

7 June 2019

Dwayne Roper
Director
Zariba Holdings Limited
715 Cameron Road
Tauranga South
Tauranga 3112

Dear Dwayne

Re: Timber pole retaining wall design and Specific requirements for building on Lots 439-444, Stage 3D, Terrace Views Subdivision, Papamoa, Tauranga

1 Introduction

Zariba Holdings Limited have commissioned Aurecon NZ Ltd. to design a continuous timber pole retaining wall to support residential development on Lots 439 to 444 (herein referred to as 'the site') within Stage 3D of the Terrace Views subdivision, Papamoa, Tauranga. The design detailed within this report is for 'Wall 1' which retains the northern area of development within Lots 439 to 444 (inclusive), and ranges in retained height from 0.5m to 1.8m. The total proposed length of the wall is 78m.

A report titled, "Parton Road Residential Subdivision – Geotechnical review of landform design and suitability for residential subdivision"¹, dated 29 January 2016, was originally prepared by Aurecon, providing information on the original geotechnical investigation completed and subsequent assessment of suitability for proposed residential development.

Aurecon's subsequent Geotechnical Completion Report (G2) for Stage 3D-E², dated 7 March 2019, documents the earthworks completed and certification to inform the development of buildings at the site. Due to space limitations, Lots 439-444 (inclusive) were designated as specific design. This was due to the buildings needing to extend over the crest of the existing 1V:3H slope and therefore requiring the construction of retaining walls, which may impact the stability of the slope. Consideration was also needed given the potential risk of future earthworks on the adjacent property undermining future walls within the lots.

This report describes the design of a timber pole retaining wall and specific requirements for building on Lots 439 to 444. Attached to this report are the following:

- Safety in Design Summary;
- Aurecon drawings:
 - Timber pole retaining wall design (247593-0009-DRG-G-0020-A);
- Lysaght drawings:
 - Sketch Retaining Wall Plan (Lysaght ref: 152870-SKT-090);
 - Boundary Interface Cross Sections Lots 439-444 (Lysaght ref: 152870-LOTS 439-444, rev 2)
- Geotechnics Lot by Lot Hand Auger logs (Lots 439-444);

¹ Aurecon, 247593 – Parton Road Residential Subdivision – Geotechnical review of landform design and suitability for residential subdivision, rev 1 dated 29 January 2016

² Aurecon, 247593 – 320 - Stage 3D-E Geotechnical Completion Report, rev 3. Dated 7 March 2019

- Perry Geotech Cone Penetration Tests (conducted during the Suitability for Subdivision and Stage 3C GCR reporting)
- Design Calculations;
- PS1 Designer Producer Statement.

Our PS1 Designer Producer Statement does not reference Clause B2 of the Building Code, Structural Durability. We are not able to provide this because there is not an effective verification method for B2 contained within the Building Code. However, we can confirm that the structural timber elements shown in our documentation have treatment selected in accordance with B2/AS1 and NZS3602:2003³.

This report will also provide foundation recommendations for buildings constructed above these retaining walls. We also understand that the dwellings will consist of single storey light-weight timber structures designed in accordance with NZS:3604 (2011)⁴

2 Design Assumptions

The following design assumptions have been made for Wall 1:

2.1 Ground Conditions

Three Cone Penetration Tests (CPT) have been conducted near the site during the suitability for subdivision phase, prior to construction. An additional two CPTs has been conducted adjacent to Lot 439 during the post-construction verification of Stage 3C earthworks as part of the Stage 3C GCR⁵. Six hand auger borings and 12 Dynamic Cone Penetration (DCP) tests were conducted during the lot by lot testing across the six lots (Lots 439-444) during the Stage 3D-E GCR. All reference geotechnical testing can be found attached.

The retained soils will comprise of engineered fill (pumice sands) and in-situ dune sands (starting at an elevation of 2.7 m RL). The foundation soils are expected to consist of medium dense to dense insitu dune sands. The proposed wall is to be built two metres away from peat within the adjacent property. Though we have designed this wall such that the peat deposits are not relied upon for passive support, it is our understanding this material may be undercut in the future during the development of the adjacent property. It is the responsibility of the developer of the adjacent land to ensure the design timber pole walls within this report are not undermined. The walls have been designed with the soil parameters outlined in Table 1.

Table 1: Design Soil Parameters

Soil Type	Unit Weight (kN/m ³)	Friction Angle (°)	Cohesion (kPa)	Su (kPa)	τ/σ Ratio	Min Strength (kPa)
Engineered Pumice Sand Fill	15	33	5	--	--	--
In-situ Dune Sands	17	32	0	--	0.1	7.2
Peat	11	23	5	15	--	--

³ NZS3602:2003 (2003) Timber and Wood-based Products for Use in Building. New Zealand

⁴ NZS3604:2011 Timber Framed Buildings

⁵ Aurecon, 247593 – 316 Stage 3C Geotechnical Completion Report, rev 0. Dated 14 November 2018

2.2 Groundwater Conditions

This design does not consider groundwater pressures acting within the active wedge of the wall. However, the foundation poles will be found below the groundwater level (2.7mRL). The wall has been designed to account for hydrostatic porewater pressures within the foundation. This design also relies on effective operation of installed wall drainage to ensure porewater pressure does not build up within the retained material. If groundwater is encountered higher than anticipated (2.7mRL), Aurecon should be notified to adjust the design accordingly.

2.3 Surcharge

Wall 1 is designed for a nominal 5 kPa surcharge at the proposed position of any residential development to simulate a one-storey residential building which is proposed to be at least 2m away from the edge of the lagging. The wall is designed using active earth pressures and thus might deflect by 2% of the wall height in the long-term life of the wall.

2.4 Wall Geometry

The ground above the wall is flat-lying to accommodate a building platform for residential development within each of the six lots (Lots 439-444). The ground below the wall is sloping downwards with a maximum slope angle of 18.5° (1V:3H). Passive support of the wall has been excluded for any material above the toe of the downslope side. All levels at the base of the wall have been surveyed and provided by Lysaght Consultants, shown on Lysaght drawing ref: 152870-LOTS 439-444. For more details on the overall design of the wall, refer to drawing 247593-0009-DRG-G-0020-A for the wall cross section design drawing.

2.5 Wall Type

The wall consists of cantilevered timber poles, with timber laggings. Pole borings will be augered through the engineered fill to provide pilot holes for subsequent vibratory driving of the timber piles into the dune sand to the target founding depth. As the pilot holes will be no greater than the SED of the timber poles, voids are not expected, however where any void space is observed this will be filled with pourable cement grout.

2.6 Load and Resistance Factors

The following design factors have been applied:

- Load factor for lateral active earth pressure = 1.6;
- Strength reduction factor on soil capacity: = 0.5.

2.7 Timber Strengths

The following timber strengths have been adopted in accordance with NZS 3603:1993 (Standards New Zealand 2003):

- Pole bending strength = 38.0 MPa (Normal density round softwood timber in green condition);
- Pole shear strength = 3.1 MPa (Normal density round softwood timber in green condition);
- Lagging flexural strength = 11.7 MPa (SG8 timber in green condition).

3 Load and Resistance Factored Design Calculations

3.1 Timber Pole Sizing

Retaining wall design sizes have been calculated to address the proposed range of retained heights and design assumptions. The design calculations were prepared using an Aurecon-developed MathCAD spreadsheet, based upon the New Zealand Building Code and Broms equations⁶. The design calculations can be referenced within the attachments. The designed wall heights and timber specifications are outlined in Table 2. In the case that timber poles are not available in a size as shown in Table 2, the next larger size should be adopted.

Table 2: Summary of Timber Pole Retaining Wall Design

Max Retained Height (mm)	Pole Small End Diameter (mm)	Pole Spacing (mm)	Pilot Hole Diameter (mm)	Embedment Depth (mm)	Lagging Thickness (mm)
1000	200	1000	100	2000	150 x 50
1800	325	1000	200	3500	150x100 (double lagged) (150x50 for upper 1.0m)

3.2 Slope Stability Analysis

A limit equilibrium slope stability analysis was conducted on the designed wall through the cross-section of Lot 442. The cases analysed, and results of the analysis are outlined in Table 3. The results of each case modelled is attached to this report attachments.

Table 3: A summary of the limit equilibrium slope stability analysis undertaken at Lot 442.

Slope Stability Case	Required Factor of Safety	Achieved Factor of Safety
Static	1.5	1.82
Static with high groundwater level	1.2	1.85
ULS Seismic	1.0	1.23

4 Construction Drawings

Drawings of the wall layout, wall elevation, design section (including construction specification), and landform of the lot are attached.

5 Wall Drainage

The wall drainage is shown on drawing 247593-0009-DRG-G-0020-A. It will comprise of 300mm of approved drainage metal wrapped with a BIDIM A19 (or similar approved) Geotextile behind the wall. The base of the wall will contain 40mm diameter weep holes spaced at intervals of 1.0m at the centre of the first row of exposed lagging between piles. The weep holes will drain into an existing drainage gully at the property boundary as per Lysaght's long-section drawing (Lysaght ref: 152870-SKT-090).

⁶ Ministry of Business Innovation and Employment (2018) B1 Structure. New Zealand

6 Excavation Restriction

Excavation deeper than 300 mm should not occur within 500 mm of the edge of the lagging in order to prevent any damage to the drainage metal.

7 Peat Undermining

It is understood the adjacent Blokarts land will likely be developed after the construction of the foundation walls. This development may require the undercut and removal of peat and replacement with engineered fill to raise the land to minimum development levels. The future developer of this land will have a duty of care to minimise risk of instability to the Terrace Views embankment and retaining structures.

To minimise any risk associated with undermining, the maximum founding levels of the retaining wall footing were determined based upon the walls inability to surcharge nor rely on the peat in the adjacent property for any support.

8 Fall Protection Barriers

It is recommended that a permanent fall protection barrier be consented and constructed as part of the residential development after the completion of construction of the proposed retaining wall. The design of this permanent fall protection barrier lies outside of the scope of this report. Until a permanent barrier is constructed, a temporary barrier will be constructed and in place.

9 Construction Considerations

9.1 Construction Method

We have assumed construction staging will follow the steps outlined:

- Auger drilling of the pilot holes and driving of timber poles through the dune sand to the design specification
- Placement of lagging and free draining backfill placed down to the existing ground surface;
- Backfilling with engineered fill and compaction to the design specifications.
- Construction of a fall protection barrier to accommodate temporary works during residential development.

9.2 Compaction Specifications and monitoring

The engineered fill material assumed in the design consists of pumice sands fill material, source from the same quarry as the rest of the Terrace Views Subdivision. This material needs to be engineered in accordance with the fill specifications outlined on drawing 247593-0009-DRG-G-0020-A. This specification outlines subgrade preparation including benching, fill placement, and compaction testing. It is noted a temporary fall protection barrier will be required during construction of the retaining wall.

9.3 Construction Monitoring

Construction monitoring by a geotechnical engineer from Aurecon is required during construction of all retaining walls. The engineer shall be notified at each of the following construction hold points to allow inspection before construction may progress:

- Timber inspection and trial of pilot holes and timber pole driving to confirm methodology;
- Inspection of lagging and drainage metal;
- Inspection of fill earthworks:

- strip topsoil;
- observe placement of fill;
- receive and certify QA testing provided by contractor.
- Final inspection, fill certification, and testing of building platform prior to construction demobilisation.

Note: the construction contractor should notify Aurecon if there are any changes to ground conditions or wall requirements assumed within the design. The installation and certification of the fall protection barriers shall be undertaken by others.

9.4 Post Construction

A PS4 producer statement will be issued by Aurecon following the completed construction of the retaining wall and upon receipt of the contractor's PS3 producer statement. These certificates will be supplied to Tauranga City Council as part of the code of compliance certification under the building consent.

10 Specific Requirements for Building - Lots 439 to 444

The suitability of Lots 439 to 444 for building is contingent on the following specific requirements being included in the planning, design and construction of dwellings and any other structure requiring a building consent under the Building Act 2004.

MBIE Guidelines 'TC2' building foundations

Building platforms for the proposed dwellings on Lots 439 to 444 are expected to be positioned over engineered fill either already placed and certified as part of the original Stage 3D-E earthworks completion or placed as part of the proposed retaining wall construction within these lots. Due to the liquefaction induced settlements predicted to occur within these lots, it is considered that the soils do not meet the definition of 'good ground' in accordance with NZS3604:2011.

In accordance with Table 5.1 within Module 3 of the MBIE guidelines the site effects from excess pore water pressure and liquefaction is assessed to be 'L3 - High' under ULS conditions. The ULS liquefaction induced settlements are predicted to range up to 205mm.

In accordance with Module 4 of the MBIE guidelines⁷, for cases where the predicted effects are deemed to be intolerable (L3 or higher), it is necessary to consider options for either ground improvement or the use of robust raft foundations, or deep foundations. We consider that the most practicable solution for this site is to specify robust raft foundations.

We have assessed the type of raft foundation system using the general guidance provided in the MBIE guidelines for repairing and rebuilding houses affected by the Canterbury earthquakes⁸. In consideration of the predicted liquefaction settlement and thickness of the non-liquefiable crust, we classify the site as Technical Category 2 (TC2) in accordance with this guideline.

Specific engineered design of a MBIE 'TC2' foundation is required for all residential buildings constructed on the subject lots with Stage 3D and 3E. Section 5.5.1 provides further discussions of TC2 foundation options/types.

⁷ New Zealand Geotechnical Society (NZGS) and Ministry of Business Innovation & Employment (MBIE), Earthquake geotechnical engineering practice; Module 4; Earthquake resistant foundation design; Revision 0 November 2016

⁸ MBIE, Repairing and rebuilding houses affected by the Canterbury earthquakes; Version 3, December 2012

Foundation Bearing Capacity

An ultimate bearing capacity of 300 kPa may be adopted for design of shallow foundations in accordance with NZ3604:2011⁹. This bearing capacity should be confirmed by a TCC Category 1 Geo-professional as part of the proposed retaining wall and earthworks, and shall be multiplied by the following reduction factors:

- SLS loading: 0.33
- ULS loading: 0.5
- Earthquake Loading: 0.7

Foundation requirements and inspections

Buildings will need to be flexible to withstand up to 25mm of differential settlement over a 6m length, as indicated by Appendix B section B1 of the NZ Building Code Handbook and Approved Documents.

As the site is not considered “good ground” as specified under NZS3604, the foundation formation is to be inspected by a suitably qualified and experienced geotechnical engineer prior to pouring the concrete. Foundations may need to be deepened or broadened or both should low strength soils be encountered during excavation. All topsoil shall be removed from beneath building foundations and floor slabs prior to building.

Building Foundation Offsets from Retaining Walls (all lots)

The retaining walls have been designed to accommodate a building surcharge from a lightweight, single storey timber framed dwelling as specified under NZS3604. A minimum setback of 2 metres from the edge of lagging is recommended for future dwellings.

Minimum building platform and finished floor levels (all lots)

The minimum building platform level for any structure requiring a building consent in accordance with RC26514 is set at +5.1mRL (Moturiki Datum). The finished ground level (which equates to the building platform level) on all subject lots varies between +5.10mRL and +6.0 mRL based on the as-built finished landform survey provided by Lysaght.

Where topsoil is encountered during construction, undercut and replacement with engineered fill will be required to achieve the minimum finished floor level. Please refer to Section 6.2 of the Stage 3D-E GCR for details on floor levels required to mitigate flood hazard.

On-site disposal of stormwater

The stormwater collected on all subject lots (Lots 439 to 444 inclusive) is to be disposed of via in-ground soakage.

The ground comprises predominantly pumice sand, fine to medium grained dune site-won sand fill, and natural cut sands. Stormwater disposed of via in-ground soakage will be reticulated within the natural dune sand material. Soakage testing was carried out by Aurecon for Stage 3D and 3E to determine the permeability of the ground to derive recommended design soakage rates.

The soakage test assessment report prepared by Aurecon is included with the Civil Asset Completion Report prepared by Lysaghts. Specific requirements for the design and construction of the soakage system are provided by Lysaght in the Terrace Views Subdivision Stage 3D-3E Civil Asset Completion Report.

⁹ NZ3604:2011 Timber Framed Buildings

The distance of foundation construction to the soak hole rings or ATLANTIS® FLO-TANK® crate system is dependent on the depth of the soak holes. The following formula should be used to determine the building foundation offset distance:

Offset distance = $D \div \sqrt{3}$, where D is the depth to base of the soakage measured from ground level.

Effluent disposal

Effluent disposal from all lots is to be piped via the established reticulation system provided at the boundary of each lot. On-site disposal of effluent is not permitted.

General Recommendations for building and Advisory Notes

The reader is referred to the Stage 3D-E GCR for general recommendations and advisory notes for building.

11 Safety In Design

Safety in Design is a standard that integrates hazard identification and risk assessment early on within the design process. The application within this project is based on a risk management approach that defines control measures during construction, operations, maintenance, and demolition.

The safe design process is intended to increase the likelihood of project safety and to document the safe design work undertaken and record associated outcomes. We welcome any Client or Contractor comments on the anticipated risk or with the Safety in Design process. A Safety in Design register with anticipated control measures and actions is enclosed. The key construction issues that were identified as the having the highest risk and their control measure are as follows:

- Earthworks on a slope. Contractor should establish physical barrier for earthworks and limit vehicles and other plant on slopes to limit the possibility of a vehicle rolling down the hill, or a plant-induced slope failure.
- Open Augered Holes. The contractor should provide a physical barrier around augered holes that do not have a pole installed to prevent people from falling in the hole;
- Improper Manual Handling of Construction Materials. The contractor needs to ensure suitable and safe construction methodology is obeyed by workers;
- Collapse of wall or batter. The contractor vehicles/plant/machinery shall not be placed within 2m (the active wedge) of the wall during construction unless advised otherwise by an Aurecon geotechnical engineer. Plant shall also work at a safe distance behind the batter;
- Working with Plant. All people on site shall maintain eye contact with operator, wear PPE, maintain distance from machines. Contractor shall also provide proper signage and barriers where applicable.

12 Limitations

This report has been prepared in accordance with the design assumptions herein. The contents of the report are for the sole use of the client. No responsibility or liability will be accepted to any third party. Data or opinions contained within the report shall not be used in other contexts or for any other purposes without prior written agreement of Aurecon New Zealand Limited.

The design covered in this report is based on data collected at specific locations and by using appropriate investigation methods within the limits of specific site constraints. Only a finite amount of information has been collected to meet the specific financial and technical requirements of the client's brief and this report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it must be appreciated that actual conditions could vary from the assumed model.

Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. The contractors should perform any additional tests as necessary for their own purposes.

Subsurface conditions, such as groundwater levels, can change over time. This should be borne in mind, particularly if the report is used after a protracted delay. This report is not to be reproduced either wholly or in part without prior written permission from Aurecon New Zealand Limited.

Yours faithfully



Miles Buob
Geotechnical Engineer



Kushant Kishore
Senior Geotechnical Engineer



Benjamin O'Loughlin
TCC Category 1 Geo-professional

Enclosed:

- Wall 1 Safety in Design register
- Wall 1 Drawings
- Hand Auger Borehole Logs
- Cone Penetration Testing Logs
- Wall 1 Design Calculations
- PS1 Producer Statement

Safe Design Risk Register – Terrace Views Retaining Wall Stage 3D

Client	Zariba	Workshop Date	24-May-19
Stakeholders	Aurecon, Zariba, Contractors, Tauranga City Council.	Revision No.	Rev A
Meeting Attendees	Miles Buob, Kushant Kishore, Ben O Loughlin.	Project No.	247593
		Project Leader	BOL

Risk

Rating

Matrix

	Likelihood of occurrence				
	5 - Very likely	4 - Good chance	3 - Likely	2 - Unlikely	1 - Very unlikely
A - Disastrous	Extreme	Extreme	Extreme	Extreme	High
B - Critical	Extreme	Extreme	Extreme	High	High
C - Serious	Extreme	High	High	Moderate	Low
D - Significant	High	High	Moderate	Low	Low
E - Minor	Moderate	Moderate	Low	Low	Low

Notes:

- This risk register has been prepared to document hazards and risk treatments associated with project elements designed by Aurecon, including subconsultants where applicable.
- The full life cycle of the project has been considered including design, construction (and commissioning), operation, maintenance, modification and demolition phases.
- The risk register is focussed on hazards resulting from atypical features specific to the design. It is expected that risks associated with generic hazards (working at heights, excavations, etc) will be addressed by other stakeholders using appropriate risk management techniques during subsequent phases of the project.
- Residual risks which cannot reasonably be actioned by Aurecon during the design phase have been identified and require action by other stakeholders during subsequent phases of the project (e.g. construction, operations, maintenance, modification or demolition).
- This risk register does not replace the need for other stakeholders to complete their own hazard identification and risk assessment for the project (including the development of safe work procedures for specific activities) in due course.

IDENTIFY HAZARD				ASSESS RISK				IMPLEMENT RISK TREATMENT					
ID	Risk Source (Hazard)	Event / Cause / Consequence	Persons Affected	Control Measure (Risk Treatment)	Likelihood	Consequence	Risk Rating	Risk Owner	Implement Control - Y/N?	Action / Comment (or justification if no action)	Action Owner(s)	Timing / Date	Status (Open / Closed)
Design Phase (Pre-construction)													
1.01	Stability of the wall	Insufficient wall sizing resulting in injuries or casualties from wall failure.	Designer, Project team	Adopt conservative design aligned with B1/VM4 and the NZTA BM.	2 - Unlikely	B - Critical	High	Project Team	Yes	Design to be undertaken and verified by competent staff.	Aurecon	During the design stage	Closed
Construction and Commissioning Phase													
2.01	Earthworks	Working on or near slopes leading to person and plant falling from one level to another, possibly causing injuries especially during wet days.	Contractor	Construction barrier to be notably established and earthworks methodology to be proven suitable and safe.	3 - Likely	C - Serious	High	Contractor	Yes	Contractor to establish physical barrier for earthworks.	Contractor	Prior to and during construction	Open
2.02	Unexpected ground conditions	Weaker foundation soils encountered than those designed for due to incomplete ground investigation. Results in insufficient wall sizing design.	Designer, Contractor	Design in accordance with site investigation. Piles are likely to be driven, should pile driving find unexpected results designer is to be notified and pile lengthened. Note this is unlikely based on the site investigation.	2 - Unlikely	C - Serious	Moderate	Contractor	Yes	Contractor to follow standard earthworks and piling practise.	Contractor	Prior to and during construction	Open
2.03	Manual handling	Manual efforts during wall construction resulting in injury. E.g. handling of reinforcing steel, pouring of concrete.	Contractor	Contractor to ensure suitable and safe construction methodology well understood by the workers.	3 - Likely	C - Serious	High	Contractor	Yes	Appropriate PPE to be worn and smooth interaction of workers.	Contractor	Construction Phase	Open
2.04	Contaminated ground - OHS hazard	Exposure of contaminated ground during construction, disturbance of contaminated ground causing illness.	Contractor	Contaminated ground awareness training to be undertaken for identification of contaminated ground.	2 - Unlikely	D - Significant	Low	Contractor	Yes	If contractor identifies potential contamination, he shall alert the Engineer immediately.	Contractor	Construction Phase	Open
2.05	Above and below ground services	Clashes and/or damage due to poorly identified services leading to injury or death. Protection of utilities required during construction.	Contractor	Undertake service locate and physically identify services on site if necessary. Gas line relocation to take place prior to wall construction works. De-energise services if necessary.	2 - Unlikely	C - Serious	Moderate	Contractor	Yes	Contractor to validate all service information on site and ensure work methods recognise and account for on site services.	Contractor	Prior to and during construction	Open
2.06	Working from height	Workers building retaining walls and engineers inspecting wall construction, falling from one level to another resulting in serious injuries.	Contractor, inspectors	Contractor to provide risk register for all staff onsite.	2 - Unlikely	D - Significant	Low	Contractor	Yes	Contractor to consider installing temporary safety fencing on top of wall during construction.	Contractor	Construction Phase	Open
2.07	Collapse of wall or batter	Collapse of wall or unrestrained batter prior to wall completion from surcharge e.g. machinery. Shall not surcharge the walls or unrestrained batter during or before construction. Shall not surcharge the walls post-construction above the design surcharge.	Contractor	Contractor vehicles/plant/machinery to not be placed within the active wedge of the wall during construction unless advised otherwise by a geotechnical engineer. Plant such as cranes, concrete trucks, excavators shall work below the retaining wall or a safe distance behind the batter.	2 - Unlikely	B - Critical	High	Contractor	Yes	Contractor to provide work plan prior to construction showing how plant will work around the wall during construction.	Contractor	Construction Phase	Open
2.08	Working with plant	Unprotected personnel struck by moving plant resulting in serious accident.	Contractor, inspectors	Maintain contact with operator. Wear PPE. Maintain distance from machines where possible. Signage, barriers.	2 - Unlikely	B - Critical	High	Contractor	Yes	Experienced plant operator to be aware of unprotected personnel. People on foot to sign in to site and notify operators of their presence.	Contractor	Construction Phase	Open
Operations and Maintenance Phase													
3.01	Security Fence	Condition of security fence above wall degrades due to damage/weathering such that they do not provide sufficient fall restraint to pedestrians.	Stakeholders	Permanent barriers should be periodically inspected for condition. Barriers to be installed in accordance with NZ Building Code-F4.	2 - Unlikely	D - Significant	Low	Wall owner	Yes	Owner to do regular inspections.	Wall owner	Maintenance	Open
3.02	Drainage	Blockage or failure of drainage.	Stakeholders	Drainage design including: filter fabric.	2 - Unlikely	D - Significant	Low	Wall owner	Yes	Drainage outlets shall be regularly maintained by wall owner.	Wall owner	Maintenance	Open

Safe Design Risk Register – Terrace Views Retaining Wall Stage 3D

Client	Zariba	Workshop Date	24-May-19
Stakeholders	Aurecon, Zariba, Contractors, Tauranga City Council.	Revision No.	Rev A
Meeting Attendees	Miles Buob, Kushant Kishore, Ben O Loughlin.	Project No.	247593
		Project Leader	BOL

