

# AORERE STAGE 2 – TOC45

Superlot AO-018

Geotechnical Completion Report

# Document Control

## AORERE STAGE 2 – SUPERLOT AO-018– GEOTECHNICAL COMPLETION REPORT

DATE	VERSION	DESCRIPTION	PREPARED BY	REVIEWED BY	AUTHORISED BY
April 2023	1.0	Geotechnical Completion Report	Andy Huang	Michael Cresswell	Elby Tang

# Distribution

Kāinga Ora - Homes and Communities

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Piritahi

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# 1.0 Introduction

Piritahi was engaged by Kāinga Ora - Homes and Communities to provide geotechnical observations during the construction stage of the Mangere Development Project, Aorere Neighbourhood Stage 2.

Construction works carried out by Piritahi on Superlot AO-018 comprised:

- Removal of the existing buildings;
- Surficial soil strip to remove contaminated soil;
- Removal of existing stormwater and wastewater lot connections; and
- Installation of a new wastewater connection at the eastern boundary of the superlot.

## 2.0 Geotechnical Investigation Report

The Geotechnical Investigation Report for this site was provided by Piritahi, "Geotechnical Report for Land Development – Aorere Stage 2 – Superlot AO-018", dated May 2022, version 1.0.

## 3.0 Site visits

Site visits to observe construction were carried out as summarised in Table 1 below and discussed in this report. Site visit reports are provided in Appendix A – Site Observation Reports.

**Table 1: Summary of geotechnical observations on Superlot AO-018**

DATE	INSPECTION BY	DESCRIPTION
7 March 2023	Geotechnics Site Technician	Subgrade testing
16 March 2023	Piritahi Geotechnical Engineer	Site walkover and subgrade testing

## 4.0 Earthworks

### 4.1 Earthworks subgrade

The existing houses within Superlot AO-018 have been removed. A surficial soil topsoil strip (approximately 0.3 m deep) was carried out across the site extent to remove potential soil contamination. Following the surface strip, the exposed subgrade comprised natural soils in the centre and the northern areas of the superlot. We were not able to observe the soils beneath a granular hardstand, which is located in the southern portion of the superlot.

Our observations of the surficial soil conditions are presented in the following sections.

## Natural Soils

The natural soils exposed comprised of Auckland Volcanic Field (AVF) SILT and clayey SILT. Shear vane and Scala penetrometer testing was undertaken on the finished subgrade level in natural soils by Piritahi Geotechnical Engineers and Geotechnics Technicians.

Shear vane testing on the existing subgrade measured undrained shear strengths ranging between 75 kPa and >223 kPa (UTP). The Scala penetrometer testing recorded blow counts ranging from 0.25 to 10 blows per 50 mm penetration across the superlot, generally averaging 1.5 blows per 50 mm. The shear vane and Scala penetrometer test results indicate the natural soils at subgrade level are generally in line with the Piritahi Geotechnical Investigation Report.

The test location plans and results for the subgrade testing carried out by Piritahi Geotechnical Engineers and Geotechnics Technicians are provided in Appendix A – Site Observation Reports.

## 4.2 Temporary granular hardstand

There is an existing granular hardfill hardstand, approximately 0.1 – 0.3 m thick, that was placed above the subgrade at the southern portion of the superlot. The location of the granular hardstand is shown on the superlot handover plan in Appendix B. The hardfill was previously placed for temporary construction access of heavy machinery and plant, and from the removed hardfill stockpiles. We were unable to inspect the underlying soils before the placement of the hardfill, however Scala penetrometer testing undertaken on this hardfill recorded >10 blows per 50mm penetration at the surface. This hardfill is not engineered for permanent use as building platforms or pavement subgrades. This hardfill remains in place at the time of this report and it is understood that this superlot is to be handed over with the hardfill left on site for future developers to use.

The Geotechnical Engineer for the future development should confirm that the underlying soils are consistent with the design of the proposed works.

# 5.0 Infrastructure

## 5.1 Infrastructure removal

Infrastructure works within Superlot AO-018 comprised the removal of the following utilities:

- Removal of 3 stormwater lot connections. The existing stormwater lot connections were generally within the upper 0.2m of the surface and were removed as part of the surficial topsoil strip.
- Removal of 3 wastewater lot connections. The wastewater lot connections were removed and backfilled with cohesive material (silt and clay) to a depth of approximately 0.5m. Shear vane testing was undertaken by the Piritahi site team within the redundant wastewater connection trenches, measuring undrained shear strengths between 170 kPa and 186 kPa. The shear vane testing results comply with the Piritahi Earthworks Fill ITP requirements.

The test frequency and methodology are shown on the Piritahi Inspection and Test Plan (ITP). The test location plans and results for the earthworks testing carried out by Piritahi's construction team can be found

in Appendix C – Piritahi Test Results. The as-built plan is attached in Appendix B – As Built Plans, and the Piritahi ITP is attached in Appendix E – Piritahi ITPs.

## 5.2 Infrastructure Installation

Infrastructure works within Superlot AO-018 comprised the installation of the following utilities:

- Installation of a new wastewater connection ('BC AO-18'), capped at the eastern boundary of the superlot connecting to the new wastewater line (at 'MH A2') along Mayflower Close. Backfill of the approximately 1.8 m deep wastewater trench were undertaken using GAP65 hardfill. Clegg hammer tests on the GAP65 hardfill recorded Clegg Impact Values (CIV) between 30 and 36. The test results achieved the compaction requirement of the Piritahi Wastewater ITP. The new wastewater connection is shown in Appendix B – As Built Plans. The backfill records are provided in Appendix C – Piritahi Test Results.

## 6.0 Statement of professional opinion on suitability of land for building construction

I, Elby Tang, of Piritahi, 139 Quay St, Auckland 1010, hereby confirm that:

1. I am a geo-professional as defined in clause 1.2.2 of NZ 4404:2010 and was retained by the Developer as the geo-professional on Stage 2 of the Aorere Development.
2. The extent of the preliminary investigations is described in the Piritahi Geotechnical Investigation Report provided by Piritahi (dated May 2022, version 1.0). As noted in the report, the scope of this investigation report is limited, as it was carried out prior to design of the development. Depending on the proposed development, supplementary geotechnical investigations, analysis and design may be required to inform detailed design and building consent.
3. Construction works carried out by Piritahi at this site comprise:
  - a. Removal of existing buildings;
  - b. Stripping of surficial soils to remove potential contaminants;
  - c. Decommissioning and removal of residential stormwater and wastewater lot connections; and
  - d. Installation of a new wastewater connection.
4. The extent of inspections during construction, and the results of all the tests and/or evaluations carried out are described in this Piritahi Geotechnical Completion Report dated April 2023, version 1.0.
5. In my professional opinion, not to be construed as a guarantee, I consider that:
  - a. Observations of the underlying soils by Piritahi to date are generally in line with the findings of the Piritahi Geotechnical Investigation Report.
  - b. As noted in the Piritahi Geotechnical Investigation Report for AO-018, the undrained shear strength of the natural soils meets the definition of "good ground" in bearing capacity and soil expansivity criteria as outlined in NZS 3604-2011. However, the natural soils at the site do not meet "good ground" criteria liquefaction susceptibility, and foundations on such soils will require consideration of the potential effects of liquefaction on the development.
  - c. The temporary granular hardstand remains at the southern portion of the site. This hardstand is not engineered for permanent use as building platforms or pavement subgrades and should be remediated or removed prior to future developments.
  - d. No backfill was undertaken following the removal of the stormwater lot connections as they were shallow (within the topsoil strip).
  - e. The removed wastewater lot connections were backfilled with compacted cohesive material to a depth of about 0.5 m. Testing of this cohesive material achieved shear vane results greater than 170 kPa. The cohesive backfill material complies with the compaction requirements of the Piritahi Earthworks Fill ITP.
  - f. A new wastewater connection, installed at the eastern boundary of the site was backfilled with GAP65 hardfill. This backfill achieved Clegg impact values of greater than 30 and complies with the Piritahi Wastewater ITP.
  - g. The subgrade may deteriorate if left exposed to the weather for an extended period or to construction traffic. For this reason, the soils should be reinspected by a Chartered Geotechnical

Engineer at the time of construction of any building foundations or pavements. It may be necessary to remove or recompact soils that have lost strength due to exposure to weather or traffic.

- h. The design of future works should consider existing stormwater manhole at the southern corner of the site, as shown on the as built plan (Appendix B). This may require avoidance, bridging or piling around the manhole.
6. This professional opinion is furnished to the territorial authority and the developer for their purposes alone on the express condition that it will not be relied upon by any other person and does not remove the necessity for the normal inspection of foundation conditions at the time of erection of any building.
7. This certificate shall be read in conjunction with my geotechnical report referred to in clause 2 above and shall not be copied or reproduced except in conjunction with the full geotechnical completion report and the geotechnical investigation report.
8. General guidance for homeowners regarding expansive soils has been enclosed in Appendix F – Foundation maintenance and footing performance: a homeowner’s guide of this report.

Signed:



Date: 4 April 2023

Elby Tang

BE Civil (Hons), ME Civil (Hons), CMEngNZ

CPEng 1020514

AC Author PSA125042

## **7.0 Applicability**

This report has been prepared for the exclusive use of our client Kāinga Ora - Homes and Communities Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

## Appendix A – Site Observation Reports

### SITE VISIT RECORD SHEET

Project Name: Aorere Stage 2	Project ID: 1007708.2086
Ref #: DIM086	Date/Time: 16/03/2023
Site Location: Superlot AO-018 (Mayflower Close, Mangere East)	Inspection by: Scott Zhang
Weather: Fine	Inspection with: N/A
Site Condition: Dry	Purpose of Visit: Site walkover
Site Induction Completed? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	JSEA completed? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
<b>Health and safety observation notes:</b> Be aware of slips/trips/falls hazards	
<b>Machinery onsite:</b> N/A	
<b>Dust/erosion &amp; sediment control:</b> N/A	
<b>Current active works:</b> N/A	
<b>Observations:</b> A representative of the Piritahi geotechnical team undertook a site walkover of Superlot AO-018. Cohesive fill (clayey SILT/silty CLAY) with trace of residual gravels (likely from removed hardfill stockpiles) were observed at the subgrade cut level across the superlot. Shear vane and Scala penetrometer testing were conducted across the subgrade by Geotechnics on 07/03/2023. Shear vane testing was undertaken in fine grained soils at 20 locations along with Scala penetrometer tests to 900 mm depth. Test locations are shown in the attached site testing report. The proposed shear vane and Scala penetrometer tests were not taken along the southern boundary as the area is covered by stockpile of cohesive fill. Corrected peak undrained shear strengths of between 75 and 232+ kPa were recorded at majority locations within the superlot, for an average of 200 kPa. This indicates the surficial soils at subgrade level is typically stiff to hard. Scala penetrometer blow counts generally ranged from 0.5 to 10+ blows per 50 mm penetration on the subgrade. It was noted from the Geotechnics testing (07/03/2023) that a weak spot was encountered at test location '1.11' which measured undrained shear strength of 37 kPa and Scala penetrometer blow counts of 0.25 blows per 50 mm penetration to a depth of 0.2 m bgl. This site visit also involved a reinspection of the weak spot. It was concluded that loose materials of removed stockpiles were previously encountered. This location was re-tested and measured a corrected undrained	

### SITE VISIT RECORD SHEET

shear strength of 112 kPa and Scala penetrometer blow counts from 0.5 blows per 50 mm to 2.5 blows per 50 mm penetrations on the subgrade.

The results for the subgrade tests and a site testing location plan are attached. These results indicate the subgrade soils are within the ITP requirements for earthworks cut.

**Agreements/recommendations onsite:**

Nil.

**Follow-ups and further actions required:**

Piritahi geotechnical team to prepare Geotechnical Completion Report for Superlot AO-018.

**Testing results and Site plan attached. Photos below.**



Photograph 1: Superlot overview – looking north west

## SITE VISIT RECORD SHEET



Photograph 2: Superlot overview – looking north east



Photograph 3: Superlot overview – looking north east

## SITE VISIT RECORD SHEET



Photograph 4: Superlot overview – looking south west



Photograph 5: Stockpile near the western boundary of the superlot



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Project Name : Aorere Stage 2-TOC045

Customer : Kainga Ora

Location: Superlot AO-018

Project Number	1007708.2086.500.300
Entered By	JALC
Checked By	-
Approved By	-

URN.	Tech.	Date	Location	Layer	Material Type	Test Type	NDM 0°			NDM 90°			AVERAGE NDM			Solid Density (t/m³) Assumed	Oven Moisture content (%)	Final Corrected		Average Air Voids (10 X Tests)	Shear Vane Reading	Retest URN	PASS / FAIL		Comments	
							Wet Density (t/m³)	Moisture Content (%)	Air Voids (%)	Wet Density (t/m³)	Moisture Content (%)	Air Voids (%)	Wet Density (t/m³)	Moisture Content (%)	Air Voids (%)			Oven Dry Density (t/m³)	Average Air Voids (%)				Reading 1	(P) Pass		(F) Fail
																					Reading 1					
1.1	JALC	7/03/2023	Superlot AO-018	Surface	ClaySILT w/ Gravels and Organics	SV	-	-	-	-	-	-	-	-	-	-	-	-	-	115	-	-	No formal specification provided. Results passed on to engineer for review.			
1.2						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	150	-	-		
1.3						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UTP	-	-	
1.4						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UTP	-	-	
1.5						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UTP	-	-	
1.6						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UTP	-	-	
1.7						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UTP	-	-	
1.8						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UTP	-	-	
1.9						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UTP	-	-	
1.10						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UTP	-	-	
1.11						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	37	-	-	
1.12						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UTP	-	-	
1.13						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	162	-	-	
1.14						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UTP	-	-	
1.15						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UTP	-	-	
1.16						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UTP	-	-	
1.17						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UTP	-	-	
1.18						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UTP	-	-	
1.19						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UTP	-	-	
1.20						SV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	75	-	-	

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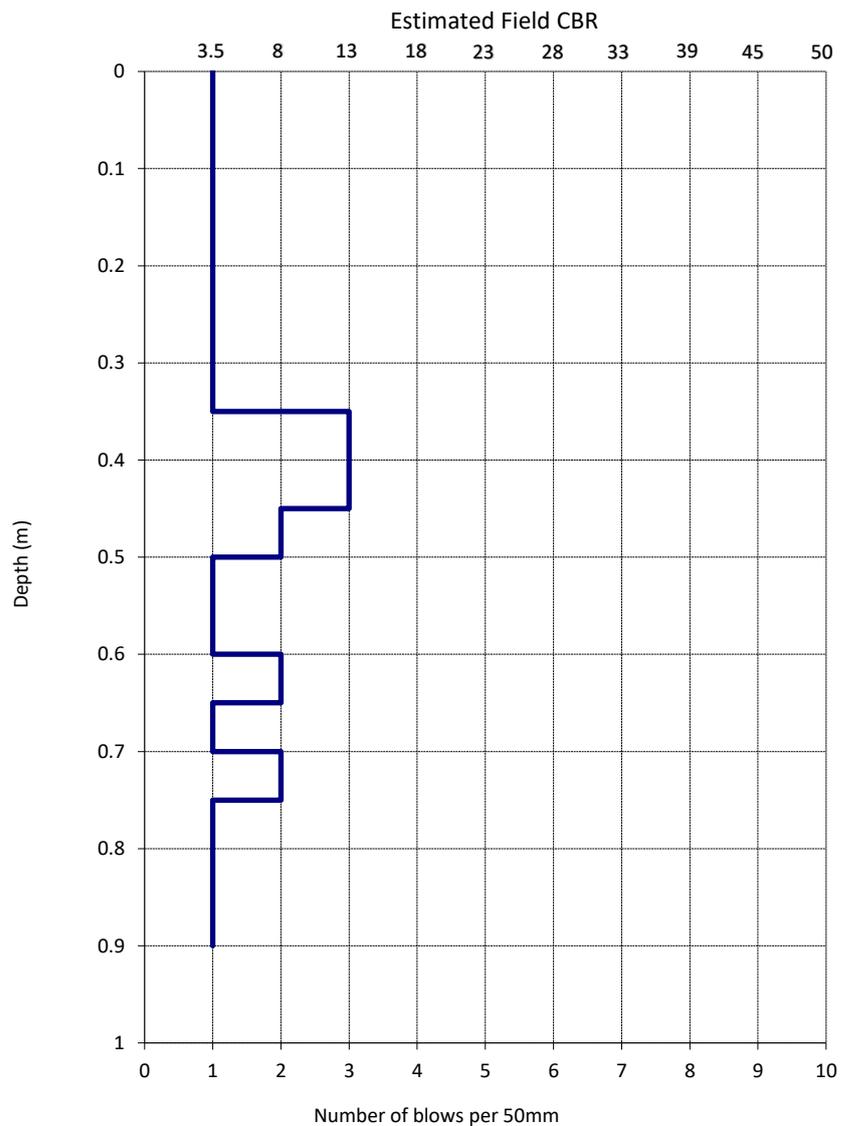
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1.1

### NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	1

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	1
100	100	1
150	150	1
200	200	1
250	250	1
300	300	1
350	350	1
400	400	3
450	450	3
500	500	2
550	550	1
600	600	1
650	650	2
700	700	1
750	750	2
800	800	1
850	850	1
900	900	1
950	950	
1000	1000	



#### Test Remarks

The estimated CBR values are based on Figure 5.3, Correlation of Dynamic Cone Penetration and CBR AUSTRROADS (2019) "Pavement Design - A Guide to the Structural Design of Road Pavements".

Tested By	JALC	Date	7/03/2023
Data Entry By	JALC	Date	7/03/2023
Checked By		Date	



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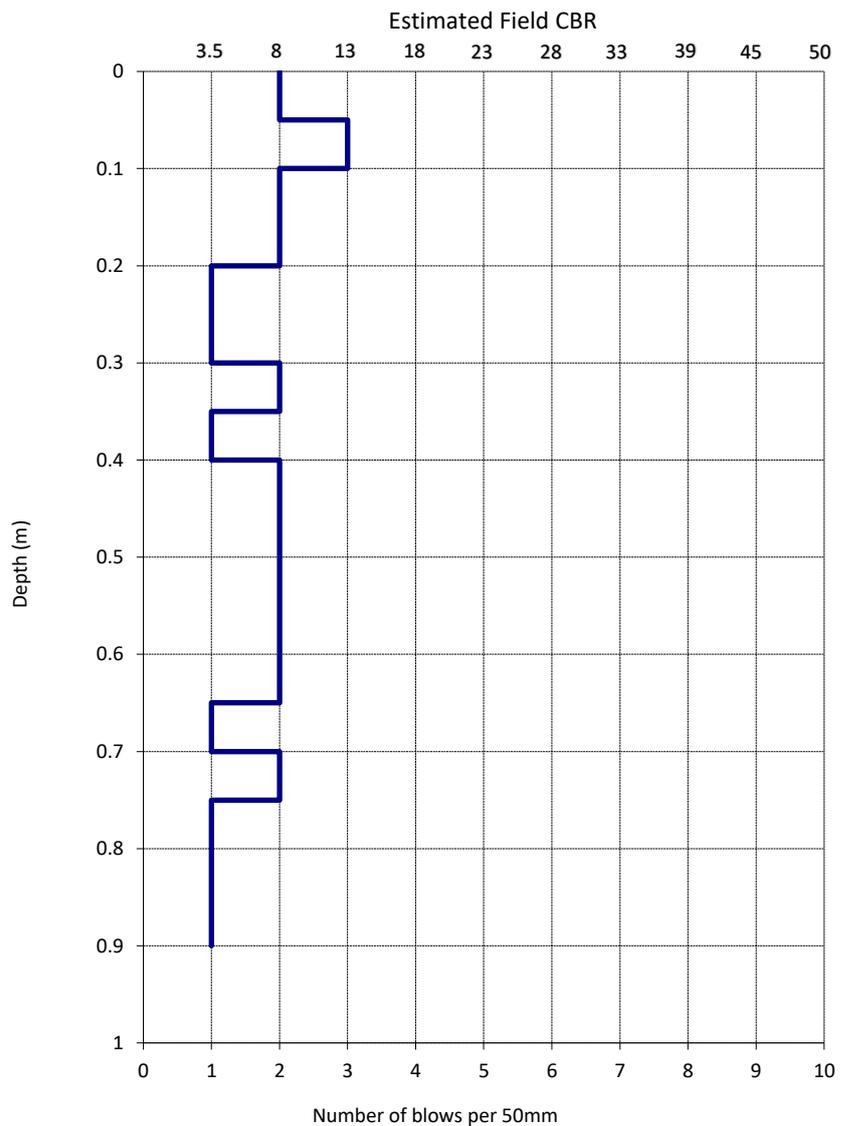
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### NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	2

