Piritahi

LAYING THE GROUNDWORK

AORERE
STAGE 2 – TOC45

Superlot AO-015

Geotechnical Completion Report

Document Control

AORERE STAGE 2 – SUPERLOT AO-019– GEOTECHNICAL COMPLETION REPORT					
DATE	VERSION	DESCRIPTION	PREPARED BY	REVIEWED BY	AUTHORISED BY
March 2023	1.0	Geotechnical Completion Report	Scott Zhang	Andy Huang	Elby Tang

Distribution

Kāinga Ora - Homes and Communities	1 PDF copy
Piritahi	1 PDF copy

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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-015 comprised:

- Removal of the existing buildings;
- Surficial soil strip to remove contaminated soil hot spots;
- Removal of existing stormwater and wastewater lot connections;
- Installation of a new wastewater manhole at the western boundary of the superlot; and
- Installation of a new stormwater connection at the northern 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-015", dated April 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-015

DATE	INSPECTION BY	DESCRIPTION
27 June 2022	Piritahi Geotechnical Engineers	Manhole subgrade inspection
25 January 2023	Piritahi Geotechnical Engineers	Site walkover and subgrade testing

4.0 Earthworks

4.1 Earthworks subgrade

The existing houses within Superlot AO-015 have been removed. An approximately 300 mm thick surficial soil topsoil strip was carried out across the site extent to remove potential soil contamination. The exposed subgrade following the surface strip comprised natural soils.

Natural Soils

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

Shear vane testing on the existing subgrade measured undrained shear strengths ranging between 73 kPa and >232 kPa, with an average shear strength of 146 kPa. The Scala penetrometer testing recorded blow counts ranging from 0.5 to 4 blows per 50 mm penetration across the superlot, averaging approximately 2 blows per 50 mm. Within this tested area, the shear strength and Scala values exceeded the subgrade cut requirements of the Earthworks ITP.

The test location plans and results for the subgrade testing carried out by Piritahi Geotechnical Engineers are provided in Appendix A – Site Observation Reports. The testing requirements can be found in Appendix E – Piritahi ITPs.

4.2 Temporary granular hardstand

There is an existing granular hardfill hardstand that was placed above the subgrade at the entrances to the north boundary 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 the purposes of temporary construction access for heavy machinery and plant. We were unable to inspect the underlying soils prior to the placement of the hardfill. 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 the underlying soils are consistent with the design of the proposed works.

4.3 Earth bund

An earth bund was previously constructed near the eastern boundary of the superlot. This bund has now been excavated to subgrade level and removed from the superlot. Corrected peak undrained shear strength of the subgrade along the removed bund measured between 96 and 232 kPa. Scala penetrometer blow counts generally ranged from 0.5 to 3.5 blows per 500mm penetration on the subgrade.

The test location plans and results for the subgrade testing carried out by Piritahi Geotechnical Engineers are provided in Appendix A – Site Observation Reports. The testing requirements can be found in Appendix E – Piritahi ITPs.

5.0 Infrastructure

5.1 Infrastructure removal

Infrastructure works within Superlot AO-015 comprised the removal of the following utilities:

- Removal of 7 stormwater lot connections. The existing stormwater lot connections were generally within the upper 200mm of subgrade and were removed as part of the surficial topsoil strip.
- Removal of 7 wastewater lot connections. The wastewater lot connections were removed and backfilled with cohesive material (silt and clay) to a depth of approximately 0.5m below the existing ground level.

Shear vane testing was undertaken by the Piritahi site team within the redundant wastewater lot connection trenches, measuring undrained shear strength between 173 and 186 kPa, averaging 181 kPa. Nuclear densometer testing undertaken by Geotechnics recorded air voids values of between 0.9% and 5.0%, averaging 2.9%. The shear vane values and nuclear densometer 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. Testing carried out by Geotechnics technicians can be found in Appendix D – Geotechnics Testing. 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-015 comprised the installation of the following utilities:

- Installation of a new stormwater connection near the north boundary of the superlot connecting to SWMH 2-13 on Winthrop Way. Backfill of the stormwater trench was undertaken using GAP65 hardfill. Clegg hammer tests on the GAP65 hardfill recorded Clegg Impact Values between 30 and 34. The test results achieved the compaction requirement of the Piritahi Stormwater ITP. The new stormwater manhole installed is shown in Appendix B – As Built Plans. The backfill records are provided in Appendix C – Piritahi Test Results.
- Installation of a new wastewater manhole (WWMH C-2) near the western superlot boundary connecting to the new wastewater line in Superlot AO-016. Testing of the subgrade at the manhole foundation level was undertaken by the Piritahi Geotechnical Engineer, recording undrained shear strengths ranging 20 to 40 kPa. A 0.5m deep subgrade undercut was undertaken. Backfill of the manhole subgrade undercut was undertaken using GAP65 hardfill. Clegg hammer tests on the GAP65 hardfill recorded Clegg Impact Values between 30 and 42. The manhole pit and trench was backfilled with cohesive material (silt and clay). Shear vane testing was undertaken by the Piritahi site team within the redundant wastewater connection trenches, measuring undrained shear strength between 138 and 169 kPa, averaging 154 kPa. The test results achieved the compaction requirements of the Piritahi Stormwater ITP. The new stormwater manhole installed 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 April 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;
   d. Installation of a new wastewater manhole; and
   e. Installation of a new stormwater 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 March 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-015, the undrained shear strength of the natural soils meet the definition of "good ground" as outlined in NZS 3604-2011. However, the natural soils at the site do not meet "good ground" criteria for soil expansivity and liquefaction susceptibility, and foundations on such soils will require consideration of the potential effects of shrink-swell and liquefaction on the development.
   c. The temporary granular hardstand remains at the northern entrance to the site. This hardstand is not engineered for permanent use as building platforms or pavement subgrades. It should be remediated or removed prior to the construction of future developments.
   d. A previously constructed earth bund was removed near the eastern boundary of the superlot. Testing of the subgrade of the earth bund achieved undrained shear strength results greater than 60 kPa and Scala penetrometer results greater than 0.5 blows per 50mm. The subgrade of the removed earth bund compiles with the compaction requirements of the Piritahi Earthwork Cut ITP.
   e. No backfill was undertaken following the removal of the stormwater lot connections that were generally 200 mm deep.
   f. The removed wastewater lot connections were backfilled with compacted cohesive material. Testing of this cohesive material achieved undrained shear strength results greater than 130 kPa,

and air voids smaller than 8%. The cohesive backfill material complies with the compaction requirements of the Piritahi Earthworks Fill ITP.

g. A new stormwater connection, installed at the northern boundary of the site was backfilled with GAP65 hardfill. This backfill achieved Clegg impact values of greater than 30 and complies with the Piritahi Stormwater ITP.

h. A new wastewater manhole, installed at the western boundary of the site was backfilled with GAP65 hardfill material at undercut and cohesive material to the subgrade level. The GAP65 backfill material achieved Clegg impact values of greater than 30 and cohesive material achieved undrained shear strength greater than 130 kPa. Backfill materials comply with the Piritahi Wastewater ITP.

i. The design of future works should take into account the new wastewater manhole and the existing wastewater line running across the centre of the superlot, as shown on the as built plan (Appendix B). This may require avoidance, bridging or piling around the manhole and pipe.

j. 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.

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: 24 March 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

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SITE VISIT RECORD SHEET

Project Name: Aorere Stage 2	Project No.: TOC45
Ref #:	Date/Time: 27/06/2022
Site Location: AO-016/AO-015	Inspection by: NIBU and SCZH
Weather: Fine	Inspection with: Amrit
Site Condition: Good	Purpose of Visit: WWMHC-2 Subgrade testing
Site Induction Completed? ☒ Yes ☐No	JSEA completed? ☒ Yes ☐No

Health and safety observation notes:

BUN60393664

Working around moving plant

- Working at heights
- S/T/F

Machinery onsite:

- 1x 20t excavator

Dust/erosion & sediment control:

- NA

Current active works:

- Excavation and installation of new wastewater line through AO-015 and AO-016

Observations:

At the time of our visit the construction team had excavated an area within AO-015 to allow for the installation of a new manhole (WWMH C-2). The construction team had excavated and uncovered the existing wastewater line running through the centre of the excavation. The invert of the line was approximately 2.9 m from the ground surface with the subgrade of the manhole tested at 3.1 m from the ground level. Groundwater was present at the base of the excavation to between 0.3 m to 0.4 m depth. The groundwater was flowing from within the Auckland Volcanic Field (AVF) material at around 1.2 m from the surrounding ground surface.

As there was no sump-pump on site the construction team used the excavator to decant the water from the base of the excavation. This allowed us to view the subgrade material at the base and within the side walls of the excavation. Based on our conversations on site, the construction team were planning on installing a sump within the backfill area to allow them to pump the groundwater and minimise its impact on the compaction.

Like the previous excavation for C-1, alluvial clay was exposed at the base. Shear vane testing was carried out within the material exposed at the subgrade level for the manhole. Results of the shear vane testing ranged from 20 kPa to 40 kPa on the subgrade material. The shear vane testing was completed beneath the groundwater-softened sloppy material that is seen in the photos.

Based on the shear vane results, the Piritahi Wastewater ITP requirements state that a 0.5 m undercut should be carried out to allow for the placement and compaction of GAP65 beneath the manhole. We understand that the construction team also plans to place geofabric and geogrid across the base of the undercut prior to placing the GAP65. Testing of the backfill should be carried out by the construction in accordance with the ITP requirement.

Agreements/recommendations onsite:

- Recommended undercutting 500 mm based on the shear vane results and ITP requirements
- Agreed compaction testing would be carried out by the construction team following compaction

SITE VISIT RECORD SHEET

Follow-ups and further actions required:

- Follow up on compaction testing QA for the manhole and the wastewater line once constructed.

Sketches/Additional comments:

Photograph 1: Existing wastewater pipe visible running through centre of excavation. Blue grey alluvium at the base.

Photograph 2: Transition from AVF to Alluvium visible with groundwater seeping from the side walls.

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SITE VISIT RECORD SHEET

Project Name: Aorere Stage 2	Project ID: 1007708.2086
Ref #: DIM086	Date/Time: 25/01/2023
Site Location: Superlot AO-015 (Winthrop Way, Mangere East)	Inspection by: Scott Zhang
Weather: Fine	Inspection with: N/A
Site Condition: Dry	Purpose of Visit: Site walkover and subgrade testing
Site Induction Completed? ☒ Yes ☐No	JSEA completed? ☒ Yes ☐No

Health and safety observation notes:

Heavy machinery operating in the area

Be aware of slips/trips/falls hazards

Machinery onsite:

2x7T excavators.

1x20T excavator

Dust/erosion & sediment control:

N/A

Current active works:

Installation of a wastewater line within adjacent Superlot AO-016; and

Construction of sidewalk (subgrade exposed) along Winthrop Way.

Observations:

A representative of the Piritahi geotechnical team undertook a site walkover and subgrade testing for the Superlot AO-015 within TOC45. Cohesive fill (clayey SILT/silty CLAY) were observed at the subgrade cut level (beneath the grass/vegetation) across the superlot.

Shear vane and Scala penetrometer testing were conducted across the subgrade.

Shear vane testing was undertaken in fine grained soils at 23 locations along with Scala penetrometer tests to 900 mm depth. Test locations are shown in the attached site testing plan. The proposed shear vane and Scala penetrometer tests were not taken at SC08 and SC15 as the area is covered by stockpile of cohesive fill.

Corrected peak undrained shear strengths of between 73 and 232+ kPa were recorded, for an average of 146 kPa. This indicates the surficial soils at subgrade level is typically stiff to hard. Scala penetrometer blow counts generally ranged from 0.5 to 4 blows per 50 mm penetration on the subgrade.

An earth bund was previously constructed near the eastern boundary of the superlot (as shown in the site plan attached), which has now been removed (cut down to the subgrade level). Corrected peak undrained shear strengths of the ground

SITE VISIT RECORD SHEET

surface within the bund was measured between 96 and 232 kPa. Scala penetrometer blow counts generally ranged from 0.5 to 3.5 blows per 50 mm penetration 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.

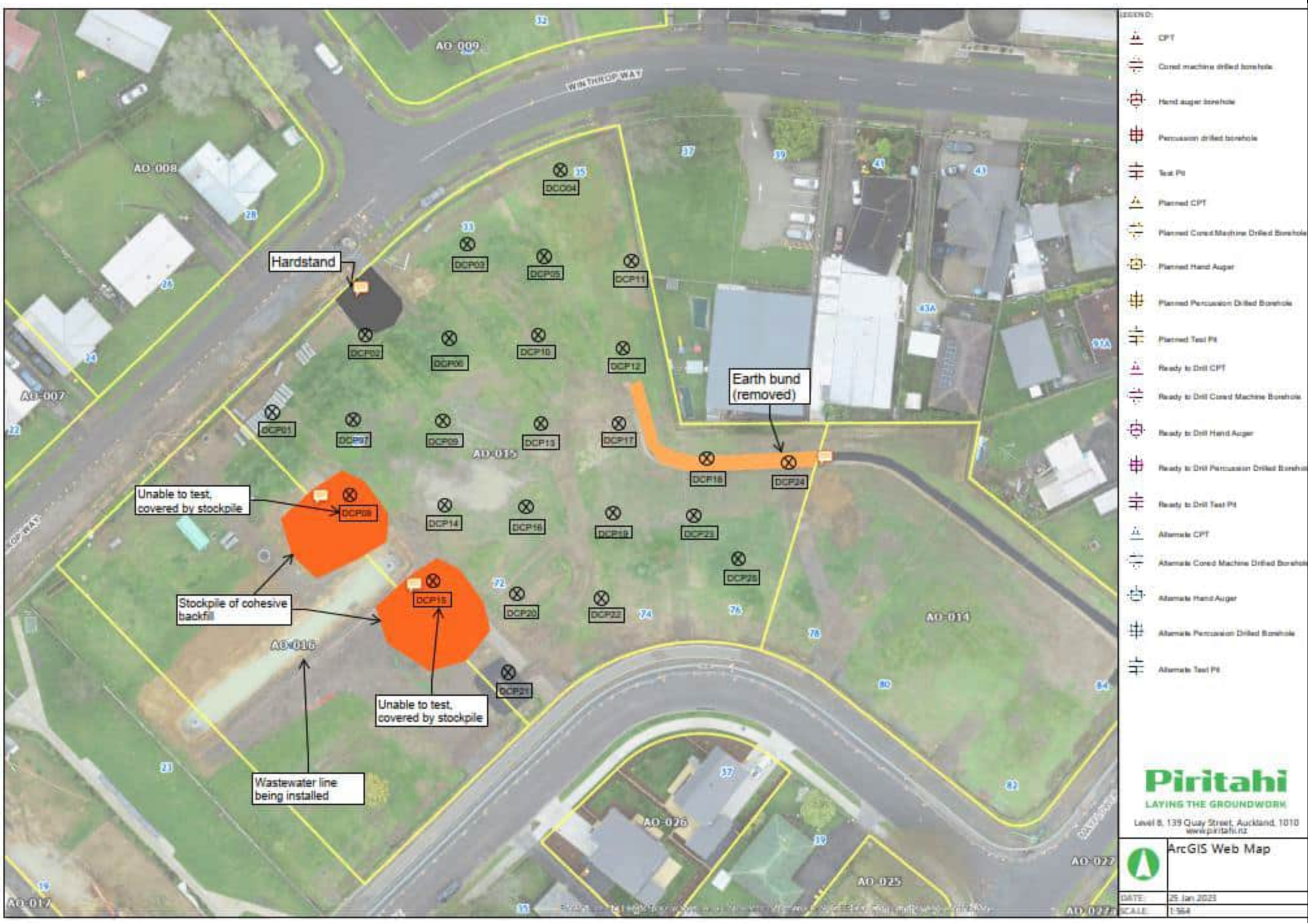
Agreements/recommendations onsite:

Nil.