Risk

Rating

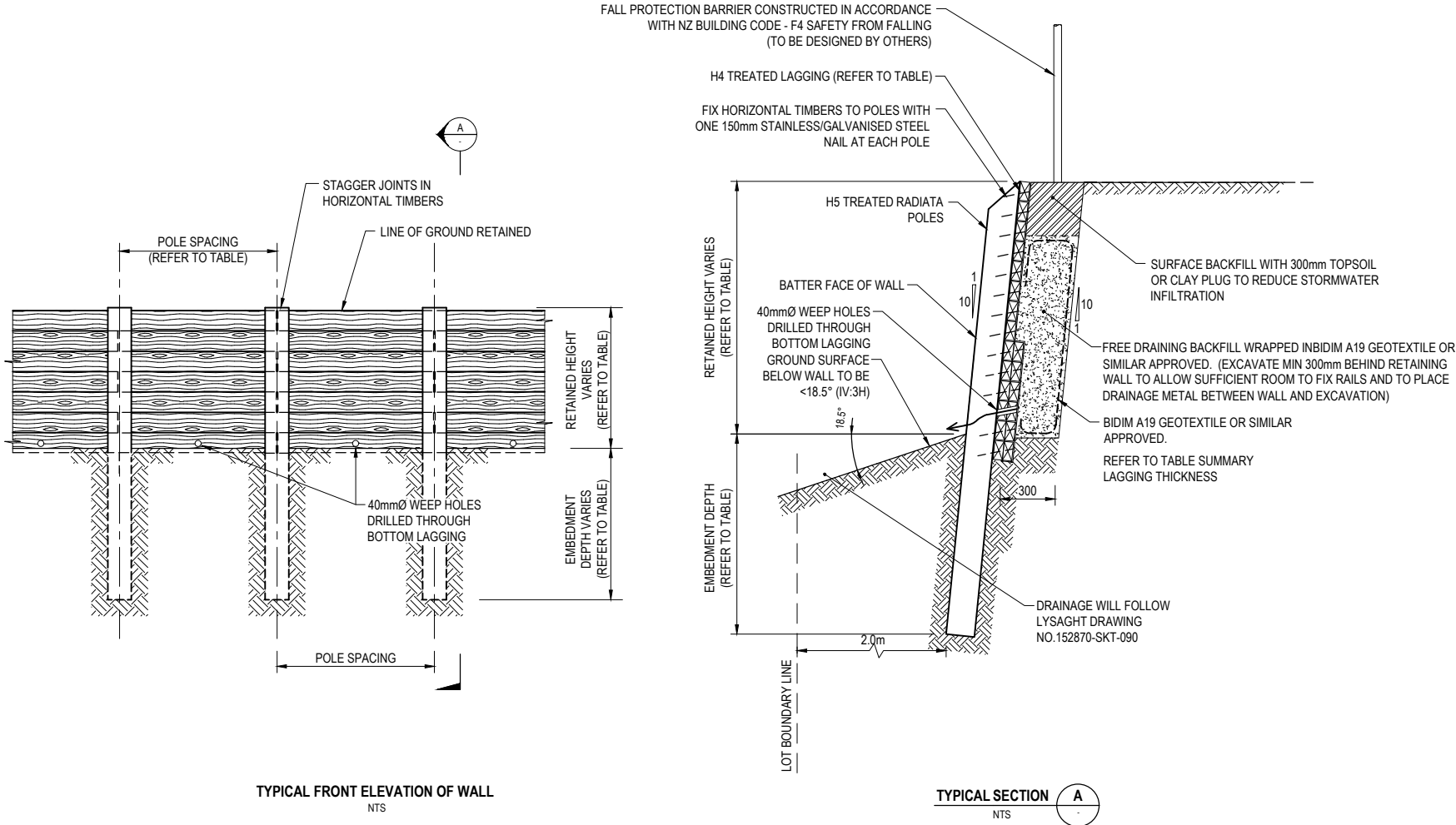
Matrix

Most Likely Consequence	Likelihood of occurrence				
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Notes:

1. This risk register has been prepared to document hazards and risk treatments associated with project elements designed by Aurecon, including subconsultants where applicable.
2. The full life cycle of the project has been considered including design, construction (and commissioning), operation, maintenance, modification and demolition phases.
3. The risk register is focussed on hazards resulting from atypical features specific to the design. It is expected that risks associated with generic hazards (working at heights, excavations, etc) will be addressed by other stakeholders using appropriate risk management techniques during subsequent phases of the project.
4. Residual risks which cannot reasonably be actioned by Aurecon during the design phase have been identified and require action by other stakeholders during subsequent phases of the project (e.g. construction, operations, maintenance, modification or demolition).
5. This risk register does not replace the need for other stakeholders to complete their own hazard identification and risk assessment for the project (including the development of safe work procedures for specific activities) in due course.

IDENTIFY HAZARD				ASSESS RISK				IMPLEMENT RISK TREATMENT					
ID	Risk Source (Hazard)	Event / Cause / Consequence	Persons Affected	Control Measure (Risk Treatment)	Likelihood	Consequence	Risk Rating	Risk Owner	Implement Control - Y/N?	Action / Comment (or justification if no action)	Action Owner(s)	Timing / Date	Status (Open / Closed)
3.03	Durability	Condition of wall materials degrading due to weathering and/or less than sufficient materials and/or construction quality. The risk is potential for having to repair wall.	Stakeholders	Concrete and steel reinforcement quality have been specified in accordance with NZS 3104 and NZS 4671 respectively	2 - Unlikely	D - Significant	Low	Wall owner	Yes	Engineer and contractor to pay attention to quality of construction materials during inspections.	Wall owner	Maintenance	Open
Modification, Demolition and Dismantling Phases													
4.01	Modification, Demolition and Dismantling	Works may be difficult and may affect SUP above due to close proximity. E.g. might be difficult to remove wall and maintain temporary support to SUP during or post works.	Stakeholders	Adopt a recognised design for modification, demolition or dismantling when or if required.	3 - Likely	D - Significant	Moderate	Wall owner	Yes	Wall height is 2m or less, which limits impacts of modification, demolition and dismantling.	Wall owner	Maintenance	Open



FOR RETAINING WALLS 3 & 4

DRIVEN TIMBER POLE RETAINING WALL SCHEDULE					
MAX RETAINED HEIGHT (mm)	SMALL END DIAMETER (mm)	POLE SPACING (mm)	PILOT HOLE DIAMETER (mm)	EMBEDMENT DEPTH (mm)	LAGGING DIMENSIONS (mm)
1000	200	1000	100	2000	150 x 50
1800	325	1000	200	3500	150 X 100 (DOUBLE LAGGED) (150x50 FOR UPPER 1.0m)
NOTE: REFER TO SKETCH RETAINING WALL PLAN LOTS 439-444 BY LYSAGHT (DRAWING No 152870-SKT-90) FOR LOCATION AND THE RETAINING WALL LONG SECTION.					

1. CAUTION:

DEEP EXCAVATIONS UNSUPPORTED DURING CONSTRUCTION MAY BE HAZARDOUS PARTICULARLY WHEN WORKING IN CONFINED SPACES. WORKSAFE NEW ZEALAND EXCAVATION SAFETY GOOD PRACTICE GUIDELINES (JULY 2016) GIVES RECOMMENDED SAFETY PROCEDURES FOR SUCH SITUATIONS. TEMPORARY EXCAVATIONS ARE THE RESPONSIBILITY OF CONTRACTORS. CONTRACTORS ARE REQUIRED TO TAKE DUE CARE AND MEASURES TO PROTECT THEIR WORKS FROM ANY SLIPS.

2. MATERIALS:

TIMBER:

TIMBER POLES SHALL BE PEELED RADIATA PINE LOGS COMPLYING WITH THE REQUIREMENT OF NZS 3605:2001 'LOAD BEARING ROUND TIMBER PILES AND POLES' TREATED TO NZS 3602:2003 SPECIFICATION H5.

DIMENSIONS OF POLES ARE SPECIFIED AS MINIMUM SMALL END DIAMETERS. ACTUAL DIAMETERS WILL BE GREATER DUE TO TAPER AND TIMBER GRADING.

LAGGING SHALL BE SG 8 GRADE TIMBER COMPLYING WITH THE REQUIREMENT OF NZS 3622:2004 'VERIFICATION OF TIMBER PROPERTIES' AND GRADED IN ACCORDANCE WITH THE PROVISIONS OF NZS 3631. LAGGING SHALL BE TREATED TO NZS 3602:2003 SPECIFICATION H4.

LAGGING TO EXTEND A MINIMUM OF 100mm BELOW EXISTING GROUND LEVEL. ALL TIMBER SHALL HAVE TPA IDENTIFICATION BRANDS VISIBLE WHEN DELIVERED TO THE SITE, AND SHALL BE PROTECTED AGAINST DAMAGE DURING STORAGE AND HANDLING.

FIXING OF HORIZONTAL TIMBERS TO POLES SHALL UTILISE STAINLESS / GALVANISED STEEL NAILS AS DETAILED.

3. EXCAVATION AND INSTALLATION:

EXCAVATION IN STAGES TO ALLOW FOR TEMPORARY SUPPORT DURING CONSTRUCTION IS REQUIRED. NO MORE THAN 3m OF UNSUPPORTED SLOPE SHALL EXIST AT ANY ONE TIME.

TIMBER PILING SHALL BE DRIVEN WITH A GRAVITY HAMMER OR POWER HAMMER IN BORED PILOT HOLES. WHEN THE NATURE OF THE DRIVING IS SUCH AS TO UNDULY INJURE THE HEADS, TIMBER PILING SHALL BE PROTECTED BY CAPS OF APPROVED DESIGN PREFERABLY HAVING A ROPE OR OTHER SUITABLE CUSHION NEXT TO THE PILE HEAD AND FITTING INTO A CASTING WHICH IN TURN SUPPORTS A TIMBER SHOCK BLOCK. WHEN THE AREA OF THE HEAD OF THE PILE IS GREATER THAN THAT OF THE FACE OF THE HAMMER, A SUITABLE CAP SHALL BE PROVIDED TO DISTRIBUTE THE BLOW OF THE HAMMER THROUGHOUT THE CROSS SECTION OF THE PILE AND THUS AVOID, AS FAR AS POSSIBLE, THE TENDENCY TO SPLIT OR SHATTER THE PILE. COLLARS OR BANDS TO PROTECT THE PILING AGAINST SPLITTING AND BROOMING SHALL BE PROVIDED.

PILE DRIVER LEADS SHALL BE CONSTRUCTED IN SUCH A MANNER AS TO AFFORD FREEDOM OF MOVEMENT TO THE HAMMER, AND SHALL BE HELD IN POSITION BY GUYS OR STIFF BRACES TO INSURE SUPPORT TO THE PILE DURING DRIVING. EXCEPT WHERE PILINGS ARE DRIVEN THROUGH WATER, THE LEADS SHALL BE OF SUFFICIENT LENGTH THAT THE USE OF A FOLLOWER WILL NOT BE NECESSARY.

CONTRACTOR SHALL PROVIDE PILOT HOLES TO MINIMIZE RISK OF DAMAGE TO PILING AND FOR THE PURPOSE OF MAINTAINING ALIGNMENT. THE MAXIMUM DEPTH OF THE PILOT HOLE SHALL BE 1.5M AND THE MAXIMUM DIAMETER SHALL BE NO GREATER THAN THE DIAMETER OF THE PILE TIP. INCREASE THE DIAMETER OR DEPTH OF THE PILOT HOLE ONLY AFTER PRIOR APPROVAL BY THE ENGINEER.

THE PILING SHALL BE DRIVEN APPROXIMATELY TO THE DEPTH SHOWN ON THE PLANS TO SECURE THE BEARING RESISTANCE. BEARING RESISTANCE SHALL BE DETERMINED BY THE SPECIFIED FORMULA AS DIRECTED BY THE GEOTECHNICAL ENGINEER.

CONTRACTOR SHALL POINT OR SQUARE-CUT PILING AS REQUIRED BY SOIL CONDITIONS. WHERE NECESSARY, PILE SHALL BE SHOED WITH METAL SHOES. PILING POINTS SHALL BE SHAPED TO SECURE EVEN AND UNIFORM BEARING ON SHOES.

AFTER DRIVING, SAW THE PILING OFF AT A TRUE PLANE AS INDICATED ON THE PLANS. THE FINAL PLAN ELEVATIONS ARE TO BE WITHIN THE ESTABLISHED ELEVATION.

IF CUTTING IS NECESSARY THE EXPOSED SURFACES SHALL BE FLOODED WITH A COPPER NAPHTHENATE TYPE OF WOOD PRESERVATIVE.

4. GALVANISING:

COMPONENTS SPECIFIED ON THE DRAWINGS AS BEING GALVANISED ARE TO BE HOT-DIP GALVANISED IN ACCORDANCE WITH AS/NZS 4680, AS/NZS 4791 OR AS/NZS 4792 AS APPROPRIATE.

IN ADDITION TO THE REQUIREMENTS OF THESE CODES, THE FOLLOWING SHALL BE COMPLIED WITH.

THE MATERIAL USED FOR HOT-DIP GALVANISING SHALL BE ZINC METAL SPECIFICALLY MADE FOR THIS PURPOSE AND SHALL BE 99.5% PURE.

THE AVERAGE WEIGHT OF ZINC COATING SHALL BE NOT LESS THAN 380 gm/sq.m FOR BOLTS AND WASHERS AND NOT LESS THAN 700 gm/sq.m FOR OTHER STRUCTURAL STEELWORK.

ALL BOLTS AND NUTS SHALL BE GALVANISED AFTER SCREW CUTTING AND TOLERANCES USED IN SCREW CUTTING SHALL MAKE ALLOWANCE FOR THIS.

DAMAGED SURFACES OR WELDED AREAS SHALL BE MADE GOOD WITH INTEZINC 352 OR EQUIVALENT APPLIED STRICTLY IN ACCORDANCE WITH THE MANUFACTURER'S REQUIREMENTS.

5. DRAINAGE

APPROVED DRAINAGE MATERIAL BACKFILLED BEHIND LAGGING WRAPPED IN GEOTEXTILE (BIDIM A19 OR SIMILAR APPROVED) AND 40mm DIAMETER WEEP HOLES TO BE DRILLED IN CENTRE OF FIRST ROW OF EXPOSED LAGGING BETWEEN EACH POLE AS SHOWN IN THE TYPICAL WALL DETAILS.

6. SETOUT/OFFSET DISTANCE

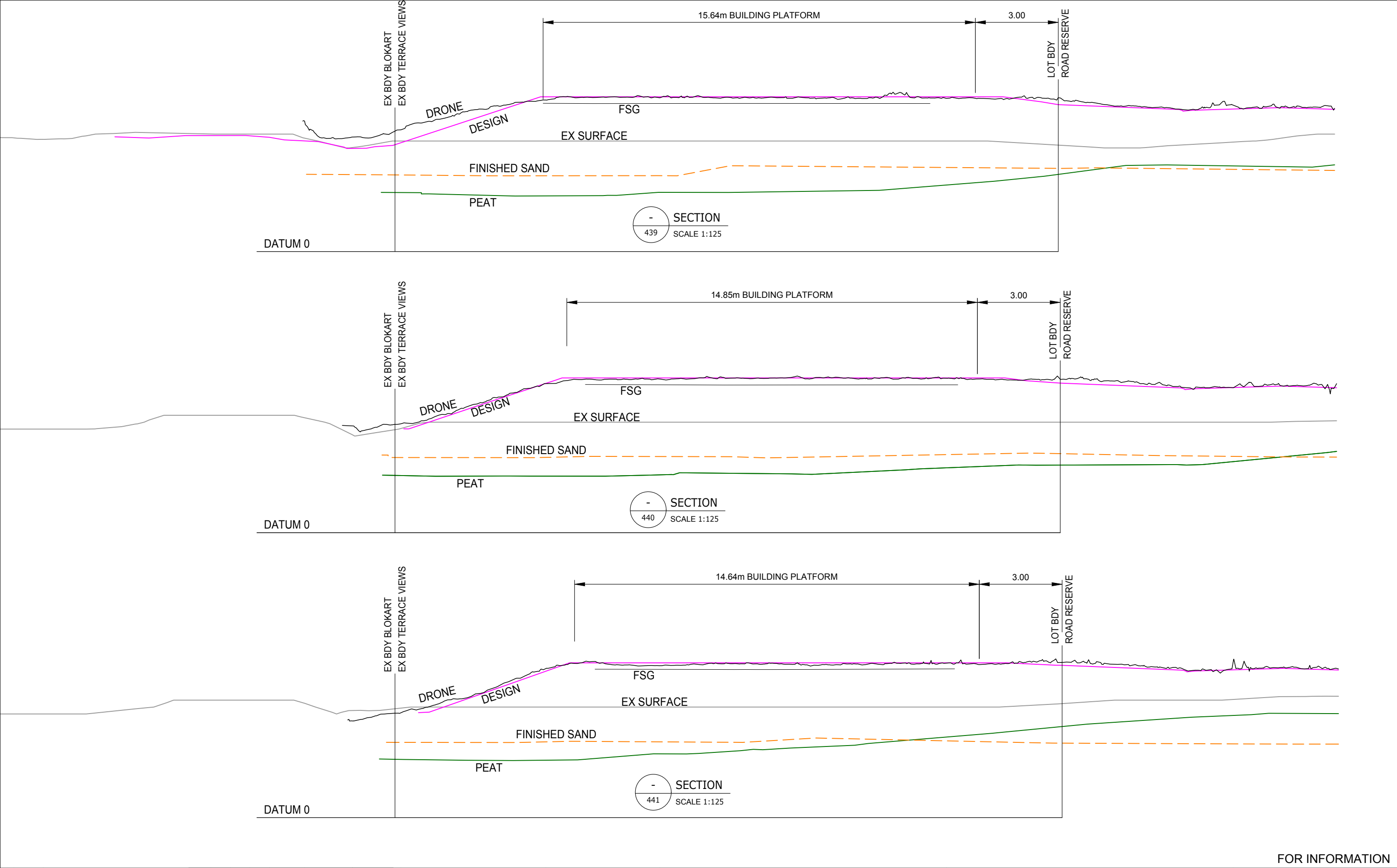
LYSAGHT CONSULTANTS LTD WILL BE PROVIDING THE SETOUT FOR THE ALIGNMENT OF THE RETAINING WALL. THE FRONT OF THE RETAINING WALL SHALL BE OFFSET A MINIMUM OF 2.35 METRES FROM THE BOUNDARY AT THE LOWEST POINT TO ENSURE A MINIMUM OF 2.0 METRES IS COVERED AT THE BASE OF THE TIMBER POLES.

WARNING
THIS WALL DESIGN IS SUITABLE FOUNDING WITHIN IN-SITU DENSE SAND WITH A MINIMUM FRICTION ANGLE OF 33 DEGREES. IT HAS BEEN DESIGN FOR A SURCHARGE OF 5kPa (SINGLE STOREY TIMBER DWELLING).

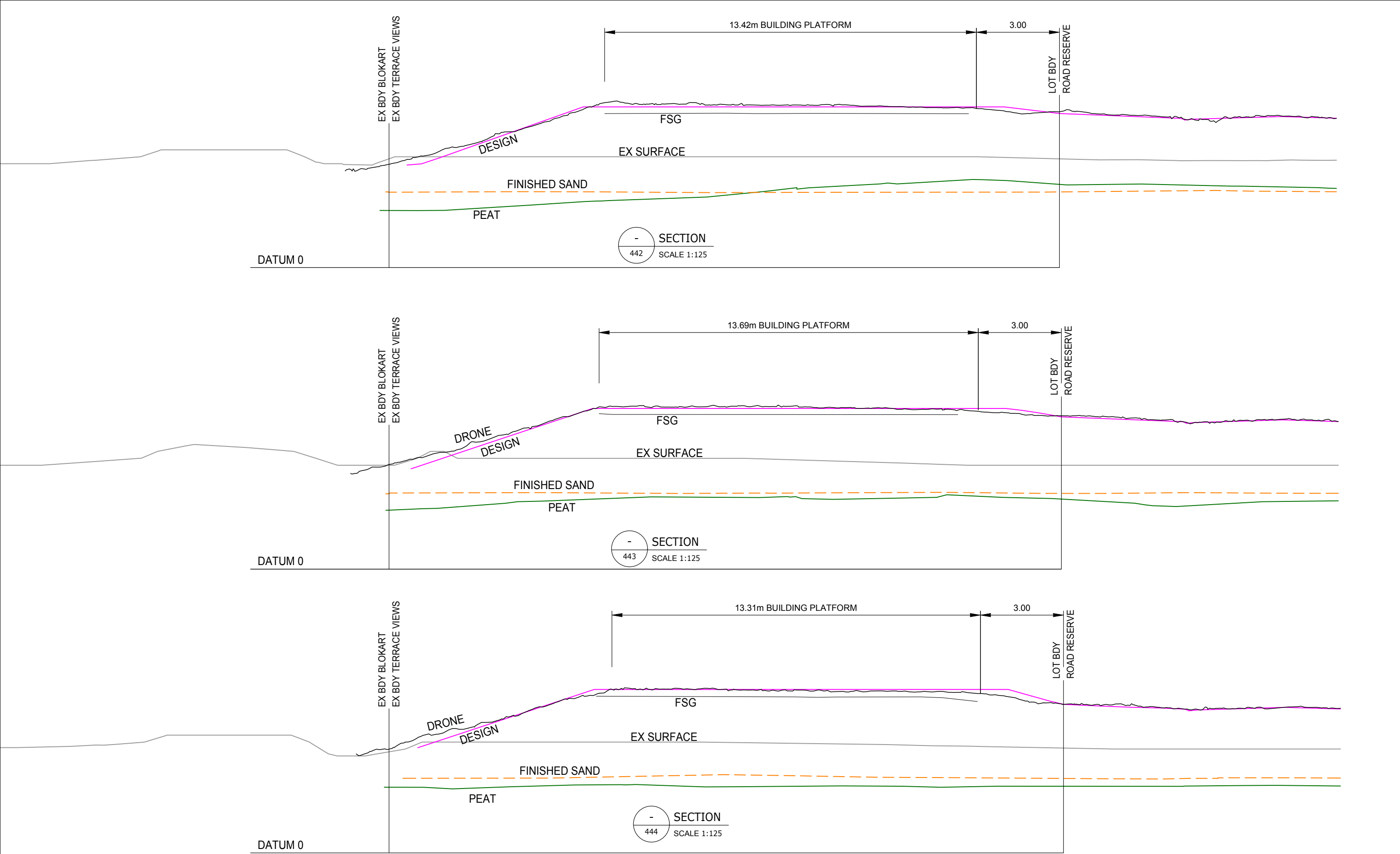
HOLD POINTS FOR INSPECTIONS BY A GEOTECHNICAL ENGINEER IS AS FOLLOWS:

- PILOT HOLE, TIMBER POLE INSPECTION
- PLACEMENT OF GEOTEXTILE WRAP AND LAGGING PRIOR TO DRAINAGE METAL AND BACKFILL
- FINAL INSPECTION PRIOR TO SITE DEMOBILISATION

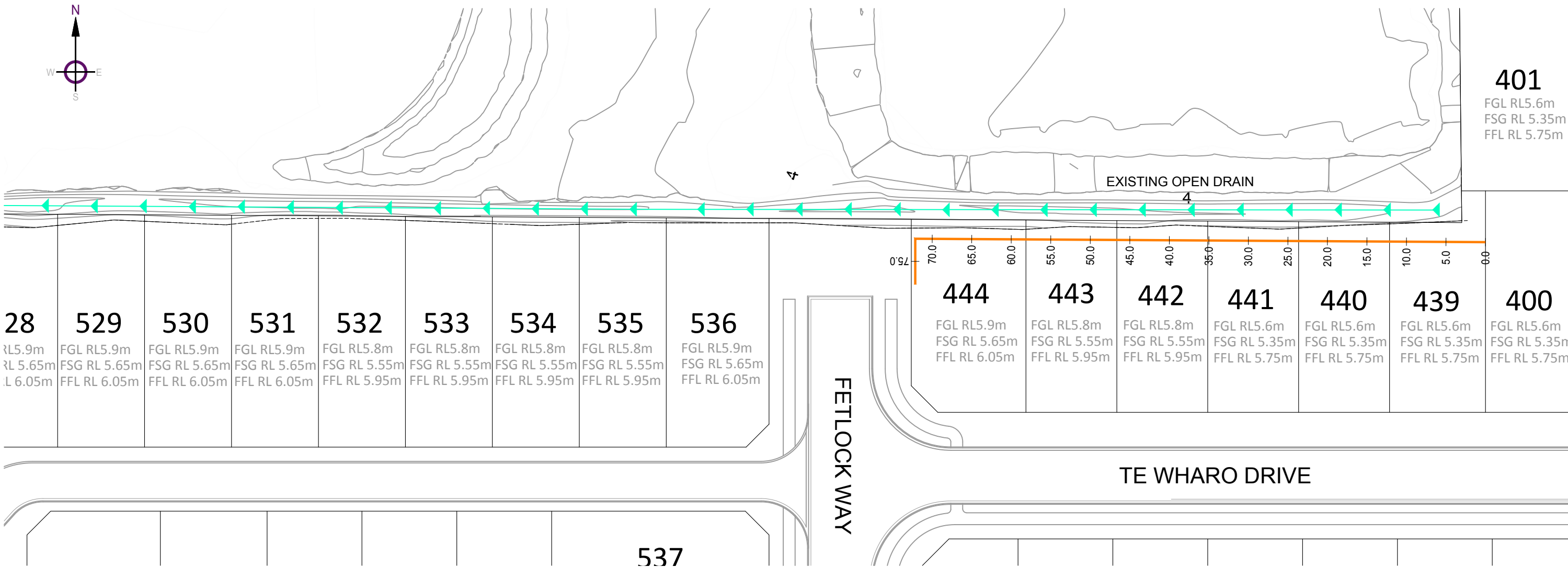
REV	DATE	REVISION DETAILS	APPROVED	SCALE	SIZE	CONSENT		PROJECT	TERRACE VIEWS SUBDIVISION PARTON ROAD, TAURANGA									
A	29.05.19	CONSENT ISSUE	B.O'Loughlin	NTS	A1	NOT FOR CONSTRUCTION												
				DRAWN		APPROVED												
				L.O'Sullivan		DATE		TITLE	TYPICAL TIMBER POLE RETAINING WALL - TYPE A2									
				DESIGNED		29.05.19												
				M.Buob		B.O'Loughlin												
				CHECKED		B.O'Loughlin		DRAWING No.	PROJECT No.	WBS	TYPE	DISC	NUMBER	REV				
				K.Kishore				247593	-	0009	-	DRG	-	G	-	0020	-	A



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										FOR INFORMATION									
							Drawn	Signed	Date		THIS DRAWING REMAINS THE PROPERTY OF LYSAGHT CONSULTANTS LTD. NO LIABILITY SHALL BE ACCEPTED FOR THE UNAUTHORISED USE OF THIS DRAWING DO NOT SCALE DRAWING	Project: TERRACE VIEWS PROPOSED RESIDENTIAL SUBDIVISION TE OKUROA DRIVE PAPAMOA	Drawing Title: EARTHWORKS - STAGE 2 BOUNDARY INTERFACE CROSS SECTIONS LOTS 439 - 444 SHEET 2	Project No.					
						AV		21/01/19	152870										
						Designed	Signed	Date	Scale (A3)										
						AV		21/01/19	AS SHOWN										
							Verified	Signed	Date					Drawing No.		Rev.			
														152870-LOTS 439-444		2			
2	6/06/19	BRL REMOVED				AV				SURVEYING, ENGINEERING & LAND DEVELOPMENT 19 Totara St, Mount Maunganui 3116 Ph 07 578 8798 www.lysaght.net.nz									
1	21/01/19	FOR INFORMATION				AV													
No.	Date	Revision Details				By	Ver.	App.											