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	2
100	100	3
150	150	2
200	200	2
250	250	1
300	300	1
350	350	2
400	400	1
450	450	2
500	500	2
550	550	2
600	600	2
650	650	2
700	700	1
750	750	2
800	800	1
850	850	1
900	900	1
950	950	
1000	1000	



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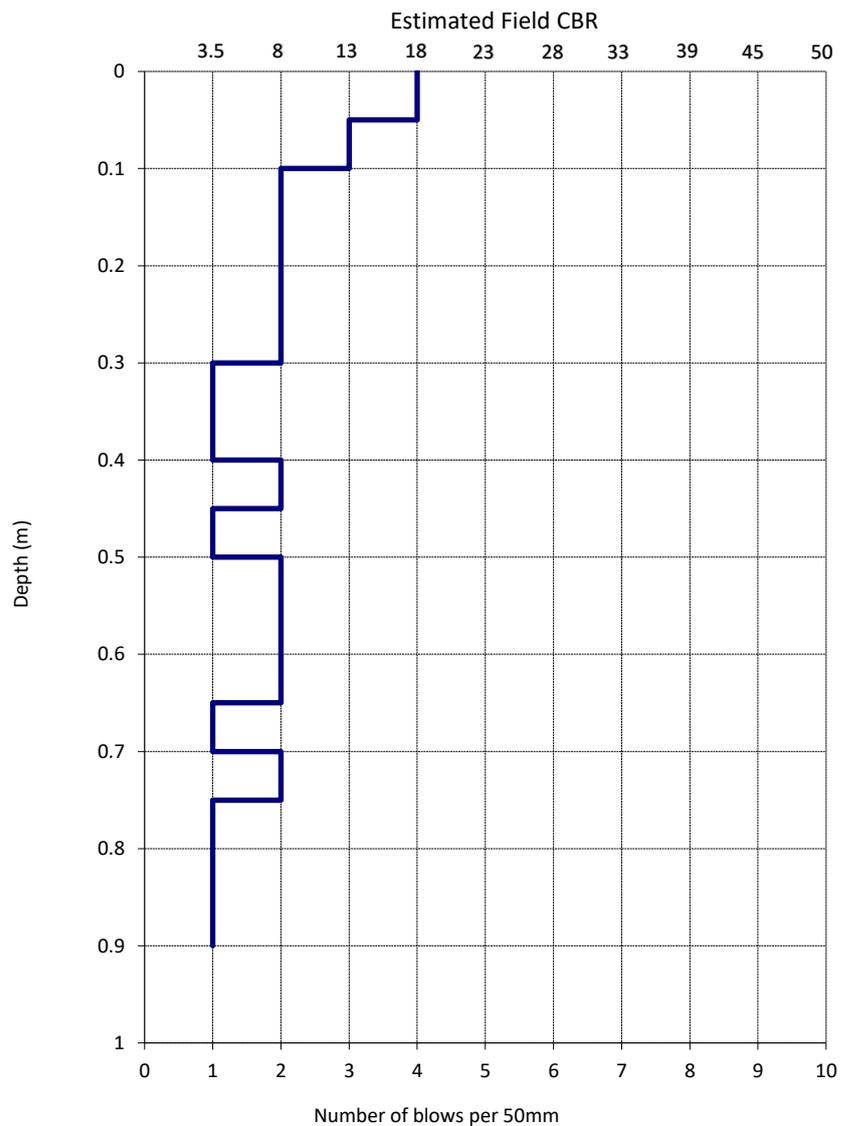
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### NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	3

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	4
100	100	3
150	150	2
200	200	2
250	250	2
300	300	2
350	350	1
400	400	1
450	450	2
500	500	1
550	550	2
600	600	2
650	650	2
700	700	1
750	750	2
800	800	1
850	850	1
900	900	1
950	950	
1000	1000	



#### Test Remarks

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Checked By		Date	



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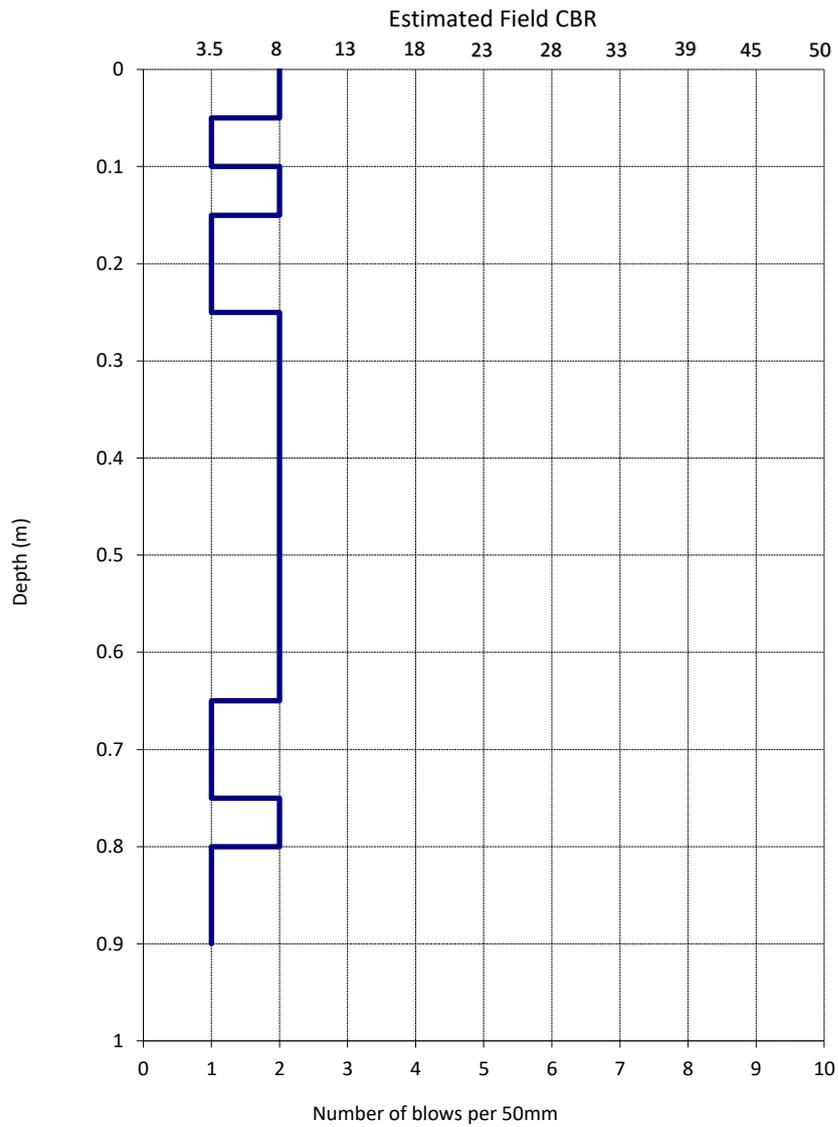
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Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	4

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	2
100	100	1
150	150	2
200	200	1
250	250	1
300	300	2
350	350	2
400	400	2
450	450	2
500	500	2
550	550	2
600	600	2
650	650	2
700	700	1
750	750	1
800	800	2
850	850	1
900	900	1
950	950	
1000	1000	



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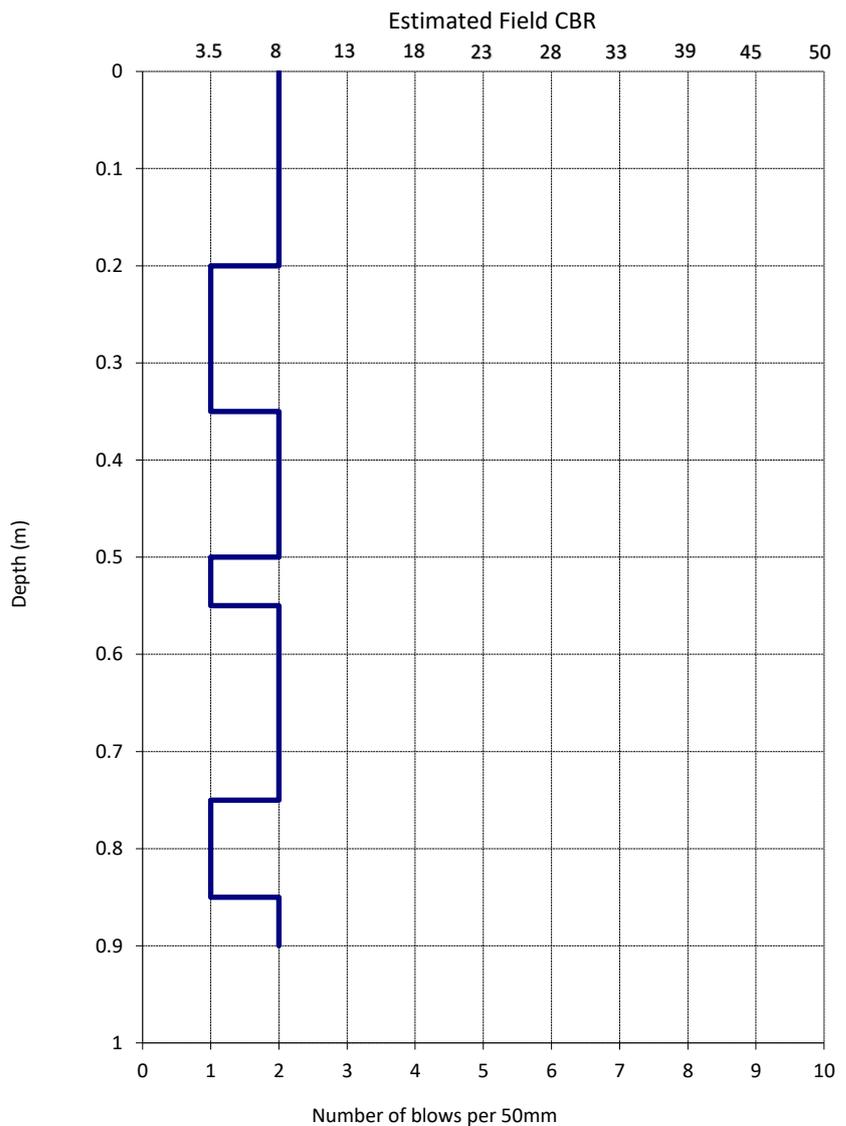
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**NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala**

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	5

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	2
100	100	2
150	150	2
200	200	2
250	250	1
300	300	1
350	350	1
400	400	2
450	450	2
500	500	2
550	550	1
600	600	2
650	650	2
700	700	2
750	750	2
800	800	1
850	850	1
900	900	2
950	950	
1000	1000	



**Test Remarks**

The estimated CBR values are based on Figure 5.3, Correlation of Dynamic Cone Penetration and CBR AUSTRROADS (2019) "Pavement Design - A Guide to the Structural Design of Road Pavements".

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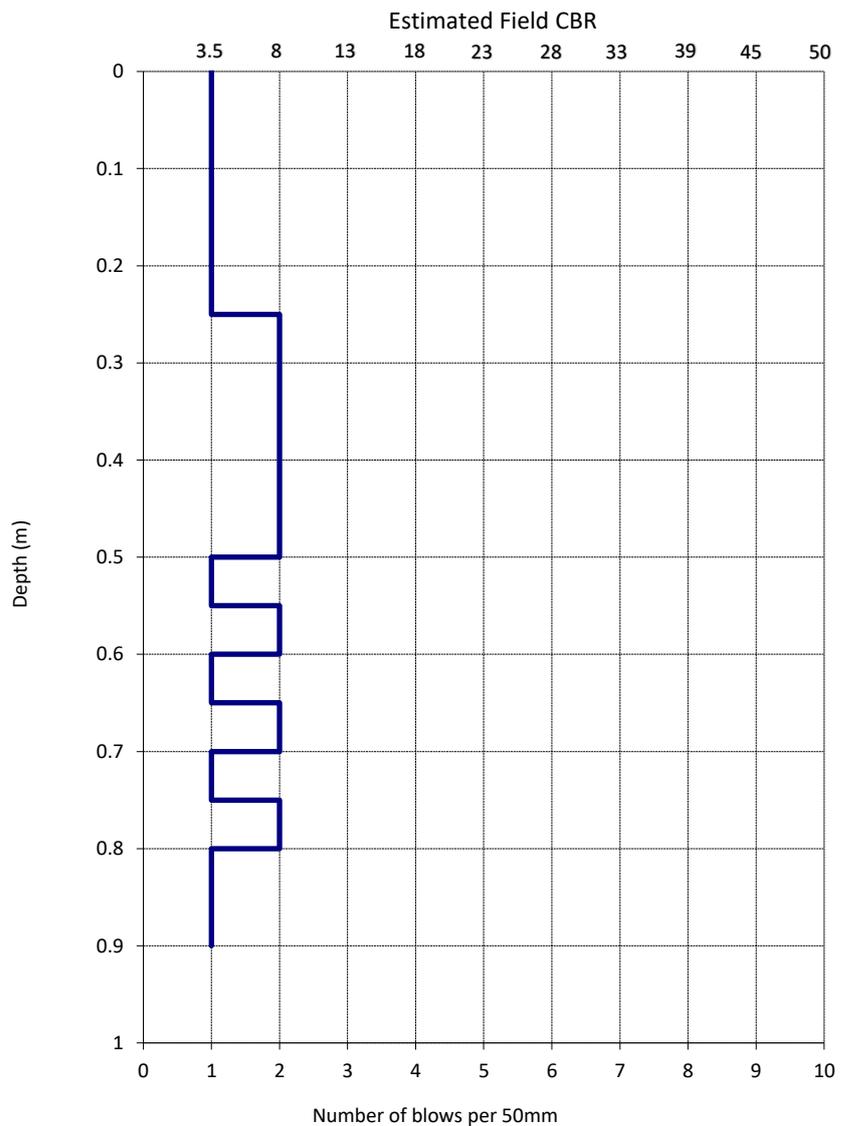
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### NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	6

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	1
100	100	1
150	150	1
200	200	1
250	250	1
300	300	2
350	350	2
400	400	2
450	450	2
500	500	2
550	550	1
600	600	2
650	650	1
700	700	2
750	750	1
800	800	2
850	850	1
900	900	1
950	950	
1000	1000	



#### Test Remarks

The estimated CBR values are based on Figure 5.3, Correlation of Dynamic Cone Penetration and CBR AUSTRROADS (2019) "Pavement Design - A Guide to the Structural Design of Road Pavements".

Tested By	JALC	Date	7/03/2023
Data Entry By	JALC	Date	7/03/2023
Checked By		Date	



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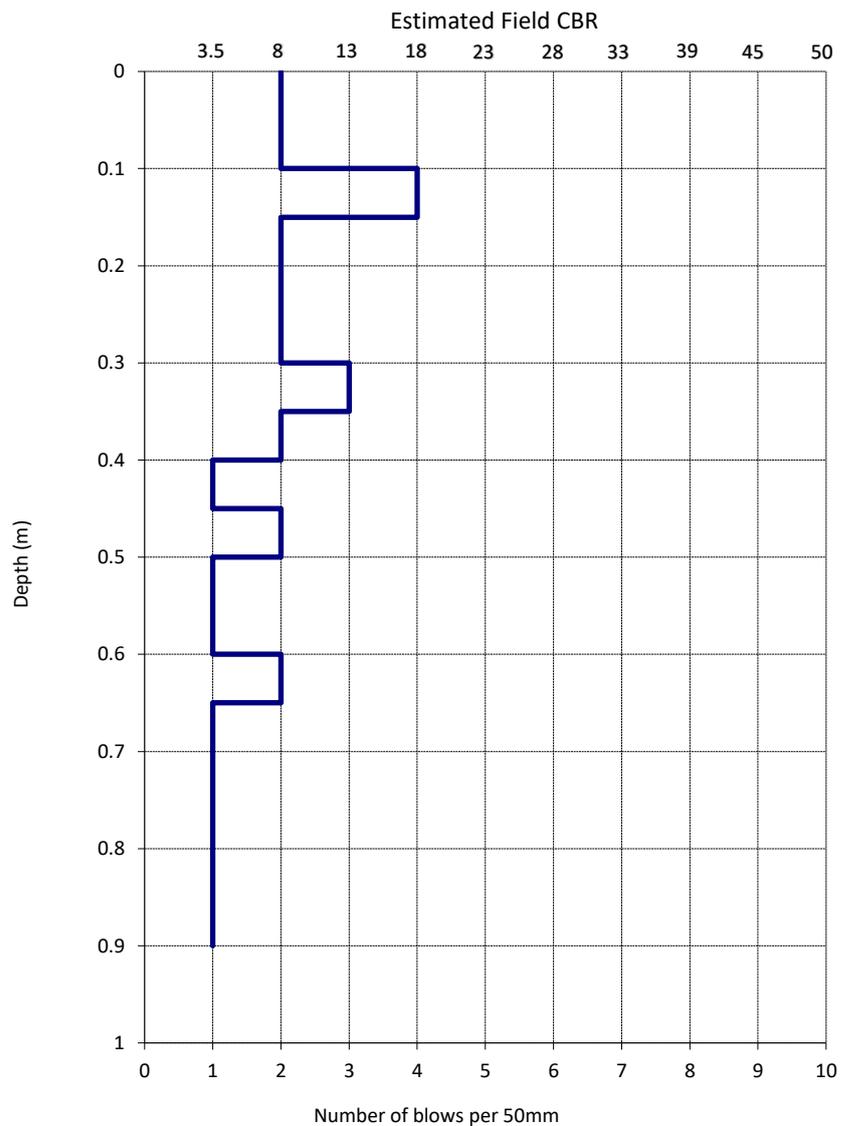
Lab Ref/URN

1.7

### NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	7

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	2
100	100	2
150	150	4
200	200	2
250	250	2
300	300	2
350	350	3
400	400	2
450	450	1
500	500	2
550	550	1
600	600	1
650	650	2
700	700	1
750	750	1
800	800	1
850	850	1
900	900	1
950	950	
1000	1000	



#### Test Remarks

The estimated CBR values are based on Figure 5.3, Correlation of Dynamic Cone Penetration and CBR AUSTRROADS (2019) "Pavement Design - A Guide to the Structural Design of Road Pavements".

Tested By	JALC	Date	7/03/2023
Data Entry By	JALC	Date	7/03/2023
Checked By		Date	



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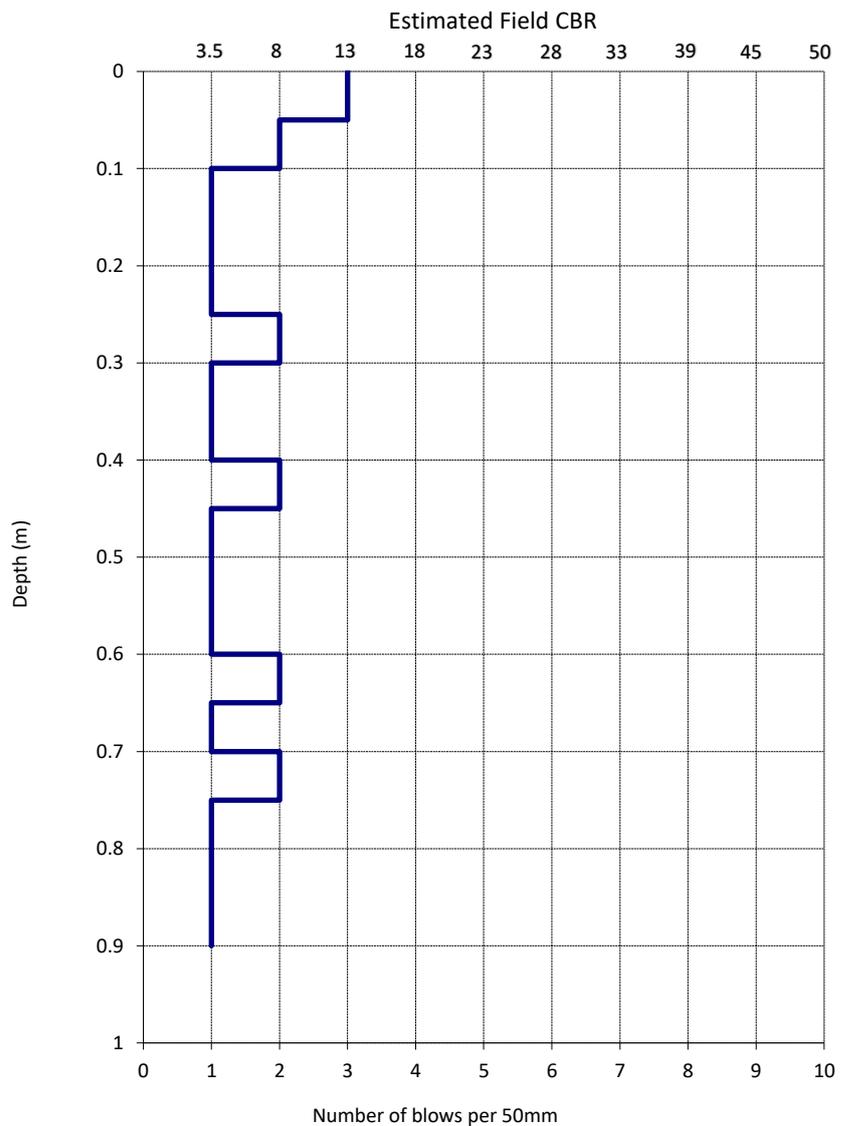
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1.8

### NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	8

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	3
100	100	2
150	150	1
200	200	1
250	250	1
300	300	2
350	350	1
400	400	1
450	450	2
500	500	1
550	550	1
600	600	1
650	650	2
700	700	1
750	750	2
800	800	1
850	850	1
900	900	1
950	950	
1000	1000	



#### Test Remarks

The estimated CBR values are based on Figure 5.3, Correlation of Dynamic Cone Penetration and CBR AUSTRROADS (2019) "Pavement Design - A Guide to the Structural Design of Road Pavements".

