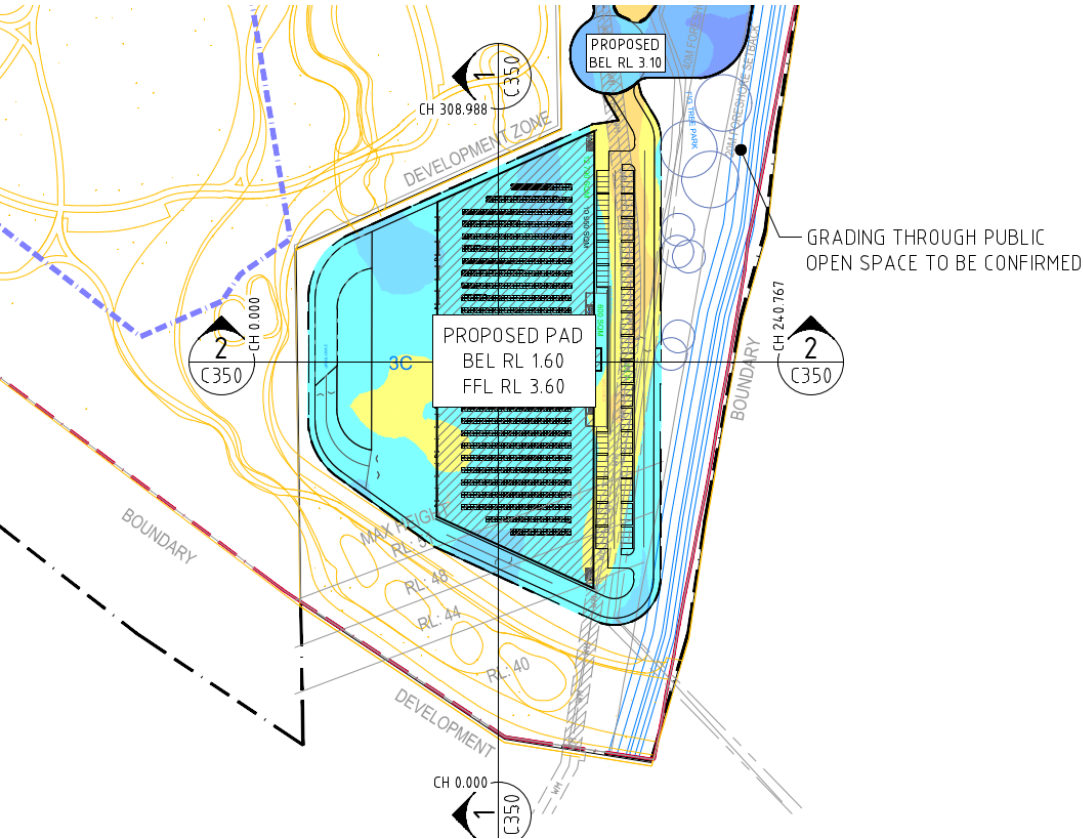
Indicative top Rock level below Building 3C is **~10m**.
However, other CPTs indicate a deeper Rock level.

● 3C: Earthwork Sections



SECTION 2

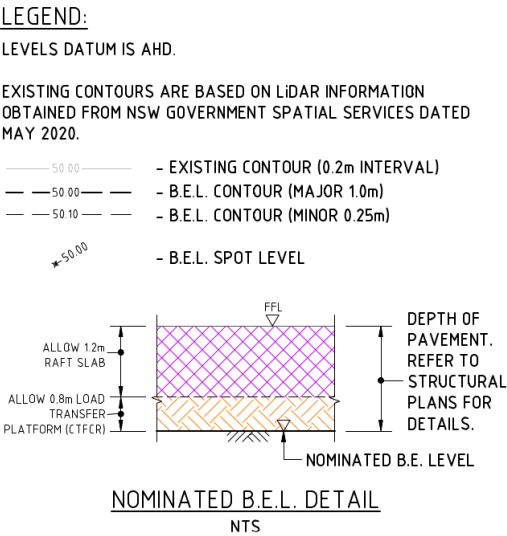
3C: Cut & Fill



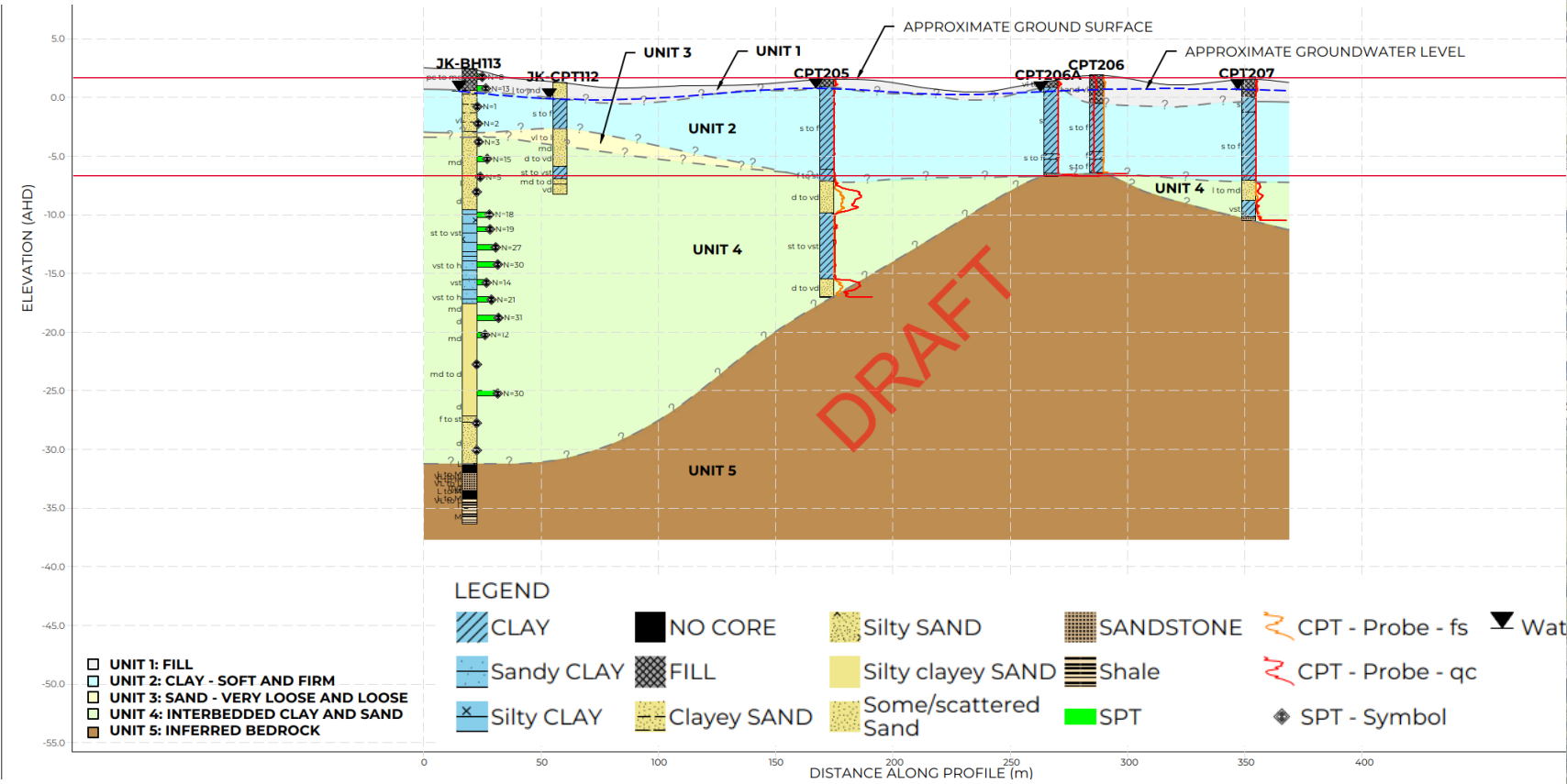
DEPTH RANGE			
No.	FROM DEPTH	TO DEPTH	COLOUR
1	-4.500	-4.000	
2	-4.000	-3.500	
3	-3.500	-3.000	
4	-3.000	-2.500	
5	-2.500	-2.000	
6	-2.000	-1.500	
7	-1.500	-1.000	
8	-1.000	-0.500	
9	-0.500	0.000	
10	0.000	0.500	
11	0.500	1.000	
12	1.000	1.500	
13	1.500	2.000	
14	2.000	2.500	
15	2.500	3.000	

Fill is expected to range between 0.5m to 1m.

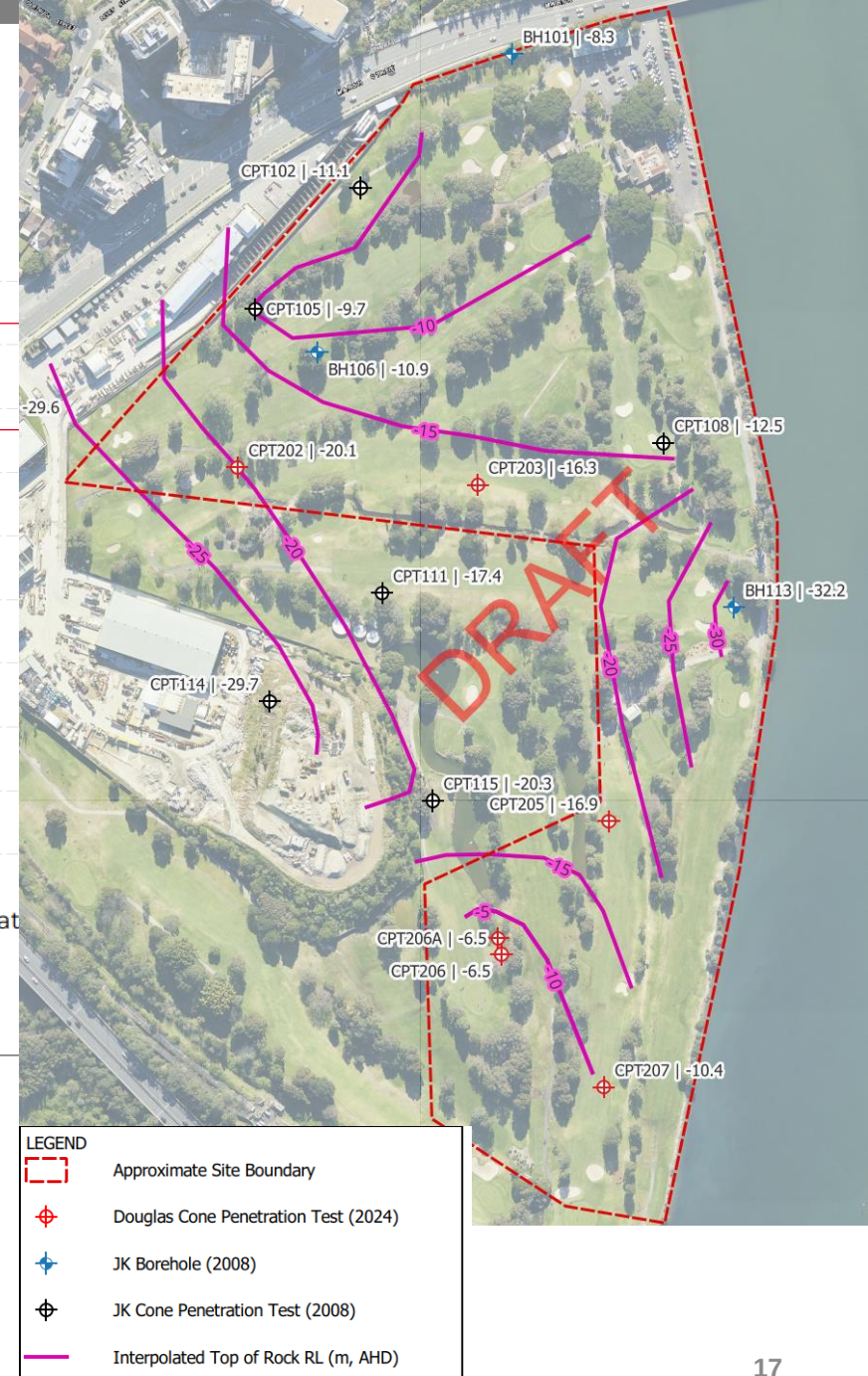
Cut is expected to be in the range of 0.5m to 1m next to the desalination pipe

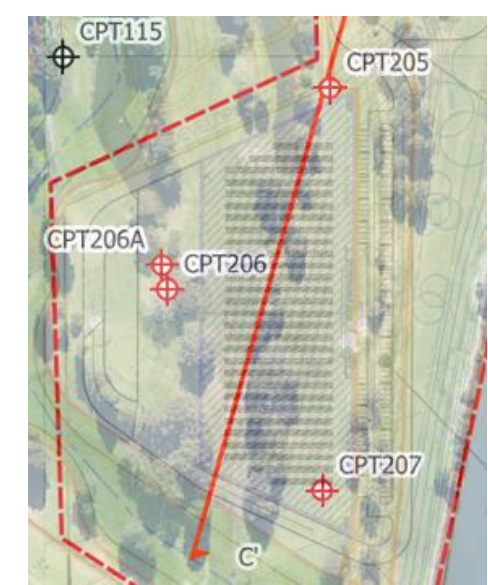
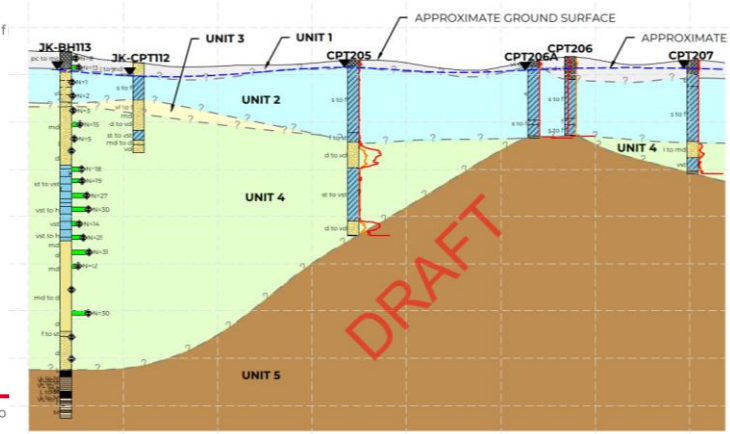
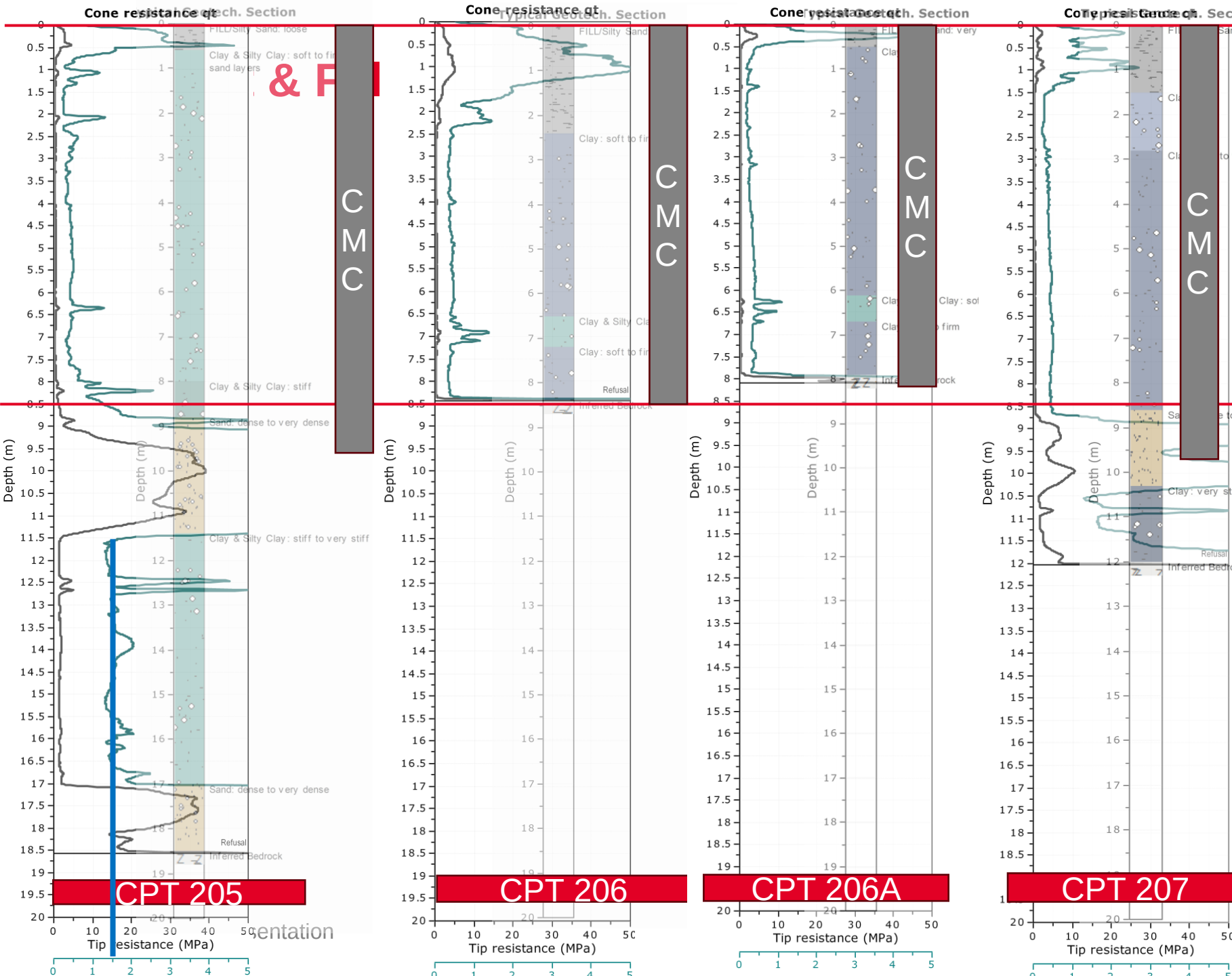


3C: Cut & Fill

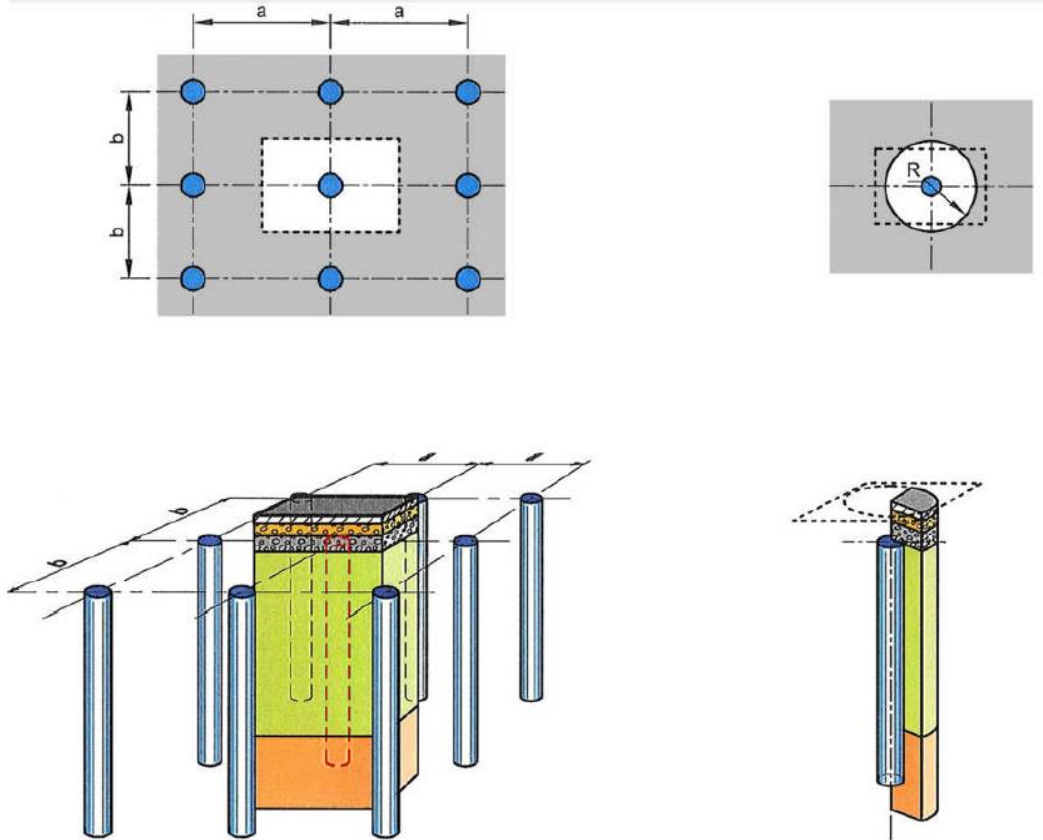


CMC length ~ 9m
GWT ~ 1m BGL





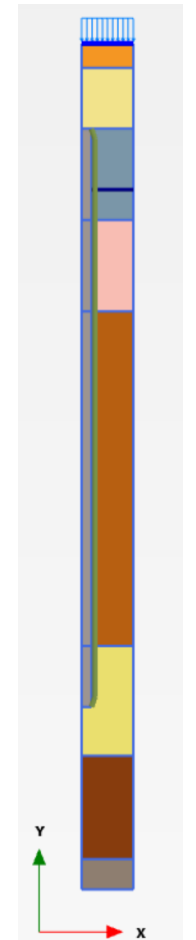
● Prelim Analysis (Profile A & B)



- ⊕ Analyses: Drained
- ⊕ Vertical load: 150 kPa
- ⊕ Diameter: $\varnothing 320\text{mm}$



Profile A

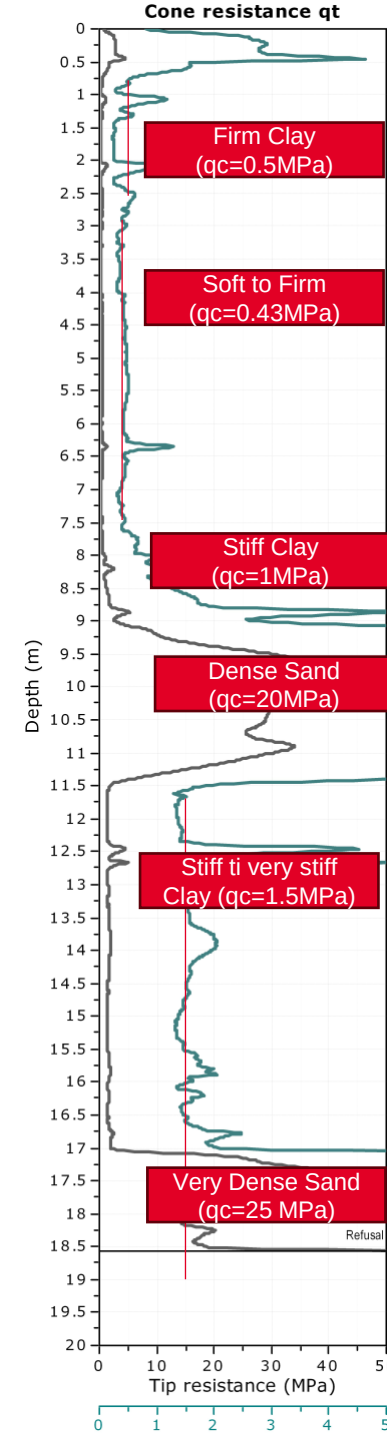


Profile B

● Geotechnical Model (CPT 205), Profile A

Unit	RL Top (m AHD)	Depth Top(m AHD)	γ_{sat} [kN/m^3]	ν [—]	E [MPa]	c [kPa]	ϕ [deg]	k (m/s)
Fill (Loose Sand)	1.6	0	19	0.3	120	0	38	Default
Firm Clay		0.7	18	0.3	5	4	20	10-9
Soft to Firm Clay		2.5	17	0.3	4	3	20	10-9
Stiff Clay		8	18	0.3	15	7	25	10-7
Dense Sand		8.7	19	0.3	75	0	37	Default
Stiff to very stiff		11.5	19	0.25	23	10	25	10-7
Dense Sand		17	19	0.3	75	0	37	Default
Rock		18.5	23	0.25	110	20	35	Default

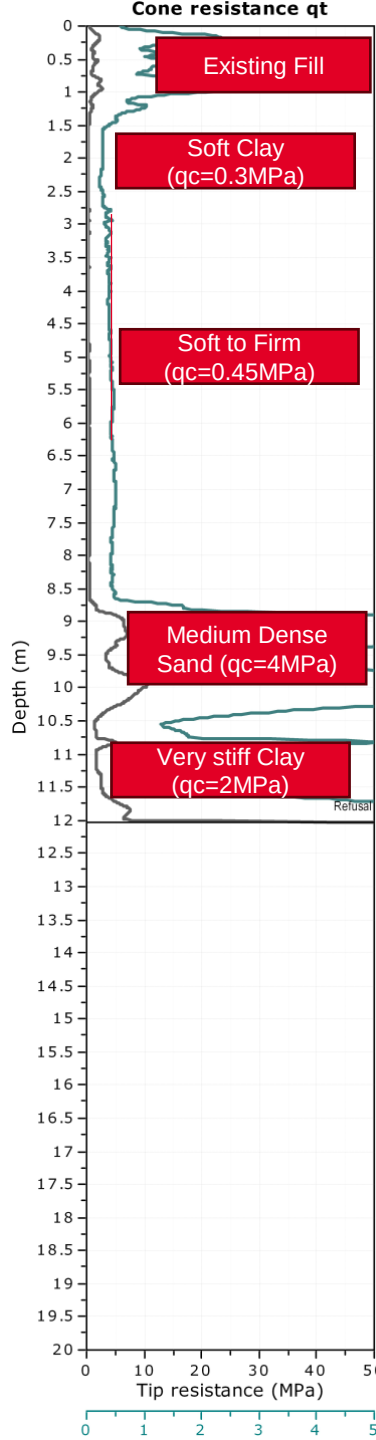
Additional Fill of 0.8m & LTP of 0.4m are assumed in the modelling of Building C, Profile A.