Follow-ups and further actions required:

Piritahi geotechnical team to prepare Geotechnical Completion Report for Superlot AO-015.

Testing results and Site plan attached. Photos below.



Subgrade Testing Plan

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SITE VISIT RECORD SHEET

Photograph 1: Superlot overview – looking west

Photograph 2: Superlot overview – looking south

SITE VISIT RECORD SHEET

Photograph 3: Superlot overview – looking north

Photograph 4: Installation of the wastewater line

SITE VISIT RECORD SHEET

Photograph 5: Earth bund near the eastern boundary of the superlot

Photograph 5: Hardstand near the northern boundary (entrance) of the superlot

SITE VISIT RECORD SHEET

Photograph 6: Construction of sideway subgrade along Winthrop Way

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Shear Vane Results

Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-15*
RL: *17.5*

Date: *25/01/2023*
Operated by: *SCZH*
Logged by: *SCZH*
Checked by:

Test No.
Sheet ***1***
of ***24***

Test	Corrected Undrained Shear Strength
1	113
2	183
3	232
4	113
5	102
6	73
7	153
9	UTP
10	143
11	100
12	102
13	113
14	92
16	186
17	83

Test	Corrected Undrained Shear Strength
18	232
19	112
20	153
21	UTP
22	UTP
23	196
24	96
25	96

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SCALA PENETROMETER LOG

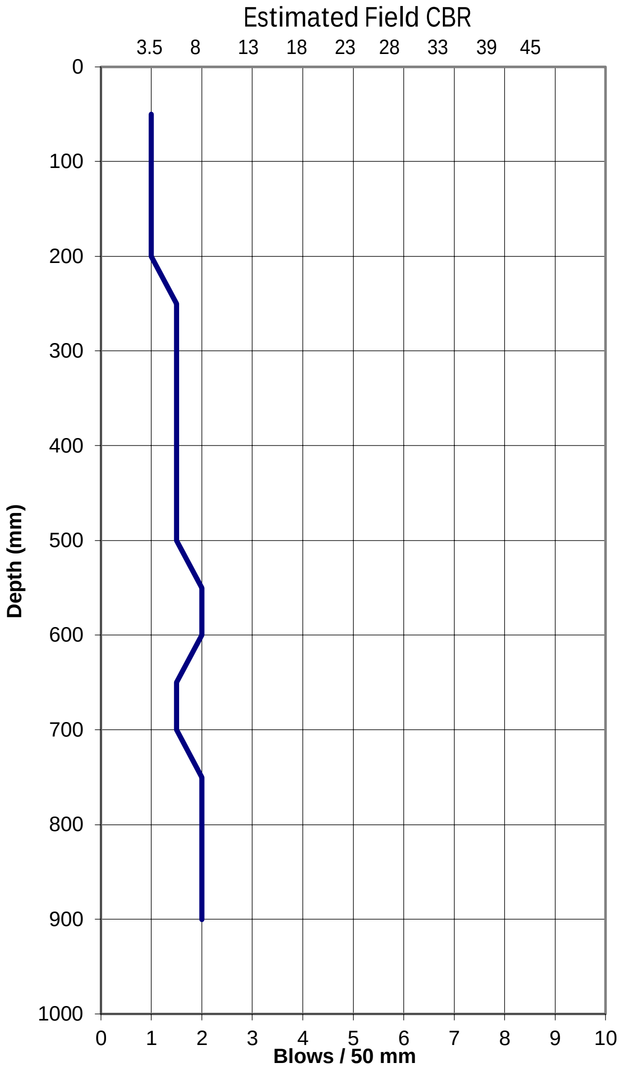
Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-15*
RL: *17.5*

Date: *25/01/2023*
Operated by: *SCZH*
Logged by: *SCZH*
Checked by:

Test No. ***DCP01***

Sheet ***2***
of ***24***

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



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

Piritahi

SCALA PENETROMETER LOG

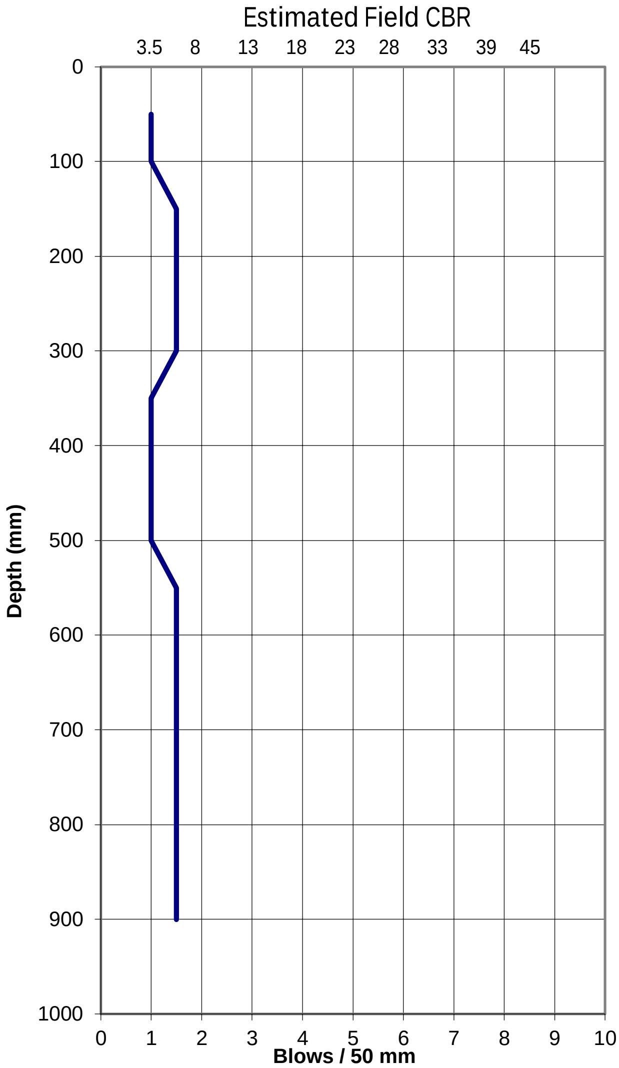
Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-15*
RL: *17.5*

Date: *25/01/2023*
Operated by: *SCZH*
Logged by: *SCZH*
Checked by:

Test No. ***DCP02***

Sheet ***3***
of ***24***

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



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

SCALA PENETROMETER LOG

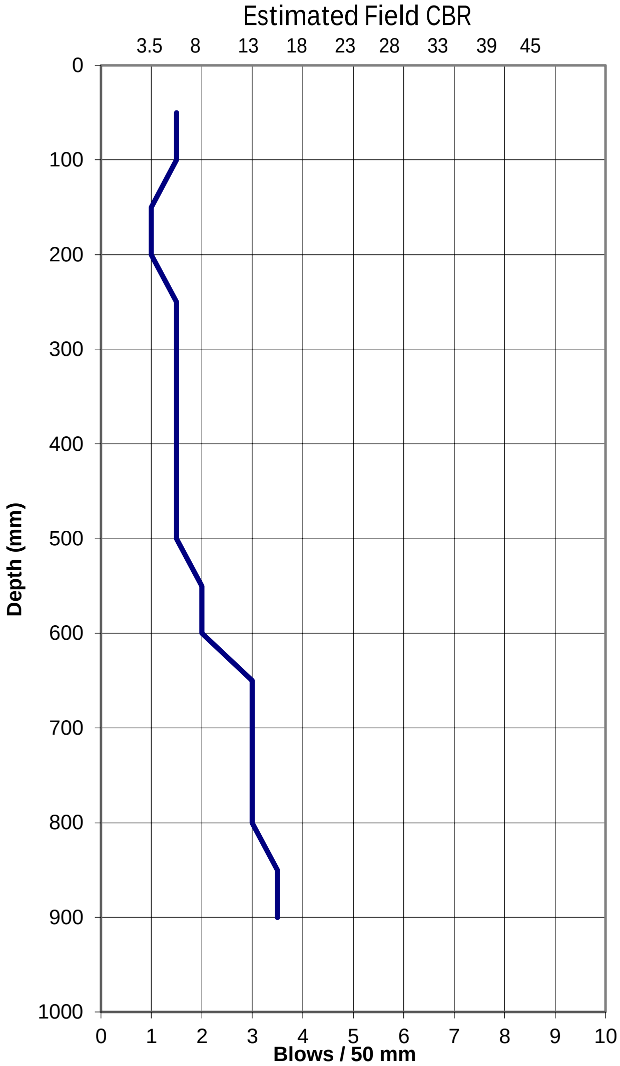
Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-15*
RL: *17.5*

Date: *25/01/2023*
Operated by: *SCZH*
Logged by: *SCZH*
Checked by:

Test No. ***DCP03***

Sheet ***4*** **of** ***24***

mm Driven	No. of Blows
50	*1.5*
100	*1.5*
150	*1*
200	*1*
250	*1.5*
300	*1.5*
350	*1.5*
400	*1.5*
450	*1.5*
500	*1.5*
550	*2*
600	*2*
650	*3*
700	*3*
750	*3*
800	*3*
850	*3.5*
900	*3.5*



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

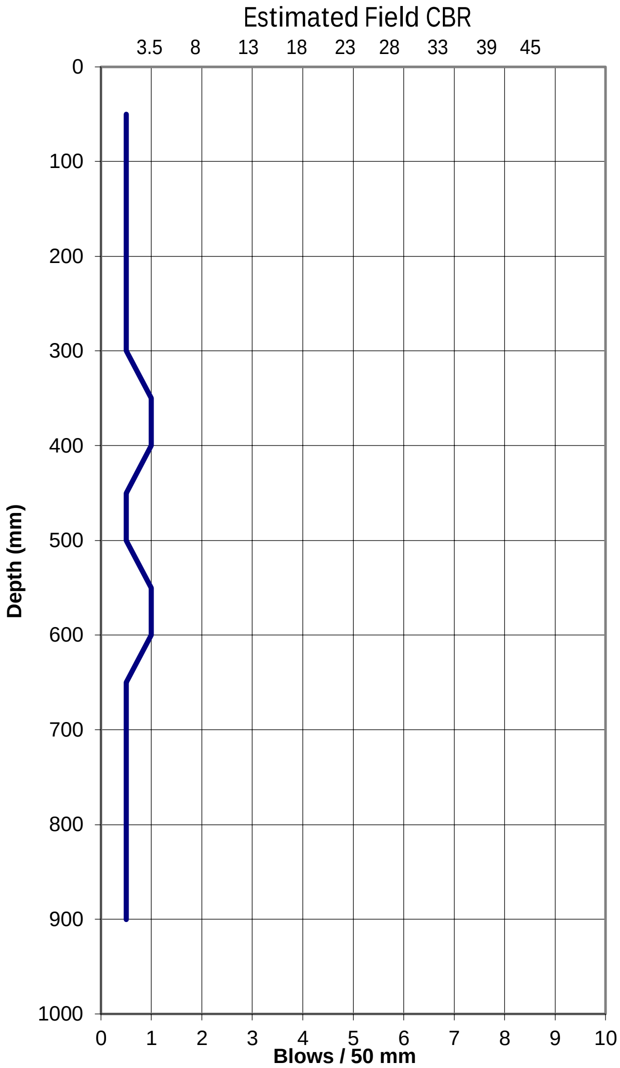
SCALA PENETROMETER LOG

Job No:	*1007708.2086*	Date:	*25/01/2023*
Project:	*Piritahi Aorere*	Operated by:	*SCZH*
Location:	*AO-15*	Logged by:	*SCZH*
RL:	*17.5*	Checked by:	

Test No. ***DCP04***

Sheet ***5***
of ***24***

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



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

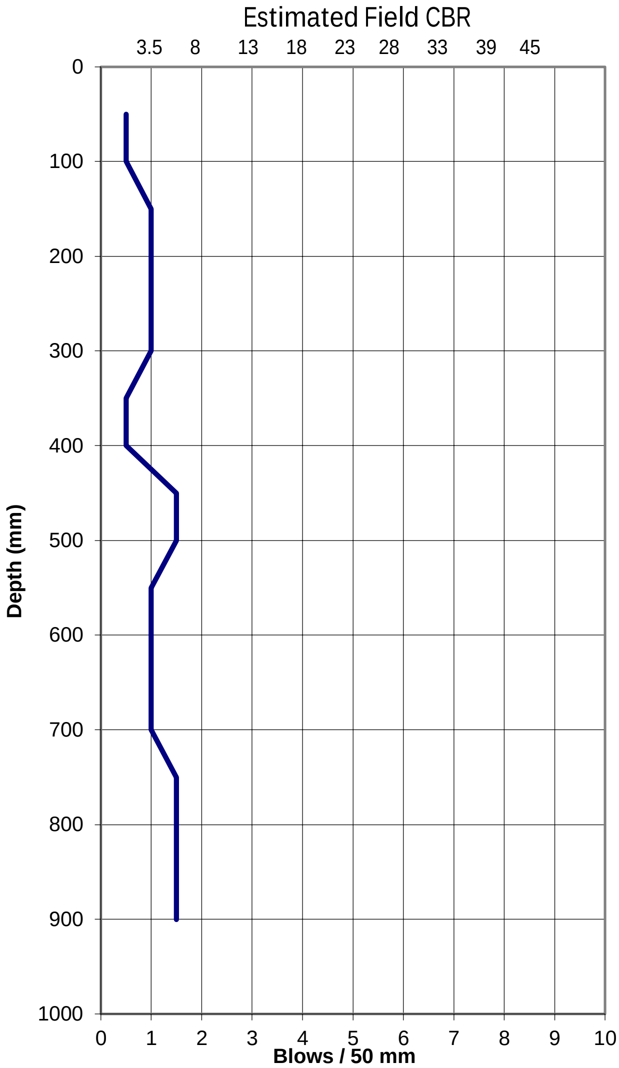
Test Method Used: NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer

Piritahi

SCALA PENETROMETER LOG

Job No: *1007708.2086*	Date: *25/01/2023*	**Test No.** ***DCP05***
Project: *Piritahi Aorere*	Operated by: *SCZH*	
Location: *AO-15*	Logged by: *SCZH*	**Sheet** ***6***
RL: *17.5*	Checked by:	**of** ***24***

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



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

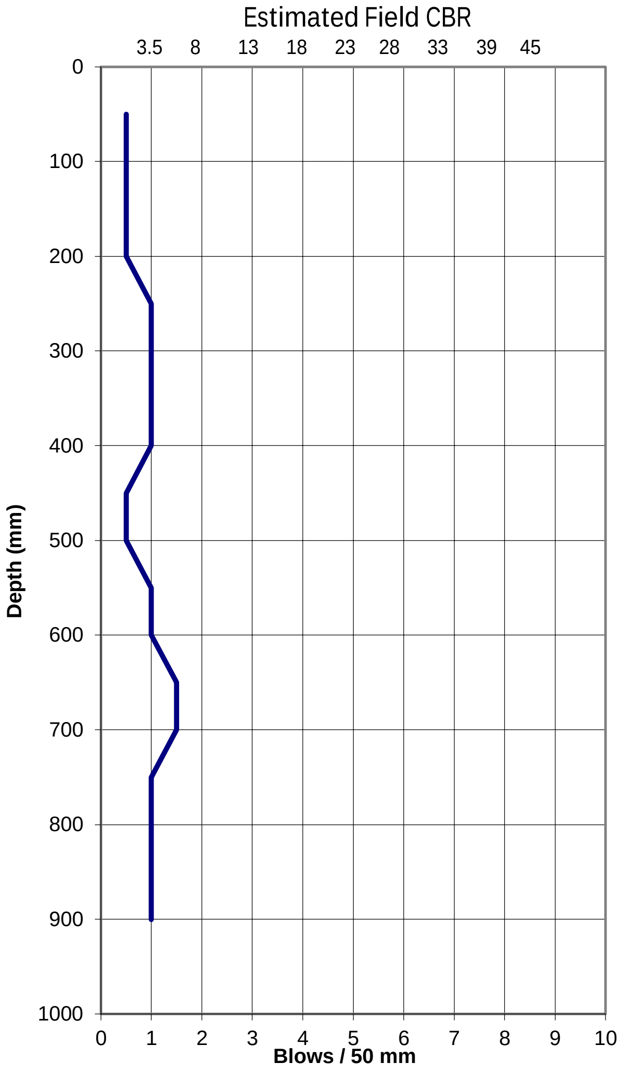
SCALA PENETROMETER LOG

Job No:	*1007708.2086*	Date:	*25/01/2023*
Project:	*Piritahi Aorere*	Operated by:	*SCZH*
Location:	*AO-15*	Logged by:	*SCZH*
RL:	*17.5*	Checked by:	

