Piritahi
LAYING THE GROUNDWORK

AORERE
STAGE 2 – TOC45

Superlot AO-019

Geotechnical Completion Report

Document Control

AORERE STAGE 2 – SUPERLOT AO-019– GEOTECHNICAL COMPLETION REPORT					
DATE	VERSION	DESCRIPTION	PREPARED BY	REVIEWED BY	AUTHORISED BY
November 2022	1.0	Geotechnical Completion Report	Cameron Taylor	Andy Huang	Elby Tang

Distribution

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

Contents

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-01 comprised:

- Removal of the existing buildings;
- Surficial soil strip to remove contaminated soil hot spots (see Site Validation Report[1] for details);
- Removal of existing stormwater and wastewater lot connections;
- Removal of a decommissioned wastewater line; and
- Removal of a decommissioned stormwater line and manhole.

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-019", 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-019

DATE	INSPECTION BY	DESCRIPTION
31 October 2022	S Zhang and C Taylor (Piritahi)	Testing on existing subgrade comprising shear vanes and Scalas

4.0 Earthworks

4.1 Earthworks subgrade

The existing houses within Superlot AO-019 have been removed. An approximately 300 mm to 500 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. The shear vane test measured undrained shear strengths ranging between 69 and 220kPa, with an average shear strength of 13 kPa. The Scala penetrometer testing

[1] Piritahi Alliance. 9 November 2022. Site Validation Report – Aorere Stage 2 Superlot AO-019.

recorded blow counts ranged from 0.5 to 4 blows per 50 mm penetration across the superlot, averaging 1 to 2 blows per 50 mm.

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

5.0 Infrastructure

5.1 Infrastructure removal

Existing infrastructure that was removed included stormwater and wastewater network pipes and residential stormwater and wastewater lot connections that were encountered during demolition works.

The existing lot connections were generally within the upper 300 to 500mm of subgrade and were removed as part of the surficial topsoil strip.

The wastewater line was removed and capped at approximately 3 m within the superlot boundary (as shown in Appendix B – As Built Plans). The removed wastewater line extending from the eastern boundary of the site to the centre of the site was backfilled with site won cohesive fill to a depth of approximately 1.8 m. Testing was undertaken by Piritahi within the backfill of the redundant wastewater line trench and measured undrained shear strengths of between 133 kPa and 139 kPa, with an average undrained shear strength of 135 kPa. Nuclear densometer testing recorded air voids readings of 3.3% and 3.0%. The shear vane testing complies the Piritahi Earthworks Fill ITP compaction criteria, The frequency of nuclear densometer testing do not comply with testing frequency required in the Earthworks Fill ITP as only one layer was tested. However, based on shear vane results and the available air voids results, we consider that cohesive fill achieves a reasonable level of compaction.

The stormwater line was removed and capped at the northern boundary of superlot AO-019. The removed stormwater line along the southwestern boundary included one manhole. The trench was backfilled with imported GAP65 material to a depth of about 2.0 m. Within the redundant stormwater line trench, Clegg hammer testing completed by the Piritahi site team measured Clegg Impact Values (CIV) between 31 and 36, for an average of 33 across all lifts. Nuclear densometer testing completed by Geotechnics produced Maximum Dry Density (MDD) values of between 92.4% and 103.2%, recording an average of 96.4%. The Clegg Impact Value results complies with the Piritahi Earthworks Fill ITP requirements, however the frequency of the nuclear densometer testing does not comply with the Earthworks Fill ITP. Based on the Clegg results and the available MDD data for the layers tested, we consider that the GAP65 achieves a reasonable level of compaction.

The backfill of the trenches generally achieve the specified bearing capacity given in the Geotechnical Report and is of comparable/higher strength than the surrounding soils.

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-019 comprised the installation of the following utilities:

- Installation of a new public stormwater line. The new stormwater line links to the existing stormwater network through an existing manhole on Winthrop Way. The new 300 mm diameter stormwater line is capped approximately 2.5 m into Superlot AO-019. Backfill of the stormwater line was undertaken using GAP65 hardfill. Clegg hammer tests on the GAP65 hardfill recorded Clegg Impact Values between 31 and 41. The test results achieved the compaction requirement of the Piritahi Stormwater ITP. The new Stormwater network 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 (within the surficial topsoil strip); and
    d. Decommissioning and removal of stormwater and wastewater network pipes. These lines were backfilled with compacted site-won cohesive fill or imported granular material to the finished subgrade level.
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 November 2022, 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-019, the undrained shear strength and expansivity of the natural soils meet the definition of "good ground" as outlined in NZS 3604-2011. The natural soils at the site do not meet "good ground" criteria for liquefaction susceptibility, and foundations on such soils will require consideration of the potential effects of liquefaction on the development.
    c. The compacted cohesive site won backfill for the removed wastewater network trench and the compacted hardfill backfill for the removed stormwater line complies with the compaction requirements of the Piritahi Earthworks Fill ITP. The frequency of the nuclear densometer testing does not meet the requirements of the Earthworks Fill ITP, however we consider the fill to achieve a reasonable level of compaction.
    d. The backfilled redundant wastewater and stormwater trenches meets the bearing capacity requirement for "good ground" and a subgrade CBR of 4%. This should be considered in the design of future developments.
    e. A new 300 mm diameter stormwater pipe was installed and capped approximately 2.5 m into the western corner of the superlot. Backfill of the stormwater trench was undertaken with GAP65 to the compaction requirements of the Piritahi Stormwater ITP.

f. 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: 16 November 2022

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

Piritahi
LAYING THE GROUNDWORK

SITE VISIT RECORD SHEET

Project Name: Aorere Stage 2	Project ID: 1007708.2029
Ref #: DLN027	Date/Time: 31/10/2022
Site Location: Superlot AO-019 (Winthrop Way, Mangere East)	Inspection by: Scott Zhang and Cameron Taylor
Weather: Clear	Inspection with: Amrit Singh (Site Engineer)
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:

Trucks and excavators.

Dust/erosion & sediment control:

N/A

Current active works:

Nil within Superlot

Observations:

Piritahi geotechnical engineers conducted a site walkover and subgrade testing for the Superlot AO-019 within TOC45.

Shear vane and Scala penetrometer testing were conducted across the subgrade. Fine grained soils (clayey SILT/silty CLAY) were observed at the subgrade cut level. Shear vane testing was undertaken in fine grained soils at No. 12 locations along with Scala penetrometer tests to 900 mm depth at No. 12 locations. Test locations are shown in the attached site testing plan.

Corrected peak undrained shear strengths of between 69 and 220+ kPa were recorded, for an average of 135 kPa. This indicates the surficial soils at subgrade level is typically very stiff to hard.

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 fill.

Agreements/recommendations onsite:

Nil.

SITE VISIT RECORD SHEET

Follow-ups and further actions required:

Nil.

Testing results and Site plan attached. Photos below.

Photograph 1: Site overview, looking West.

Piritahi
LAYING THE GROUNDWORK

SITE VISIT RECORD SHEET

Photograph 2: 3 m wide Granular backfill strip on Superlot boundary with Henwood Road.

4
3
5
2
6
12
AO-019
7
1
11
Approx. 3m wide strip of granular material.
10
8
9
AO-020
Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors
LEGEND:
Scala Penetrometer and Shear Vane testing location
Piritahi
LAYING THE GROUNDWORK
Level 8, 139 Quay Street, Auckland, 1010
www.piritahi.nz
ArcGIS Web Map
DATE: 01 Nov 2022
SCALE: 1:282

LAYING THE GROUNDWORK

Shear Vane Results

Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-19*
RL: *18*

Date: *31/10/2022*
Operated by: *CATA and SCZH*
Logged by: *CATA and SCZH*
Checked by:

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

Test	Corrected Undrained Shear Strength
1	69
2	220
3	160
4	148
5	138
6	104
7	138
8	110
9	82
10	107
11	157
12	170

NOTE: Shear vane tests were carried out at the same location as scala penetrometer test, e.g. test 1 corresponds with the location of DCP01

Piritahi

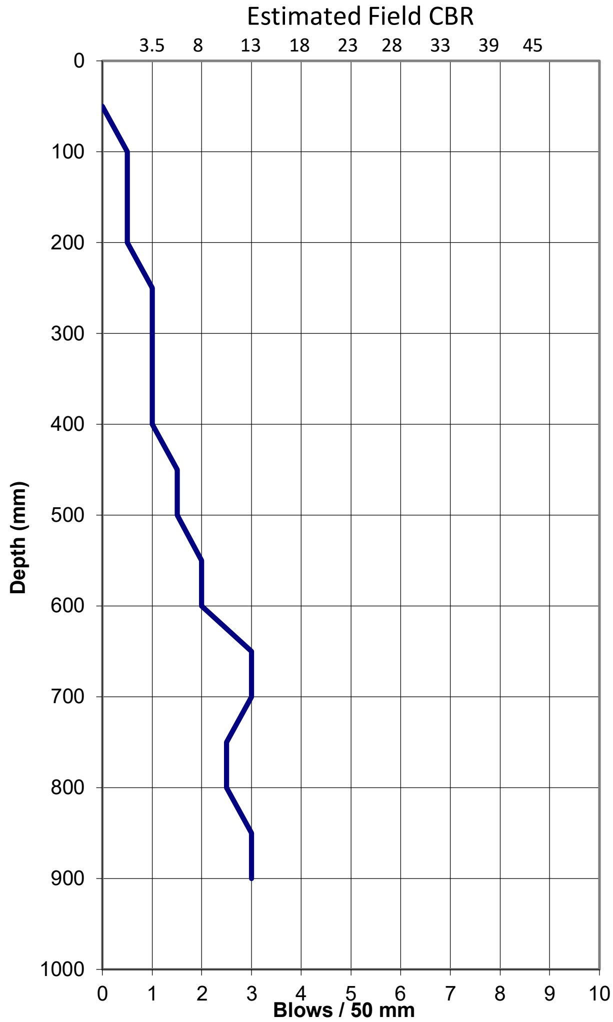
SCALA PENETROMETER LOG

Job No:	*1007708.2086*	Date:	*31/10/2022*
Project:	*Piritahi Aorere*	Operated by:	*CATA and SCZH*
Location:	*AO-19*	Logged by:	*CATA and SCZH*
RL:	*18*	Checked by:	

Test No. ***DCP01***

Sheet ***1*** **of** ***1***

mm Driven	No. of Blows
50	*0*
100	*0.5*
150	*0.5*
200	*0.5*
250	*1*
300	*1*
350	*1*
400	*1*
450	*1.5*
500	*1.5*
550	*2*
600	*2*
650	*3*
700	*3*
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