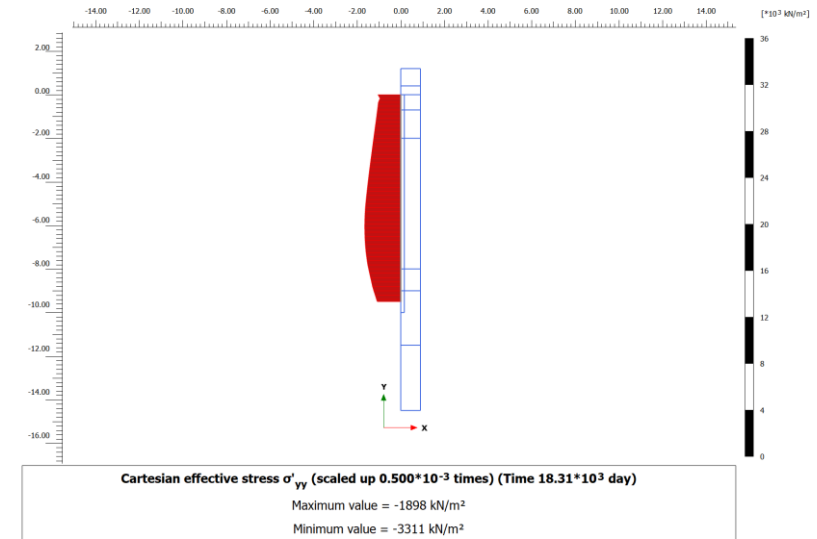
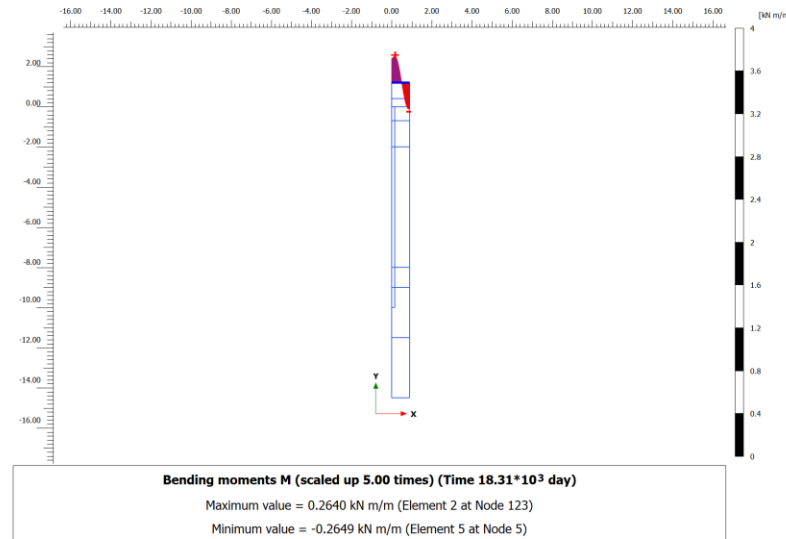
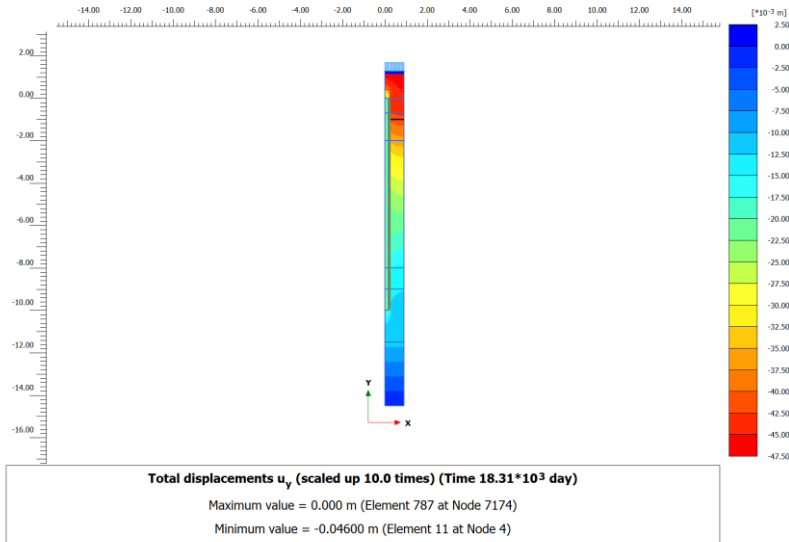
● Geotechnical Model (CPT 207), Profile B

Unit	RL Top (m AHD)	Depth Top(m AHD)	γ_{sat} [kN/m ³]	ν [—]	E [MPa]	c [kPa]	ϕ [deg]	k(m/s)
Fill (Loose Sand)	1.4	0	19	0.3	120	0	38	Default
Soft Clay		1.2	17	0.3	3	2	20	10-9
Soft to Firm Clay		3	18	0.3	4	4	20	10-8
Medium Dense Sand		8.5	18	0.3	35	0	33	Default
Very Stiff Clay		10.3	19	0.25	27	10	25	10-7
Rock		12	23	0.25	110	20	35	Default

Additional Fill of 0.8m & LTP of 0.4m are assumed in the modelling of Building C, Profile B

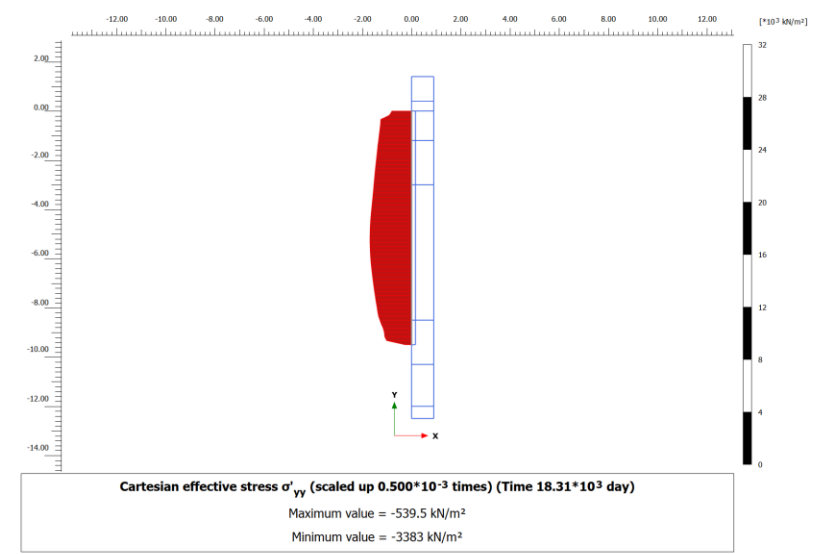
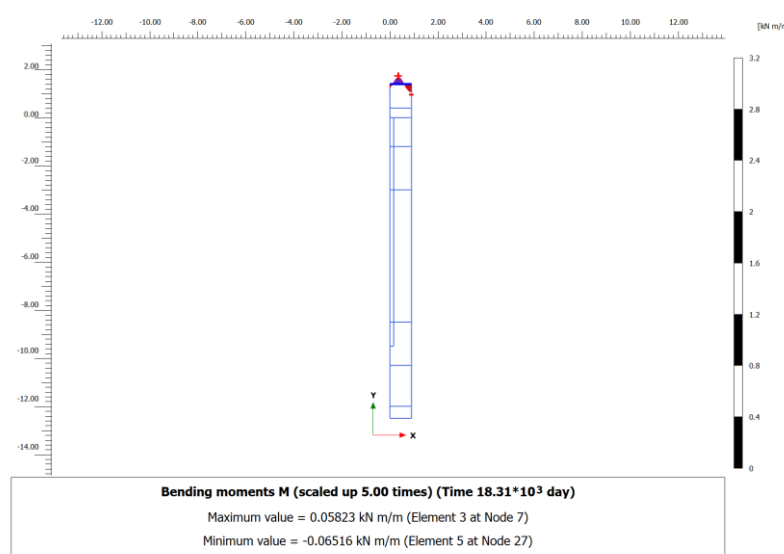
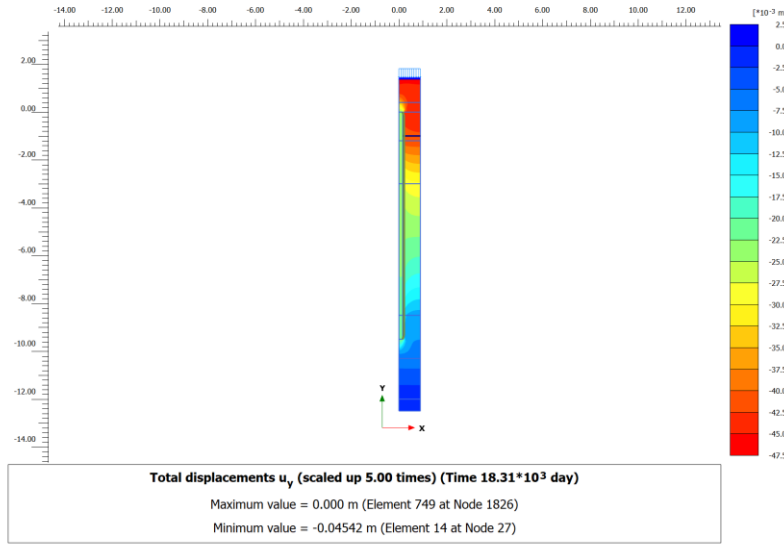


● Prelim Analysis (Profile A), Total Load of 100 kPa



- + CMCs are anchored in MD Sand, ~ 9m length
- + 1.6m c/c, Ø320
- + LTP 0.4m

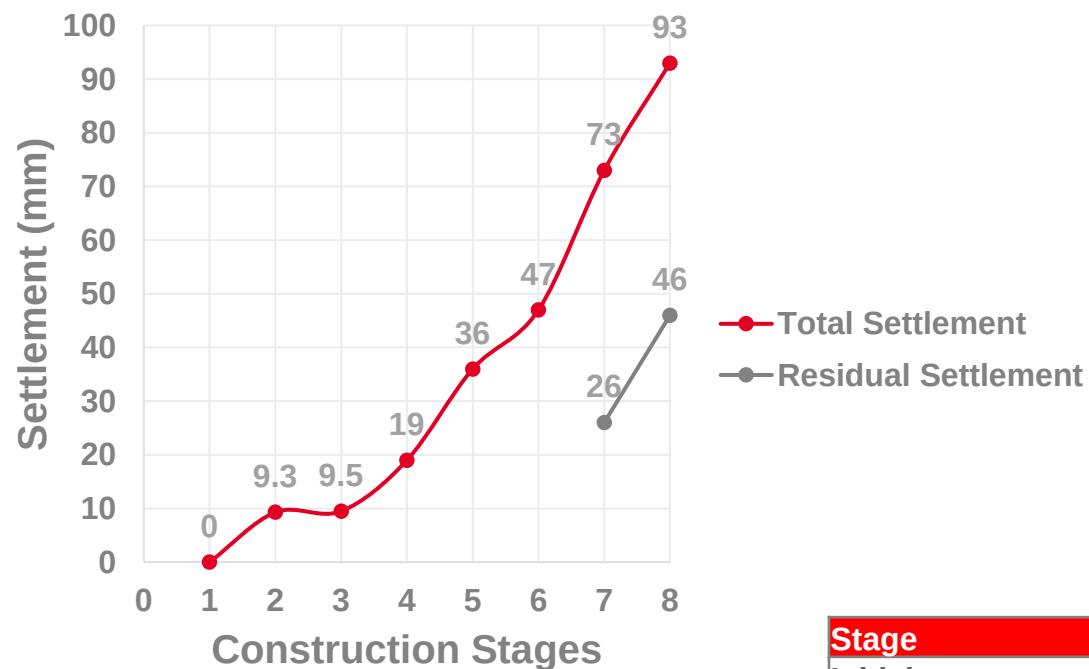
● Prelim Analysis (Profile B), Total Load of 100 kPa



- ⊕ CMCs are anchored in MD Sand, ~ 9m length
- ⊕ 1.6m c/c, Ø320
- ⊕ LTP 0.4m

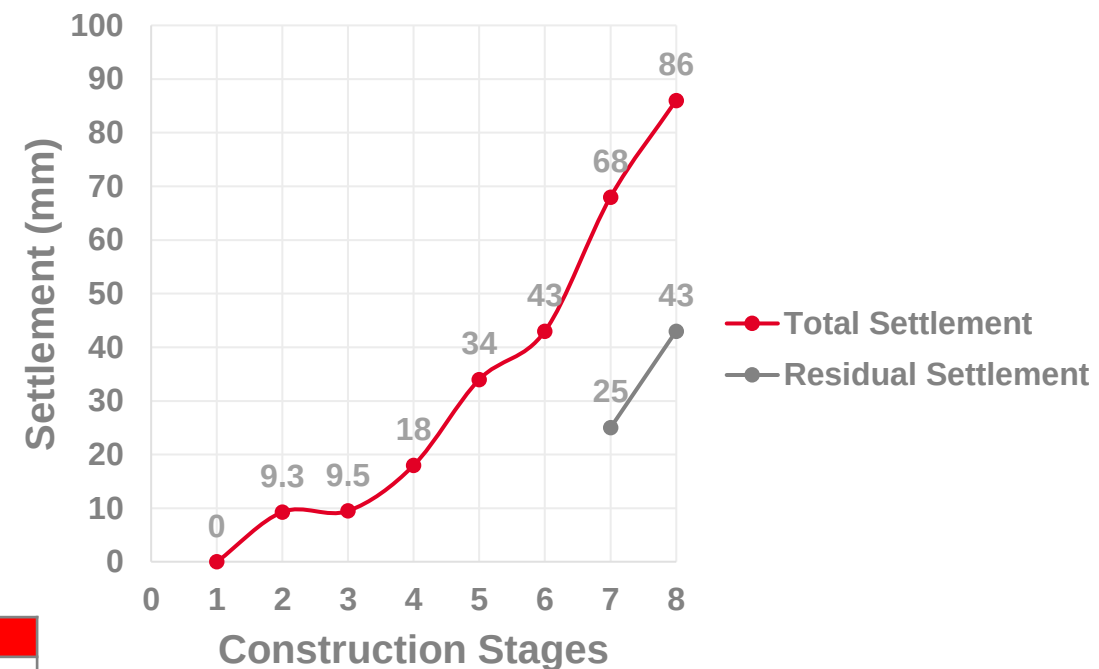
- **Building C (Stagging → Profile B); 2.1mc/c**

Building 3C ; CMC Ø320

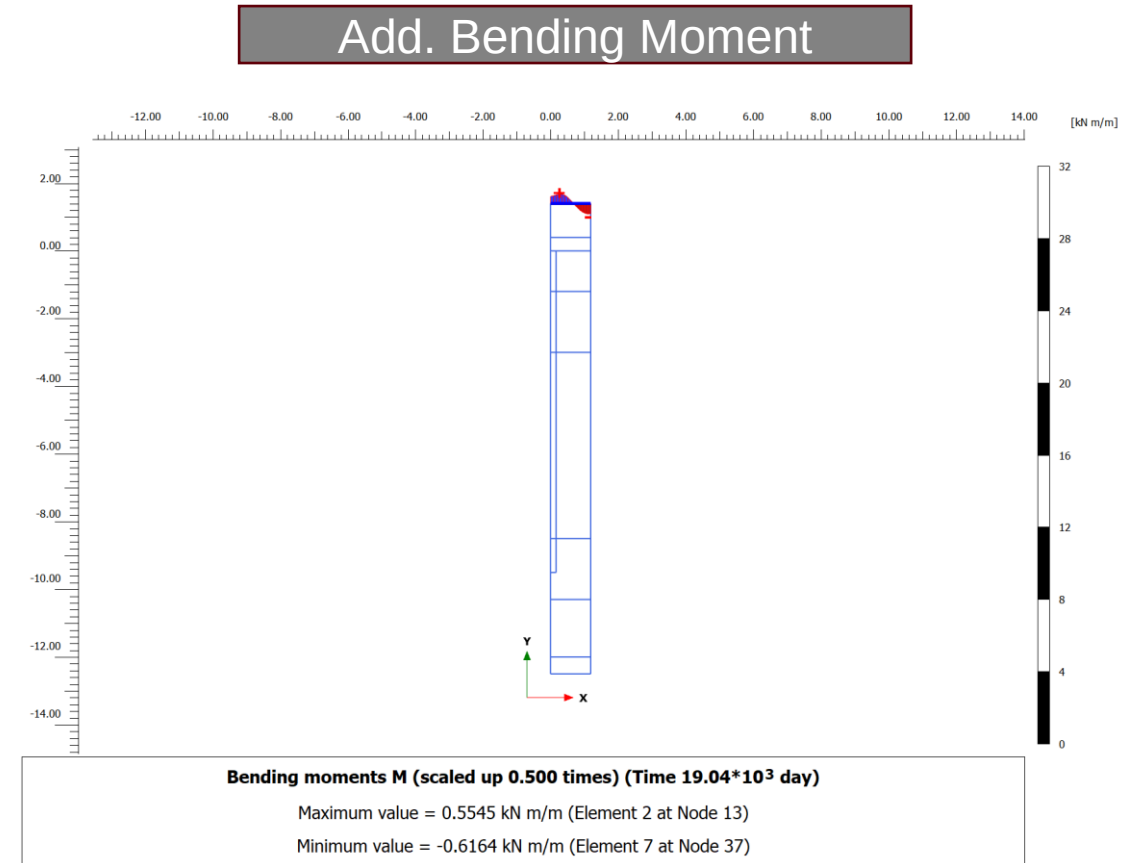
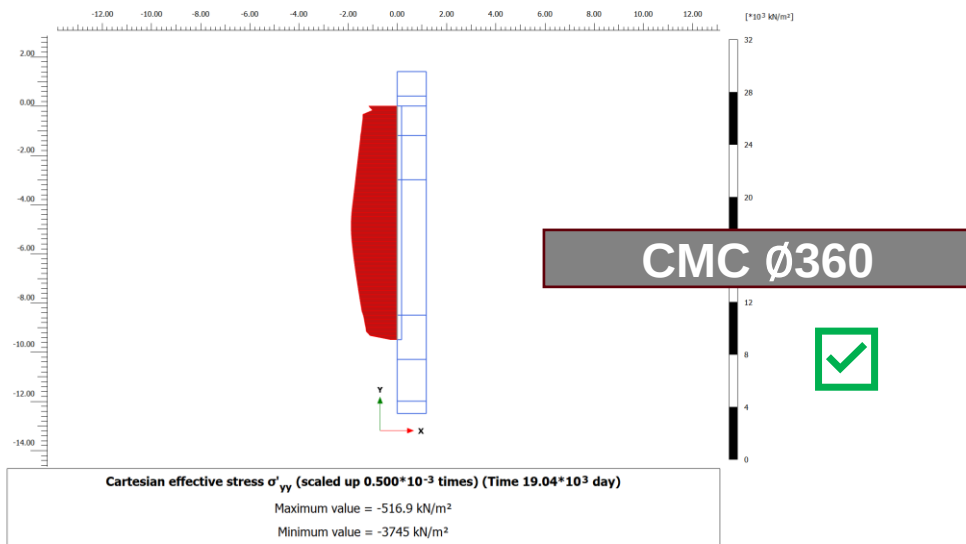
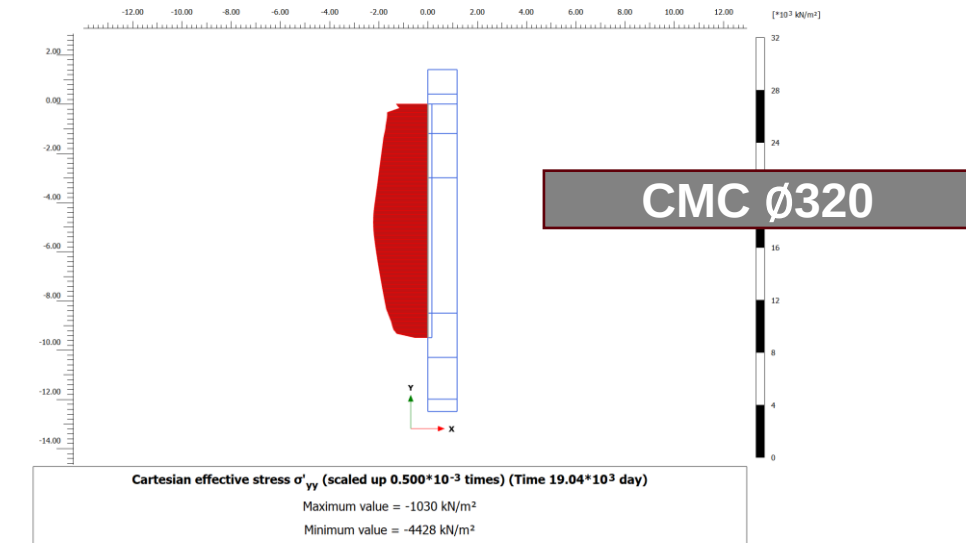