Test No. ***DCP06***

Sheet ***7*** **of** ***24***

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



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

SCALA PENETROMETER LOG

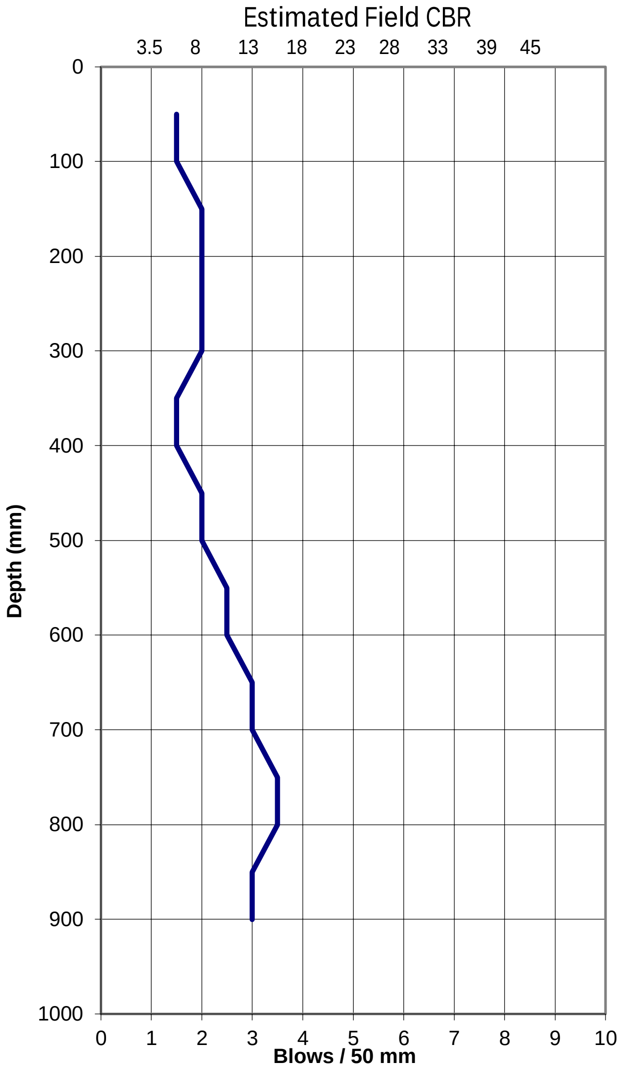
Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-15*
RL: *17.5*

Date: *25/01/2023*
Operated by: *SCZH*
Logged by: *SCZH*
Checked by:

Test No. ***DCP07***

Sheet ***8***
of ***24***

mm Driven	No. of Blows
50	*1.5*
100	*1.5*
150	*2*
200	*2*
250	*2*
300	*2*
350	*1.5*
400	*1.5*
450	*2*
500	*2*
550	*2.5*
600	*2.5*
650	*3*
700	*3*
750	*3.5*
800	*3.5*
850	*3*
900	*3*



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

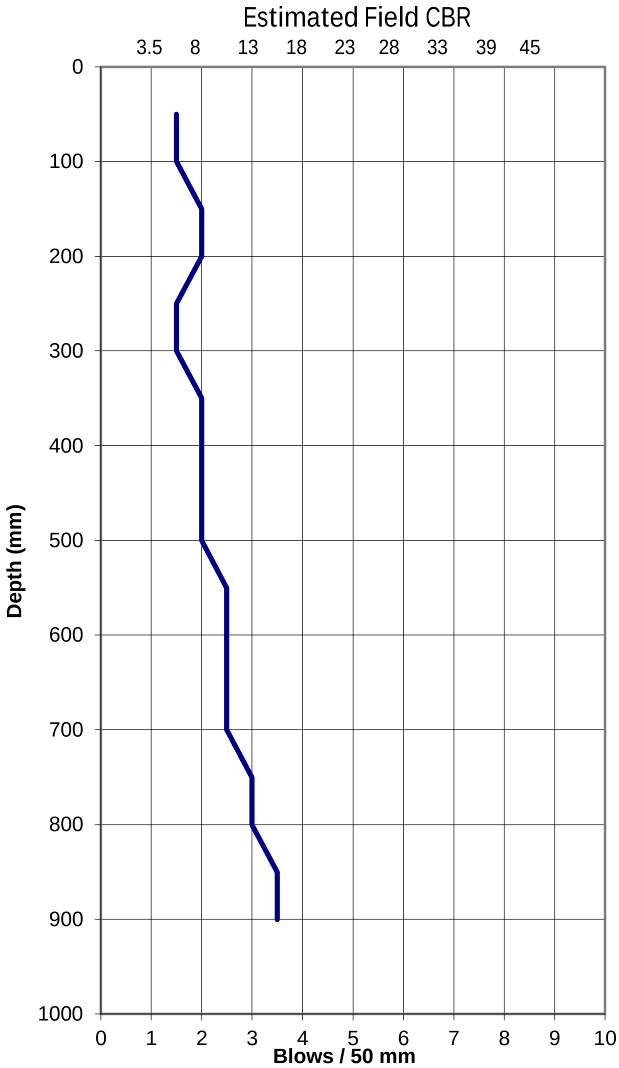
SCALA PENETROMETER LOG

Job No:	*1007708.2086*	Date:	*25/01/2023*
Project:	*Piritahi Aorere*	Operated by:	*SCZH*
Location:	*AO-15*	Logged by:	*SCZH*
RL:	*17.5*	Checked by:	

Test No. ***DCP09***

Sheet ***9*** **of** ***24***

mm Driven	No. of Blows
50	*1.5*
100	*1.5*
150	*2*
200	*2*
250	*1.5*
300	*1.5*
350	*2*
400	*2*
450	*2*
500	*2*
550	*2.5*
600	*2.5*
650	*2.5*
700	*2.5*
750	*3*
800	*3*
850	*3.5*
900	*3.5*



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

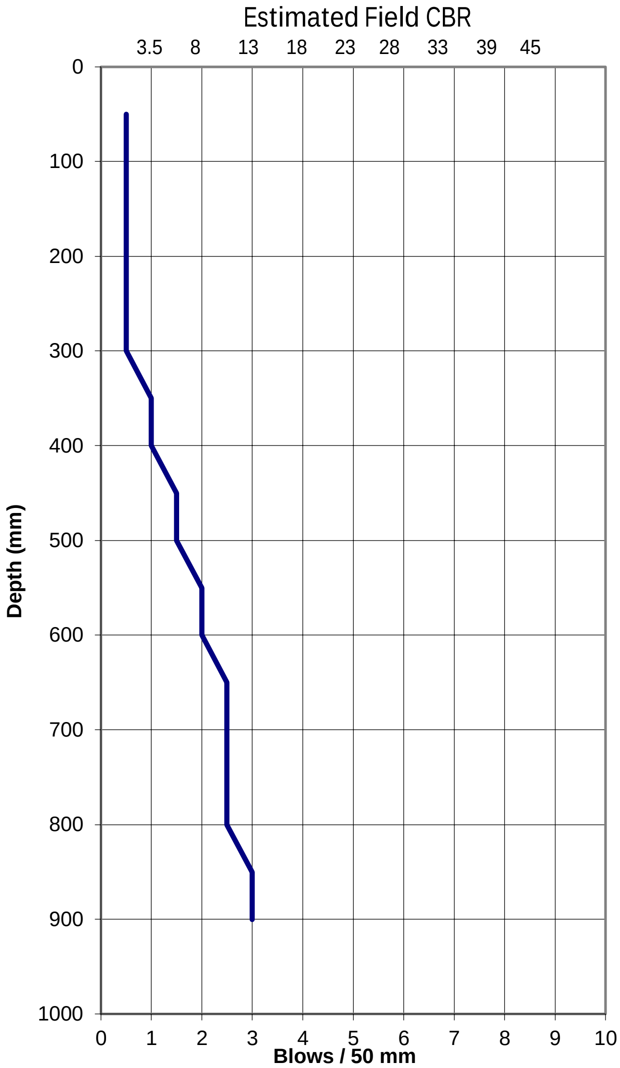
SCALA PENETROMETER LOG

Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-15*
RL: *17.5*

Date: *25/01/2023*
Operated by: *SCZH*
Logged by: *SCZH*
Checked by:

Test No. ***DCP10***
Sheet ***10***
of ***24***

mm Driven	No. of Blows
50	*0.5*
100	*0.5*
150	*0.5*
200	*0.5*
250	*0.5*
300	*0.5*
350	*1*
400	*1*
450	*1.5*
500	*1.5*
550	*2*
600	*2*
650	*2.5*
700	*2.5*
750	*2.5*
800	*2.5*
850	*3*
900	*3*



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

Piritahi

SCALA PENETROMETER LOG

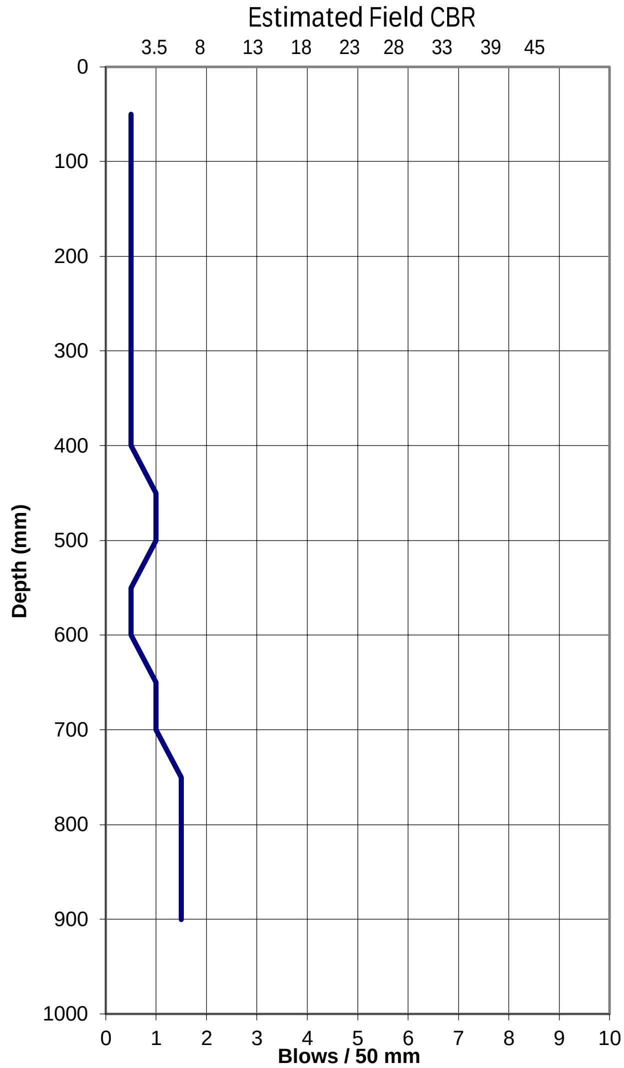
Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-15*
RL: *17.5*

Date: *25/01/2023*
Operated by: *SCZH*
Logged by: *SCZH*
Checked by:

Test No. ***DCP11***

Sheet ***11***
of ***24***

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



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

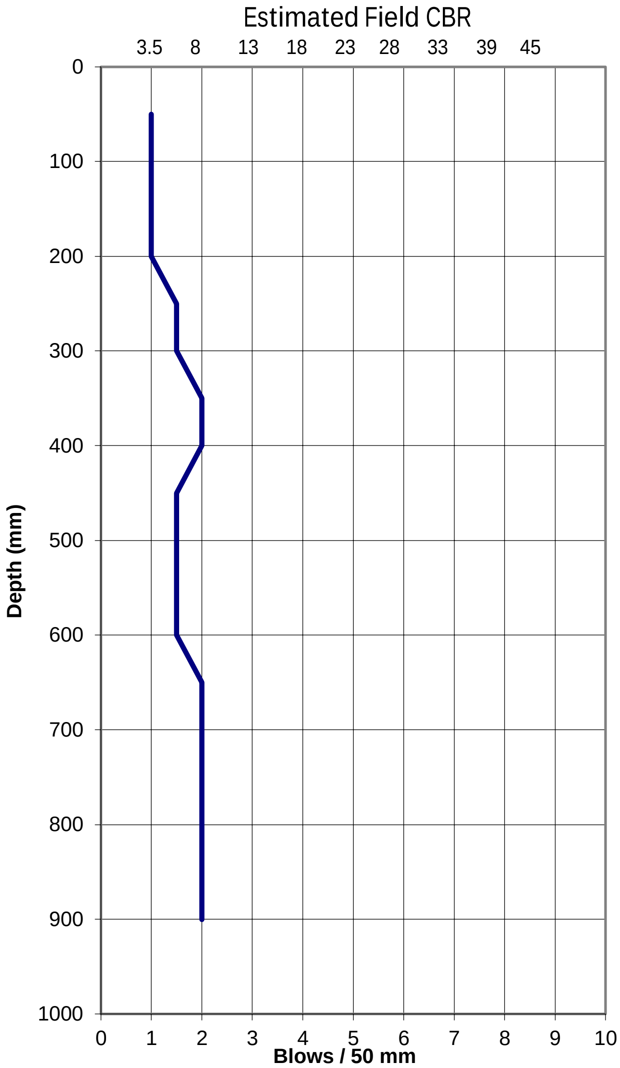
SCALA PENETROMETER LOG

Job No:	*1007708.2086*	Date:	*25/01/2023*
Project:	*Piritahi Aorere*	Operated by:	*SCZH*
Location:	*AO-15*	Logged by:	*SCZH*
RL:	*17.5*	Checked by:	

Test No. ***DCP12***

Sheet ***12***
of ***24***

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



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

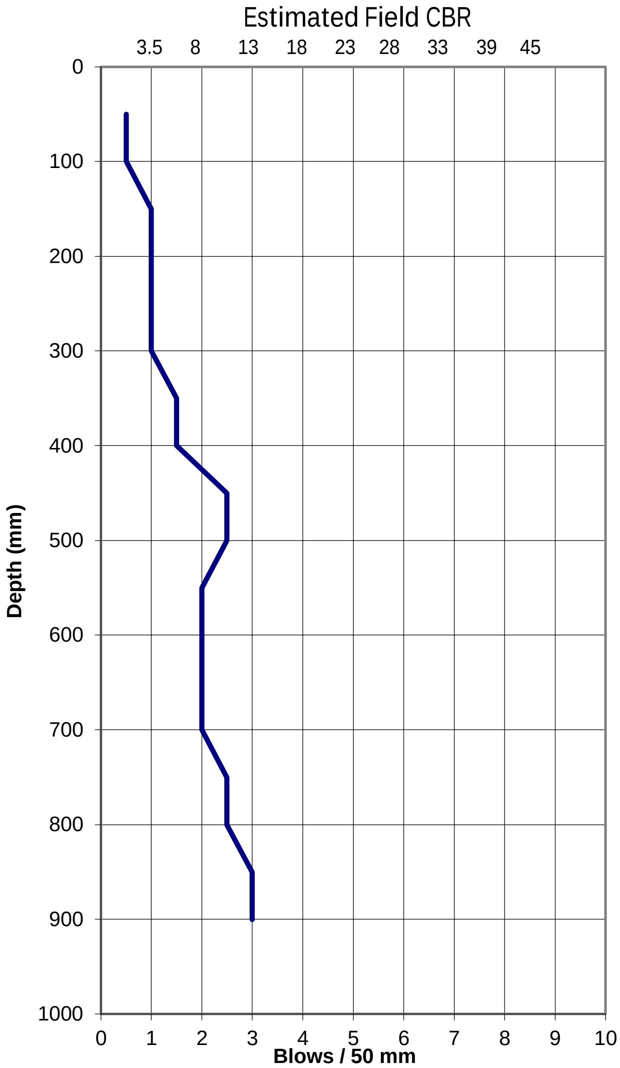
SCALA PENETROMETER LOG

Job No:	*1007708.2086*	Date:	*25/01/2023*
Project:	*Piritahi Aorere*	Operated by:	*SCZH*
Location:	*AO-15*	Logged by:	*SCZH*
RL:	*17.5*	Checked by:	