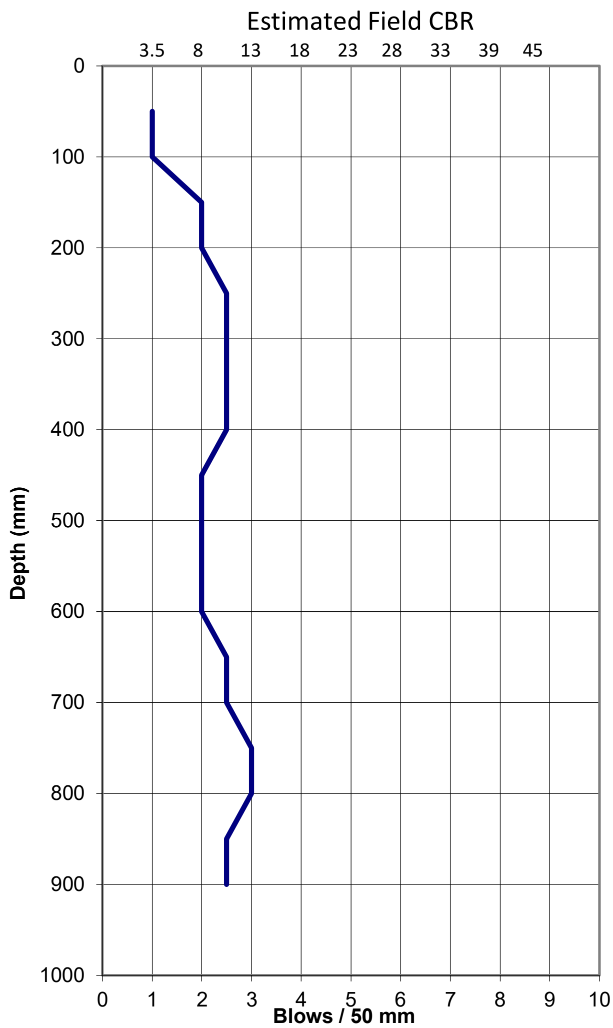
SCALA PENETROMETER LOG

Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-19*
RL: *18*

Date: *31/10/2022*
Operated by: *CATA and SCZH*
Logged by: *CATA and SCZH*
Checked by:

Test No. ***DCP02***
Sheet ***1***
of ***1***

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

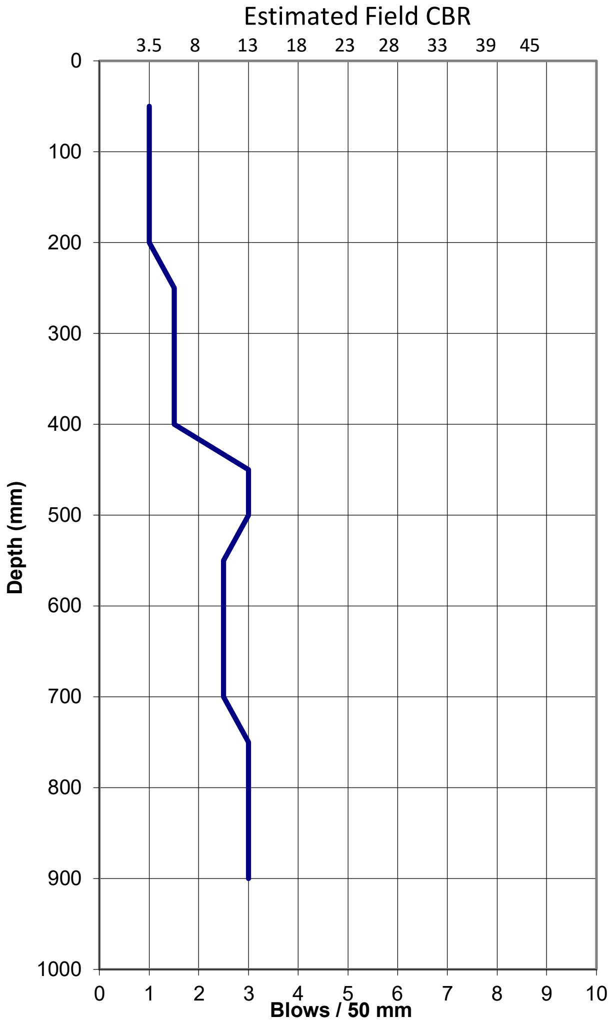
SCALA PENETROMETER LOG

Job No:	*1007708.2086*	Date:	*31/10/2022*
Project:	*Piritahi Aorere*	Operated by:	*CATA and SCZH*
Location:	*AO-19*	Logged by:	*CATA and SCZH*
RL:	*18*	Checked by:	

Test No. ***DCP03***

Sheet ***1*** **of** ***1***

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	*3*
500	*3*
550	*2.5*
600	*2.5*
650	*2.5*
700	*2.5*
750	*3*
800	*3*
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

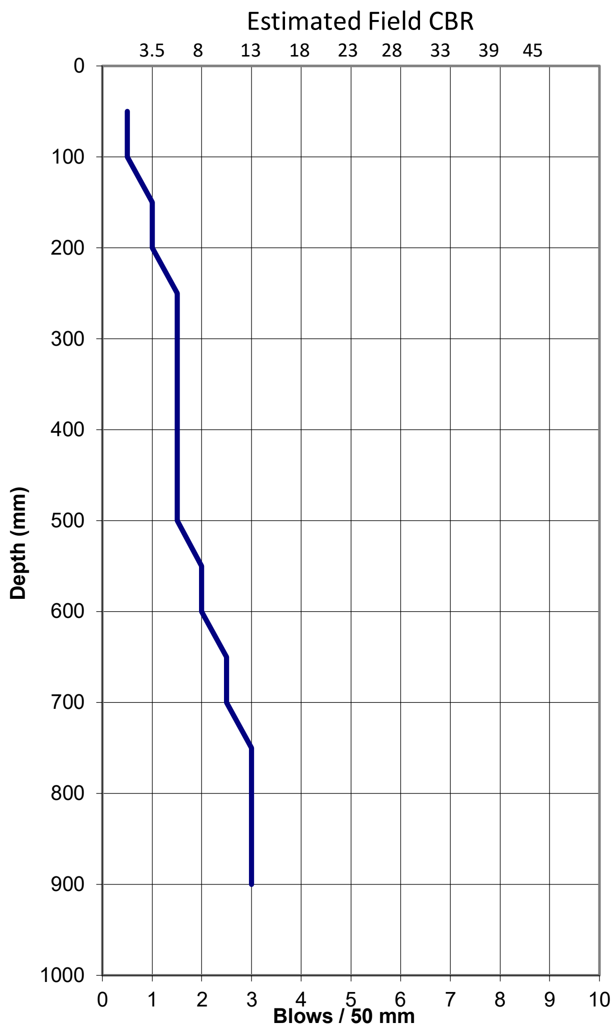
Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-19*
RL: *18*

Date: *31/10/2022*
Operated by: *CATA and SCZH*
Logged by: *CATA and SCZH*
Checked by:

Test No. ***DCP04***

Sheet ***1***
of ***1***

mm Driven	No. of Blows
50	*0.5*
100	*0.5*
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	*2.5*
700	*2.5*
750	*3*
800	*3*
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

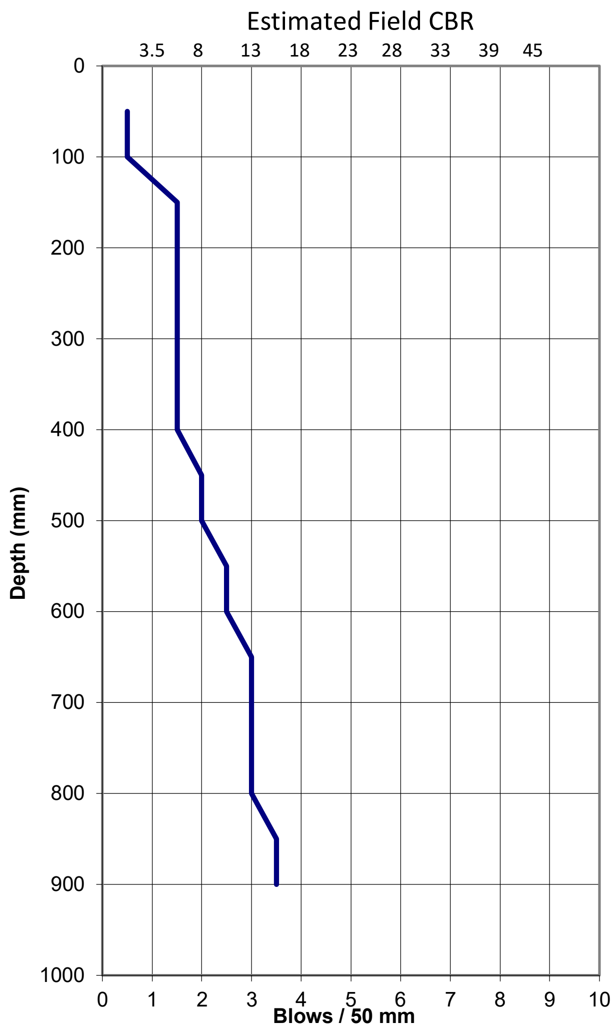
SCALA PENETROMETER LOG

Job No:	*1007708.2086*	Date:	*31/10/2022*
Project:	*Piritahi Aorere*	Operated by:	*CATA and SCZH*
Location:	*AO-19*	Logged by:	*CATA and SCZH*
RL:	*18*	Checked by:	

Test No. ***DCP05***

Sheet ***1*** **of** ***1***

mm Driven	No. of Blows
50	*0.5*
100	*0.5*
150	*1.5*
200	*1.5*
250	*1.5*
300	*1.5*
350	*1.5*
400	*1.5*
450	*2*
500	*2*
550	*2.5*
600	*2.5*
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