Tested By	JALC	Date	7/03/2023
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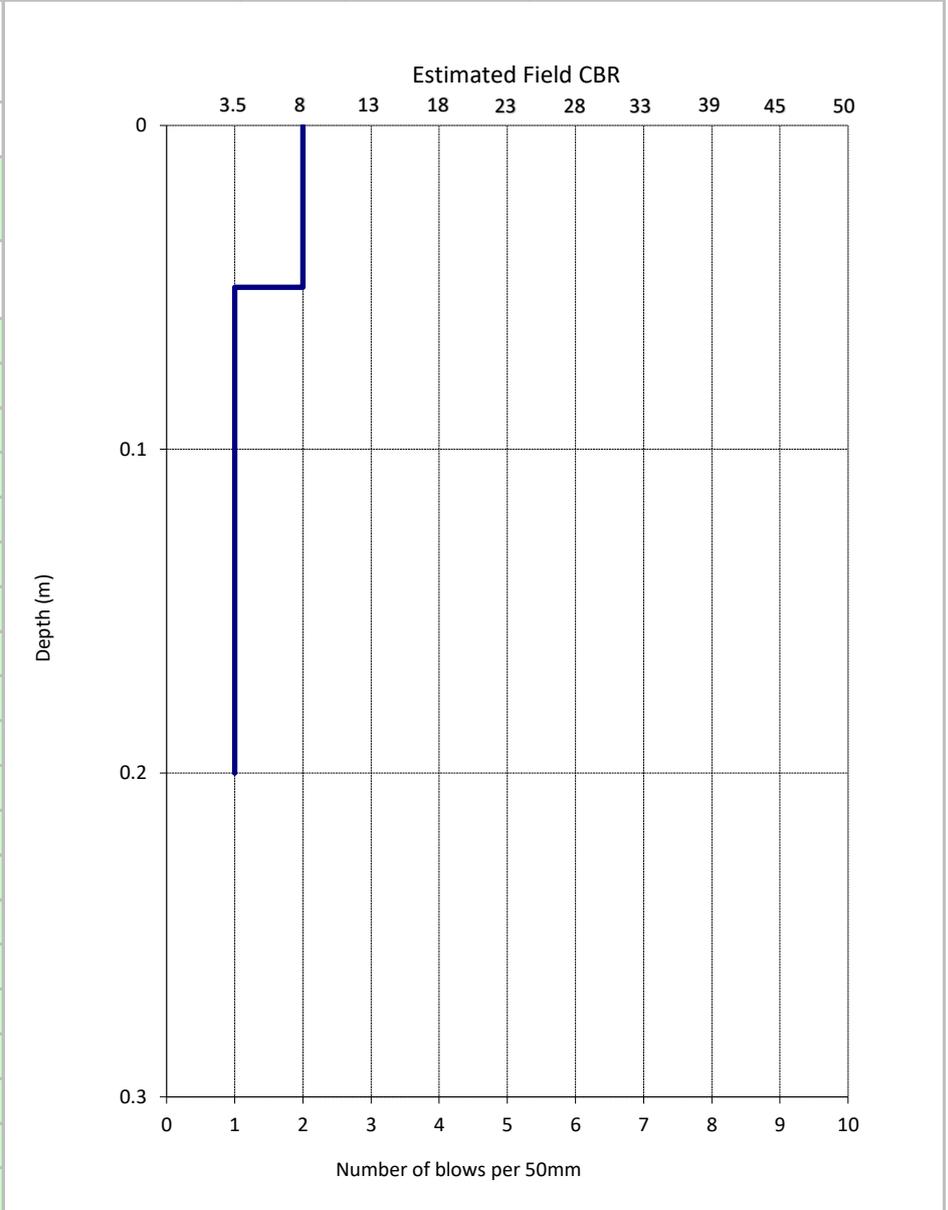
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### NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	9

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	2
100	100	1
150	150	1
200	200	1
250	250	UTP
300	300	
350	350	
400	400	
450	450	
500	500	
550	550	
600	600	
650	650	
700	700	
750	750	
800	800	
850	850	
900	900	
950	950	
1000	1000	



#### Test Remarks

Scala penetrometer 'double bouncing' at 0.25m.

The estimated CBR values are based on Figure 5.3, Correlation of Dynamic Cone Penetration and CBR AUSTRROADS (2019) "Pavement Design - A Guide to the Structural Design of Road Pavements".

Please note Estimated Field CBR cannot be calculated over 10 blows.

Tested By	JALC	Date	7/03/2023
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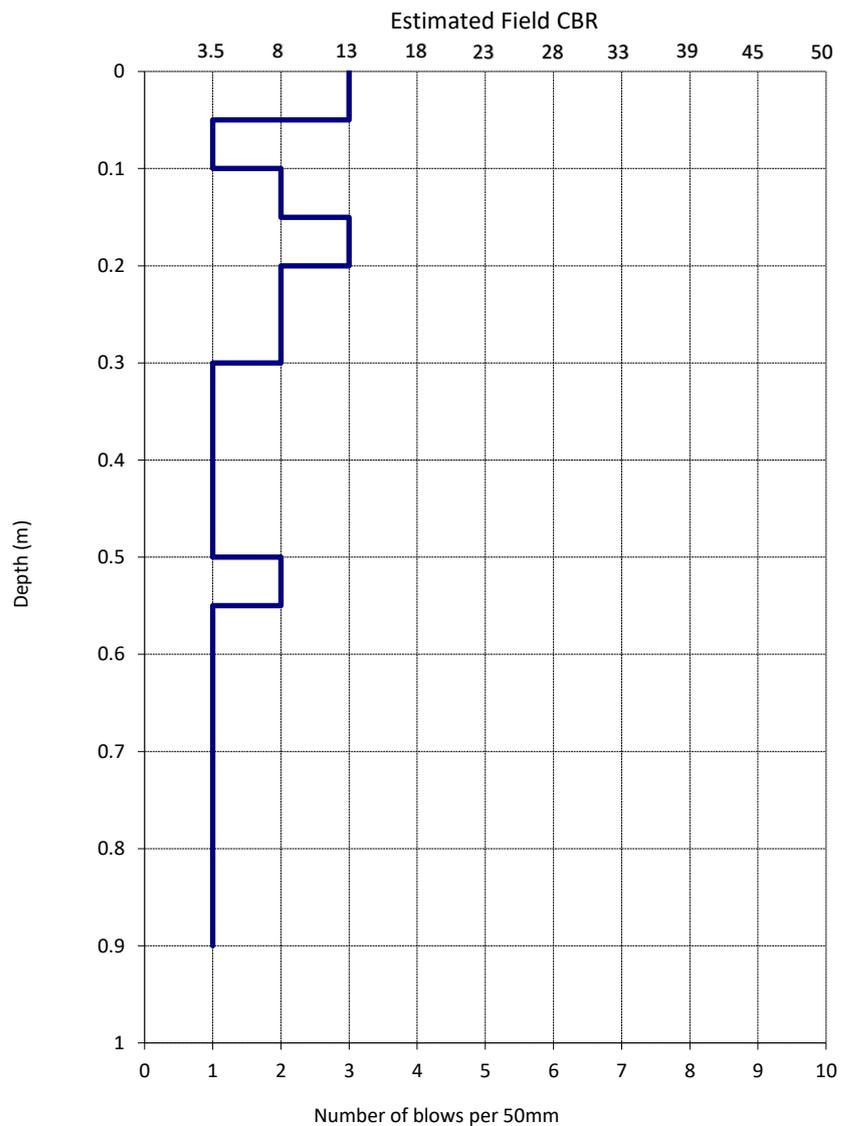
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1.10

### NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	10

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	3
100	100	1
150	150	2
200	200	3
250	250	2
300	300	2
350	350	1
400	400	1
450	450	1
500	500	1
550	550	2
600	600	1
650	650	1
700	700	1
750	750	1
800	800	1
850	850	1
900	900	1
950	950	
1000	1000	



#### Test Remarks

The estimated CBR values are based on Figure 5.3, Correlation of Dynamic Cone Penetration and CBR AUSTRROADS (2019) "Pavement Design - A Guide to the Structural Design of Road Pavements".

Tested By	JALC	Date	7/03/2023
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Checked By		Date	



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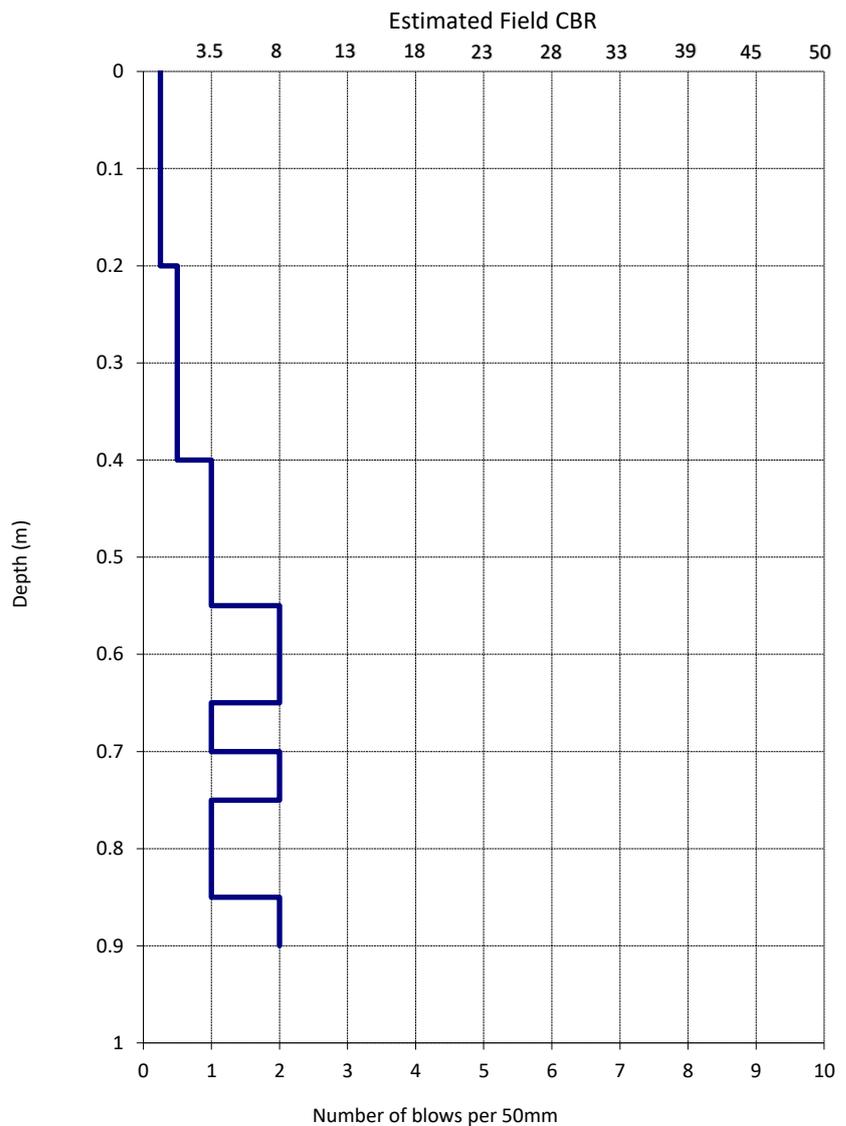
Lab Ref/URN

1.11

### NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	11

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	0.25
100	100	0.25
150	150	0.25
200	200	0.25
250	250	0.5
300	300	0.5
350	350	0.5
400	400	0.5
450	450	1
500	500	1
550	550	1
600	600	2
650	650	2
700	700	1
750	750	2
800	800	1
850	850	1
900	900	2
950	950	
1000	1000	



#### Test Remarks

The estimated CBR values are based on Figure 5.3, Correlation of Dynamic Cone Penetration and CBR AUSTRROADS (2019) "Pavement Design - A Guide to the Structural Design of Road Pavements".

Tested By	JALC	Date	7/03/2023
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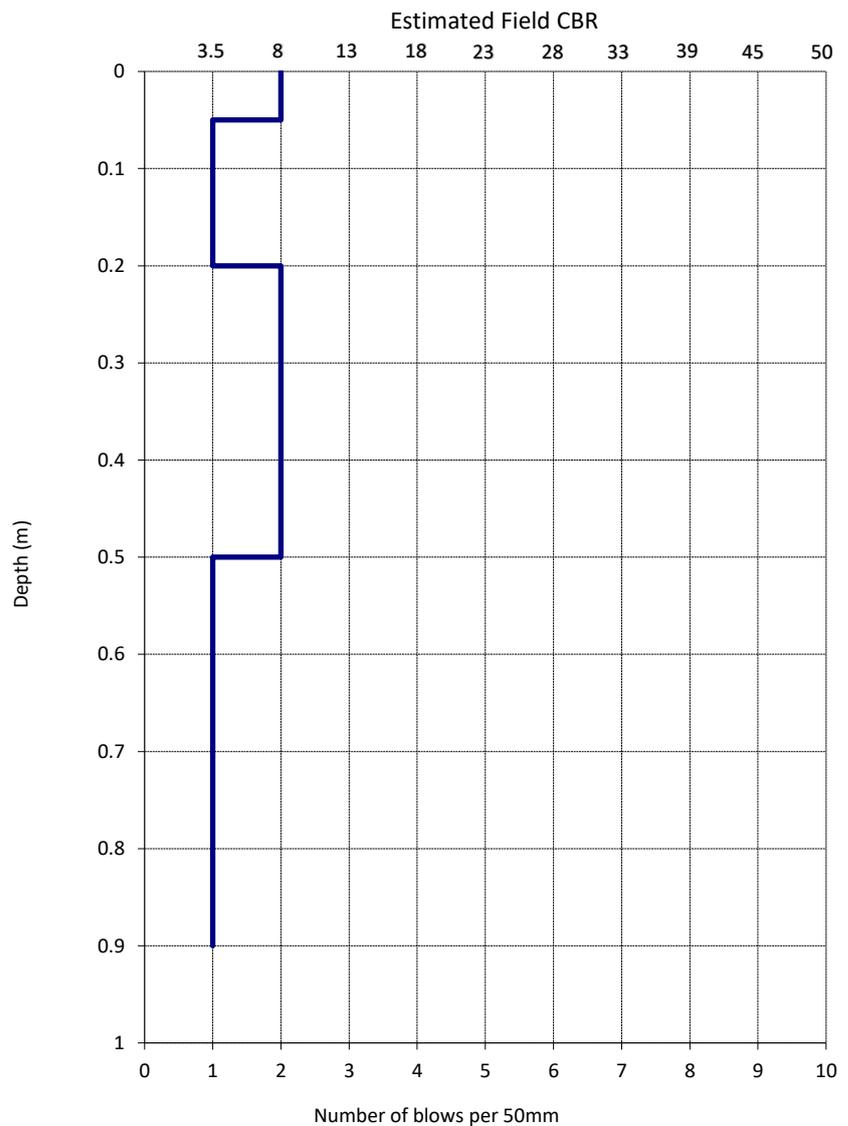
Lab Ref/URN

1.12

**NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala**

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	12

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	2
100	100	1
150	150	1
200	200	1
250	250	2
300	300	2
350	350	2
400	400	2
450	450	2
500	500	2
550	550	1
600	600	1
650	650	1
700	700	1
750	750	1
800	800	1
850	850	1
900	900	1
950	950	
1000	1000	



**Test Remarks**

The estimated CBR values are based on Figure 5.3, Correlation of Dynamic Cone Penetration and CBR AUSTRROADS (2019) "Pavement Design - A Guide to the Structural Design of Road Pavements".

Tested By	JALC	Date	7/03/2023
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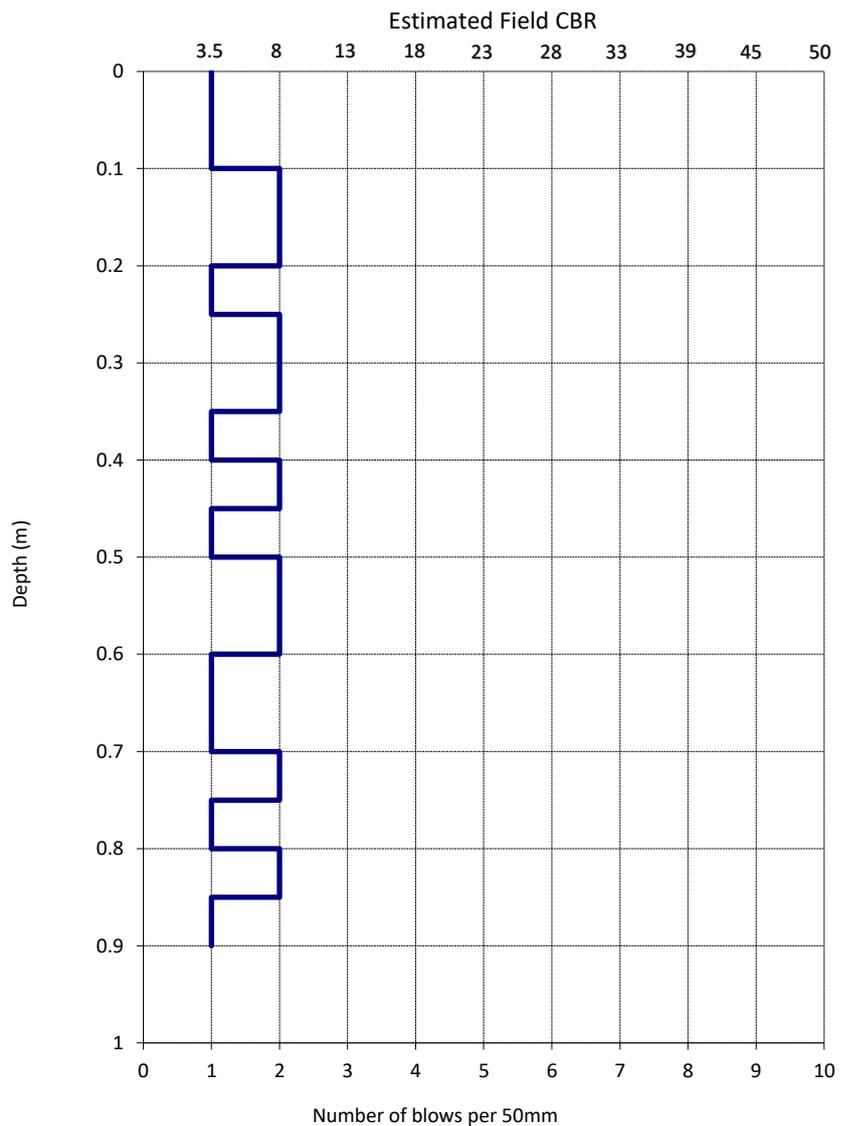
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### NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	13

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	1
100	100	1
150	150	2
200	200	2
250	250	1
300	300	2
350	350	2
400	400	1
450	450	2
500	500	1
550	550	2
600	600	2
650	650	1
700	700	1
750	750	2
800	800	1
850	850	2
900	900	1
950	950	
1000	1000	



#### Test Remarks

The estimated CBR values are based on Figure 5.3, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (2019) "Pavement Design - A Guide to the Structural Design of Road Pavements".