Test No. ***DCP13***

Sheet ***13*** **of** ***24***

mm Driven	No. of Blows
50	*0.5*
100	*0.5*
150	*1*
200	*1*
250	*1*
300	*1*
350	*1.5*
400	*1.5*
450	*2.5*
500	*2.5*
550	*2*
600	*2*
650	*2*
700	*2*
750	*2.5*
800	*2.5*
850	*3*
900	*3*



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

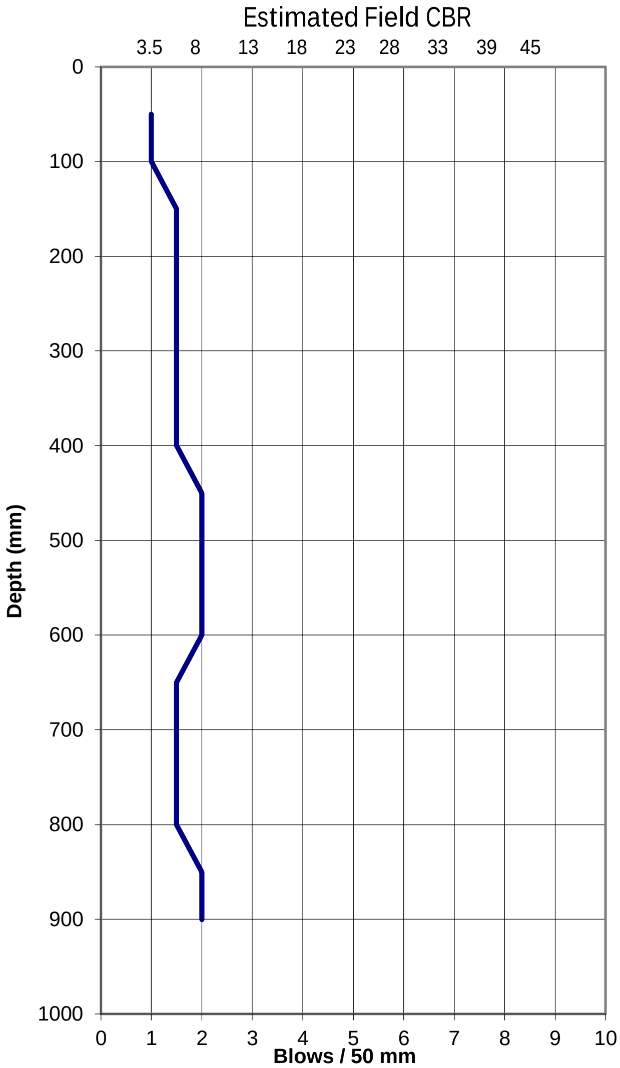
SCALA PENETROMETER LOG

Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-15*
RL: *17.5*

Date: *25/01/2023*
Operated by: *SCZH*
Logged by: *SCZH*
Checked by:

Test No. ***DCP14***
Sheet ***14***
of ***24***

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



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

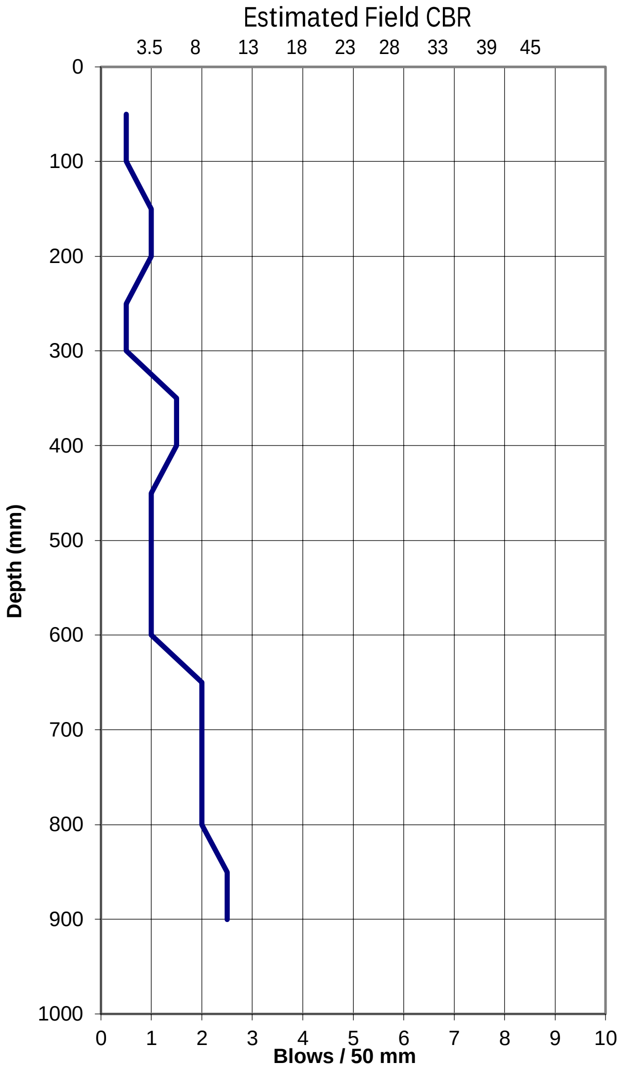
SCALA PENETROMETER LOG

Job No:	*1007708.2086*	Date:	*25/01/2023*
Project:	*Piritahi Aorere*	Operated by:	*SCZH*
Location:	*AO-15*	Logged by:	*SCZH*
RL:	*17.5*	Checked by:	

Test No. ***DCP16***

Sheet ***15*** **of** ***24***

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



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

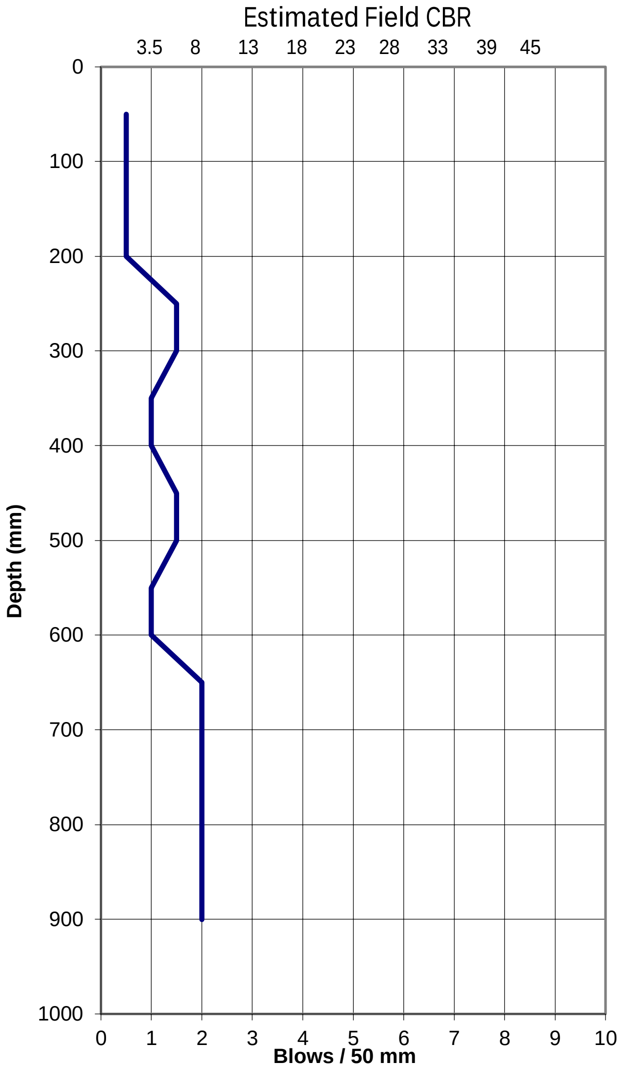
SCALA PENETROMETER LOG

Job No:	*1007708.2086*	Date:	*25/01/2023*
Project:	*Piritahi Aorere*	Operated by:	*SCZH*
Location:	*AO-15*	Logged by:	*SCZH*
RL:	*17.5*	Checked by:	

Test No. ***DCP17***

Sheet ***16*** **of** ***24***

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



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

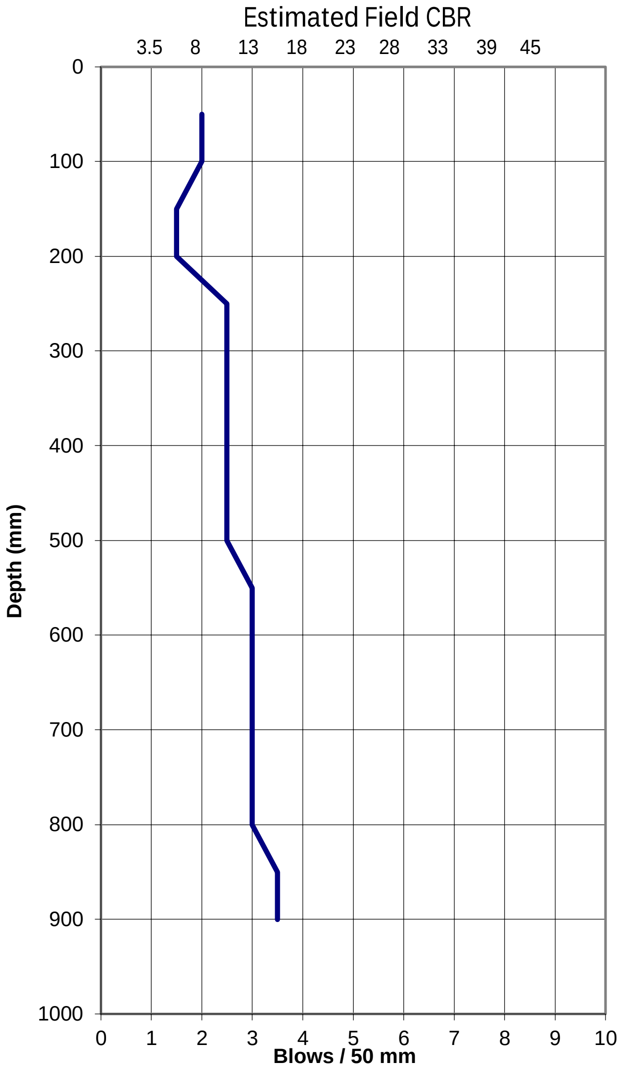
SCALA PENETROMETER LOG

Job No:	*1007708.2086*	Date:	*25/01/2023*
Project:	*Piritahi Aorere*	Operated by:	*SCZH*
Location:	*AO-15*	Logged by:	*SCZH*
RL:	*17.5*	Checked by:	

Test No. ***DCP18***

Sheet ***17***
of ***24***

mm Driven	No. of Blows
50	*2*
100	*2*
150	*1.5*
200	*1.5*
250	*2.5*
300	*2.5*
350	*2.5*
400	*2.5*
450	*2.5*
500	*2.5*
550	*3*
600	*3*
650	*3*
700	*3*
750	*3*
800	*3*
850	*3.5*
900	*3.5*



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

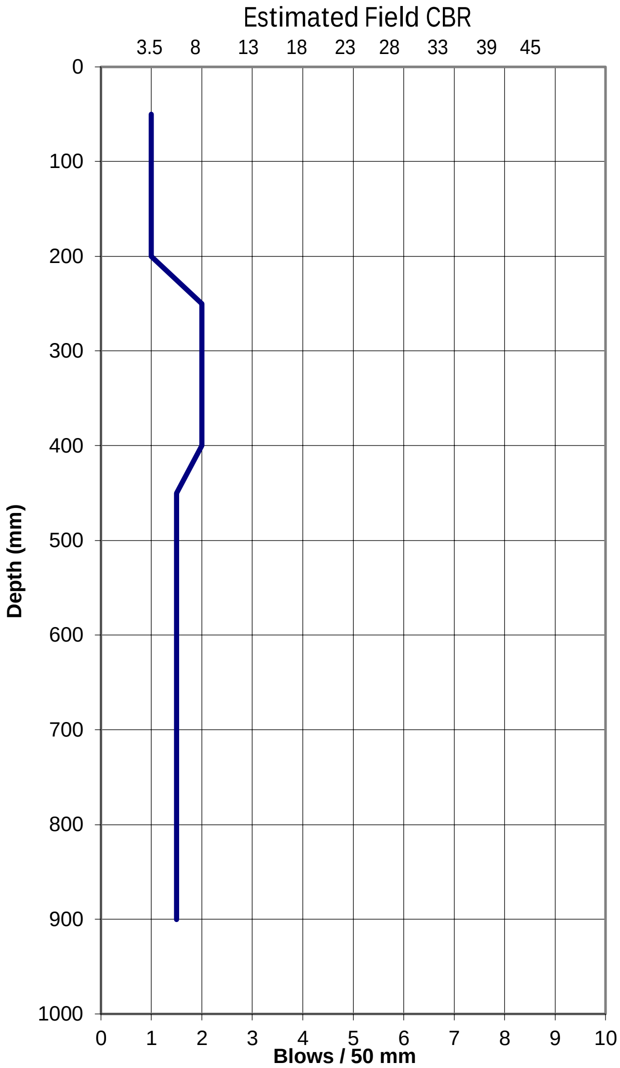
SCALA PENETROMETER LOG

Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-15*
RL: *17.5*

Date: *25/01/2023*
Operated by: *SCZH*
Logged by: *SCZH*
Checked by:

Test No. ***DCP19***
Sheet ***18***
of ***24***

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



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

SCALA PENETROMETER LOG

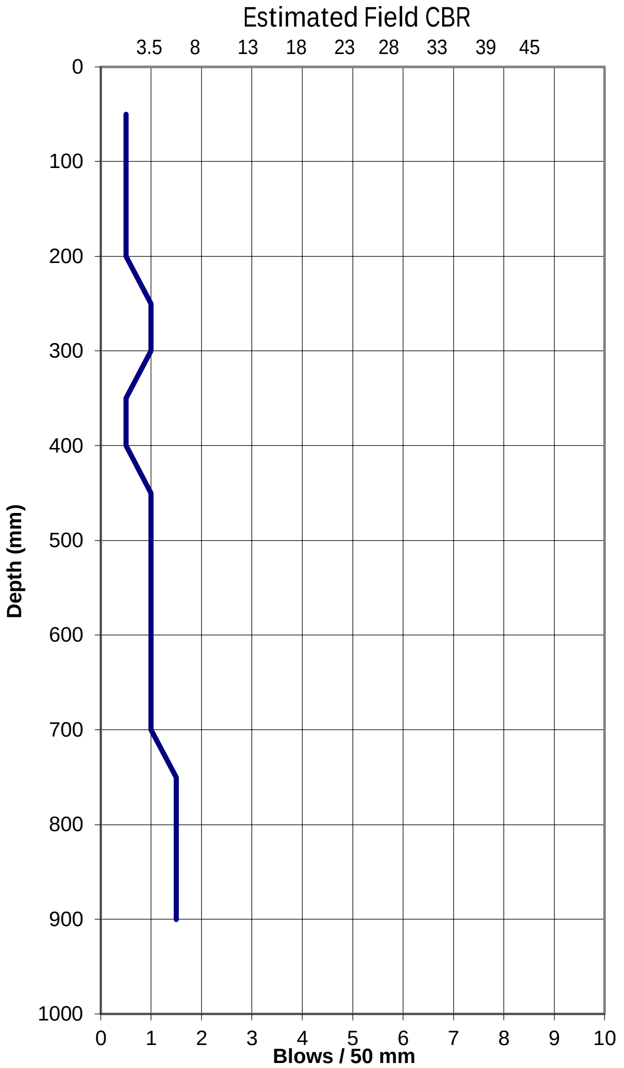
Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-15*
RL: *17.5*