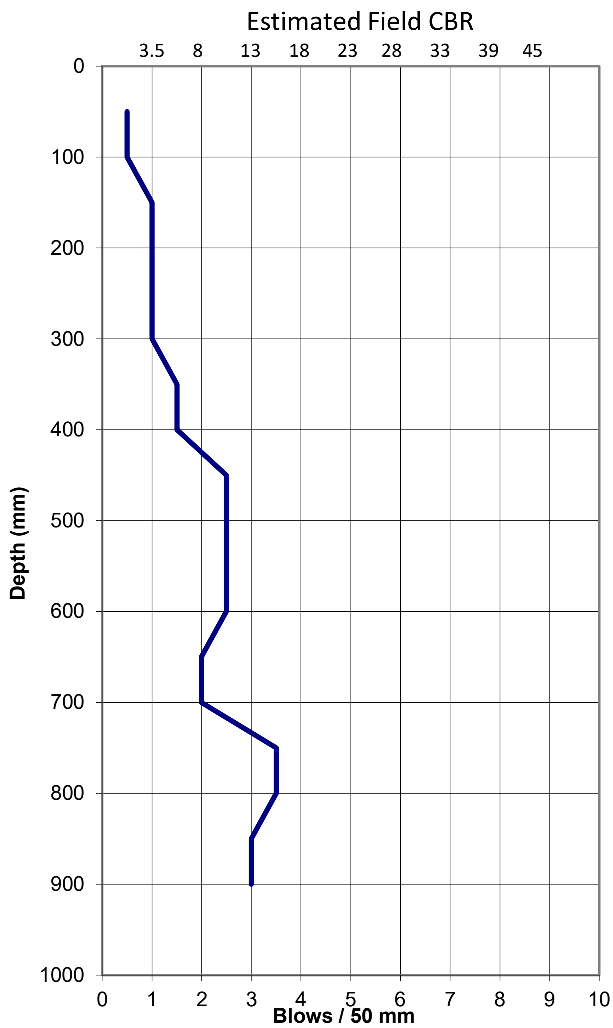
SCALA PENETROMETER LOG

Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-19*
RL: *18*

Date: *31/10/2022*
Operated by: *CATA and SCZH*
Logged by: *CATA and SCZH*
Checked by:

Test No. ***DCP06***
Sheet ***1***
of ***1***

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	*2.5*
600	*2.5*
650	*2*
700	*2*
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

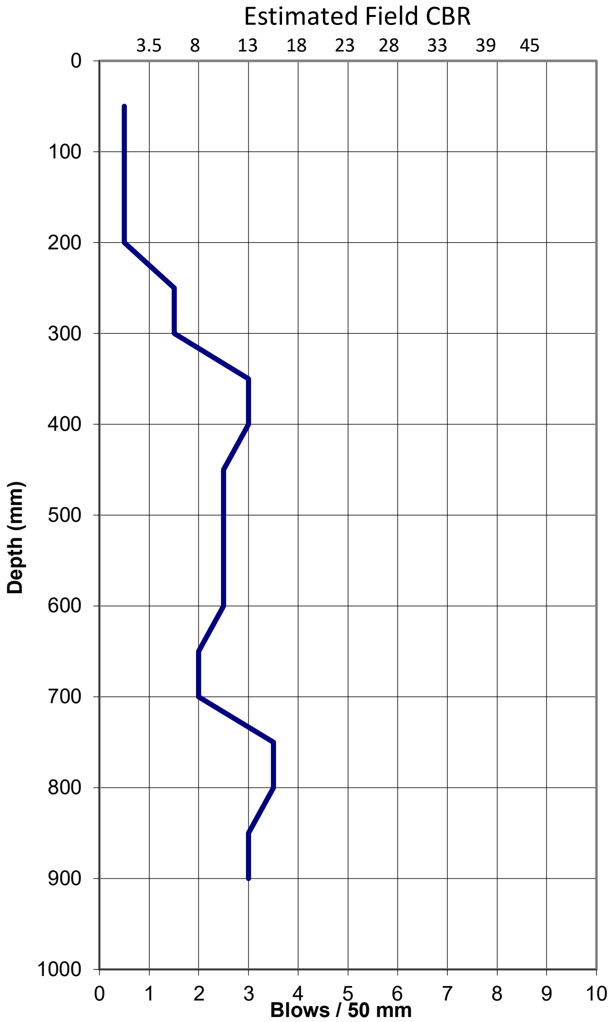
Job No: *1007708.2086*
Project: *Piritahi Aorere*
Location: *AO-19*
RL: *18*

Date: *31/10/2022*
Operated by: *CATA and SCZH*
Logged by: *CATA and SCZH*
Checked by:

Test No. ***DCP07***

Sheet ***1*** **of** ***1***

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

Piritahi

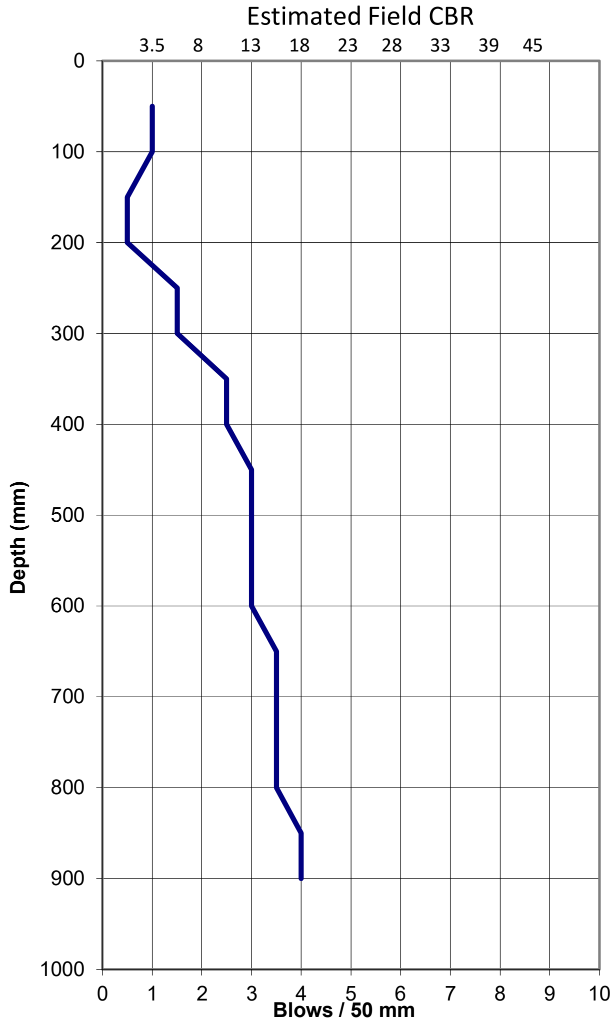
SCALA PENETROMETER LOG

Job No:	*1007708.2086*	Date:	*31/10/2022*
Project:	*Piritahi Aorere*	Operated by:	*CATA and SCZH*
Location:	*AO-19*	Logged by:	*CATA and SCZH*
RL:	*18*	Checked by:	

Test No. ***DCP08***

Sheet ***1*** **of** ***1***

mm Driven	No. of Blows
50	*1*
100	*1*
150	*0.5*
200	*0.5*
250	*1.5*
300	*1.5*
350	*2.5*
400	*2.5*
450	*3*
500	*3*
550	*3*
600	*3*
650	*3.5*
700	*3.5*
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

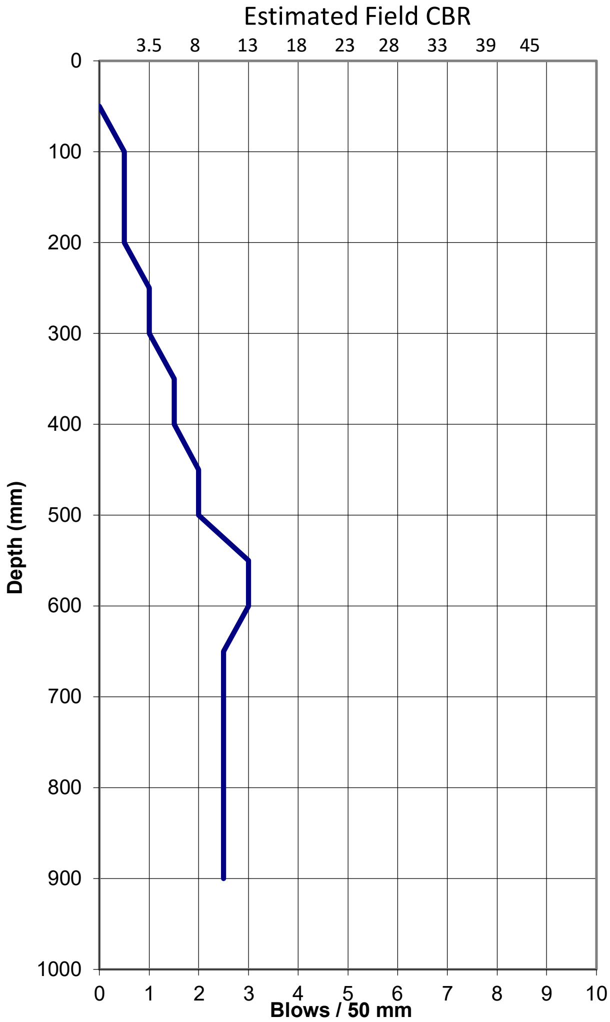
SCALA PENETROMETER LOG

Job No:	*1007708.2086*	Date:	*31/10/2022*
Project:	*Piritahi Aorere*	Operated by:	*CATA and SCZH*
Location:	*AO-19*	Logged by:	*CATA and SCZH*
RL:	*18*	Checked by:	

Test No. ***DCP09***

Sheet ***1*** **of** ***1***

mm Driven	No. of Blows
50	*0*
100	*0.5*
150	*0.5*
200	*0.5*
250	*1*
300	*1*
350	*1.5*
400	*1.5*
450	*2*
500	*2*
550	*3*
600	*3*
650	*2.5*
700	*2.5*
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'

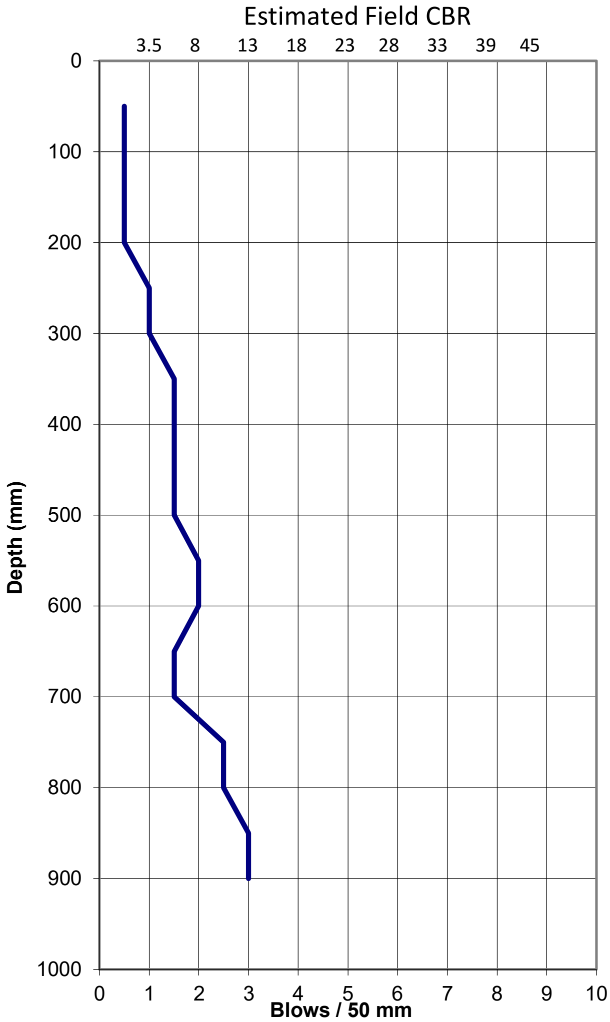
Test Method Used: NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer

Piritahi

SCALA PENETROMETER LOG

Job No: *1007708.2086*	Date: *31/10/2022*	**Test No.**	***DCP10***
Project: *Piritahi Aorere*	Operated by: *CATA and SCZH*		
Location: *AO-19*	Logged by: *CATA and SCZH*	**Sheet**	***1***
RL: *18*	Checked by:	**of**	***1***

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

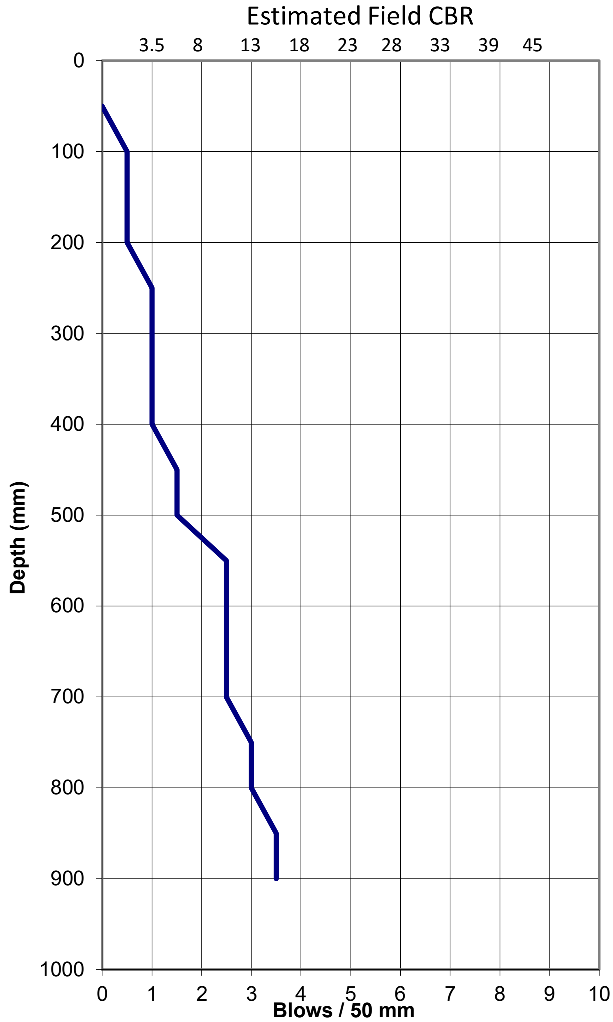
SCALA PENETROMETER LOG

Job No:	*1007708.2086*	Date:	*31/10/2022*
Project:	*Piritahi Aorere*	Operated by:	*CATA and SCZH*
Location:	*AO-19*	Logged by:	*CATA and SCZH*
RL:	*18*	Checked by:	

Test No. ***DCP11***

Sheet ***1*** **of** ***1***

mm Driven	No. of Blows
50	*0*
100	*0.5*
150	*0.5*
200	*0.5*
250	*1*
300	*1*
350	*1*
400	*1*
450	*1.5*
500	*1.5*
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'

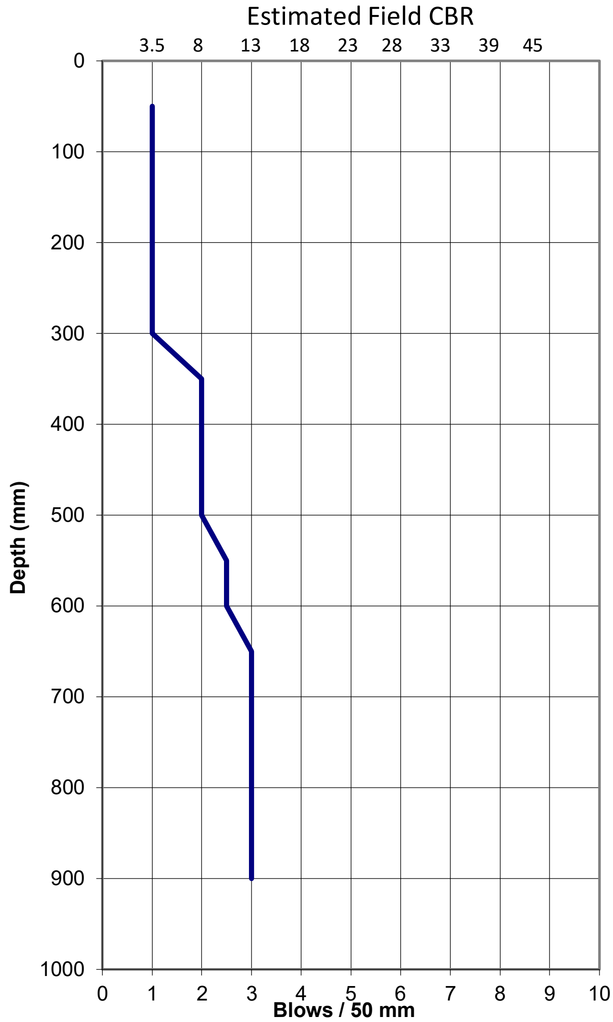
Test Method Used: NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer

Piritahi

SCALA PENETROMETER LOG

Job No: *1007708.2086*	Date: *31/10/2022*	**Test No.**	***DCP12***
Project: *Piritahi Aorere*	Operated by: *CATA and SCZH*		
Location: *AO-19*	Logged by: *CATA and SCZH*	**Sheet**	***1***
RL: *18*	Checked by:	**of**	***1***

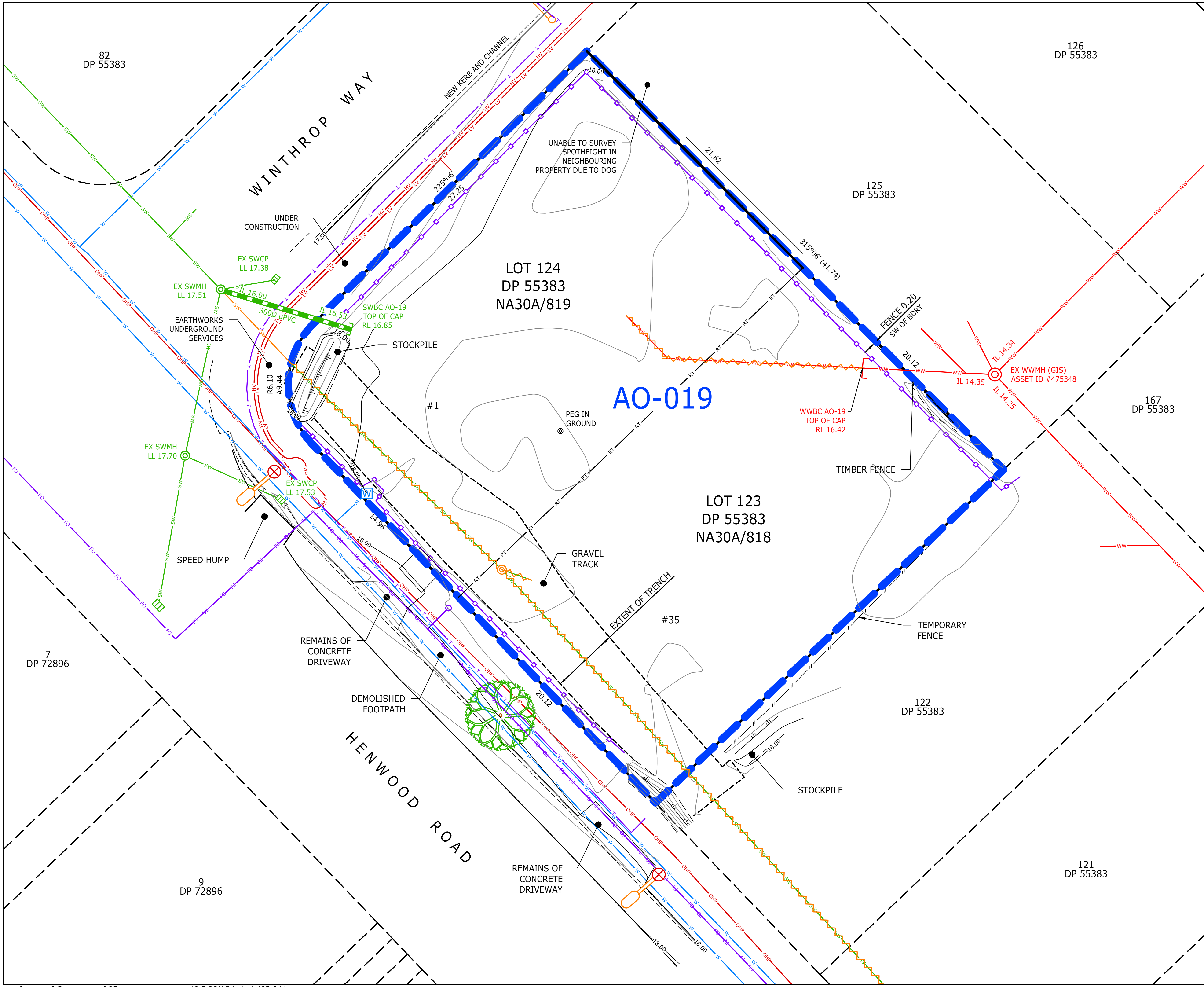
mm Driven	No. of Blows
50	*1*
100	*1*
150	*1*
200	*1*
250	*1*
300	*1*
350	*2*
400	*2*
450	*2*
500	*2*
550	*2.5*
600	*2.5*
650	*3*
700	*3*
750	*3*
800	*3*
850	*3*
900	*3*



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

Appendix B – As Built Plans



0 2.5 6.25 12.5 SCALE (m) 1:125 @A1
1:250 @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.