Tested By	JALC	Date	7/03/2023
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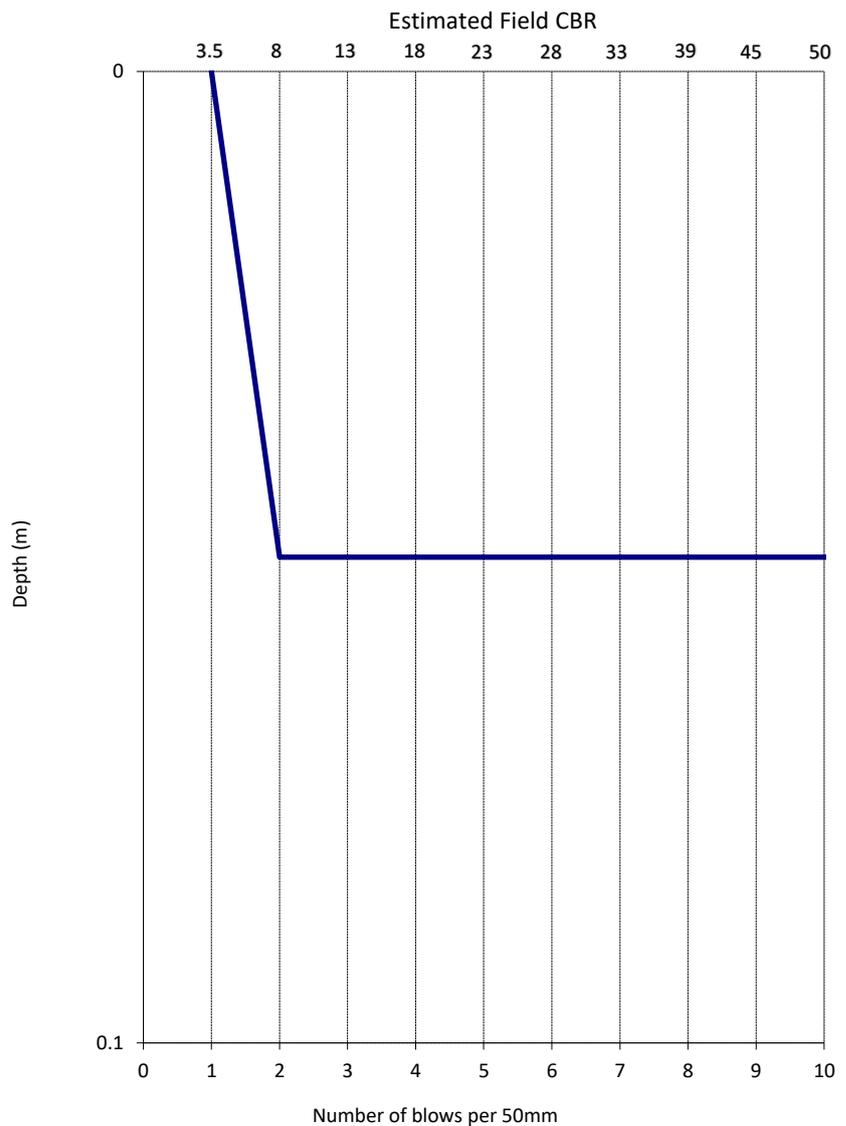
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### NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	14

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	UTP
100	100	
150	150	
200	200	
250	250	
300	300	
350	350	
400	400	
450	450	
500	500	
550	550	
600	600	
650	650	
700	700	
750	750	
800	800	
850	850	
900	900	
950	950	
1000	1000	



#### Test Remarks

Scala penetrometer 'double bouncing' at surface.

The estimated CBR values are based on Figure 5.3, Correlation of Dynamic Cone Penetration and CBR AUSTRROADS (2019) "Pavement Design - A Guide to the Structural Design of Road Pavements".

Please note Estimated Field CBR cannot be calculated over 10 blows.

Tested By	JALC	Date	7/03/2023
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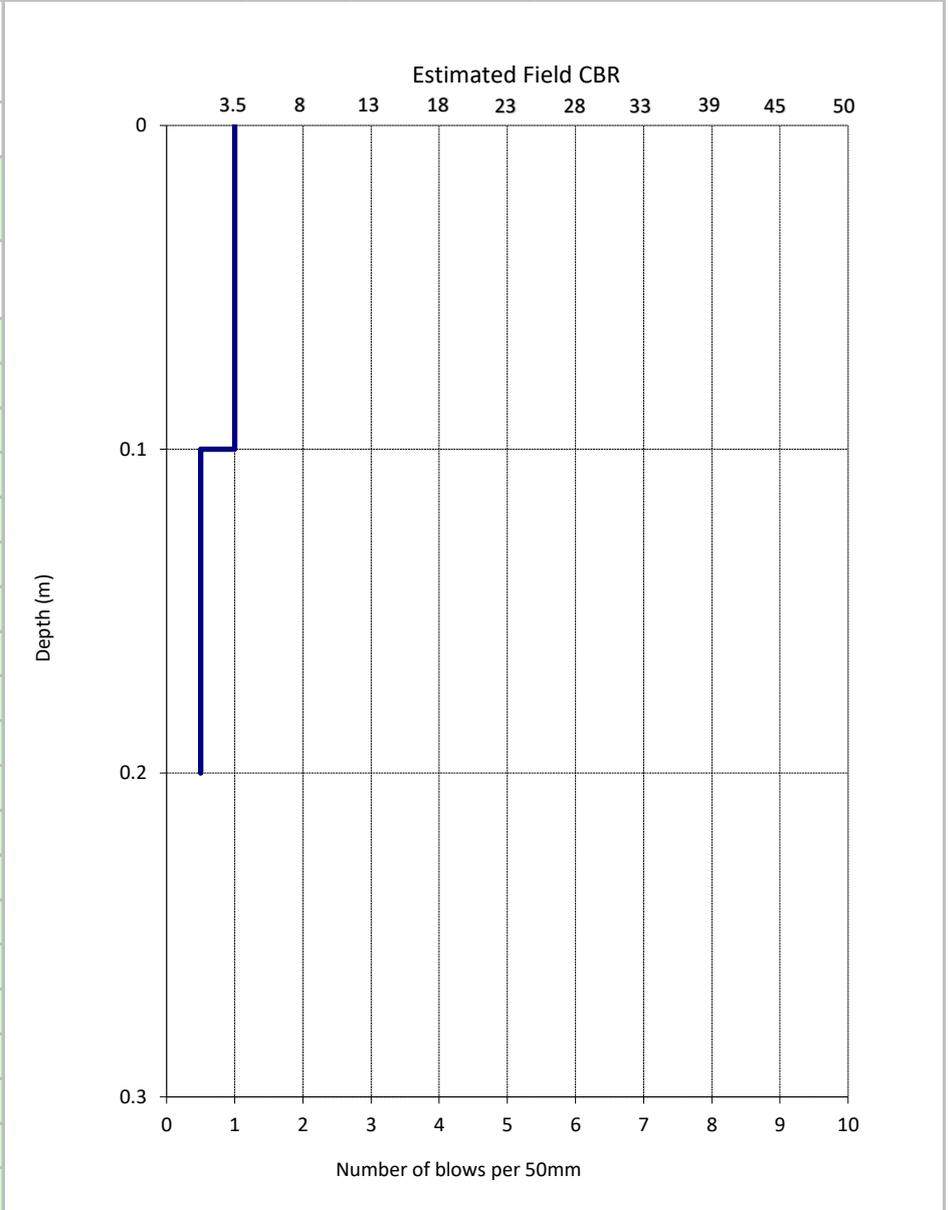
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### NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	15

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	1
100	100	1
150	150	0.5
200	200	0.5
250	250	UTP
300	300	
350	350	
400	400	
450	450	
500	500	
550	550	
600	600	
650	650	
700	700	
750	750	
800	800	
850	850	
900	900	
950	950	
1000	1000	



#### Test Remarks

Scala penetrometer 'double bouncing' at 0.25m.

The estimated CBR values are based on Figure 5.3, Correlation of Dynamic Cone Penetration and CBR AUSTRROADS (2019) "Pavement Design - A Guide to the Structural Design of Road Pavements".

Please note Estimated Field CBR cannot be calculated over 10 blows.

Tested By	JALC	Date	7/03/2023
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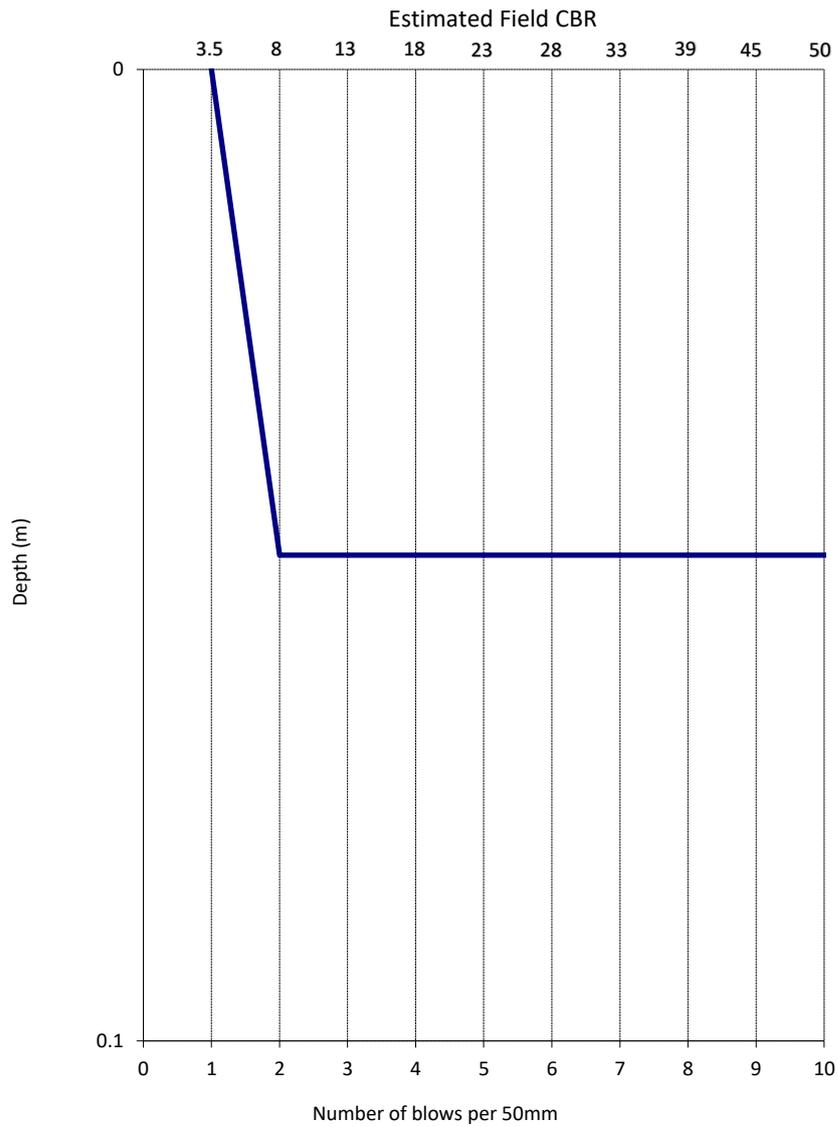
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1.16

### NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	16

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	UTP
100	100	
150	150	
200	200	
250	250	
300	300	
350	350	
400	400	
450	450	
500	500	
550	550	
600	600	
650	650	
700	700	
750	750	
800	800	
850	850	
900	900	
950	950	
1000	1000	



#### Test Remarks

Scala penetrometer 'double bouncing' at surface.

The estimated CBR values are based on Figure 5.3, Correlation of Dynamic Cone Penetration and CBR AUSTRROADS (2019) "Pavement Design - A Guide to the Structural Design of Road Pavements".

Please note Estimated Field CBR cannot be calculated over 10 blows.

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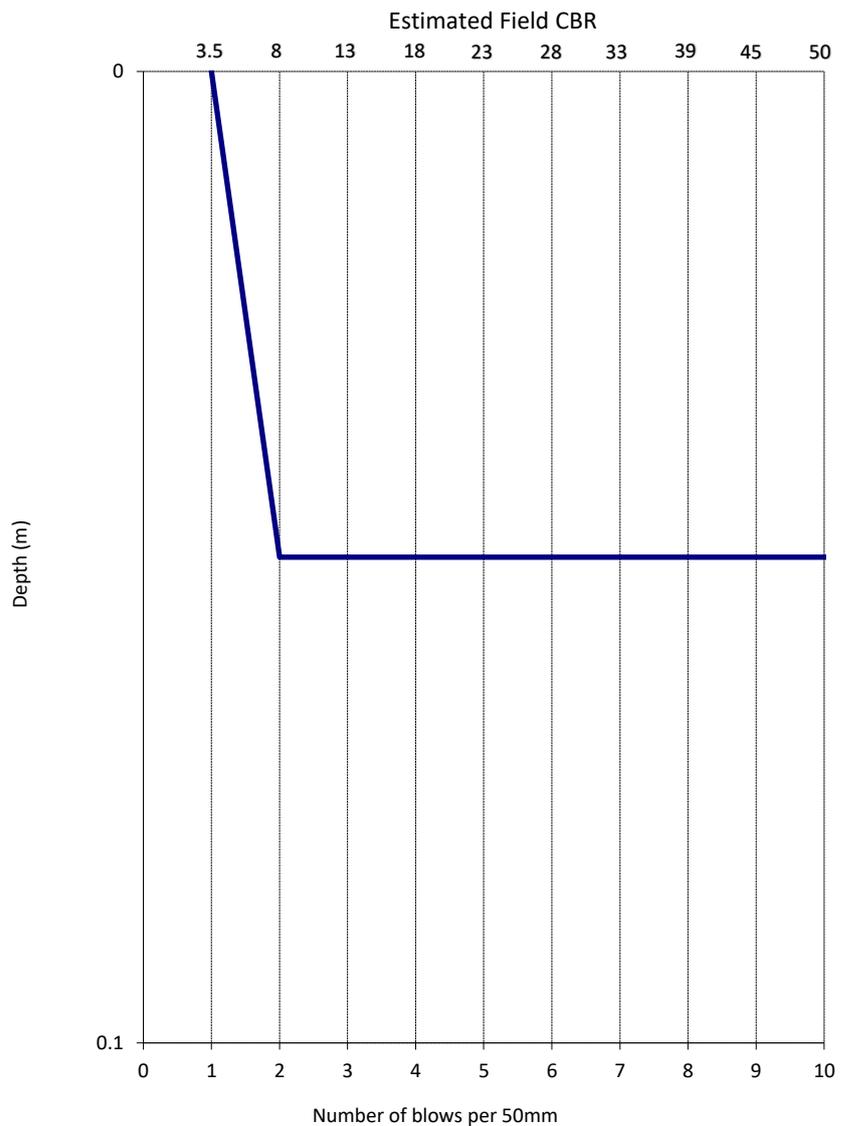
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1.17

### NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	17

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	UTP
100	100	
150	150	
200	200	
250	250	
300	300	
350	350	
400	400	
450	450	
500	500	
550	550	
600	600	
650	650	
700	700	
750	750	
800	800	
850	850	
900	900	
950	950	
1000	1000	



#### Test Remarks

Scala penetrometer 'double bouncing' at surface.

The estimated CBR values are based on Figure 5.3, Correlation of Dynamic Cone Penetration and CBR AUSTRROADS (2019) "Pavement Design - A Guide to the Structural Design of Road Pavements".

Please note Estimated Field CBR cannot be calculated over 10 blows.

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Checked By		Date	



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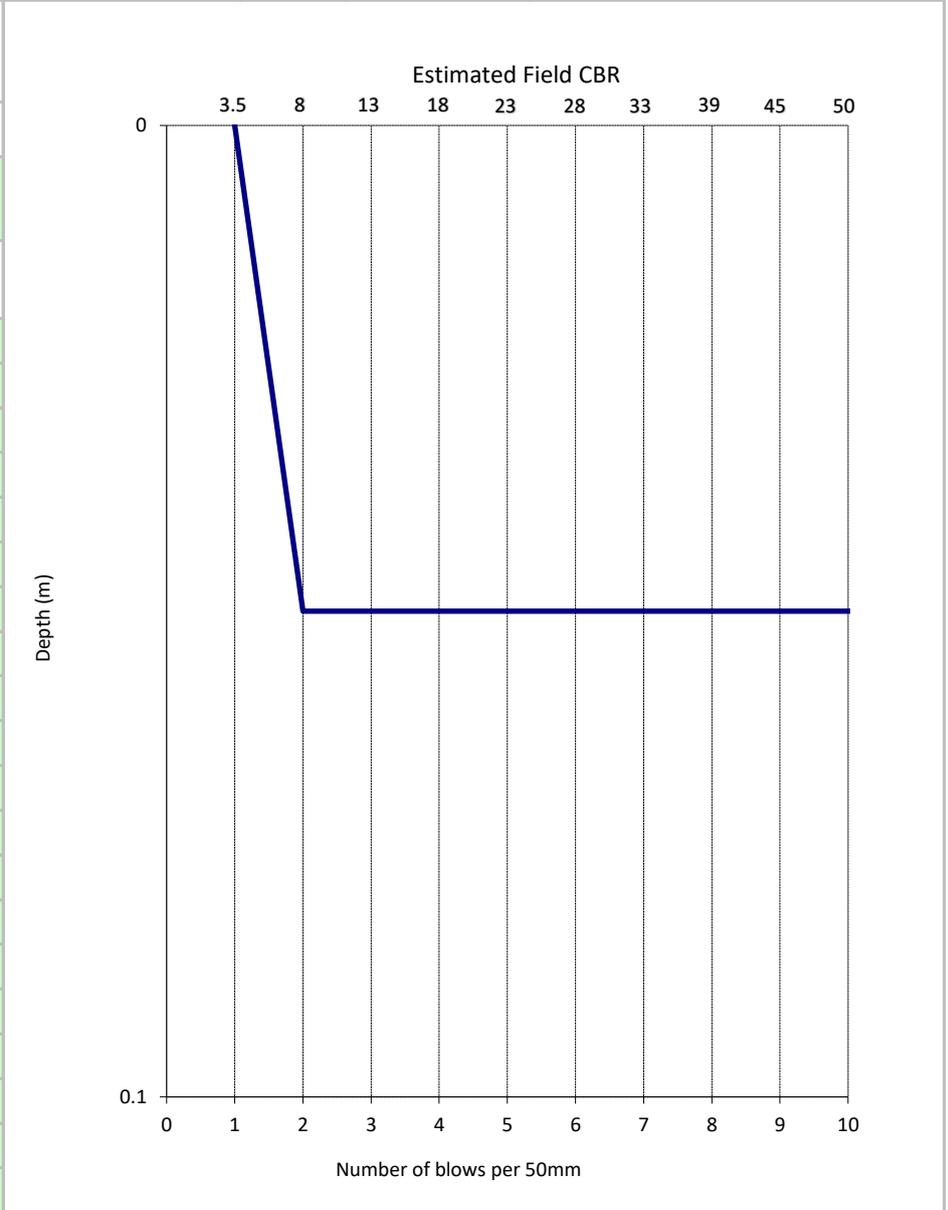
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1.18

**NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala**

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	18

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	UTP
100	100	
150	150	
200	200	
250	250	
300	300	
350	350	
400	400	
450	450	
500	500	
550	550	
600	600	
650	650	
700	700	
750	750	
800	800	
850	850	
900	900	
950	950	
1000	1000	



**Test Remarks**

Scala penetrometer 'double bouncing' at surface.

The estimated CBR values are based on Figure 5.3, Correlation of Dynamic Cone Penetration and CBR AUSTRROADS (2019) "Pavement Design - A Guide to the Structural Design of Road Pavements".

Please note Estimated Field CBR cannot be calculated over 10 blows.