Date: *25/01/2023*
Operated by: *SCZH*
Logged by: *SCZH*
Checked by:

Test No. ***DCP20***

Sheet ***19***
of ***24***

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



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

Piritahi

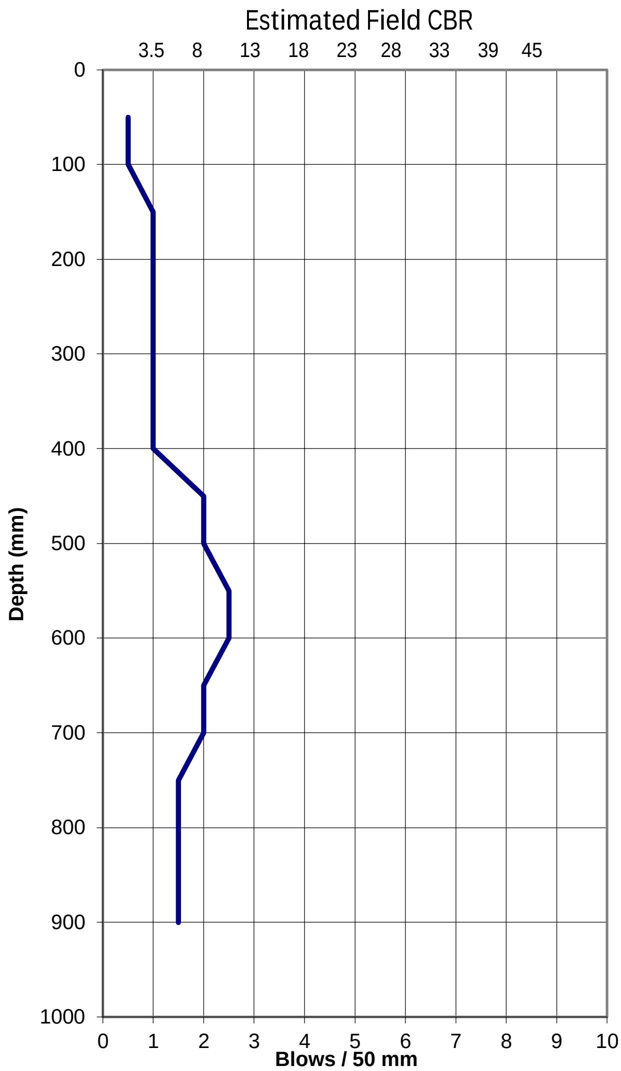
SCALA PENETROMETER LOG

Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-15*
RL: *17.5*

Date: *25/01/2023*
Operated by: *SCZH*
Logged by: *SCZH*
Checked by:

Test No. *DCP21*
Sheet *20*
of *24*

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



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

Piritahi

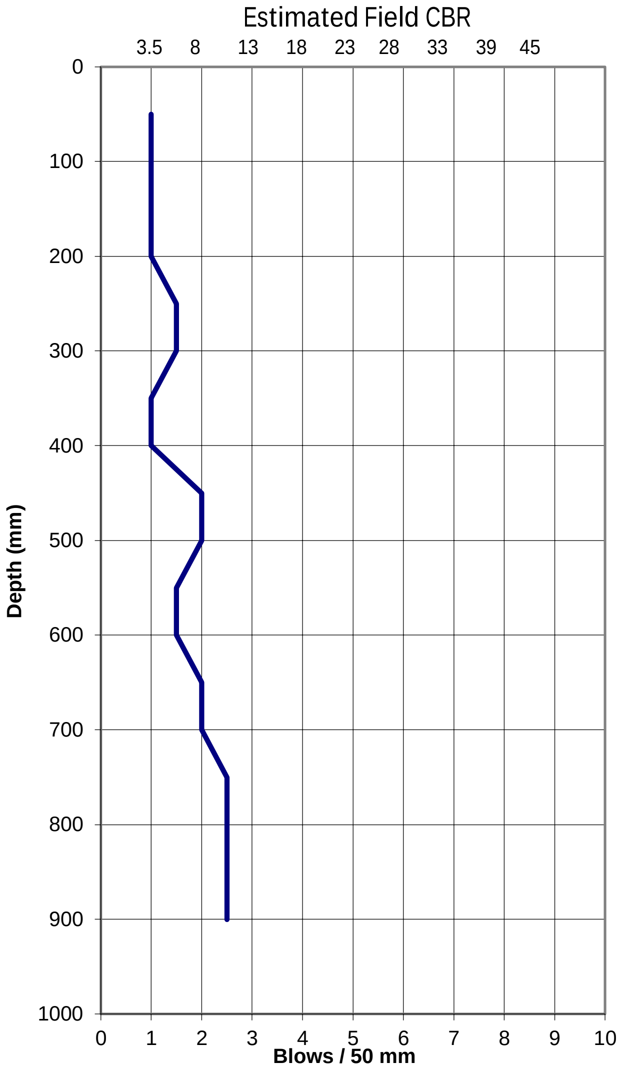
SCALA PENETROMETER LOG

Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-15*
RL: *17.5*

Date: *25/01/2023*
Operated by: *SCZH*
Logged by: *SCZH*
Checked by:

Test No. ***DCP22***
Sheet ***21***
of ***24***

mm Driven	No. of Blows
50	*1*
100	*1*
150	*1*
200	*1*
250	*1.5*
300	*1.5*
350	*1*
400	*1*
450	*2*
500	*2*
550	*1.5*
600	*1.5*
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 AUSTROADS (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

Piritahi

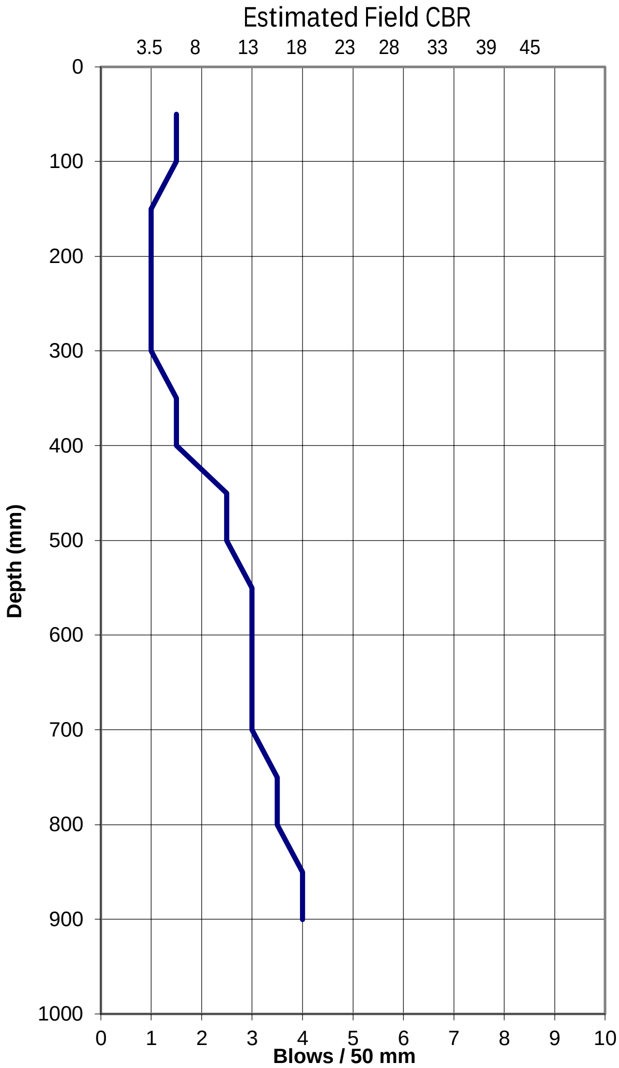
SCALA PENETROMETER LOG

Job No:	*1007708.2086*	Date:	*25/01/2023*
Project:	*Piritahi Aorere*	Operated by:	*SCZH*
Location:	*AO-15*	Logged by:	*SCZH*
RL:	*17.5*	Checked by:	

Test No. ***DCP23***

Sheet ***22***
of ***23***

mm Driven	No. of Blows
50	*1.5*
100	*1.5*
150	*1*
200	*1*
250	*1*
300	*1*
350	*1.5*
400	*1.5*
450	*2.5*
500	*2.5*
550	*3*
600	*3*
650	*3*
700	*3*
750	*3.5*
800	*3.5*
850	*4*
900	*4*



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

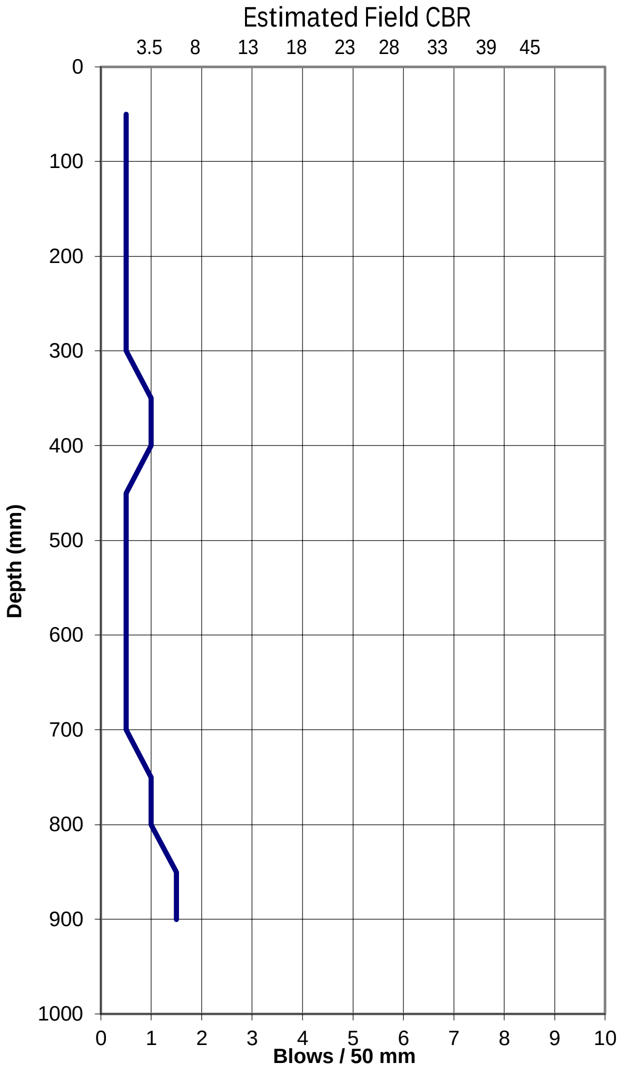
SCALA PENETROMETER LOG

Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-15*
RL: *17.5*

Date: *25/01/2023*
Operated by: *SCZH*
Logged by: *SCZH*
Checked by:

Test No. ***DCP24***
Sheet ***23***
of ***24***

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



Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (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

Piritahi

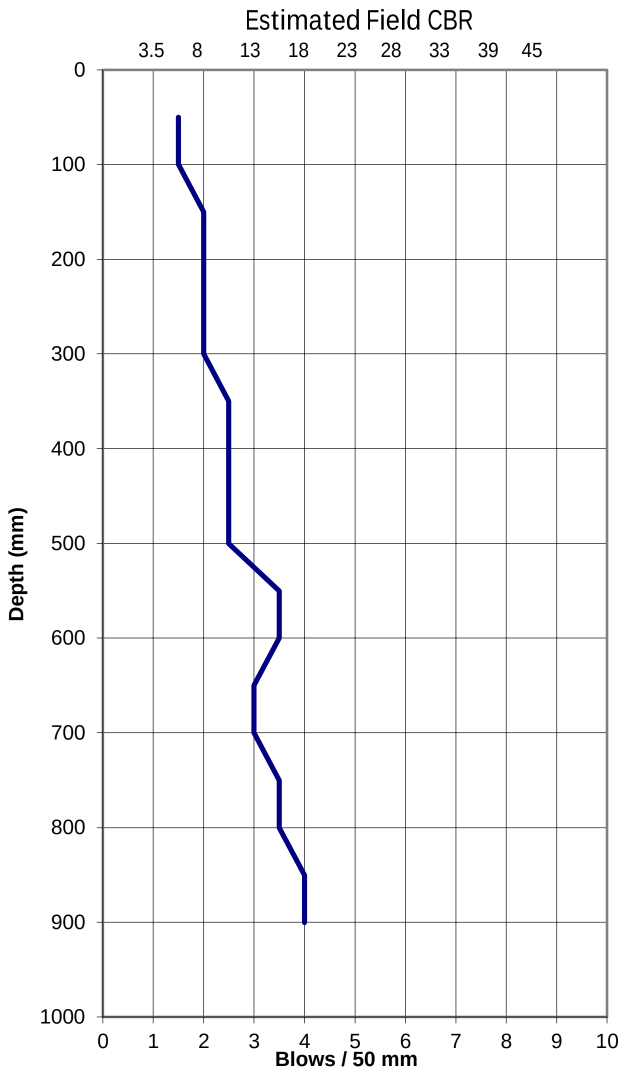
SCALA PENETROMETER LOG

Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-15*
RL: *17.5*

Date: *25/01/2023*
Operated by: *SCZH*
Logged by: *SCZH*
Checked by:

Test No. ***DCP25***
Sheet ***24*** **of** ***24***

mm Driven	No. of Blows
50	*1.5*
100	*1.5*
150	*2*
200	*2*
250	*2*
300	*2*
350	*2.5*
400	*2.5*
450	*2.5*
500	*2.5*
550	*3.5*
600	*3.5*
650	*3*
700	*3*
750	*3.5*
800	*3.5*
850	*4*
900	*4*