- NOTES:
- 1. ALL WORKS ARE TO BE CARRIED OUT IN ACCORDANCE WITH TAURANGA CITY COUNCIL'S INFRASTRUCTURE DEVELOPMENT CODE, THE NEW ZEALAND BUILDING CODE, AND BAY OF PLENTY REGIONAL COUNCIL'S EROSION AND SEDIMENT CONTROL GUIDELINES.
 - 2. ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE
 - 3. LEVELS ARE IN TERMS OF MOTURIKI VERTICAL DATUM 1953.
 - 4. BOUNDARIES AND AREAS ARE APPROXIMATE ONLY AND ARE SUBJECT TO CHANGE. FINAL BOUNDARIES WILL BE IN ACCORDANCE WITH CITY PLAN AND LINZ REQUIREMENTS.
 - 5. BOUNDARIES NOT FOR BUILDING DESIGN PURPOSES.

LEGEND:

PROPOSED TIMBER RETAINING WALL
BOTTOM OF BANK

	LOT 439		LOT 440		LOT 441		LOT 442		LOT 443		LOT 444	
DATUM R.L.1.00												
BOTTOM OF BANK R.L		3.86	3.78	3.76	3.77	3.80	3.79	3.77	3.73	3.61	3.62	3.72
BOTTOM OF WALL R.L		4.52	4.44	4.36	4.28	4.20	4.14	4.09	4.03	4.01	4.03	4.06
WALL HEIGHT		1.08	1.16	1.24	1.32	1.40	1.46	1.53	1.77	1.79	1.77	1.74
TOP OF WALL R.L	5.60	5.60	5.60	5.60	5.60	5.60	5.60	5.62	5.80	5.80	5.80	5.80
CHAINAGE	0.00	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00	55.00

CONTRACTOR TO CONFIRM BOTTOM OF BANK LEVEL BEFORE COMMENCEMENT OF WORKS AND NOTIFY ENGINEER IF THERE IS ANY DISCREPANCY

LONGITUDINAL SECTION OF RETAINING WALL
HOR. SCALE 1:500
VER SCALE 1:250

FOR INFORMATION														
						Drawn	Signed	Date	 THIS DRAWING REMAINS THE PROPERTY OF LYSAGHT CONSULTANTS LTD. NO LIABILITY SHALL BE ACCEPTED FOR THE UNAUTHORISED USE OF THIS DRAWING DO NOT SCALE DRAWING	Project: TERRACE VIEWS PROPOSED RESIDENTIAL SUBDIVISION TE OKUROA DRIVE PAPAMOA	Drawing Title: SKETCH RETAINING WALL PLAN LOTS 439-444	Project No.		
								152870						
								Scale (A3)						
								1:500						
						Verified	Signed	Date	SURVEYING, ENGINEERING & LAND DEVELOPMENT 19 Totara St, Mount Maunganui 3116 Ph 07 578 8798 www.lysaght.net.nz			Drawing No.		Rev.
												152870-SKT-090		-
-	17/05/19	FOR INFORMATION			RD			Approved	Signed	Date				
No.	Date	Revision Details			By	Ver.	App.	PM		17/05/19				



HAND AUGER LOG

HOLE Id: Lot 439

Hole Location: See Location Plan

SHEET: 1 OF 1

PROJECT: GTG AURECON TERRACE VIEWS STG 3 D&E - SI										LOCATION: Terrace View, Papamoa										JOB No.: 1009168.0000																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												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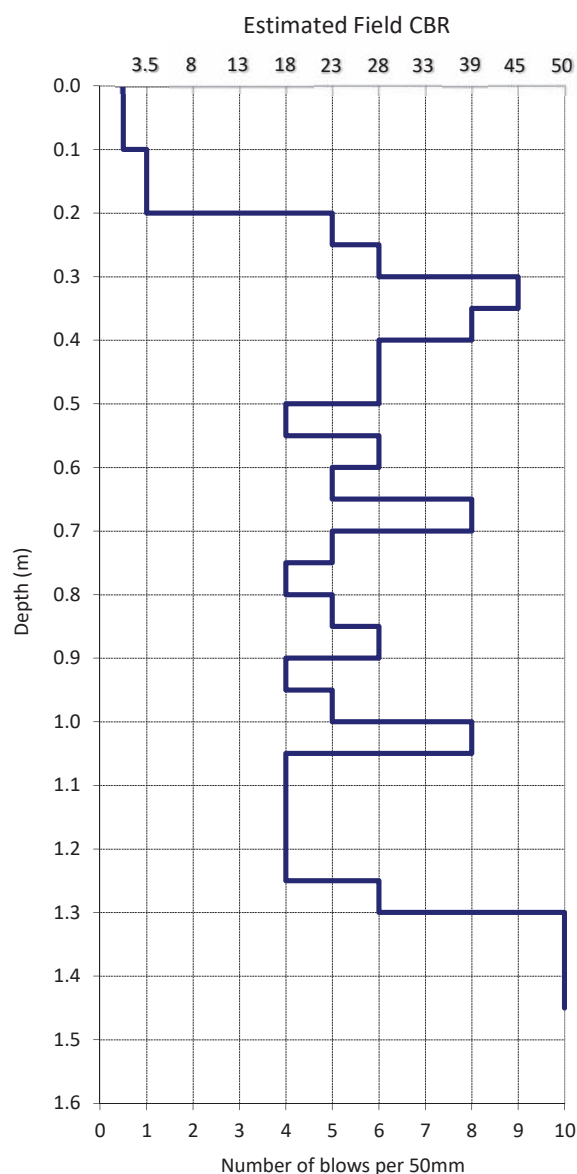
 GEOTECHNICS	15C Amber Crescent Judea Tauranga 3110 New Zealand p. +64 7 571 0280		Page 1 of 1	
			Lab Ref/URN	
			016/19	

NZS 4402: 1998 Test 6.5.2 Dynamic Cone Penetrometer - Scala					
Project Name		TERRACE VIEWS STAGE 3 D & E - SITE INVESTIGATION		Project ID	
Customer Project ID		Terrace Views Stage 3 D & E		Equipment ID	
Site Location		Papamoa		Material Source	
Material Description		See Lot 439 borehole log.		Test Series	
Depth from ground surface to commencement of penetration (m)		0.0		Test Number	
Chainage		Offset		Lane	
Vertical distance driven (mm)	Depth (mm)	Number of blows	Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	0.5	1050	1050	
100	100	0.5	1100	1100	
150	150	1	1150	1150	
200	200	2	1200	1200	
250	250	6	1250	1250	
300	300	7	1300	1300	
350	350	8	1350	1350	
400	400	8	1400	1400	
450	450	7	1450	1450	
500	500	7	1500	1500	
550	550	10	1550	1550	
600	600	9	1600	1600	
650	650	14	1650	1650	
700	700	16	1700	1700	
750	750		1750	1750	
800	800		1800	1800	
850	850		1850	1850	
900	900		1900	1900	
950	950		1950	1950	
1000	1000		2000	2000	

Test Remarks					

Tested By	PIFA	Date	1/02/2019
Data Entry By	TASR	Date	1/02/2019
Checked By	RWM	Date	7/02/2019

 GEOTECHNICS	15C Amber Crescent Judea Tauranga 3110 New Zealand p. +64 7 571 0280		Page 1 of 1		
			Lab Ref/URN		
			016/19		
NZS 4402: 1998 Test 6.5.2 Dynamic Cone Penetrometer - Scala					
Project Name	TERRACE VIEWS STAGE 3 D & E - SITE INVESTIGATION		Project ID	1009168.0.0.0	
Customer Project ID	Terrace Views Stage 3 D & E		Equipment ID	TG0851	
Site Location	Papamoa		Material Source	Unknown	
Material Description	See Lot 439 borehole log.		Test Series	Terrace Views/010219/SC391-400,439-443,483-487	
Depth from ground surface to commencement of penetration (m)		0.0	Test Number	Lot 439 B	
Chainage Offset Lane					
Vertical distance driven (mm)	Depth (mm)	Number of blows	Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	0.5	1050	1050	8
100	100	0.5	1100	1100	4
150	150	1	1150	1150	4
200	200	1	1200	1200	4
250	250	5	1250	1250	4
300	300	6	1300	1300	6
350	350	9	1350	1350	10
400	400	8	1400	1400	10
450	450	6	1450	1450	10
500	500	6	1500	1500	
550	550	4	1550	1550	
600	600	6	1600	1600	
650	650	5	1650	1650	
700	700	8	1700	1700	
750	750	5	1750	1750	
800	800	4	1800	1800	
850	850	5	1850	1850	
900	900	6	1900	1900	
950	950	4	1950	1950	
1000	1000	5	2000	2000	
Test Remarks					
Tested By	PIFA		Date	1/02/2019	
Data Entry By	TASR		Date	1/02/2019	
Checked By	RWM		Date	7/02/2019	





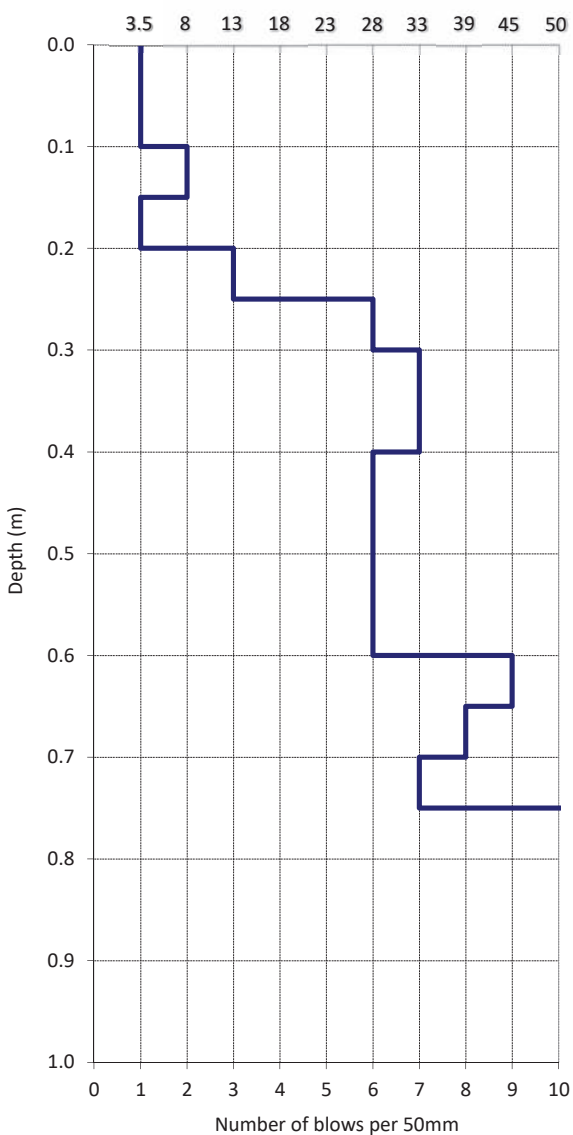
HAND AUGER LOG

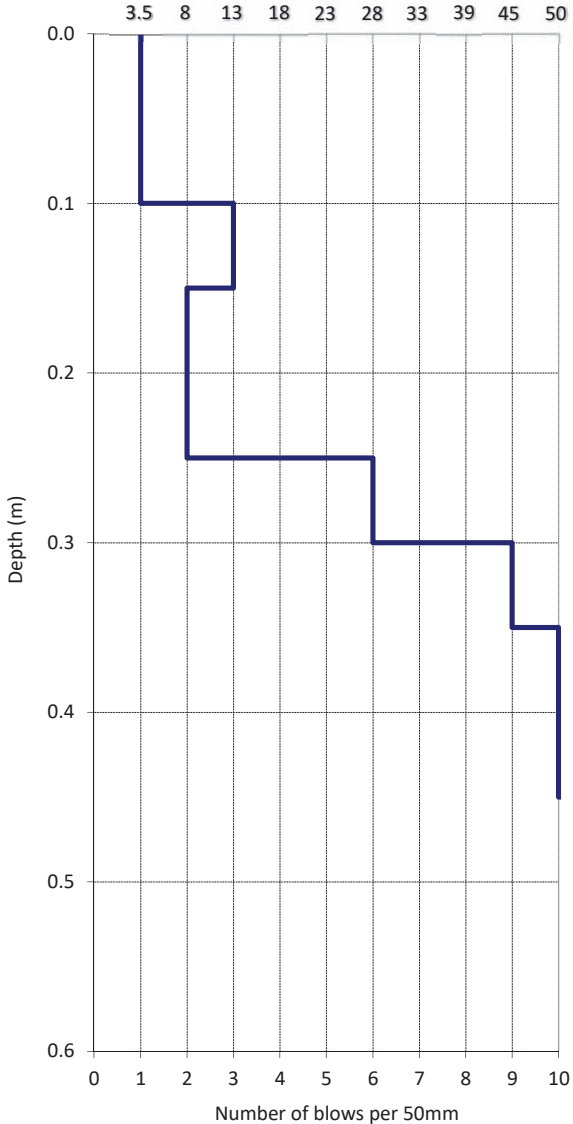
HOLE Id: Lot 440

Hole Location: See Location Plan

SHEET: 1 OF 1

PROJECT: GTG AURECON TERRACE VIEWS STG 3 D&E - SI										LOCATION: Terrace View, Papamoa										JOB No.: 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HAND AUGER LOG

HOLE Id: Lot 441

Hole Location: See Location Plan

SHEET: 1 OF 1

[illegible]

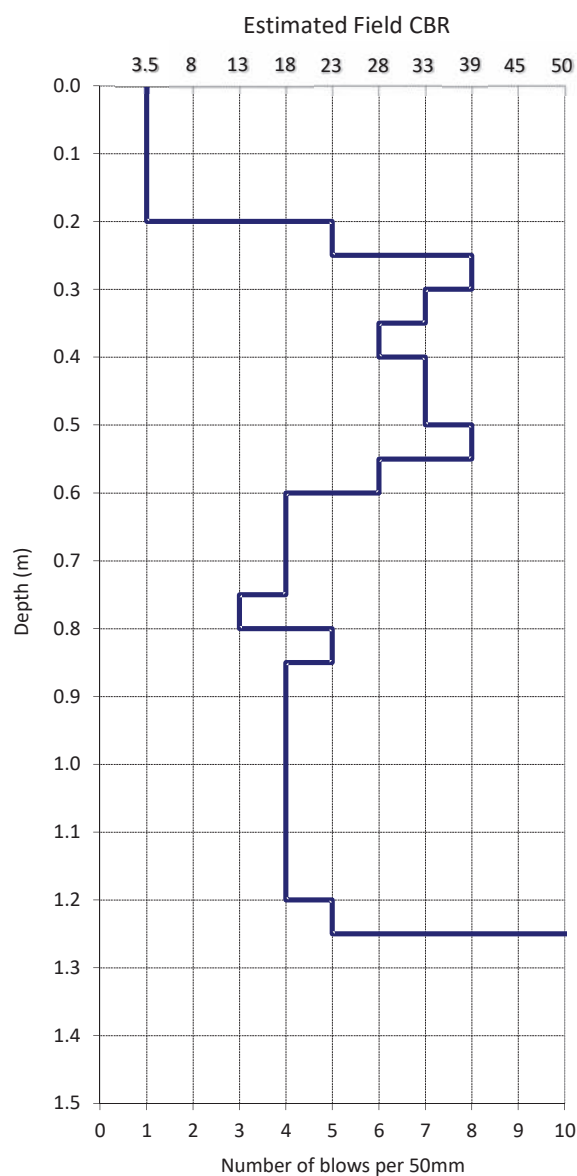
 GEOTECHNICS	15C Amber Crescent Judea Tauranga 3110 New Zealand p. +64 7 571 0280		Page 1 of 1	
			Lab Ref/URN	
			016/19	

NZS 4402: 1998 Test 6.5.2 Dynamic Cone Penetrometer - Scala					
Project Name		TERRACE VIEWS STAGE 3 D & E - SITE INVESTIGATION		Project ID	
Customer Project ID		Terrace Views Stage 3 D & E		Equipment ID	
Site Location		Papamoa		Material Source	
Material Description		See Lot 441 borehole log.		Test Series	
Depth from ground surface to commencement of penetration (m)		0.0		Test Number	

Chainage		Offset		Lane	
Vertical distance driven (mm)	Depth (mm)	Number of blows	Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	1	1050	1050	4
100	100	1	1100	1100	4
150	150	1	1150	1150	4
200	200	1	1200	1200	4
250	250	5	1250	1250	5
300	300	8	1300	1300	13
350	350	7	1350	1350	14
400	400	6	1400	1400	13
450	450	7	1450	1450	
500	500	7	1500	1500	
550	550	8	1550	1550	
600	600	6	1600	1600	
650	650	4	1650	1650	
700	700	4	1700	1700	
750	750	4	1750	1750	
800	800	3	1800	1800	
850	850	5	1850	1850	
900	900	4	1900	1900	
950	950	4	1950	1950	
1000	1000	4	2000	2000	

Test Remarks			

Tested By	PIFA	Date	1/02/2019
Data Entry By	TASR	Date	1/02/2019
Checked By	RWM	Date	7/02/2019



 GEOTECHNICS	15C Amber Crescent Judea Tauranga 3110 New Zealand p. +64 7 571 0280		Page 1 of 1	
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Chainage		Offset		Lane	
Vertical distance driven (mm)	Depth (mm)	Number of blows	Vertical distance driven (mm)	Depth (mm)	Number of blows
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100	100	2	1100	1100	
150	150	3	1150	1150	
200	200	2	1200	1200	
250	250	1	1250	1250	
300	300	7	1300	1300	
350	350	9	1350	1350	
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900	900	10	1900	1900	
950	950		1950	1950	
1000	1000		2000	2000	

Test Remarks					

Tested By	PIFA	Date	1/02/2019
Data Entry By	TASR	Date	1/02/2019
Checked By	RWM	Date	7/02/2019



HAND AUGER LOG

HOLE Id: **Lot 442**

Hole Location: See Location Plan

SHEET: 1 OF 1

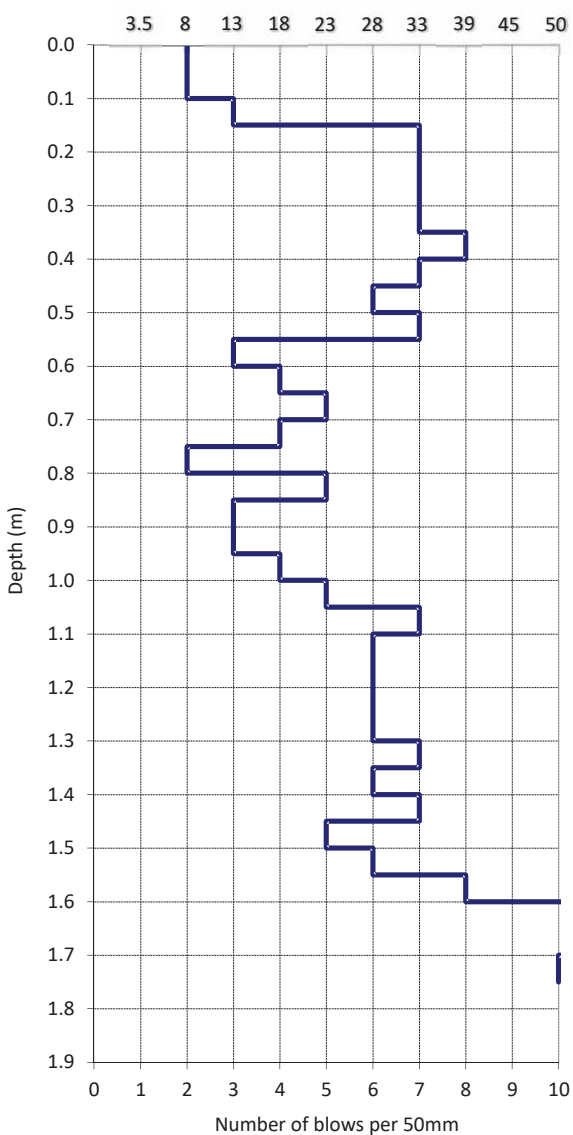
PROJECT: GTG AURECON TERRACE VIEWS STG 3 D&E - SI										LOCATION: Terrace View, Papamoa										JOB No.: 1009168.0000																			
CO-ORDINATES: (NZTM2000)										DRILL TYPE: 50mm Hand Auger										HOLE STARTED: 08/01/2019																			
R.L.:										DRILL METHOD: HA										HOLE FINISHED: 08/01/2019																			
DATUM:										LOGGED BY: PIFA										CHECKED: RWM																			
GEOLOGICAL										ENGINEERING DESCRIPTION																													
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION										WATER CORE RECOVERY (%) METHOD SCALA PENETROMETER (Blows/50mm) TESTS SAMPLES RL (m) DEPTH (m)										GRAPHIC LOG WEATHERING MOISTURE CONDITION STRENGTH/DENSITY CLASSIFICATION SHEAR STRENGTH (kPa)										Description and Additional Observations									
										1 2 3 4 5 6 7 8 9 10 20 30 40 50 60 70 80 90 100 110 120																													
										100 HA																				Organic SILT, with some sand; dark brownish black. stiff, moist to wet, non-plastic; sand, fine to medium.									
										0.5										M D MD										Fine to coarse SAND, with minor gravel, trace silt, light yellowish brown. Dense, moist, well graded; gravel, fine, subrounded to subangular, pumiceous. 0.55m: Changes to medium dense.									
										1.0										D										1.0m: Changes to dense.									
										1.5										W VD										1.4m: Changes to brown; wet; gravel, fine to medium. 1.6m: Changes to very dense.									
										2.0																				End of borehole at 2.00 mbgl. No standing groundwater encountered.									

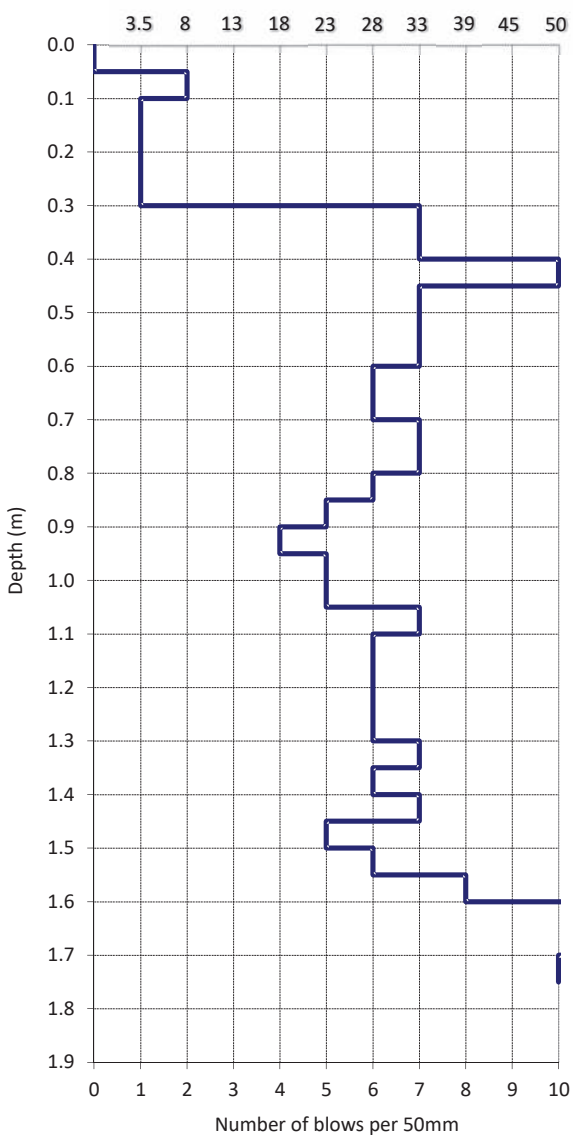
COMMENTS:

 Hole Depth
 2m

Scale 1:13

Rev.: A

 GEOTECHNICS	15C Amber Crescent Judea Tauranga 3110 New Zealand p. +64 7 571 0280		Page 1 of 1																																																																																																																																					
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HAND AUGER LOG

HOLE Id: **Lot 443**

Hole Location: See Location Plan

SHEET: 1 OF 1

PROJECT: GTG AURECON TERRACE VIEWS STG 3 D&E - SI										LOCATION: Terrace View, Papamoa										JOB No.: 1009168.0000																																																																					
CO-ORDINATES: (NZTM2000)										DRILL TYPE: 50mm Hand Auger										HOLE STARTED: 08/01/2019																																																																					
R.L.:										DRILL METHOD: HA										HOLE FINISHED: 08/01/2019																																																																					
DATUM:										LOGGED BY: PIFA										CHECKED: RWM																																																																					
GEOLOGICAL										ENGINEERING DESCRIPTION																																																																															
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION										WATER CORE RECOVERY (%) METHOD										SCALA PENETROMETER (Blows/50mm)										TESTS SAMPLES RL (m) DEPTH (m)										GRAPHIC LOG MOISTURE CONDITION WEATHERING STRENGTH/DENSITY CLASSIFICATION SHEAR STRENGTH (kPa)										Description and Additional Observations																																							
																				1 2 3 4 5 6 7 8 9																																																																					
																				1 1 2 5 10 9 7 6 8 6 7 5 5 4 4 4 4 4 3 4 6 6 5 4 4 5 4 6 6 5 4 16 >>																																								Organic SILT, with some sand; dark brownish black. Stiff, moist to wet, non-plastic; sand, fine to medium.																													
																																																																						Fine to coarse SAND, with minor silt and gravel; light greyish brown. Dense, moist, well graded; gravel, fine, subrounded to subangular, pumiceous.																			
																																																																																1.4m: Changes to dark greyish brown; wet.									
																																																																																1.55m: Changes to very dense.									
																																																																																1.95m: Changes to pinkish brown.									
																																																																																End of borehole at 2.0 mbgl.									
																																																																																No standing groundwater encountered.									