Stage	Event
Initial	1
LTP (0.4m)	2
CMC	3
Fill (1m)	4
Dead Load (40 kPa)	5
Dead Load (Over 2 Y)	6
Full Loading (100 kPa)	7
Full Loading (50 Y)	8

Building 3C ; CMC Ø360



● Axial Stress inside CMC + Moment inside Slab



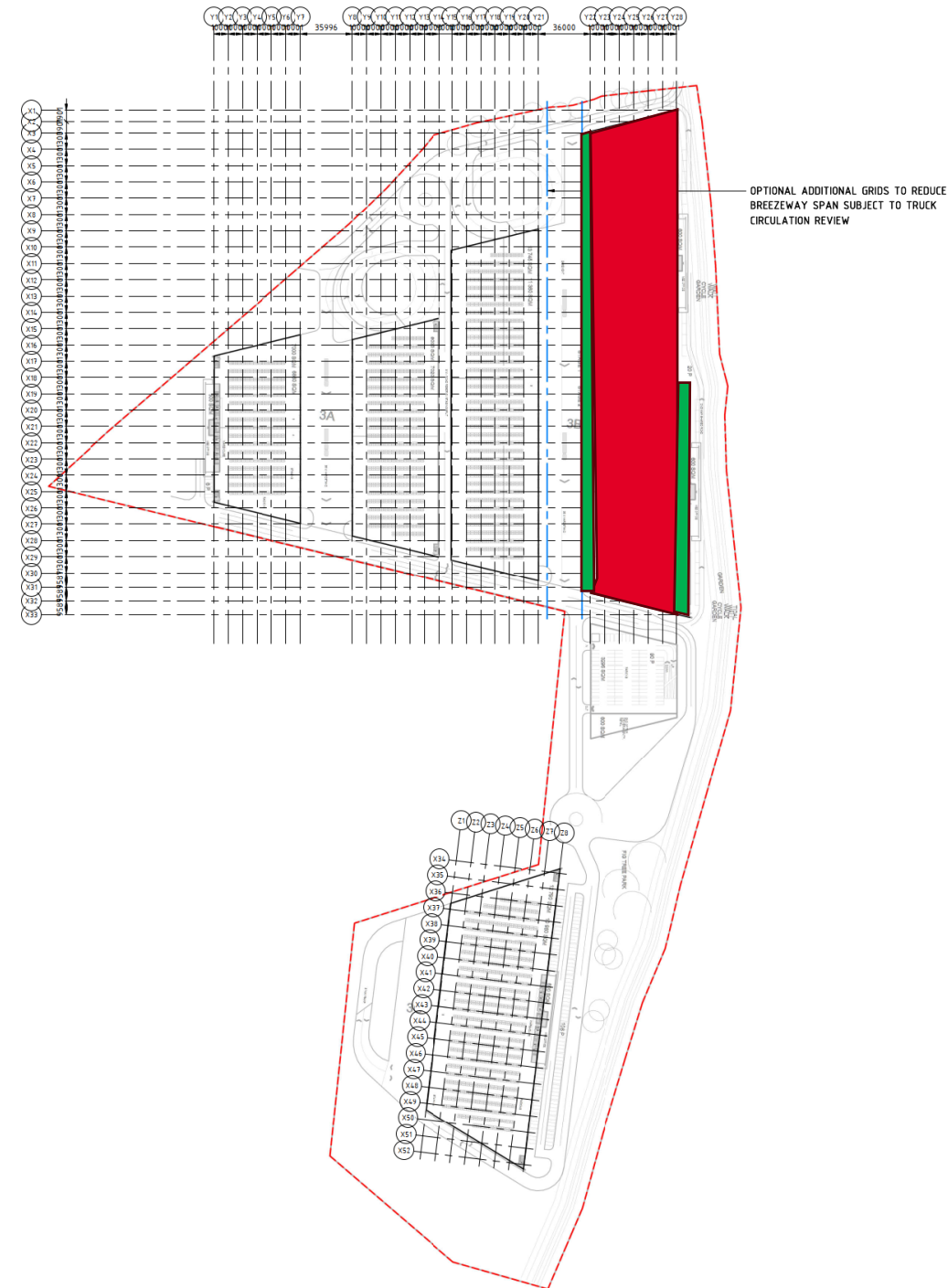


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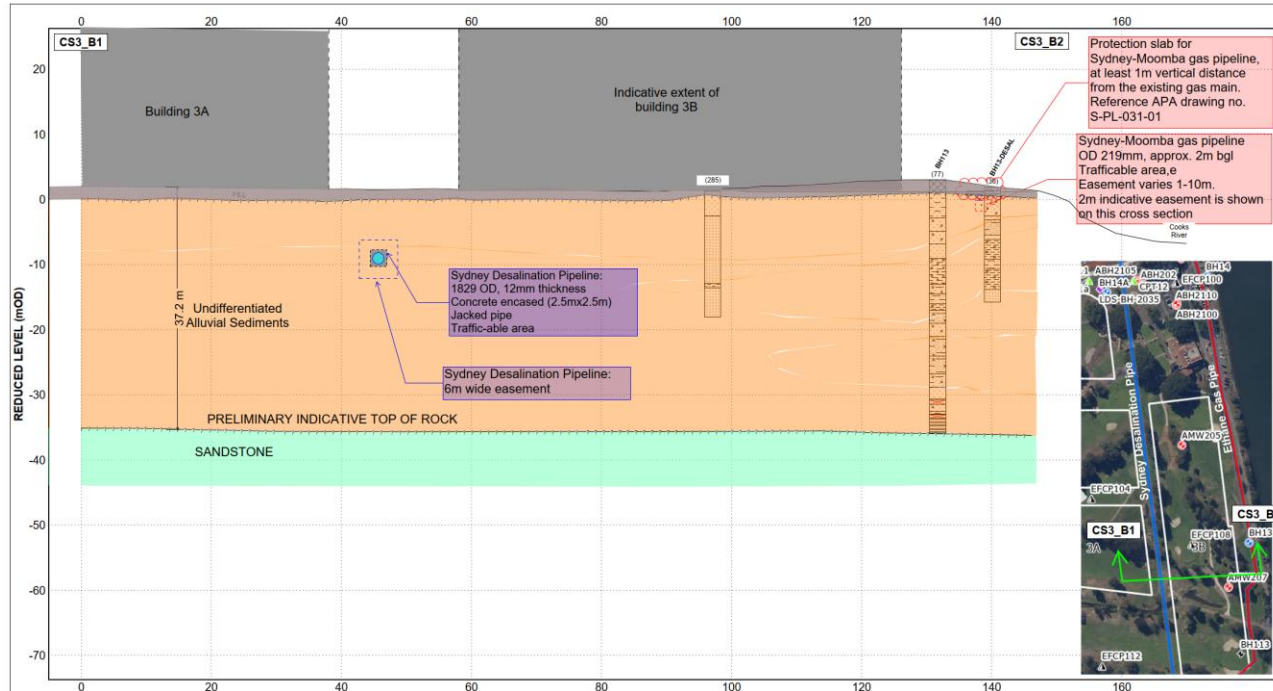
Building 3B

~21890 m² & 1672 m² (Hardstand)

CMC



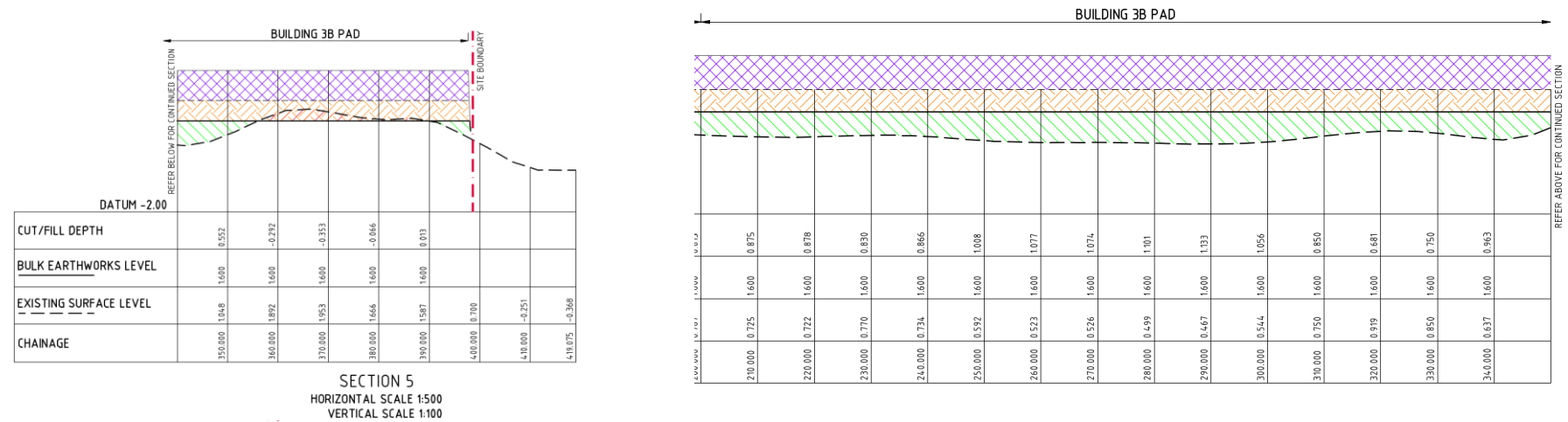
● Building 3B



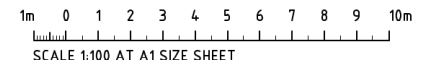
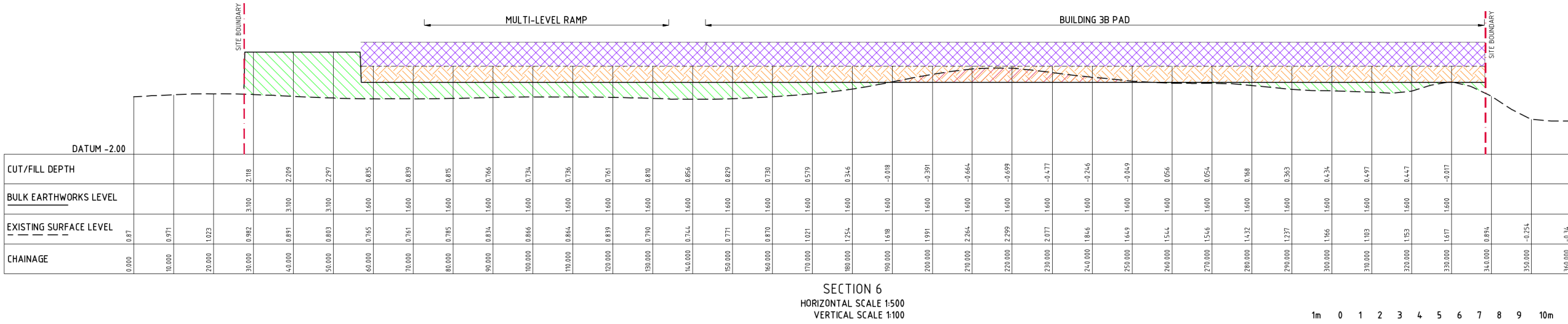
Indicative top **Rock depth** below the Building 3B is **~ -35 m**

The Desalination pipeline between Buildings 3A & 3B is at **~10m** below the ground level.

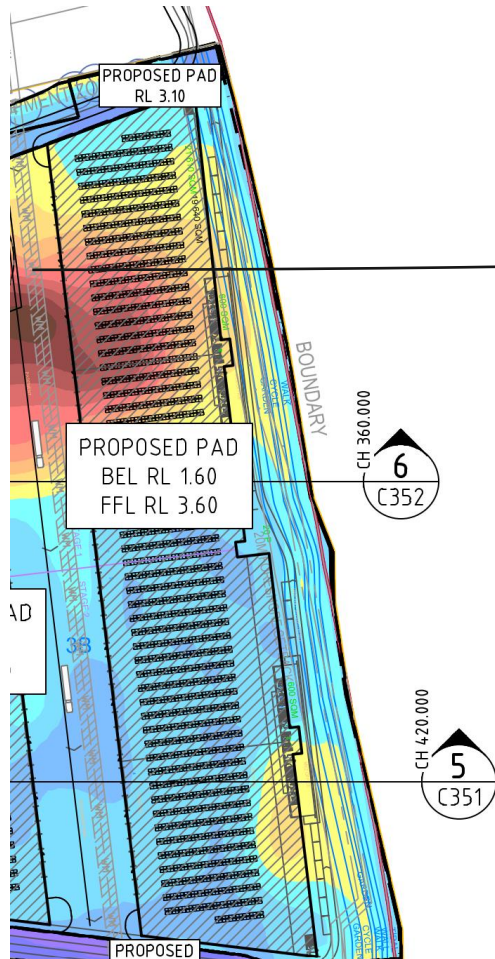
3B: Earthwork Sections



- Assuming Fill of 1.2m
- LTP of 0.4m



● 3B: Cut & Fill



DEPTH RANGE		
FROM DEPTH	TO DEPTH	COLOUR
-4.500	-4.000	Dark Brown
-4.000	-3.500	Brown
-3.500	-3.000	Red-Brown
-3.000	-2.500	Red
-2.500	-2.000	Red-Orange
-2.000	-1.500	Orange
-1.500	-1.000	Light Orange
-1.000	-0.500	Yellow
-0.500	0.000	Light Yellow
0.000	0.500	Light Green
0.500	1.000	Green
1.000	1.500	Dark Green
1.500	2.000	Blue-Green
2.000	2.500	Blue
2.500	3.000	Dark Blue

Fill is expected to range between 1m to 1.5m.
Cut is expected to be in the range of 0.5m to 3m

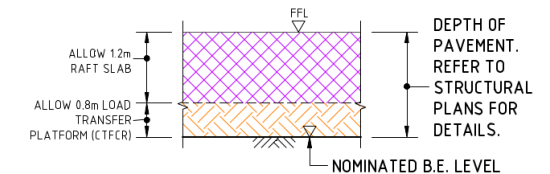
→ A relative heavy cut of ~ 3m is expected between Buildings A and B in the northern part near the desalination pipe.

LEGEND:

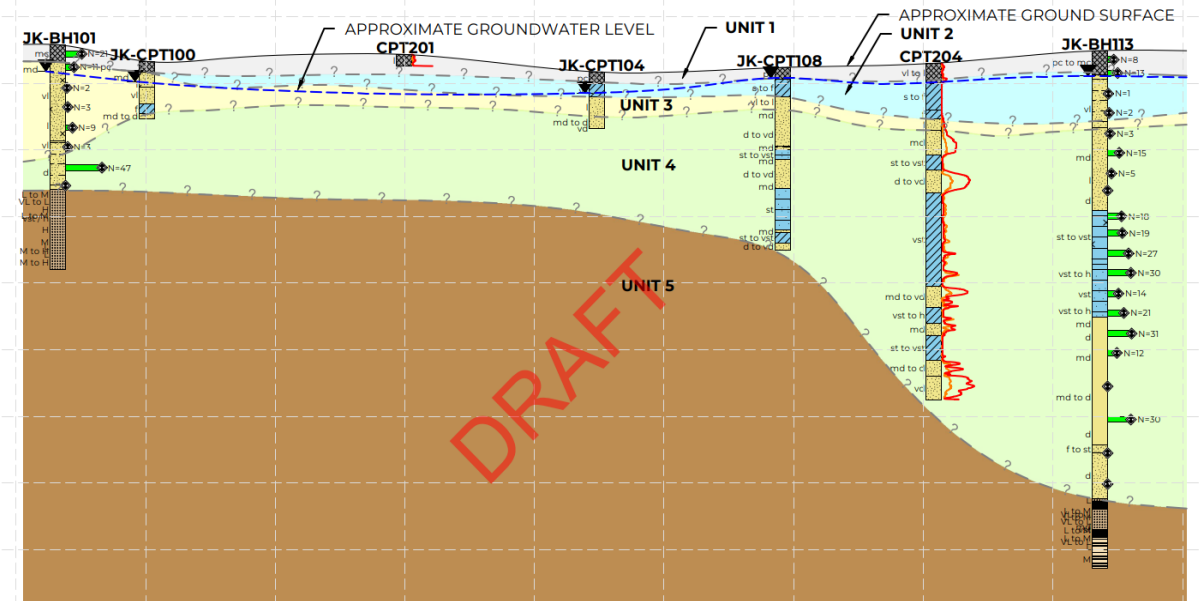
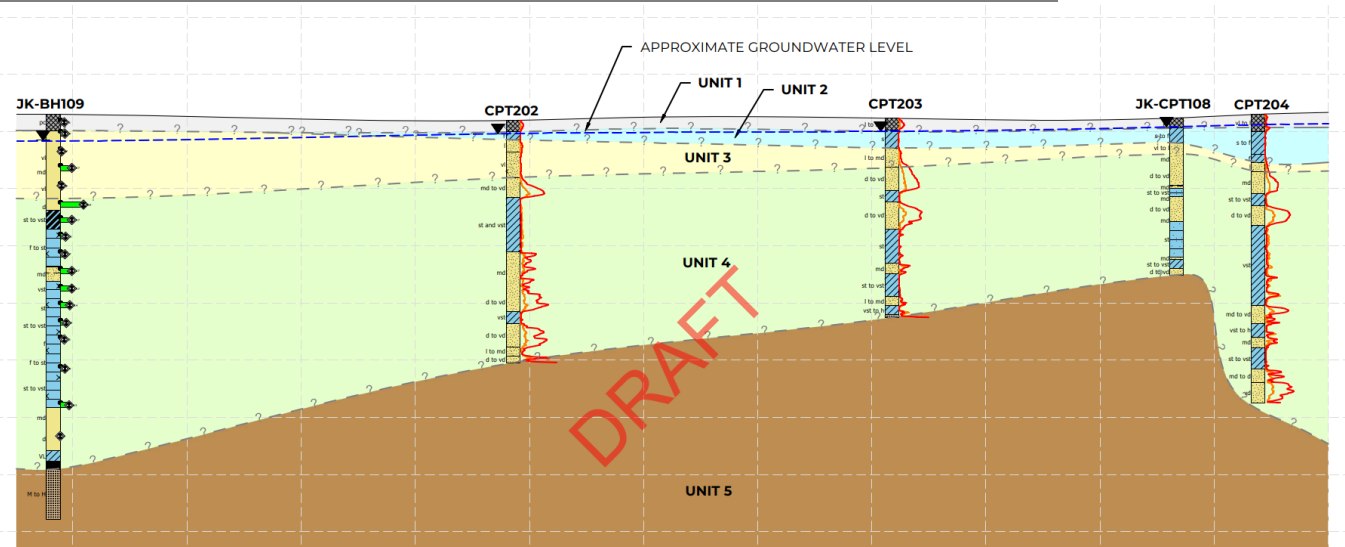
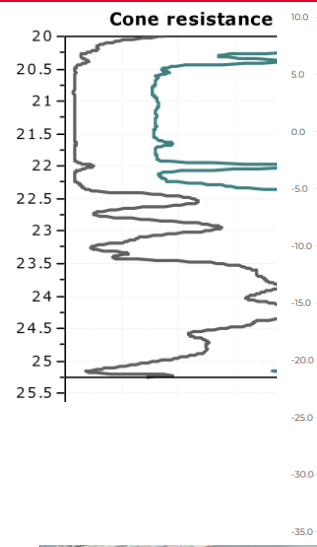
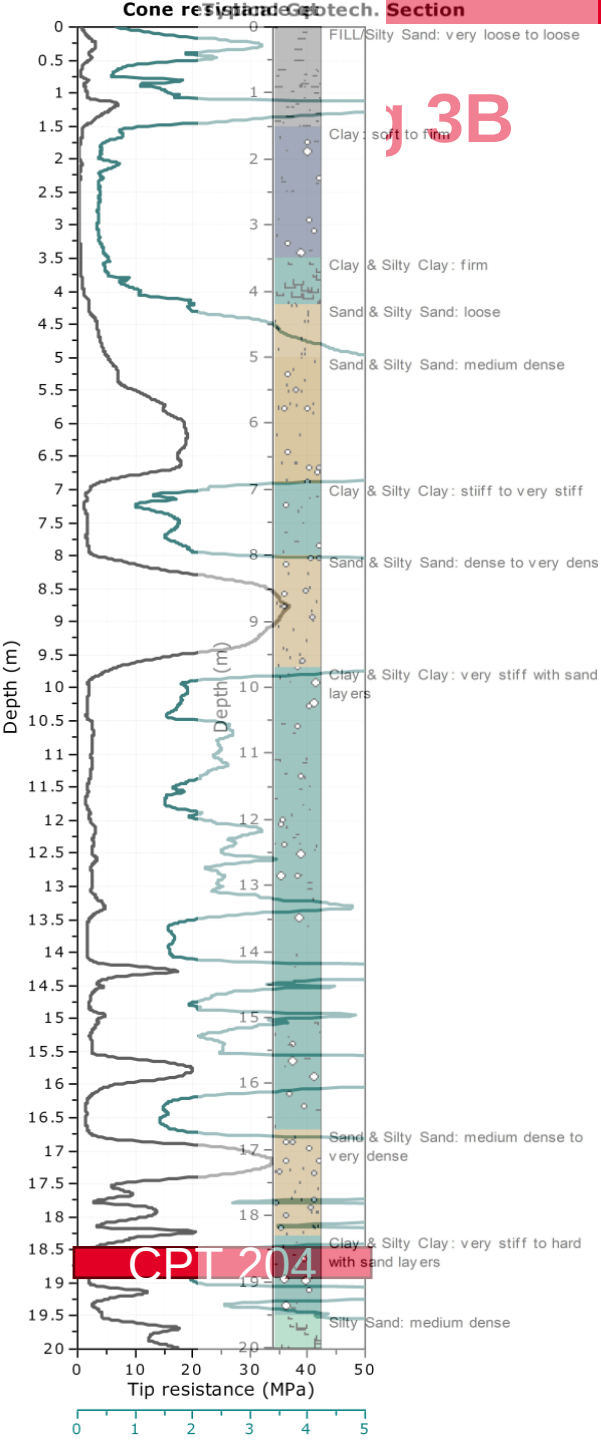
LEVELS DATUM IS AHD.

EXISTING CONTOURS ARE BASED ON LIDAR INFORMATION OBTAINED FROM NSW GOVERNMENT SPATIAL SERVICES DATED MAY 2020.