Tested By	JALC	Date	7/03/2023
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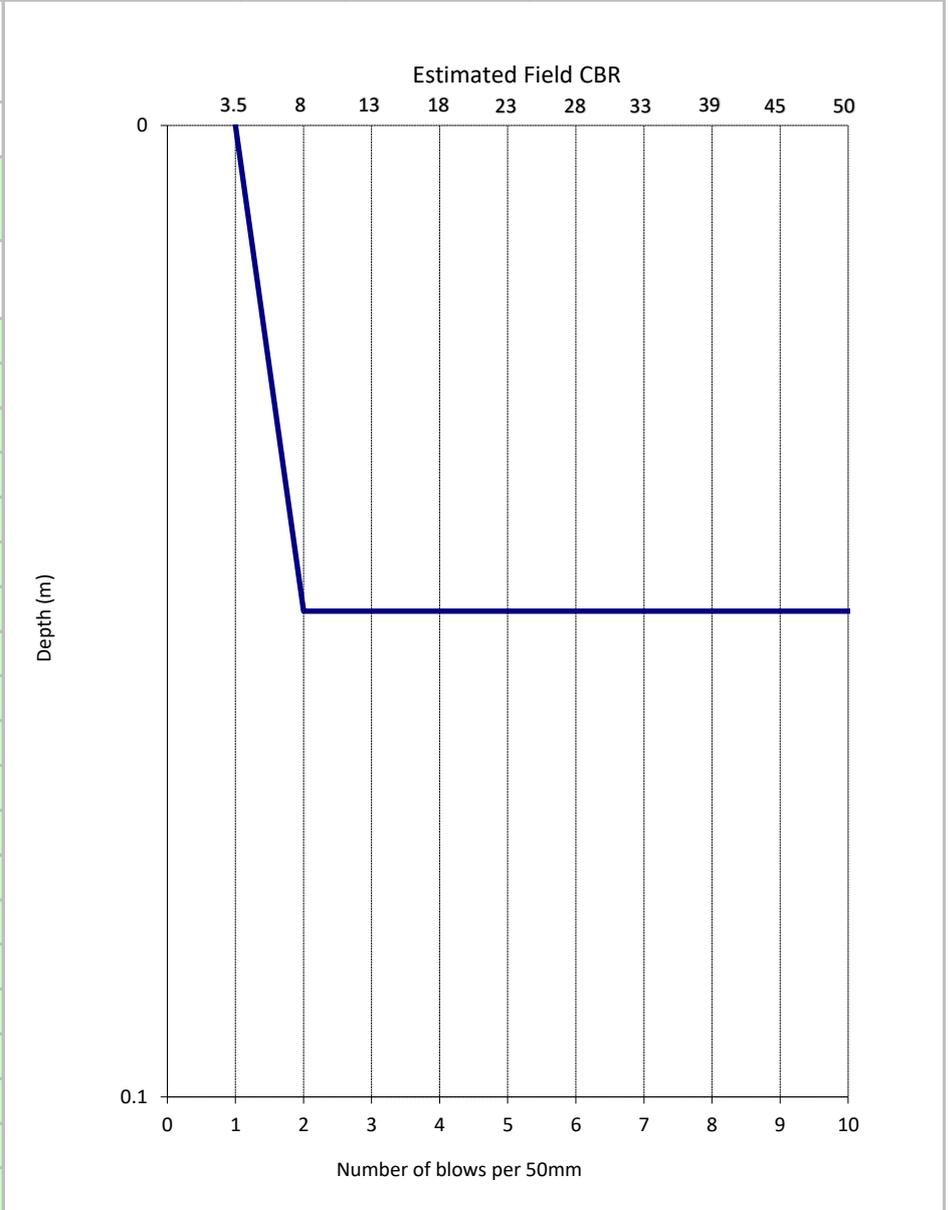
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1.19

### NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	19

Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	UTP
100	100	
150	150	
200	200	
250	250	
300	300	
350	350	
400	400	
450	450	
500	500	
550	550	
600	600	
650	650	
700	700	
750	750	
800	800	
850	850	
900	900	
950	950	
1000	1000	



#### Test Remarks

Scala penetrometer 'double bouncing' at surface.

The estimated CBR values are based on Figure 5.3, Correlation of Dynamic Cone Penetration and CBR AUSTRROADS (2019) "Pavement Design - A Guide to the Structural Design of Road Pavements".

Please note Estimated Field CBR cannot be calculated over 10 blows.

Tested By	JALC	Date	7/03/2023
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Checked By		Date	



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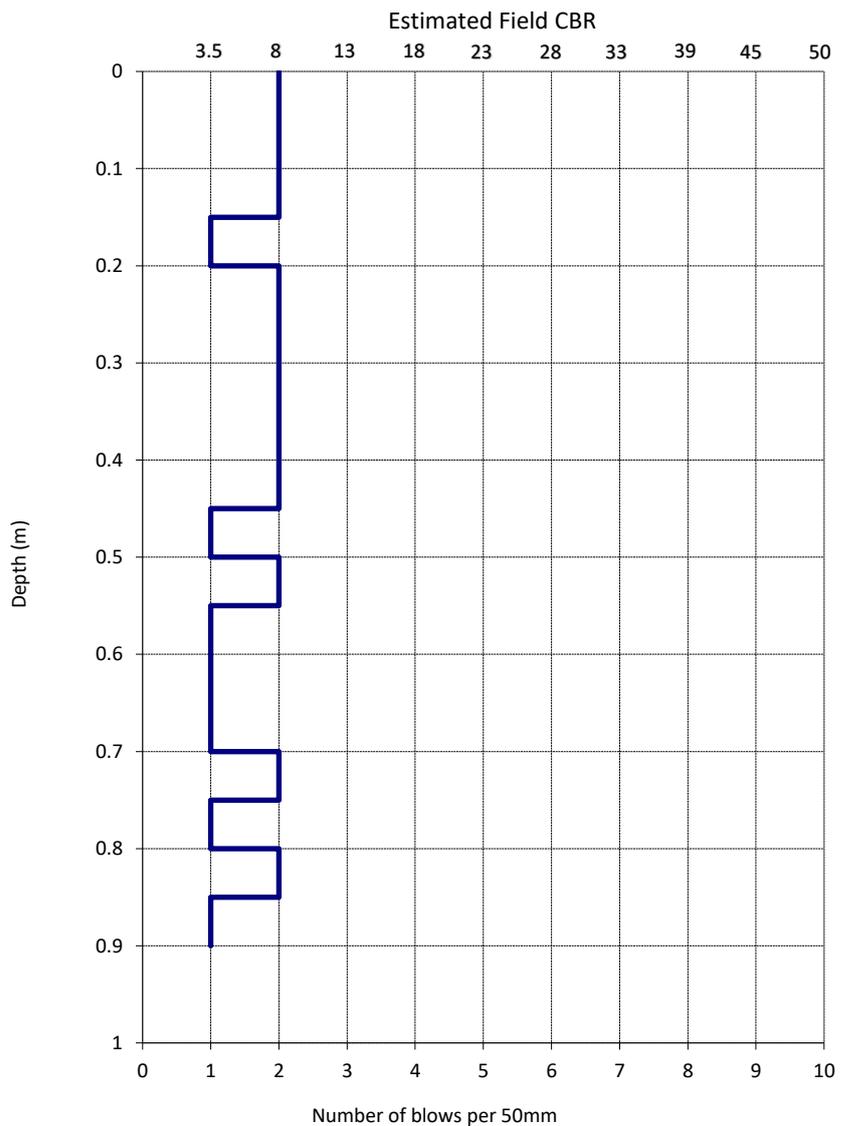
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1.20

### NZS 4402: 1988 Test 6.5.2 Dynamic Cone Penetrometer - Scala

Project Name	Aorere Stage 2 TOC045	Project ID	1007708.2086.500.300
Customer Project ID	-	Equipment ID	CAM 103
Site Location	Superlot AO-018	Material Source	Unknown
Material Description	ClaySILT with Gravels	Test Series	DCP 1 - 20
Depth from ground surface to commencement of penetration (m)		Test Number	20

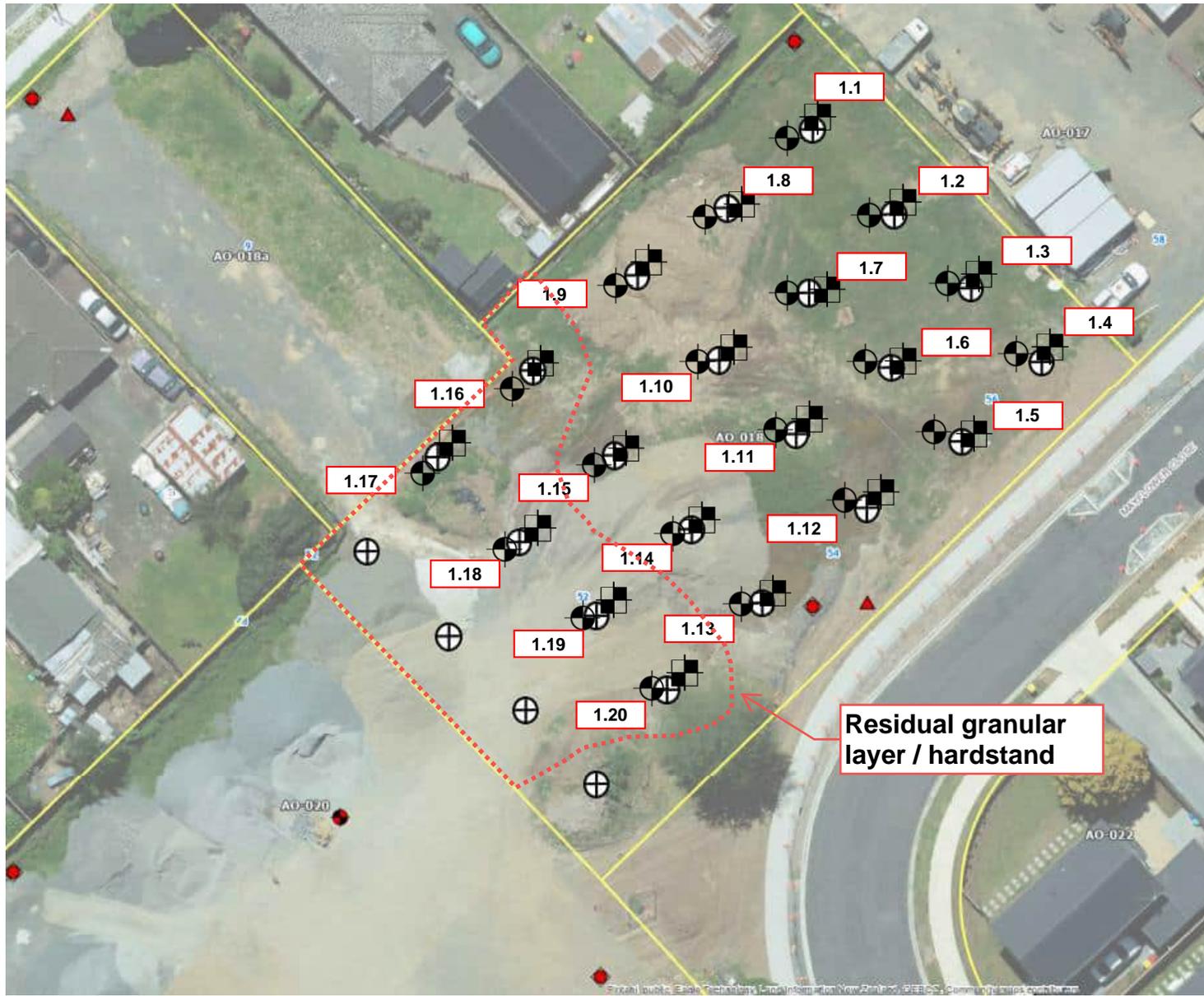
Chainage	Offset	Lane
-	-	-
Vertical distance driven (mm)	Depth (mm)	Number of blows
50	50	2
100	100	2
150	150	2
200	200	1
250	250	2
300	300	2
350	350	2
400	400	2
450	450	2
500	500	1
550	550	2
600	600	1
650	650	1
700	700	1
750	750	2
800	800	1
850	850	2
900	900	1
950	950	
1000	1000	



#### Test Remarks

The estimated CBR values are based on Figure 5.3, Correlation of Dynamic Cone Penetration and CBR AUSTRROADS (2019) "Pavement Design - A Guide to the Structural Design of Road Pavements".

Tested By	JALC	Date	7/03/2023
Data Entry By	JALC	Date	7/03/2023
Checked By		Date	



**Legend:**

-  Impact Hammer
-  NDM (DT and SV Set)
-  Shear Vane Set
-  Scala
-  Test Area

**Test Location Plan**

Site:	Aorere Stage 2-TOC045	Job Name:	Aorere Stage 2-TOC045	Drawn:	JALC	Date:	07/03/2023
Location:	Superlot AO-018	Job No.:	1007708.2086.500.300	URN:	1	Date:	07/03/2023
		Lab Ref:	- N/A	Scale:	Not to Scale	Rev.:	1



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### Shear Vane Results

Job No: 1007708.2086	Date: 16/03/2023	<b>Test No.</b> 1.11
Project: Piritahi Aorere	Operated by: SCZH	<b>Sheet</b> 1 <b>of</b> 2
Location: AO-18	Logged by: SCZH	
RL: 17.5	Checked by:	

Test	Corrected Undrained Shear Strength
1.11	112



Piritahi

**SCALA PENETROMETER LOG**

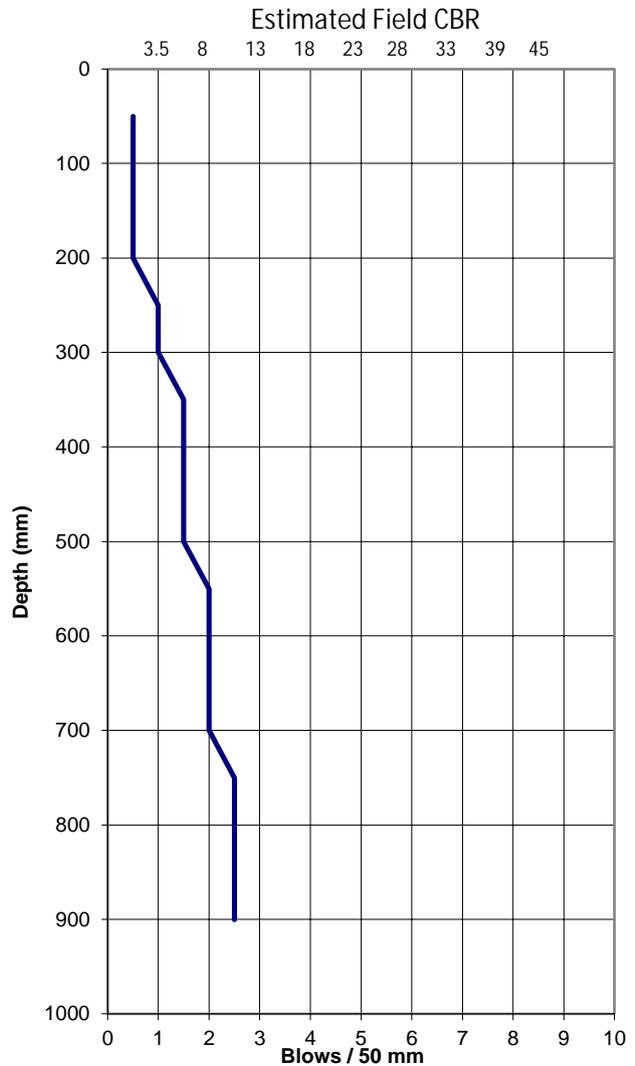
Job No: 1007708.2086  
 Project: Piritahi Aorere  
 Location: AO-18  
 RL: 17.5

Date: 16/03/2023  
 Operated by: SCZH  
 Logged by: SCZH  
 Checked by:

**Test No. DCP1.11**

**Sheet 2  
 of 2**

mm Driven	No. of Blows
50	0.5
100	0.5
150	0.5
200	0.5
250	1
300	1
350	1.5
400	1.5
450	1.5
500	1.5
550	2
600	2
650	2
700	2
750	2.5
800	2.5
850	2.5
900	2.5



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTRROADS (1992) 'Pavement Design - A Guide to the Structural Design of Road Pavements'

Test Method Used: NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer

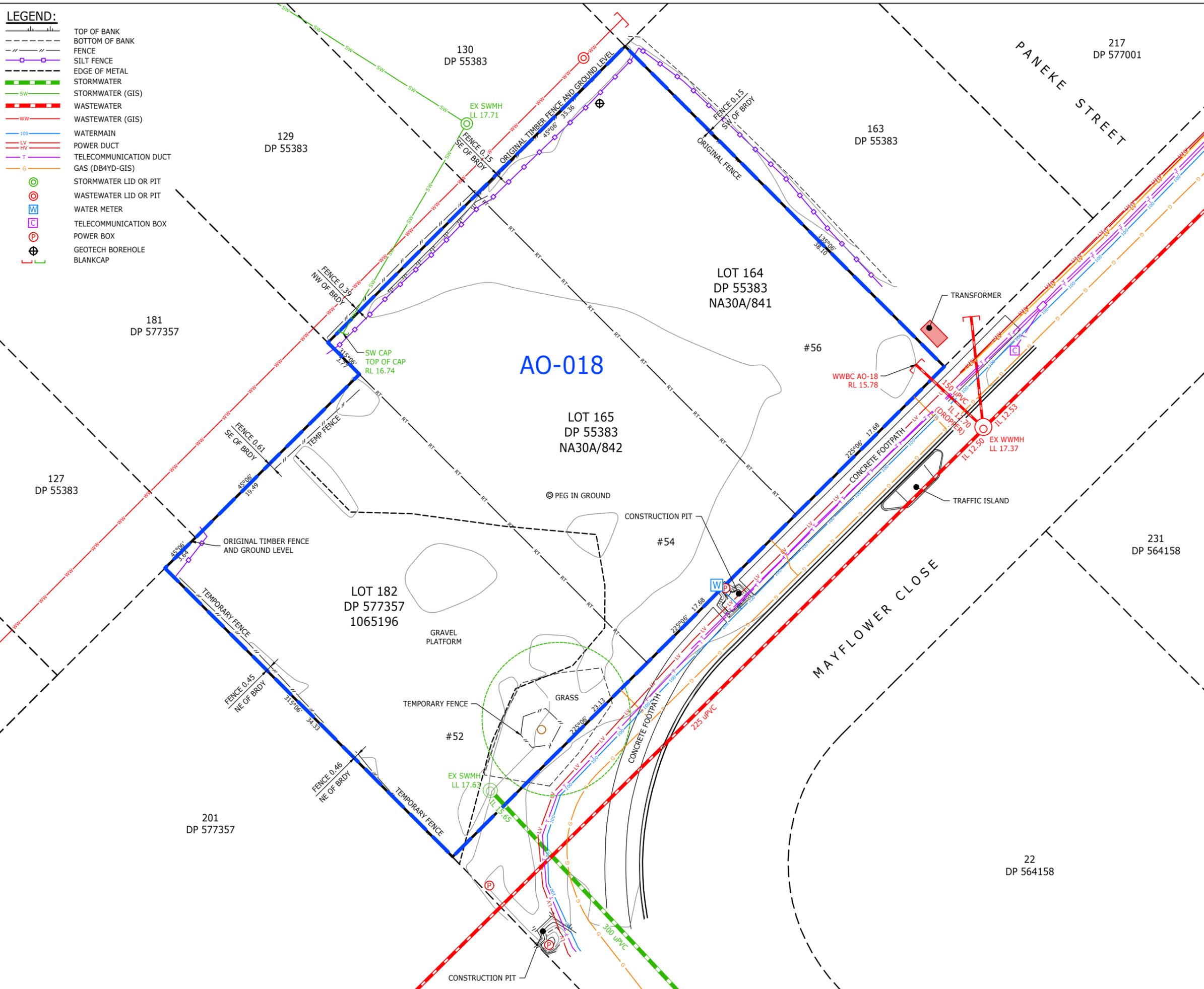
## Appendix B – As Built Plans

**LEGEND:**

- TOP OF BANK
- BOTTOM OF BANK
- FENCE
- SILT FENCE
- EDGE OF METAL
- STORMWATER
- STORMWATER (GIS)
- WASTEWATER
- WASTEWATER (GIS)
- WATERMAIN
- POWER DUCT
- TELECOMMUNICATION DUCT
- GAS (DB4YD-GIS)
- STORMWATER LID OR PIT
- WASTEWATER LID OR PIT
- WATER METER
- TELECOMMUNICATION BOX
- POWER BOX
- GEOTECH BOREHOLE
- BLANKCAP

**NOTES:**

1. LEVELS ARE IN TERMS OF AUCKLAND VERTICAL DATUM 1946  
ORIGIN OF LEVELS  
S166 SO 55792  
RL 17.38
2. COORDINATES ARE IN TERMS OF NZ GEODETIC DATUM 2000  
MT EDEN CIRCUIT  
ORIGIN OF COORDINATES  
S166 SO 55792  
789350.09mN  
405249.75mE
3. CONTOURS ARE AT 0.2m INTERVALS. CONTOURS SHOWN WITHIN THE SURVEYED AREA HAVE BEEN ELECTRONICALLY COMPUTED FROM SPOT HEIGHT DETERMINATIONS AND MAY NOT REPRESENT THE TRUE GROUND LEVELS. CONTOURS SHOWN OUTSIDE THE SURVEYED AREA ARE SOURCED FROM AUCKLAND COUNCIL LIDAR & VERIFIED BY PIRITAHĪ TO WITHIN +/- 50mm. ANY CRITICAL HEIGHTS SHOULD BE CHECKED ON SITE PRIOR TO DESIGN AND CONSTRUCTION COMMENCING.
4. THIS PLAN HAS BEEN CARRIED OUT TO TOPOGRAPHICAL STANDARDS. ALL LEVELS SHOWN ARE CORRECT AT TIME OF SURVEY. CRITICAL DIMENSIONS AND LEVELS SHOULD BE VERIFIED.
5. BOUNDARIES SHOWN ON THIS PLAN ARE FROM LT 583101 AND HAVE NOT BEEN SURVEYED. A BOUNDARY DEFINITION SURVEY SHOULD BE CARRIED OUT TO ESTABLISH EXACT BOUNDARY POSITIONS ON SITE.
6. ALL EASEMENTS, COVENANTS AND OTHER LEGAL INSTRUMENTS ASSOCIATED WITH THIS SITE ARE CORRECT AS AT THE DATE OF ISSUE OF THIS DRAWING.
7. REFER TO DRAWING FILE FOR FROZEN LAYERS : SPOT HEIGHTS AND 3D SURFACE.