COMMENTS:

 Hole Depth
2m

Scale 1:13

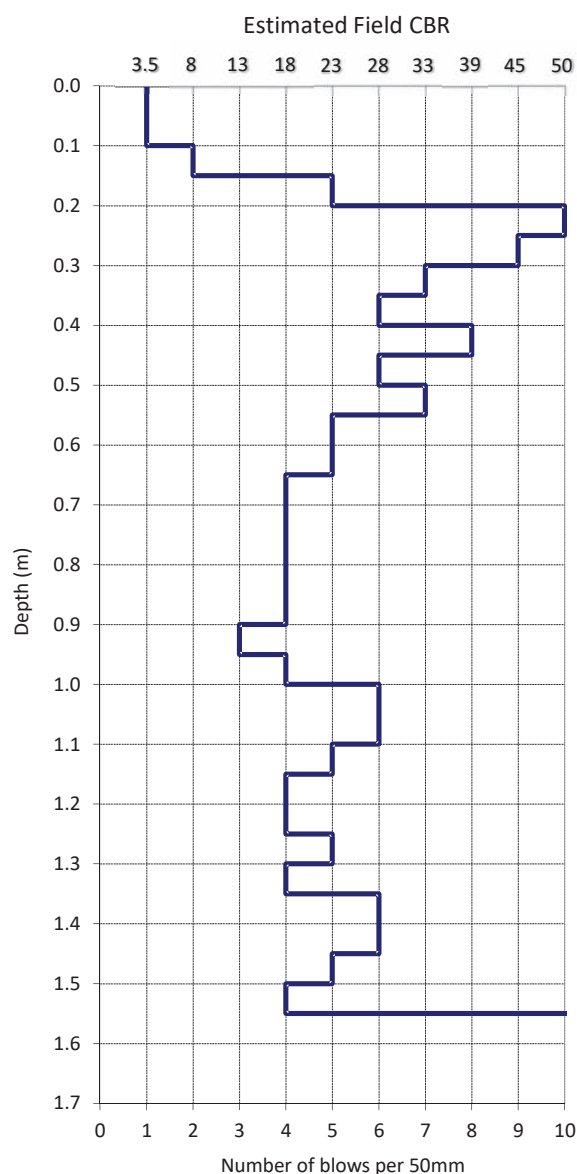
Rev.: A

 GEOTECHNICS	15C Amber Crescent Judea Tauranga 3110 New Zealand p. +64 7 571 0280		Page 1 of 1	
			Lab Ref/URN	
			016/19	

NZS 4402: 1998 Test 6.5.2 Dynamic Cone Penetrometer - Scala					
Project Name		TERRACE VIEWS STAGE 3 D & E - SITE INVESTIGATION		Project ID	
Customer Project ID		Terrace Views Stage 3 D & E		Equipment ID	
Site Location		Papamoa		Material Source	
Material Description		See Lot 443 borehole log.		Test Series	
Depth from ground surface to commencement of penetration (m)		0.0		Test Number	
Chainage		Offset		Lane	
Vertical distance driven (mm)	Depth (mm)	Number of blows	Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	1	1050	1050	6
100	100	1	1100	1100	6
150	150	2	1150	1150	5
200	200	5	1200	1200	4
250	250	10	1250	1250	4
300	300	9	1300	1300	5
350	350	7	1350	1350	4
400	400	6	1400	1400	6
450	450	8	1450	1450	6
500	500	6	1500	1500	5
550	550	7	1550	1550	4
600	600	5	1600	1600	16
650	650	5	1650	1650	
700	700	4	1700	1700	
750	750	4	1750	1750	
800	800	4	1800	1800	
850	850	4	1850	1850	
900	900	4	1900	1900	
950	950	3	1950	1950	
1000	1000	4	2000	2000	

Test Remarks					

Tested By	PIFA	Date	1/02/2019
Data Entry By	TASR	Date	1/02/2019
Checked By	RWM	Date	7/02/2019

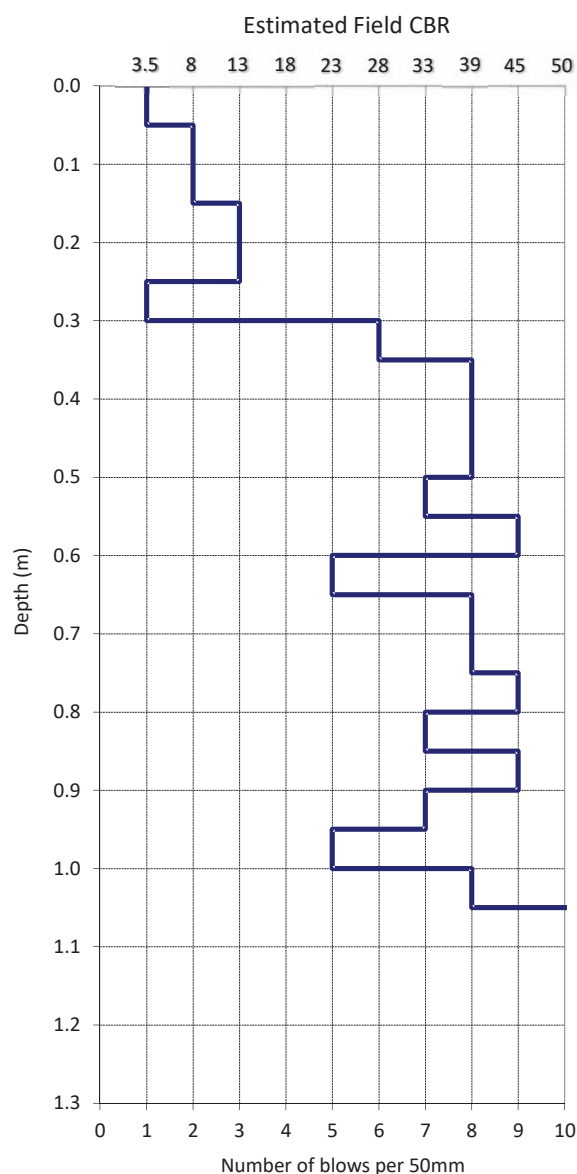


 GEOTECHNICS	15C Amber Crescent Judea Tauranga 3110 New Zealand p. +64 7 571 0280		Page 1 of 1	
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NZS 4402: 1998 Test 6.5.2 Dynamic Cone Penetrometer - Scala					
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Customer Project ID		Terrace Views Stage 3 D & E		Equipment ID	
Site Location		Papamoa		Material Source	
Material Description		See Lot 443 borehole log.		Test Series	
Depth from ground surface to commencement of penetration (m)		0.0		Test Number	
Chainage		Offset		Lane	
Vertical distance driven (mm)	Depth (mm)	Number of blows	Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	1	1050	1050	8
100	100	2	1100	1100	11
150	150	2	1150	1150	18
200	200	3	1200	1200	
250	250	3	1250	1250	
300	300	1	1300	1300	
350	350	6	1350	1350	
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450	450	8	1450	1450	
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850	850	7	1850	1850	
900	900	9	1900	1900	
950	950	7	1950	1950	
1000	1000	5	2000	2000	

Test Remarks					

Tested By	PIFA	Date	1/02/2019
Data Entry By	TASR	Date	1/02/2019
Checked By	RWM	Date	7/02/2019





HAND AUGER LOG

HOLE Id: Lot 444

Hole Location: See Location Plan

SHEET: 1 OF 1

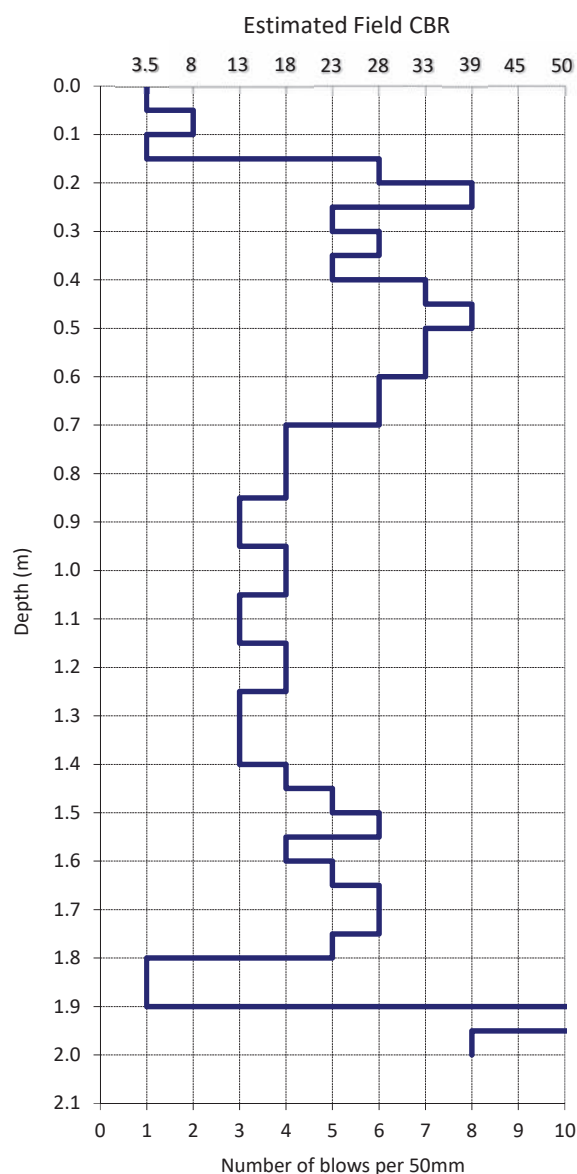
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 GEOTECHNICS	15C Amber Crescent Judea Tauranga 3110 New Zealand p. +64 7 571 0280		Page 1 of 1	
			Lab Ref/URN	
			022/19	

NZS 4402: 1998 Test 6.5.2 Dynamic Cone Penetrometer - Scala					
Project Name		TERRACE VIEWS STAGE 3 D & E - SITE INVESTIGATION		Project ID	
Customer Project ID		Terrace Views Stage 3 D & E		Equipment ID	
Site Location		Papamoa		Material Source	
Material Description		See Lot 444 borehole log.		Test Series	
Depth from ground surface to commencement of penetration (m)		0.0		Test Number	
Chainage		Offset		Lane	
Vertical distance driven (mm)	Depth (mm)	Number of blows	Vertical distance driven (mm)	Depth (mm)	Number of blows
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250	250	8	1250	1250	4
300	300	5	1300	1300	3
350	350	6	1350	1350	3
400	400	5	1400	1400	3
450	450	7	1450	1450	4
500	500	8	1500	1500	5
550	550	7	1550	1550	6
600	600	7	1600	1600	4
650	650	6	1650	1650	5
700	700	6	1700	1700	6
750	750	4	1750	1750	6
800	800	4	1800	1800	5
850	850	4	1850	1850	1
900	900	3	1900	1900	1
950	950	3	1950	1950	12
1000	1000	4	2000	2000	8

Test Remarks					

Tested By	PIFA	Date	9/12/2018
Data Entry By	TASR	Date	1/02/2019
Checked By	RWM	Date	7/02/2019





15C Amber Crescent
Judea
Tauranga 3110
New Zealand
p. +64 7 571 0280

Page 1 of 1

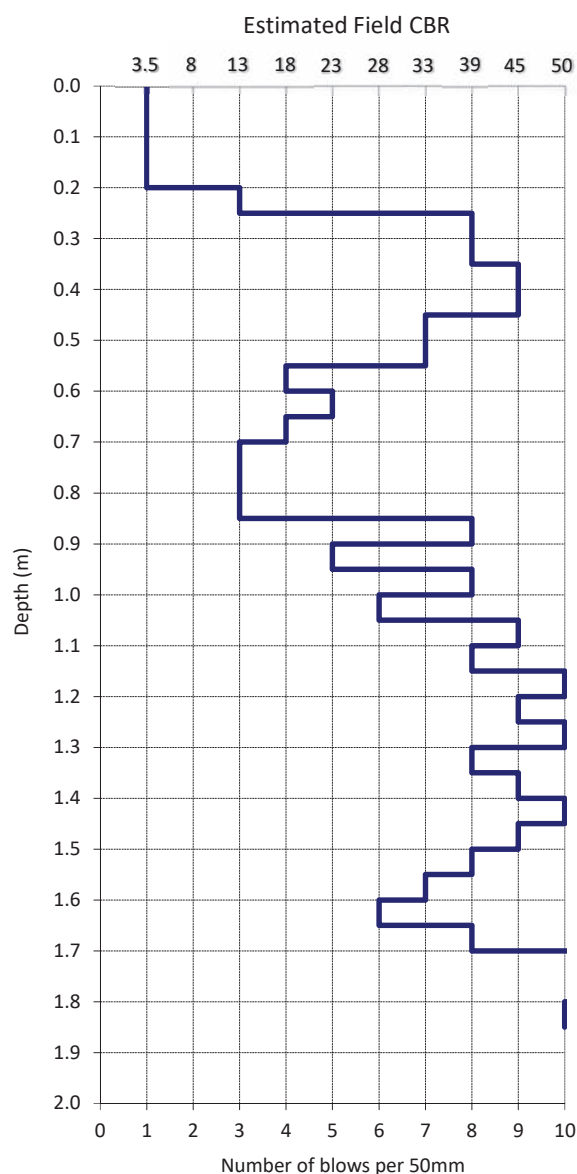
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NZS 4402: 1998 Test 6.5.2 Dynamic Cone Penetrometer - Scala

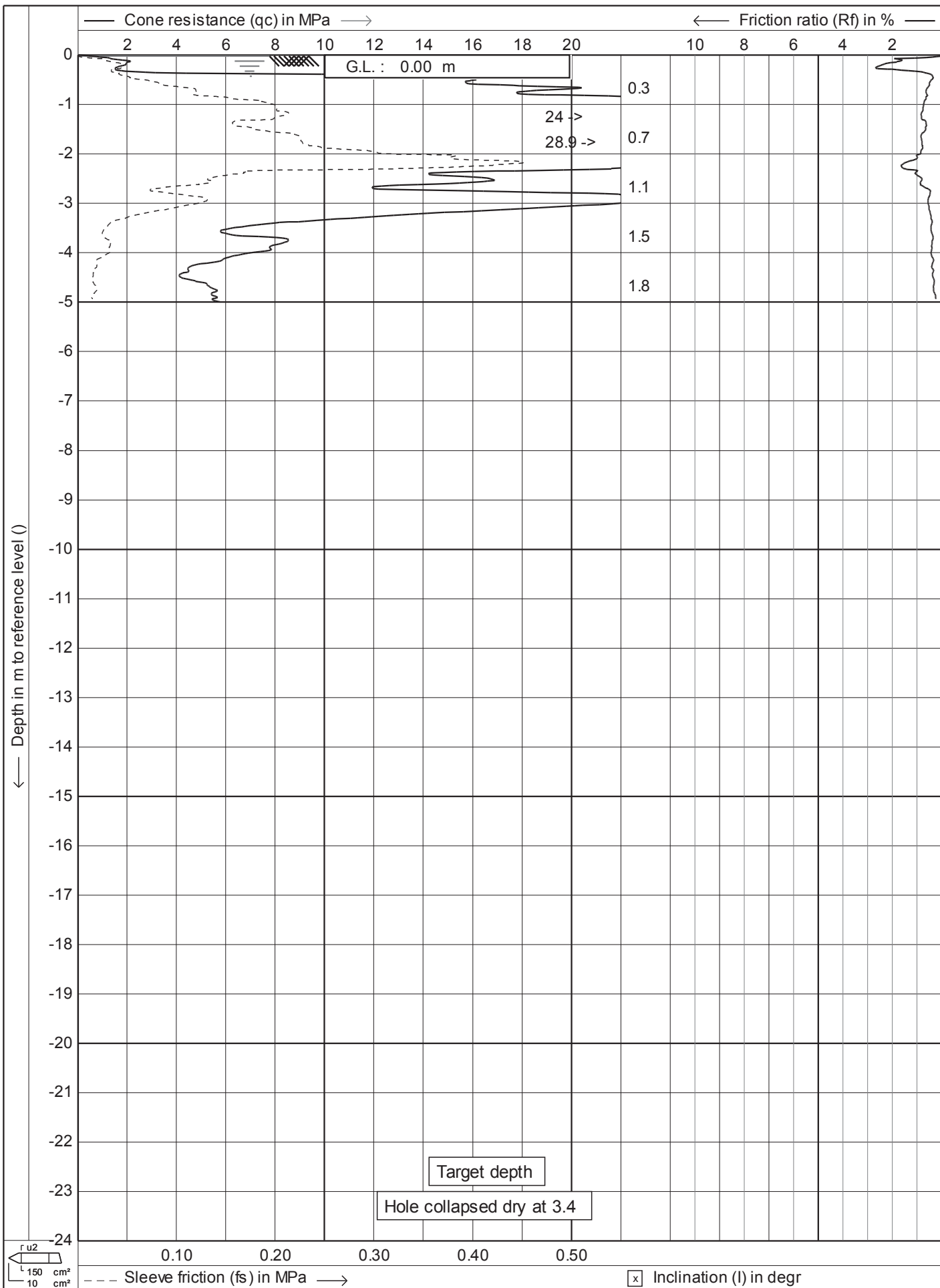
Project Name	TERRACE VIEWS STAGE 3 D & E - SITE INVESTIGATION		Project ID	1009168.0.0.0
Customer Project ID	Terrace Views Stage 3 D & E		Equipment ID	TG0851
Site Location	Papamoa		Material Source	Unknown
Material Description	See Lot 444 borehole log.		Test Series	Terrace Views/091218/SC444-446
Depth from ground surface to commencement of penetration (m)		0.0	Test Number	Lot 444 B

Chainage		Offset		Lane	
Vertical distance driven (mm)	Depth (mm)	Number of blows	Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	1	1050	1050	6
100	100	1	1100	1100	9
150	150	1	1150	1150	8
200	200	1	1200	1200	10
250	250	3	1250	1250	9
300	300	8	1300	1300	10
350	350	8	1350	1350	8
400	400	9	1400	1400	9
450	450	9	1450	1450	10
500	500	7	1500	1500	9
550	550	7	1550	1550	8
600	600	4	1600	1600	7
650	650	5	1650	1650	6
700	700	4	1700	1700	8
750	750	3	1750	1750	11
800	800	3	1800	1800	12
850	850	3	1850	1850	10
900	900	8	1900	1900	
950	950	5	1950	1950	
1000	1000	8	2000	2000	



Test Remarks

Tested By	PIFA	Date	9/12/2018
Data Entry By	TASR	Date	1/02/2019
Checked By	RWM	Date	7/02/2019



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

Position: **0, 0 RD**

Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-103** 1/14

← Depth in m to reference level ()

— Dynamic pore pressure (u2) in MPa →

-0.1 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3

G.L. : 0.00 m

0.3

0.7

1.1

1.5

1.8

Target depth

Hole collapsed dry at 3.4

0.00 0.20 0.40 0.60 0.80 1.00 1.20
--- Equilibrium pore pressure (u0) in MPa →

☒ Inclination (I) in degr



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

Position: **0, 0 RD**

Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-103** 2/14

← Depth in m to reference level ()

— Corrected cone resistance (qt) in MPa →

2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

G.L. : 0.00 m

24 ->

28.9 ->

Target depth

Hole collapsed dry at 3.4

150 cm²
10 cm²



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

Position: **0, 0 RD**

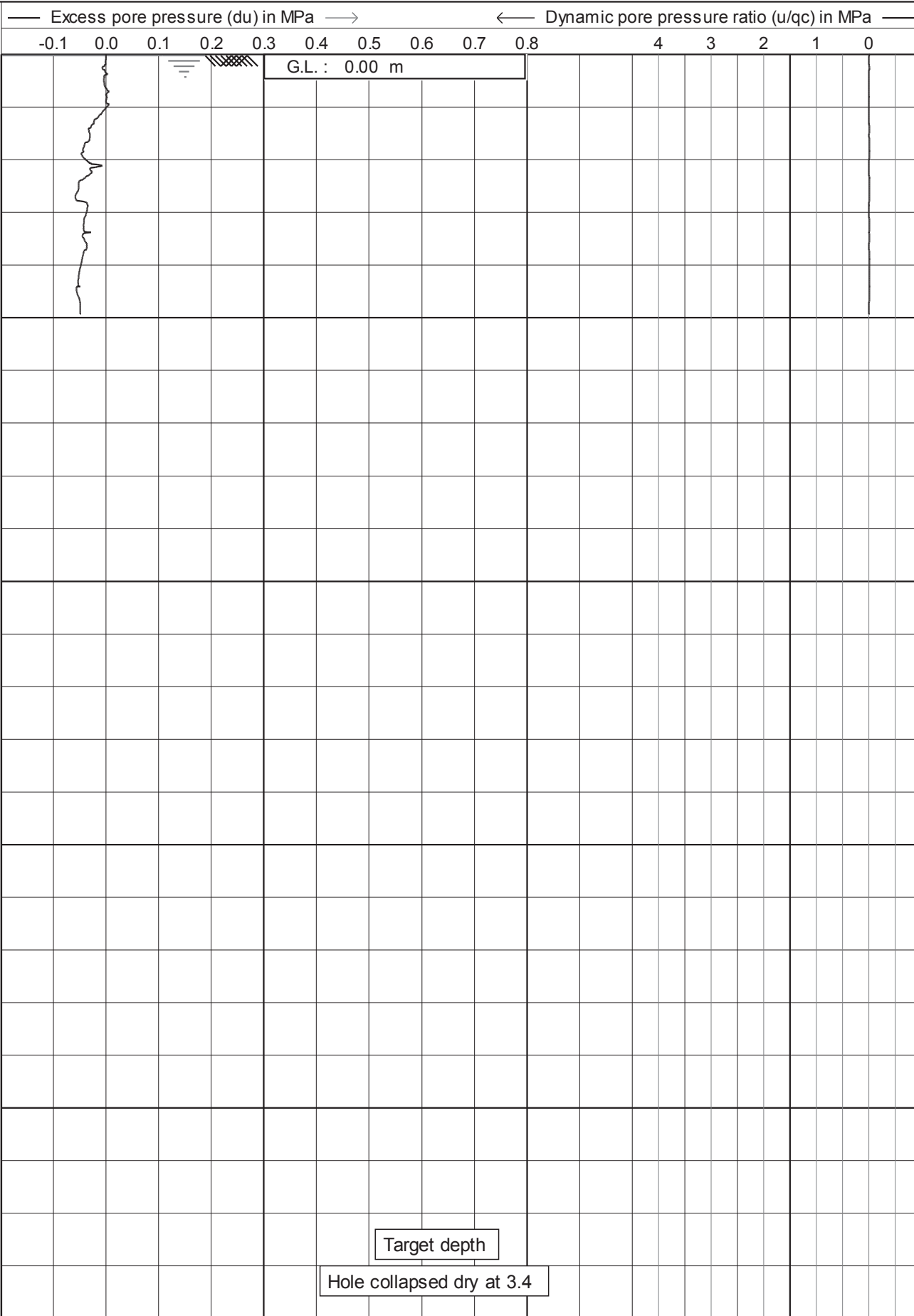
Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-103** 3/14

← Depth in m to reference level ()



150 cm²
10 cm²



Test according A.S.T.M Standard D 5778-12 Project : Site Investigations Location: Terrace Views - Papamoa Position: 0, 0 RD	Date : 17/10/2018	
	Cone no. : C10CFIP.C14433	
	Project no. : 05AU2	
	CPT no. : AU18-103	4/14

← Depth in m to reference level ()

