410 Colombo Street, Sydenham
PO Box 13960, Christchurch 8141, New Zealand
T: +64 3 366 3521 // **F:** +64 3 366 3188
E: info@beca.com // **www.ch2mbeca.co.nz**

Christchurch City Council
PO Box 73014
Christchurch 8154
New Zealand

7 November 2016

Attention: Ben Scott

Dear Ben

Land Testing of Alternative Sites for Disposal of Treated Wastewater from Akaroa

Please find attached the following reports on investigations into proposed application of treated wastewater to land on alternative sites in Robinsons Bay valley, Takamatua Valley and Pompeys Pillar.

- Infiltration Testing Results for Akaroa Treated Wastewater Disposal Via Irrigation – Robinsons Bay and Pompeys Pillar, Pattle Delamore Partners Ltd, 7 November 2016
- Akaroa Wastewater Disposal Alternative Sites Stage 2 – Geotechnical Report. CH2M Beca Ltd, 4 November 2016

Our executive summary of the findings of the two investigations is set out below.

Infiltration Testing Results for Akaroa Treated Wastewater Disposal Via Irrigation – Robinsons Bay and Pompeys Pillar (Pattle Delamore Partners Ltd)

Pattle Delamore Partners Ltd (PDP) have been engaged by CH2M Beca Ltd (Beca) to carry out site investigations to better determine the suitability of the soils at sites for the irrigation of effluent from the proposed Akaroa wastewater treatment plant. PDP had previously carried out infiltration testing on land in and around the Takamatua Peninsula to identify suitable land for this purpose. However geotechnical investigations ruled out much of this land and so alternative sites in Robinsons Bay valley and Pompeys Pillar were selected for further work.

Site investigations were carried out from 26 – 29 September 2016 in conjunction with geotechnical investigations of the loess material at each site. The PDP investigations involved:-

- Assessing the soil type at each location (including the depth of the topsoil, presence and depth of any low permeability layer)
- Measuring the depth of root penetration to assist in estimating the Plant Available Water (PAW).
- Measuring the infiltration rate
- Estimating the land area required for irrigation and the amount of storage that would be needed at each location.

Robinsons Bay Observations

- The ground conditions observed within the potentially irrigable zone within Robinsons Bay are generally similar to existing Wainui irrigation sites and hence are considered suitable overall for application of wastewater to land.
- Infiltration rates, soil PAW and depth to groundwater vary from the lower through mid-to-upper valley areas.

- Site 1 at the bottom of the valley has high groundwater and this may constrain irrigation especially during winter.
- Sites 2 and 3 in mid valley have higher PAW and 2-3 m depth to groundwater. These areas are considered favourable for irrigation year round but only represent 20% of total area required
- Sites 4 and 5 in the upper valley are more extensive, with lower PAW, lower soil permeability and greater depth to groundwater observed. Soil ripping may improve the land permeability to allow wastewater to be applied during winter and therefore decrease storage requirements.
- Robinsons Bay is the most suitable site of the three areas under investigation due to more favourable PAW and infiltration characteristics overall compared with Takamatua Valley and Pompeys Pillar.

Pompeys Pillar Observations

- The ground conditions observed within the potentially irrigable zone at Pompeys Pillar are considered suitable overall for application of wastewater to land, although they exhibit consistently lower permeability than other sites.
- The presence of low permeability soils may limit the application rate. However, the available area is very extensive, and the wastewater application area can be increased to meet the loading requirements to counter lower permeability.

Akaroa Wastewater Disposal Alternative Sites Stage 2 – Geotechnical Report (CH2M Beca Ltd)

A Beca engineering geologist attended site during the 26 – 29 September works to observe the test pits excavated, install piezometers on the boreholes that were drilled, and log the soil and rock from the excavations. The scope of work undertaken provides preliminary information to make a first order assessment for the three alternative areas being considered in Takamatua Valley, Robinsons Bay Valley and Pompeys Pillar. The Beca report presents the results of preliminary geotechnical investigations to inform the option of applying treated wastewater to the three potential land areas.

The general conclusions from the Beca report are as follows:

Takamatua and Robinsons Bay

- Soils in these valleys are composed of silts including loess colluvium, and sandy silts overlying gravel
- Central lower-gradient areas have comparatively low risk of ground movement
- However there is potential for localised erosion at points where groundwater exits the ground such as banks of water courses and other slopes

Pompeys Pillar

- Soils at Pompeys Pillar are composed of loess with groundwater at depth (likely within the bedrock)
- Irrigation may cause localised instability around cliff tops and steeper zones around incised gullies

Overall findings

The overall findings from the land testing of the alternative sites include:

- None of the sites are considered to be fatally flawed based on the investigative work and information obtained to date.
- There are some overall differences in the soil types, land gradients and groundwater levels at the different sites which have implications for land irrigation scheme design and operation at each site.

Taking into account previous work the following conclusions can be made:

- Pompeys Pillar land is feasible but is significantly higher cost than other sites due to requirements for a high pressure pipeline from Akaroa, and more expensive storage due to sloping ground at potential storage sites
- Takamatua Valley scheme would be problematic due to land constraints and areas of high groundwater. The topography of the valley dictates that suitably sloping and potentially irrigable land in the valley floor is a long and thin zone. By the time buffer zones to waterways and adjacent properties are accounted for the residual irrigable areas are marginally adequate for the area required
- The amount of area required for irrigation and storage for all sites is unchanged from the first round of investigations

Further details can be found in the attached reports.

Yours faithfully

Raelene Stewart
Technical Director - Project Management

on behalf of
CH2M Beca Ltd
Direct Dial: +64 3 363 3465
Email: raelene.stewart@beca.com

Copy
Andrew Brough, PDP

www.ch2mbeca.com

Report

Akaroa Wastewater Disposal Alternative Sites Stage 2 - Geotechnical Report

Prepared for Christchurch City Council

Prepared by CH2M Beca Ltd

4 November 2016

Revision History

Revision N°	Prepared By	Description	Date
A	**Leeza Becroft**	For Information	4/11/2016

Document Acceptance

Action	Name	Signed	Date
Prepared by	**Leeza Becroft**		4/11/2016
Reviewed by	**Richard Young**		4/11/2016
Approved by	**Greg Offer**		4/11/2016
on behalf of	CH2M Beca		

Executive Summary

The Christchurch City Council (CCC) has commissioned CH2M Beca Ltd (Beca) to conduct a further geotechnical investigation into three proposed alternative sites for the disposal of treated wastewater from Akaroa wastewater treatment plant via irrigation onto the surface or subsurface of the area(s). The purpose of the investigations was to conduct a preliminary assessment of the suitability of the three areas for irrigation of treated wastewater, and to install piezometers to measure groundwater levels in Robinsons Bay Valley and Takamatua Valley.

Area 1 is located 4.5 km north of Akaroa Township on Robinsons Bay Valley Road, and comprises farmland adjacent to several residential sections. Area 2 is located 2 km north of Akaroa Township on Takamatua Valley Road. The area also comprises farmland adjacent to residential sections. Area 3 is located on farmland on Pompeys Pillar, accessed through Fishermans Bay Road, 9.5 km south east of Akaroa Township.

Site investigations to total depths between 3 m and 6 m were carried out in September 2016 comprising four machine boreholes with piezometers and one test pit in Area 1 (Robinsons Bay Valley), two machine boreholes with piezometers in Area 2 (Takamatua Valley) and three infiltration test pits in Area 3 (Pompeys Pillar). In parallel Beca commissioned PDP to carry out infiltration investigations and assessment, the results of which are reported separately.

The site investigations encountered ground conditions that were broadly consistent with the published geology comprising alluvial fans in the lower reaches of the valleys and loess and loess colluvium in the upper reaches and on Pompeys Pillar. In the valleys the alluvium comprised variable interbeds of silt, sand and gravel, being encountered up to an elevation of between approximately 30 m and 60 m RL. Towards the sea the alluvium is likely to be more extensive, becoming thinner and narrower inland. Within the valleys and at higher elevations on Pompeys Pillar colluvium, loess colluvium and reworked loess are present, typically between approximately 60 m and 140 m RL. These materials are generally thicker at lower elevations, becoming thinner at higher levels.