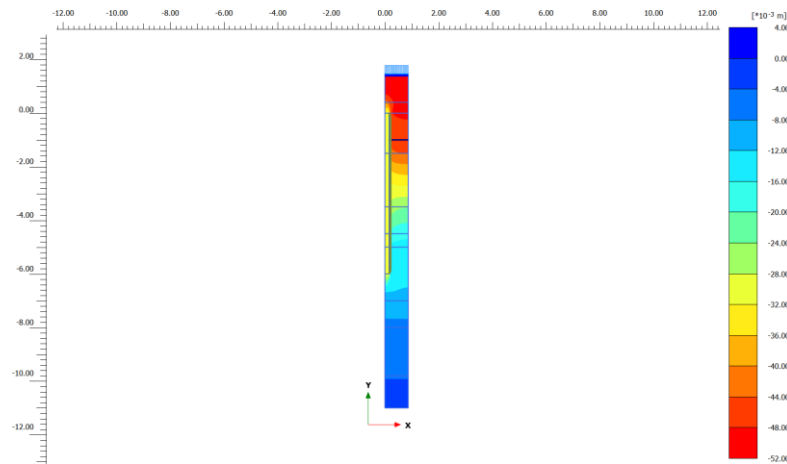
- 50.00 — — — — — EXISTING CONTOUR (0.2m INTERVAL)
- 50.00 — — — — — B.E.L. CONTOUR (MAJOR 1.0m)
- 50.10 — — — — — B.E.L. CONTOUR (MINOR 0.25m)
- ★ 50.00 — — — — — B.E.L. SPOT LEVEL



NOMINATED B.E.L. DETAIL
 NTS



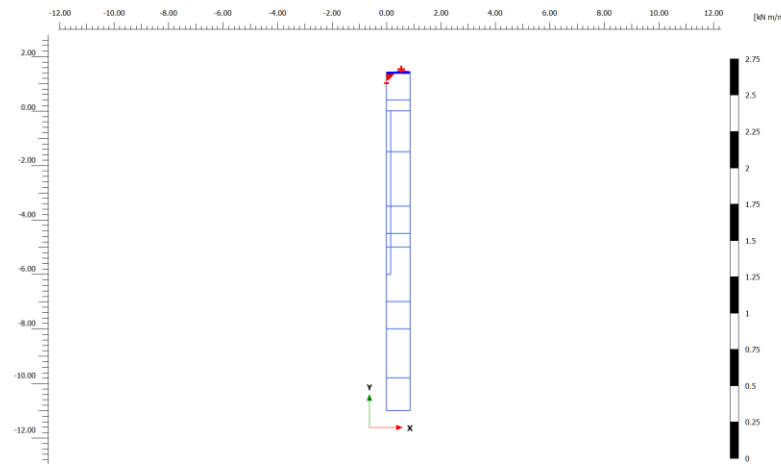
- **Total Settlement < 50mm; Total Load of 120 kPa**



Total displacements u_y (scaled up 5.00 times) (Time 18.31*10³ day)

Maximum value = 0.000 m (Element 902 at Node 8123)

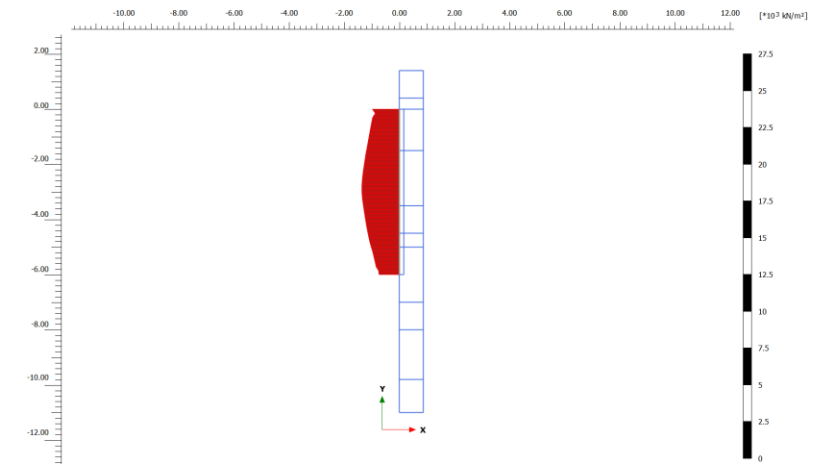
Minimum value = -0.05098 m (Element 20 at Node 4)



Bending moments M (scaled up 5.00 times) (Time 18.31*10³ day)

Maximum value = 0.01921 kN m/m (Element 4 at Node 69)

Minimum value = -0.05659 kN m/m (Element 1 at Node 4)



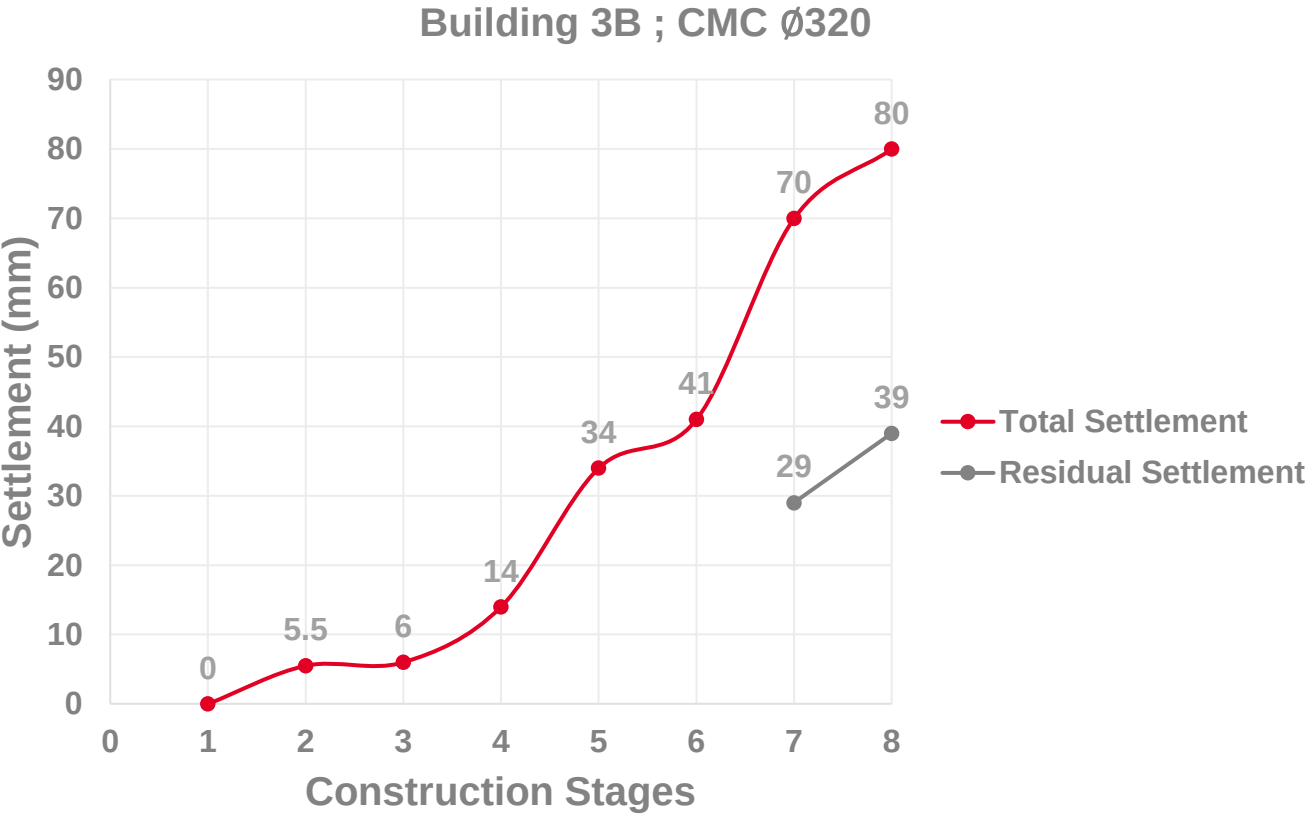
Cartesian effective stress σ'_{yy} (scaled up 0.500*10⁻³ times) (Time 18.31*10³ day)

Maximum value = -1469 kN/m²

Minimum value = -2722 kN/m²

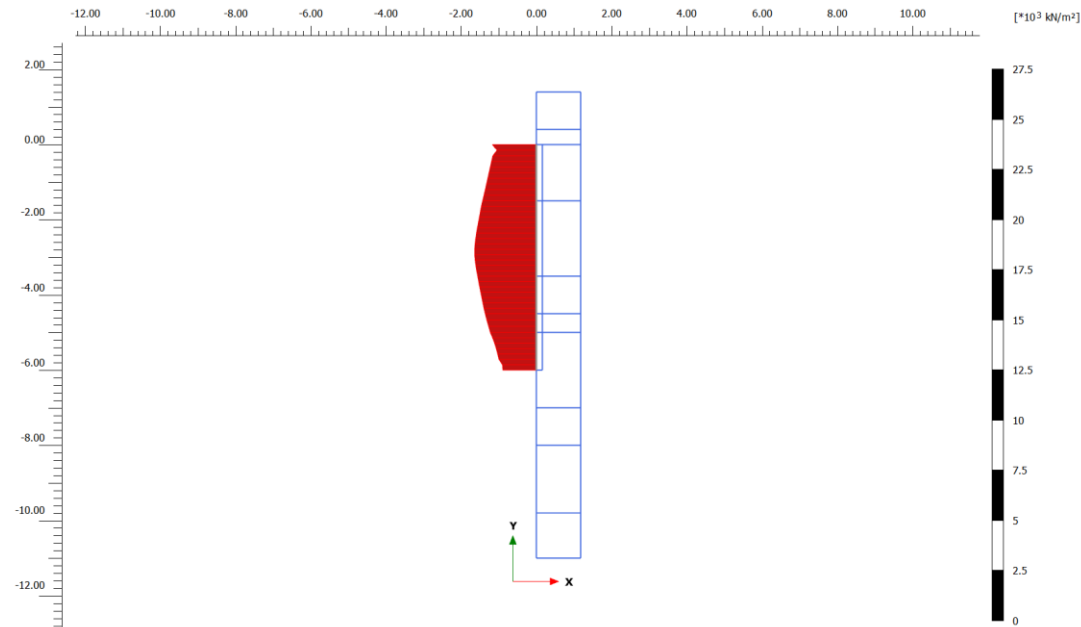
- ⊕ CMCs are anchored in MD Sand, ~ 6m length
- ⊕ 1.6m c/c, Ø320
- ⊕ LTP 0.4m

● **Building 3B (Stagging); 2.1mc/c**

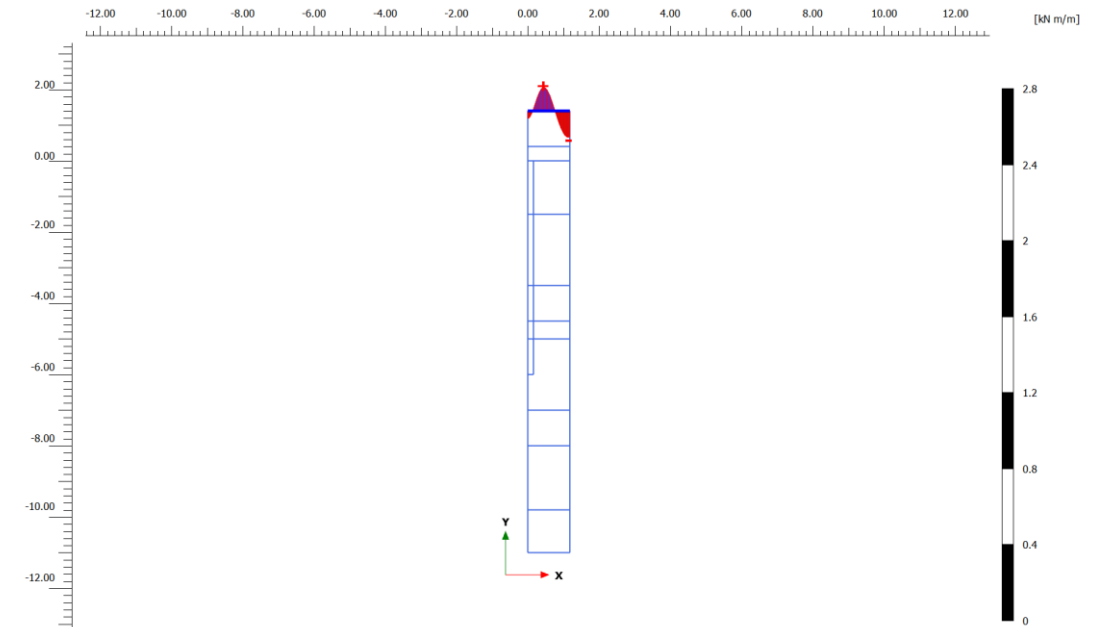


Stage	Event
Initial	1
LTP (0.4m)	2
CMC	3
Fill (1m)	4
Dead Load (50 kPa)	5
Dead Load (Over 2 Y)	6
Full Loading (120 kPa)	7
Full Loading (50 Y)	8

- **Building 3B (Stagging); 2.1mc/c**



CMC Ø320



Add. Bending Moment



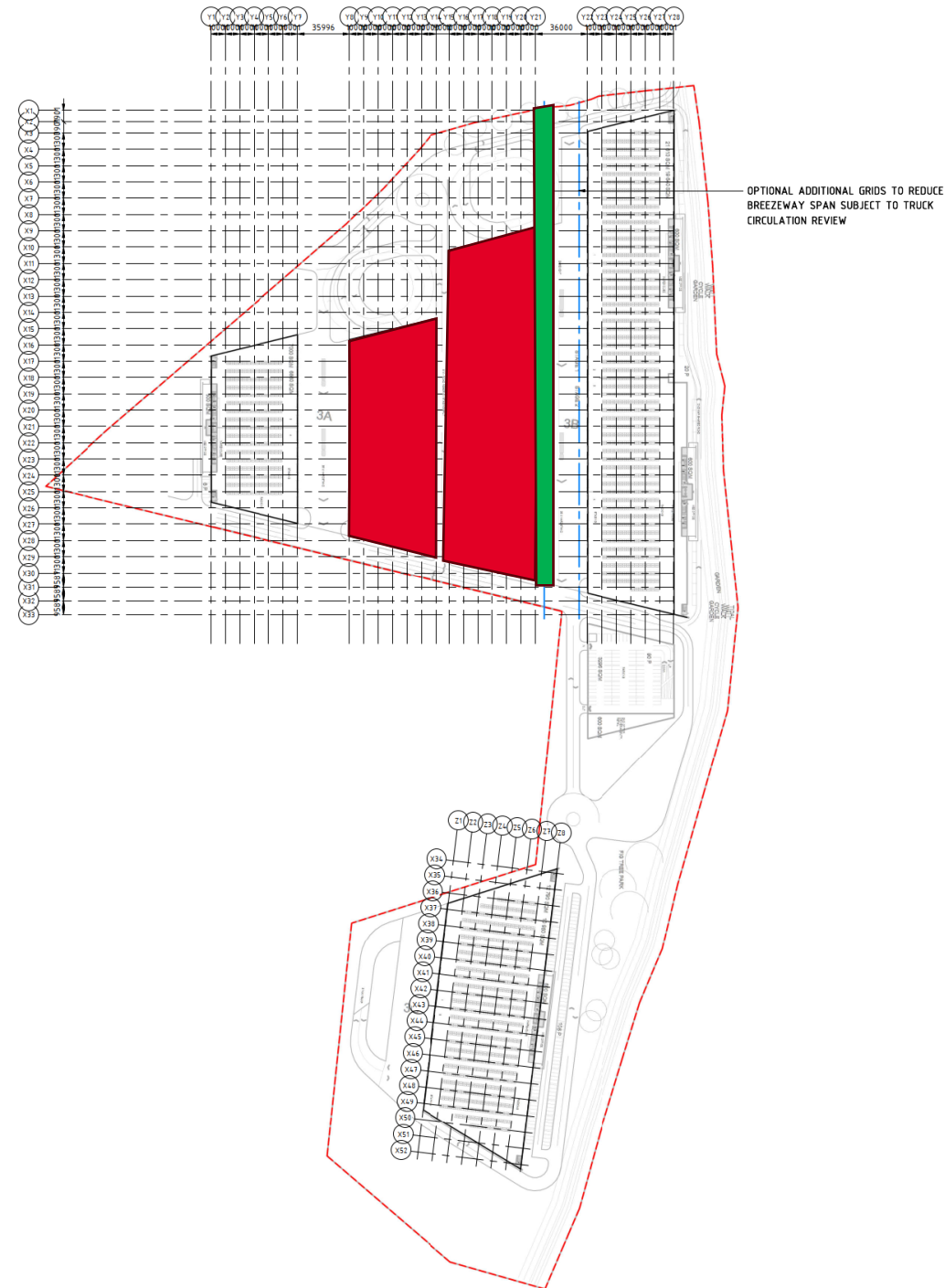


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Buildings 3A

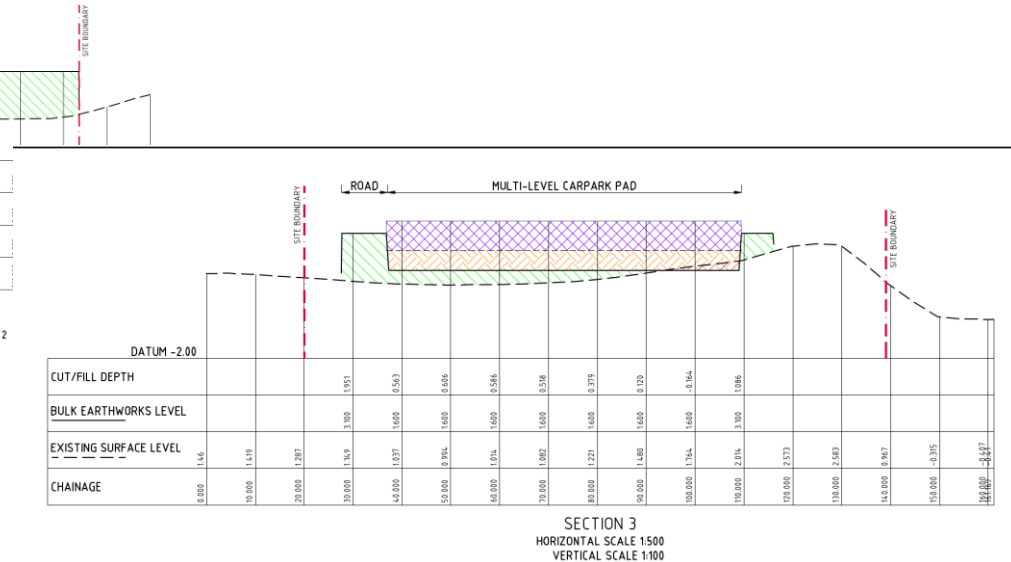
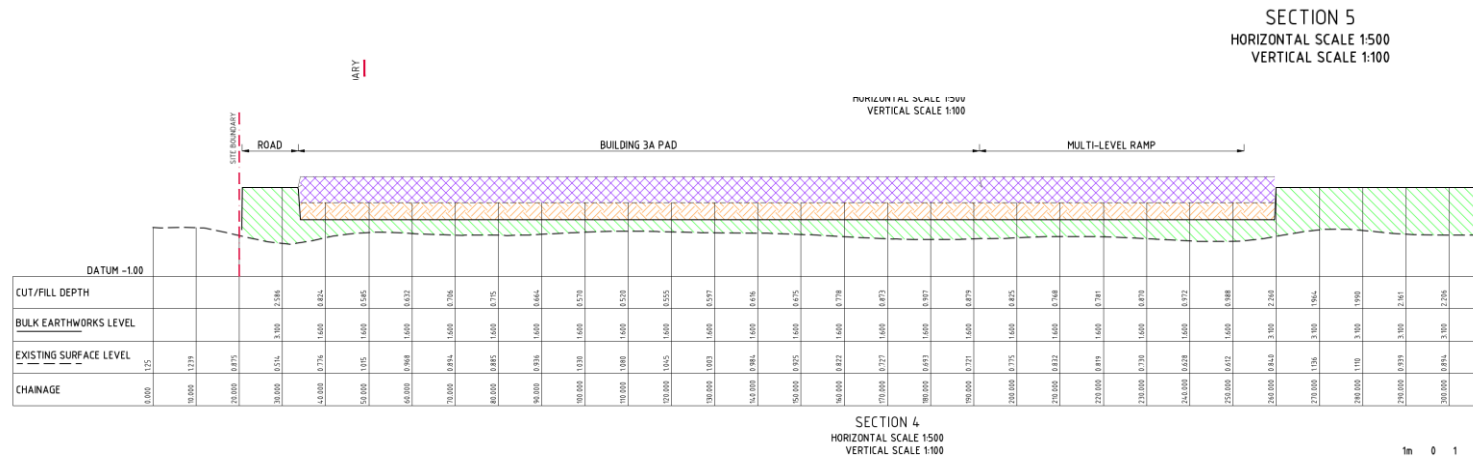
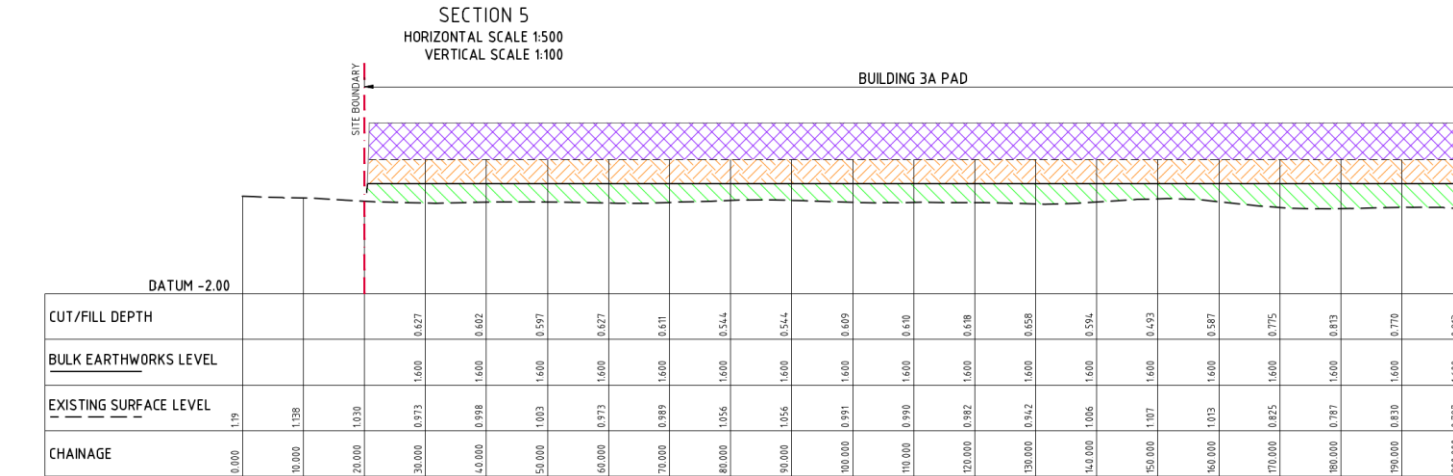
~23797 m^2 & 5934 m^2 (Hardstand)