— Effective cone resistance (q_e) in MPa —→

2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

G.L. : 0.00 m

24 ->

28.9 ->

Target depth

Hole collapsed dry at 3.4

150 cm²
10 cm²



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

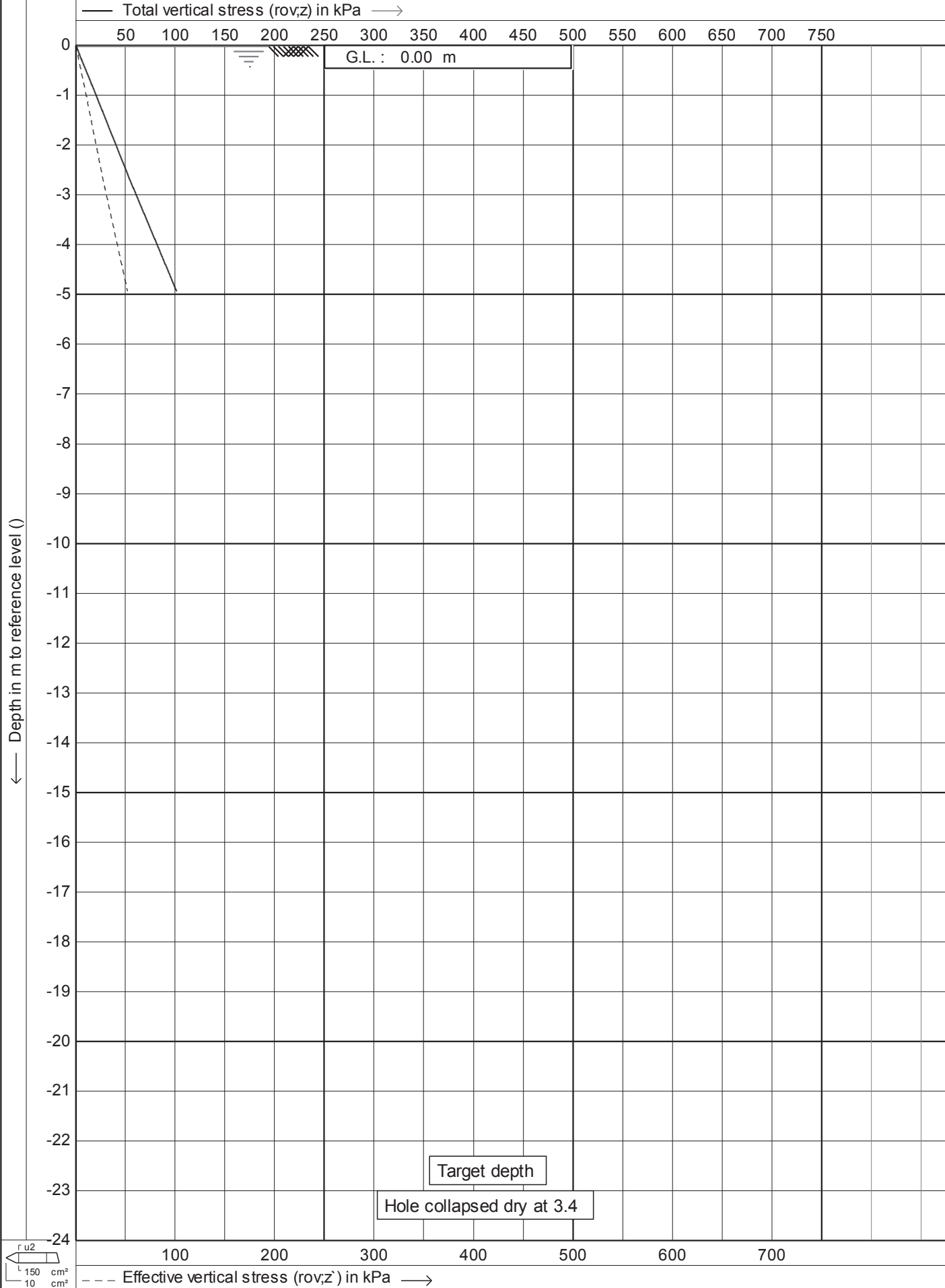
Position: **0, 0 RD**

Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-103** 5/14



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

Position: **0, 0 RD**

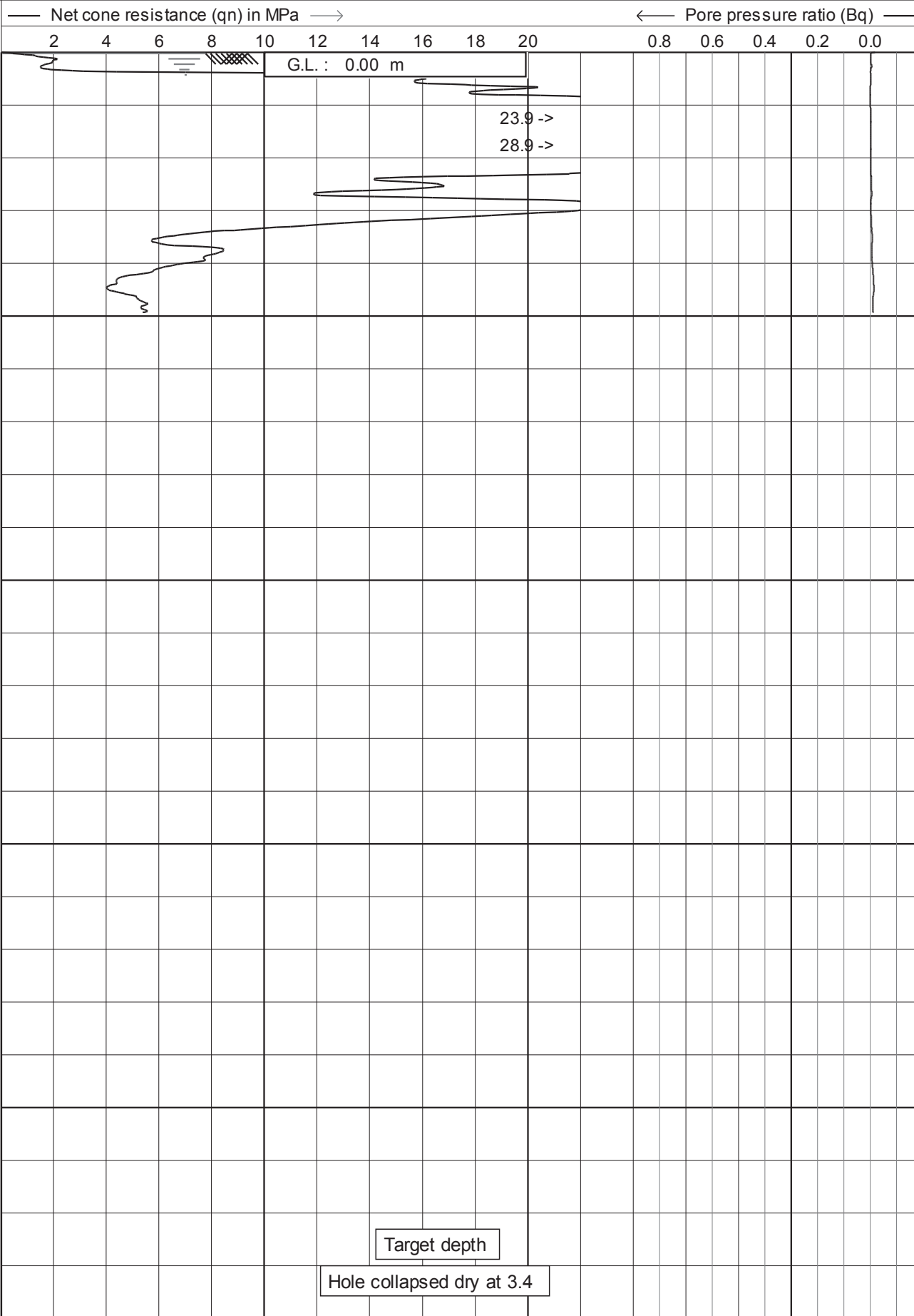
Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-103** **6/14**

← Depth in m to reference level ()



150 cm²
10 cm²



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

Position: **0, 0 RD**

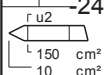
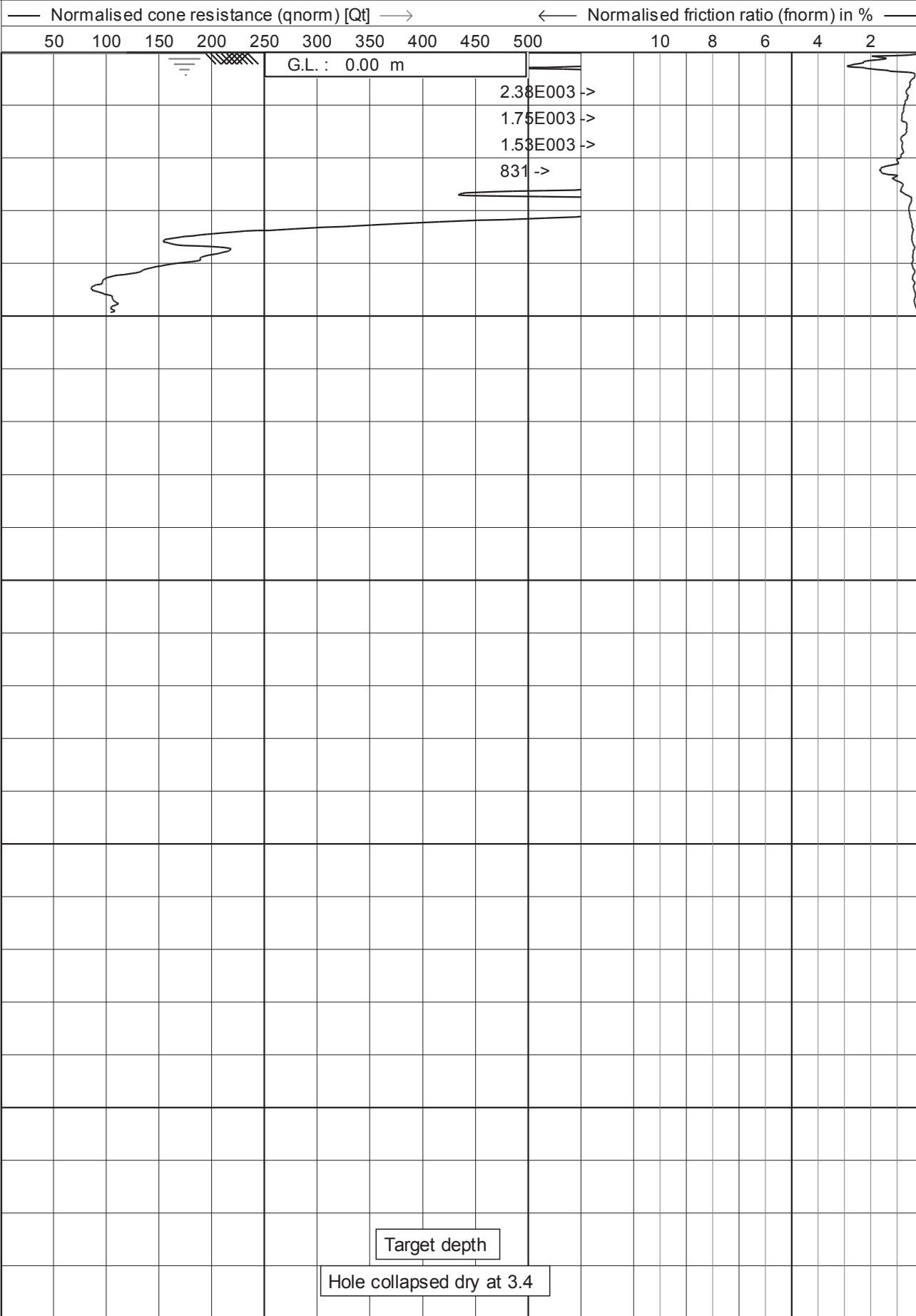
Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-103** 7/14

Depth in m to reference level ()



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

Position: **0, 0 RD**

Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-103** 8/14

← Depth in m to reference level ()

— Soil behaviour type index (Ic) —→

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5

G.L. : 0.00 m

0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
-20
-21
-22
-23
-24

(2) Organic soils
(3) Clay
(4) Silt mixtures
(5) Sand mixtures
(6) Sand clean to silty
(7) Gravelly sand

ru2
150 cm²
10 cm²

7

6

5

4

3

2



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

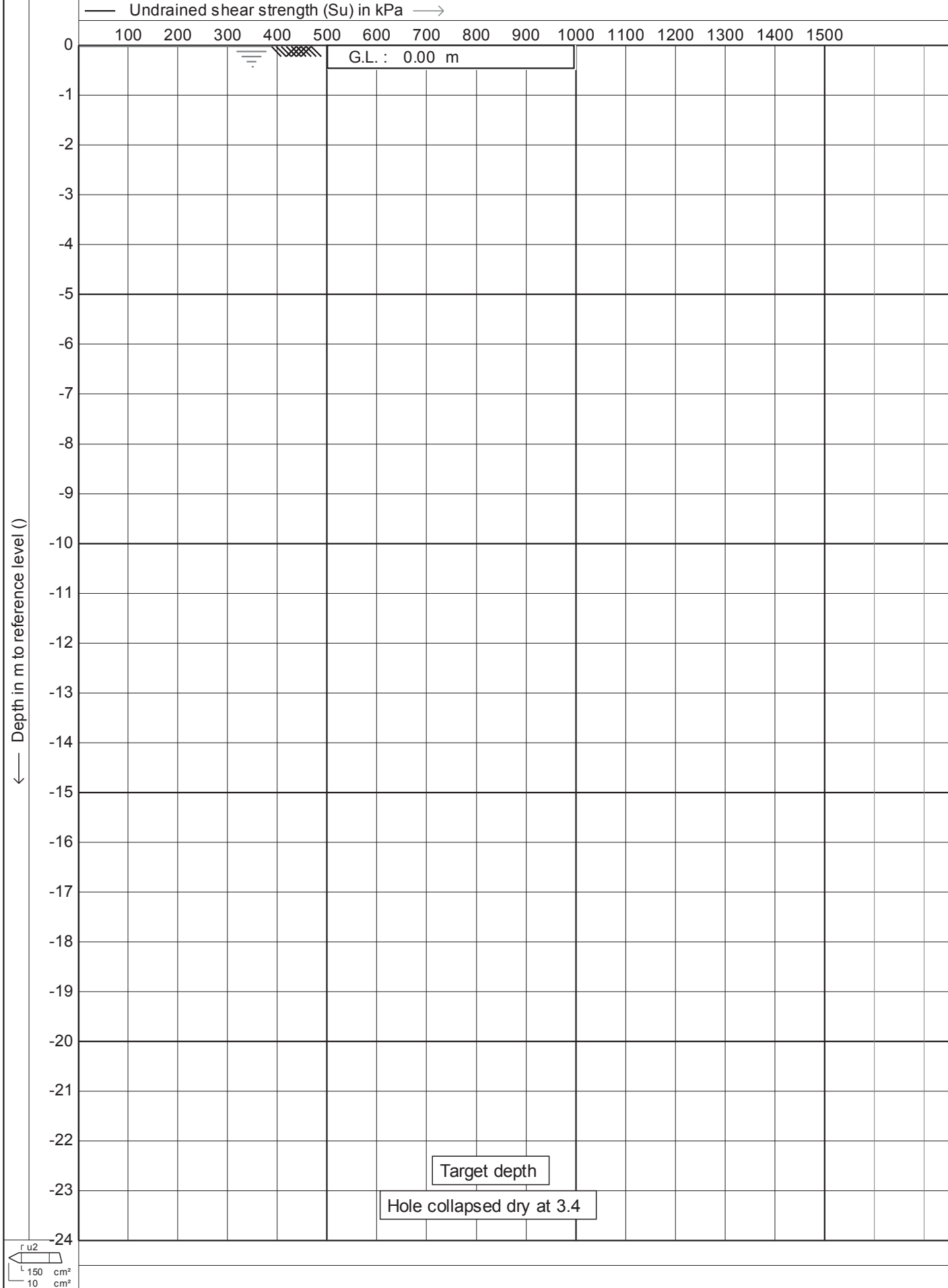
Position: **0, 0 RD**

Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-103** 9/14



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

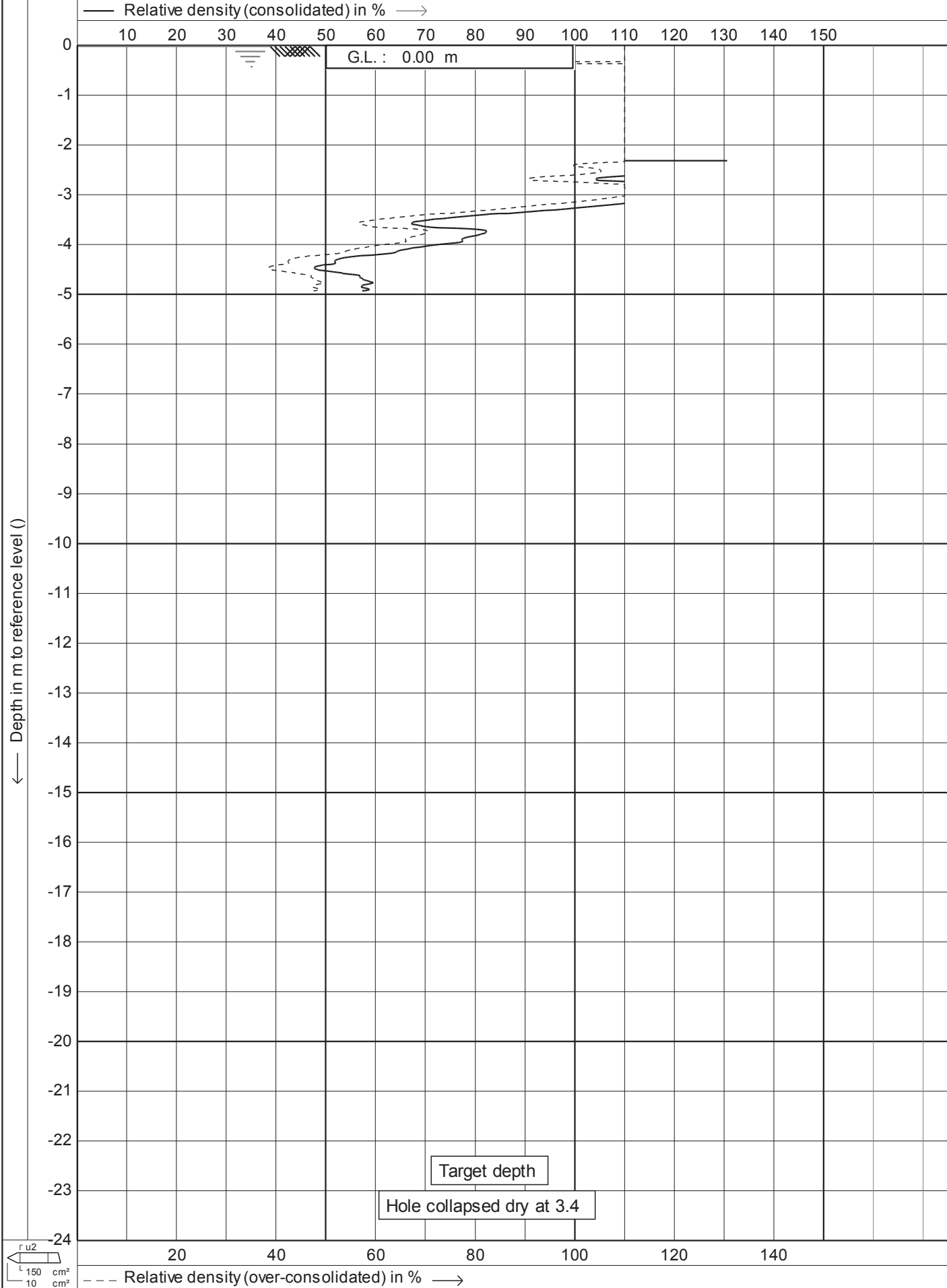
Position: **0, 0 RD**

Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-103** 10/14



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

Position: **0, 0 RD**

Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-103** 11/14

← Depth in m to reference level ()

— Equivalent SPT N60 Value —→

5 10 15 20 25 30 35 40 45 50 55 60 65 70 75

G.L. : 0.00 m

0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
-20
-21
-22
-23
-24

Target depth

Hole collapsed dry at 3.4

150 cm²
10 cm²



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

Position: **0, 0 RD**

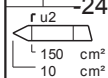
Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-103**

12/14



- (0) Not defined
- (1) Sensitive, fine grained
- (2) Organic soils-peats
- (3) Clays-clay to silty clay
- (4) Clayey silt to silty clay
- (5) Sand mixtures
- (6) Sands
- (7) Gravelly sand to sand
- (8) Very stiff sand to clayey sand
- (9) Very stiff fine grained


 150 cm
 10 cm



← Depth in m to reference level ()

Internal friction angle in degrees →

5 10 15 20 25 30 35 40 45 50 55 60 65 70 75

G.L. : 0.00 m

150 cm²
10 cm²

Target depth

Hole collapsed dry at 3.4



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

Position: **0, 0 RD**

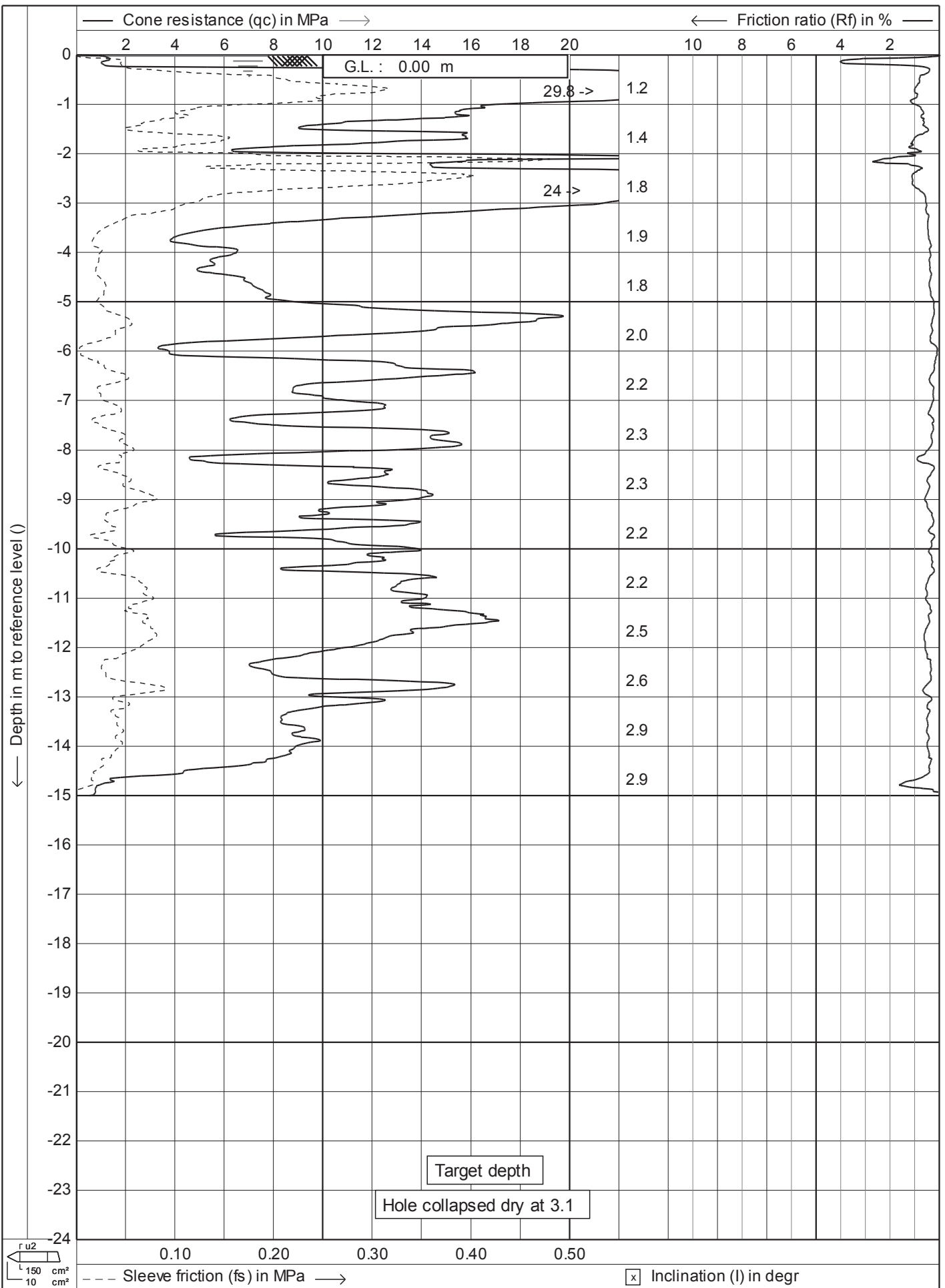
Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-103**