LEGEND:

- TOP OF BANK
- BOTTOM OF BANK
- FENCE
- SILT FENCE
- EDGE OF METAL
- STORMWATER
- SANITARY SEWER
- STORMWATER REMOVED
- WASTEWATER REMOVED
- ABANDONED STORMWATER
- WATERMAIN (DB4YD-GIS)
- OVERHEAD POWERLINE (DB4YD-GIS)
- HIGH VOLTAGE (DB4YD-GIS)
- LOW VOLTAGE (DB4YD-GIS)
- TELECOMMUNICATION (DB4YD-GIS)
- STORMWATER LID OR PIT
- SANITARY SEWER LID OR PIT
- STORMWATER CATCHPIT
- WATER METER
- BLANKCAP
- LUMINAIRE
- STREET LIGHT

Kāinga Ora
Homes and Communities

Piritahi
LAYING THE GROUNDWORK

1	FOR HANDOVER	RBH	11.11.2022
REVISION DETAILS		BY	DATE

PROJECT:
AORERE
STAGE 2

DESCRIPTION:
SUPERLOT AO-019
HANDOVER PLAN

SURVEYED	MJS	11.2022
DESIGNED		
DRAWN	CA	11.2022
CHECKED	RBH	11.11.2022
APPROVED	RBH	11.11.2022

N

SCALE	1:125 @A1	1:250 @A3	REVISION
STATUS	FOR HANDOVER		1
PRECINCT	MĀNGERE		
DWG NO	TOC054-AO19		

Synergy Version:

Plot Date: 1:20:26 pm, 14 November 2022, COLE AINU'U

File: C:\12DS\DATA\SYNERGYSERVER\TOC045 - AORERE STAGE 2_1168\1D\04 SURVEY\CAD\TOC045-AO0-0019.DWG

Appendix C – Piritahi Test Results

Piritahi
LAYING THE GROUNDWORK

CLEGG HAMMER TEST RECORD SHEET

TOC No & Name:	AORERE STAGE 2	Date:	20/10/2022
Location/Description	AO-019	Layer:	Subgrade to FFL

Test Methods:

Material Type:	GAP 65	Clegg Hammer ID:	713434.03 / 19.0029 S/N
Material Description:	Hardfill Backfill	Calibration Expiry Date:	28/10/2023
Criteria:	According to ITP >30	Drops:	4

Test Location Number	Location		Clegg Impact Value (CIV)	Test Location Number	Location		Clegg Impact Value (CIV)
	Dist. from DS MH (m)	Depth (mm)			Dist. from DS MH (m)	Depth (mm)	
1	Ref Site Plan	1.7m	32	3	Ref Site Plan	1.7m	32
	Ref Site Plan	1.5m	34		Ref Site Plan	1.5m	34
	Ref Site Plan	1.2m	33		Ref Site Plan	1.2m	32
	Ref Site Plan	1.0m	30		Ref Site Plan	1.0m	32
	Ref Site Plan	0.8m	32		Ref Site Plan	0.8m	36
	Ref Site Plan	0.6m	36		Ref Site Plan	0.6m	33
	Ref Site Plan	0.4m	32		Ref Site Plan	0.4m	33
	Ref Site Plan	0.2m	32		Ref Site Plan	0.2m	31
	Ref Site Plan	0.0m	31		Ref Site Plan	0.0m	33
2	Ref Site Plan	1.7m	36	4	Ref Site Plan	1.7m	32
	Ref Site Plan	1.5m	32		Ref Site Plan	1.5m	34
	Ref Site Plan	1.2m	34		Ref Site Plan	1.2m	32
	Ref Site Plan	1.0m	33		Ref Site Plan	1.0m	32
	Ref Site Plan	0.8m	36		Ref Site Plan	0.8m	36
	Ref Site Plan	0.6m	33		Ref Site Plan	0.6m	33
	Ref Site Plan	0.4m	33		Ref Site Plan	0.4m	33
	Ref Site Plan	0.2m	31		Ref Site Plan	0.2m	31
	Ref Site Plan	0.0m	32		Ref Site Plan	0.0m	33

LAYING THE GROUNDWORK

CLEGG HAMMER TEST RECORD SHEET

Tested By:	Harjot Singh	Date: 10/11/2022
Reviewed By:	Glen Gibbon	Date: 10/11/2022

Test Locations
Not Included in this.
1
2
3
4
AO-019
AO-020
WINTHROP WAY
HENWOOD ROAD
300 Concrete
100 AC
DTI 2.5
DTI 1.9
375 CLS
150 AC
150 PE (Rising)
40 AC
20 PE
100 PVC-U

Piritahi
LAYING THE GROUNDWORK

SHEAR VANE FIELD TEST RECORD SHEET

TOC No & Name:	AORERE STAGE 2	Date:	20/8/2022
Location:	AO-019	Layer:	Subgrade to FFL, (3 layers)

Test Methods:

Material Type: Site won cohesive fill	Shear Vane ID: 3048
Material Description: Moist Clay	Calibration Expiry Date: 29/10/2023
Site Plan Attached: Refer to attached site plan	Vane Conversion Factor: 1.327

Test Location Number	Location (Or Show on Site Plan)		Shear Vane Uncorrected Dial Readings (kPa) (4 Readings per Test Location)					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 (WW)	Ref Site Plan	1.5m Depth	90	100	105	110	101	101 x 1.327 = 134
	Ref Site Plan	1.0m Depth	100	UTP	UTP	UTP	100	100 x 1.327 = 133
	Ref Site Plan	0.5m Depth	100	100	110	105	105	105 x 1.327 = 139
	Ref Site Plan	0.0m Depth	90	100	105	110	101	101 x 1.327 = 134
2 (WW)	Ref Site Plan	1.5m Depth	90	100	105	110	101	101 x 1.327 = 134
	Ref Site Plan	1.0m Depth	100	UTP	UTP	UTP	100	100 x 1.327 = 133
	Ref Site Plan	0.5m Depth	100	100	110	105	105	105 x 1.327 = 139
	Ref Site Plan	0.0m Depth	90	105	110	100	101	104 x 1.327 = 138
3 (WW)	Ref Site Plan	1.5m Depth	100	100	110	105	105	105 x 1.327 = 139
	Ref Site Plan	1.0m Depth	90	100	105	110	101	101 x 1.327 = 134
	Ref Site Plan	0.5m Depth	100	100	110	105	105	105 x 1.327 = 139
	Ref Site Plan	0.0m Depth	90	100	105	110	101	101 x 1.327 = 134
4 (WW)	Ref Site Plan	1.5m Depth	90	100	105	110	101	101 x 1.327 = 134
	Ref Site Plan	1.0m Depth	100	UTP	UTP	UTP	100	100 x 1.327 = 133
	Ref Site Plan	0.5m Depth	100	UTP	UTP	UTP	100	100 x 1.327 = 133
	Ref Site Plan	0.0m Depth	90	105	110	100	101	104 x 1.327 = 138
5 (WW)	Ref Site Plan	1.5m Depth	90	100	105	110	101	101 x 1.327 = 134
	Ref Site Plan	1.0m Depth	90	100	105	110	101	101 x 1.327 = 134

Piritahi

LAYING THE GROUNDWORK

SHEAR VANE FIELD TEST RECORD SHEET

	Ref Site Plan	0.3m Depth	100	100	110	105	105	105 x 1.327 = 139
	Ref Site Plan	0.0m Depth	90	100	105	110	101	101 x 1.327 = 134

Tested By: Amrit Singh	Date: 20/8/2022
Reviewed By: Glen Gibbons	Date: 09/11/2022

WINTHROP WAY
HENWOOD ROAD
1
2
3
4
5
150 AC
100 PVC-U
100 PVC-U
100 PVC-U
150 AC
AO-019
Test Locations
100 PVC-U
AO-020
150 AC
Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Piritahi Testing

Shea Farrell
Created Tue, 15 Nov 2022, 1:58 PM (UTC+13)

Hardfill/Backfill Testing

Testing Instructions
Granular Back Fill - Clegg Hammer testing is to be undertaken at 12m intervals (minimum 2 per line) with one test completed in the bedding/haunching, overlay and backfill zones to ensure satisfactory compaction is achieved.

Cohesive Soil Backfill (i.e. Clay) - Shear Vane testing is to be undertaken at 12m intervals with one test completed in the bedding/haunching (clegg), overlay and backfill zones to ensure satisfactory compaction is achieved.

Refer to the Piritahi Test and Inspection Plan for minimum test requirement.

Photo and video

Line ID Existing to ao-19

Testing

Location from Downstream Manhole, m	Location	Soil and Test Type	Test Depth, m	Value 1 (CIV or KPA)
5	Carriage Way or within 1m of Kerb	Granular (Clegg)	1.2	41
5	Carriage Way or within 1m of Kerb	Granular (Clegg)	0.9	31
5	Carriage Way or within 1m of Kerb	Granular (Clegg)	0.6	39
5	Carriage Way or within 1m of Kerb	Granular (Clegg)	0.3	32
5	Carriage Way or within 1m of Kerb	Granular (Clegg)	0	39
5	Carriage Way or within 1m of Kerb	Granular (Clegg)	1.8	33

Value 2 (CIV or KPA)	Average Value	Photo	Comments
32	36.50	  See full page photos attached at end of PDF	Hardfill
42	36.50	  See full page photos attached at end of PDF	

Value 2 (CIV or KPA)	Average Value	Photo	Comments
41	40.00	  See full page photos attached at end of PDF	
32	32.00	  See full page photos attached at end of PDF	
32	35.50	  See full page photos attached at end of PDF	
32	32.50	  See full page photos attached at end of PDF	Bedding under pipe

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:05 pm
Tags:
Description:
Comments:

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:05 pm
Tags:
Description:
Comments:

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:05 pm
Tags:
Description:
Comments:

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:05 pm
Tags:
Description:
Comments:

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:13 pm
Tags:
Description:
Comments:

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:13 pm
Tags:
Description:
Comments:

No GPS information available

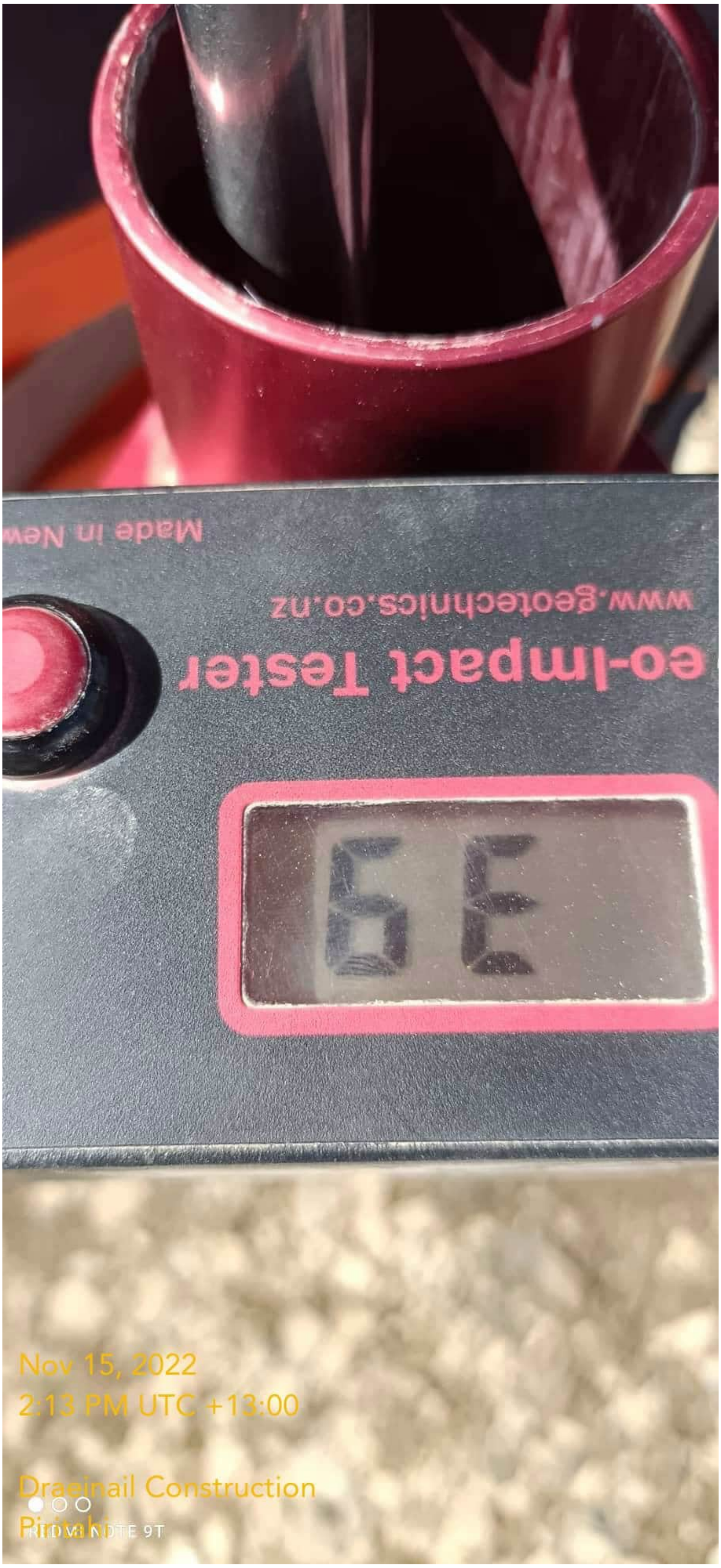
Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:13 pm
Tags:
Description:
Comments:

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:13 pm
Tags:
Description:
Comments:

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:13 pm
Tags:
Description:
Comments:



No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:13 pm
Tags:
Description:
Comments:

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:13 pm
Tags:
Description:
Comments:

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:13 pm
Tags:
Description:
Comments:

Appendix D – Geotechnics Testing

GEOTECHNICS

31 October 2022
Our Ref: 1041000.0045.1.0/Rep6
Customer Ref: K0023819

Korahi Alliance Limited
Level 8, 139 Quay Street
Auckland 1010

Attention: Amrit Singh

Dear Amrit

TOC045-Mangere-Aorere-Stage 2-DIM086/CIM086. Superlot AO-019

Site Report – Quality Assurance Testing

Customer's Instructions

We were instructed to complete:

Nuclear densometer testing at the above-mentioned site when requested by the customer and report the results.

Specifications

Specification provided by Harjot (Piritahi) states that compaction must be $\geq$ 92% of MDD.

Refer to Piritahi ITP: AAAA-DS-ITP-0002-Earthworks-Fill

Laboratory Determined Parameters of Material:

Material Type	Maximum Dry Density	Optimum Water Content	Solid Density (Assumed)	Report Reference Number/Supplier
	t/m^3	%	t/m^3	
MANARC65	2.20	-	-	Verbally provided on site by Harjot

Date of Procedure

Testing was carried out on the 21st of October 2022.

Locations

Test locations were determined on site by the Geotechnics technician on behalf of the customer. Individual test locations were selected to be representative of the test area.

The attached plan(s) provides indicative locations only and is not to scale. All other information we provide regarding location should be referenced to the asset owner.

Method

NZS 4407:2015 Test 4.3 Method using a nuclear surface moisture density-gauge (Backscatter mode) - NDM

Material Description

Material descriptions are provided in the attached results. All descriptions were provided by the customer.

Results

The following is attached:

- Hardfill Summary & Test Location Plans.

Test Remarks

NDM – Backscatter

The test method may not be appropriate for materials containing a nominal maximum particle size of >40 mm.

The wet density and moisture content were measured by the nuclear densometer.

The calculation of percentage compaction is obtained from NDM density values and customer provided maximum dry density (MDD) target.

Pass/Fail Criteria

We accept no liability for any circumstances that may arise due to the inclusion of the pass/fail criteria or the use of this information by third parties. Pass/fail criteria are based solely on numerical values with no consideration given to uncertainty and are not covered under the IANZ endorsement of these results.

General Remarks

This report has been prepared for the benefit of Korahi Alliance Limited, with respect to the particular brief given to us and it cannot be relied upon in other contexts or for any other purpose without our prior review and agreement.

The inherent uncertainties of site investigation work, mean the nature and continuity of subsoil away from the test location could vary from the data logged.

Material descriptions are not covered under the IANZ endorsement of this report.

Please reproduce this report in full when transmitting to others or including in internal reports.

If we can be of any further assistance, feel free to get in touch. Contact details are provided at the bottom of the letterhead page.

GEOTECHNICS LTD

Report approved by:

Daniel Brasting
Project Manager
Key Technical Person

Authorised for Geotechnics by:

Digitally signed by Anthony Gilliland
DN: cn=Anthony Gilliland, c=NZ, email=agilliland@geotechnics.co.nz
Date: 2022.10.31 16:44:18 +13'00'

Anthony Gilliland
Project Director

ACCREDITED IANZ TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

31-Oct-22
t:\geotechnicsgroup\projects\1041000\1041000.0045\issueddocuments\report 6 - superlot ao-019\31 october 2022.docx

GEOTECHNICS

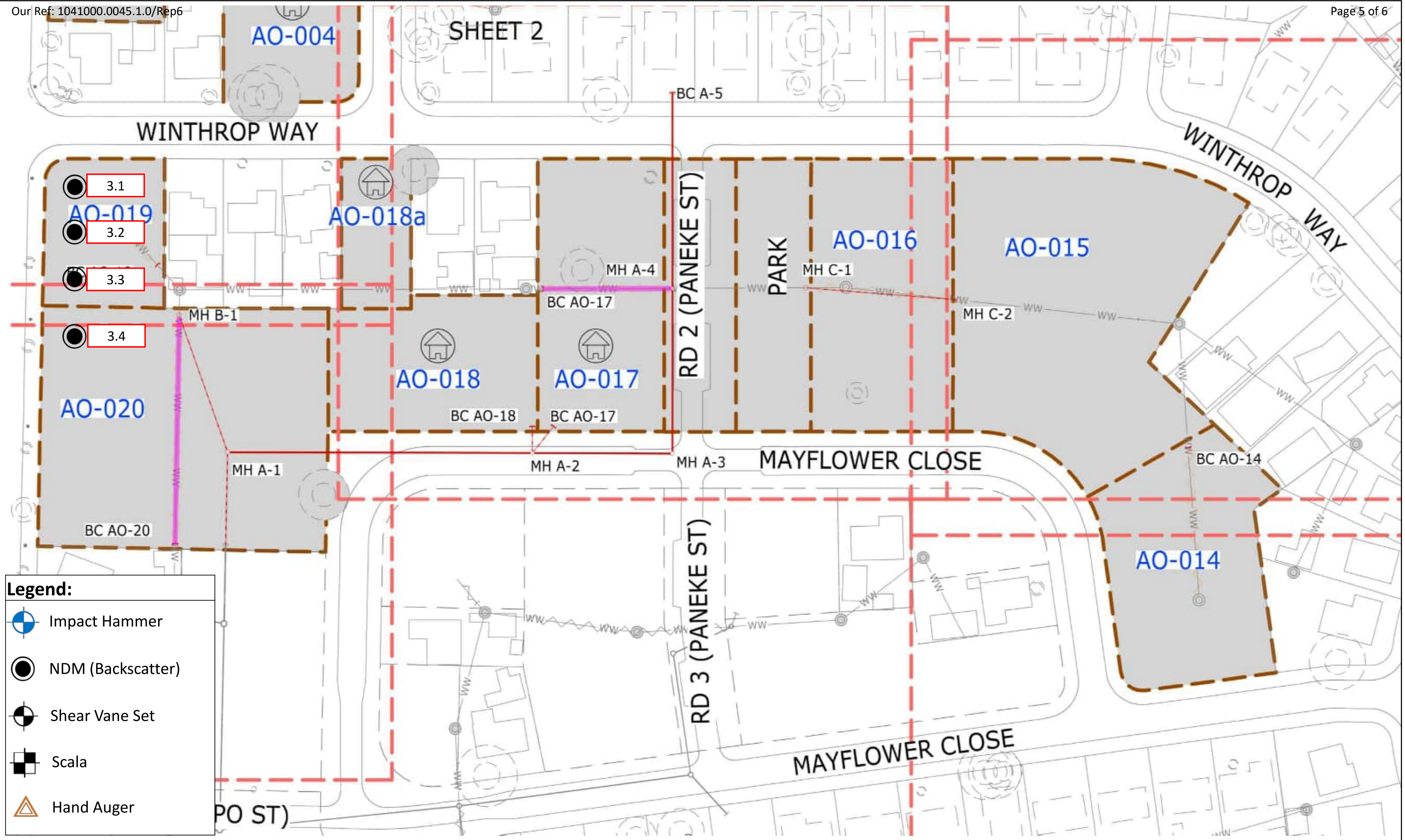
1 Hill Street
Onehunga
Auckland 1061
New Zealand
p. +64 9 356 3510

Project Name: TOC045-Mangere-Aorere-Stage 2-

Customer: Piritahi

Project Number	**1041000.0045.1.0/Rep6**
Entered By	**KELF**
Checked By	**DAMC**
Approved by KTP	**DBRA**