CMC



3A: Earthwork Sections

- Assuming Fill of 1.5m (including LTP)
- Excessive Fill next to the building



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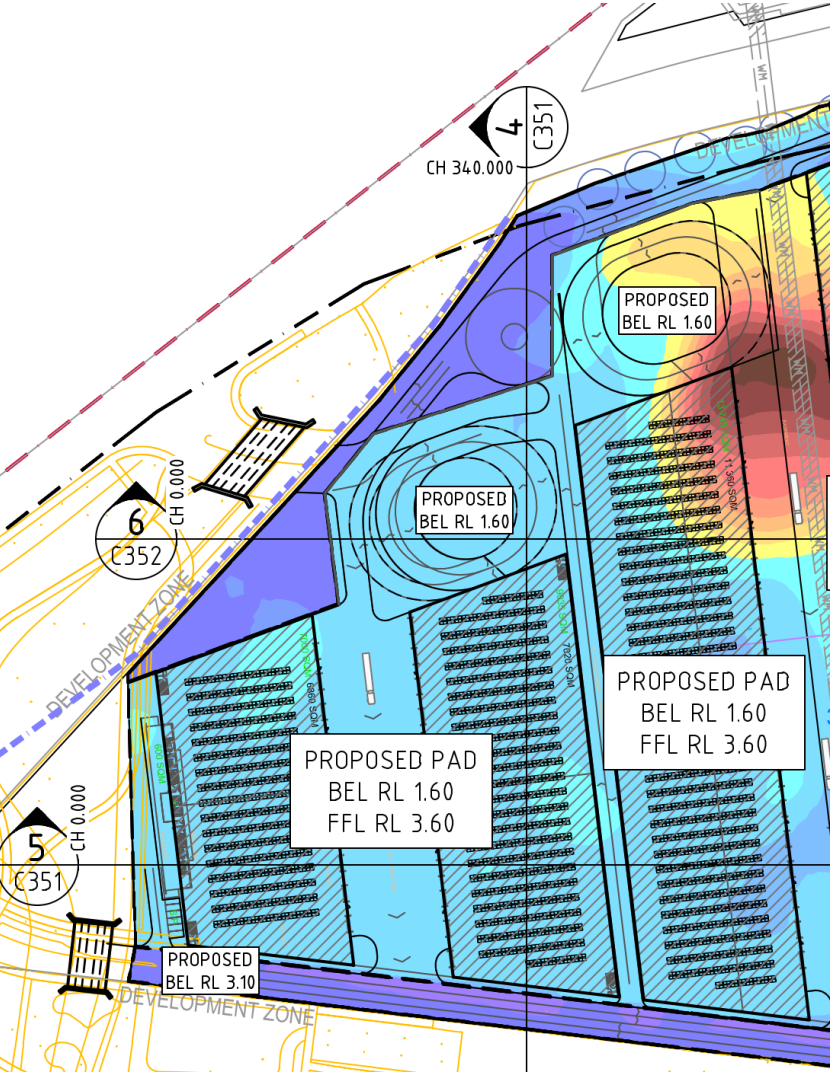


Stockland



CRC
COSTIN ROE
CONSULTING
CIVIL &
STRUCTURAL
ENGINEERS

- 3A: Cut & Fill

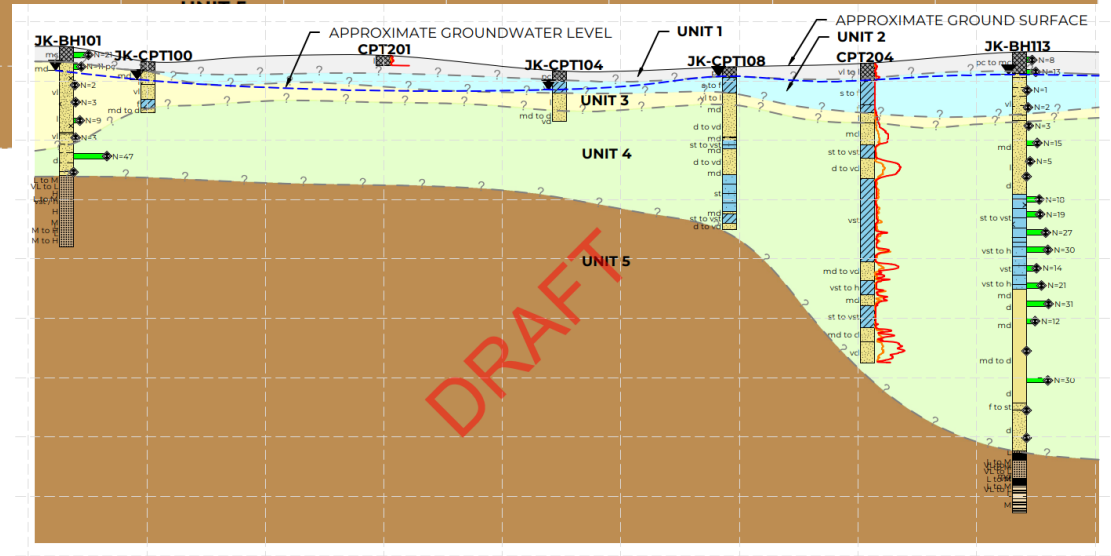
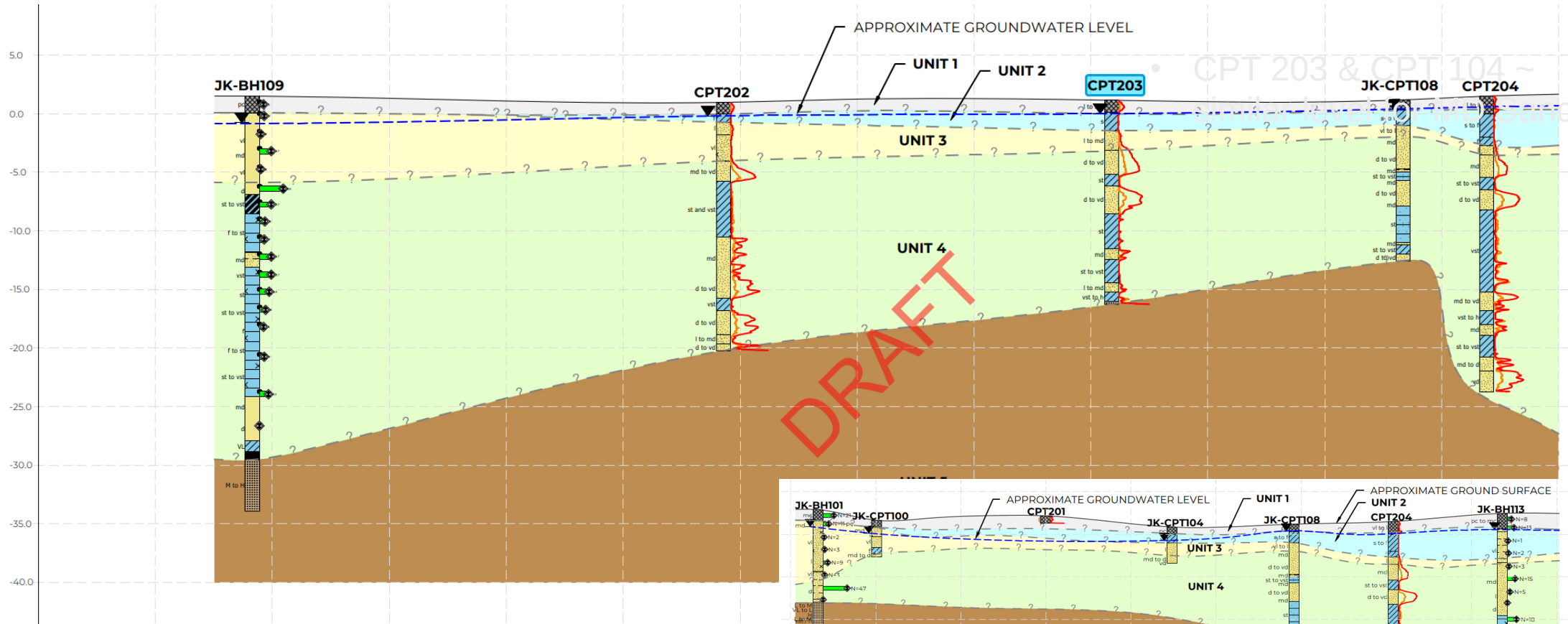


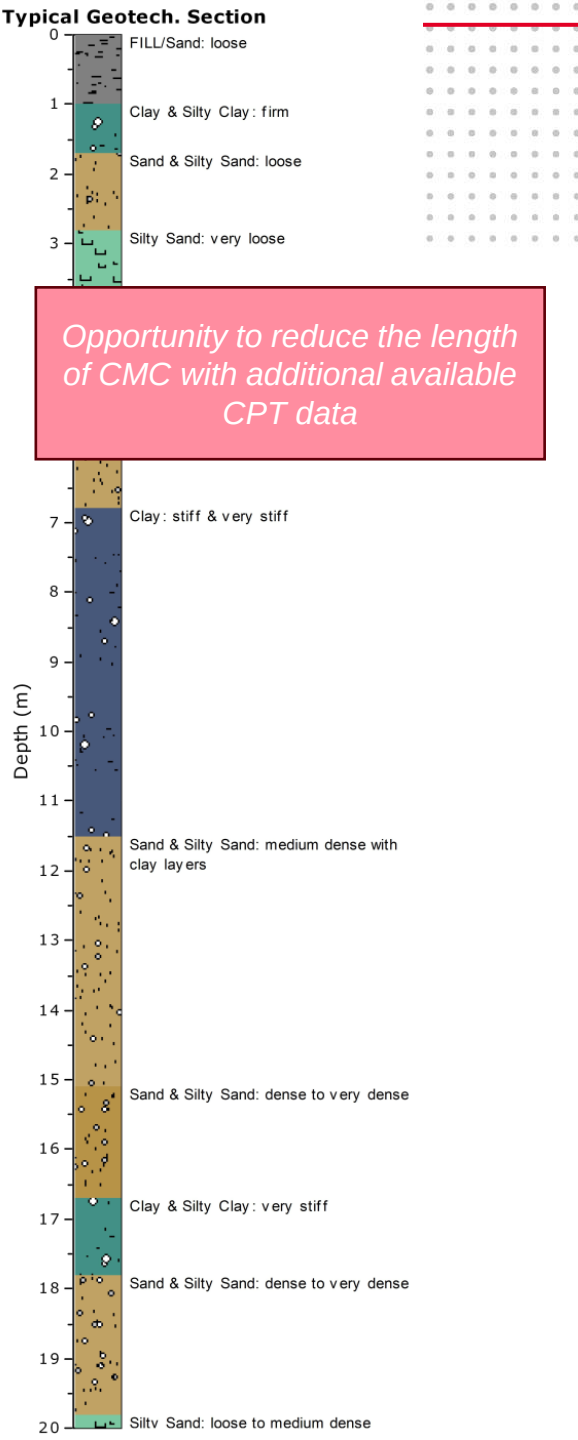
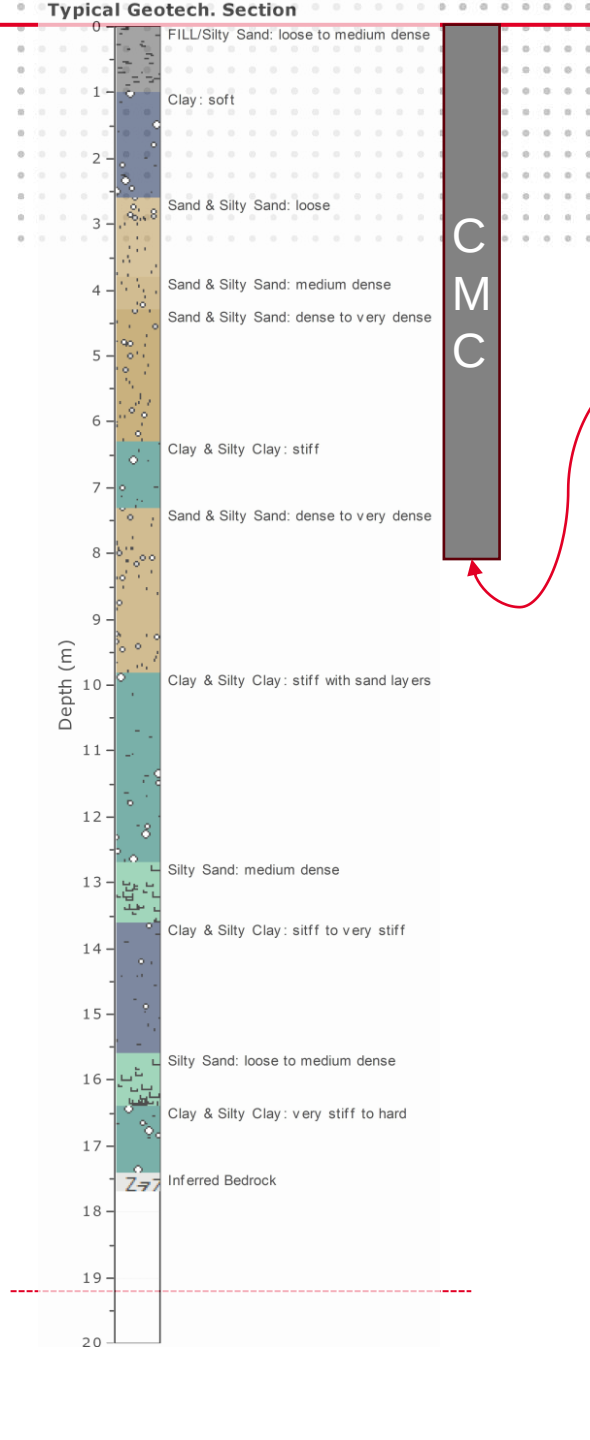
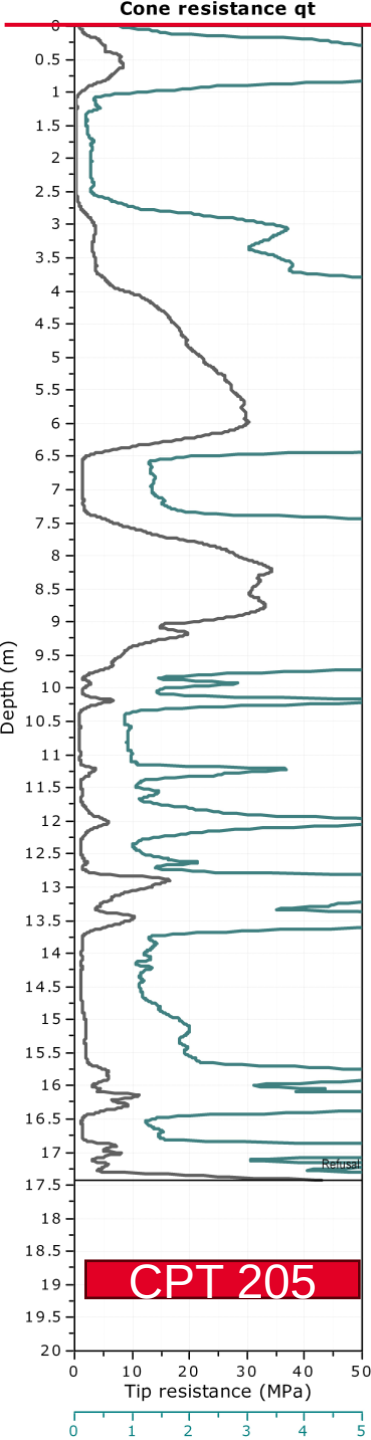
Fill is expected to be ~1.5m.

Cut is expected to range from 0.5m to 3m, located next to the desalination Pipe

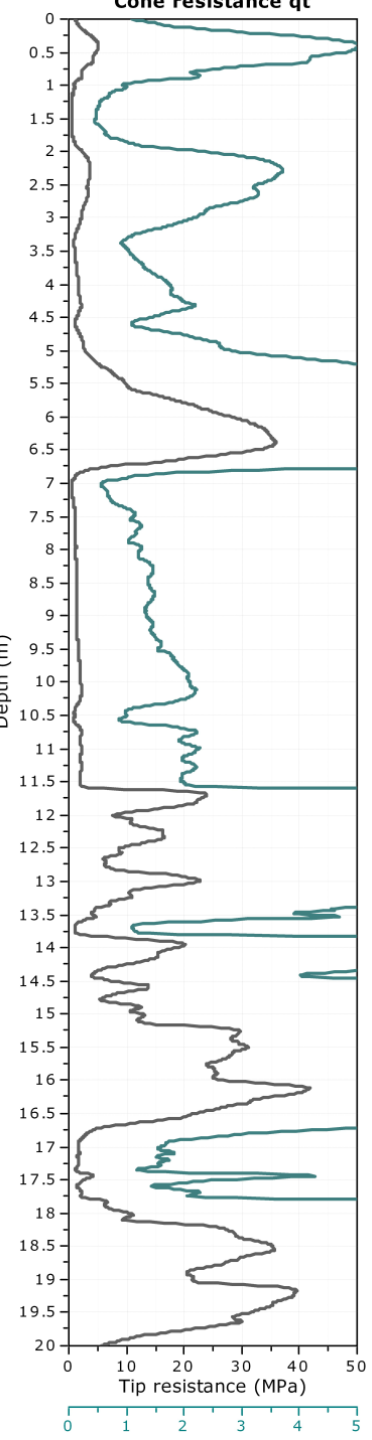
DEPTH RANGE			
No.	FROM DEPTH	TO DEPTH	COLOUR
1	-4.500	-4.000	
2	-4.000	-3.500	
3	-3.500	-3.000	
4	-3.000	-2.500	
5	-2.500	-2.000	
6	-2.000	-1.500	
7	-1.500	-1.000	
8	-1.000	-0.500	
9	-0.500	0.000	
10	0.000	0.500	
11	0.500	1.000	
12	1.000	1.500	
13	1.500	2.000	
14	2.000	2.500	
15	2.500	3.000	

● Stratigraphy

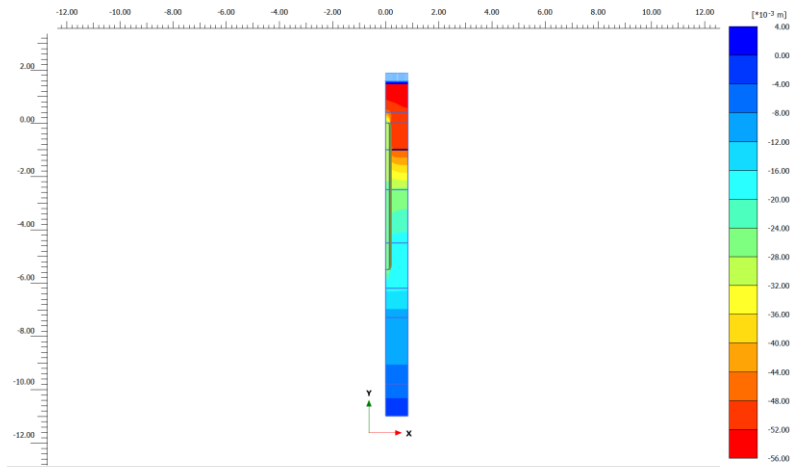




Opportunity to reduce the length of CMC with additional available CPT data

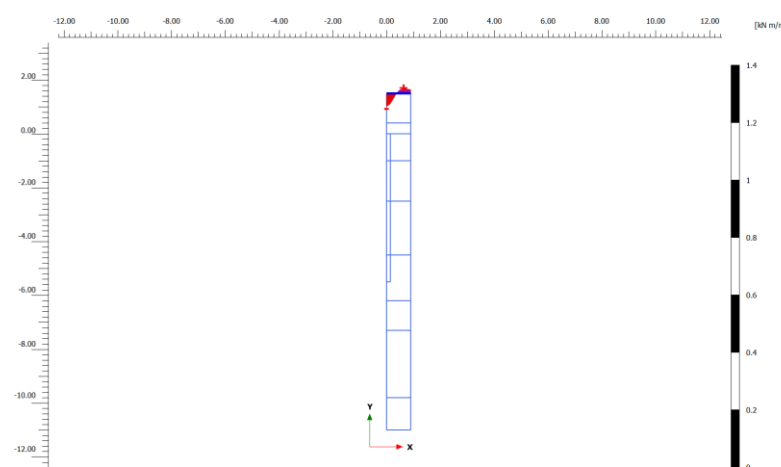


● 3A: Total Settlement < 50mm ; Total Load of 120 kPa



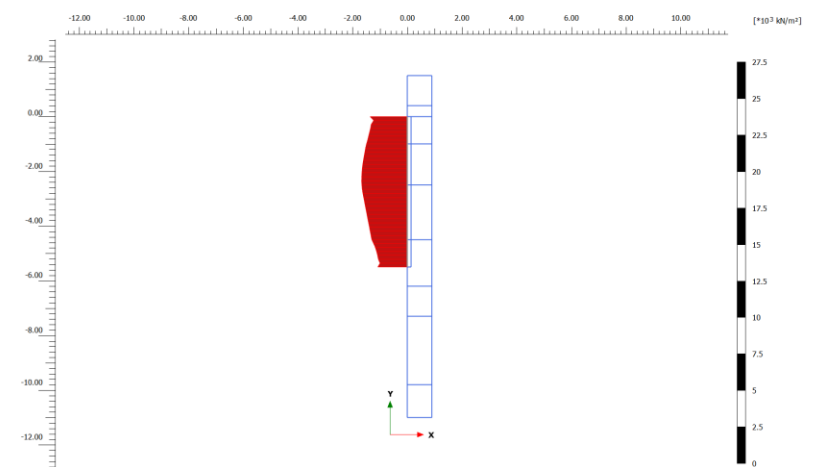
Total displacements u_y (scaled up 5.00 times) (Time $18.31 \cdot 10^3$ day)

Maximum value = 0.000 m (Element 902 at Node 8000)
Minimum value = -0.05381 m (Element 36 at Node 29)



Bending moments M (scaled up 10.0 times) (Time $18.31 \cdot 10^3$ day)

Maximum value = 0.01720 kN m/m (Element 5 at Node 123)
Minimum value = -0.04731 kN m/m (Element 1 at Node 1)