14/14



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

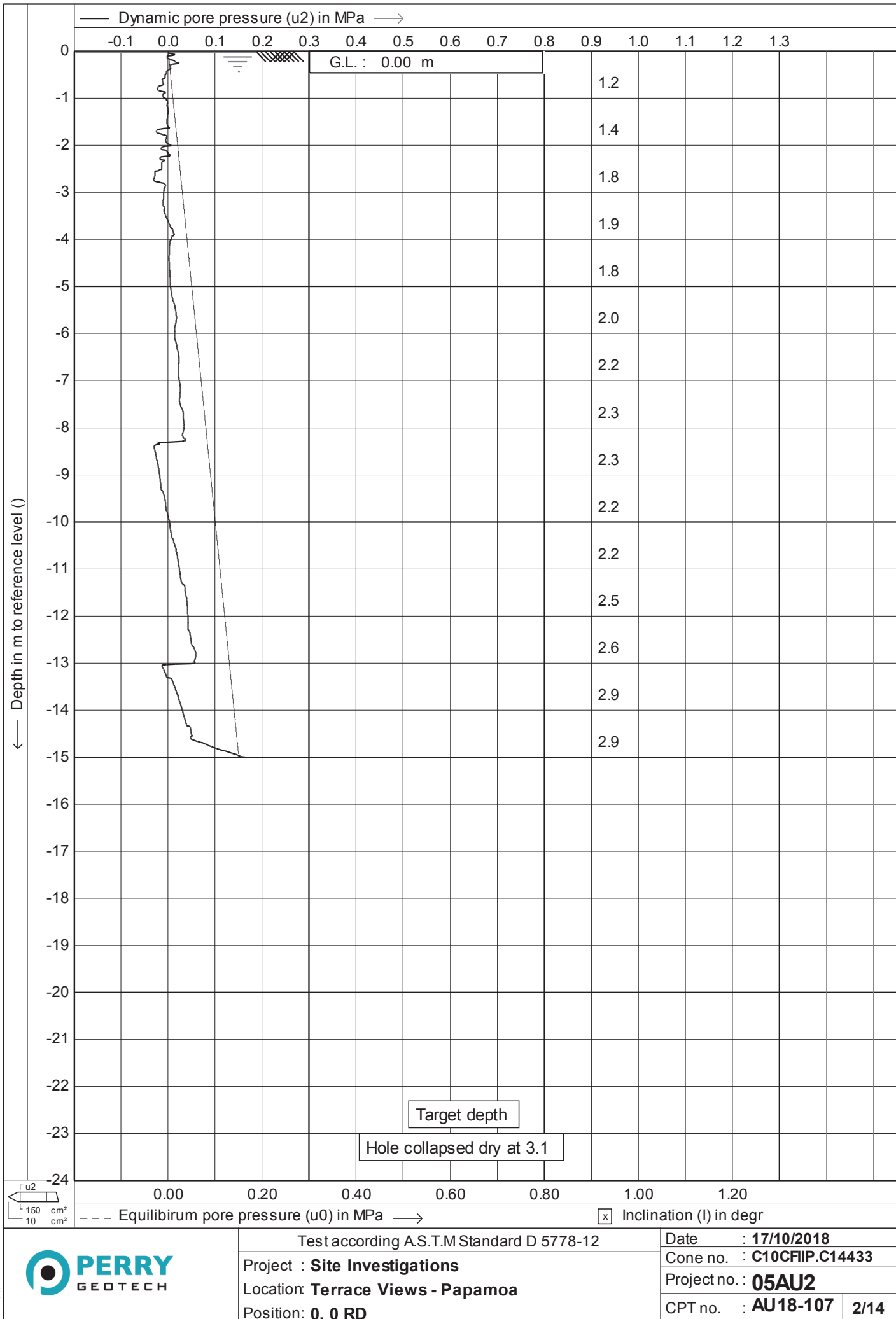
Position: **0, 0 RD**

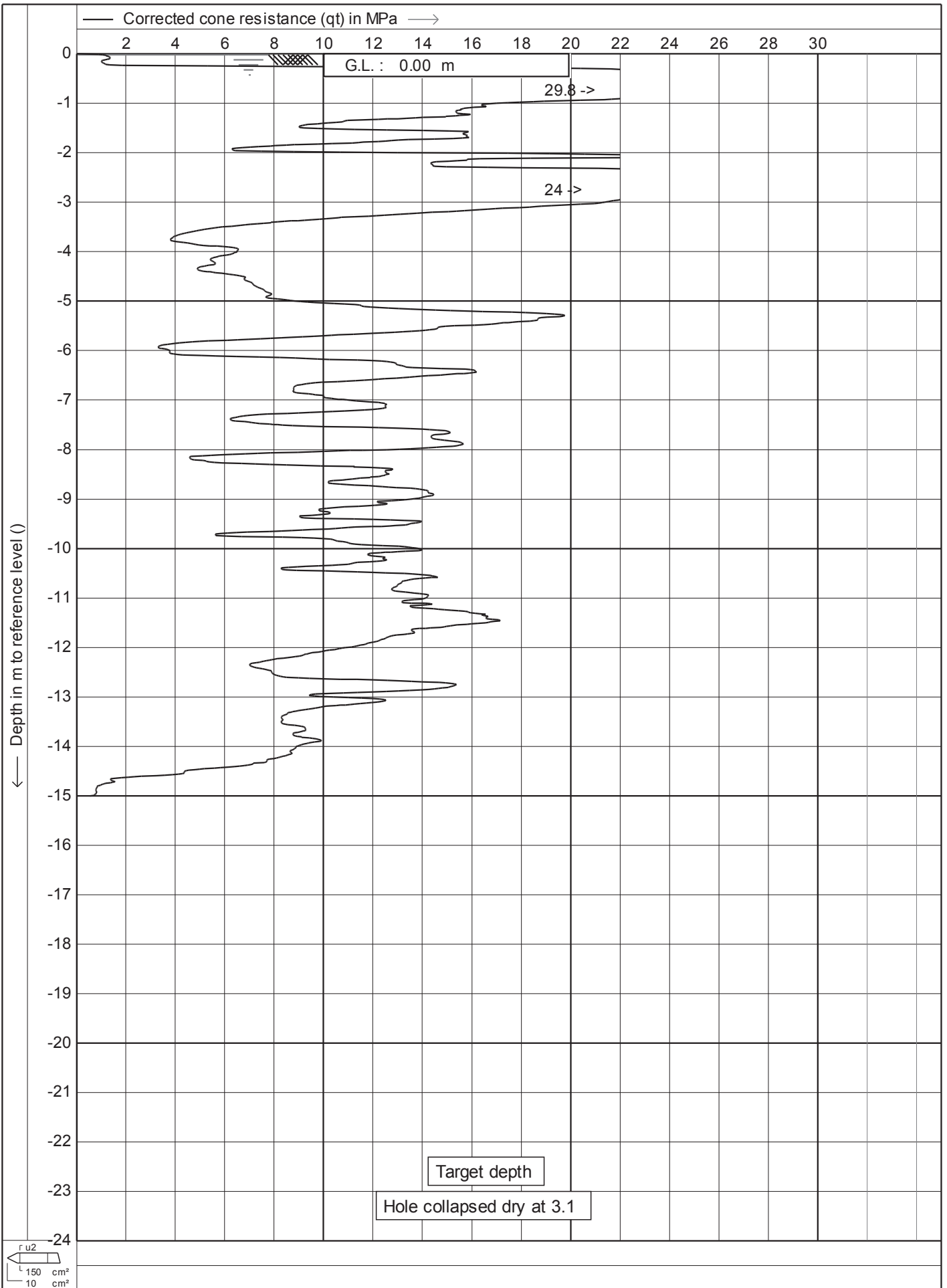
Date : **17/10/2018**

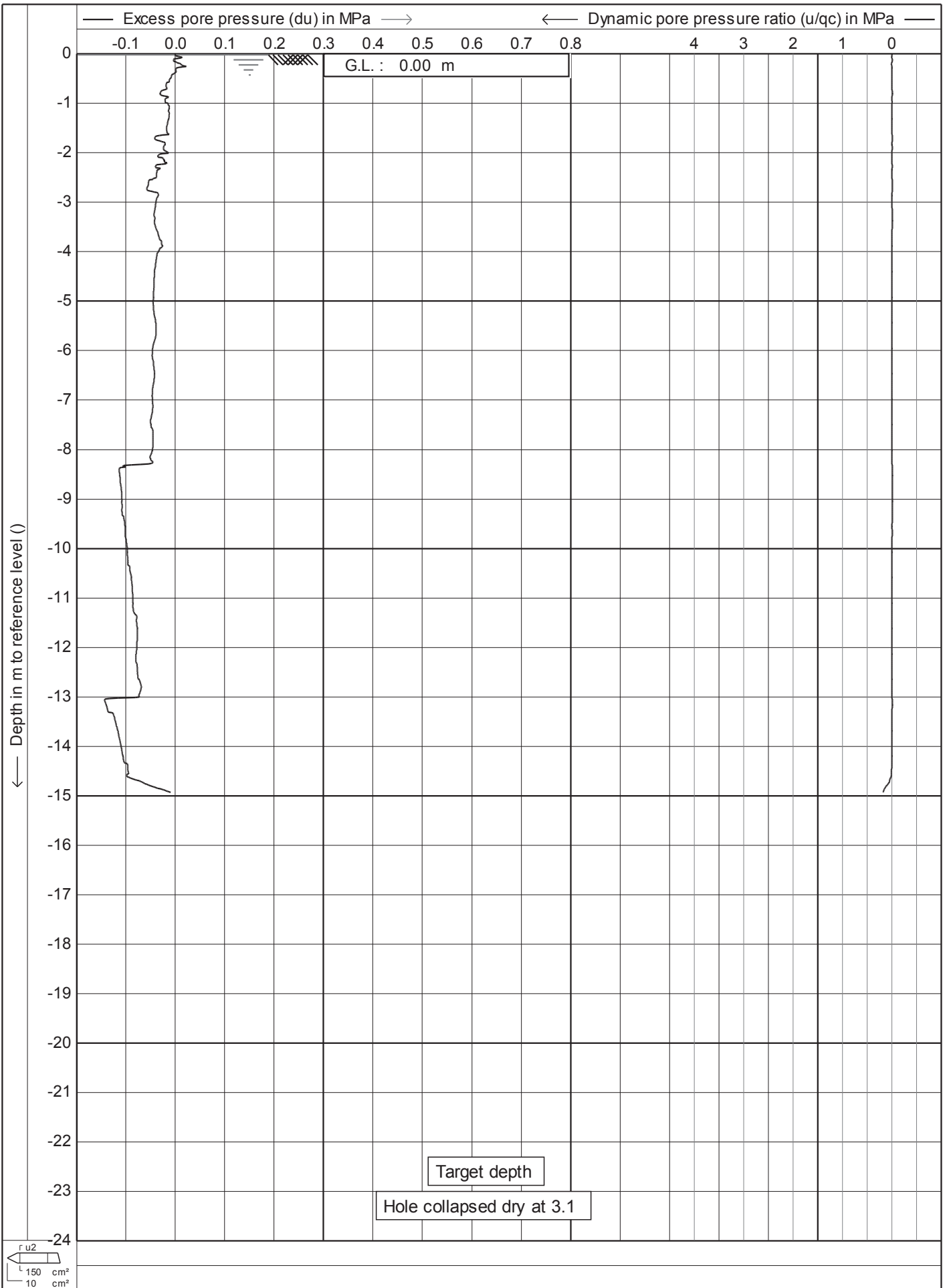
Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-107** 1/14







Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

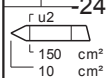
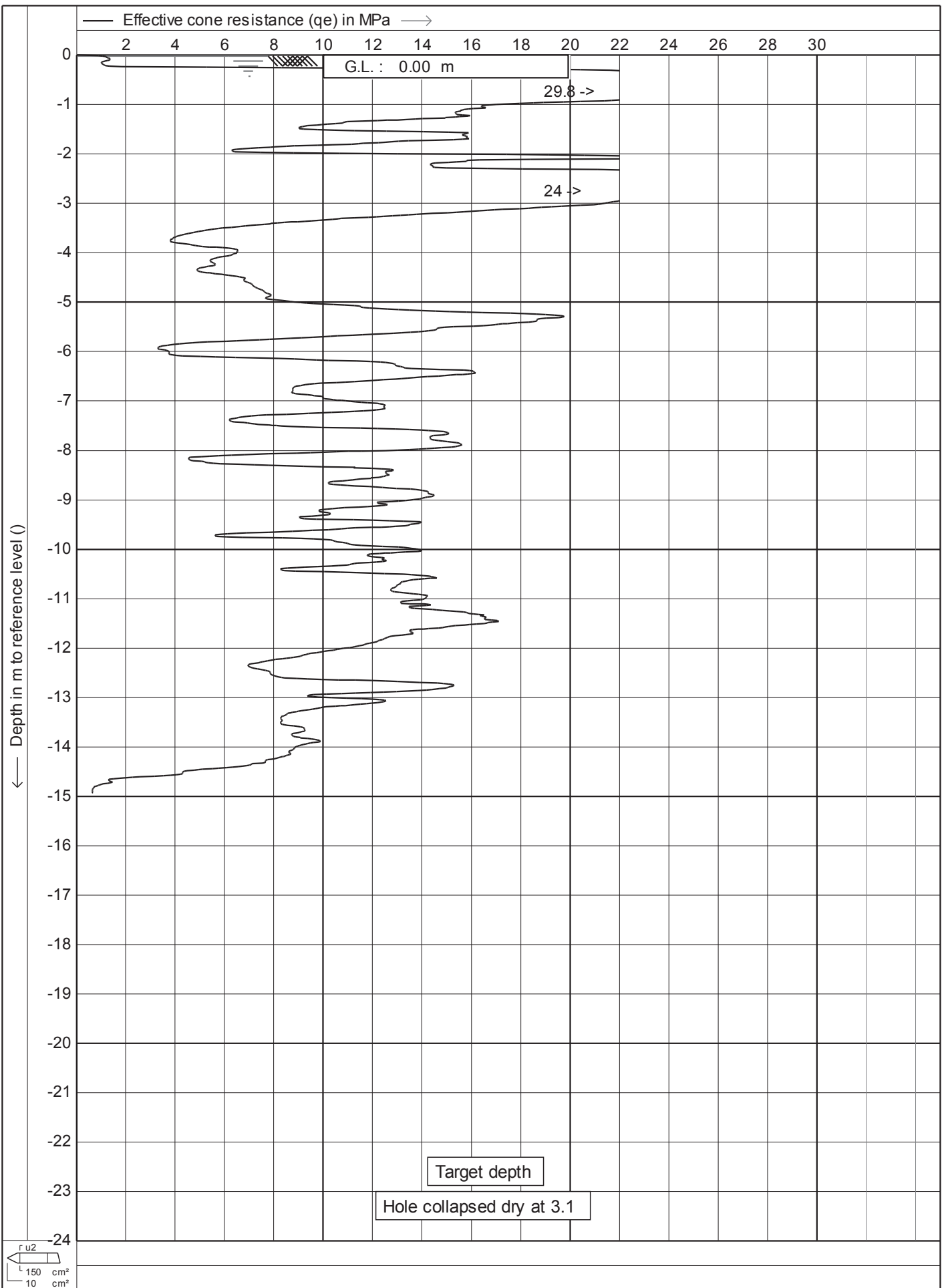
Position: **0, 0 RD**

Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-107** 4/14



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

Position: **0, 0 RD**

Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

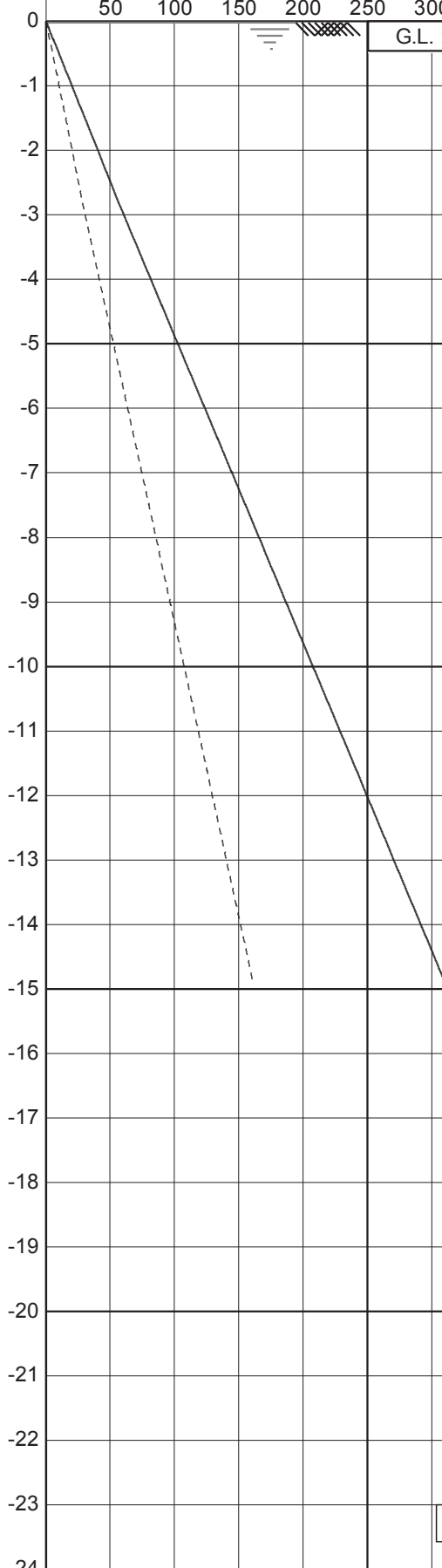
CPT no. : **AU18-107** **5/14**

Depth in m to reference level ()

— Total vertical stress (rov,z) in kPa —>

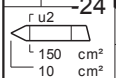
50 100 150 200 250 300 350 400 450 500 550 600 650 700 750

G.L. : 0.00 m



Target depth

Hole collapsed dry at 3.1



--- Effective vertical stress (rov,z') in kPa -->

100

200

300

400

500

600

700



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

Position: **0, 0 RD**

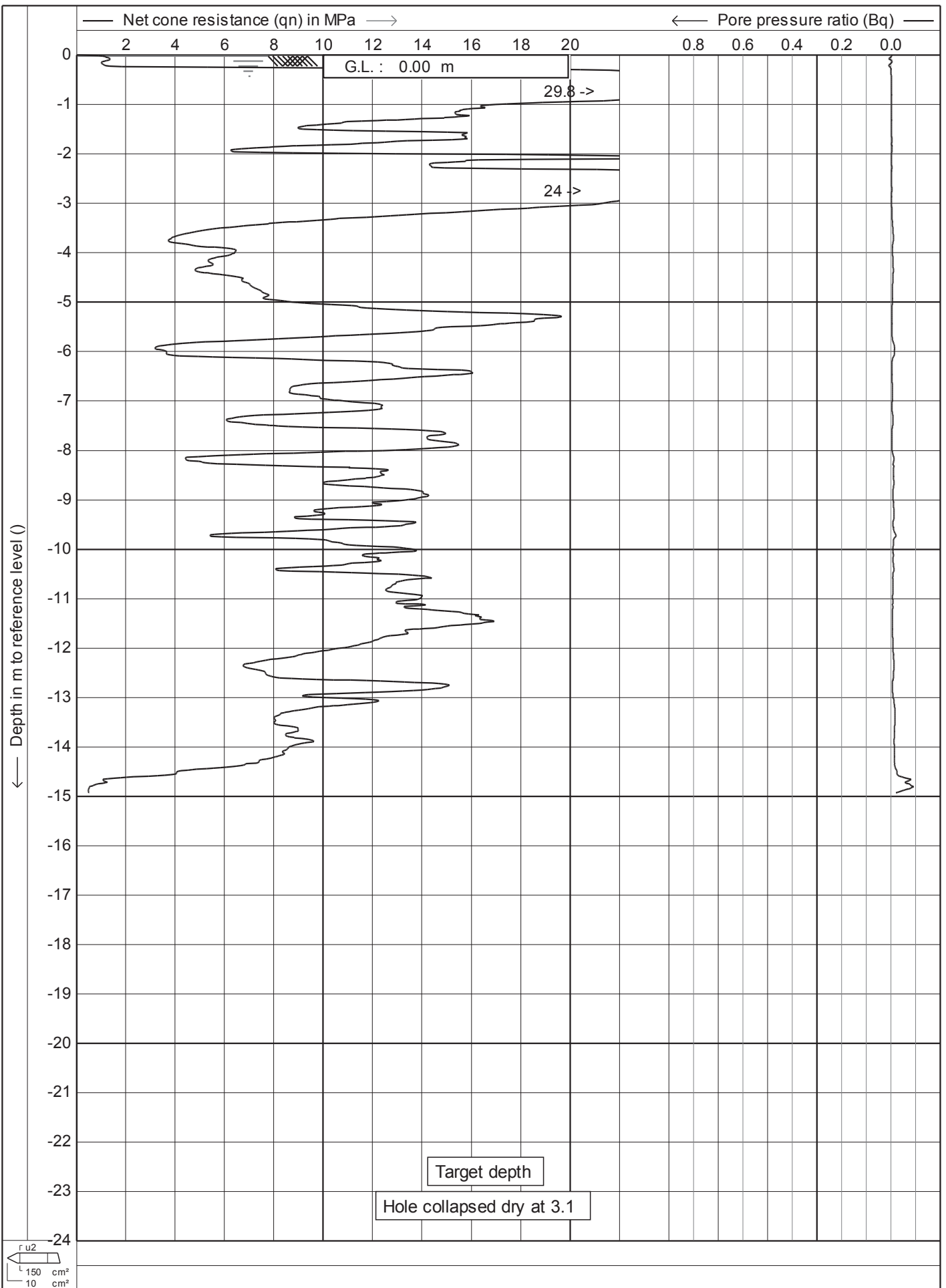
Date : **17/10/2018**

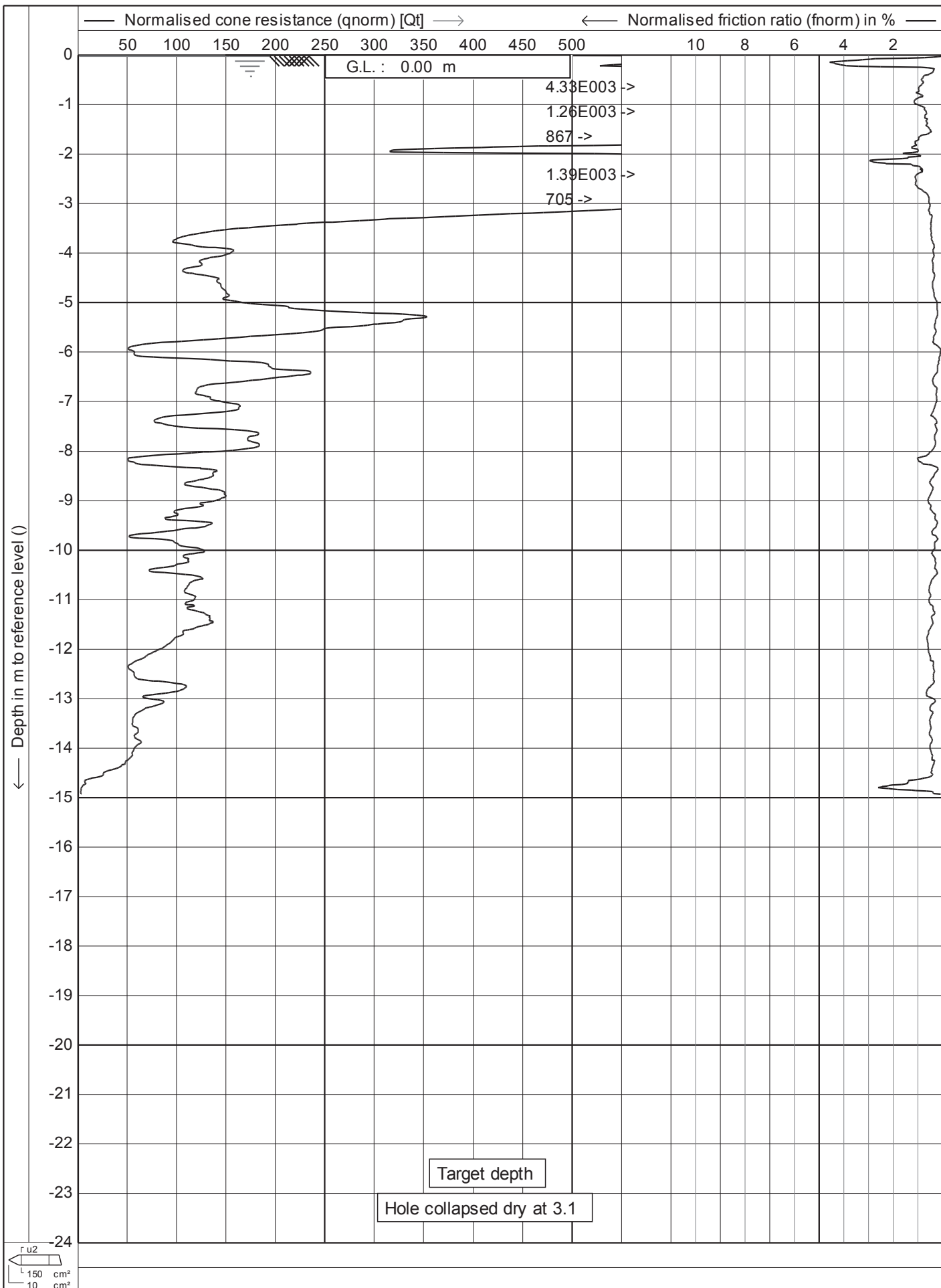
Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-107**

6/14





Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

Position: **0, 0 RD**

Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

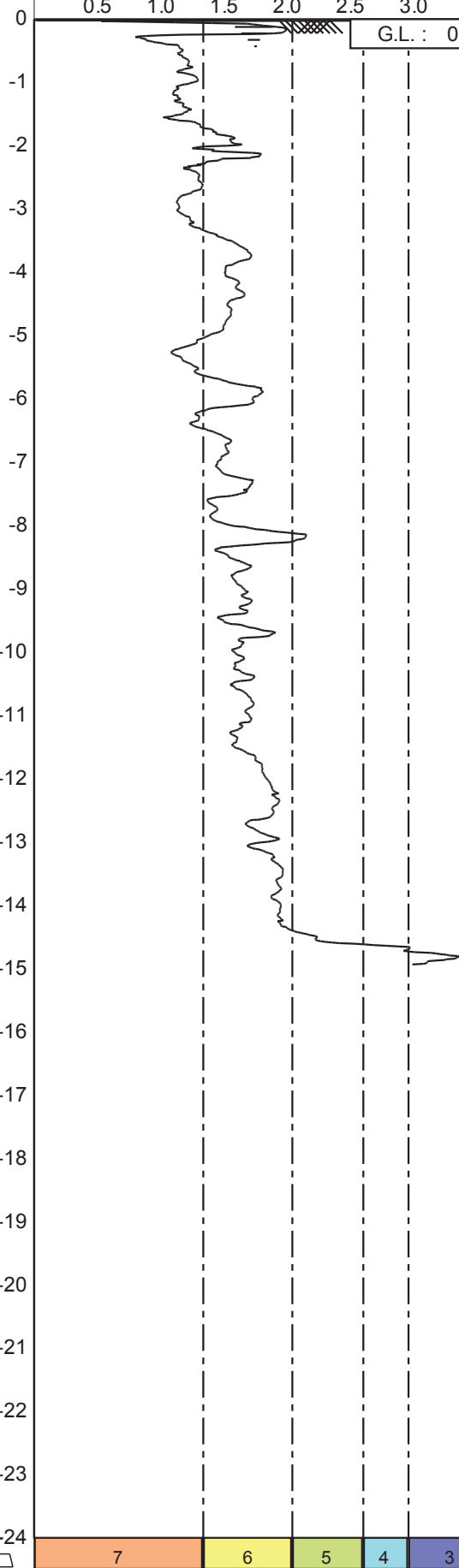
CPT no. : **AU18-107** 8/14

← Depth in m to reference level ()

— Soil behaviour type index (Ic) —→

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5

G.L. : 0.00 m



(2) Organic soils
(3) Clay
(4) Silt mixtures
(5) Sand mixtures
(6) Sand clean to silty
(7) Gravelly sand

150 cm²
10 cm²



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

Position: **0, 0 RD**

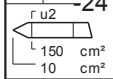
Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-107** 9/14

← Depth in m to reference level ()



Test according A.S.T.M Standard D 5778-12		Date : 17/10/2018
Project : Site Investigations		Cone no. : C10CFIP.C14433
Location: Terrace Views - Papamoa		Project no. : 05AU2
Position: 0, 0 RD		CPT no. : AU18-107 10/14

Depth in m to reference level ()

— Relative density (consolidated) in % —>

10 20 30 40 50 60 70 80 90 100 110 120 130 140 150

G.L. : 0.00 m

126 ->

Target depth

Hole collapsed dry at 3.1

--- Relative density (over-consolidated) in % -->



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

Position: **0, 0 RD**

Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-107**

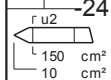
11/14

← Depth in m to reference level ()

— Equivalent SPT N60 Value —→

5 10 15 20 25 30 35 40 45 50 55 60 65 70 75

G.L. : 0.00 m



Target depth

Hole collapsed dry at 3.1



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

Position: **0, 0 RD**

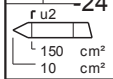
Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-107**