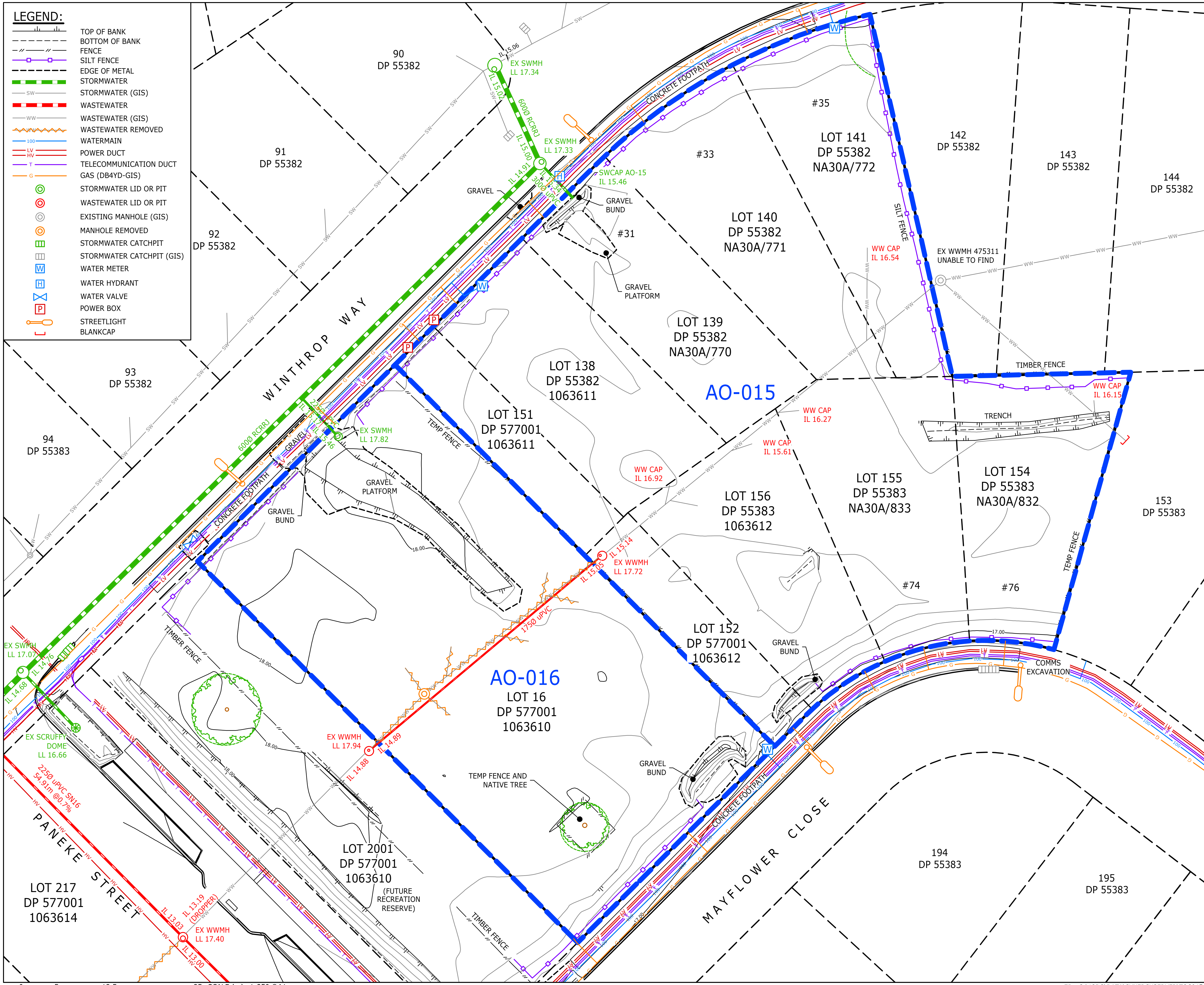
Note: The estimated CBR values are based upon Fig. 5, Correlation of Dynamic Cone Penetration and CBR AUSTROADS (1992) 'Pavement Design - A Guide to the Structural Design of Road Pavements'

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)
- WASTEWATER REMOVED
- WATERMAIN
- POWER DUCT
- TELECOMMUNICATION DUCT
- GAS (DB4YD-GIS)
- STORMWATER LID OR PIT
- WASTEWATER LID OR PIT
- EXISTING MANHOLE (GIS)
- MANHOLE REMOVED
- STORMWATER CATCHPIT
- STORMWATER CATCHPIT (GIS)
- WATER METER
- WATER HYDRANT
- WATER VALVE
- POWER BOX
- STREETLIGHT
- BLANKCAP



0 5 12.5 25 SCALE (m) 1:250 @A1
1:500 @A3

NOTES:

1. LEVELS ARE IN TERMS OF AUCKLAND VERTICAL DATUM 1946
   ORIGIN OF LEVELS
   S166 SO 55792 (CA09)
   RL 17.38
2. COORDINATES ARE IN TERMS OF NZ GEODETIC DATUM 2000
   MT EDEN CIRCUIT
   ORIGIN OF COORDINATES
   S166 SO 55792 (CA09)
   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 PIRITAHI 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 LAND INFORMATION NZ DCDB 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.
6. REFER TO DRAWING FILE FOR FROZEN LAYERS : SPOT HEIGHTS AND 3D SURFACE.

Kāinga Ora
Homes and Communities

Piritahi
LAYING THE GROUNDWORK

1	FOR HANDOVER	RBH	22.03.2023
REVISION DETAILS		BY	DATE

PROJECT:
AORERE
STAGE 2

DESCRIPTION:
SUPERLOT AO-15 AND AO-16
HANDOVER PLAN

N	SURVEYED	MJS	03.2023
	DESIGNED	-	-
	DRAWN	CA	03.2023
	CHECKED	RBH	22.03.2023
	APPROVED	RBH	22.03.2023
SCALE	1:250 @A1	1:500 @A3	REVISION
STATUS	FOR HANDOVER		1
PRECINCT	MĀNGERE		
DWG NO	TOC045-AO1-1516		

Synergy Version:

Plot Date: 1:16:22 pm,23 March 2023, COLE AINU'U

File: C:\12DS\DATA\SYNERGYSERVER\TOC045 - AORERE STAGE 2_1168\1D\04 SURVEY\CAD\TOC045-AO1-1516.DWG

Appendix C – Piritahi Test Results

LAYING THE GROUNDWORK

CHECKLIST FOR REMOVING REDUNDANT SERVICE AND BACKFILLING

TOC No & Name:	TOC45, AORERE	**Physical Work Start Date:**	6/04/2022
Location/Description:	A0-015, Existing Services Removal		

Activities/Items to be checked: ***Discipline: Removing old Services*** ***EPA NO.: N/A***

NO	Activity/Item	Checked OK? (Y/N/NA)	Checked By	Remarks/ Hold Point Initials
0	Drawings No.: - Drawing Rev.: -	Yes	Harjot	-
1	Dig permit in place, readily available and current	Yes	Harjot/ David	Dig permit was reviewed and discussed with the operator and spotter
2	Underground services identified and exposed on site and photos taken.	Yes	Harjot	See photos attached below
3	Unsuitable/suitable material identified by CPS prior to excavation	Yes	Harjot	Photos of capped lot connections attached
4	Identified material and the redundant services/drainage features/lot connections/pipe(s) removed and photos taken.	Yes	Harjot	WW lines were As-built and capped 1 meter of the main line
5	Trench extents of redundant services /drainage features /lot connection/pipe(s) surveyed and presented on as-builts, with the exclusion of lot connections that are less than 600mm deep.	Yes	Blago Mitevski	
6	Exposed trench foundation inspected by CPS/Designer and Shear Vane and Scala tested as per Item 2.3 of AAAA-DS-ITP-0002 Earthworks - Fill prior to backfilling **- CPS Hold Point**		CPS	CPS Initial:_______________
7	Backfill material test results meet the requirements of Item 1.1 of AAAA-DS-ITP-0002 Earthworks - Fill (IANZ test report required) - Backfilling to be recorded by suitable photos.	Yes	Harjot	Backfill Material Type: Cohesive Backfill

CHECKLIST FOR REMOVING REDUNDANT SERVICE AND BACKFILLING

8	Trench backfilling compaction tested in layers and acceptable in accordance with Item 2.7 of ITP-DS-ITP-0002 Earthworks - Fill (Shear Vane/Clegg/ NDM test report required)	Yes	Harjot & Geotechnics	Shear Vanes and NDMs for laterals at a depth of greater than 600 mm
9	Stabilisation of final surfaces finished and inspected by CPS **- CPS Hold Point**		CPS	CPS Initial:______________

Verification and Review:

☒ **I confirm that the above work has been completed and checked as required.**

Project/Site Engineer **Name: Harjot Singh** **Signature: Harjot Singh** **Date: 25/10/2022**

☐ **I confirm that QA checks for the above work have been completed and compliant.**

QA Engineer **Name:** **Signature:** **Date:**

CHECKLIST FOR REMOVING REDUNDANT SERVICE AND BACKFILLING

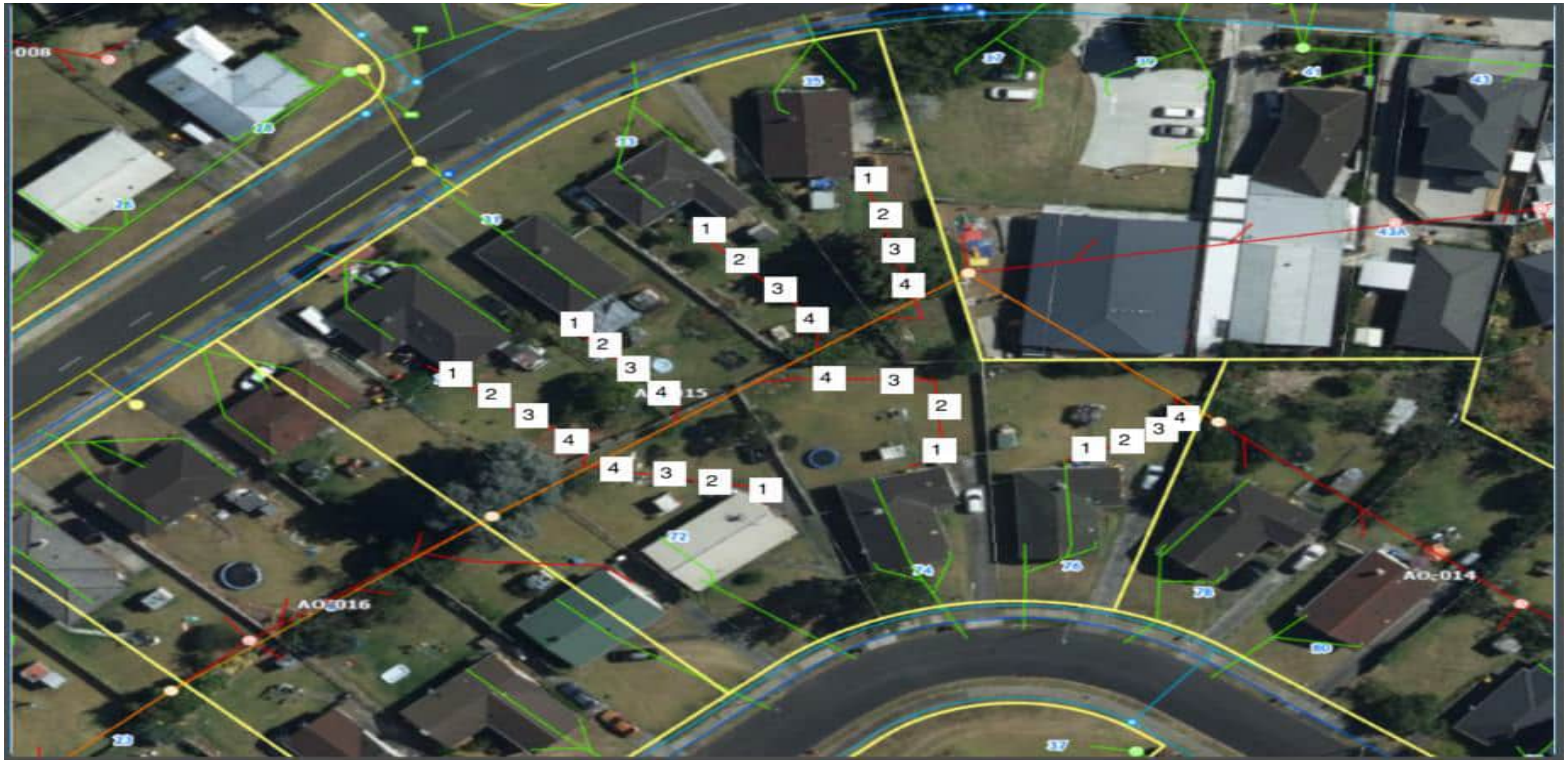
Test Location Number	Location (Or Show on Site Plan)		Shear Vane Uncorrected Dial Readings (kPa) Waste-Water removed laterals					Corrected Average Shear Strength (kPa)
	Dist. from DS MH (m)	Test R. L. /Depth(m)	Reading 1	Reading 2	Reading 3	Reading 4	Average Reading	
72 Mayflower	n/a	n/a	140	140	102	140	130.5	173.6
74 Mayflower	n/a	n/a	140	120	120	140	130	172.9
76 Mayflower	n/a	n/a	140	140	140	140	140	186.2
29 Winthrop Way	n/a	n/a	130	140	140	140	137.5	182.9
31 Winthrop Way	n/a	n/a	140	140	140	140	140	186.2
33 Winthrop Way	n/a	n/a	140	140	136	132	137	182.21
35 Winthrop Way	n/a	n/a	140	140	140	140	140	186.2

Tested By: Harjot. S	**Date: 12/04/2022**
Reviewed By: Amrit. S	**Date: 25/10/2022**

Please Note – The SW laterals we removed for these properties were inside the topsoil or in the first 200 mm depth of the clay therefore no testing was undertaken for the SW redundant lines that were removed.

CHECKLIST FOR REMOVING REDUNDANT SERVICE AND BACKFILLING

Site Plan for shear vane testing




MADE IN
NEW ZEALAND
GEOTECHNICS
VANE
3048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CHECKLIST FOR REMOVING REDUNDANT SERVICE AND BACKFILLING

CHECKLIST FOR REMOVING REDUNDANT SERVICE AND BACKFILLING

CHECKLIST FOR REMOVING REDUNDANT SERVICE AND BACKFILLING

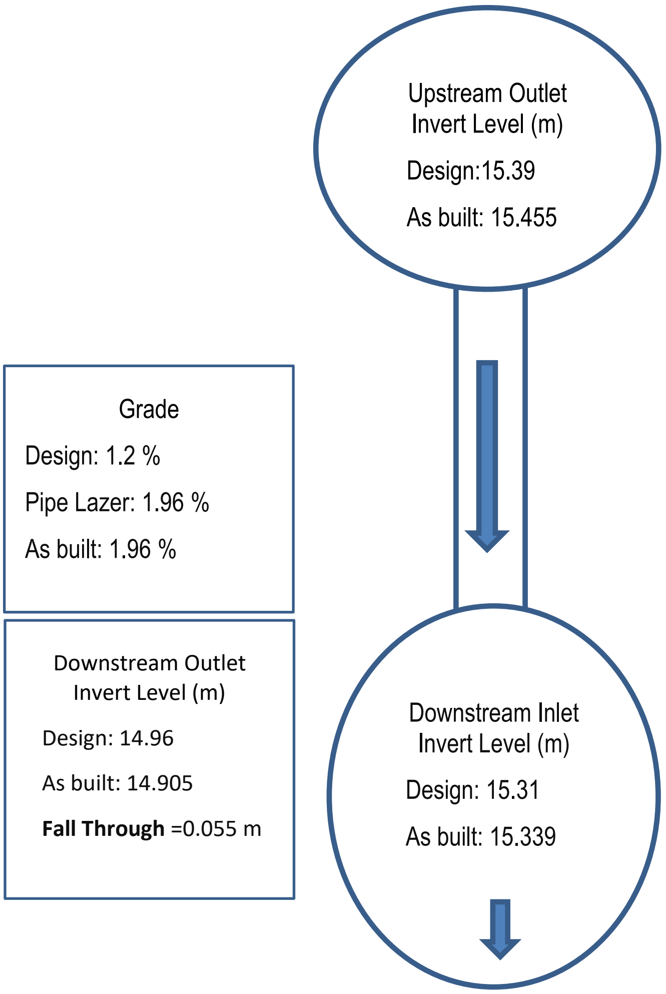
CHECKLIST FOR DRAINAGE PIPELINE AND MANHOLE INSTALLATION

TOC No & Name:	Toc 45, Aorere	**Physical Work Start Date:**	22-09-2022
Location/Description:	Winthrop Way MH 2-13 TO BC A0-15		
IFC Drawing No:	TOC045-002-4004	**Revision:**	A

Downstream Manhole (MH) #: MH 2-13		
Status	**New**	**Existing**
Dia. (mm)	**1500**	
Type	**SW**	**WW**
Epoxied	**YES**	
Water tight	**YES**	
Depth	**2.39**	
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)		

Pipe Line Ref #: LINE A0-15	
Dia. (mm)	**300**
Length (m)	**5.91m**
Material	**UPVC**
Class	**SN16**

Upstream Blank Cap #: BC A0-15		
Status	**New**	**Existing**
Dia. (mm)	**300**	
Type	**SW**	**WW**
Epoxied	**YES**	
Water tight	**YES**	
Depth	**2.23**	
Note: as above		
Throat depth	**N/A**	
Note: as above		