URN.	Tech.	Date	Material Type	Location	Layer	Chainage	Offset	Nuclear Density (Backscatter)								Impact Value 1	Retest URN	PASS / FAIL	Comments
								Wet Density (t/m^3)	Dry Density (t/m^3)	Moisture Content (%)	Maximum Dry Density (t/m^3)	% Maximum Dry Density	Solid Density (t/m^3)	% Solid Density	% Total Voids			(P) Pass (F) Fail	
3.1	KELF	21/10/2022	MANARC65	Trench Fill Area	1st Lift	-	-	**2.17**	**2.03**	**6.6**	**2.20**	**92.4%**	**-**	**-**	**-**	-	**-**	**P**	**Specification provided requires ≥ 92% of the MDD.**
3.2						-	-	**2.25**	**2.15**	**4.7**	**2.20**	**97.5%**	**-**	**-**	**-**	-	**-**	**P**	
3.3						-	-	**2.18**	**2.07**	**5.3**	**2.20**	**94.0%**	**-**	**-**	**-**	-	**-**	**P**	
3.4						-	-	**2.16**	**2.02**	**6.6**	**2.20**	**92.0%**	**-**	**-**	**-**	-	**-**	**P**	
4.1	KELF	21/10/2022	MANARC65	Trench Fill Area	2nd Lift	-	-	**2.20**	**2.13**	**3.4**	**2.20**	**96.9%**	**-**	**-**	**-**	-	**-**	**P**	
4.2						-	-	**2.36**	**2.27**	**4.0**	**2.20**	**103.2%**	**-**	**-**	**-**	-	**-**	**P**	
4.3						-	-	**2.17**	**2.07**	**4.7**	**2.20**	**94.2%**	**-**	**-**	**-**	-	**-**	**P**	
4.4						-	-	**2.27**	**2.18**	**4.3**	**2.20**	**98.9%**	**-**	**-**	**-**	-	**-**	**P**	
4.5						-	-	**2.26**	**2.16**	**4.6**	**2.20**	**98.3%**	**-**	**-**	**-**	-	**-**	**P**	

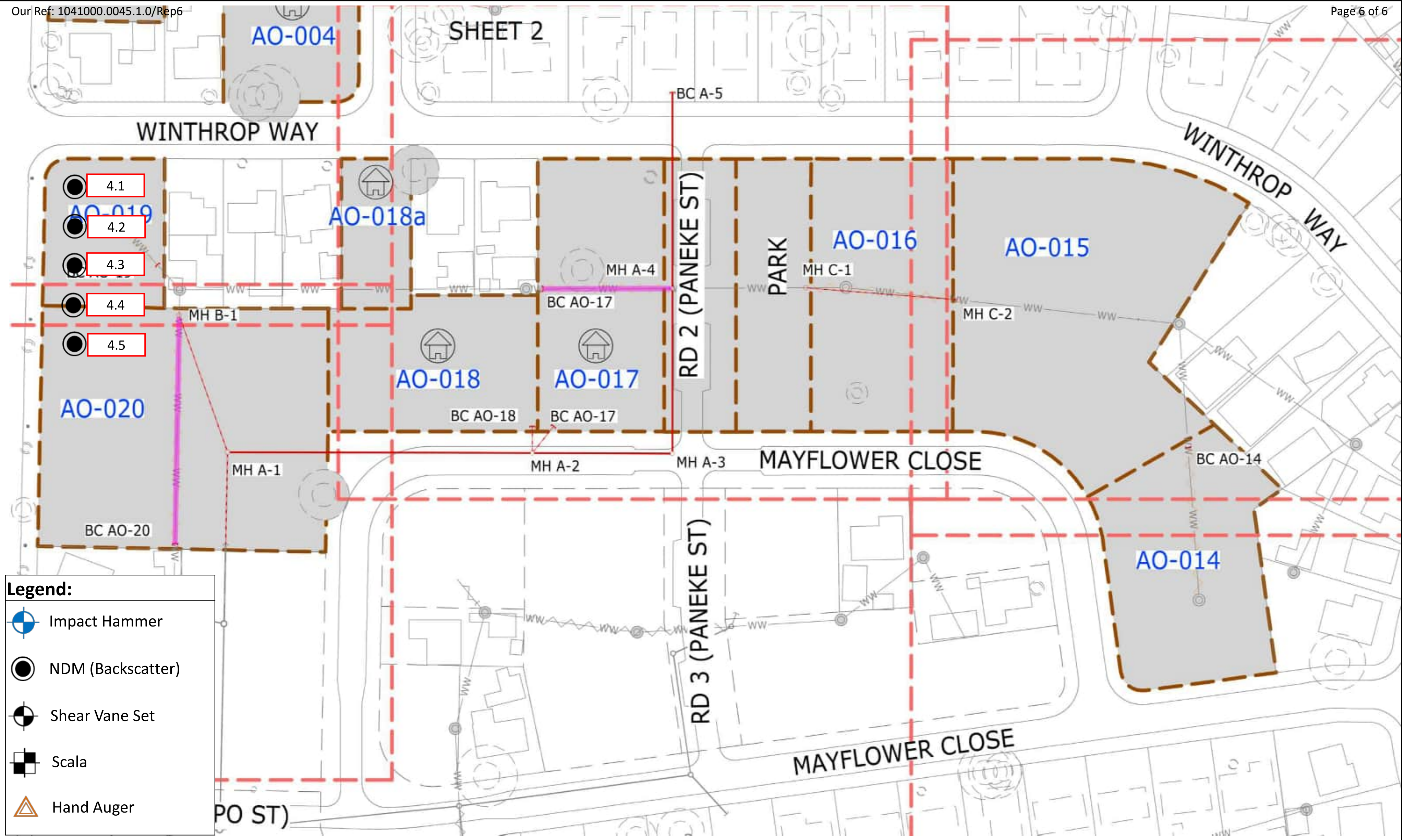


GEOTECHNICS LTD.
1 Hill Street, Onehunga
Auckland, New Zealand
ph. +64 (0)9 356 3510
e. enquiry@geotechnics.co.nz
w. www.geotechnics.co.nz

GEOTECHNICS

Test Location Plan

Site:	Mangere Precinct TOC45	Job Name:	TOC045-Mangere-Aorere-Stage 2-DIM086/CIM086	Drawn:	KELF	Date:	21/10/2022
Location:	Superlot AO-019	Job No.:	1041000.0045.1.0/Rep6	URN:	3	Date:	21/10/2022
		Lab Ref:	- N/A	Scale:	Not to Scale	Rev.:	1



GEOTECHNICS LTD.
1 Hill Street, Onehunga
Auckland, New Zealand
ph. +64 (0)9 356 3510

e. enquiry@geotechnics.co.nz

w. www.geotechnics.co.nz

Test Location Plan

Site:	Mangere Precinct TOC45	Job Name:	TOC045-Mangere-Aorere-Stage 2-DIM086/CIM086	Drawn:	KELF	Date:	21/10/2022
Location:	Superlot AO-019	Job No.:	1041000.0045.1.0/Rep6	URN:	4	Date:	21/10/2022
		Lab Ref:	- N/A	Scale:	Not to Scale	Rev.:	1

29 August 2022
Our Ref: 1041000.0045.1.0/Rep3

Korahi Alliance Limited
Level 8, 139 Quay Street
Auckland 1010

Attention: Amrit Singh

Dear Amrit,

TOC045-Mangere-Aorere-Stage 2-DIM086/CIM086. Superlot AO-019

Site Report – Quality Assurance Testing

Customer's Instructions

We were instructed to complete:

Nuclear densometer and shear vane testing at the above-mentioned site when requested by the customer and report the results.

Specifications

Specification provided by Amrit (Piritahi) states that average air voids must be ≤ 8% with maximum value 10%.
Average shear vane values over 4 readings ≥ 130 kPa with no value below 120 kPa.

Refer to Piritahi ITP AAAA-DS-ITP-0002-Earthworks-Fill.

Date of Procedure

Testing was carried out on the 25th of May 2022.

Locations

Test locations were determined on site by the Geotechnics technician on behalf of the customer. Individual test locations were selected to be representative of the test area.

The attached plan(s) provides indicative locations only and is not to scale. All other information we provide regarding location should be referenced to the asset owner.

Methods

NZGS 8:2001 - Test method for determining the vane shear strength of a cohesive soil using a hand held shear vane

NZS 4407:2015 Test 4.2 - Method using a nuclear surface moisture-density gauge (Direct Transmission Mode) – NDM

NZS 4407:2015 Test 3.1 - Determination of water content

Material Description

Material descriptions are provided in the attached results. All descriptions were provided by the customer.

Results

The following is attached:

- Earthworks Summary & Test Location Plans.

Test Remarks

Shear Vane

Shear Vane tests are potentially unsuitable for material described in the earthworks summary as ‘claySILT w/ Gravel.’ Tests in this material may not be compliant with the stated test method and results are therefore not covered under the IANZ endorsement of this report.

NDM – Direct Transmission

The test method may not be appropriate for materials containing a nominal maximum particle size of >40 mm.

Nuclear densometers are calibrated for a bulk density range of 1,728 kg/m^3 to 2,756 kg/m^3. Test results outside of these bulk density limits are not covered under the IANZ endorsement of this report.

An assumed solid density value of 2.70 t/m^3 was agreed with the customer. We do not take responsibility for misrepresentation or misinterpretation arising from the use of this assumed value to calculate air voids.

Where oven calculated air voids are negatives, these have been reported as zero.

The calculation of air voids is based on wet density (measured by the nuclear densometer), moisture content (measured by oven drying) and solid density (either assumed or measured by laboratory testing). Negative air voids may be caused by incorrect assumed solid density or due to the variability of onsite material when compared to that tested in a laboratory.

Determination of Water Content

Samples used for the determination of the water content were taken from each test location and disposed of after 24 hours.

Pass/Fail Criteria

We accept no liability for any circumstances that may arise due to the inclusion of the pass/fail criteria or the use of this information by third parties. Pass/fail criteria are based solely on numerical values with no consideration given to uncertainty and are not covered under the IANZ endorsement of these results.

General Remarks

This report has been prepared for the benefit of Korahi Alliance Limited, with respect to the particular brief given to us and it cannot be relied upon in other contexts or for any other purpose without our prior review and agreement.

The inherent uncertainties of site investigation work, mean the nature and continuity of subsoil away from the test location could vary from the data logged.

Material descriptions are not covered under the IANZ endorsement of this report.

Please reproduce this report in full when transmitting to others or including in internal reports.

If we can be of any further assistance, feel free to get in touch. Contact details are provided at the bottom of the letterhead page.

GEOTECHNICS LTD

Report prepared by:	Authorised for Geotechnics by:
....	....
Daniel McKay Auckland Field Coordinator	Anthony Gilliland Project Director

Report checked by:

....