The investigation data suggests that the depth to groundwater increases from approximately 0.5 m to 1.0 m below ground level (bgl) at lower elevations, to approximately 1.5 m bgl in Takamatua Valley and 2.5 m to 3.5 m bgl in Robinsons Bay Valley at higher elevations. Groundwater, which was not encountered in any of the exploratory holes on Pompeys Pillar, is expected to be located in the bedrock (Akaroa Volcanic Group) at some depth below ground level. Ongoing monitoring of the piezometers is recommended to confirm these preliminary levels.

The Akaroa Wastewater Upgrade Irrigation - Preliminary Geotechnical Assessment (CH2M Beca, June 2016) identified that because loess is a highly erodible and moisture sensitive soil, increasing the groundwater level will exacerbate the historical gullying and shallow erosion and may result in an increase in frequency of movement of deep seated slope movements. The areas that were selected for this subsequent assessment (Stage 2) exclude land sloping at greater than 15 °, hence the slope stability issues identified in the preliminary (Stage 1) assessment, whilst still having the potential to occur, are expected to have a considerably lower likelihood of occurrence.

In the central areas of the Takamatua and Robinsons Bay valleys the risk of inducing instability in the alluvial soils underlying the valley floor is comparatively low. The exception is where silt soils locally form the banks of water courses or other slopes, which may slump when saturated. The layered silt and gravels have anisotropic hydraulic properties, with different values when measured parallel to layers and perpendicular to

layers. It is recommended that the effects of applying the treated wastewater to the land on the water quality of the existing water courses be assessed if the scheme is developed.

On the higher elevation valley slopes and on Pompeys Pillar the risk of instability is greater than on the valley floor. Whilst this is mitigated to a degree by selecting slopes inclined at less than 15 ° some erosion and movement of these higher slopes, including the top of the cliffs and above locally steep gullies can be expected.

Surficial creep and erosion can be partially mitigated by establishing trees over the irrigation areas, as the tree roots mechanically stabilise the near surface soils and abstract water from the ground which, in silt soils, induces a suction in the pore water between the soil particles, increasing the effective strength of the soil.

Contents

Appendices

1 Introduction

1.1 Background

CH2M Beca Ltd (Beca) has been commissioned by the Christchurch City Council (CCC) to undertake geotechnical investigations at locations that are under consideration by CCC as potential sites for irrigation to land of wastewater from the Akaroa Wastewater Treatment Plant (WWTP).

In June 2016 Beca undertook a preliminary geotechnical assessment to inform the option of applying treated effluent to potential land areas on, and between, Takamatua headland and Takamatua valley (*Akaroa Wastewater Upgrade Irrigation - Preliminary Geotechnical Assessment Report*, June 2016). Following discussions with CCC and the Ngāi Tahu parties it was concluded that there were some risks around the effect of irrigation on the stability of already marginal slopes, noting that the effect of applying treated wastewater to land will increase the risk of instability occurring, particularly during heavy rainfall events. On this basis criteria were established for defining potentially suitable areas on the Akaroa peninsula (*Akaroa Wastewater Investigation of Alternative Sites for Land Irrigation Report*, August 2016).

The outcome from this screening was that alternative application areas should be considered as part of a Stage 2 assessment, the alternative areas being located on farmland in Takamatua valley, Robinsons Bay valley and Pompeys Pillar.

This report presents the results of preliminary geotechnical investigations to inform the option of applying treated wastewater to these three land areas. The preliminary findings will be subject to further investigation and assessment, which will be required if the study areas are selected for wastewater disposal.

1.2 Scope

The scope of geotechnical investigation carried out is as follows:-

- Takamatua Valley - observe the excavation of, and log the soils from two boreholes, including recording groundwater level (if encountered)
- Robinsons Valley – observe the excavation of, and log the soils from four boreholes and one test pit, including recording groundwater level (if encountered)
- Pompeys Pillar - observe the excavation of, and log the soils from three infiltration test pits, including recording groundwater level (if encountered)
- Prepare engineering logs of the soils encountered
- Develop a high level ground model for the 3 areas
- Qualitatively assess the effect of the proposed irrigation on the ground conditions, identifying major geotechnical risks
- Report on the findings of the investigations and assessment.

In parallel with the preliminary geotechnical assessment, Beca has commissioned PDP to carry out infiltration investigations and assessment, the results of which are reported separately (refer PDP Letter of October 2016 titled *Infiltration testing results for Akaroa treated wastewater disposal via irrigation – Robinsons Bay and Pompeys Pillar*).

1.3 Proposed Development

CCC is considering the option of land disposal as a method of discharging treated wastewater from the Akaroa wastewater treatment plant. Based on the Stage 1 work the indicative total proposed discharge area

will need to be approximately 25 to 30 hectares, depending on whether irrigation is to trees or pasture. The screening, which considered aspects of land stability, minimum land parcel size, erosion zones and setback distances from residential properties, streams and the coastline, identified areas in Robinsons Bay valley (Area 1), the Takamatua valley (Area 2) and on Pompeys Pillar (Area 3). The areas considered are identified in the Beca report *Akaroa Wastewater Investigation of Alternative Sites for Land Irrigation* (August 2016) and Figure 1.

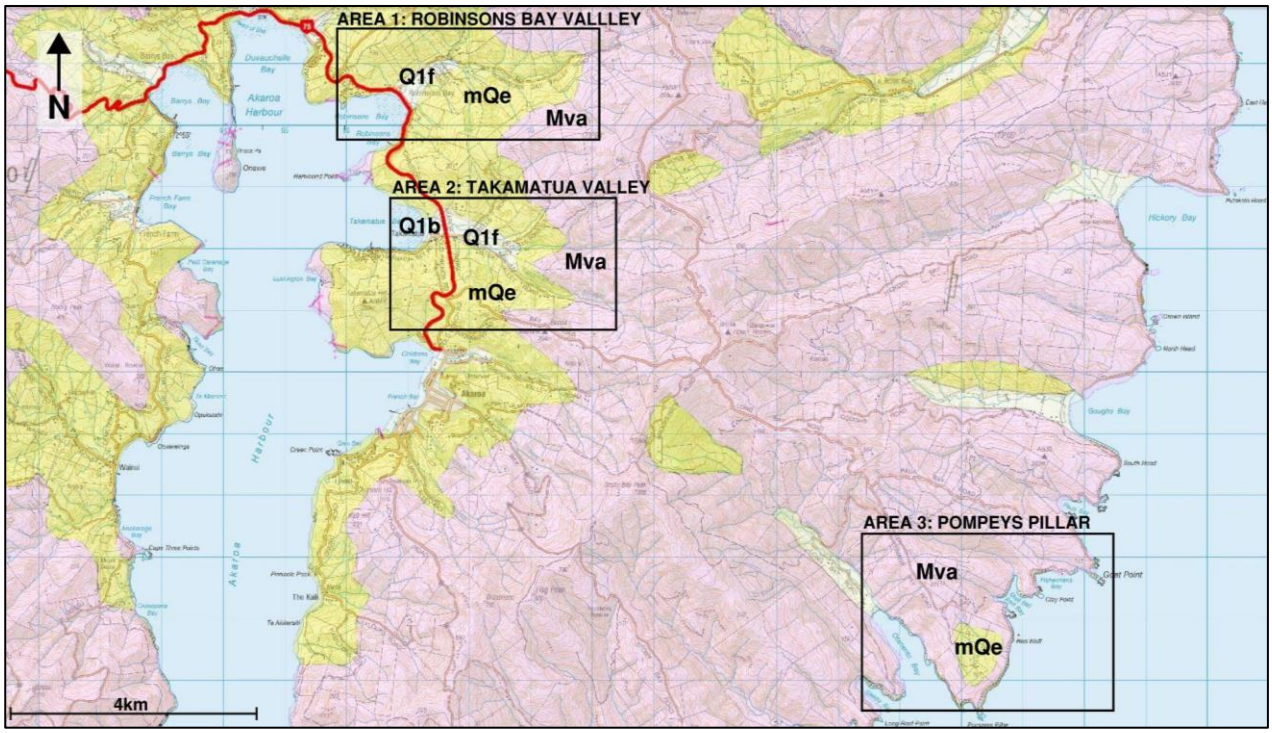


Figure 1. Site Locations and Geology

The currently proposed irrigation will be carried out by either drip irrigation or spray irrigation with a maximum average loading rate of 7.1 mm per day for irrigation to pasture or 5 mm per day beneath trees, over the 27 hectares. The design land application rates being considered for land irrigation under trees (refer *Akaroa Wastewater – Concept Design Report for Alternatives to Harbour Outfall,* Beca, May 2016*)* are:

- Loading rate of 5 mm/day in summer (December to February)
- Loading rate of 1.5 mm/day in winter (June to August)
- Loading rate of 3 mm/day for remainder of the year
- Constraints when rainfall exceeds 50 mm/day or averages more than 50 mm/day over a number of days (the maximum is 5 days for the rainfall data available).