1	FOR HANDOVER	RBH	30.03.23
REVISION DETAILS		BY	DATE

PROJECT: **AORERE STAGE 2**

DESCRIPTION: **SUPERLOT AO-018 HANDOVER PLAN**

N	SURVEYED	MJS	03.2023
	DESIGNED	-	-
	DRAWN	CA	03.2023
	CHECKED	RBH	31.03.2023
	APPROVED	RBH	31.03.2023

SCALE	1:150 @A1	1:300 @A3	REVISION
STATUS	FOR HANDOVER		1
PRECINCT	MĀNGERE		
DWG NO	TOC045-A018		

0 3 7.5 15 SCALE (m) 1:150 @A1 1:300 @A3

## Appendix C – Piritahi Test Results

## SHEAR VANE FIELD TEST RECORD SHEET

<b>TOC No &amp; Name:</b>	Aorere, TOC 45	<b>Date:</b>	27/06/2022
<b>Location:</b>	A0-018	<b>Layer:</b>	2 (0.3 each)

Test Methods: Shear Vane

<b>Material Type: Cohesive Fill</b>	<b>Shear Vane ID: 3048</b>
<b>Material Description: Clay</b>	<b>Calibration Expiry Date: 14/10/2023</b>
<b>Site Plan Attached: Yes</b>	<b>Vane Conversion Factor: 1.333</b>

Waste-  
Water - 56  
Mayflower  
Close

Test Location Number	Location (Or Show on Site Plan)		Shear Vane Uncorrected Dial Readings (kPa)					Corrected Average Shear Strength (kPa)
	Dist. from DS MH (m)	Test R. L. /Depth(m)	Reading 1	Reading 2	Reading 3	Reading 4	Average Reading	
1		0.3	140	140	140	140	137	182.2
2		0.3	120	130	130	132	128	170.2
1		0	140	128	140	140	137	182.21
2		0	140	140	140	140	140	186.2
<b>Tested By: Harjot Singh</b>								
<b>Reviewed By: Amrit Singh</b>								

Waste-  
Water - 54  
Mayflower  
Close

Test Location Number	Location (Or Show on Site Plan)		Shear Vane Uncorrected Dial Readings (kPa)					Corrected Average Shear Strength (kPa)
	Dist. from DS MH (m)	Test R. L. /Depth(m)	Reading 1	Reading 2	Reading 3	Reading 4	Average Reading	
1	n/a	0.3	140	140	140	140	140	186.2
2	n/a	0.3	140	140	140	140	140	186.2
1	n/a	0	UTP	UTP	UTP	UTP	UTP	-
2	n/a	0	UTP	UTP	UTP	UTP	UTP	-
<b>Tested By:</b>							Harjot Singh	
<b>Reviewed By: Amrit Singh</b>								

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## SHEAR VANE FIELD TEST RECORD SHEET

Waste-  
Water 52  
Mayflower  
Close

Test Location Number	Location (Or Show on Site Plan)		Shear Vane Uncorrected Dial Readings (kPa)					Corrected Average Shear Strength (kPa)
	Dist. from DS MH (m)	Test R. L. /Depth(m)	Reading 1	Reading 2	Reading 3	Reading 4	Average Reading	
1	n/a	0.3	140	140	140	140	140	186.2
2	n/a	0.3	140	140	140	140	140	186.2
1	n/a	0	130	UTP	UTP	130	130	172.9
2	n/a	0	130	130	132	132	131	174.23
					Tested By:		Harjot Singh	
					Reviewed By: Amrit Singh			

**SHEAR VANE FIELD TEST RECORD SHEET**

Site Plan for A0-018

Notes:

- 1) All the SW laterals were in the topsoil layer therefore no testing on them was.
- 2) As per the ITP – no NDM testing was required as the depths were less than 600 for both WW and SW.
- 3) Length of the trench was approximately 15 meters max, therefore 2 tests were done per trench.



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**SHEAR VANE FIELD TEST RECORD SHEET**



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**SHEAR VANE FIELD TEST RECORD SHEET**



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SHEAR VANE FIELD TEST RECORD SHEET



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**SHEAR VANE FIELD TEST RECORD SHEET**



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## SHEAR VANE FIELD TEST RECORD SHEET



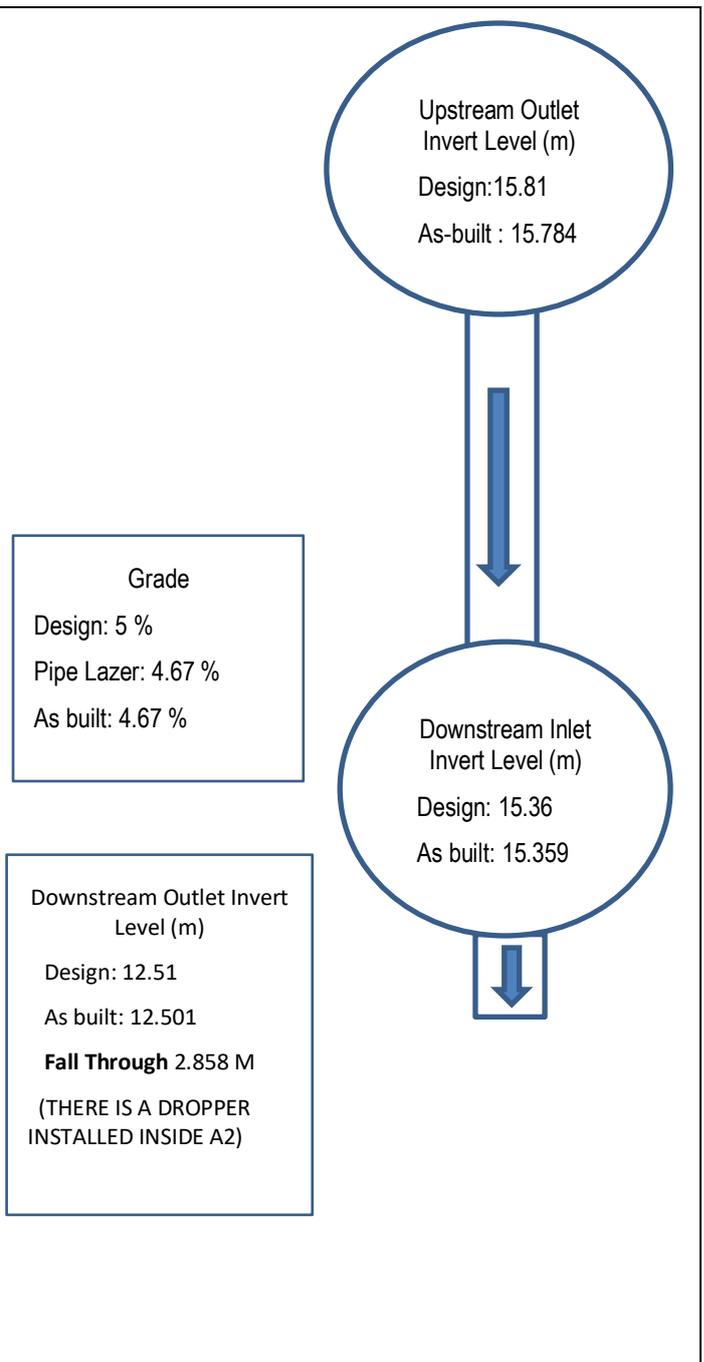
## CHECKLIST FOR DRAINAGE PIPELINE AND MANHOLE INSTALLATION

TOC No & Name:	Toc 45, Aorere	Physical Work Start Date:	10/10/2022
Location/Description:	WWMH A-2 TO BC A0-18		
IFC Drawing No:	TOC045-002-5002	Revision:	A

<b>Upstream Blank cap (MH) #: BC A0-018</b>		
Status	<b>New</b>	Existing
Dia. (mm)	150	
Type	SW	<b>WW</b>
Epoxied	n/a	
Water tight	YES	
Depth	1.80 m	
Note: Depth is measured from MH Base to underside of Concrete Lid.		
Throat depth	N/A	
Note: Throat depth is measured from underside of concrete lid to finished final lid level (FSL)		

<b>Pipe Line Ref #: LINE A0-18</b>	
Dia. (mm)	150
Length (m)	8.63m
Material	UPVC
Class	SN16

<b>Downstream Manhole (MH) #: MH A-2</b>		
Status	<b>New</b>	Existing
Dia. (mm)	1200	
Type	SW	<b>WW</b>
Epoxied	YES	
Water tight	YES	
Depth	4.79	
Note: as above		
Throat depth	N/A	
Note: as above		



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**CHECKLIST FOR DRAINAGE PIPELINE AND MANHOLE INSTALLATION**

Activities/Items to be checked: *Discipline: Waste Water*

*EPA NO.: EPA - 132180*

NO	Activity/Item	Checked OK? (Y/N/NA)	Checked By	Remarks/ Hold Point Initials
1	Underground services identified and marked out	Yes	Amrit, Harjot	Marked out on site + on the B4UDIG plans
2	Setting out of the manhole (position and level) completed and fully understood	Yes	John Bucholz	Surveyor
NO	Activity/Item	Checked OK? (Y/N/NA)	Checked By	Remarks/ Hold Point Initials
3	Trench formation/foundation inspected and any unsuitable material identified by CPS/Designer - <b>CPS Hold Point</b>	Yes	CPS	CPS Initial: <b>gg</b>
4	Trench formation/foundation shear vane tested	Yes	Harjot/ Amrit	See site test records attached
5	Undercut inspected (if applicable): <ul style="list-style-type: none"> <li>● Undercut Depth: 0.5 m</li> <li>● Undercut Type: GAP65</li> <li>● Material Source : STEVENSONS</li> </ul>	Yes	Geotech- Cameron	Inspected by Cameron- (report attached)
6	Bedding inspected and clegg tested): <ul style="list-style-type: none"> <li>● Bedding Depth: 100 mm</li> <li>● Bedding Type: Gap 20</li> <li>● Material Source: Stevensons Aggregate</li> </ul>	Yes	Amrit / Harjot	See site test records attached
7	Pipes and manholes inspected and free of any damage	Yes	Amrit/ Harjot	Yes, free of any damage
8	Pipes and manholes installed as per design drawings and specification - <b>CPS Hold Point</b>	Yes	CPS	CPS Initial: <b>gg</b>
9	Backfill compacted in layers and tested	Yes	Amrit/Harjot	See site test records attached and/or IANZ Test Reports
10	Test results reviewed and compactness achieved for (Photo required):	Yes	Amrit/Harjot	Photos attached

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**CHECKLIST FOR DRAINAGE PIPELINE AND MANHOLE INSTALLATION**

<input checked="" type="checkbox"/> Foundation Backfilling	<input checked="" type="checkbox"/> Bedding	<input checked="" type="checkbox"/>			
---	---	-------------------------------------	--	--	--

Photos below taken and attached (Tick Applicable )		
<input checked="" type="checkbox"/> Flexible Joints	<input checked="" type="checkbox"/> Pipe Joint	<input checked="" type="checkbox"/> Excavation
<input checked="" type="checkbox"/> Haunching	<input checked="" type="checkbox"/> Manhole benching	<input checked="" type="checkbox"/> Undercut if required

**Verification and Review:**

<input checked="" type="checkbox"/> I confirm that the above work has been completed and checked as required.			
Subcontractor	Name: Dean Strong	Signature:	Date: 21/10/2022
PE/SE (Piritahi)	Name: Harjot Singh	Signature: H.S	Date: 21/10/2022
CPS	Name: Glen Gibbons	Signature: G Gibbons	Date: 22.02.23

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**CLEGG HAMMER TEST RECORD SHEET**

**Test Methods:**

<b>Material Type:</b> CLAY	<b>Shear Vane ID:</b> S/NO 3048
<b>Material Description:</b> Clay	<b>Calibration Expiry Date:</b> 14/10/2023
<b>Site Plan Attached:</b> See Geotech Report	<b>Vane Conversion Factor:</b> 1.333

<b>TOC No &amp; Name:</b>	TOC 45, AORERE	<b>Date:</b>	10/10/2022
<b>Location/Description</b>	WWMH A-2 TO BC A0-018	<b>Layer:</b>	0.2m

**Test Methods:**

<b>Material Type:</b>	Gap 20	<b>Clegg Hammer ID:</b>	S/NO 20-0055
<b>Material Description:</b>	Hardfill	<b>Calibration Expiry Date:</b>	31/10/2023
<b>Criteria:</b>	Gap20 CIV > 12	<b>Drops:</b>	4

<b>Material Type:</b>	Gap 65	<b>Clegg Hammer ID:</b>	S/NO 20-0055
<b>Material Description:</b>	Hardfill	<b>Calibration Expiry Date:</b>	31/10/2023

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**CLEGG HAMMER TEST RECORD SHEET**

<b>Criteria:</b>	<b>Gap65 CIV &gt; 30 no single value &lt; 28 and 0.2 m Layers</b>	<b>Drops:</b>	<b>4</b>
------------------	---	---------------	----------

<i>Testing Equipment Information</i>		
<i>Glegg Hammer ID</i>	<i>Shear Vane ID</i>	<i>Shear Vane Correction Factor</i>
<i>S/NO 20-0055</i>	<i>S/NO 3048</i>	<i>1.333</i>

<i>Trench Foundation Test Records ( Correction Factor not Applied )</i>								
	<i>Material</i>	<i>D/s MH</i>	<i>5m</i>	<i>20m</i>	<i>35m</i>	<i>60m</i>	<i>75m</i>	<i>BC A0-18</i>
<i>Shear Vane</i>	<i>CLAY</i>	<i>A-2</i>	<i>80</i>	<i>N/A</i>	<i>N/A</i>	<i>N/A</i>	<i>N/A</i>	<i>BC A0-18</i>

<i>Material Type and Source ( WWMH A-2)</i>					
<i>Undercut Depth</i>	<i>0.5m</i>	<i>Type</i>	<i>Gap65</i>	<i>Source</i>	<i>STEVENSON'S</i>
<i>Bedding Depth</i>	<i>0.1m</i>	<i>Type</i>	<i>Gap20</i>	<i>Source</i>	<i>STEVENSON'S</i>
<i>Backfill Depth</i>	<i>4.0 m</i>	<i>Type</i>	<i>Gap65</i>	<i>Source</i>	<i>STEVENSON'S</i>

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**CLEGG HAMMER TEST RECORD SHEET**

				<i>Source</i>	<i>STEVENSON'S</i>
<p><i>Undercut Link : <a href="https://synergy.piritahi.nz/5">Synergy12d://synergy.piritahi.nz/5</a> MANGERE/TOC045 - Aorere Stage                  2/1D/06 Geotech/Site inspections Geotech</i></p>					

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**CLEGG HAMMER TEST RECORD SHEET**

*Backfill Test Record (CLEGG) A2 TO BC A0-18*

<i>Test Type</i>	<i>Depth</i>	<i>D/s MH</i>	<i>0-15m</i>				<i>15-30m</i>				<i>30-45m</i>				<i>BC A0-18</i>			
			<i>T1</i>	<i>T2</i>	<i>T3</i>	<i>T4</i>	<i>T1</i>	<i>T2</i>	<i>T3</i>	<i>T4</i>	<i>T1</i>	<i>T2</i>	<i>T3</i>	<i>T4</i>				
		<i>MH A2</i>																<i>BC A0-18</i>
Clegg	0.0	<b>A2</b>	31	31	30	30		n/a	n/a	n/a	n/a		n/a	n/a	n/a	n/a		<b>BC A0-18</b>
Clegg	0.2m	<b>A2</b>	30	30	30	33		n/a	n/a	n/a	n/a		n/a	n/a	n/a	n/a		<b>BC A0-18</b>
Clegg	0.4m	<b>A2</b>	30	33	30	30		n/a	n/a	n/a	n/a		n/a	n/a	n/a	n/a		<b>BC A0-18</b>
Clegg	0.6m	<b>A2</b>	31	34	33	36		n/a	n/a	n/a	n/a		n/a	n/a	n/a	n/a		<b>BC A0-18</b>
Clegg	0.8m	<b>A2</b>	32	31	31	31		n/a	n/a	n/a	n/a		n/a	n/a	n/a	n/a		<b>BC A0-18</b>
Clegg	1.0m	<b>A2</b>	33	30	30	30		n/a	n/a	n/a	n/a		n/a	n/a	n/a	n/a		<b>BC A0-18</b>
Clegg	1.2m	<b>A2</b>	33	34	33	34		n/a	n/a	n/a	n/a		n/a	n/a	n/a	n/a		<b>BC A0-18</b>
Clegg	1.4m	<b>A2</b>	31	33	31	33		n/a	n/a	n/a	n/a		n/a	n/a	n/a	n/a		<b>BC A0-18</b>
Clegg	1.6m	<b>A2</b>	30	30	34	31		n/a	n/a	n/a	n/a		n/a	n/a	n/a	n/a		<b>BC A0-18</b>
Clegg	1.8m	<b>A2</b>	33	36	33	32		n/a	n/a	n/a	n/a		n/a	n/a	n/a	n/a		<b>BC A0-18</b>

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**CLEGG HAMMER TEST RECORD SHEET**

*Backfill Test Record (CLEGG) A-2*

Test Type	Depth	WW MH	0-15m (at 0m)					15-30m					30-45m					
			T1	T2	T3	T4		T1	T2	T3	T4		T1	T2	T3	T4		
Clegg	Under Cut	A2	30	30	31	31	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clegg	Bedding	A2	17	18	18	18	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clegg	0.0	A2	33	29	31	31	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clegg	0.2m	A2	34	32	33	33	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clegg	0.4m	A2	30	30	32	32	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clegg	0.6m	A2	31	33	32	30	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clegg	0.8m	A2	32	33	31	33	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clegg	1.0m	A2	30	30	31	31	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clegg	1.2m	A2	32	36	35	35	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clegg	1.4m	A2	31	34	32	31	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clegg	1.6m	A2	31	32	32	32	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clegg	1.8m	A2	34	36	35	35	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clegg	2.0m	A2	31	31	32	31	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clegg	2.2m	A2	31	30	31	32	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clegg	2.4m	A2	30	30	31	32	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clegg	2.6m	A2	30	30	30	29	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clegg	2.8m	A2	30	31	31	30	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clegg	3.0m	A2	31	32	32	32	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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**CLEGG HAMMER TEST RECORD SHEET**

Clegg	3.2	A2	30	30	31	31	N/A										
Clegg	3.4	A2	30	31	33	32	N/A										

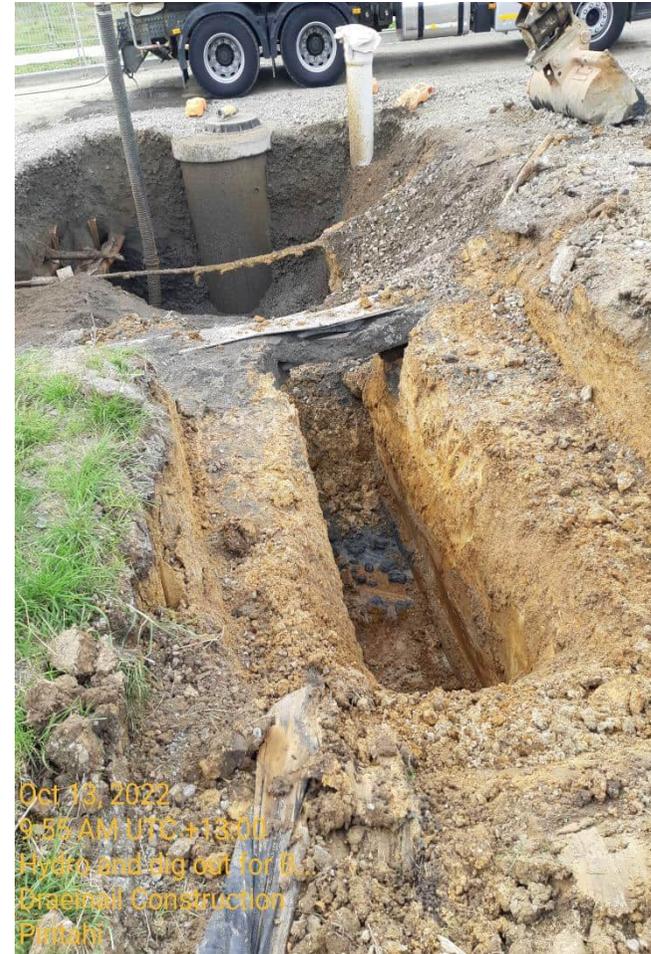
Once printed this document becomes uncontrolled. Refer to Piritahi Alliance QMS in 12D Synergy for controlled copy.