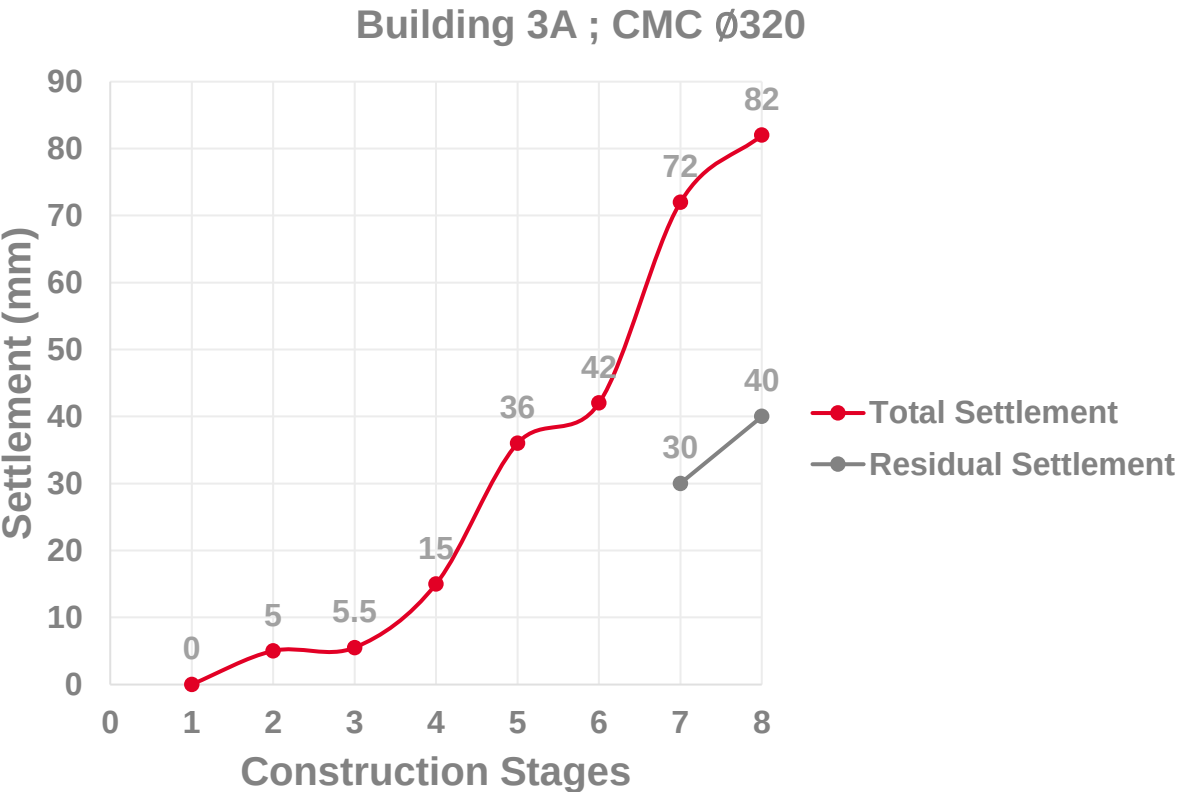


Cartesian effective stress σ'_{yy} (scaled up $0.500 \cdot 10^{-3}$ times) (Time $18.31 \cdot 10^3$ day)

Maximum value = -1990 kN/m²
Minimum value = -3335 kN/m²

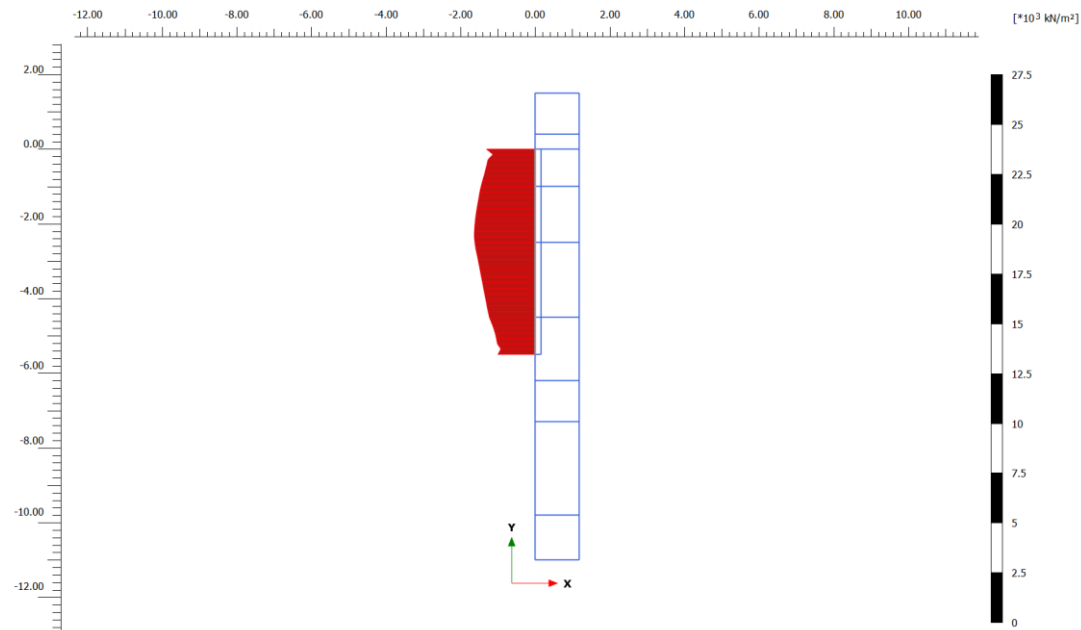
- ⊕ CMCs are anchored in MD Sand, ~ 5.5m length
- ⊕ 1.55m c/c, $\varnothing 280$
- ⊕ LTP 0.4m

● Building 3A (Stagging); 2.1mc/c



Stage	Event
Initial	1
LTP (0.4m)	2
CMC	3
Fill (1m)	4
Dead Load (50 kPa)	5
Dead Load (Over 2 Y)	6
Full Loading (120 kPa)	7
Full Loading (50 Y)	8

- **Building 3A (Stagging); 2.1mc/c**

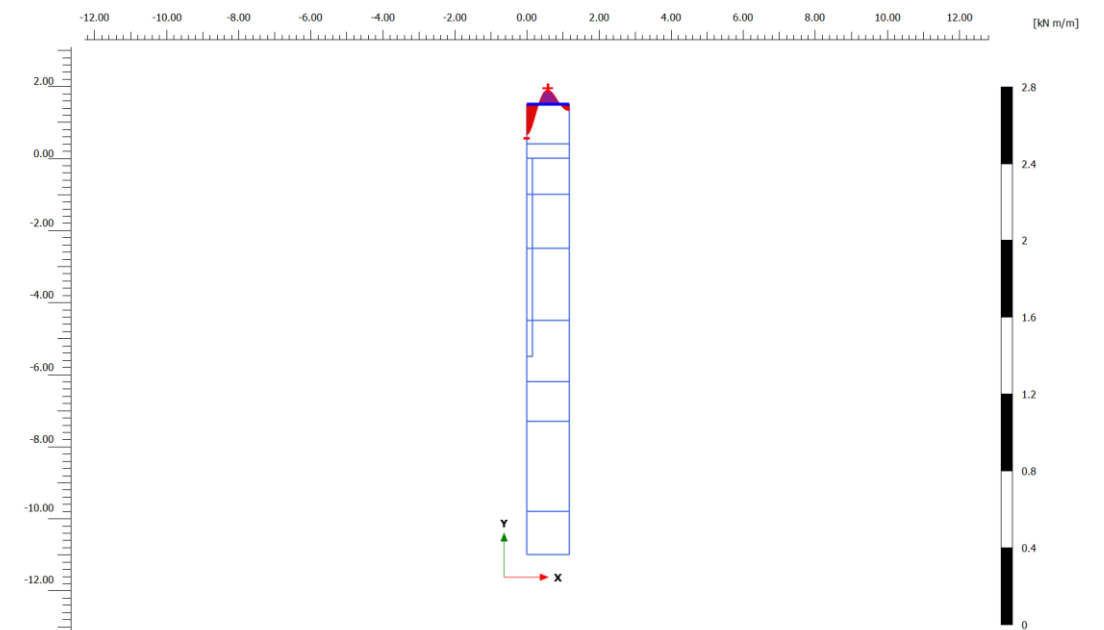


Cartesian effective stress σ'_{yy} (scaled up $0.500 \cdot 10^{-3}$ times) (Time $19.04 \cdot 10^3$ day)

Maximum value = -1835 kN/m²

Minimum value = -3261 kN/m²

CMC Ø320



Bending moments M (scaled up 5.00 times) (Time $19.04 \cdot 10^3$ day)

Maximum value = 0.07981 kN m/m (Element 5 at Node 81)

Minimum value = -0.1704 kN m/m (Element 1 at Node 177)

Add. Bending Moment



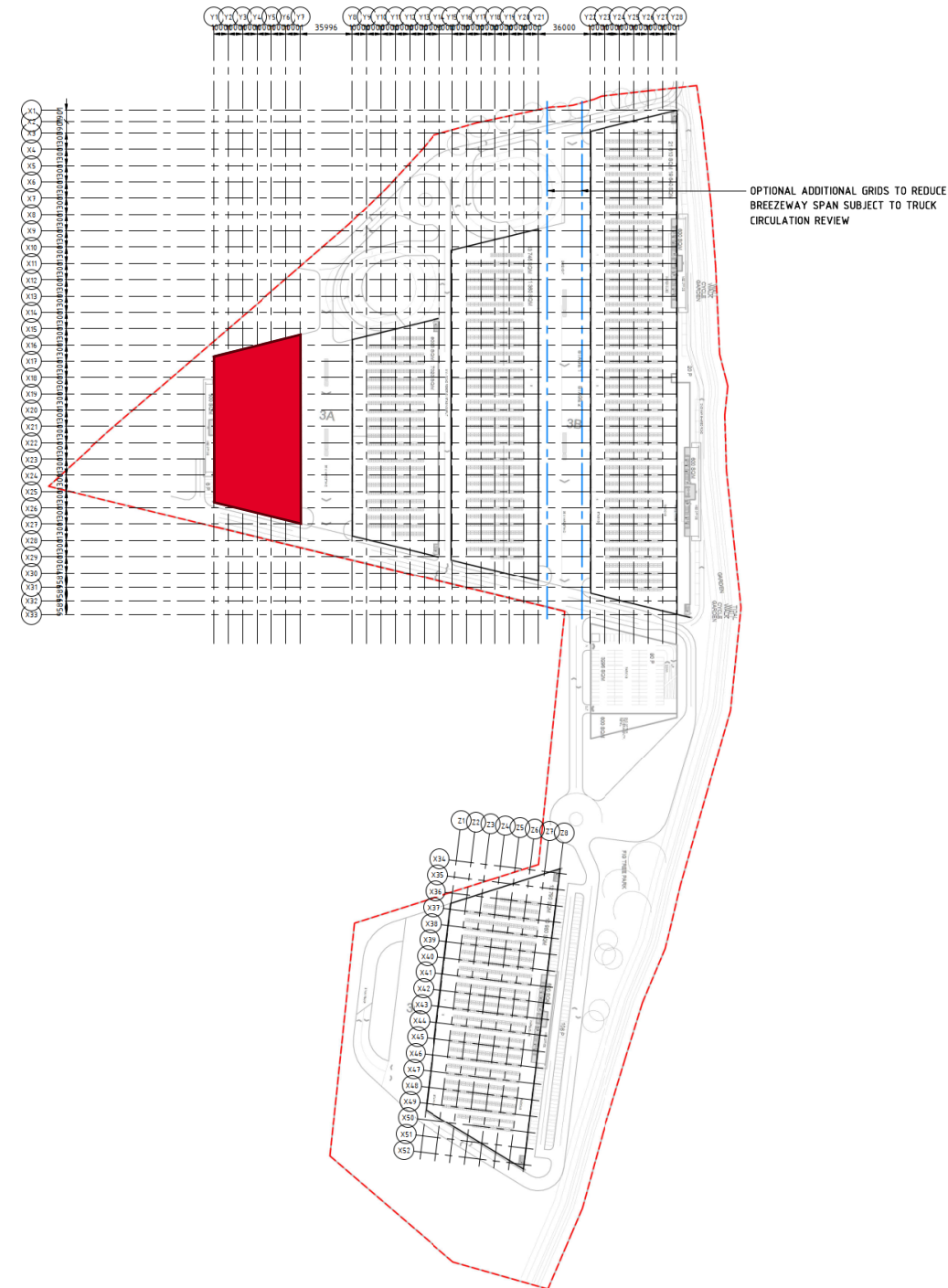


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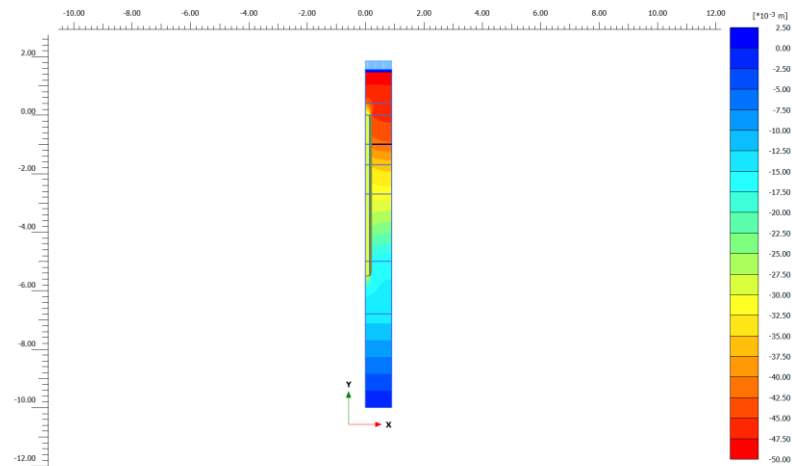
Buildings 3A

~7536 m²

CMC



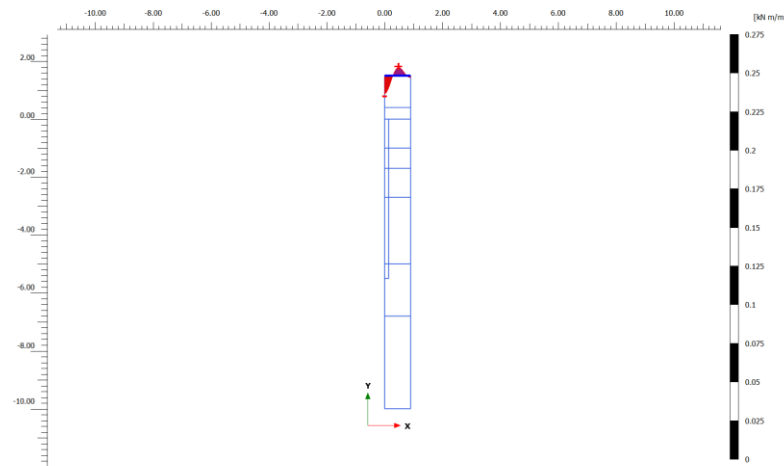
● Building 3A: Total Settlement < 50mm ; Total Load of 120 kPa



Total displacements u_y (scaled up 5.00 times) (Time 18.31×10^3 day)

Maximum value = 0.000 m (Element 909 at Node 8228)

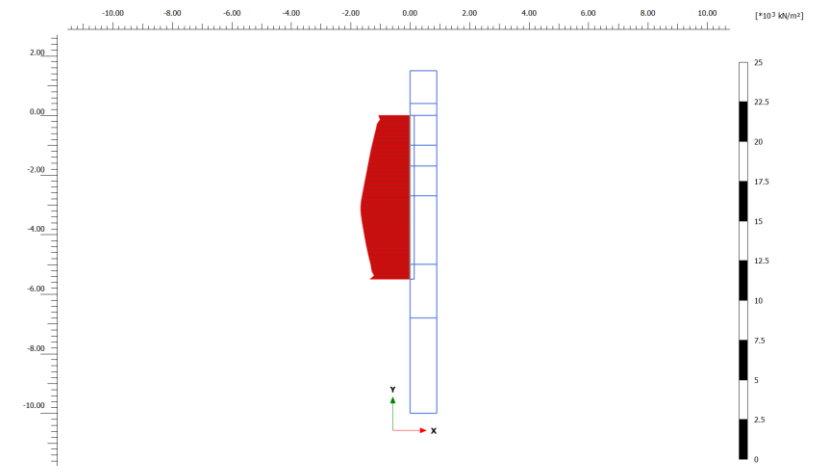
Minimum value = -0.04854 m (Element 33 at Node 1)



Bending moments M (scaled up 50.0 times) (Time 18.31×10^3 day)

Maximum value = 5.664×10^{-3} kN m/m (Element 4 at Node 105)

Minimum value = -0.01258 kN m/m (Element 1 at Node 1)



Cartesian effective stress σ'_{yy} (scaled up 0.500×10^{-3} times) (Time 18.31×10^3 day)

Maximum value = -2006 kN/m²

Minimum value = -3317 kN/m²

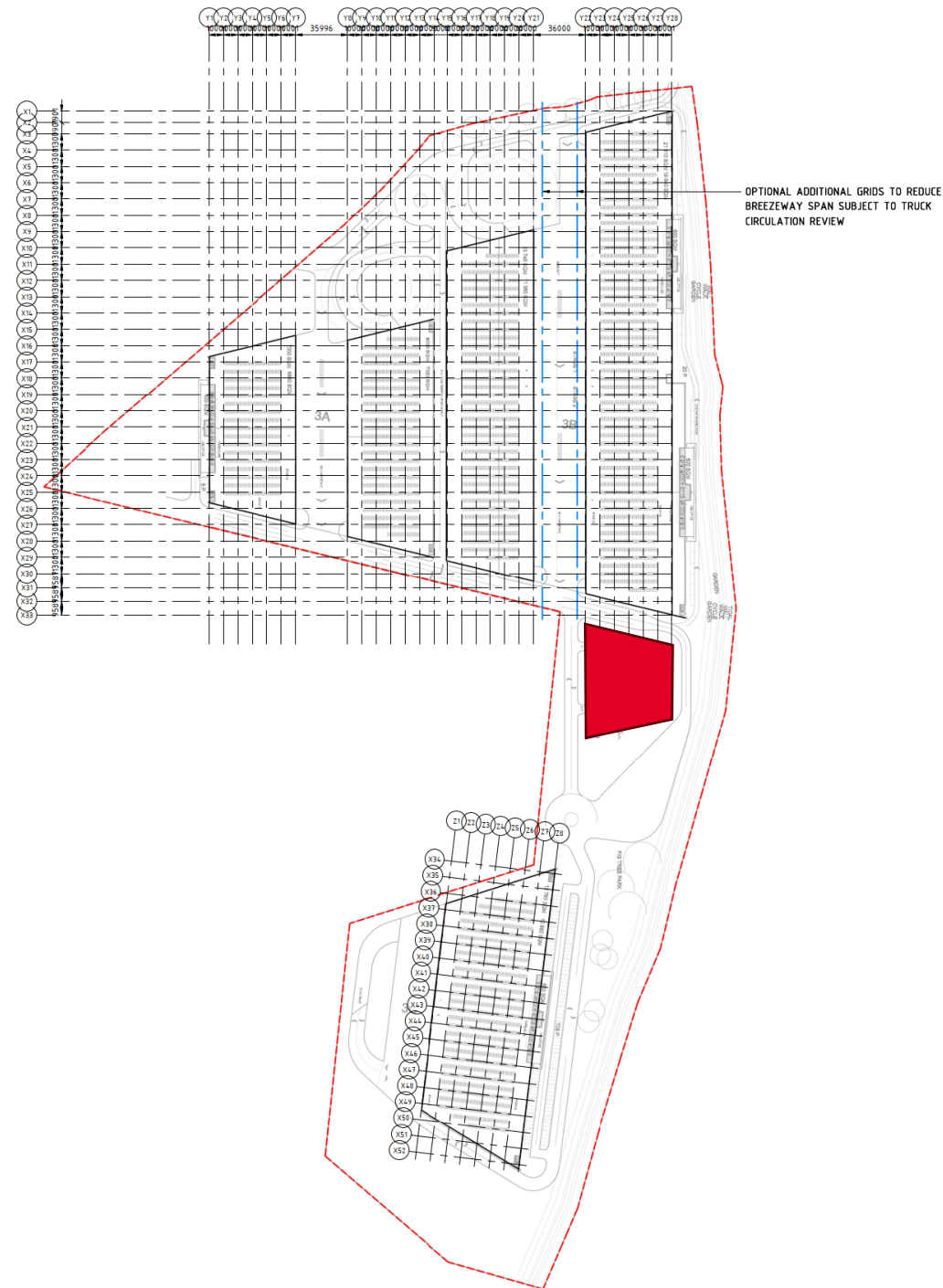
- ⊕ CMCs are anchored in MD Sand, ~ 5.5m length
- ⊕ 1.6m c/c, $\varnothing 280$
- ⊕ LTP 0.4m



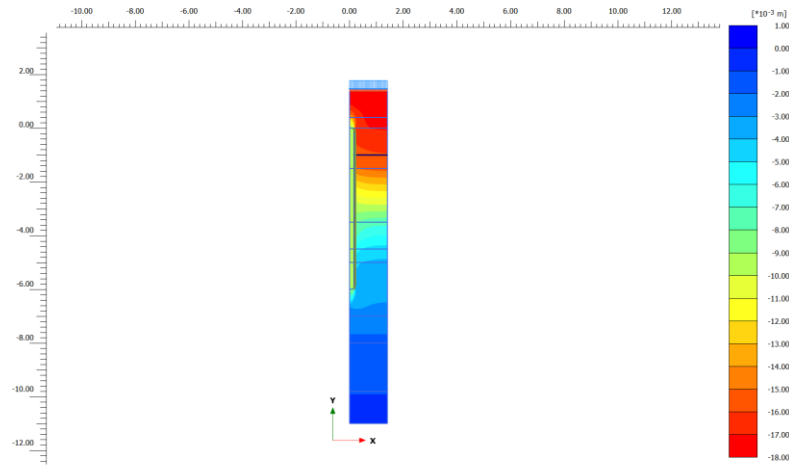
Car Park

~4247 m²

CMC

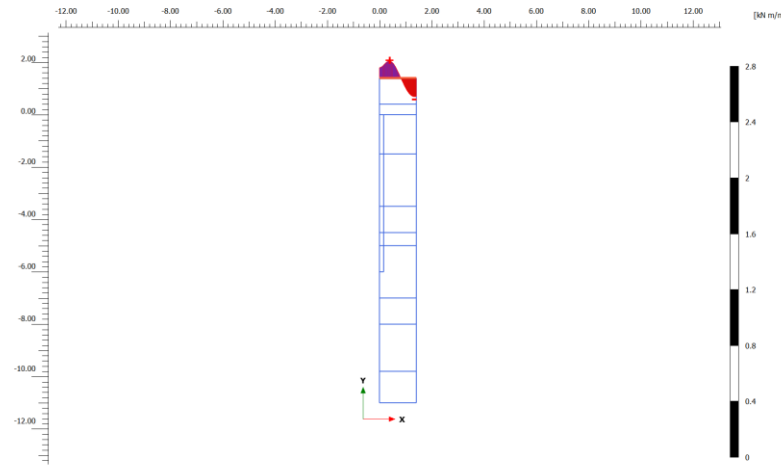


● Car Park: Total Settlement < 25mm



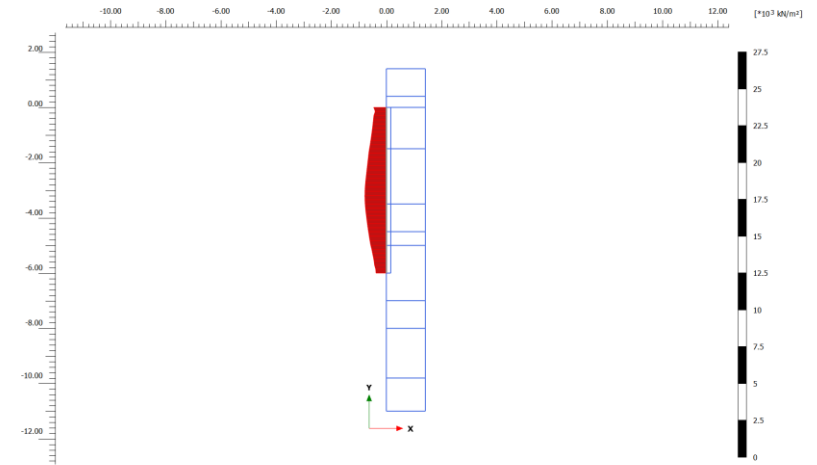
Total displacements u_y (scaled up 20.0 times) (Time $18.31 \cdot 10^3$ day)