If the allowable irrigation is less than wastewater flows or cannot occur due to high rainfall or other constraints (such as high groundwater), the treated wastewater will be stored in a storage basin and irrigated when there is sufficient capacity in the land.

2 Area Description

2.1 Location

For the purposes of this report the areas have been divided as follows:-

- Area 1 is located on farmland on Robinsons Bay Valley Road. The total irrigable area is 55.6 Ha. The farmland comprises flat and sloping land. There are several residential sections adjacent to the proposed area; a 5 m buffer separates these properties from the potential irrigated area. This area is located 4.5 km north of Akaroa Township, and ranges in elevation from 1 m to 160 m above mean sea level.

- Area 2 is located at Takamatua Valley Road, on farmland adjacent to several residential sections. The total irrigable area, allowing for 5 m buffer zone as above, is 49.7 Ha. The area is located 2 km north of Akaroa Township, and has elevation 1 m to 60 m above mean sea level.

- Area 3 is located on farmland on Pompeys Pillar, accessed via Fishermans Bay Road. The total irrigable area is 100.1 Ha. The area is located 9.5 km to the southeast of Akaroa Township and ranges in elevation from 100 m to 240 m above mean seal level.

For spray irrigation the buffer zone is 25 m, with a correspondingly greater land requirement.

2.2 Area Geology

The published geological map (Forsyth *et. al.*, 2008) shows that Area 1 (Robinsons Bay Valley) is underlain by a Quaternary Alluvial Fan (Q1) in the lower reaches of the valley and by loess (Q2-Q13) in the upper reaches. These units are underlain by the Akaroa Volcanic Group (Miocene – 8 to 9 million years old [Ma]). The geological descriptions given for these units are:

- Alluvial fan (Q1f): grey to brown, generally unweathered, silty subangular gravel and sand with minor peat in alluvial fans
- Loess (mQe): yellow-brown windblown silt deposits, locally with sand or clay, >3 m thick and commonly in multiple layers; thicker downslope
- Akaroa Volcanic Group (Mva): Basaltic to trachytic lava flows intercalated with tuff, pyroclastic breccia and agglomerate.

Area 2 (Takamatua Valley) is located in a valley similar to Area 1 (Robinsons Bay Valley) and similarly has loess in the upper section of the site and a young alluvial fan in the lower section. Additionally, along the shoreline a young (Q1b) beach deposit described as “unweathered sand in bay head beach deposits” is identified.

Area 3 (Pompeys Pillar) is understood to be underlain by the Akaroa Miocene Volcanic Group, overlain by Loess.

3 Scope of Investigation

3.1 Field Investigations

The geotechnical investigations at Area 1 (Robinsons Bay Valley) comprised:

- Four machine boreholes (BH1, BH2, BH3, BH4);
- Installation of four piezometers in the boreholes;
- One test pit to 3.6 m depth (TP5).

The geotechnical investigations Area 2 (Takamatua Valley) comprised:

- Two Machine Boreholes (BH5, BH6);
- Installation of two piezometers in these boreholes.

The geotechnical investigations at Area 3 (Pompeys Pillar) comprised:

- Three infiltration test pits

The exploratory borehole and test pit locations are shown on the figures in Appendix A.

The site investigation commenced on 26th September 2016 and was completed on 29th September 2016. The geotechnical site investigations were observed by a Beca Engineering Geologist. Unless otherwise stated, all soil and rock logging has been undertaken by a Beca Engineering Geologist in general accordance with New Zealand Geotechnical Society Guidelines (NZGS, 2005). All logs have been verified by a Beca Senior Engineering Geologist.

3.2 Machine Boreholes

Machine boreholes were drilled by McMillan Drilling Ltd using a sonic drill rig. A summary of all machine boreholes undertaken is given in Table 1.

Table 1: Summary of Boreholes Drilled.

BH No.	Area	Easting	Northing	R.L. ground (m)	Total Depth (m)	Installation Details
BH1	Area 1 (Robinsons Bay Valley)	5154486	1596918	1.3	6.08	Standpipe Piezometer
BH2	Area 1 (Robinsons Bay Valley)	5154754	1597254	12.5	6.08	Standpipe Piezometer
BH3	Area 1 (Robinsons Bay Valley)	5154950	1597711	30.7	6.08	Standpipe Piezometer
BH4	Area 1 (Robinsons Bay Valley)	5154945	1597709	30.7	3.04	Standpipe Piezometer
BH5	Area 2 (Takamatua Valley)	5152227	1597794	9	4.56	Standpipe Piezometer
BH6	Area 2 (Takamatua Valley)	5151907	1598527	34.4	4.56	Standpipe Piezometer

All core samples were logged on site by a Beca Engineering Geologist. Machine borehole logs and core photographs are presented in Appendix B. After the core samples had been logged, they were placed in labelled core boxes before being stored at the Beca storage facility. Upon completion, all boreholes not requiring installations were backfilled with bentonite and cement.

3.3 Instrumentation

3.3.1 Standpipe Piezometers

Standpipe piezometers were installed in all six of the machine boreholes in order to measure groundwater levels. Appendix C provides as-built record of the standpipe piezometers constructed at each location. A summary of the piezometer installations is provided in Table 2.

Table 2: Summary of Standpipe Piezometer Installations.

Borehole/ Piezometer	Piezometer Type	Response zone top (m bgl)	Response zone bottom (m bgl)	Final depth[A] (m bgl)	Response zone lithology	Cover type
BH1-P	single standpipe	3.00	6.00	5.97	Gravelly SILT	Red Stand-up Toby
BH2-P	single standpipe	1.40	4.40	4.46	Sandy GRAVEL; SILT	Red Stand-up Toby
BH3-P	single standpipe	3.58	6.08	5.87	Gravelly SILT; GRAVEL	Red Stand-up Toby
BH4-P[B]	single standpipe	1.04	3.04	-	Sandy SILT; GRAVEL	Red Stand-up Toby
BH5-P	single standpipe	0.97	4.47	4.30	Clayey SILT; GRAVEL; gravelly SILT	Flush top
BH6-P	single standpipe	1.00	3.00	3.71	SILT; Gravelly SILT; sandy SILT	Flush top

[A] Final depth of borehole post development, measured on installation of transducer.

[B] Piezometer installed, but no transducer on request of PDP.

The standpipe piezometer installations consist of 50 mm diameter PVC pipe with a slotted screen section located in the response zone of interest. The boreholes were backfilled with K1 sand. The boreholes were capped with bentonite from 0.8 m to 0.2 m and finished up with concrete to ground level. Lockable red Stand-up Tobys were installed in BH1-4, in the farmland. Lockable flush mounted covers were installed in BHs 5 and 6 on the road reserve. Each of the piezometers was developed by PDP using a submersible pump.

3.4 Test and Infiltration Pits

McMillans Drilling Ltd were contracted to excavate infiltration pits for infiltration testing using a 1.8 tonne excavator. The pits were approximately 1.5 by 0.8 m in plan area and ranged from 0.4 to 0.55 m depth.

Alan Hemsley was contracted to excavate a single test pit for geotechnical investigation and two infiltration pits for infiltration testing using a 2.5 tonne excavator. The geotechnical test pit was approximately 1.5 by 1.0 m in plan area and had depth 3.6 m. The infiltration pits were approximately 1.5 by 1.0 m in plan area and ranged from 0.4 to 0.55 m depth.

Material excavated from the test pits and infiltration pits was logged and sampled by an Engineering Geologist. The test pit logs and photographs are presented in Appendix D.

Table 3: Summary of Test Pit (TP) and Infiltration Pits (IP).