**CLEGG HAMMER TEST RECORD SHEET**



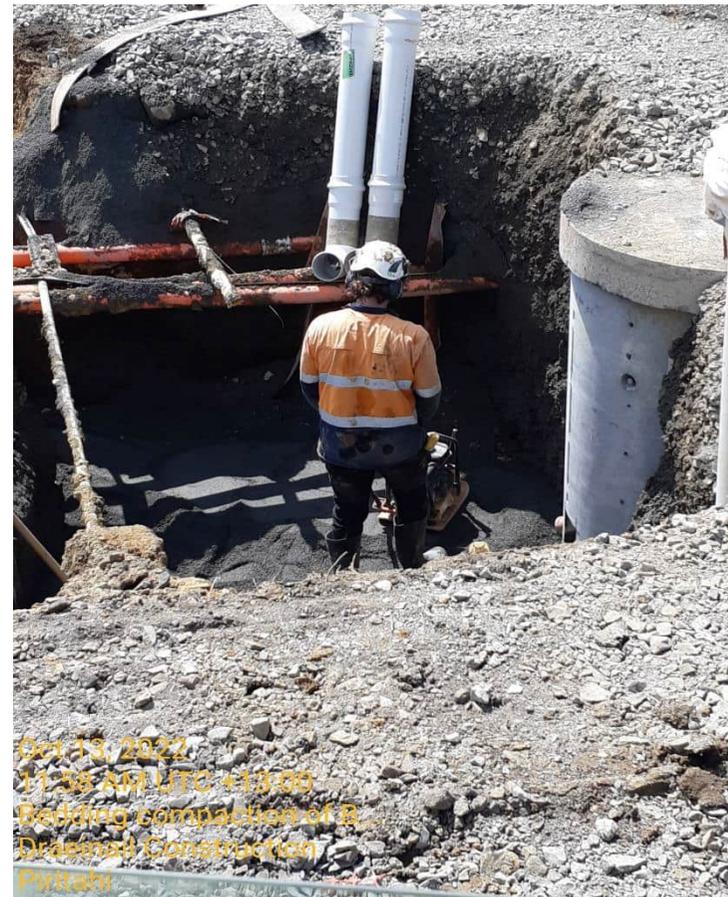
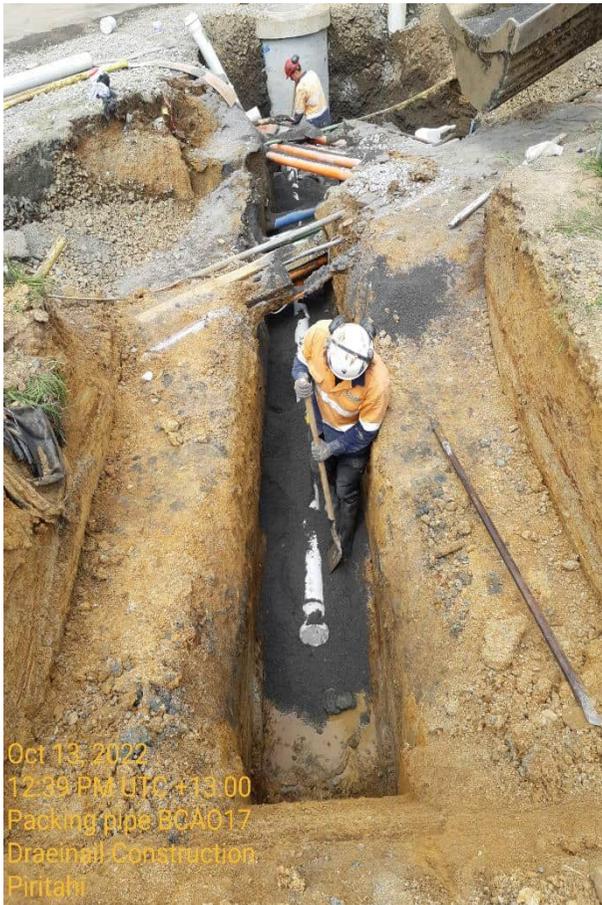
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**CLEGG HAMMER TEST RECORD SHEET**



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**CLEGG HAMMER TEST RECORD SHEET**



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## Appendix D – Geotechnics Testing

**Refer to the Geotechnics testing provided in Appendix A**

## Appendix E – Piritahi ITPs

## INSPECTION AND TEST PLAN



TOC No.:		ITP No.:	AAAA-DS-ITP-0001 (Revision 2)	EPA No.:	
TOC Name:		ITP Title:	ITP for Earthworks - Cut	Scope of this ITP:	

**NOTE: This ITP is to be signed off as one of superlot handover/bulk earthworks construction work pack closeout supporting QA documents at the completion of each superlot/construction work pack.**

Item No:	Inspection / Test Description	Hold(H), Witness(W), Review(R), Inspection(I)			Frequency	Test by Whom	Conformance Criteria	Reference Detail	Required Records	Compliance Verification		
		Constructor	CPS/Designer	Territory Authority						Constructor (Y/N/NA)	CPS (Y/N/NA)	Comments
0	Pre-construction Meeting	H	R	R	Prior to commencing the construction works	NA	Construction monitoring, surface surveys, testing frequency and expectations agreed and meeting minuted.	Auckland QAM	Meeting Minutes			
	Subcontractor Kick-off Meeting	H			Once prior to commencing the construction works	NA	Piritahi QA expectations and requirements addressed and meeting minuted	Specified	Meeting Minutes			
1	<b>Cut/Excavation Materials</b>											
1.1	Excavation Material Testing	H	H		Prior to cut	IANZ Laboratory	Material to be excavated shall be tested for contamination if exporting off superlot and/or for use as site-won fill.	Site Specific Remediation Plans	Land Remediation Notice; IANZ Test Report(s); Piritahi Construction Checklist (AAAA-CN-CHK-0008 - Earthworks - Cut)			
2	<b>Construction</b>											
2.1	Original Ground Level Survey and Setting Out	I	R		Prior to clearance and topsoil stripping	NA	Constructor and Designer may jointly visually inspect undertake check or take spot levels as they consider necessary to confirm the accuracy of these drawings and levels.	ATCOP / ACCOP	Piritahi Construction Checklist (AAAA-CN-CHK-0008 - Earthworks - Cut)			
2.2	Clearance and Topsoil Stripping	I	I		After clearance and topsoil stripping	NA	Topsoil (that does not require remediation) shall be removed within the limits of the earthworks and stockpiled within superlot boundaries clear of any 'contaminated' insitu or stockpiled material.	Site Specific Remediation Plans	Land Remediation Notice; Piritahi Construction Checklist (AAAA-CN-CHK-0008 - Earthworks - Cut)			
2.3	Post Topsoil Strip Survey and Setting Out	I	R		Prior to cut	NA	As per drawings	ATCOP / ACCOP	Piritahi Construction Checklist (AAAA-CN-CHK-0008 - Earthworks - Cut)			
2.4	Unsuitable Material Cut to Waste	I	R		As required	NA	Material identified as requiring remediation to be removed as instructed by CPS/Land Remediation Specialists.	Site Specific Remediation Plans	Land Remediation Notice; Piritahi Construction Checklist (AAAA-CN-CHK-0008 - Earthworks - Cut)			
2.5	Suitable Material Cut to Fill	I	R		Prior to excavation for use on site	IANZ Laboratory	Site won material that does not require remediation can be used within the superlot boundary. MDD and OMC are required for site-won fill material. If the site won material is to be exported, then environmental testing is required.	Site Specific Remediation Plans	Land Remediation Notice; IANZ Test Report(s); Piritahi Construction Checklist (AAAA-CN-CHK-0008 - Earthworks - Cut)			
2.6	Cut Subgrade Testing	R	R		As specified by Designer/Geotechnical Team at excavated subgrade level	Constructor/IANZ Laboratory	Specified by Designer/Geotechnical Team prior to commencement of construction (Subject to agreement with Kāinga Ora)	Specified	Piritahi Construction Checklist (AAAA-CN-CHK-0008 - Earthworks - Cut)			
2.7	Undercut & Backfilling Inspection and Testing	H	H		Before and after undercutting and when required (subject to CPS/Designer's instruction)	Constructor/IANZ Laboratory	Specified by CPS/Designer	Specified	Backfill compaction test report(s) as per AAAA-DS-ITP - Earthworks - Fill (if applicable) Piritahi Construction Checklist (AAAA-CN-CHK-0008 - Earthworks - Cut)			
2.8	As-built Survey	R	R		After cutting or backfilling of undercutting	NA	The top of embankment shall not vary more than 0.5m into the flatter area; Section areas (flatter than 1.5:1): levels shall be to within 150mm of the contours or spot levels indicated.	ATCOP / ACCOP	As-built Survey			
2.9	Stabilisation of Final Surfaces	I	I		At finished levels	NA	Smooth drum rolled surfaces with cross fall. Protected with mulch or temporary hardfill cover	Specified	Piritahi Construction Checklist (AAAA-CN-CHK-0008 - Earthworks - Cut)			
3	<b>Post Construction</b>											
3.1	Final Inspection (Piritahi Internal)	H	H		At the completion of cut (i.e., each superlot and/or construction work pack)	NA	No unacceptable defects	ACTOP Section 16.9.1	Photos			

Constructor	Name:	Signature:	Date:
CPS	Name:	Signature:	Date:
QA	Name:	Signature:	Date:

## INSPECTION AND TEST PLAN



TOC No.:		ITP No.:	AAAA-DS-ITP-0002 (Revision 2)	EPA No.:	
TOC Name:		ITP Title:	ITP for Earthworks - Fill (Including decanting Earth Bunds and Backfilled Redundant Service Trenches)	Scope of this ITP:	

**NOTE: This ITP is to be signed off as one of superlot handover/bulk earthworks construction work pack closeout supporting QA documents at the completion of each superlot/construction work pack.**

Item No.	Inspection / Test Description	Hold(H), Witness(W), Review(R), Inspection(I)			Frequency	Test by Whom	Conformance Criteria	Reference Detail	Required Records	Compliance Verification		
		Constructor	CPS/Designer	Territory Authority						Constructor (Y/N/NA)	CPS (Y/N/NA)	Comments
0	Pre-construction Meeting	H	R	R	Prior to commencing the construction works	NA	Construction monitoring expectations, frequency and timeframes agreed between construction and testing teams and meeting minutes distributed	NA	Meeting Minutes			
	Subcontractor Kick-off Meeting	H			Once prior to commencing the construction works	NA	Piritahi QA expectations and requirements addressed and meeting minutes	Specified	Meeting Minutes			
1	<b>Fill Materials</b>											
1.1	Fill Materials	H	R		Prior to filling 1 initial test for each material and then 1 test per 5,000 m3 for that particular material type.	IANZ Laboratory	Prior to filling (site stockpile to be sampled); (1) Site won material: MDD and OMC (standard Proctor compaction test); (2) Imported cohesive fill: Natural Water Content, Atterberg Limits and Linear Shrinkage for NZS3604 expansivity, and Shrink Swell Test for AS2870; (3) Imported granular: PSD, MDD, OMC and Weathering Quality Index (NZS4407:2015 Test 3.11)	Specified	IANZ Test Report(s); Piritahi Construction Checklist (AAAA-CN-CHK-0009 - Earthworks - Fill)			
2	<b>Construction QA/QC Requirements</b>											
2.1	Setting Out	I	I		Prior to undercutting/filling	NA	By Construction Surveyor as specified in Civil Specification	ACCOP ATCOP	Piritahi Construction Checklist (AAAA-CN-CHK-0009 - Earthworks - Fill)			
2.2	Inspection of subgrade or exposed undercut surface	H	H		Prior to filling or backfilling of undercutting	NA	By CPS and Geotechnical Engineer/Geologist prior to filling	Specified	Piritahi Construction Checklist (AAAA-CN-CHK-0009 - Earthworks - Fill)			
2.3	Testing of subgrade	R	R		Prior to filling: - 10 m by 10 m grid for bulk earthworks; or, - 1 test (Shear Vane&Scala) per 15m for trenches	Constructor	a) Shear Vane: >=60 kPa and b) Scala Penetrometer Test: >=1 blow per 50 mm to 1 m below base of fill	Specified	Shear Vane & Scala Test Records; Piritahi Construction Checklist (AAAA-CN-CHK-0009 - Earthworks - Fill)			
2.4	Testing of undercut surface (if applicable)	R	R		Prior to backfilling of undercutting	Constructor	Specified by CPS/Designer	Specified	Shear Vane/Scala Test Records when required; Piritahi Construction Checklist (AAAA-CN-CHK-0009 - Earthworks - Fill)			
2.5	Benching	I	I		As directed by CPS/Designer	NA	Any portion of the ground whose slope is steeper than three horizontal to one vertical shall be benched before filling is placed on it; The base of the benches shall be sloped inwards at a slope of 12 horizontal to 1 vertical. The longitudinal profile of each bench shall be graded to ensure adequate drainage and safe discharge of water.	Specified	Piritahi Construction Checklist (AAAA-CN-CHK-0009 - Earthworks - Fill)			
2.6	Inspection of Earthwork Filling in Layers	I	I		During filling at every 0.5m height intervals	NA	The thickness of each loose layer (lift) is to be approximately 250mm to 300mm achieve <b>maximum 200mm thick compacted layers</b>	Specified	Piritahi Construction Checklist (AAAA-CN-CHK-0009 - Earthworks - Fill)			
2.7	Compaction Testing in Layers	H	R		Testing undertaken at every 0.5 m height interval.  <b>Within Road Reserves:</b> - Clegg 10m by 10m grid and NDM 20m by 20m grid for bulk earthworks; or, - 1 test (Clegg&NDM) per 15m for trenches  <b>Within Superlot Boundaries:</b> <b>1. Cohesive fill (imported or site won):</b> - Shear vane 10m by 10m grid and NDM 20m by 20m grid for bulk earthworks; or, - 1 test (Shear vane&NDM) per 15m for trenches  <b>2. Granular fill (imported):</b> - Clegg 10m by 10m grid and NDM 20m by 20m grid for bulk earthworks; or, - 1 test (Clegg&NDM) per 15m for trenches  <b>3. SPR/ROP:</b> - Shear vane and Clegg 10m by 10m grid and NDM 20m by 20m grid for bulk earthworks; or, - 1 test (Shear vane, Clegg&NDM) per 15m for trenches  NOTE: NDM not required for less than 600mm deep backfilled trenches within Superlots, however, Clegg or shear vane tests are required.	Constructor - Shear vane & Clegg;  IANZ Laboratory - NDM	<b>Within Road Reserves:</b> GAP65: CIV (average) >= 30 and no single value < 28 and MDD > =95%; GAP40: CIV (average) >= 23 and no single value < 21 and MDD >= 95% Other approved materials: to be checked with CPS/Designer.  <b>Within Superlot Boundaries</b> <b>1. Cohesive fill (imported or site won):</b> - Shear vane (average over 4 readings) >= 130kPa and no single reading < 120kPa; and, - NDM with Air Voids (average) < 8% and no single Air Void > 10%  <b>2. Granular fill (imported):</b> - GAP65: CIV (average) >= 30 and no single value < 28 and MDD >= 92% - GAP40: CIV (average) >= 23 and no single value < 21 and MDD >= 92% - GAP100: CIV (average) >= 30 and no single value < 28 and MDD >= 92%  <b>3. SPR/ROP:</b> - CIV (average) >= 30 and no single value < 28; and, - Shear vane (average over 4 readings) >= 130kPa and no single reading < 120kPa; and, - MDD >= 92% and Air Voids (Average) < 8% and no single Air Void > 10%	Specified	IANZ NDM Test Report(s); Shear Vane and/or Clegg Test Records; Piritahi Construction Checklist (AAAA-CN-CHK-0009 - Earthworks - Fill)			
2.8	Tolerances (As-built)	H	R		As specified	NA	Final Road Subgrades: -20 +0mm Fill; Batters: -0 +150mm; All other fill areas: +0 -75mm	ATCOP Section 16.9.1	As-built Survey			
2.9	Stabilisation of final surfaces	I	I		At finished levels	NA	Smooth drum rolled surfaces with cross fall. Protected with mulch or temporary hardfill cover	Specified	Piritahi Construction Checklist (AAAA-CN-CHK-0009 - Earthworks - Fill)			
3	<b>Post Construction</b>											
3.1	Final Inspection (Piritahi Internal)	H	H		At the completion of fill (i.e., each superlot and/or construction work pack)	NA	No unacceptable defects	ACTOP Section 16.9.1	Photos			

Constructor	Name:	Signature:	Date:
CPS	Name:	Signature:	Date:
QA	Name:	Signature:	Date:

## INSPECTION AND TEST PLAN

TOC No.:		ITP No.:	AAAA-DS-ITP-0004 (Revision 4)	EPA No.:	
TOC Name:		ITP Title:	ITP for Sewer Networks	Scope of this ITP:	

**NOTE: This ITP is to be signed off as one of CS3/CS4/CoA and/or EACC application supporting QA documents at the completion of each EPA.**

Item No.	Inspection / Test Description	Hold(H), Witness(W), Review(R), Inspection(I)			Frequency	Test by Whom	Conformance Criteria	Reference Detail	Required Records	Compliance Verification		
		Constructor	CPS/ Designer	Territory Authority						Constructor (Y/N/NA)	CPS (Y/N/NA)	Comments
0	Watercare Pre-construction Meeting	H	R	R	Once prior to commencing the construction works	NA	Construction monitoring frequency and expectations agreed and meeting minuted	Watercare Compliance Policy	Meeting Minutes			
	Subcontractor Kick-off Meeting	H			Once prior to commencing the construction works	NA	Piritahi QA expectations and requirements addressed and meeting minuted	Specified	Meeting Minutes			
1	Material Compliance											
1.1	Pipes and Miscellaneous Precast Units (Manhole, Lid, Catchpit/Cesspit, Inlet and Outlet, etc)	I/R	R		Material Certificate/Compliance Statement to cover all the pipes & other precast units is to be provided to Quality Engineer for each Precinct every 6 months or at a change of source.	NA	1. Types, sizes and classes are as per the design drawings. 2. Conformance criteria refer to relevant material standards.	Watercare relevant material standards	Material Certificate(s)/Compliance Statement(s) from Supplier			
1.2	Aggregates for Bedding, Haunch, Overlay and Backfill	I/R	R		Material Certificate/Compliance Statement is to be provided to Quality Engineer for each Precinct every 6 months or at a change of source.	IANZ Laboratory	1. The granular material for bedding, haunch, overlay and backfill shall be hard clean, chemically stable crushed stone that would not break down when wetted. Shale or gravely conglomerates are not suitable materials. 2. The granular materials agreed to use include GAP7, GAP20, GAP40, GAP65 and ROP/SPR. 3. Supplier shall provide IANZ Test Reports for PSD, MDD and DI (Density Index). 4. Aggregate MDD and DI test results will be accepted as they are. 5. Aggregate PSD shall meet the specified grading curve envelopes as per Appendix A of this ITP (To be provided).	Specified	PSD, MDD and DI IANZ Test Report(s) from Supplier			
1.3	In situ Concrete	I/R	R		When products are delivered to site and before products are incorporated into the works	NA	In situ concrete for all drainage works shall be a minimum of 20MPa unless specified otherwise on the drawings.	Specified	Concrete Delivery Dockets			
1.4	Steel Reinforcement & Miscellaneous Steel Inc. Bolts and Nuts	I/R	R		When products are delivered to site and before products are incorporated into the works	NA	1. Types, sizes and classes are as per the design drawings. 2. Conformance criteria refer to relevant material standards.	NA	Material Certificate(s)/Compliance Statement(s) from Supplier			
2	Watercare Construction QA/QC Requirements - Open Trench Sewer											
2.1	Pipeline											
2.1.1	Trenching	I			After excavation	NA	1. Trench location, width, level and depth as per drawing and setting out. 2. Trench width minimum: - Nom. pipe Ø ≤150mm = 100mm from edge of pipe. - Nom. pipe Ø >150mm, ≤300mm = 150mm from edge of pipe.	Specified	Watercare QC Checklist for Pipe Laying; Piritahi Construction Checklist for Sewer			