Daniel Brasting
Project Manager
Key Technical Person

ACCREDITED TESTING LABORATORY

Test results indicated as not accredited are outside the scope of the laboratory's accreditation

29-Aug-22
t:\geotechnicsgroup\projects\1041000\1041000.0045\issueddocuments\report 3 - superlot ao-019 earthworks\29 august 2022.docx

GEOTECHNICS

1 Hill Street
Onehunga
Auckland, NZ
ph. +64 9 356 3510

Job Name :TOC045-Mangere-Aorere-Stage 2-DIM086/CIM086

Customer : Piritahi

Job #	1041000.0045.1.0/Rep3
Entered By	KINO
Checked By	DAMC
Approved By	DBRA

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	KINO	25/05/2022	Lateral 1	1.5m Below Finish Level	ClaySILT with Gravel	NDM / SV	1.66	50.6	3.7	1.65	52.5	3.0	**1.65**	**51.6**	**3.3**	2.70	43.5	1.15	**7.2**	188	UTP	UTP	UTP	>188	-	**P**	Specification provided states that average air voids must be ≤ 8% with 10% maximum value. Average shear vane values ≥ 120kPa. Average = 8%
1.2			Lateral 2			NDM / SV	1.69	47.0	3.4	1.68	50.1	2.8	**1.68**	**48.6**	**3.0**	2.70	37.4	1.22	**8.8**	188	UTP	UTP	UTP	>188	-	**P**	

Legend:

- Impact Hammer
- NDM (Backscatter)
- Shear Vane
- Scala
- Hand Auger

GEOTECHNICS LTD.
1 Hill Street, Onehunga
Auckland, New Zealand
ph. +64 (0)9 356 3510
e. enquiry@geotechnics.co.nz
w. www.geotechnics.co.nz

Test Location Plan

Site:	Mangere Precinct TOC45	Job Name:	TOC045-Mangere-Aorere-Stage 2-DIM086/CIM086	Drawn:	KINO	Date:	26/05/2022
Location:	Superlot AO-019	Job No.:	1041000.0045.1.0/Rep3	URN:	1	Date:	25/05/2022
		Lab Ref:	- N/A	Scale:	Not to Scale	Rev.:	1

N

Piritahi Testing

Shea Farrell
Created Tue, 15 Nov 2022, 1:58 PM (UTC+13)

Hardfill/Backfill Testing

Testing Instructions
Granular Back Fill - Clegg Hammer testing is to be undertaken at 12m intervals (minimum 2 per line) with one test completed in the bedding/haunching, overlay and backfill zones to ensure satisfactory compaction is achieved.

Cohesive Soil Backfill (i.e. Clay) - Shear Vane testing is to be undertaken at 12m intervals with one test completed in the bedding/haunching (clegg), overlay and backfill zones to ensure satisfactory compaction is achieved.

Refer to the Piritahi Test and Inspection Plan for minimum test requirement.

Photo and video

Line ID Existing to ao-19

Testing

Location from Downstream Manhole, m	Location	Soil and Test Type	Test Depth, m	Value 1 (CIV or KPA)
5	Carriage Way or within 1m of Kerb	Granular (Clegg)	1.2	41
5	Carriage Way or within 1m of Kerb	Granular (Clegg)	0.9	31
5	Carriage Way or within 1m of Kerb	Granular (Clegg)	0.6	39
5	Carriage Way or within 1m of Kerb	Granular (Clegg)	0.3	32
5	Carriage Way or within 1m of Kerb	Granular (Clegg)	0	39
5	Carriage Way or within 1m of Kerb	Granular (Clegg)	1.8	33

Value 2 (CIV or KPA)	Average Value	Photo	Comments
32	36.50	  See full page photos attached at end of PDF	Hardfill
42	36.50	  See full page photos attached at end of PDF	

Value 2 (CIV or KPA)	Average Value	Photo	Comments
41	40.00	  See full page photos attached at end of PDF	
32	32.00	  See full page photos attached at end of PDF	
32	35.50	  See full page photos attached at end of PDF	
32	32.50	  See full page photos attached at end of PDF	Bedding under pipe

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:05 pm
Tags:
Description:
Comments:

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:05 pm
Tags:
Description:
Comments:

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:05 pm
Tags:
Description:
Comments:

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:05 pm
Tags:
Description:
Comments:

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:13 pm
Tags:
Description:
Comments:

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:13 pm
Tags:
Description:
Comments:

No GPS information available

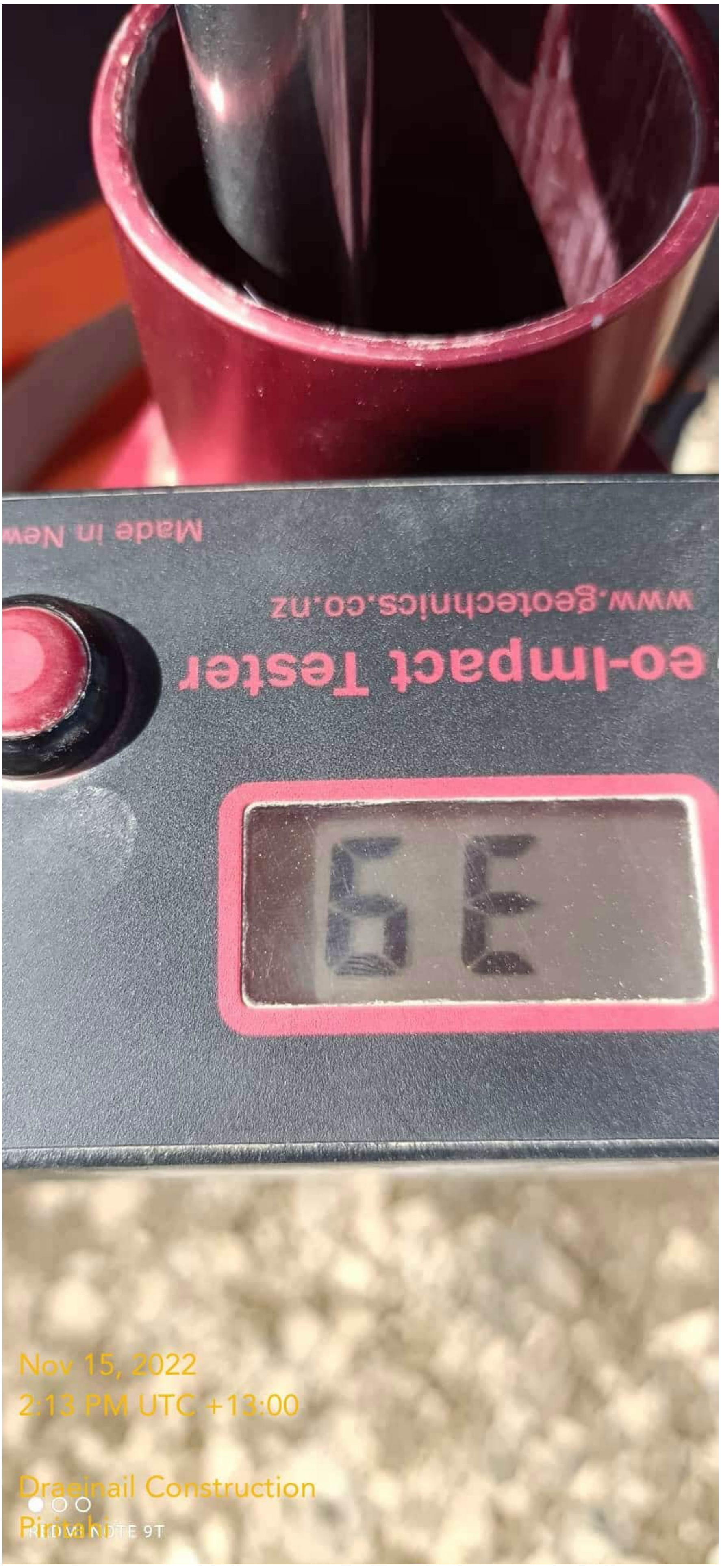
Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:13 pm
Tags:
Description:
Comments:

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:13 pm
Tags:
Description:
Comments:

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:13 pm
Tags:
Description:
Comments:



No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:13 pm
Tags:
Description:
Comments:

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:13 pm
Tags:
Description:
Comments:

No GPS information available

Captured by: Shea Farrell
Captured on: Tue, 15 Nov 2022, 2:13 pm
Tags:
Description:
Comments:

Appendix E – Piritahi ITPs

INSPECTION AND TEST PLAN

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

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

Item No:	Inspection / Test Description	Hold(H), Witness(W), Review(R), Inspection(I)			Frequency	Test by Whom	Conformance Criteria	Reference Detail	Required Records	Compliance Verification		
		Constructor	*CPS/Designer*	*Territory Authority*						Constructor (Y/N/NA)	CPS (Y/N/NA)	Comments
0	**Pre-construction Meeting**	H	R	R	Prior to commencing the construction works	NA	Construction monitoring, surface surveys, testing frequency and expectations agreed and meeting minuted.	Auckland QAM	Meeting Minutes			
	Subcontractor Kick-off Meeting	H			Once prior to commencing the construction works	NA	Piritahi QA expectations and requirements addressed and meeting minuted	Specified	Meeting Minutes			
1	**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:

Piritahi
LAYING THE GROUNDWORK

INSPECTION AND TEST PLAN - STORMWATER

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>

INSPECTION AND TEST PLAN - STORMWATER

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

CSIRO 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

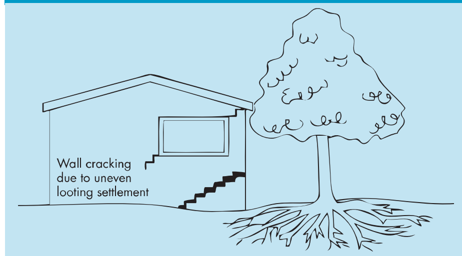
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the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

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.

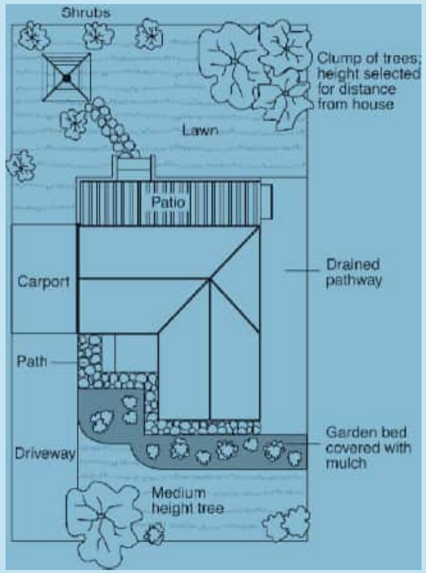
Condensation

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.

Gardens for a reactive site



The garden

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

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

Existing trees

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

Information on trees, plants and shrubs

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

Excavation

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

Remediation

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

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

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

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

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

Distributed by
CSIRO PUBLISHING Locked Bag 10, Clayton South VIC 3169
Tel (03) 9545 8400 1300 788 000 www.publish.csiro.au
Email: publishing.sales@csiro.au