BH No.	Area	Easting	Northing	R.L. ground (m)	Total Depth (m)	Observed & Logged by
IP1[A]	Area 1 (Robinsons Bay Valley)	5154486	1596918	4.5	0.42	PDP
IP2 [A]	Area 1 (Robinsons Bay Valley)	5154755	1597253	19	0.55	
IP3 [A]	Area 1 (Robinsons Bay Valley)	5154953	1597711	38	0.52	
IP4 [B]	Area 1 (Robinsons Bay Valley)	5154944	1597705	38	0.35	
IP5	Area 1 (Robinsons Bay Valley)	5154726	1599198	160	0.48	Beca Engineering Geologist
TP5	Area 1 (Robinsons Bay Valley)	5154726	1599198	160	3.6	
IP8	Area 3 (Pompeys Pillar)	5146116	1605690	235	0.4	
IP9	Area 3 (Pompeys Pillar)	5145295	1606009	160	0.48	
IP10	Area 3 (Pompeys Pillar)	5145113	1606373	105	0.46	

[A] Infiltration Pits were not logged as adjacent to borehole of the same number

[B] Infiltration pit not logged as not observed

3.5 Groundwater Monitoring

Solinst Leveloggers, which were installed in boreholes BH1, BH2, BH3, BH5 and BH6, were set to record groundwater levels at 15 minute intervals. The piezometers were dipped at the time of level logger installation following piezometer development, and the results are recorded in Table 4. Water levels encountered during drilling can be found in the borehole logs in Appendix B.

The results of subsequent groundwater level monitoring from the level loggers are given in the PDP report (*Infiltration testing results for Akaroa treated wastewater disposal via irrigation – Robinsons Bay and Pompeys Pillar*, November 2016).

Table 4: Groundwater Measurements in Piezometers at Time of Level Logger Installation

Borehole/ Piezometer ID	Date of measurement	Groundwater level (m bgl)	Groundwater Level[A] (m RL)
BH1	28/09/2016 13:30	0.70	0.6
BH2	29/09/2016 15:50	3.89	8.61
BH3	29/09/2016 14:00	2.44	28.26
BH4	29/09/2016 14:00	Dry	-
BH5	29/09/2016 13:15	0.69	8.31
BH6	28/09/2016 18:00	1.35	33.05

[A] Elevation for each borehole estimated using Environment Canterbury (ECan) 1 m contours

3.6 Infiltration Testing

Falling head permeability tests were conducted by PDP Ltd within infiltration rings in the infiltration pits, and on the surface next to each pit (refer to PDP letter *Infiltration testing results for Akaroa treated wastewater disposal via irrigation – Robinsons Bay and Pompeys Pillar* of October 2016 for the details).

4 Conceptual Ground Model

4.1 Geological Setting

The ground conditions encountered in the investigation are broadly consistent with the published geological information either being derived from, or comprising, Quaternary alluvium and loess overlying the Akaroa Volcanic Group. The alluvium, present beneath the floors of the two valleys, has been derived from loess and the Akaroa Volcanic Group. The colluvium and loess colluvium have also been derived from the same source materials, being transported down the slopes under gravity.

Higher on the slopes the colluvium will be predominantly formed of loess soils washed off the hills and gradually accumulating towards the foot of the slopes. Lower down the slopes and across the lower valley floors is a more variable sequence of coarser sediments which were probably deposited by alluvial action when sea level was lower. These comprise interbedded silt, sand and gravel and will vary laterally as well as vertically. Although not proven in this investigation, it might be expected that towards the bottom of the alluvium, near the contact with bedrock, the sediments become more gravelly. Underlying these terrestrial sediments is the Akaroa Volcanic Group.

The investigations suggest that the alluvial silt, sand and gravel occurs up to an elevation of some 30 m to 60 m RL. Towards the sea the alluvium is likely to be more extensive, becoming thinner and narrower inland.

Within the valleys and at higher elevations on Pompeys Pillar, colluvium, loess colluvium and reworked loess are present, typically between approximately 60 m and 140 m RL. These materials are generally thicker at lower elevations, becoming thinner at higher levels. Away from the valleys on Pompeys Pillar the Akaroa Volcanic Group is overlain by loess.

The ground conditions at each of the test areas are summarised below.

4.2 Robinsons Bay Valley (Area 1)

Table 6 summarises the ground conditions encountered in the Robinsons Bay Valley based on information from the four boreholes and one test pit.

Table 5: Ground conditions at Robinsons Bay Valley

Unit	Approximate Depth (m)	Approximate Layer thickness (m)	Typical Description	Geological Unit
-	0	0.15	Topsoil	N/A
0[1]	0.1	2.4	SILT, organic SILT and fibrous ORGANICS	Possible Fill / Beach Deposits
1	0.15	1.5	Sandy SILT, some to trace clay, trace gravel	Alluvium
2[2]	1.65	1.5 to 2.0	Sandy GRAVEL, trace cobbles, silt and clay	Alluvium
3	3.5	> 2.3	Sandy SILT, some to trace clay, trace gravel	Alluvium
4[3]	5.6	> 0.5	GRAVEL, some sand, trace silt	Alluvium

Notes: 1. Only encountered in BH 1 (located towards the coast)
2. Absent in BH1 (located towards the coast) and TP5 (inland)
3. Absent in TP5 (inland)

The investigations indicate a broadly consistent pattern of interlayered silt and gravel / cobbles, although the consistency of this stratigraphy between the exploratory holes is likely to be more variable than that suggested.

Near surface silt, in the order of 1.5m thick, was encountered in all the exploratory holes. The silt contained supplementary gravel confirming its likely alluvial origin, although the material in TP5 may well be loess colluvium. In BH1 the silt contained organic materials and gravel, being underlain by a fibrous organic layer.

The interbedded gravel underlying the upper silt was noted in the central valley floor, being absent in TP5, higher up the valley and BH1, close to the coast. This is consistent with the geological model indicating alluvial deposition of more granular deposits at lower elevations.

It is expected that the silt at higher elevations is loess colluvium which is expected to be present above the valley floor.

Groundwater was measured at approximately 0.5m to 1.0m depth at lower elevations (BH1), becoming deeper, at approximately 2.5m to 3.5m at higher elevations. It will be important to confirm any variation in the groundwater level in the central valley area (BHs 2, 3 and 4) by the ongoing monitoring of the piezometers.

4.3 Takamatua Valley

Table 5 presents a summary of ground conditions encountered in the Takamatua Valley based on information from the two boreholes.

Table 6: Ground Conditions at Takamatua Valley.

Unit	Depth (m)	Layer Thickness (m)	Description	Geological Unit
-	0	0.2	Topsoil	N/A
1	0.2	2.4 (lower elevations) 3.2 (higher elevations)	SILT, some to trace clay, minor to trace sand and gravel	Alluvium
2	2.4 to 3.2	0.7 (lower elevations) 0.2 (higher elevations)	GRAVEL and COBBLES, trace of silt	Alluvium
3	3.0 to 3.4	unproven	Gravelly, sandy SILT	Alluvium

The two boreholes, which were spaced hundreds of metres apart, did indicate consistent horizons of near surface and deeper silt, with a variable horizon of gravel and cobbles. However, the soil distribution in the valley is likely to be more variable than that suggested by the two boreholes, with differing thicknesses of alluvial silt, sand and gravel at different locations. These deposits are mapped as Alluvium. There is potential for loess colluvium to be present at higher elevations.

Groundwater was measured at approximately 0.5m to 1.0m depth at lower elevations, becoming deeper, at approximately 1.5m at higher elevations. It is recommended that this should be confirmed, and any variation investigated, by the ongoing monitoring of the piezometers.

4.4 Pompeys Pillar

Table 4-3 presents a summary of ground conditions at Pompeys Pillar based on information from the three shallow infiltration test pits.

Table 4-3 - Ground model for Pompeys Pillar

Unit	Depth (m)	Approximate Layer thickness (m)	Description	Geological Unit
-	0	0.15 – 0.2	Topsoil	N/A
1	0.15 – 0.2	> 0.3	SILT, some to trace clay, minor to trace sand and gravel	Loess/Loess Colluvium

The ground conditions encountered in the shallow infiltration test pits were consistent, comprising loess. In the higher elevation pit (IP8) a 0.3 m thick horizon of loess colluvium was present immediately beneath the topsoil. Elsewhere there was no evidence that the loess was not *in situ*.