## INSPECTION AND TEST PLAN

Item No.	Description	Priority	Frequency	Location	Method	Responsibility	Frequency	Acceptance Criteria	Records																		
2.1.2	Trench Foundation & Undercutting	H	H		<p>Shear Vane for trench foundation to be tested: - For trenches <math>\geq 30m</math> - every 15m - For trenches <math>&lt; 30m</math> - min 2 tests</p> <p>Clegg for backfilling of undercut to be tested: - For trenches <math>\geq 30m</math> - 1 test every 15m - For trenches <math>&lt; 30m</math> - min 2 tests</p>	Constructor	<p>1. Remove any unsuitable foundation material in accordance with the below table:</p> <table border="1"> <thead> <tr> <th>Shear vane strength (in clay/silt)</th> <th>Scala Penetrometer (in sand/gravel)</th> <th>Undercut and backfill</th> </tr> </thead> <tbody> <tr> <td><math>\geq 80</math> kPa</td> <td><math>\leq 50</math>mm per blow</td> <td>No undercut required</td> </tr> <tr> <td>60-80 kPa</td> <td>60mm per blow</td> <td>200mm compacted hardfill</td> </tr> <tr> <td>40-60 kPa</td> <td>80mm per blow</td> <td>350mm compacted hardfill</td> </tr> <tr> <td>20-40 kPa</td> <td>100mm per blow</td> <td>500mm compacted hardfill</td> </tr> <tr> <td><math>&lt; 20</math> kPa or highly organic</td> <td>200mm per blow</td> <td>Contact the design engineer</td> </tr> </tbody> </table> <p>2. Undercutting to have a transition slope of 1:5 between undercut section and the normal foundation.</p> <p>3. Backfill material (GAP65 or GAP40) shall be selected as per the design drawings and the required compactness is as below:</p> <p>(1) GAP 65: CIV (average over 30m length) <math>&gt; 30</math> &amp; no single value <math>&lt; 28</math>. OR: (2) GAP 40: CIV (average over 30m length) <math>&gt; 23</math> &amp; no single value <math>&lt; 21</math>.</p> <p><b>Note:</b> If it is not possible to undertake the required Clegg tests, then a visual inspection – Hold Point shall be done by CPS Lead who may engage the geotechnical engineer when required.</p>	Shear vane strength (in clay/silt)	Scala Penetrometer (in sand/gravel)	Undercut and backfill	$\geq 80$ kPa	$\leq 50$ mm per blow	No undercut required	60-80 kPa	60mm per blow	200mm compacted hardfill	40-60 kPa	80mm per blow	350mm compacted hardfill	20-40 kPa	100mm per blow	500mm compacted hardfill	$< 20$ kPa or highly organic	200mm per blow	Contact the design engineer	Specified	Watercare QC Checklist for Pipe Laying; Piritahi Construction Checklist for Sewer; Shear Vane/Clegg Test Record
Shear vane strength (in clay/silt)	Scala Penetrometer (in sand/gravel)	Undercut and backfill																									
$\geq 80$ kPa	$\leq 50$ mm per blow	No undercut required																									
60-80 kPa	60mm per blow	200mm compacted hardfill																									
40-60 kPa	80mm per blow	350mm compacted hardfill																									
20-40 kPa	100mm per blow	500mm compacted hardfill																									
$< 20$ kPa or highly organic	200mm per blow	Contact the design engineer																									
2.1.3	Pipe Bedding	I/H	R		<p>Clegg for bedding to be tested: - For trenches <math>\geq 30m</math> - 1 test every 15m - For trenches <math>&lt; 30m</math> - min 2 tests</p>	Constructor	<p><b>Bedding Depth:</b> 150mm compacted thickness 100mm min thickness under pipe socket</p> <p>Bedding material (GAP7 or GAP20) shall be selected as per the design drawings and the required compaction is as below:</p> <p>- GAP 7 &amp; GAP 20: CIV (average over 30m length) <math>&gt; 12</math> &amp; CIV no less than 10.</p> <p><b>Note:</b> If it is not possible to undertake the required Clegg tests, then a visual inspection – Hold Point shall be done by CPS Lead who may engage the geotechnical engineer when required.</p>	Specified	Watercare QC Checklist for Pipe Laying; Piritahi Construction Checklist for Sewer; Clegg Test Record																		
2.1.4	Pipe and Duct Laying	H	H	As required		NA	<p>1. Pipe laying should be true to the line, levels and grades as per design drawings.</p> <p>2. Pipe position tolerance: <math>\pm 50</math>mm; pipe level tolerance: <math>\pm 30</math>mm 3. Horizontal/Position tolerance for HDD, pipe jacking, boring or tunnelling: <math>\pm 100</math>mm</p>	Specified	Watercare QC Checklist for Pipe Laying; Piritahi Construction Checklist for Sewer																		
2.1.5	Pipe Surrounding	I/H	R		<p>Clegg for bedding to be tested: - For trenches <math>\geq 30m</math> - 1 test every 15m - For trenches <math>&lt; 30m</math> - min 2 tests</p>	Constructor	<p>Pipe Surrounding: - Minimum 150mm above top of pipe - Max layer thickness = 200mm</p> <p>- Surrounding material (GAP7 or GAP20) shall be selected as per the design drawings and the required compaction is as below:</p> <p>- GAP 7 &amp; GAP 20: CIV (average over 30m length) <math>&gt; 12</math> &amp; CIV no less than 10.</p> <p><b>Note:</b> If it is not possible to undertake the required Clegg tests, then a visual inspection – Hold Point shall be done by CPS Lead who may engage the geotechnical engineer when required.</p>	Specified	Watercare QC Checklist for Pipe Laying; Piritahi Construction Checklist for Sewer; Clegg Test Record																		
2.1.6	Overlay Zone (Up to 300mm above pipe crown)	I/R	R		<p>Within Road Reserve - NDM to be tested: - For trenches <math>\geq 30m</math> of more - every 15m per layer - For trenches <math>&lt; 30m</math> - min 2 tests per layer</p> <p>Within Superlot Boundary - Clegg to be tested: - For trenches <math>\geq 30m</math> of more - every 15m per layer - For trenches <math>&lt; 30m</math> - min 2 tests per layer</p>	NDM/MDD - IANZ Laboratory; Clegg - Constructor	<p><b>Within Road Reserves</b> Hardfill Backfill placed in layers not exceeding 300mm thickness &amp; Compacted to 90% MDD.</p> <p><b>Within Superlot Boundaries</b> 1. Granular fill shall be free of organics (max particle size 150mm) and placed in layers not exceeding 300mm. 2. Overlay material (GAP65, GAP40 or GAP20) shall be selected as per the design drawings and the required compactness is as below:</p> <p>(1) GAP 65: CIV (average over 30m length) <math>&gt; 30</math> &amp; no single value <math>&lt; 28</math>. OR: (3) GAP 40: CIV (average over 30m length) <math>&gt; 23</math> &amp; no single value <math>&lt; 21</math>. OR: (4) GAP20: CIV (average over 30m length) <math>&gt; 12</math> &amp; no single value <math>&lt; 10</math>.</p>	Specified	Watercare QC Checklist for Pipe Laying; Piritahi Construction Checklist for Sewer; NDM Test Report and/or Clegg Test Record																		

## INSPECTION AND TEST PLAN

2.1.7	Lower Backfill Zone (excludes the top 1m of the backfill layer)	I/R	R		<p>Within Road Reserve - NDM to be tested: - For trenches <math>\geq 30m</math> of more - every 15m per layer - For trenches <math>&lt; 30m</math> - min 2 tests per layer</p> <p>Within Superlot Boundary - Shear Vane/Clegg to be tested: - For trenches <math>\geq 30m</math> of more - every 15m per layer - For trenches <math>&lt; 30m</math> - min 2 tests per layer</p>	<p>NDM/MDD - IANZ Laboratory; Shear Vane/Clegg - Constructor</p>	<p><b>Within Road Reserves</b> Hardfill Backfill placed in layers not exceeding 300mm thickness &amp; Compacted to 90% MDD.</p> <p><b>Within Superlot Boundaries</b> 1. Cohesive or granular fill shall be free of organics (max particle size 150mm) placed in layers not exceeding 300mm.</p> <p>2. Lower backfill zone material (Cohesive, GAP65, GAP40 or GAP20) shall be selected as per the design drawings and the required compactness is as below: (1) Cohesive fill: Shear Vane (Average over 4 readings) <math>&gt; 130</math> and no single reading <math>&lt; 120</math>. OR: (2) GAP 65: CIV (average over 30m length) <math>&gt; 30</math> &amp; no single value <math>&lt; 28</math>. OR: (3) GAP 40: CIV (average over 30m length) <math>&gt; 23</math> &amp; no single value <math>&lt; 21</math>. OR: (4) GAP20: CIV (average over 30m length) <math>&gt; 12</math> &amp; no single value <math>&lt; 10</math>. (5) ROP/SPR: (To be provided by Designer)</p>	Specified	Piritahi Construction Checklist for Stormwater; Piritahi Construction Checklist for Sewer; NDM Test Report and/or Shear Vane/Clegg Test Record																					
2.1.8	Upper Backfill Zone (the Top 1m of the Backfill layer)	I/R	R		The same as above Lower Backfill Zone	<p>NDM/MDD - IANZ Laboratory; Shear Vane/Clegg - Constructor</p>	<p><b>Within Road Reserves</b> Hardfill Backfill placed in layers not exceeding 300mm thickness &amp; Compacted to 95% MDD.</p> <p><b>Within Superlot Boundaries</b> The same requirement as above Lower Backfill Zone "Within Superlot Boundaries"</p>	Specified	Piritahi Construction Checklist for Stormwater; Piritahi Construction Checklist for Sewer; NDM Test Report and/or Shear Vane/Clegg Test Record																					
2.2	Manhole																													
2.2.1	Manhole Excavation	I			After excavation	NA	As per drawing and setting out (location, width level and depth)																							
2.2.2	Manhole Foundation & Undercutting	H	H		<p>Shear Vane for manhole foundation to be tested: - Minimum 2 tests per manhole location</p> <p>Clegg for backfilling of undercut to be tested: - Minimum 2 tests per manhole location</p>	Constructor	<p>1. Remove any unsuitable foundation material in accordance with the below table:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Shear vane strength (in clay/silt)</th> <th>Scala Penetrometer (in sand/gravel)</th> <th>Undercut and backfill</th> </tr> </thead> <tbody> <tr> <td><math>\geq 80</math> kPa</td> <td><math>\leq 50</math>mm per blow</td> <td>No undercut required</td> </tr> <tr> <td>60-80 kPa</td> <td>60mm per blow</td> <td>200mm compacted hardfill</td> </tr> <tr> <td>40-60 kPa</td> <td>80mm per blow</td> <td>350mm compacted hardfill</td> </tr> <tr> <td>20-40 kPa</td> <td>100mm per blow</td> <td>500mm compacted hardfill</td> </tr> <tr> <td><math>&lt; 20</math> kPa or highly organic</td> <td>200mm per blow</td> <td>Contact the design engineer</td> </tr> </tbody> </table> <p>2. Undercutting to have a transition slope of 1:5 between undercut section and the normal foundation.</p> <p>3. Backfill material (GAP65 or GAP40) shall be selected as per the design drawings and the required compaction is as below: (1) GAP 65: CIV (average per manhole) <math>&gt; 30</math> &amp; no single value <math>&lt; 28</math>. OR: (2) GAP 40: CIV (average per manhole) <math>&gt; 23</math> &amp; no single value <math>&lt; 21</math>.</p> <p>Note: If it is not possible to undertake the required Clegg tests, then a visual inspection – Hold Point shall be done by CPS Lead who may engage the geotechnical engineer when required.</p>	Shear vane strength (in clay/silt)	Scala Penetrometer (in sand/gravel)	Undercut and backfill	$\geq 80$ kPa	$\leq 50$ mm per blow	No undercut required	60-80 kPa	60mm per blow	200mm compacted hardfill	40-60 kPa	80mm per blow	350mm compacted hardfill	20-40 kPa	100mm per blow	500mm compacted hardfill	$< 20$ kPa or highly organic	200mm per blow	Contact the design engineer	Specified	Watercare QC Checklist for Manhole; Piritahi Construction Checklist for Sewer; Shear Vane/Clegg Test Record			
Shear vane strength (in clay/silt)	Scala Penetrometer (in sand/gravel)	Undercut and backfill																												
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$< 20$ kPa or highly organic	200mm per blow	Contact the design engineer																												
2.2.3	Manhole Bedding	I/H	R		<p>Within Road Reserve - NDM to be tested: - Minimum 2 tests per manhole location</p> <p>Within Superlot Boundaries - Clegg for bedding to be tested: - Minimum 2 tests per manhole location</p>	<p>NDM/DI - IANZ Laboratory; Clegg - Constructor</p>	<p>Bedding Depth = 75mm</p> <p><b>Within Road Reserves</b> NDM Testing to be done for checking if 60% Density Index (DI) is achieved</p> <p><b>Within Superlot Boundaries</b> Bedding material (GAP7 or GAP20) shall be selected as per the design drawings and the required compactness and the criteria is as below: GAP 7 &amp; GAP 20: GAP20: CIV (average per manhole) <math>&gt; 12</math> &amp; no single value <math>&lt; 10</math>.</p>	Specified	Watercare QC Checklist for Manhole; Piritahi Construction Checklist for Sewer; NDM/DI and/or Clegg Test Record																					
2.2.4	Manhole Installation & As-builts	I/R	I		After installation and before backfilling	Constructor	1. Manhole installation shall be as per the drawings with the top levelling with the surrounding surfacing and benching inside the manhole (which typically is after backfilling of manhole).	Specified	Watercare QC Checklist for Manhole; Piritahi Construction Checklist for Sewer																					

## INSPECTION AND TEST PLAN

2.2.5	Manhole Backfilling	I/R	R		Within Road Reserves - NDM for backfilling to be tested: - Minimum 2 tests per manhole location  Within Superlot Boundaries - Clegg for backfilling to be tested: - Minimum 2 tests per manhole location	Constructor	<b>Within Road Reserves</b> Hardfill Backfill placed in layers not exceeding 300mm thickness & Compacted to 95% MDD. <b>Within Superlot Boundaries</b> 1. Cohesive or granular fill shall be free of organics (max particle size 150mm) placed in layers not exceeding 300mm.  2. Backfill material (Cohesive, GAP65, GAP40, GAP20 or ROP/SPR) shall be selected as per the design drawings and the required compaction is as below: (1) Cohesive fill: Shear Vane (Average over 4 readings) >130 and no single reading < 120. OR: (2) GAP 65: CIV (average per manhole) > 30 & CIV no less than 28. OR: (3) GAP 40: CIV (average per manhole) > 23 & CIV no less than 21. OR: (4) GAP 20: CIV (average per manhole) > 12 & CIV no less than 10. OR: (5) ROP/SPR: (To be provided by Designer)	Specified	Watercare QC Checklist for Manhole; Piritahi Construction Checklist for Sewer; NDM and/or Shear Vane/Clegg Test Record				
2.3	CCTV Inspection	I/R	H		After backfilling and/or before road surfacing as per Piritahi CCTV Process	NA	Conformance criteria refer to Watercare General Civil Construction Standards unless otherwise specified.	Watercare General Civil Construction Standard (Ver. 1.1)	Watercare QC Checklist for Pipe Laying; CCTV Tape and Log				
2.4	Deflection Check, Testing and Disinfection	I/R	H		As required	NA	Conformance criteria refer to Watercare General Civil Construction Standards unless otherwise specified.	Watercare General Civil Construction Standard (Ver. 1.1)	Watercare QC Checklist for Pipe Laying; Pressure Test Report				
2.5	As-built Survey	R	R		As required	NA	Meet Watercare relevant standards	SWCoP	As-built Site Checker & Certificated As-built Drawings				
3	Watercare QC Requirements - Other Special Processes												
3.1	Boring or Thrusting	I	I		As required	NA	Conformance criteria refer to Watercare standards (refer to Watercare QA/QC Template C3.2.9) unless otherwise specified.	Watercare General Civil Construction Standard (Ver. 1)	Watercare QA/QC Template C3.2.9 (AAAA-CN-CHK-1004)				
3.2	Horizontal Directional Drilling (HDD)	I	I		As required	NA	Conformance criteria refer to Watercare standards (refer to Watercare QA/QC Template C3.2.6) unless otherwise specified.	Watercare General Civil Construction Standard (Ver. 1)	Watercare QA/QC Template C3.2.6 (AAAA-CN-CHK-1005)				
3.3	Installation of Pipes with Different Materials	I	I		As required	NA	Conformance criteria refer to Watercare standards (refer to Watercare QA/QC Template C3.4.4, C3.6.5, C3.7.2, C3.7.2) unless otherwise specified.	Project Drawings and Watercare General Civil Construction Standard (Ver. 1)	Appropriate Watercare QA/QC Templates (e.g., AAAA-CN-CHK-1006/1007/1008/1009)				
3.4	Pipeline and Structure Pressure/Field Testing	H	I		As required	Constructor	Conformance criteria refer to relevant project specifications and standards.	Watercare Code of Practice Appendix C: Field Testing of Pipelines	Pressure Test Report				
4	Post Construction												
4.1	Final Inspection (Piritahi Internal)	H	H		At the completion of each EPA	NA	No unacceptable defects	Watercare General Civil Construction Standard (Ver. 1.1)	Photos				
										Constructor	Name:	Signature:	Date:
										CPS	Name:	Signature:	Date:
										QA	Name:	Signature:	Date:

## Appendix F – Foundation maintenance and footing performance: a homeowner’s guide

# Foundation Maintenance and Footing Performance: A Homeowner's Guide



PUBLISHING  
BTF 18-2011  
replaces  
Information  
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

## Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870-2011, the Residential Slab and Footing Code.

## Causes of Movement

### Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

### Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

### Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume, particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

### Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

### Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.

In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

### Tree root growth

Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

### Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Shrinkage gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

### Effects of Uneven Soil Movement on Structures

#### Erosion and saturation

Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpendos).

Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

#### Seasonal swelling/shrinkage in clay

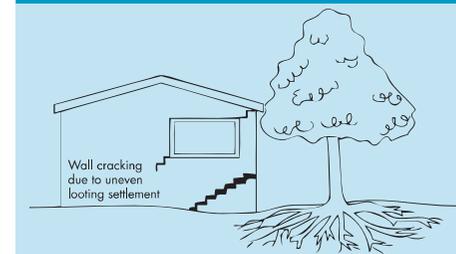
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the

### Trees can cause shrinkage and damage



external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

### Movement caused by tree roots

In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

### Complications caused by the structure itself

Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

### Effects on full masonry structures

Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

## GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites, which may experience only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes

### Notes

1. Where controlled fill has been used, the site may be classified A to E according to the type of fill used.
2. Filled sites. Class P is used for sites which include soft fills, such as clay or silt or loose sands; landslide; mine subsidence; collapsing soils; soil subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise.
3. Where deep-seated moisture changes exist on sites at depths of 3 m or greater, further classification is needed for Classes M to E (M-D, H1-D, H2-D and E-D).

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

#### Effects on framed structures

Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation causes a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

#### Effects on brick veneer structures

Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

#### Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem. Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.

- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

#### Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870-2011.

AS 2870-2011 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

#### Prevention/Cure

##### Plumbing

Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

##### Ground drainage

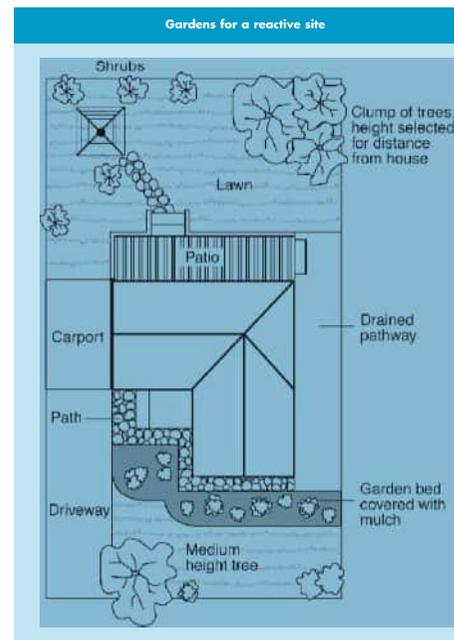
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish water table height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

##### Protection of the building perimeter

It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving should



extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

##### Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

**Warning:** Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

#### The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

#### Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

#### Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

#### Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

#### Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

**This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.**

### CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly.	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired.	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted.	15–25 mm but also depends on number of cracks	4

The information in this and other issues in the series was derived from various sources and was believed to be correct when published.

The information is advisory. It is provided in good faith and not claimed to be an exhaustive treatment of the relevant subject.

Further professional advice needs to be obtained before taking any action based on the information provided.

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