Activities/Items to be checked: **Discipline: Storm 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

Piritahi
LAYING THE GROUNDWORK

CHECKLIST FOR DRAINAGE PIPELINE AND MANHOLE INSTALLATION

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 **- CPS Hold Point**	Yes	CPS	CPS Initial:
4	Trench formation/foundation shear vane tested	Yes	Harjot/ Amrit	See site test records attached
5	Undercut inspected (if applicable): • Undercut Depth: 0.5 m • Undercut Type: GAP65 • Material Source : Stevensons	No		See attached Geotec Report
6	Bedding inspected and clegg tested): • Bedding Depth: 100 mm • Bedding Type: Gap 20 • Material Source: Stevensons Aggregate	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 **- CPS Hold Point**	Yes	CPS	CPS Initial:
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): ☑ Foundation ☑ Bedding ☑ Backfilling	Yes	Amrit/Harjot	Photos attached

Photos below taken and attached (Tick Aplicable)		
☑ Flexible Joints	☑ Pipe Joint	☑ Excavation
☑ Haunching	☑ Manhole benching	☑ Undercut if required

Verification and Review:

☒ **I confirm that the above work has been completed and checked as required.**

Subcontractor	**Name: Shea. F**	**Signature:**	**Date: 29/09/2022**
PE/SE (Piritahi)	**Name: Harjot Singh**	**Signature: H.S**	**Date: 29/09/2022**
Quality Engineer	**Name:**	**Signature:**	**Date:**

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LAYING THE GROUNDWORK

CLEGG HAMMER TEST RECORD SHEET

TOC No & Name:	TOC 45, AORERE	**Date:**	**29/09/2022**
Location:	SW MH 2-13 TO BC A0-15	**Layer:**	0.2

Test Methods:

Material Type: CLAY	**Shear Vane ID: S/NO 3048**
Material Description: Clay	**Calibration Expiry Date: 14/10/2023**
Site Plan Attached: N/a	**Vane Conversion Factor: 1.33**

Test Methods:

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

Test Methods:

Material Type:	**Gap 65**	**Clegg Hammer ID:**	*S/NO 20-0055*
Material Description:	**Hardfill**	**Calibration Expiry Date:**	**31/10/2023**
Criteria:	**Gap65 CIV > 30 and no single value < 28, in 0.2 m Layers**	**Drops:**	**4**

CLEGG HAMMER TEST RECORD SHEET

Testing Equipment Information		
Glegg Hammer ID	Shear Vane ID	Shear Vane Correction Factor
S/NO 20-0055	S/NO 3048	1.33

Trench Foundation Test Records (Correction Factor not applied)								
	Material	D/s MH	20m	40m	45m	60m	75m	U/s BC A0-15
Shear Vane	CLAY	2-13	102	N/A	N/A	N/A	N/A	BC A0-15

Material Type and Source					
Undercut Depth	-	Type	Gap65	Source	STEVENSON'S
Bedding Depth	0.1m	Type	Gap20	Source	STEVENSON'S
Backfill Depth	2.39 m	Type	Gap65	Source	STEVENSON'S
Undercut Link – 5 MANGERE/TOC045 - Aorere Stage 2/1D/06 Geotech/Site inspections Geotech/TOC045-GE-MEM-0008.pdf					

CLEGG HAMMER TEST RECORD SHEET

Backfill Test Record (CLEGG) MH A0-016- Saddle 2-12

Test Type	***Depth***	***D/s MH***	***0-15m***					***15-30m***					***30-45m***					***U/s BC***
		MH 2-13	***T1***	***T2***	***T3***	***T4***		***T1***	***T2***	***T3***	***T4***		***T1***	***T2***	***T3***	***T4***		***BC A0-15***
Granular (Clegg)	Bedding	***MH 2-13***	12	13	13	13	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	***BC A0-15***
Granular (Clegg)	0.0 (1m ap)	***MH 2-13***	30	32	34	33	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	***BC A0-15***
Granular (Clegg)	0.2m	***MH 2-13***	33	31	33	33	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	***BC A0-15***
Granular (Clegg)	0.4m	***MH 2-13***	31	31	32	32	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	***BC A0-15***
Granular (Clegg)	0.6m	***MH 2-13***	30	30	33	34	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	***BC A0-15***
Granular (Clegg)	0.8m	***MH 2-13***	30	31	33	32	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	***BC A0-15***
Granular (Clegg)	1.0m	***MH 2-13***	30	33	34	32	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	***BC A0-15***
Granular (Clegg)	1.2m	***MH 2-13***	30	32	32	34	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	***BC A0-15***

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LAYING THE GROUNDWORK

CLEGG HAMMER TEST RECORD SHEET

Backfill Test Record (CLEGG) MH 2-13																		
Test Type	***Depth***	***D/s MH***	***0-15m***					***15-30m***					***30-45m***					
		MH 2-13	***T1***	***T2***	***T3***	***T4***		***T1***	***T2***	***T3***	***T4***		***T1***	***T2***	***T3***	***T4***		
Granular (Clegg)	Bedding	*MH 2-13*	12	13	12	12	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Granular (Clegg)	0.2m	*MH 2-13*	32	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	
Granular (Clegg)	0.4m	*MH 2-13*	31	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	
Granular (Clegg)	0.6m	*MH 2-13*	30	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	
Granular (Clegg)	0.8m	*MH 2-13*	32	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	
Granular (Clegg)	1.0m	*MH 2-13*	30	32	32	34	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Granular (Clegg)	1.2m	*MH 2-13*	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	
Granular (Clegg)	1.4m	*MH 2-13*	32	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	
Granular (Clegg)	1.6m	*MH 2-13*	42	33	33	34	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 HAMMER TEST RECORD SHEET

CLEGG HAMMER TEST RECORD SHEET

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SHEAR VANE FIELD TEST RECORD SHEET

TOC No & Name:	Aorere, TOC 45	**Date:**	13-06-2022
Location:	WWMH C1	**Layer:**	250mm

Test Methods: Shear Vane

Criteria – Shear Vane >= 130 kPa Shear Vane every 250 layer

Material Type: Cohesive Fill	**Shear Vane ID: 3048**
Material Description: Clay	**Calibration Expiry Date: 14/10/2023**
Site Plan Attached: Yes	**Vane Conversion Factor: 1.33**

WWMH C1

Test Location Number	Location (Or Show on Site Plan)		Shear Vane Uncorrected Dial Readings (kPa) Waste-Water Lateral 1					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	0.2	100	110	106	105	105	139.5
	0	0.2	120	110	110	118	114.5	152.3
2	0	0.2	130	128	110	108	119	154.7
	0	0.2	114	110	112	110	119	154.7
3	0	0.4	108	120	118	120	116.5	155
	0	0.4	126	130	128	130	128.5	171
4	0	0.6	120	110	118	112	115	152
	0	0.6	108	130	128	126	123	163.6
5	0	0.8	104	108	108	106	106.5	141.6
	0	0.8	116	130	128	108	106.5	141.6
6	0	1.0	110	122	110	120	115.5	153.6
	0	1.0	108	118	112	108	111.5	148.3
7	0	1.2	108	108	108	110	108.5	144.3
	0	1.2	120	116	120	130	121.5	161.6
8	0	1.4	108	110	118	110	111.5	148.3
	0	1.4	140	108	110	140	124.5	165.6

SHEAR VANE FIELD TEST RECORD SHEET

9	0	1.6	104	116	120	106	111.5	148.3

Test Location Number	Location (Or Show on Site Plan)		Shear Vane Uncorrected Dial Readings (kPa) Waste-Water Lateral 2					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	
	0	1.6	136	122	110	108	119	158.3
10	0	1.8	110	108	122	110	112.5	149.6
	0	1.8	136	120	125	108	122.2	162.5
11	0	2.0	110	108	110	110	109.5	145.6
	0	2.0	110	108	120	120	114.5	152.3

Tested By: Harjot.S	**Date: 16.02.2023**
Reviewed By: Amrit .S	**Date: 16.02.2023**

WWMH C2

Test Location Number	Location (Or Show on Site Plan)		Shear Vane Uncorrected Dial Readings (kPa) Waste-Water Lateral 1					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	0.2	110	108	122	110	112.5	149.6
	0	0.2	136	120	130	125	127.8	169.9
2	0	0.2	110	112	110	110	110.5	146.9
	0	0.2	110	108	120	120	114.5	152.3
3	0	0.4	110	122	110	120	115.5	153.6
	0	0.4	116	118	112	112	114.5	152.3

Piritahi
LAYING THE GROUNDWORK

SHEAR VANE FIELD TEST RECORD SHEET

4	0	0.6	112	114	110	110	111.5	148.3
	0	0.6	120	116	120	130	121.5	161.6
5	0	0.8	110	120	120	110	115	152.9
	0	0.8	120	110	112	112	113.5	150.9
6	0	1.0	110	128	120	120	119.5	158.9
	0	1.0	112	116	120	108	114	151.62
7	0	1.2	110	110	112	128	115	152.9
	0	1.2	120	120	114	124	119.5	158.9
8	0	1.4	120	116	120	130	121.5	161.5
	0	1.4	104	104	102	106	104	138.32
9	0	1.6	116	130	128	120	123.5	164.2

Test Location Number	Location (Or Show on Site Plan)		Shear Vane Uncorrected Dial Readings (kPa) Waste-Water Lateral 2					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	
	0	1.6	116	110	108	110	111	147.63
10	0	1.8	116	130	128	108	120.5	160.3
	0	1.8	110	122	110	120	115.5	153.6
11	0	2.0	108	118	112	108	111.5	148.3
	0	2.0	120	130	128	124	125.5	166.9

Tested By: Harjot.S	**Date:** 16.02.2023
Reviewed By: Amrit .S	**Date:** 16.02.2023

Appendix D – Geotechnics Testing

GEOTECHNICS	1 Hill Street Onehunga Auckland 1061 New Zealand p. +64 9 356 3510	**Project Name : Mangere TOC45 Superlot AO-014-AO-016** **Customer : Piritahi**	

Project Number	**1041000.0045.1.0/**
Entered By	**PEFE/LIWO**
Checked By	-
Approved By	-

URN.	Tech.	Date	Location	Layer	Material Type	Test Type	NDM 0^0			NDM 90^0			**AVERAGE NDM**			Solid Density (t/m^3) Assumed	Oven Moisture content (%)	**Final Corrected**		**Shear Vane Reading (kPa)**					**Retest URN**	**PASS / FAIL**	**Comments**
							Wet Density (t/m^3)	Moisture Content (%)	Air Voids (%)	Wet Density (t/m^3)	Moisture Content (%)	Air Voids (%)	Wet Density (t/m^3)	Moisture Content (%)	Air Voids (%)			Oven Dry Density (t/m^3)	Average Air Voids (%)	Reading 1	Reading 2	Reading 3	Reading 4	Average SV (4 x Tests)		(P) Pass (F) Fail	
1.1	LIWO	3/05/2022	Lateral Line 1	Initial Lift (~500mm)	ClaySILT w/ gravels	NDM / SV	1.80	38.4	1.7	1.80	37.8	2.1	**1.80**	**38.1**	**1.9**	2.70	34.8	1.34	**3.9**	198	198	198	198	198	-	**P**	Specification provided by Piritahi requires an average shear vane reading ≥ 130 kPa, with no individual reading < 120 kPa. Air voids have a maximum average < 8%, with no individual reading > 10%.
1.2			Lateral Line 2			NDM / SV	1.78	38.5	2.7	1.79	37.9	3.0	**1.78**	**38.2**	**2.9**	2.70	36.4	1.31	**3.9**	198	198	195	167	190	-	**P**	
1.3			Lateral Line 3			NDM / SV	1.81	40.4	0.1	1.80	38.6	1.7	**1.81**	**39.5**	**0.9**	2.70	37.4	1.31	**2.1**	198	198	184	198	195	-	**P**	
1.4			Lateral Line 4			NDM / SV	1.70	45.0	3.8	1.70	40.0	6.3	**1.70**	**42.5**	**5.0**	2.70	39.2	1.22	**6.8**	198	198	198	170	191	-	**P**	
1.5			Lateral Line 5			NDM / SV	1.71	41.3	5.3	1.70	40.7	6.3	**1.70**	**41.0**	**5.8**	2.70	37.4	1.24	**7.8**	198	198	198	198	198	-	**P**	
1.6			Lateral Line 6			NDM / SV	1.78	36.4	3.9	1.79	37.1	3.4	**1.79**	**36.8**	**3.7**	2.70	36.7	1.31	**3.7**	198	170	184	198	188	-	**P**	
2.1	PEFE	5/05/2022	Drainage backfill	Initial Lift (~500mm)	claySILT	NDM / SV	1.73	39.7	4.8	1.71	41.4	5.2	**1.72**	**40.6**	**5.0**	2.70	39.9	1.23	**5.3**	171	163	206	240	195	-	**P**	
2.2						NDM / SV	1.66	49.3	3.8	1.68	49.5	2.8	**1.67**	**49.4**	**3.3**	2.70	40.9	1.19	**7.6**	189	141	240	209	195	-	**P**	
2.3						NDM / SV	1.72	42.2	4.0	1.73	38.8	5.8	**1.72**	**40.5**	**4.9**	2.70	36.5	1.26	**7.1**	240	240	240	240	240	-	**P**	
2.4						NDM / SV	1.72	42.7	3.9	1.72	39.7	5.4	**1.72**	**41.2**	**4.6**	2.70	41.1	1.22	**4.7**	240	240	240	240	240	-	**P**	
2.5						NDM / SV	1.76	47.8	0.0	1.77	46.7	0.0	**1.76**	**47.3**	**0.0**	2.70	36.1	1.29	**5.4**	240	240	240	240	240	-	**P**	
2.6						NDM / SV	1.72	41.1	4.9	1.70	42.2	5.0	**1.71**	**41.7**	**5.0**	2.70	38.2	1.24	**6.9**	158	146	168	154	156	-	**P**	
2.7						NDM / SV	1.76	38.4	4.3	1.73	40.0	4.6	**1.74**	**39.2**	**4.5**	2.70	34.1	1.30	**7.5**	240	240	240	240	240	-	**P**	
2.8						NDM / SV	1.79	36.1	3.9	1.79	35.5	4.3	**1.79**	**35.8**	**4.1**	2.70	36.3	1.31	**3.8**	240	240	240	240	240	-	**P**	
2.9						NDM / SV	1.85	35.9	0.7	1.86	35.6	0.2	**1.86**	**35.8**	**0.4**	2.70	34.8	1.38	**1.0**	240	240	240	240	240	-	**P**	
2.10						NDM / SV	1.76	43.1	1.2	1.77	37.6	4.2	**1.77**	**40.4**	**2.7**	2.70	33.3	1.32	**6.8**	189	149	231	240	202	-	**P**	

PROVISIONAL

These results have not yet passed our entire quality assurance process.
They should be used with caution and may be subject to change.

PROVISIONAL

"These results have not yet passed our entire quality assurance process. They should be used with caution and may be subject to change.