Groundwater was not encountered in any of the exploratory holes. This is consistent with the topographical and geological setting, with groundwater expected to be located in the bedrock (Akaroa Volcanic Group) at some depth below ground level.

5 Geotechnical Risks

5.1 Background

The Beca June 2016 report *Akaroa Wastewater Upgrade Irrigation - Preliminary Geotechnical Assessment Report*, June 2016), identified geotechnical risks associated with applying treated effluent to land areas on, and between, Takamatua headland and Takamatua valley. On the more steeply sloping land the presence of existing shallow and deep seated instability was identified within the loess soils. Because loess is a highly erodible and moisture sensitive soil it was noted that increasing the groundwater level in the slope will exacerbate gullying and shallow erosion and may result in an increase in frequency of movement of the historic deep seated land instabilities at the loess/rock contact.

The study areas considered in this Stage 2 assessment have been screened to exclude land sloping at greater than 15 °, as well as land with slopes below it that are greater than 15 ° (except Pompeys Pillar where instability is expected to primarily occur above steep cliffs and gullies, with no effect on downhill properties, etc.). Hence the issues identified in the Stage 1 assessment, whilst still having the potential to occur, are expected to have a considerably lower risk profile for the areas in this Stage 2 assessment. Additionally the ground conditions underlying the central areas of the Takamatua and Robinsons Bay valleys comprise alluvial silt and gravel. These materials are less susceptible to erosion than the loess soils and reworked loess soils. The loess and loess colluvium found at higher elevations in the valleys and on Pompeys Pillar will share some of the characteristics of the loess soils studied on the Takamatua headland.

5.2 Robinson's Bay Valley (Area 1) and Takamatua Valley (Area 2)

The risk of inducing instability in the alluvial soils underlying the valley floor is comparatively low. The exception is where silt soils locally form the banks of water courses or other slopes. In these instances increasing the moisture content of the soils may cause the silt to slump. Where gravel is present in the banks and slopes this risk will be significantly lower. Movement of such silt slopes would be expected to occur following periods of heavy rainfall, or during seismic activity.

The layered silt and gravel will have anisotropic permeability, with dominant groundwater flow being horizontally through the gravel. The higher flow through the gravels may generate erosion around discharge points.

The effects of applying the treated wastewater to land on the water quality of existing water courses will be a function of the time the treated wastewater takes to pass through the soils and the nature of the soils it is passing through. Assessment of water quality effects is beyond the scope of this report, but it is recommended that this is undertaken if the scheme is to be developed in this area.

On the higher elevation slopes underlain by loess and loess colluvium, the risk of instability is greater than on the valley floor. Slopes inclined at less than 15 ° have been used as one of the criteria in selecting the study areas. However the dispersive nature of the loess is likely to result in some erosion and potential instability in these higher areas. It is of note that reworked loess, such as loess colluvium, is more susceptible to erosion and instability than *in situ* loess.

Shallow surface instability can be mitigated to a degree by planting trees in irrigation areas. The tree roots provide an amount of mechanical stabilisation of the near surface soils. Additionally the trees abstract water from the ground, which in fine grained soils such as silt is expected to induce a suction in the pore water between the soil particles. This suction increases the effective strength of the soil.

5.3 Pompeys Pillar

The exploratory holes indicate that the area selected on Pompeys Pillar is underlain by loess, with some shallow loess colluvium at higher elevations. The preceding discussions on the behaviour of loess applies to this area. The area selected on Pompeys Pillar is generally inclined at less than 15 °. However, loess deposits at the top of the cliffs and above locally steep gullies could become destabilised over time due to upgradient wastewater application.

Water flow is expected to be predominantly vertical through the loess. However locally, cemented layers or pans within the loess may lead to lateral flow above the pans. If the applied water reaches the bedrock, flow is expected to be controlled by the fractures and interconnected pore spaces within the Akaroa Volcanic Group. It would be reasonable to anticipate some flow along the bedrock surface, the water potentially issuing as a concentrated flow capable of eroding the overlying loess and/or adjacent soils.

Applicability Statement

This report has been prepared by CH2M Beca on the specific instructions of our Client. It is solely for our Client's use for the purpose for which it is intended in accordance with the agreed scope of work. Any use or reliance by any person contrary to the above, to which CH2M Beca has not given its prior written consent, is at that person's own risk.

This report contains the data from field investigations. The field investigations have been undertaken at discrete locations and no inferences about the nature and continuity of ground conditions away from the investigation locations are made. Furthermore logs are provided presenting description of the soils and geology based on our observation of the samples recovered in the fieldwork and may not be truly representative of the actual underlying conditions.

Should you be in any doubt as to the applicability of this report and/or its recommendations for the proposed development as described herein, and/or encounter materials on site that differ from those described herein, it is essential that you discuss these issues with the authors before proceeding with any work based on this document.

References

Akaroa Wastewater – Concept Design Report for Alternatives to Harbour Outfall, May 2016, Beca Ref. NZ1-11926513

Akaroa Wastewater Investigation of Alternative Sites for Land Irrigation Report, August 2016 Beca Ref: NZ1-12974542-8

Akaroa Wastewater Upgrade Irrigation - Preliminary Geotechnical Assessment Report, June 2016, Beca Ref: NZ1-12646865-6

Forsyth, P.J.; Barrell, D.J.A.; Jongens, R. (compilers) 2008: Geology of the Christchurch area: scale 1:250,000. Lower Hutt: GNS Science. Institute of Geological & Nuclear Sciences 1:250,000 geological map 16. 67 p. + 1 folded map

Infiltration testing results for Akaroa treated wastewater disposal via irrigation – Robinsons Bay and Pompeys Pillar, November 2016, PDP Letter.

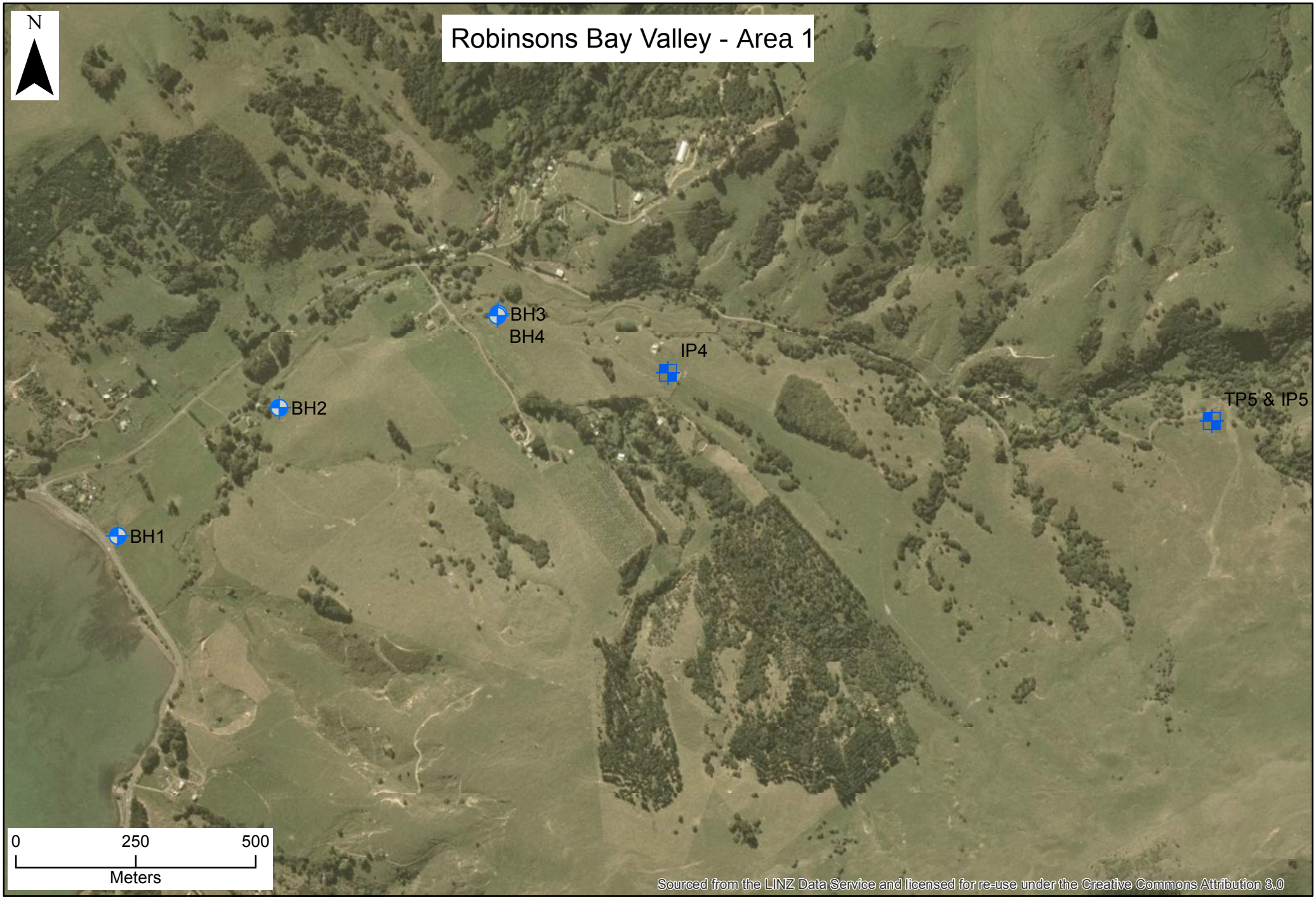
NZ Geotechnical Society, 2005: Field Description for Soil and Rock. Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes.