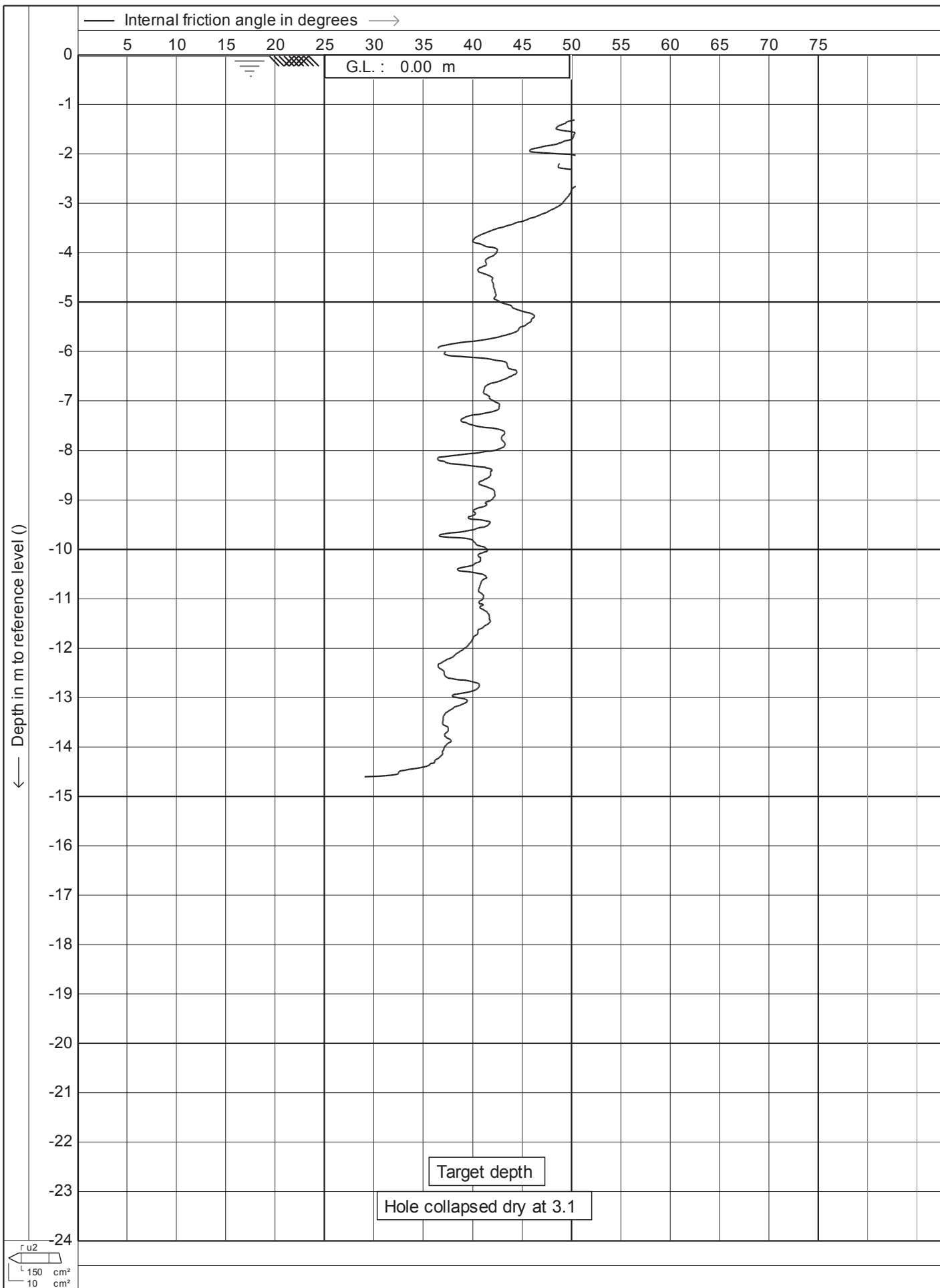
12/14



Project : **Site Investigations**
Location: **Terrace Views - Papamoa**
Position: **0, 0 RD**

CPT no. : **AU18-107**

13/14



Test according A.S.T.M Standard D 5778-12

Project : **Site Investigations**

Location: **Terrace Views - Papamoa**

Position: **0, 0 RD**

Date : **17/10/2018**

Cone no. : **C10CFIP.C14433**

Project no. : **05AU2**

CPT no. : **AU18-107**

This Mathcad sheet is for cantilever timber pole walls in cohesionless soils. It is based on the NZ Building Code Handbook

Written by Ian McPherson Wellington Office. See Ian for any changes. Revised 27 July 2004 for Broms factors

1. Edited 24 September 2018 by Miles Buob for passive earth coefficient on sloping ground

JOB DESCRIPTION

Job Name: Terrace Views Stage 3D Retaining Walls

Job No: 247593

Engineer: KK

UNIT DEFINITIONS

$$\text{kPa} := 1000 \frac{\text{N}}{\text{m}^2} \quad \text{kN} := 1000\text{N} \quad \text{MPa} := 1000 \cdot \text{kPa} \quad \text{kNm} := 1000 \cdot \text{N} \cdot \text{m} \quad \text{deg} := \frac{\pi}{180}$$

INPUT PARAMETERS (input highlighted values)

Soil properties

$\phi := 33\text{deg}$ Backfill angle of friction

$\phi_w := 22\text{deg}$ Angle of wall friction

$\beta := 0\text{deg}$ Inclination of backfill surface

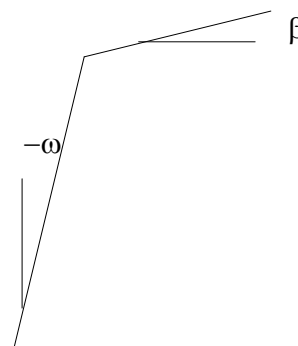
$\phi_f := 33\text{deg}$ Foundation angle of friction

$\omega := 0\text{deg}$ Inclination of back of wall, see diagram for orientation

$\gamma_b := 15 \frac{\text{kN}}{\text{m}^3}$ Unit weight of backfill (kN/m³) $Q_s := 5\text{kPa}$ Surcharge load

$\gamma_f := 10 \frac{\text{kN}}{\text{m}^3}$ Unit weight of foundation soils (allow for submerged weight as appropriate)

$\alpha := 0\text{deg}$ Slope angle from horizontal below retaining wall for passive earth pressure calculation (Should be negative if downsloping away from retaining wall)



$$K_a := \frac{(\cos(\phi - \omega))^2}{\left[(\cos(\omega))^2 \cdot \cos(\phi_w + \omega) \cdot \left(1 + \sqrt{\frac{\sin(\phi_w + \phi) \cdot \sin(\phi - \beta)}{\cos(\phi_w + \omega) \cdot \cos(\beta - \omega)}} \right)^2 \right]} \quad K_a = 0.26$$

$$K_p := \frac{\cos(\phi)^2}{\left[1 - \left(\sin(\phi)^2 + \sin(\phi) \cdot \cos(\phi) \cdot \tan(\alpha) \right)^{0.5} \right]^2} \quad K_p = 3.39$$

Wall and Pole Dimensions

$H_{\text{retained}} := 1.0\text{m}$ Wall height. Should include any wedge of ground in front of the poles considered to give no lateral support

$D_{\text{pole}} := 0.2\text{m}$ Pole short end diameter

$D_{\text{hole}} := 0.2\text{m}$ Normally hole diameter = $D_{\text{pole}} + 150\text{mm}$ for timber poles

$\text{Pole_Spacing} := 1.0\text{m}$ Pole spacing

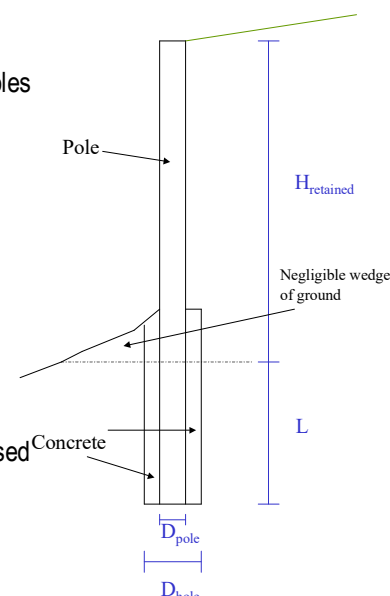
$L := 2.0\text{m}$ Depth of pile embedment

$f := H_{\text{retained}} \cdot 0.333$ Point of application of active thrust above ground

$f = 0.33\text{m}$

Pole spacing must be at least 4 times the diameter of the hole for the full capacity to be realised

$$\text{Broms} := \min\left(\frac{0.33 \cdot \text{Pole_Spacing}}{D_{\text{hole}}}, 1\right) \quad \text{Broms} = 1.00$$



Soil Ultimate Limit State Factors

$LF_{\text{ep}} := 1.6$ Load factor for lateral earth pressure

$\Phi := 0.5$ Strength reduction factor on soil capacity

Pole Properties

$\Phi_{\text{pole}} := 0.8$ For timber pole

$k_{20b} := .9$ Peeling or shaving factor bending

$k_{21b} := 0.85$ Steaming factor for bending

$k_{20s} := 1.00$ Peeling or shaving factor in shear

$k_{21s} := 0.9$ Steaming factor for shear

$k_1 := 0.6$ Load duration factor (0.6 = permanent, 0.8 = med eg snow/live/vehicle, 1.0 = wind/EQ)

$k_4 := 1.0$ Load factor in shear

$f_b := 38\text{MPa}$ Allowable bending stress (38MPa normal poles, 52MPa high strength poles, 14.8MPa sawn)

$f_s := 3.1\text{MPa}$ Allowable shear stress (3.1MPa normal poles, 3.5MPa high strength poles, 2.4MPa sawn)

CALCULATIONS

Pole Capacities

$$I(A) := \pi \cdot \frac{(D_{\text{pole}})^4}{64} \quad \text{Second moment of area of pole (m}^4\text{)}$$

$$I(A) = 7.85 \times 10^{-5} \text{ m}^4$$

Note this value is slightly conservative because it disregards the taper which can be taken as 1.5mm per metre length of pile

$$M_y(A) := f_b \cdot k_1 \cdot k_{20b} \cdot k_{21b} \cdot \Phi_{\text{pole}} \cdot \left(\frac{I(A)}{0.5 \cdot D_{\text{pole}}} \right) \quad \text{Pole ultimate factored moment capacity } M_y(A) = 10.96 \cdot \text{kNm}$$

$$V := f_s \cdot k_1 \cdot k_4 \cdot k_{20s} \cdot k_{21s} \cdot \Phi_{\text{pole}} \cdot \frac{0.72 \cdot \pi (D_{\text{pole}})^2}{4} \quad \text{Pole ultimate factored shear capacity } V = 30.29 \cdot \text{kN}$$

Note 0.72 shear area factor based on 0.9 for a circle from old ETABS manual factored by 0.8. The 0.8 factor comes from ETABS manual factor of 5/6 for beams and NZ timber code value of 2/3 ie (2/3)/(5/6) = 0.8.

Wall Loads

$$P_a := 0.5 \cdot K_a \cdot \gamma_b \cdot H_{\text{retained}}^2 \cdot L F_{ep} \cdot \text{Pole_Spacing} \quad P_a = 3.17 \cdot \text{kN} \quad \text{Active thrust per pole}$$

$$P_s := Q_s \cdot K_a \cdot H_{\text{retained}} \cdot L F_{ep} \cdot \text{Pole_Spacing} \quad P_s = 2.12 \cdot \text{kN} \quad \text{Surcharge load per pole}$$

$$H_{\text{ultmat_required}} := (P_a + P_s) \quad H_{\text{ultmat_required}} = 5.29 \cdot \text{kN} \quad \text{Required pole capacity for material strength (long pole case)}$$

$$H_{\text{ultsoil_required}} := \frac{(P_a + P_s)}{\Phi} \quad H_{\text{ultsoil_required}} = 10.58 \cdot \text{kN} \quad \text{Required pole capacity for soil strength (short pole case)}$$

$$M := P_a \cdot \frac{H_{\text{retained}}}{3} + P_s \cdot \frac{H_{\text{retained}}}{2} \quad M = 2.12 \cdot \text{kNm} \quad \text{Pole moment at ground level}$$

Capacity of Isolated Piles in Sand

Short Pole Equations (ie ground capacity critical - pile is assumed to be infinitely strong)

$$H_{u_short} := \text{Broms} \cdot K_p \cdot D_{\text{hole}} \cdot L^3 \cdot \frac{\gamma_f}{2 \cdot (f + L)} \quad H_{u_short} = 11.63 \cdot \text{kN} \quad \text{per pole}$$

$$M_{\text{max}} := H_{u_short} \cdot \left(\frac{2}{3} \cdot \sqrt{\frac{2 \cdot H_{u_short}}{3 \cdot \text{Broms} \cdot K_p \cdot D_{\text{hole}} \cdot \gamma_f}} + f \right) \quad M_{\text{max}} = 12.16 \cdot \text{kNm}$$

$$g_c := \sqrt{\frac{2 \cdot H_{u_short}}{3 \cdot \text{Broms} \cdot K_p \cdot \gamma_f \cdot D_{\text{hole}}}} \quad \text{height below ground level of maximum moment} \quad g_c = 1.069 \text{ m} \quad L = 2.00 \text{ m}$$

Long Pole Equations (ie timber capacity critical - H_u derived from pile bending cap M_y)

$$H_{u_long} := \text{root} \left[H_{u_short} \cdot \left(\frac{2}{3} \cdot \sqrt{\frac{2 \cdot H_{u_short}}{3 \cdot \text{Broms} \cdot K_p \cdot D_{\text{hole}} \cdot \gamma_f}} + f \right) - M_y(A), H_{u_short} \right] \quad H_{u_long} = 10.76 \cdot \text{kN} \quad \text{per pole}$$

$$g_{c_long} := \sqrt{\frac{2 \cdot H_{u_long}}{3 \cdot \text{Broms} \cdot K_p \cdot \gamma_f \cdot D_{\text{hole}}}} \quad g_{c_long} = 1.03 \text{ m}$$

OUTPUT VALUES

Checking failure of the pole in shear

$$H_{\text{ultmat_required}} = 5.29 \cdot \text{kN} \quad \text{per pole} \quad \text{Required timber capacity}$$

$$V = 30.29 \cdot \text{kN} \quad \text{per pole} \quad \text{Shear capacity of timber}$$

$$\text{Status} := \begin{cases} \text{"NG"} & \text{if } V < H_{\text{ultmat_required}} \\ \text{"OK"} & \text{otherwise} \end{cases}$$

Status = "OK"

Checking failure of the pole in flexure

$$M_y(A) = 10.96 \cdot \text{kNm} \quad \text{Bending Capacity of Pole}$$

$$M = 2.12 \cdot \text{kNm} \quad \text{Bending moment at ground surface}$$

$$\text{Status} = \begin{cases} \text{"NG"} & \text{if } M_y(A) < M \\ \text{"OK"} & \text{otherwise} \end{cases}$$

Status = "OK"

Checking failure of the soil

$$H_{\text{ultsoil_required}} = 10.58 \cdot \text{kN} \quad \text{per pole} \quad \text{Required soil capacity with capacity reduction factor included}$$

$$H_{u_short} = 11.63 \cdot \text{kN} \quad \text{per pole} \quad \text{Available soil capacity}$$

$$\text{Status} := \begin{cases} \text{"NG"} & \text{if } H_{u_short} < H_{\text{ultsoil_required}} \\ \text{"OK"} & \text{otherwise} \end{cases}$$

Status = "OK"

Note that in cantilever retaining walls, the maximum moment in the pole is below the surface. This is only important for driven piles, which do not have a ring of concrete below the ground strengthening them. For driven piles, the following case needs also be checked:

Checking failure of the pole in flexure below the surface

$H_{ultmat_required} = 5.29 \cdot kN$	per pole	Required timber capacity
$H_{u_long} = 10.76 \cdot kN$	per pole	Available timber pole capacity before pole fails in bending

$\text{Status} := \begin{cases} \text{"Not App"} & \text{if } D_{hole} > D_{pole} \\ \text{"NG"} & \text{if } H_{u_long} < H_{ultmat_required} \wedge D_{hole} = D_{pole} \\ \text{"OK"} & \text{otherwise} \end{cases}$

Status = "OK"

Design of Lagging

This spreadsheet is for design of timber lagging for pole walls. Written by Alan Wightman. Maintained by Wellington Office

Revisions

- 1) November 2006 for lower allowable timber bending stresses.
- 2) Feb 07 to correct error in ϕM_n by IDM.
- 3) Feb 08 to allow for adjusting pressure on lagging for pole spacing
- 4) May 08 by Ian McPherson to include deflections

Job Name: Lot 242 Kennedy Ridge Development

Job No 503901

Engineer: MB

Assume lagging lies across a single span

$$\frac{\text{kN}}{\text{m}} := 1000 \cdot \text{N} \quad \frac{\text{kPa}}{\text{m}^2} := 1000 \cdot \frac{\text{N}}{\text{m}^2} \quad \frac{\text{MPa}}{\text{m}^2} := 1000 \cdot \text{kPa}$$

Enter input parameters

$$K_a := 0.295 \quad \text{Soil Active pressure} \quad \gamma := 15 \frac{\text{kN}}{\text{m}^3} \quad \text{Backfill unit weight} \quad E := 5.5 \text{ GPa} \quad \text{Lagging stiffness}$$

$$H_{\text{ret}} := 1.0 \text{ m} \quad \text{Depth of lagging. May be different from wall height} \quad L := 1.20 \text{ m} \quad \text{(Pole spacing)}$$

$$B := 150 \text{ mm} \quad \text{Lagging width (not too important 150mm normally OK)} \quad \text{sur} := 2 \text{ kPa} \quad \text{(surcharge)}$$

$$S_f := 0.8 \quad \text{Active pressure reduction factor to allow arching between the poles. Use say 0.6 for poles up to 1m spacing and something less as poles spacing decreases. Justify choice of } S_f \text{ in calcs}$$

$$L_f := 1.6 \quad \text{Load factor. Normally 1.6 static (G + Surcharge) and 1.0 earthquake (G + EQ)}$$

$$\text{Pressure} := L_f (K_a \cdot \gamma \cdot H_{\text{ret}} + K_a \cdot \text{sur}) \cdot S_f \quad \text{Pressure} = 6.419 \cdot \text{kPa}$$

$$\text{convert pressure to UDL on plank} \quad \omega := \text{Pressure} \cdot B \quad \omega = 0.963 \cdot \frac{\text{kN}}{\text{m}}$$

$$\text{Maximum moment in the plank} \quad M_{\text{star}} := \omega \cdot \frac{L^2}{8} \quad M_{\text{star}} = 173 \cdot \text{N} \cdot \text{m}$$

$$\text{Nominal Lagging thickness} \quad t_{\text{nom}} := 50 \cdot \text{mm}$$

$$\text{Actual Lagging thickness} \quad t := \begin{cases} 46 \cdot \text{mm} & \text{if } t_{\text{nom}} = 50 \cdot \text{mm} \\ 67 \cdot \text{mm} & \text{if } t_{\text{nom}} = 75 \cdot \text{mm} \\ 92 \cdot \text{mm} & \text{if } t_{\text{nom}} = 100 \cdot \text{mm} \end{cases} \quad t = 46 \cdot \text{mm}$$

$$\text{timber factors} \quad \phi := 0.8 \quad k_1 := 0.6 \quad k_4 := 1 \quad k_8 := .98$$

$$\text{timber flexural strength} \quad f_b := 11.7 \cdot \text{MPa} \quad \text{Note this stress is for VSG8, VSG10, or G8 timber at 25\% water content as per latest timber Code amendments. Use 7.5MPa for No.1 Framing grade timber}$$

$$\phi M_n := \phi \cdot k_1 \cdot k_4 \cdot k_8 \cdot f_b \cdot t^2 \cdot B \cdot \frac{1}{6} \quad \phi M_n = 291.1 \cdot \text{N} \cdot \text{m} \quad \text{Status} := \begin{cases} \text{"OK"} & \text{if } \phi M_n > M_{\text{star}} \\ \text{"NG"} & \text{if } \phi M_n \leq M_{\text{star}} \end{cases} \quad \text{Status} = \text{"OK"}$$

$$I := B \cdot \frac{t^3}{12} \quad I = 1.217 \times 10^{-6} \text{ m}^4$$

$$\text{Deflection} := 5 \cdot \frac{\omega}{L_f} \cdot \frac{L^4}{384 \cdot E \cdot I} \quad \text{Deflection} = 2 \cdot \text{mm}$$

Note L.f included to get back to unfactored loads for calculating settlement.

This Mathcad sheet is for cantilever timber pole walls in cohesionless soils. It is based on the NZ Building Code Handbook

Written by Ian McPherson Wellington Office. See Ian for any changes. Revised 27 July 2004 for Broms factors

1. Edited 24 September 2018 by Miles Buob for passive earth coefficient on sloping ground

JOB DESCRIPTION

Job Name: Terrace Views Stage 3D Retaining Walls

Job No: 247593

Engineer: KK / AF / MB

UNIT DEFINITIONS

$$\text{kPa} := 1000 \frac{\text{N}}{\text{m}^2} \quad \text{kN} := 1000\text{N} \quad \text{MPa} := 1000 \cdot \text{kPa} \quad \text{kNm} := 1000 \cdot \text{N} \cdot \text{m} \quad \text{degrad} := \frac{\pi}{180}$$

INPUT PARAMETERS (input highlighted values)

Soil properties

$\phi := 33\text{deg}$ Backfill angle of friction

$\phi_w := 22\text{deg}$ Angle of wall friction

$\beta := 0\text{deg}$ Inclination of backfill surface

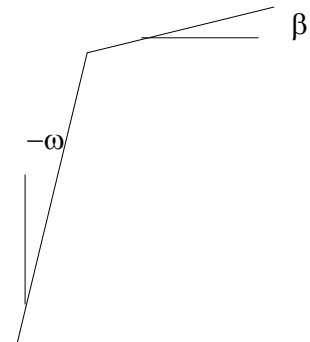
$\phi_f := 33\text{deg}$ Foundation angle of friction

$\omega := 0\text{deg}$ Inclination of back of wall, see diagram for orientation

$\gamma_b := 15 \frac{\text{kN}}{\text{m}^3}$ Unit weight of backfill (kN/m³) $Q_s := 5\text{kPa}$ Surcharge load

$\gamma_f := 10 \frac{\text{kN}}{\text{m}^3}$ Unit weight of foundation soils (allow for submerged weight as appropriate)

$\alpha := 0\text{deg}$ Slope angle from horizontal below retaining wall for passive earth pressure calculation (Should be negative if downsloping away from retaining wall)



$$K_a := \frac{(\cos(\phi - \omega))^2}{\left[(\cos(\omega))^2 \cdot \cos(\phi_w + \omega) \cdot \left(1 + \sqrt{\frac{\sin(\phi_w + \phi) \cdot \sin(\phi - \beta)}{\cos(\phi_w + \omega) \cdot \cos(\beta - \omega)}} \right)^2 \right]}$$

$$K_a = 0.26$$

$$K_p := \frac{\cos(\phi)^2}{\left[1 - \left(\sin(\phi)^2 + \sin(\phi) \cdot \cos(\phi) \cdot \tan(\alpha) \right)^{0.5} \right]^2}$$

$$K_p = 3.39$$

Wall and Pole Dimensions

$H_{\text{retained}} := 2.2\text{m}$ Wall height. Should include any wedge of ground in front of the poles considered to give no lateral support

$D_{\text{pole}} := 0.325\text{m}$ Pole short end diameter

$D_{\text{hole}} := 0.325\text{m}$ Normally hole diameter = $D_{\text{pole}} + 150\text{mm}$ for timber poles

$\text{Pole_Spacing} := 1.0\text{m}$ Pole spacing

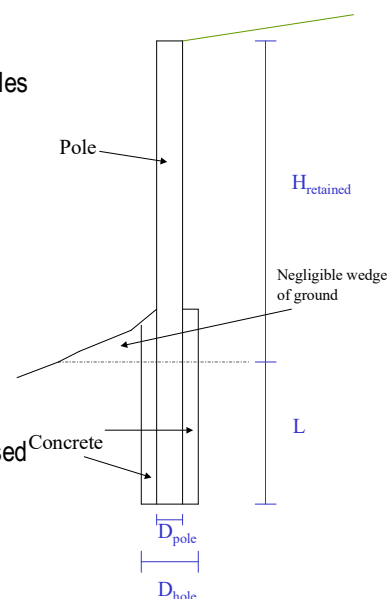
$L := 3.1\text{m}$ Depth of pile embedment

$f := H_{\text{retained}} \cdot 0.333$ Point of application of active thrust above ground

$f = 0.73\text{m}$

Pole spacing must be at least 4 times the diameter of the hole for the full capacity to be realised

$$\text{Broms} := \min\left(\frac{0.33 \cdot \text{Pole_Spacing}}{D_{\text{hole}}}, 1\right) \quad \text{Broms} = 1.00$$



Soil Ultimate Limit State Factors

$\text{LF}_{\text{ep}} := 1.6$ Load factor for lateral earth pressure

$\Phi := 0.5$ Strength reduction factor on soil capacity

Pole Properties

$\Phi_{\text{pole}} := 0.8$ For timber pole

$k_{20b} := .9$ Peeling or shaving factor bending

$k_{21b} := 0.85$ Steaming factor for bending

$k_{20s} := 1.00$ Peeling or shaving factor in shear

$k_{21s} := 0.9$ Steaming factor for shear

$k_1 := 0.6$ Load duration factor (0.6 = permanent, 0.8 = med eg snow/live/vehicle, 1.0 = wind/EQ)

$k_4 := 1.0$ Load factor in shear

$f_b := 38\text{MPa}$ Allowable bending stress (38MPa normal poles, 52MPa high strength poles, 14.8MPa sawn)

$f_s := 3.1\text{MPa}$ Allowable shear stress (3.1MPa normal poles, 3.5MPa high strength poles, 2.4MPa sawn)

CALCULATIONS

Pole Capacities

$$I(A) := \pi \cdot \frac{(D_{\text{pole}})^4}{64} \quad \text{Second moment of area of pole (m4)}$$

$$I(A) = 5.48 \times 10^{-4} \text{ m}^4$$

Note this value is slightly conservative because it disregards the taper which can be taken as 1.5mm per metre length of pile

$$M_y(A) := f_b \cdot k_1 \cdot k_{20b} \cdot k_{21b} \cdot \Phi_{\text{pole}} \cdot \left(\frac{I(A)}{0.5 \cdot D_{\text{pole}}} \right) \quad \text{Pole ultimate factored moment capacity } M_y(A) = 47.03 \cdot \text{kNm}$$

$$V := f_s \cdot k_1 \cdot k_4 \cdot k_{20s} \cdot k_{21s} \cdot \Phi_{\text{pole}} \cdot \frac{0.72 \cdot \pi (D_{\text{pole}})^2}{4} \quad \text{Pole ultimate factored shear capacity } V = 79.99 \cdot \text{kN}$$

Note 0.72 shear area factor based on 0.9 for a circle from old ETABS manual factored by 0.8. The 0.8 factor comes from ETABS manual factor of 5/6 for beams and NZ timber code value of 2/3 ie (2/3)/(5/6) = 0.8.