Maximum value = 0.000 m (Element 1278 at Node 11823)
Minimum value = -0.01764 m (Element 57 at Node 193)



Bending moments M (scaled up 5.00 times) (Time $18.31 \cdot 10^3$ day)

Maximum value = 0.1299 kN m/m (Element 3 at Node 2)
Minimum value = -0.1426 kN m/m (Element 9 at Node 195)



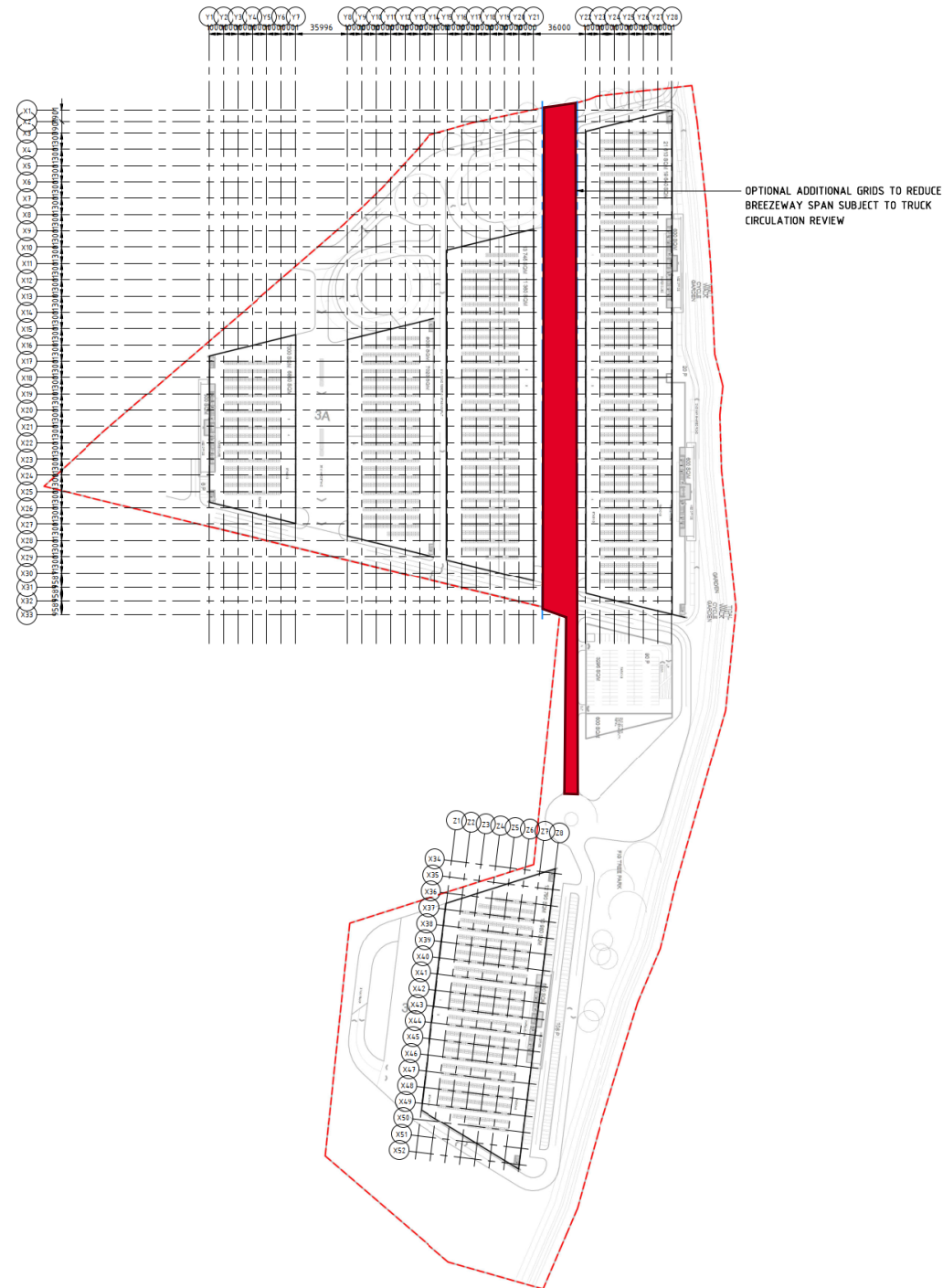
Cartesian effective stress σ'_{yy} (scaled up $0.500 \cdot 10^{-3}$ times) (Time $18.31 \cdot 10^3$ day)

Maximum value = -755.8 kN/m²
Minimum value = -1559 kN/m²

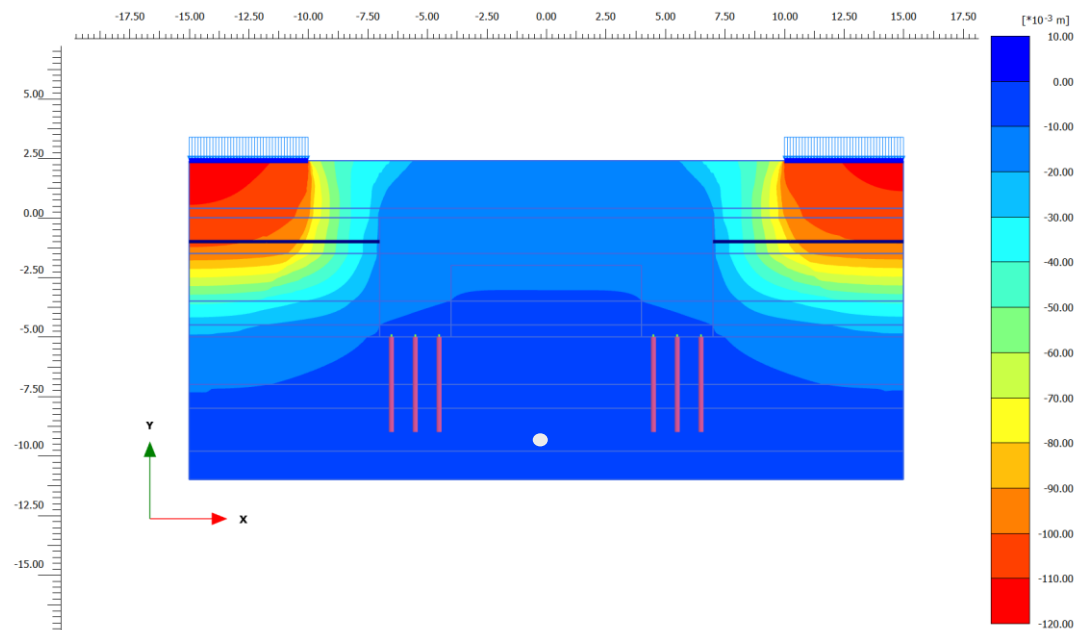
- ⊕ CMCs are anchored in MD Sand, ~ 6m length
- ⊕ 2.5m c/c, Ø320
- ⊕ LTP 0.4m
- ⊕ Raft of 0.4m thickness
- ⊕ Total loading of 30 kPa



CMC + MSM



● Movement

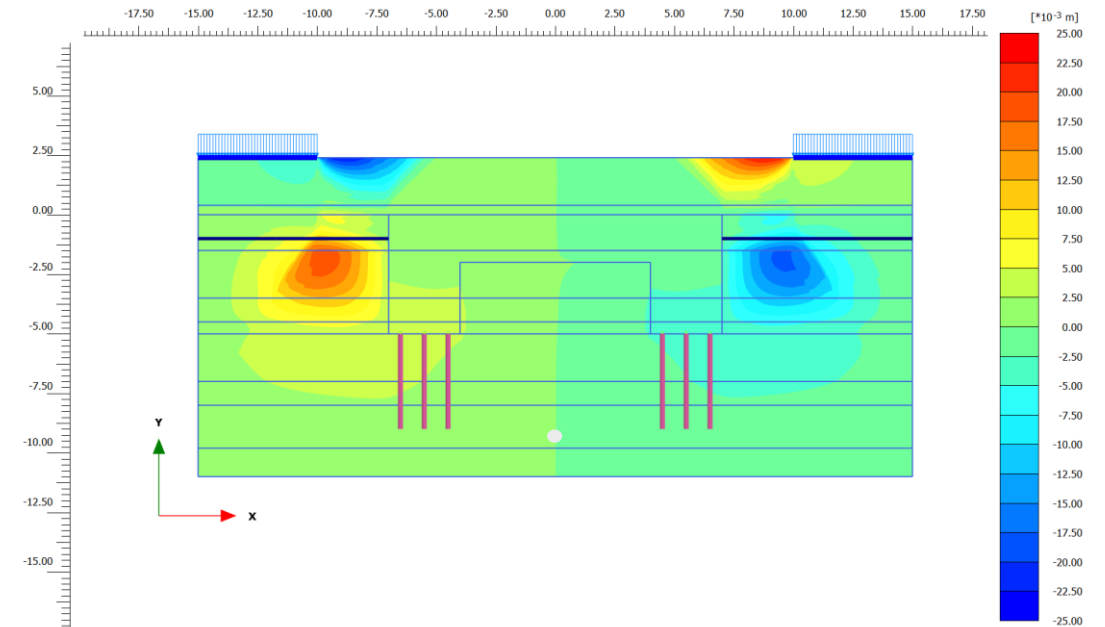


Total displacements u_y (scaled up 5.00 times)

Maximum value = 0.000 m (Element 3064 at Node 26831)

Minimum value = -0.1131 m (Element 451 at Node 17063)

Maximum Settlement of the soil above the desalination pipe level ~2mm



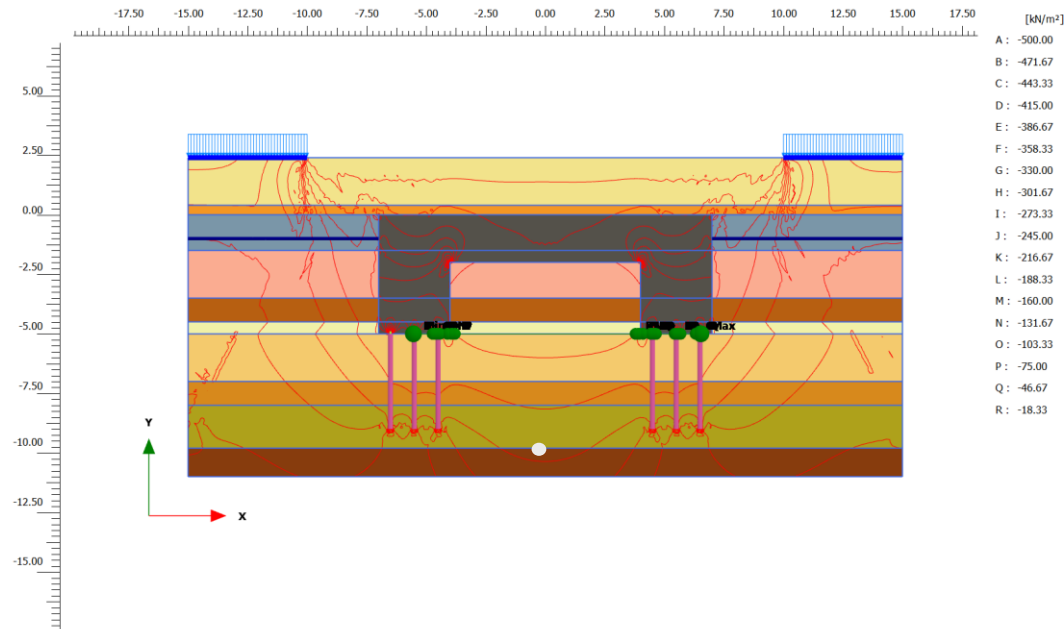
Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.02350 m (Element 84 at Node 2319)

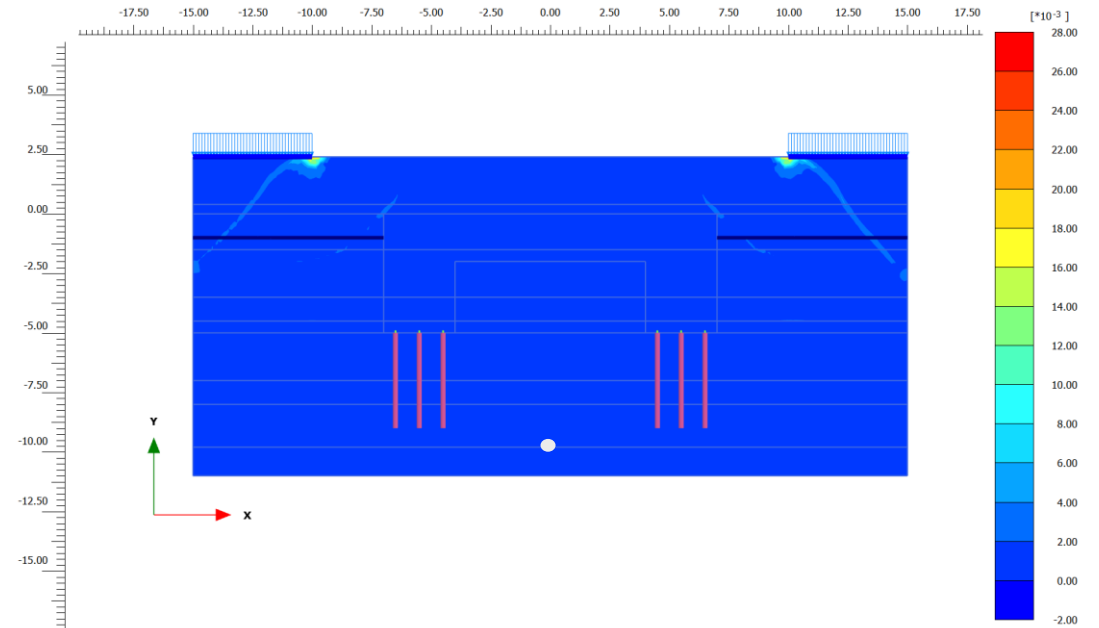
Minimum value = -0.02258 m (Element 16 at Node 16521)

Maximum lateral movement of the soil above the desalination pipe level ~1mm

● Concentration of Movement and FOS



Concentration of the Stress away of the pipe



FOS ~ 2.2 (Long Term)

- **Program (3C; 3B; 3A; Hardstand; Car Park; CMC for Bridging, Design & Additional Soil Investigation)**

Please refer to the
Menard Offer Letter
for pricing details.

- + 3 Rigs
- + ~ 4 Months



Low headroom rig at Sydney Gateway



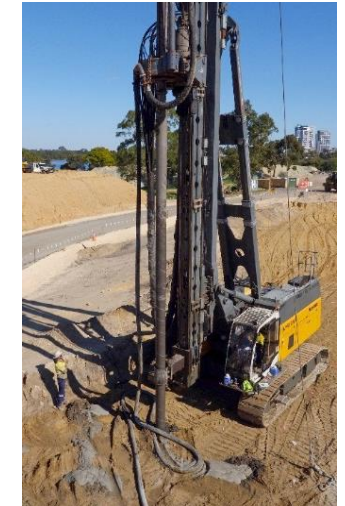
LIEBHERR LRB255

300kPa bearing pressure



LIEBHERR LRB155

275kPa bearing pressure



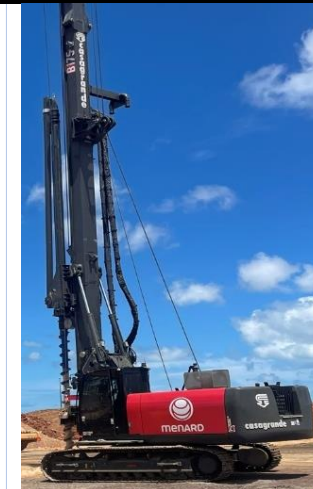
LIEBHERR LB24

275kPa bearing pressure



CASAGRANDE B250

300kPa bearing pressure



CASAGRANDE B175

250kPa bearing pressure



BAUER BG15H

250kPa bearing pressure

• Proposed Sequence

Step 0: Initial conditions



Step 1: Excavation (strip of 300mm top soil)

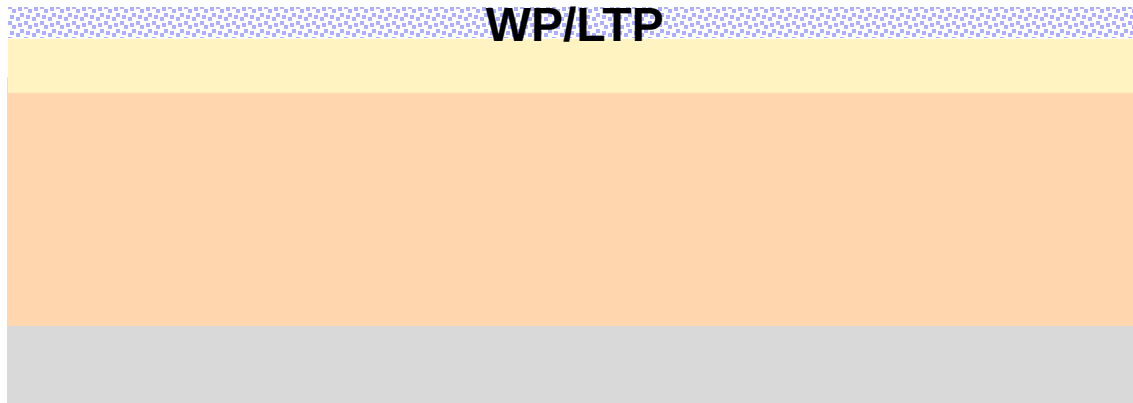


Task: Menard or Others

● Proposed Sequence

Step 2: Install working platform

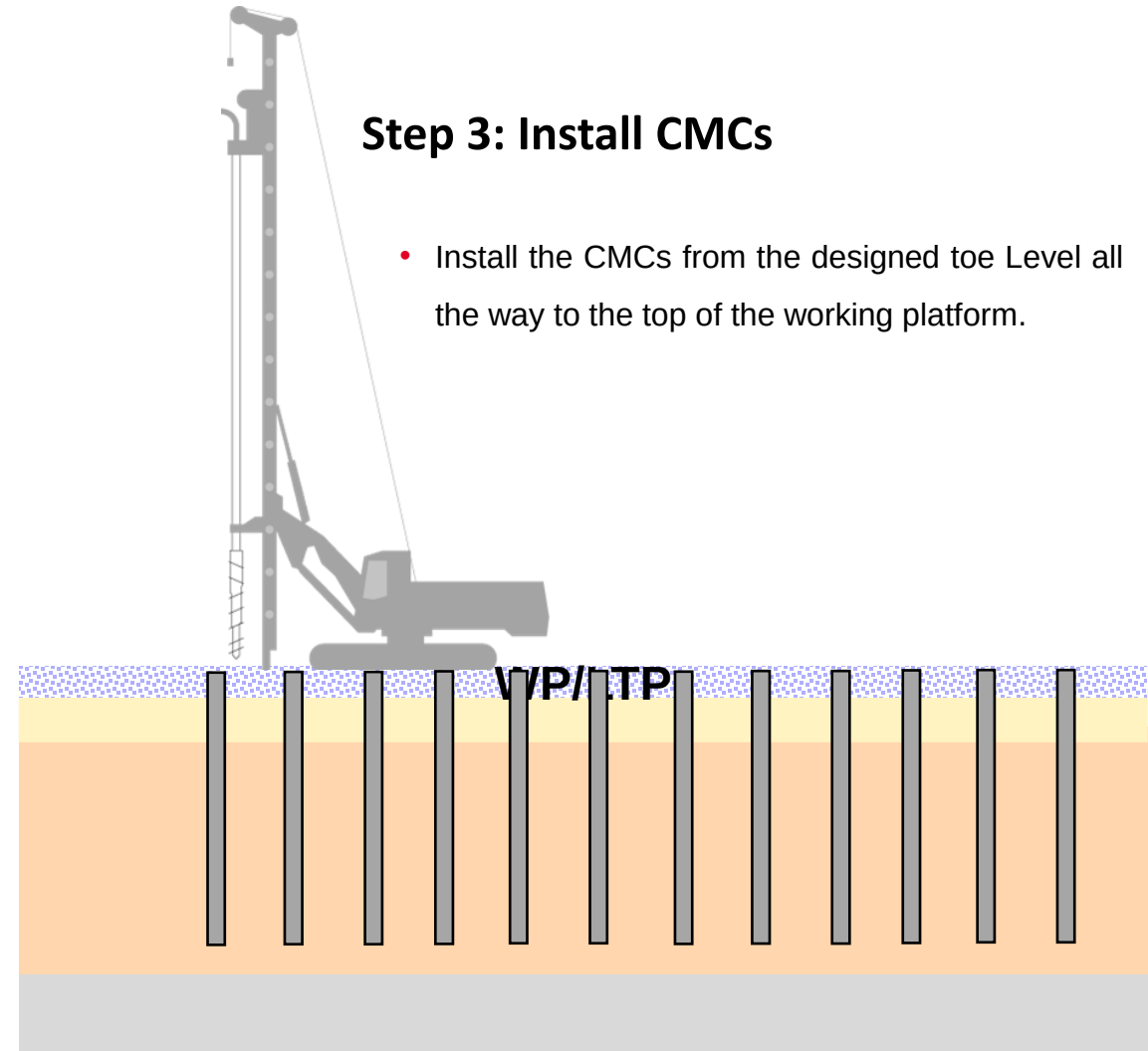
- If the WP includes the same material as the LTP, it can be used as LTP.
- Piling Rig bearing pressure ~ 275 kPa
- Excavator mounted auger ~ 150 kPa



Task: Menard or Others

Step 3: Install CMCs

- Install the CMCs from the designed toe Level all the way to the top of the working platform.