NZ Standard 4402, 1986, Methods of Testing Soils for Civil Engineering Purposes

Appendix A

Site Plan and Locations of Investigations

Robinsons Bay Valley - Area 1



No.	Revision	By	Chk	Appd	Date

Drawing Originator: CH2M Beca

Original Scale (A1)
Reduced Scale (A3)

Design			Approved For Construction*
Drawn			
Dsg Verifier			
Dwg Check			Date

* Refer to Revision 1 for Original Signature

Client: Christchurch City Council

Project: Akaroa Wastewater Disposal Alternative Sites Stage 2

Title: Robinsons Bay Valley Site 1

Discipline: Site Map

Job Number: 6517986

Rev.: 0

DO NOT SCALE

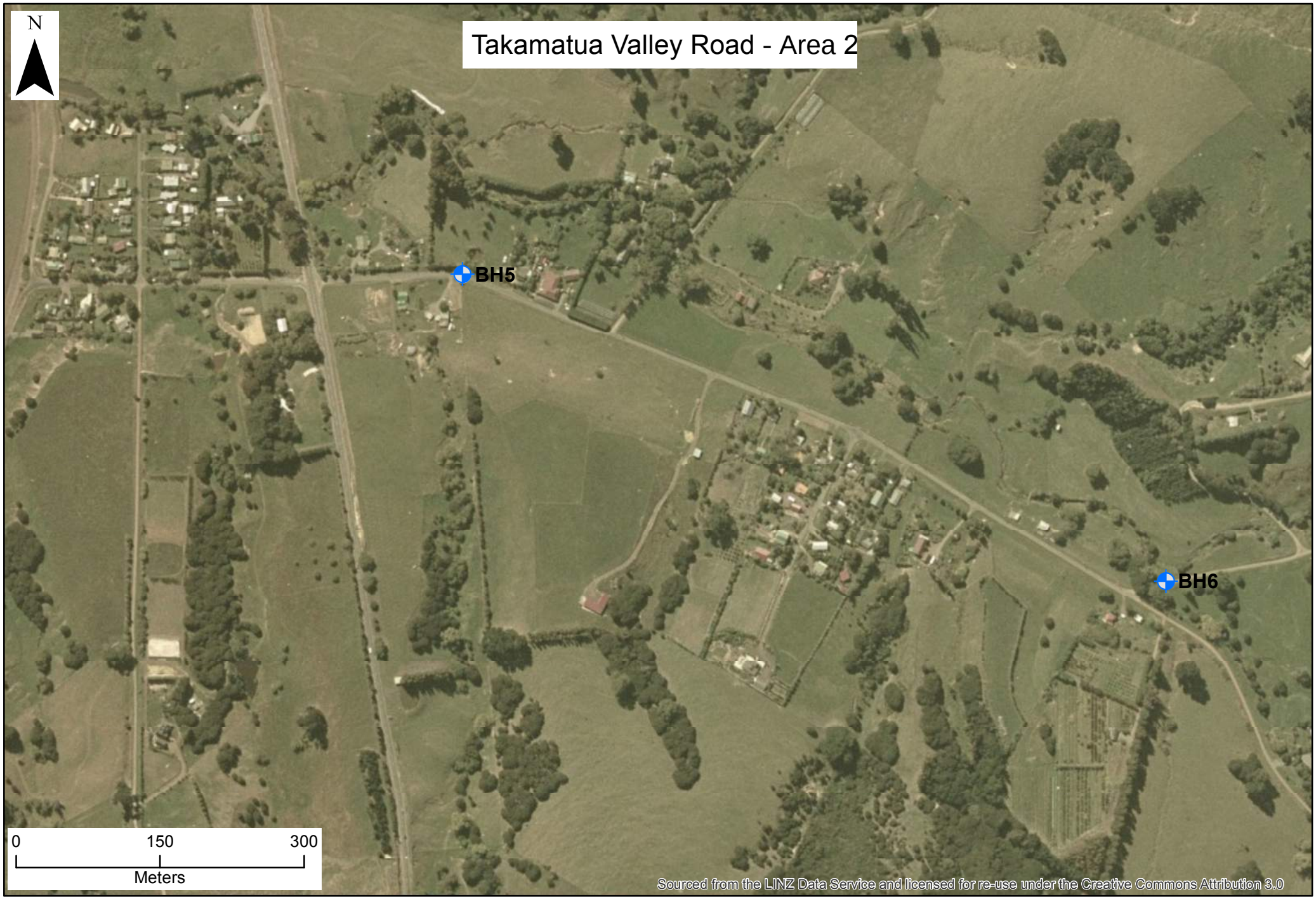
IF IN DOUBT ASK.

www.beca.com

www.beca.com

BLUEBEAM

Takamatua Valley Road - Area 2



No.	Revision	By	Chk	Appd	Date

Drawing Originator: CH2M Beca

Original Scale (A1)
Reduced Scale (A3)