Wall Loads

$$P_a := 0.5 \cdot K_a \cdot \gamma_b \cdot H_{\text{retained}}^2 \cdot L F_{\text{ep}} \cdot \text{Pole_Spacing} \quad P_a = 15.36 \cdot \text{kN} \quad \text{Active thrust per pole}$$

$$P_s := Q_s \cdot K_a \cdot H_{\text{retained}} \cdot L F_{\text{ep}} \cdot \text{Pole_Spacing} \quad P_s = 4.65 \cdot \text{kN} \quad \text{Surcharge load per pole}$$

$$H_{\text{ultmat_required}} := (P_a + P_s) \quad H_{\text{ultmat_required}} = 20.01 \cdot \text{kN} \quad \text{Required pole capacity for material strength (long pole case)}$$

$$H_{\text{ultsoil_required}} := \frac{(P_a + P_s)}{\Phi} \quad H_{\text{ultsoil_required}} = 40.03 \cdot \text{kN} \quad \text{Required pole capacity for soil strength (short pole case)}$$

$$M := P_a \cdot \frac{H_{\text{retained}}}{3} + P_s \cdot \frac{H_{\text{retained}}}{2} \quad M = 16.38 \cdot \text{kNm} \quad \text{Pole moment at ground level}$$

Capacity of Isolated Piles in Sand

Short Pole Equations (ie ground capacity critical - pile is assumed to be infinitely strong)

$$H_{u_short} := \text{Broms} \cdot K_p \cdot D_{\text{hole}} \cdot L^3 \cdot \frac{\gamma_f}{2 \cdot (f + L)} \quad H_{u_short} = 42.85 \cdot \text{kN} \quad \text{per pole}$$

$$M_{\text{max}} := H_{u_short} \cdot \left(\frac{2}{3} \cdot \sqrt{\frac{2 \cdot H_{u_short}}{3 \cdot \text{Broms} \cdot K_p \cdot D_{\text{hole}} \cdot \gamma_f}} + f \right) \quad M_{\text{max}} = 77.37 \cdot \text{kNm}$$

$$g_c := \sqrt{\frac{2 \cdot H_{u_short}}{3 \cdot \text{Broms} \cdot K_p \cdot \gamma_f \cdot D_{\text{hole}}}} \quad \text{height below ground level of maximum moment} \quad g_c = 1.610 \text{ m} \quad L = 3.10 \text{ m}$$

Long Pole Equations (ie timber capacity critical - H_u derived from pile bending cap M_y)

$$H_{u_long} := \text{root} \left[H_{u_short} \cdot \left(\frac{2}{3} \cdot \sqrt{\frac{2 \cdot H_{u_short}}{3 \cdot \text{Broms} \cdot K_p \cdot D_{\text{hole}} \cdot \gamma_f}} + f \right) - M_y(A), H_{u_short} \right] \quad H_{u_long} = 29.09 \cdot \text{kN} \quad \text{per pole}$$

$$g_{c_long} := \sqrt{\frac{2 \cdot H_{u_long}}{3 \cdot \text{Broms} \cdot K_p \cdot \gamma_f \cdot D_{\text{hole}}}} \quad g_{c_long} = 1.33 \text{ m}$$

OUTPUT VALUES

Checking failure of the pole in shear

$$H_{\text{ultmat_required}} = 20.01 \cdot \text{kN} \quad \text{per pole} \quad \text{Required timber capacity}$$

$$V = 79.99 \cdot \text{kN} \quad \text{per pole} \quad \text{Shear capacity of timber}$$

$$\text{Status} := \begin{cases} \text{"NG"} & \text{if } V < H_{\text{ultmat_required}} \\ \text{"OK"} & \text{otherwise} \end{cases}$$

Status = "OK"

Checking failure of the pole in flexure

$$M_y(A) = 47.03 \cdot \text{kNm} \quad \text{Bending Capacity of Pole}$$

$$M = 16.38 \cdot \text{kNm} \quad \text{Bending moment at ground surface}$$

$$\text{Status} = \begin{cases} \text{"NG"} & \text{if } M_y(A) < M \\ \text{"OK"} & \text{otherwise} \end{cases}$$

Status = "OK"

Checking failure of the soil

$$H_{\text{ultsoil_required}} = 40.03 \cdot \text{kN} \quad \text{per pole} \quad \text{Required soil capacity with capacity reduction factor included}$$

$$H_{u_short} = 42.85 \cdot \text{kN} \quad \text{per pole} \quad \text{Available soil capacity}$$

$$\text{Status} := \begin{cases} \text{"NG"} & \text{if } H_{u_short} < H_{\text{ultsoil_required}} \\ \text{"OK"} & \text{otherwise} \end{cases}$$

Status = "OK"

Note that in cantilever retaining walls, the maximum moment in the pole is below the surface. This is only important for driven piles, which do not have a ring of concrete below the ground strengthening them. For driven piles, the following case needs also be checked:

Checking failure of the pole in flexure below the surface

$H_{ultmat_required} = 20.01 \cdot kN$	per pole	Required timber capacity
$H_{u_long} = 29.09 \cdot kN$	per pole	Available timber pole capacity before pole fails in bending

$\text{Status} := \begin{cases} \text{"Not App"} & \text{if } D_{hole} > D_{pole} \\ \text{"NG"} & \text{if } H_{u_long} < H_{ultmat_required} \wedge D_{hole} = D_{pole} \\ \text{"OK"} & \text{otherwise} \end{cases}$

Status = "OK"

Design of Lagging

This spreadsheet is for design of timber lagging for pole walls. Written by Alan Wightman. Maintained by Wellington Office

Revisions

- 1) November 2006 for lower allowable timber bending stresses.
- 2) Feb 07 to correct error in ϕM_n by IDM.
- 3) Feb 08 to allow for adjusting pressure on lagging for pole spacing
- 4) May 08 by Ian McPherson to include deflections

Job Name: Lot 242 Kennedy Ridge Development

Job No 503901

Engineer: MB

Assume lagging lies across a single span

$$\frac{\text{kN}}{\text{m}} := 1000 \cdot \text{N} \quad \frac{\text{kPa}}{\text{m}^2} := 1000 \cdot \frac{\text{N}}{\text{m}^2} \quad \frac{\text{MPa}}{\text{m}^2} := 1000 \cdot \text{kPa}$$

Enter input parameters

$$K_a := 0.295 \quad \text{Soil Active pressure} \quad \gamma := 15 \frac{\text{kN}}{\text{m}^3} \quad \text{Backfill unit weight} \quad E := 5.5 \text{ GPa} \quad \text{Lagging stiffness}$$

$$H_{\text{ret}} := 2.0 \text{ m} \quad \text{Depth of lagging. May be different from wall height} \quad L := 1.20 \text{ m} \quad \text{(Pole spacing)}$$

$$B := 150 \text{ mm} \quad \text{Lagging width (not too important 150mm normally OK)} \quad \text{sur} := 2 \text{ kPa} \quad \text{(surcharge)}$$

$$S_f := 0.8 \quad \text{Active pressure reduction factor to allow arching between the poles. Use say 0.6 for poles up to 1m spacing and something less as poles spacing decreases. Justify choice of } S_f \text{ in calcs}$$

$$L_f := 1.6 \quad \text{Load factor. Normally 1.6 static (G + Surcharge) and 1.0 earthquake (G + EQ)}$$

$$\text{Pressure} := L_f (K_a \cdot \gamma \cdot H_{\text{ret}} + K_a \cdot \text{sur}) \cdot S_f \quad \text{Pressure} = 12.083 \cdot \text{kPa}$$

$$\text{convert pressure to UDL on plank} \quad \omega := \text{Pressure} \cdot B \quad \omega = 1.812 \cdot \frac{\text{kN}}{\text{m}}$$

$$\text{Maximum moment in the plank} \quad M_{\text{star}} := \omega \cdot \frac{L^2}{8} \quad M_{\text{star}} = 326 \cdot \text{N} \cdot \text{m}$$

$$\text{Nominal Lagging thickness} \quad t_{\text{nom}} := 100 \cdot \text{mm}$$

$$\text{Actual Lagging thickness} \quad t := \begin{cases} 46 \cdot \text{mm} & \text{if } t_{\text{nom}} = 50 \cdot \text{mm} \\ 67 \cdot \text{mm} & \text{if } t_{\text{nom}} = 75 \cdot \text{mm} \\ 92 \cdot \text{mm} & \text{if } t_{\text{nom}} = 100 \cdot \text{mm} \end{cases} \quad t = 92 \cdot \text{mm}$$

$$\text{timber factors} \quad \phi := 0.8 \quad k_1 := 0.6 \quad k_4 := 1 \quad k_8 := .98$$

$$\text{timber flexural strength} \quad f_b := 11.7 \cdot \text{MPa} \quad \text{Note this stress is for VSG8, VSG10, or G8 timber at 25\% water content as per latest timber Code amendments. Use 7.5MPa for No.1 Framing grade timber}$$

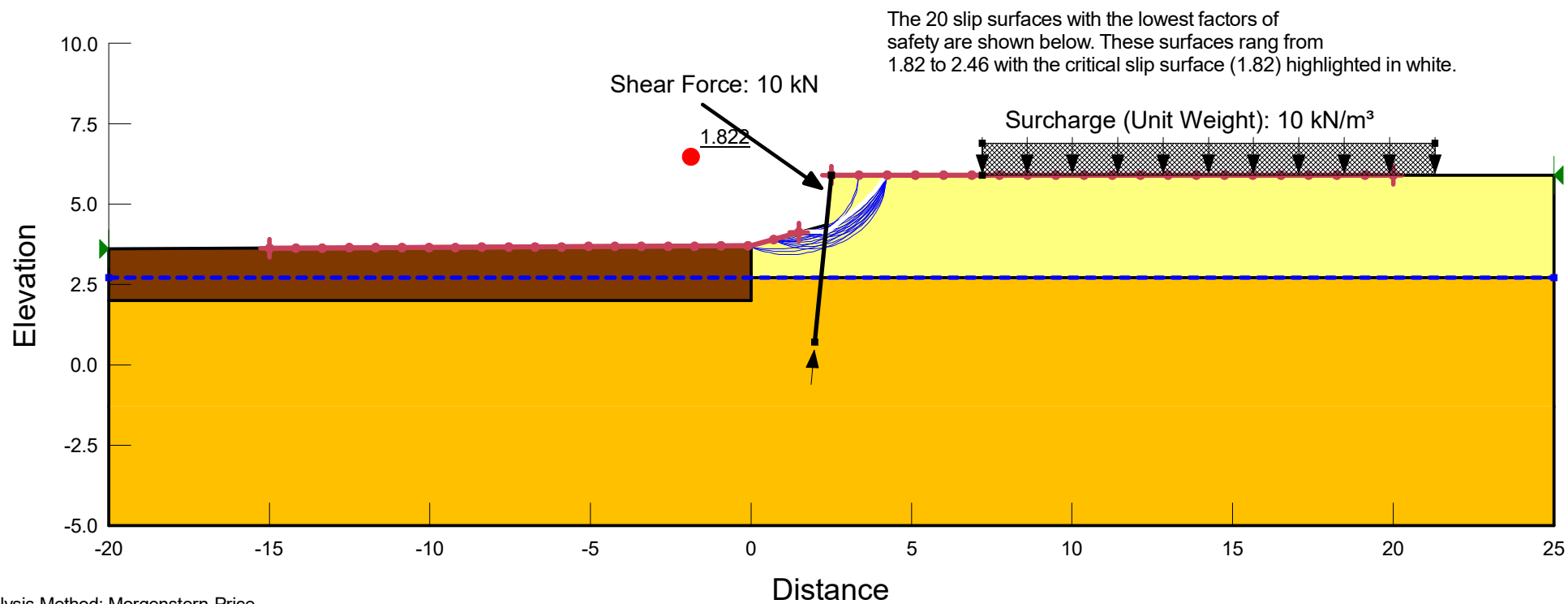
$$\phi M_n := \phi \cdot k_1 \cdot k_4 \cdot k_8 \cdot f_b \cdot t^2 \cdot B \cdot \frac{1}{6} \quad \phi M_n = 1164.6 \cdot \text{N} \cdot \text{m} \quad \text{Status} := \begin{cases} \text{"OK"} & \text{if } \phi M_n > M_{\text{star}} \\ \text{"NG"} & \text{if } \phi M_n \leq M_{\text{star}} \end{cases} \quad \text{Status} = \text{"OK"}$$

$$I := B \cdot \frac{t^3}{12} \quad I = 9.734 \times 10^{-6} \text{ m}^4$$

$$\text{Deflection} := 5 \cdot \frac{\omega}{L_f} \cdot \frac{L^4}{384 \cdot E \cdot I} \quad \text{Deflection} = 1 \cdot \text{mm}$$

Note L.f included to get back to unfactored loads for calculating settlement.

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	Dune Sand	Mohr-Coulomb	17	0	32	0	1
	Engineered Fill (Pumice Sand)	Mohr-Coulomb	15	5	33	0	1
	Peat (Drained)	Mohr-Coulomb	11	5	23	0	1



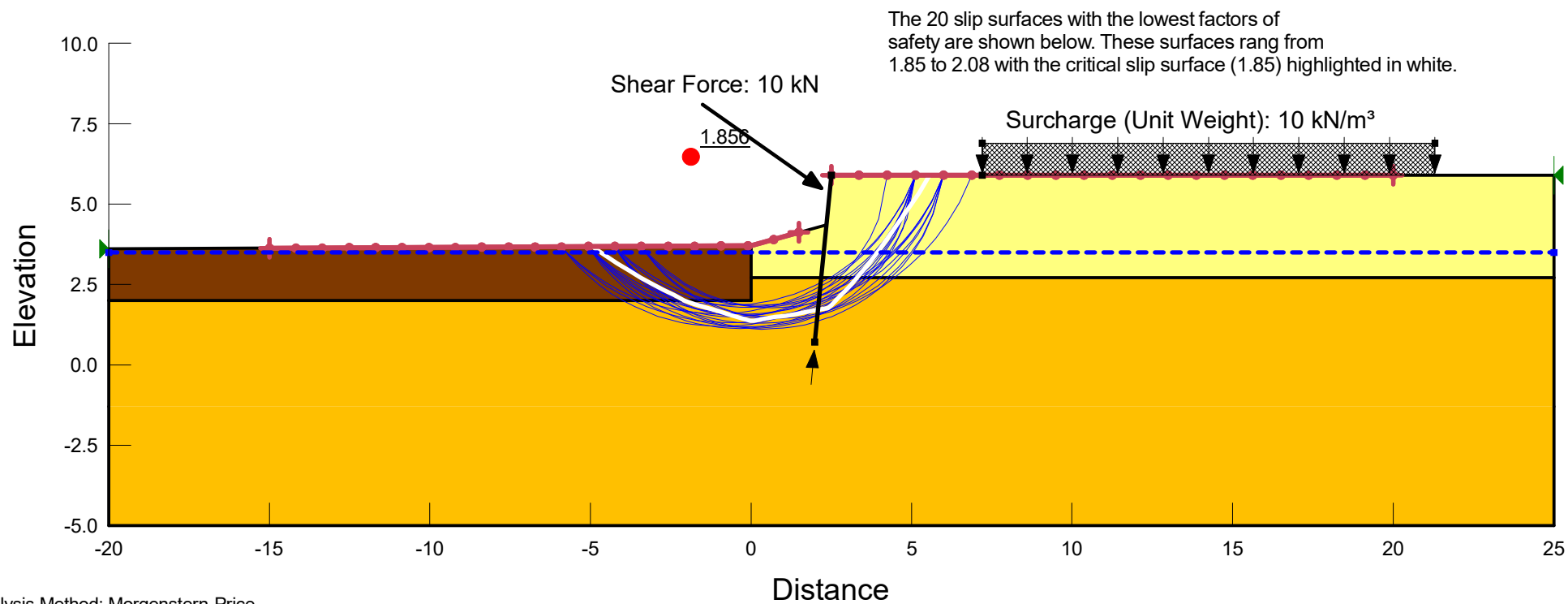
Analysis Method: Morgenstern-Price

PGA(h) = PGA(v) =



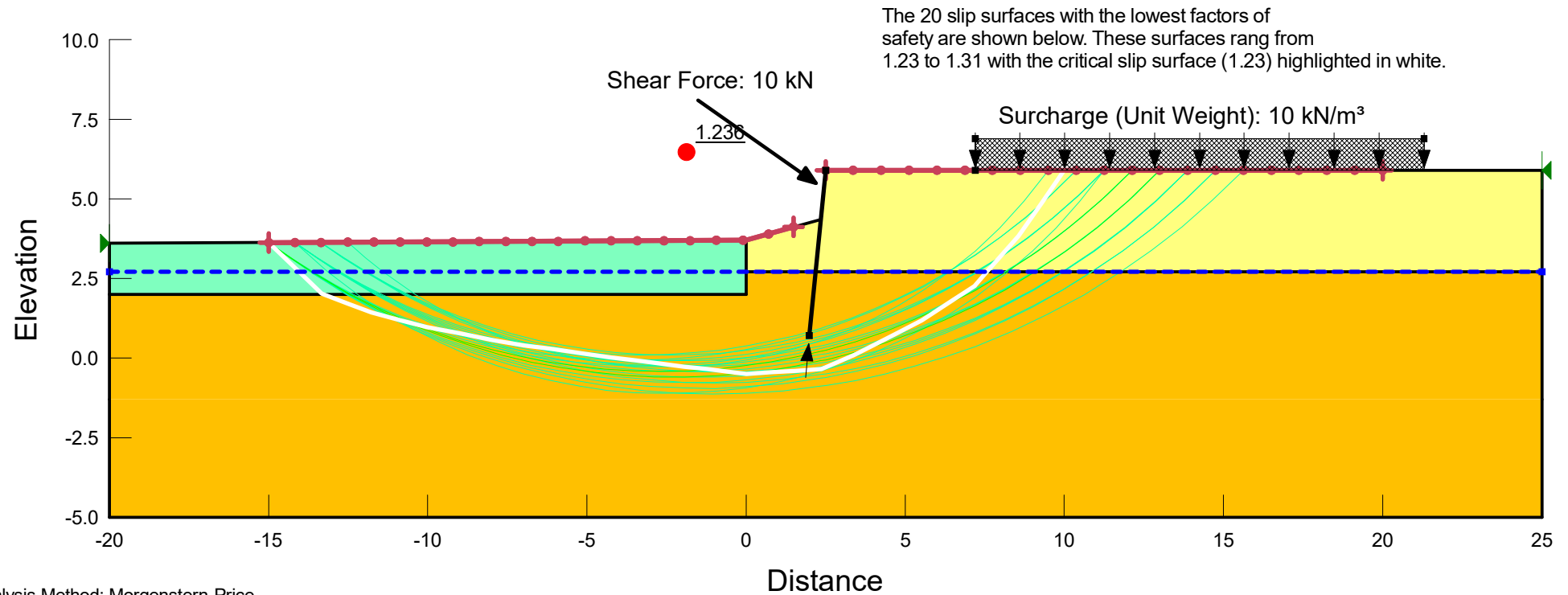
PROJECT: TERRACE VIEWS STAGE 3D TIMBER POLE RETAINING WALL		
CLIENT: ZARIBA HOLDINGS LTD	ASSESSMENT: 1. Static (Drained)	
PROJECT NUMBER: 247593-009	ENGINEER: Miles Buob	14/05/2019 1:191.01953

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	Dune Sand	Mohr-Coulomb	17	0	32	0	1
	Engineered Fill (Pumice Sand)	Mohr-Coulomb	15	5	33	0	1
	Peat (Drained)	Mohr-Coulomb	11	5	23	0	1



	PROJECT: TERRACE VIEWS STAGE 3D TIMBER POLE RETAINING WALL				
	CLIENT: ZARIBA HOLDINGS LTD		ASSESSMENT: 2. Static w/ High GWL		
	PROJECT NUMBER: 247593-009		ENGINEER: Miles Buob	14/05/2019	1:191.01953

Color	Name	Model	Unit Weight (kN/m ³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	Dune Sand	Mohr-Coulomb	17		0	32	0	1
	Engineered Fill (Pumice Sand)	Mohr-Coulomb	15		5	33	0	1
	Peat (undrained)	Undrained (Phi=0)	11	15				1

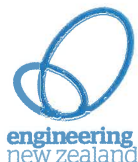


Analysis Method: Morgenstern-Price

PGA(h) = 0.26 PGA(v) =



PROJECT: TERRACE VIEWS STAGE 3D TIMBER POLE RETAINING WALL		
CLIENT: ZARIBA HOLDINGS LTD	ASSESSMENT: 4. ULS Seismic Case	
PROJECT NUMBER: 247593-009	ENGINEER: Miles Buob	14/05/2019 1:191.01953



New Zealand
Institute of Architects
Incorporated



Building Code Clause(s) B1

PRODUCER STATEMENT – PS1 – DESIGN

(Guidance on use of Producer Statements (formerly page 2) is available at www.engineeringnz.org)

ISSUED BY: AURECON NEW ZEALAND LIMITED
(Design Firm)

TO: ZARIBA HOLDINGS LIMITED
(Owner/Developer)

TO BE SUPPLIED TO: TAURANGA CITY COUNCIL
(Building Consent Authority)

IN RESPECT OF: CANTILEVER TIMBER POLE RETAINING WALL DESIGN
(Description of Building Work)

AT: TERRACE VIEWS SUBDIVISION - PARTON ROAD, TAURANGA
(Address)

Town/City: TAURANGA LOT 439-444 DP SO
(Address)

We have been engaged by the owner/developer referred to above to provide:

RETAINING WALL DESIGN AND CONSTRUCTION OBSERVATIONS

(Extent of Engagement)

services in respect of the requirements of Clause(s) B1 of the Building Code for:

☐ All or ☒ Part only (as specified in the attachment to this statement), of the proposed building work.

The design carried out by us has been prepared in accordance with:

☒ Compliance Documents issued by the Ministry of Business, Innovation & Employment B1/VM4 or
(verification method/acceptable solution)

☐ Alternative solution as per the attached schedule

The proposed building work covered by this producer statement is described on the drawings titled:

Terrace Views Subdivision Timber Pole Retaining Wall Design and numbered 247593-0009-DRG-G-0020;
together with the specification, and other documents set out in the schedule attached to this statement.

On behalf of the Design Firm, and subject to:

- (i) Site verification of the following design assumptions Ground Conditions, Auger Holes, Positions and Drainage
- (ii) All proprietary products meeting their performance specification requirements;

I believe on reasonable grounds that a) the building, if constructed in accordance with the drawings, specifications, and other documents provided or listed in the attached schedule, will comply with the relevant provisions of the Building Code and that b), the persons who have undertaken the design have the necessary competency to do so. I also recommend the following level of construction monitoring/observation:

☐ CM1 ☐ CM2 ☐ CM3 ☐ CM4 ☐ CM5 (Engineering Categories) or ☒ as per agreement with owner/developer (Architectural)

I, ZHEN FANG am: ☒ CPEng 1150135 # ☐ Reg Arch #
(Name of Design Professional)

I am a member of: ☒ Engineering New Zealand ☐ NZIA and hold the following qualifications: BSC, MSC, PHD, CPENG

The Design Firm issuing this statement holds a current policy of Professional Indemnity Insurance no less than \$200,000*.

The Design Firm is a member of ACENZ: ☒

SIGNED BY ZHEN FANG (Signature) Zhen Fang
(Name of Design Professional)

ON BEHALF OF AURECON NEW ZEALAND LIMITED Date 28/05/2019
(Design Firm)

Note: This statement shall only be relied upon by the Building Consent Authority named above. Liability under this statement accrues to the Design Firm only. The total maximum amount of damages payable arising from this statement and all other statements provided to the Building Consent Authority in relation to this building work, whether in contract, tort or otherwise (including negligence), is limited to the sum of \$200,000.*

This form is to accompany **Form 2 of the Building (Forms) Regulations 2004** for the application of a Building Consent.
THIS FORM AND ITS CONDITIONS ARE COPYRIGHT TO ACENZ, ENGINEERING NEW ZEALAND AND NZIA

GUIDANCE ON USE OF PRODUCER STATEMENTS

Producer statements were first introduced with the Building Act 1991. The producer statements were developed by a combined task committee consisting of members of the New Zealand Institute of Architects, Institution of Professional Engineers New Zealand, Association of Consulting Engineers New Zealand in consultation with the Building Officials Institute of New Zealand. The original suit of producer statements has been revised at the date of this form as a result of enactment of the Building Act (2004) by these organisations to ensure standard use within the industry.

The producer statement system is intended to provide Building Consent Authorities (BCAs) with reasonable grounds for the issue of a Building Consent or a Code Compliance Certificate, without having to duplicate design or construction checking undertaken by others.

PS1 Design Intended for use by a suitably qualified independent design professional in circumstances where the BCA accepts a producer statement for establishing reasonable grounds to issue a Building Consent;

PS2 Design Review Intended for use by a suitably qualified independent design professional where the BCA accepts an independent design professional's review as the basis for establishing reasonable grounds to issue a Building Consent;

PS3 Construction Forms commonly used as a certificate of completion of building work are Schedule 6 of NZS 3910:2013 or Schedules E1/E2 of NZIA's SCC 2011²

PS4 Construction Review Intended for use by a suitably qualified independent design professional who undertakes construction monitoring of the building works where the BCA requests a producer statement prior to issuing a Code Compliance Certificate.

This must be accompanied by a statement of completion of building work (Schedule 6).

The following guidelines are provided by ACENZ, IPENZ and NZIA to interpret the Producer Statement.

Competence of Design Professional

This statement is made by a Design Firm that has undertaken a contract of services for the services named, and is signed by a person authorised by that firm to verify the processes within the firm and competence of its designers.

A competent design professional will have a professional qualification and proven current competence through registration on a national competence based register, either as a Chartered Professional Engineer (CPEng) or a Registered Architect.

Membership of a professional body, such as the Institution of Professional Engineers New Zealand (IPENZ) or the New Zealand Institute of Architects (NZIA), provides additional assurance of the designer's standing within the profession. If the design firm is a member of the Association of Consulting Engineers New Zealand (ACENZ), this provides additional assurance about the standing of the firm.

Persons or firms meeting these criteria satisfy the term "suitably qualified independent design professional".

*Professional Indemnity Insurance

As part of membership requirements, ACENZ requires all member firms to hold Professional Indemnity Insurance to a minimum level.

The PI Insurance minimum stated on the front of this form reflects standard, small projects. If the parties deem this inappropriate for large projects the minimum may be up to \$500,000.

Professional Services during Construction Phase

There are several levels of service which a Design Firm may provide during the construction phase of a project (CM1-CM5 for Engineers³). The Building Consent Authority is encouraged to require that the service to be provided by the Design Firm is appropriate for the project concerned.

Requirement to provide Producer Statement PS4

Building Consent Authorities should ensure that the applicant is aware of any requirement for producer statements for the construction phase of building work at the time the building consent is issued as no design professional should be expected to provide a producer statement unless such a requirement forms part of the Design firm's engagement.

Attached Particulars

Attached particulars referred to in this producer statement refer to supplementary information appended to the producer statement.

Refer Also:

- 1 Conditions of Contract for Building & Civil Engineering Construction NZS 3910: 2013
- 2 NZIA Standard Conditions of Contract SCC 2011
- 3 Guideline on the Briefing & Engagement for Consulting Engineering Services (ACENZ/IPENZ 2004)
- 4 PN Guidelines on Producer Statements

www.acenz.org.nz
www.ipenz.org.nz
www.nzia.co.nz