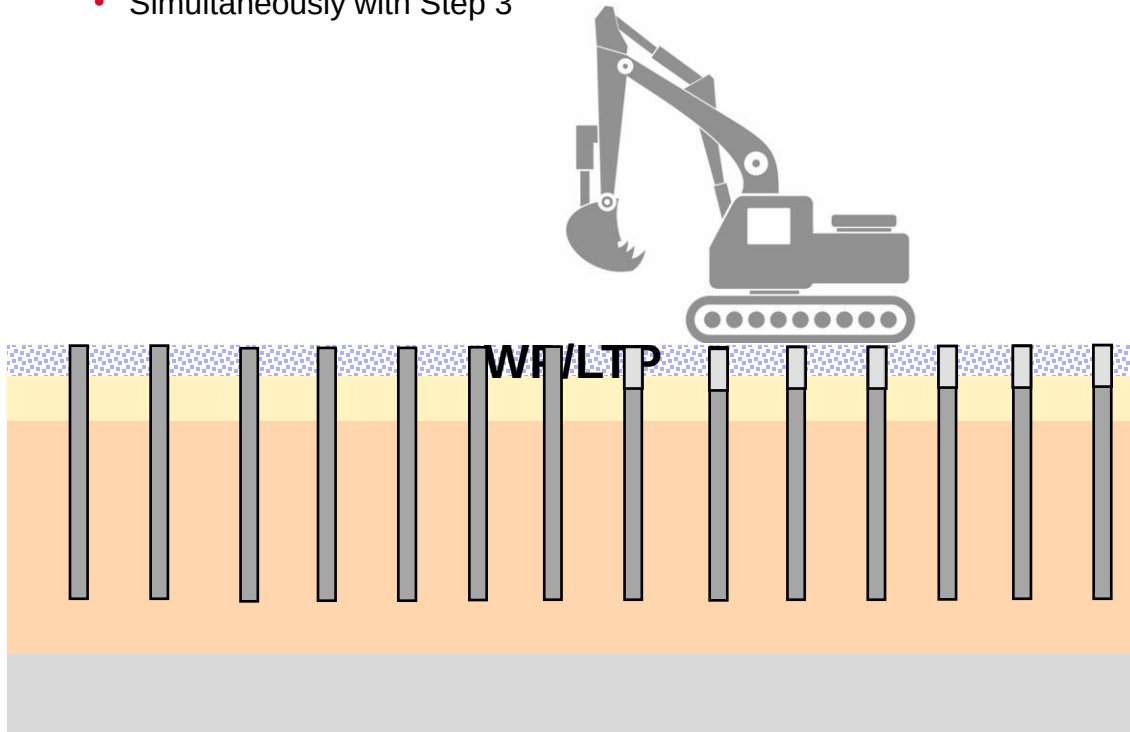


Task: Menard

• Proposed Sequence

Step 4: Post-Cut CMCs

- Post-cut the CMCs to their final cut-off level, using an excavator while the concrete is still fresh.
- Simultaneously with Step 3

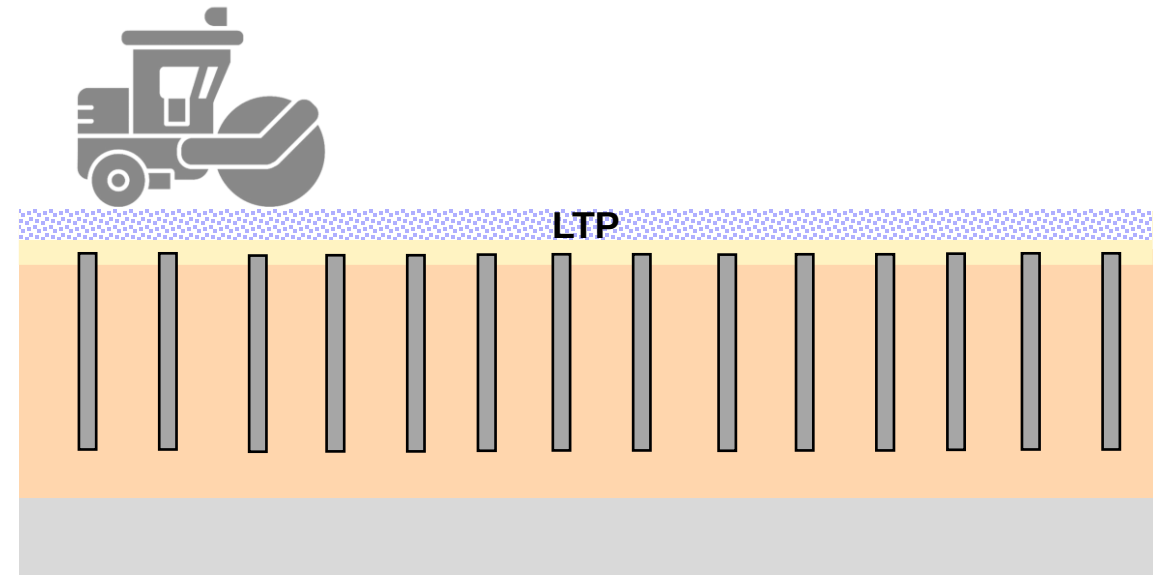


Task: Menard

Step 5: Compacting WP → LTP

LTP material to be dense well graded aggregate made of inert, sound, durable particles of recycled concrete or crushed stone with the following properties:

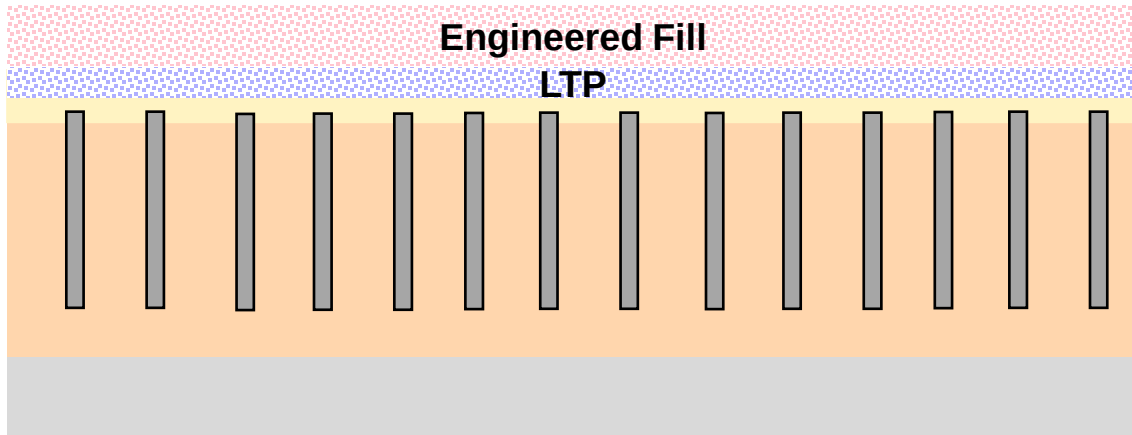
- effective internal friction angle of min. 38° at constant volume conditions
- the maximum particle size shall be limited to 75mm, 50% passing 19mm sieve and less than 8% passing 75 μ m sieve
- average dry unit of density of 2t/m³



Task: Menard or Others

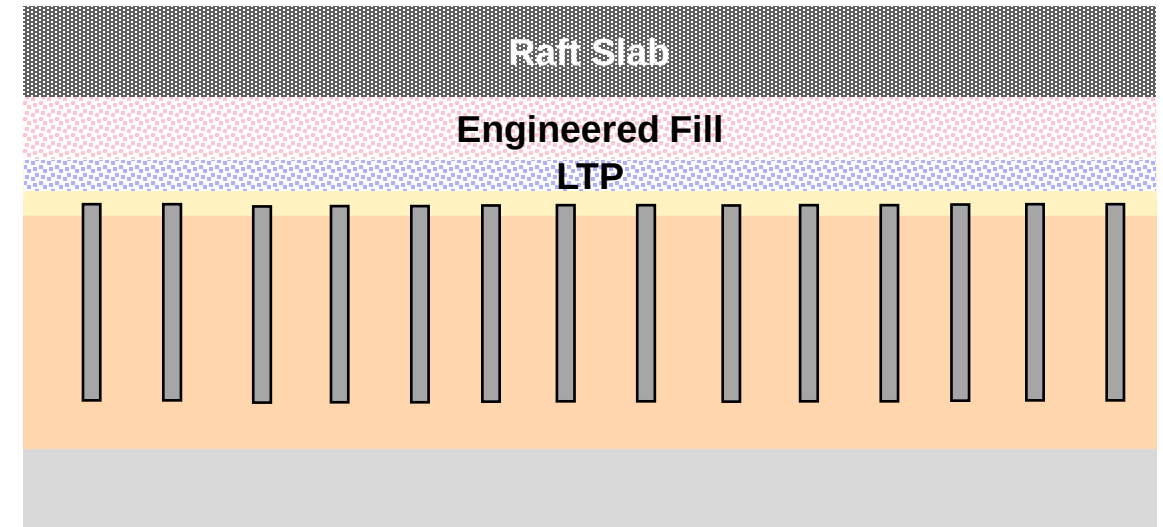
● Proposed Sequence

Step 5: Install Engineered Fill up to the FSL



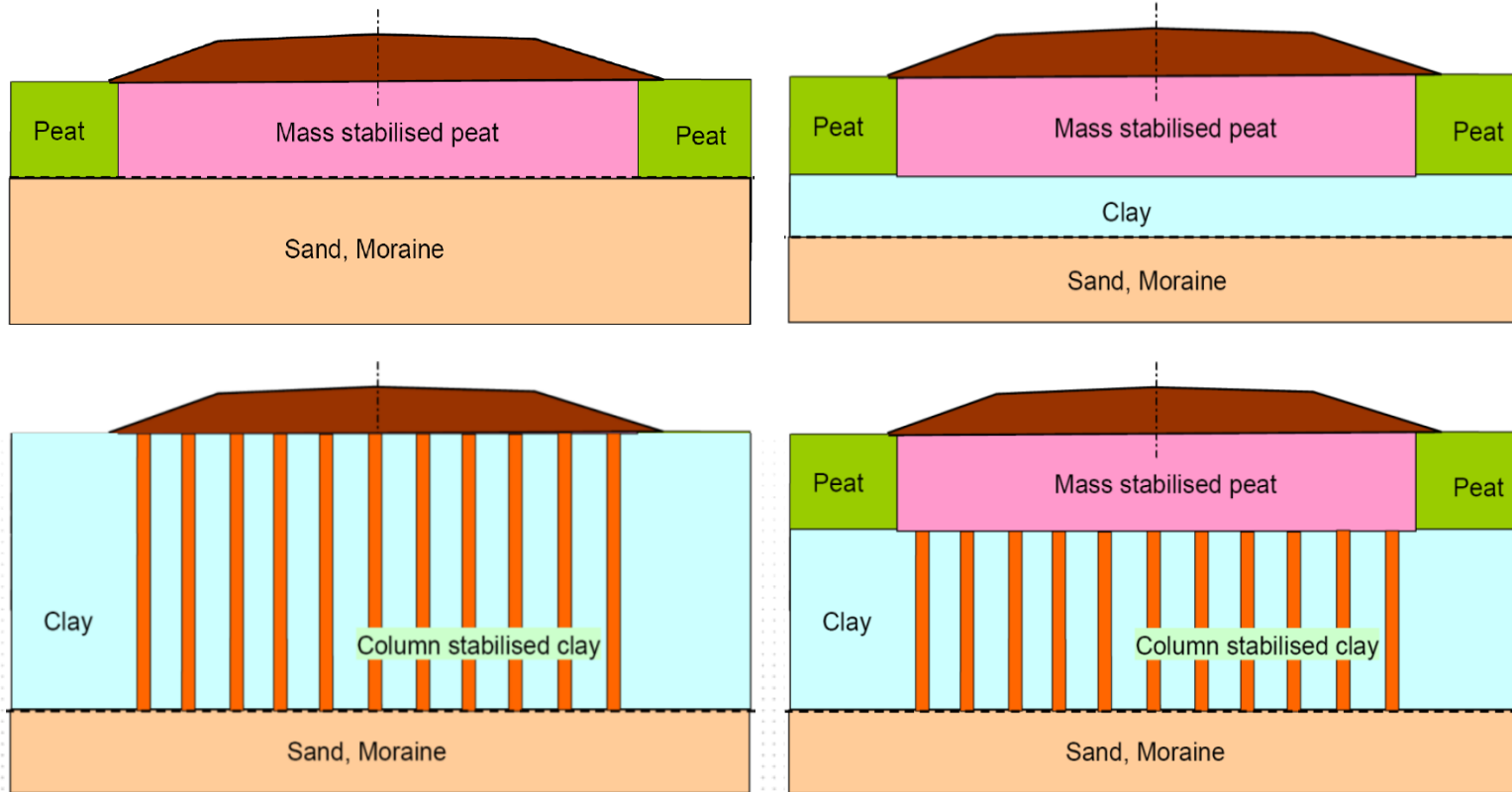
Task: Menard or Others

Step 6: Install the structures



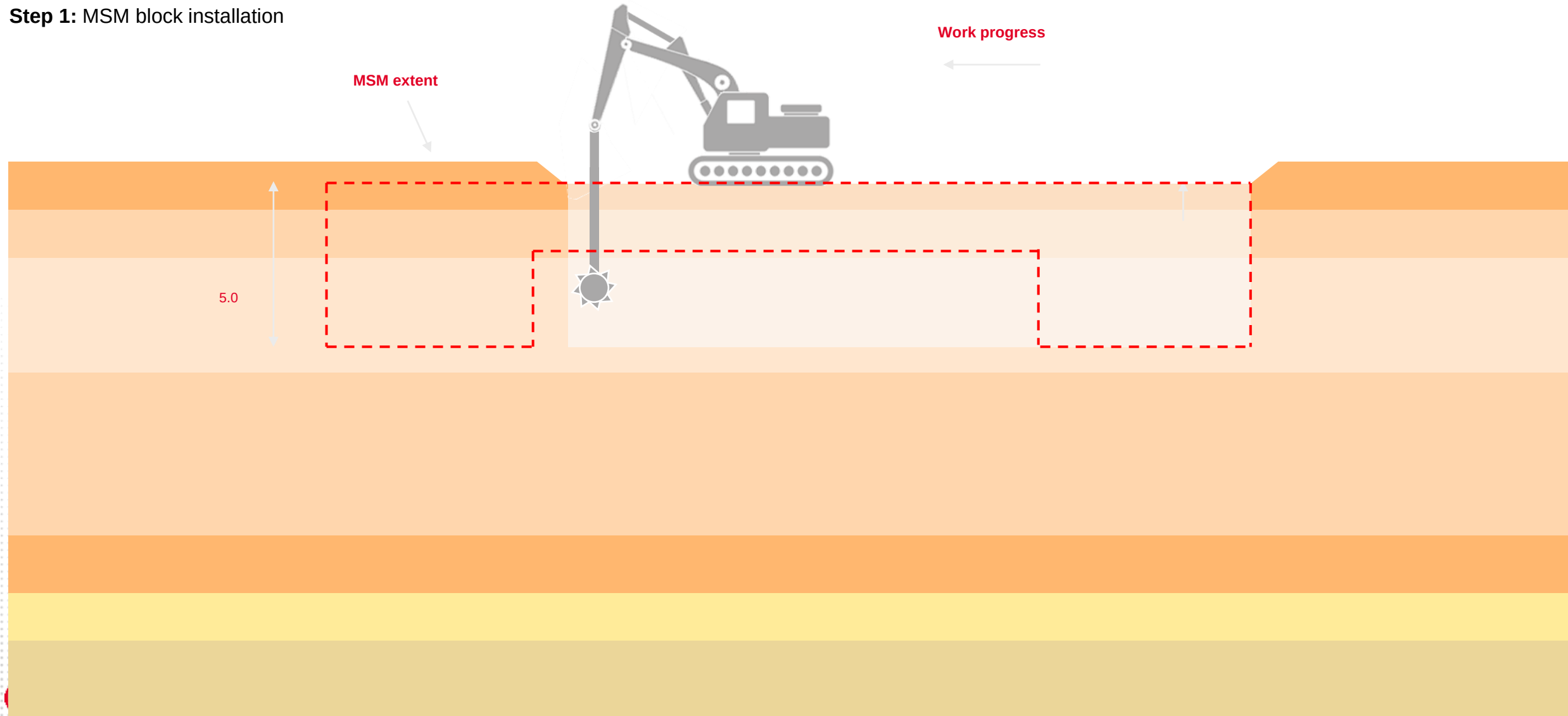
Task: By others

• Hybrid Solution (CMC under Soil Mixing Block)



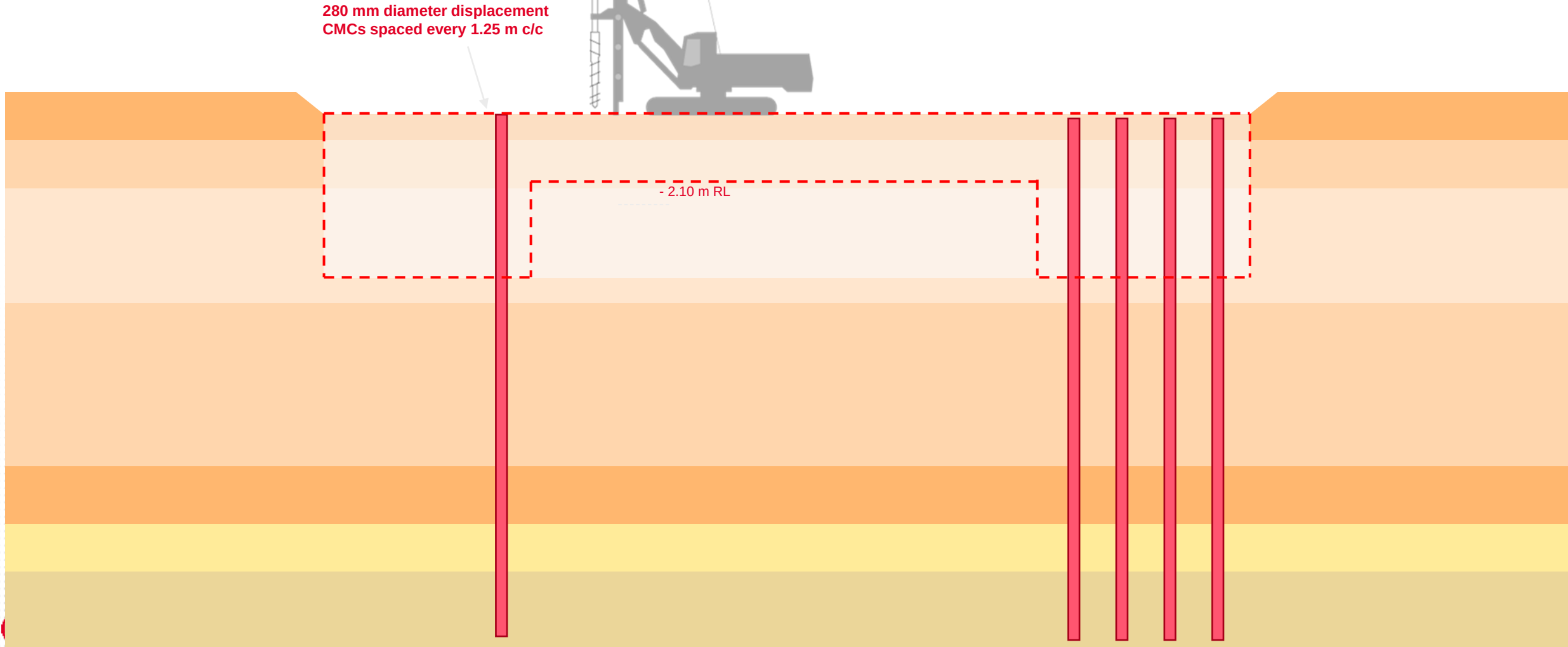
• Construction sequence: step 1

Step 1: MSM block installation



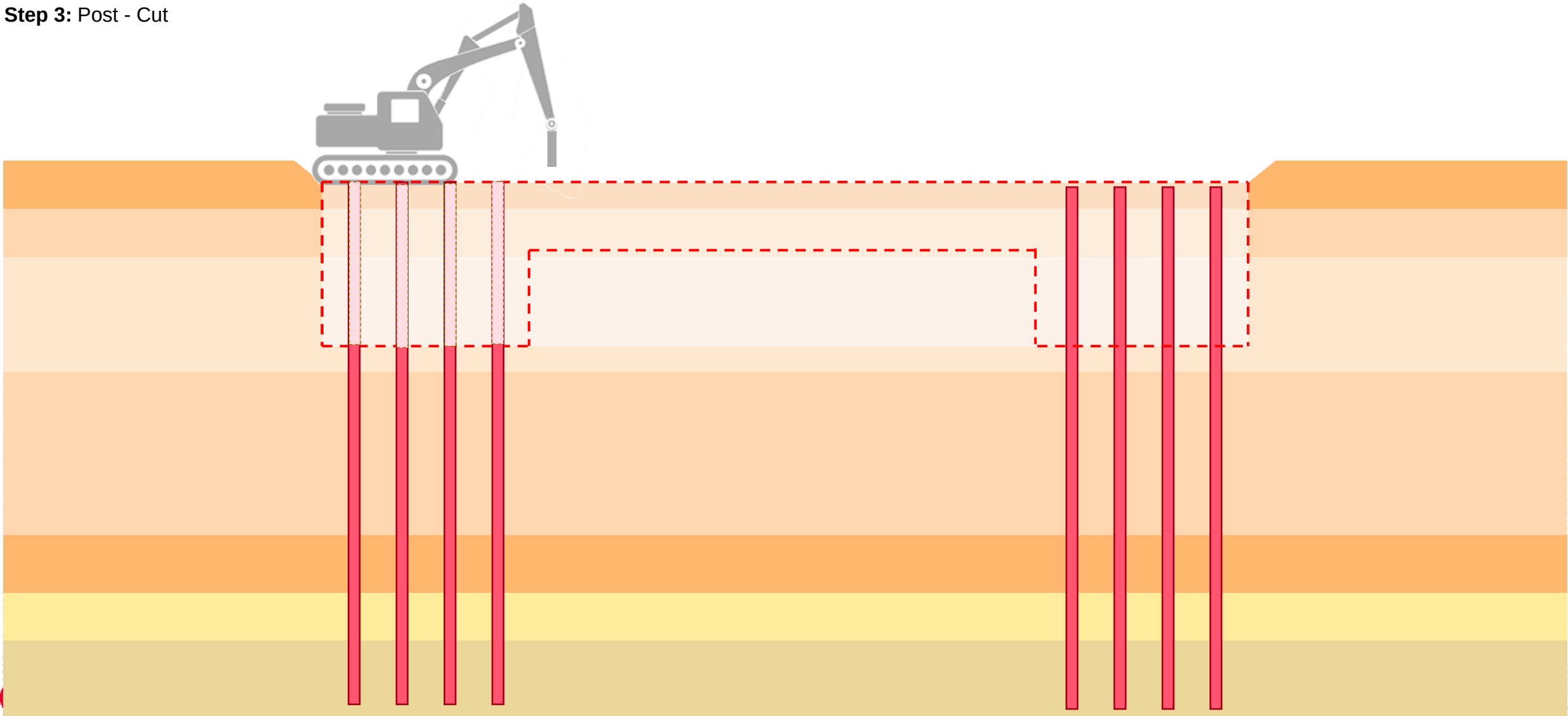
• Construction sequence: step 2

Step 2: CMC installation



• Construction sequence: step 4

Step 3: Post - Cut



- **Construction sequence: step 5**

Step 4: Final Product