Design			Approved For Construction*
Drawn			
Dsg Verifier			
Dwg Check			Date

* Refer to Revision 1 for Original Signature

Client: Christchurch City Council

Project: Akaroa Wastewater Disposal Alternative Sites Stage 2

Title: Takamatua Valley Site 2

Discipline: Site Map

Job Number: 6517986

Rev.: 0

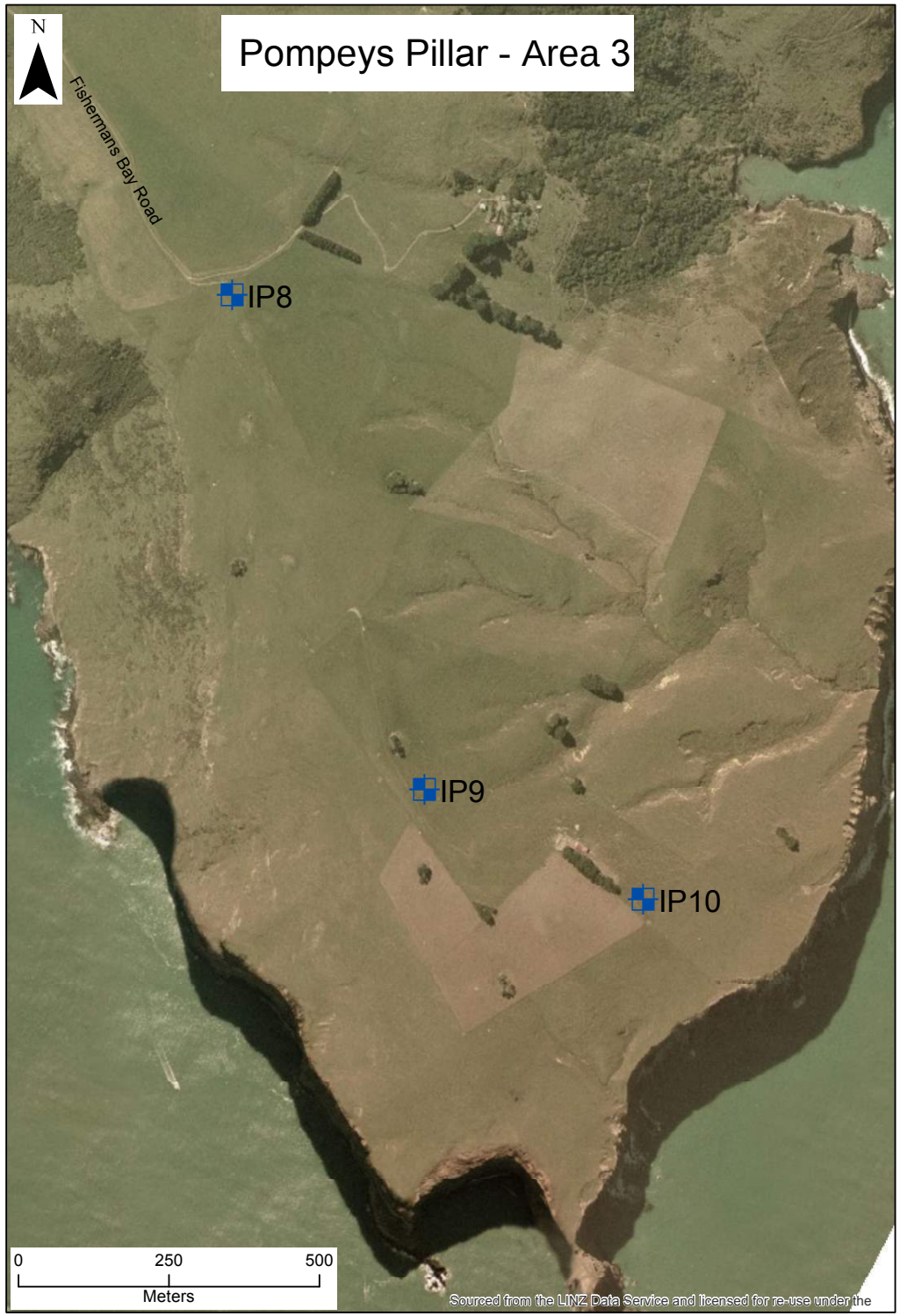
DO NOT SCALE

IF IN DOUBT ASK.

www.beca.com

www.beca.com

BLUEBEAM



NOTE:
1.

No.	Revision	By	Chk	Appd	Date

Original Scale (A1)
Reduced Scale (A3)

Design			Approved For Construction*
Drawn			
Dsg Verifier			
Dwg Check			Date

* Refer to Revision 1 for Original Signature

Drawing Originator:
CH2M BECA

Client:
Christchurch City Council

Project:
Akaroa Wastewater Disposal Alternative Sites
Stage 2

Title:
Pompeys Pillar
Site 3

Discipline
Site Map

Job Number
6517986

Rev.
0

www.beca.com

www.beca.com

DO NOT SCALE

IF IN DOUBT ASK.

Appendix B

Borehole Logs and Core Photographs

Log Key Sheet

WATER

Water level on date shown

METHOD *(shows drilling method)*

OB	open barrel
Wash	wash boring
TT	triple tube
UT	thin walled undisturbed tube
SPT	standard penetration test – open nose sampler
Nc	standard penetration test – solid nose sampler
MA	machine auger
PS	piston sample
PCT	percussion – top drive
PCB	percussion – bottom drive
Conc	concentrics
Sonic	sonic
HA	hand auger
VE	vacuum excavation

SAMPLES

Dx	Disturbed sample, number x
Bx	Bulk sample, number x
Ux(d)	Undisturbed sample, number x, tube diameter d in mm
Wx	Water sample, number x

MOISTURE

Dry, looks and feels dry
Moist, no free water on hand when remoulding
Wet, free water on hand when remoulding
Saturated, soil below water table

SOIL AND ROCK DESCRIPTIONS

Soil and Rock Descriptions are generally as described in the NZ Geotechnical Society "Field Description of Soil and Rock – Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes", dated December 2005.
Vane Shear Strength measurements in accordance with the NZ Geotechnical Society "Guideline for hand held shear vane test" dated August 2001.

IN SITU TESTS

SV	= 40/10	In situ shear strength and remoulded shear strength respectively, as measured by Geotechnics/ Pilcon Shear Vane
τ	= 50/12	Vane shear strength and remoulded vane shear strength respectively, corrected to BS1377
UTP	=	Unable To Penetrate with Shear Vane
N	= 15	SPT uncorrected blow count for 300mm penetration
N_c	= 50+	SPT uncorrected blow count for 300 mm penetration using solid nose sampler

★	**Laboratory Test(s) carried out:**
AL	Atterberg limits
UU	Unconsolidated undrained triaxial
PSD	Particle size
CU	Consolidated undrained triaxial
CONS	Consolidation
COMP	Compaction
UCS	Unconfined compression

WEATHERING

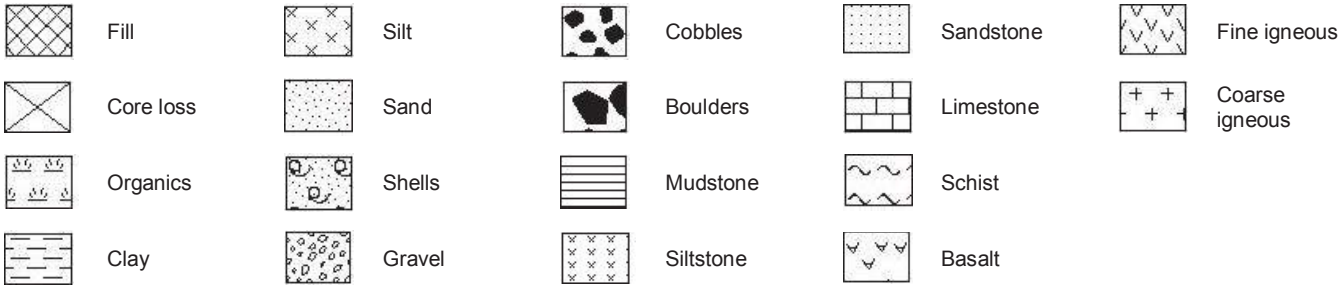
CW	Completely weathered
HW	Highly weathered
MW	Moderately weathered
SW	Slightly weathered
UW	Unweathered

CONSISTENCY

Cohesive Soils	Undrained Shear Strength (kPa)
Very soft	<12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	>200

Non-cohesive Soils	SPT – Uncorrected
Very loose	0 to 4
Loose	4 to 10
Medium dense	10 to 30
Dense	30 to 50
Very dense	>50

GRAPHIC LOG (1 or a combination of the following)



ORGANIC SOILS

Von Post Degree of Humification

H1	Completely unconverted and mud-free peat, when pressed gives clear water and plant structure is visible.
H2	Practically unconverted and mud-free peat, when pressed gives almost clear water and plant structure is visible.
H3	Very slightly decomposed or very slightly muddy peat, when pressed gives marked muddy water, no peat substance passes through the fingers and plant structure is less visible.
H4	Slightly decomposed or slightly muddy peat, when pressed gives marked muddy water and plant structure is less visible.
H5	Moderately decomposed or very muddy peat with growth structure evident but slightly obliterated.
H6	Moderately decomposed or very muddy peat with indistinct growth structure.
H7	Fairly well decomposed or very muddy peat but the growth structure can just be seen.
H8	Well decomposed or very muddy peat with very indistinct growth structure.
H9	Practically decomposed or mud-like peat in which almost no growth structure is evident
H10	Completely decomposed or mud peat where no growth structure can be seen, entire substance passes through the fingers when pressed.