Legend:

- Impact Hammer
- NDM (DT & SV Set)
- Shear Vane
- Scala
- Hand Auger
- Testing Area

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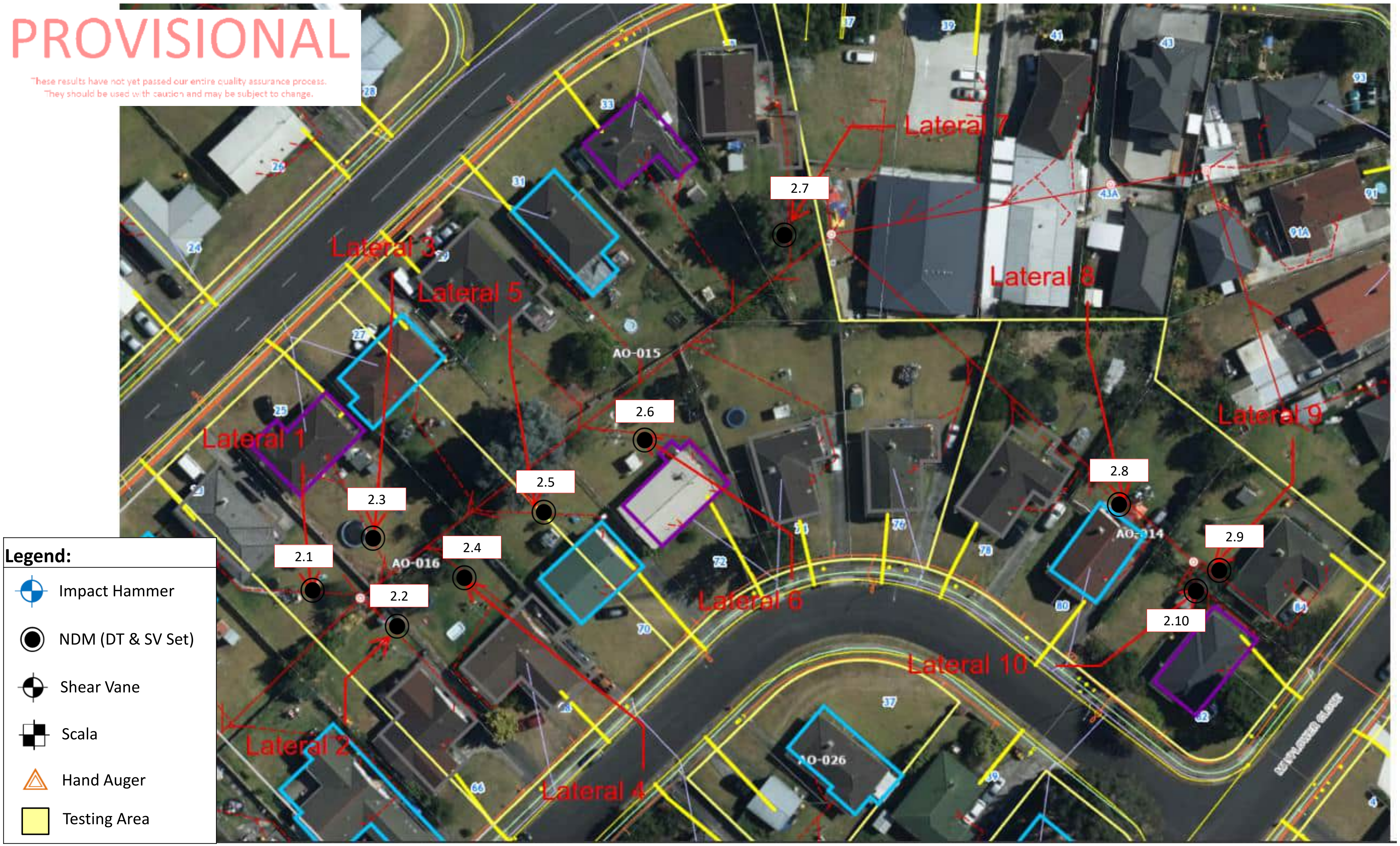
GEOTECHNICS

Test Location Plan

Site:	Mangere Precinct TOC45	Job Name:	Mangere Precinct TOC45	Drawn:	LIWO	Date:	3/05/2022
Location:	Superlots AO-014-AO-016	Job No.:	1041000.0029.0.0/1	URN:	1	Date:	3/05/2022
		Lab Ref:	- N/A	Scale:	Not to Scale	Rev.:	1

N



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Test Location Plan

Site:	Mangere Precinct TOC45	Job Name:	Mangere Precinct TOC45	Drawn:	PEFE	Date:	5/05/2022
Location:	Superlots AO-014-AO-016	Job No.:	1041000.0029.0.0/1	URN:	2	Date:	5/05/2022
		Lab Ref:	- N/A	Scale:	Not to Scale	Rev.:	1

N

Appendix E – Piritahi ITPs

INSPECTION AND TEST PLAN

Piritahi
LAYING THE GROUNDWORK

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	**Cut/Excavation Materials**											
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/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	**Construction**											
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 Fiinal 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	**Post Construction**											
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

Piritahi
LAYING THE GROUNDWORK

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 minuted	Specified	Meeting Minutes			
1	**Fill Materials**											
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	**Construction QA/QC Requirements**											
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 **maximum 200mm thick compacted layers**	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. **Within Road Reserves:** - Clegg10m by 10m grid and NDM 20m by 20m grid for bulk earthworks; or, - 1 test (Clegg&NDM) per 15m for trenches **Within Superlot Boundaries:** 1. Cohesive fill (imported or site won): - 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 2. Granular fill (imported): - Clegg10m by 10m grid and NDM 20m by 20m grid for bulk earthworks; or, - 1 test (Clegg&NDM) per 15m for trenches 3. SPR/ROP: - 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 - Sher vane & Clegg; IANZ Laboratory - NDM	**Within Road Reserves:** 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 checkled with CPS/Designer. **Within Superlot Boundaries** 1. Cohesive fill (imported or site won): - 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% 2. Granular fill (imported): - 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% 3. SPR/ROP: - 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	**Post Construction**											
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 - STORMWATER

Piritahi
LAYING THE GROUNDWORK

TOC No.:		**ITP No.:**	AAAA-DS-ITP-0005 (Revision 6)	**EPA No.:**	
TOC Name:		**ITP Title:**	ITP for Stormwater	**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	**Pre-construction Meeting**	H	R	R	Prior to commencing the construction works	NA	Construction monitoring level agreed and meeting minuted	NA	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.	NA	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 envelops as per Appendix A of this ITP (To be provided).	Specified	PSD, MDD and DI IANZ Test Report(s) from Supplier			
1.3	Insitu Concrete	I/R	R		When products are delivered to site and before products are incorporated into the works	NA	Insitu 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	**Construction QA/QC Requirements**											
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. The minimum width of the trench should be such that the barrel of the pipe is not closer than 150mm to the trench wall or shoring. 3. Enough space for the trench shields should be allowed for.	Specified	Piritahi Construction Checklist for Stormwater			

<table>
<tr><td>2.1.2</td><td>Trench Foundation & Undercutting</td><td>H</td><td>H</td><td></td><td>Shear Vane for trench foundation to be tested:
- For trenches ≥ 30m - every 15m
- For trenches < 30m - min 2 tests

Clegg for backfilling of undercut to be tested:
- For trenches ≥30m - 1 test every 15m
- For trenches <30m - min 2 tests</td><td>Constructor</td><td>1. Remove any unsuitable foundation material in accordance with the below table:
<table>
<tr><th>Shear vane strength (in clay/silt)</th><th>Scala Penetrometer (in sand/gravel)</th><th>Undercut and backfill</th></tr>
<tr><td>≥80 kPa</td><td>≤50mm 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><20 kPa or highly organic</td><td>200mm per blow</td><td>Contact the design engineer</td></tr>
</table>
2. Undercutting to have a transition slope of 1:5 between the undercut section and the normal foundation.

3. Backfill material (GAP65 or GAP40) shall be selected as per the design drawings and the required compactness is as below:

For backfill
(1) GAP 65: CIV (average over 30m length/average per manhole) > 30 & no single value < 28. OR:
(2) GAP 40: CIV (average over 30m length/ average per manhole) > 23 & no single value < 21.

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.</td><td>Specified</td><td>Piritahi Construction Checklist for Stormwater; Shear Vane/Clegg Test Record</td><td></td><td></td><td></td></tr>
<tr><td>2.1.3</td><td>Pipe Bedding</td><td>I/H</td><td>R</td><td></td><td>Clegg for bedding to be tested:
- For trenches ≥30m - 1 test every 15m
- For trenches <30m - min 2 tests

Note:
Every Clegg test shall have 4 readings recorded.</td><td>Constructor</td><td><u>H2 Support Type Bedding Depth:</u>
100mm if Ø < 1500mm
150mm if Ø >1500mm
Max layer thickness 150mm

Bedding material (GAP7 or GAP20) shall be selected as per the design drawings and the required compactness is as below:

- GAP 7 & GAP 20: CIV (average over 30m length/ average per manhole) > 12 & CIV no less than 10.

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.</td><td>Auckland Council SWCoP Drawing SW03
NZS3725 Table 5</td><td></td><td></td><td></td><td></td></tr>
<tr><td>2.1.4</td><td>Pipe Haunch</td><td>I/H</td><td>R</td><td></td><td>Clegg for haunch to be tested:
- For trenches ≥30m - 1 test every 15m per layer
- For trenches <30m - min 2 tests per layer</td><td>Constructor</td><td><u>H2 Support Type Bedding Depth:</u>
Haunch Zone Depth = 0.3 x Pipe Ø
Max layer thickness 150mm

Haunch material (GAP7 or GAP20) shall be selected as per the design drawings and the required compactness is as below:

- GAP 7 & GAP 20: CIV (average over 30m length/ average per manhole) > 12 & CIV no less than 10.

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.</td><td>Auckland Council SWCoP Drawing SW03
NZS3725 Table 5</td><td>Piritahi Construction Checklist for Stormwater; Clegg Test Record</td><td></td><td></td><td></td></tr>
<tr><td>2.1.5</td><td>Pipe laying</td><td>H</td><td>H</td><td></td><td>After pipe laying</td><td>NA</td><td>1. Pipe laying should be true to the line, levels and grades as per design drawings.
2. Pipe position tolerance: +/-50mm; pipe level tolerance: +/-30mm
3. Horizontal/Position tolerance for HDD, pipe jacking, boring or tunnelling: +/-100mm

Note:
AC SW CoP for Grade: As-built gradients shall be no less than 0.1% and no greater than 25%.</td><td>Specified</td><td>Piritahi Construction Checklist for Stormwater</td><td></td><td></td><td></td></tr>
</table>

2.1.6	Trench Backfill	I/R	R		Within Road Corridor - Clegg to be tested (No need NDM): - For trenches in Berms every 15m min two per layer - For trenches in Carriageways and footpaths every 5m min two tests per layer Within Superlot Boundary - Clegg to be tested: - For trenches ≥30m of more - every 15m per layer - For trenches <30m - min 2 tests per layer	Constructor	**Within Road Reserves Including Berms (Up to Subbase Level)** Hardfill Backfill placed in layers not exceeding 200mm thickness & Compacted to: Carriageway CIV > 25 which is equivalent to 90% MDD - Under the Sub-Base Footpath CIV > 15 - Under the Sub-Base Bearm CIV > 10 **Within Superlot Boundaries** 1. Granular fill shall be free of organics (max particle size 150mm) and placed in layers not exceeding 200mm. 2. Overlay material (GAP65, GAP40 or GAP20) shall be selected as per the design drawings and the required compactness is as below: (1) GAP 65: CIV (average over 30m length/average per manhole) > 30 & no single value < 28. OR: (2) GAP 40: CIV (average over 30m length/ average per manhole) > 23 & no single value < 21. (3) GAP 20: CIV (average over 30m length/ average per manhole) > 12 & CIV no less than 10.	National Code of Practice Section 5.5.3, 5.5.4 and 5.5.5	Piritahi Construction Checklist for Stormwater; 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)	NA	Piritahi Construction Checklist for Stormwater			
2.2.2	Manhole Foundation & Undercutting	H	H		Shear Vane for manhole foundation to be tested: - Minimum 2 tests per manhole location Clegg for backfilling of undercut to be tested: - Minimum 2 tests per manhole location	Constructor	1. Remove any unsuitable foundation material in accordance with the below table: Shear vane strength (in clay/silt) / Scala Penetrometer (in sand/gravel) / Undercut and backfill ≥80 kPa / ≤50mm 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. 2. Undercutting to have a transition slope of 1:5 between the undercut section and the normal manhole or connecting pipeline foundation. 3. Backfill material (GAP65 or GAP40) shall be selected as per the design drawings and the required compactness is as below: (1) GAP 65: CIV (average over 30m length/average per manhole) > 30 & no single value < 28. OR: (2) GAP 40: CIV (average over 30m length/ average per manhole) > 23 & no single value < 21. 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.	Specified	Piritahi Construction Checklist for Stormwater; Shear Vane/Clegg Test Record			
2.2.3	Manhole Bedding	I/H	R		Clegg for bedding to be tested: - Minimum 2 tests per manhole location	Constructor	Bedding Depth and material as per detail drawing (min 75mm) Compaction values: CIV > 12 & CIV no less than 10.	Specified	Construction Checklist for Stormwater; 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). 2. Manhole position tolerance: +/-50mm 3. Manhole lid level tolerance: +/-30mm	Specified	Piritahi Construction Checklist for Stormwater			

2.2.5	Manhole Backfilling	I/R	R		Within Road Reserves Including Berms - Compaction for backfilling to be tested using Clegg (No need NDM): - Minimum 2 tests per manhole location Within Superlot Boundaries - Compaction for backfilling to be tested using Clegg (aggregates) or Share Vane (cohesive fill) - No need NDM: - Minimum 2 tests per manhole location	Constructor	**Within Road Reserves Including Berms (Up to Subbase Level)** Hardfill Backfill placed in layers not exceeding 200mm thickness & compacted to CIV>25 which is equivalent to 90% MDD. **Within Superlot Boundaries** 1. Cohesive or granular fill shall be free of organics (max particle size 150mm) placed in layers not exceeding 300mm. 2. Lower backfill zone material (Cohesive, GAP65, GAP40, GAP20 or ROP/SPR) shall be selected as per the design drawings and the required compactness is as below: (1) Cohesive fill: Shear Vane (Average over 4 readings) >130 and no single reading < 120. OR: (2) GAP 65: CIV (average over 30m length/average per manhole) > 30 & no single value < 28. OR: (3) GAP 40: CIV (average over 30m length/ average per manhole) > 23 & no single value < 21. (4) GAP 20: CIV (average over 30m length/ average per manhole) > 12 & CIV no less than 10. (5) ROP/SPR: (To be provided by Designer)	Specified	Piritahi Construction Checklist for Stormwater; 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	Meet Auckland Council relevant standards	SWCoP	CCTV Tapes and Logs			
2.4	**As-built Survey**	R	R		As required	NA	Meet Auckland Council relevant standards	SWCoP	As-built Site Checker & Certificated As-built Drawings			
3	**Post Construction**											
3.1	Final Inspection (Piritahi Internal)	H	H	H	At the completion of each EPA	NA	No unacceptabale defects	SWCoP	Photos			

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.

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; landslip; 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).

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. Swelling 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 perpends).

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.

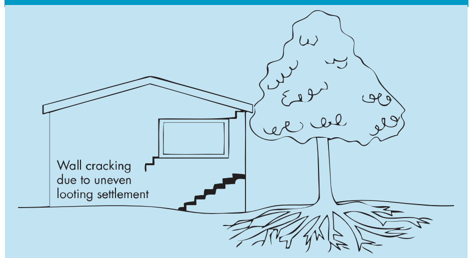
Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends 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.

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 watertable 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.

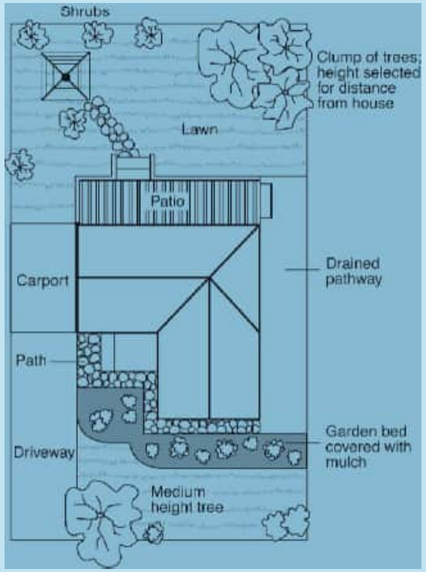
Protection of the building perimeter

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.

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

Gardens for a reactive site



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.

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