BOREHOLE No: BH1

MACHINE BOREHOLE LOG

SHEET 1 of 1

PROJECT:	Akaroa Wastewater Disposal Alternatives	JOB NUMBER:	6517986
SITE LOCATION:	Akaroa	CLIENT:	Christchurch City Council

CIRCUIT:	NZTM	BOREHOLE LOCATION:	Robinsons Valley		
COORDINATES:	N 5,154,486 m	R L:	1.3 m	COORDINATE ORIGIN:	MAP
	E 1,596,918 m	DATUM:	LVD	ACCURACY:	±1m

DRILLING						IN-SITU TESTS							
FLUID LOSS	DAILY WATER LEVEL	CORE RECOVERY	METHOD	CASING	RQD	SV	τ (kPa)	SPT 'N'	SAMPLES	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	R L (m)
	27/09/2016 11:00:00 a.m.	100 %	Sonic							0		Soft SILT, minor organics, some fine sand, trace clay; dark brown; moist; low plasticity. Organics: amorphous, roots. [topsoil].		1
												Soft fine sandy SILT, some clay, some organics, moist, low plasticity. Organics: amorphous, roots.		
										1		Soft clayey SILT, trace fine gravel, trace organics; brown; wet; high plasticity. Gravel: HW, subrounded, trachyte. Organics: charcoal.	POSSIBLE FILL	2
		80 %	Sonic							2		Loosely packed fibrous ORGANICS, some fine sand; black; wet; non plastic. Organics: bark, amorphous.		3
										3		Soft fine to coarse gravelly SILT, some clay, some fine to coarse sand; dark grey; saturated; low plasticity. Gravel: SW to MW, subrounded to subangular, basalt.		4
												2.84 - 3.04 m: no recovery.		
		80 %	Sonic									Soft fine to coarse gravelly SILT, some clay, some fine to coarse sand; dark grey; saturated; low plasticity. Gravel: SW to MW, subrounded to subangular, basalt.		5
										4		4.32 - 4.52 m: no recovery.		
		80 %	Sonic									Soft fine to coarse gravelly SILT, some clay, some fine to coarse sand; dark grey; saturated; low plasticity. Gravel: SW to MW, subrounded to subangular, basalt.	ALLUVIAL DEPOSITS	6
										5		4.9 m: moderately thick (200mm) bed of cobbles and coarse gravels; SW; subrounded, basalt.		7
										6		5.85 m: single cobble; SW, subrounded, basalt.		
												5.88 - 6.08 m: no recovery.		
												END OF LOG @ 6.08 m		
										7				8

				COMMENTS:
DATE STARTED:	26/9/16	DRILLED BY:	McMillans Drilling	Co-ordinates and elevation obtained from the ECan GIS viewer. Static groundwater observed at 0.55 mbgl on 27/09/2016 11:00 am.
DATE FINISHED:	26/9/16	EQUIPMENT:	Sonic Rig	
LOGGED BY:	LB	DRILL METHOD:	Sonic	
SHEAR VANE No:	N/A	DRILL FLUID:	Water	
		DIAMETER/INCLINATION:	123 mm/ -90°	

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:40

CH2M BECO

BOREHOLE No: BH2

MACHINE BOREHOLE LOG

SHEET 1 of 1

PROJECT:	Akaroa Wastewater Disposal Alternatives	JOB NUMBER:	6517986
SITE LOCATION:	Akaroa	CLIENT:	Christchurch City Council

CIRCUIT: NZTM
COORDINATES: N 5,154,754 m
E 1,597,254 m

BOREHOLE LOCATION: Robinsons Valley
R L: 12.5 m
DATUM: LVD

COORDINATE ORIGIN: MAP
ACCURACY: ±1m

DRILLING						IN-SITU TESTS								
FLUID LOSS	DAILY WATER LEVEL	CORE RECOVERY	METHOD	CASING	RQD	SV	τ (kPa)	SPT 'N'	SAMPLES	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	R L (m)
	29/09/2016 1:00:00 p.m.	20 %	Sonic							0		Soft fine sandy SILT; minor organics; dark brown; moist; non plastic. Organics: rootlets, amorphous. [topsoil].		
												Stiff fine sandy SILT, trace clay, trace organics, trace medium sand; brown; moist; low plasticity.		13
												0.36 m: moderately thin (80mm) clay bed; light brown; high plasticity.		
										1		0.4 - 1.52 m: no recovery.		
		100 %	Sonic											14
										2		Fine sandy fine to coarse GRAVEL; some silt; brown; non plastic. Gravel: SW, subrounded to subangular, basalt; HW, subrounded, reddish orange, trachyte.		
													ALLUVIAL DEPOSITS	15
										3				
		100 %	Sonic											16
										4		Stiff SILT, minor fine to medium gravel, some clay, some fine to coarse sand; brown; wet; high plasticity. Gravel: SW, subrounded to subangular, basalt; EW, subrounded, trachyte.		
														17
												4.56 m: single cobble (65mm): SW, subrounded, basalt.		
		100 %	Sonic							5				
														18
										6				
												END OF LOG @ 6.08 m		
										7				19

DATE STARTED:	26/9/16	DRILLED BY:	McMillans Drilling	COMMENTS:
DATE FINISHED:	26/9/16	EQUIPMENT:	Sonic Rig	Co-ordinates and elevation obtained from the ECan GIS viewer. Static groundwater observed at 2.335 mbgl on 29/09/2016 1:00 pm.
LOGGED BY:	LB	DRILL METHOD:	Sonic	
SHEAR VANE No:	N/A	DRILL FLUID:	Water	
		DIAMETER/INCLINATION:	123 mm/ -90°	

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:40

BOREHOLE No: BH3

CH2M BECO

MACHINE BOREHOLE LOG

SHEET 1 of 1

PROJECT: Akaroa Wastewater Disposal Alternatives — JOB NUMBER: 6517986

SITE LOCATION: Akaroa — CLIENT: Christchurch City Council

CIRCUIT: NZTM — BOREHOLE LOCATION: Robinsons Valley

COORDINATES: N 5,154,950 m — R L: 30.7 m — COORDINATE ORIGIN: MAP

E 1,597,711 m — DATUM: LVD — ACCURACY: ±1m

DRILLING: FLUID LOSS	DRILLING: DAILY WATER LEVEL	DRILLING: CORE RECOVERY	DRILLING: METHOD	DRILLING: CASING	DRILLING: RQD	IN-SITU TESTS: SV	IN-SITU TESTS: τ (kPa)	IN-SITU TESTS: SPT 'N'	SAMPLES	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	R L (m)
	29/09/2016 2:00:00 p.m.	80 %	Sonic							0		Soft fine sandy SILT, minor organics, trace clay; brown; wet; low plasticity. Organics: amorphous, roots. [topsoil].		31
												Soft fine sandy SILT, some clay, trace gravel, trace organics; brown; wet; low plsticity. Organics: rootlets, charcoal. Gravel: SW, subrounded basalt.		
										1		1.12 - 1.52 m: no recovery.		32
		80 %	Sonic									Loosely packed fine to coarse GRAVEL,; dark grey; saturated; non plastic. Gravel: SW, subrounded to subangular, basalt.		
										2		Loosely packed silty fine to coarse GRAVEL, trace clay; dark brown; saturated; low plasticity (matrix). Gravel: SW, subrounded to subangular, basalt.		33
												2.74 - 3.04 m: no recovery.		
		100 %	Sonic							3		COBBLES: SW, subrounded, grey, basalt.	ALLUVIAL DEPOSITS	
												Firm fine to coarse gravelly SILT, some clay; dark brown, mottled brown; saturated; high plasticty. Gravel: SW, subrounded to subangular, basalt.		34
										4				
														35
										5				
		100 %	Sonic											36
												Loosely packed fine to coarse GRAVEL; some coarse sand; trace silt; dark grey; saturated; non plastic.		
										6				
												END OF LOG @ 6.08 m		37
										7				

DATE STARTED: 28/9/16 — DRILLED BY: McMillans Drilling

DATE FINISHED: 28/9/16 — EQUIPMENT: Sonic Rig

LOGGED BY: LB — DRILL METHOD: Sonic

SHEAR VANE No: N/A — DRILL FLUID: Water

DIAMETER/INCLINATION: 123 mm/ -90°

COMMENTS:

Co-ordinates and elevation obtained from the ECan GIS viewer. Static groundwater observed at 2.455 mbgl on 29/09/2016 2:00 pm.

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:40

CH2M Beca

BOREHOLE No: BH4

MACHINE BOREHOLE LOG

SHEET 1 of 1

PROJECT: Akaroa Wastewater Disposal Alternatives — JOB NUMBER: 6517986

SITE LOCATION: Akaroa — CLIENT: Christchurch City Council

CIRCUIT: NZTM — BOREHOLE LOCATION: Robinsons Valley

COORDINATES: N 5,154,945 m — R L: 30.7 m — COORDINATE ORIGIN: MAP

E 1,597,709 m — DATUM: LVD — ACCURACY: ±1m

DRILLING						IN-SITU TESTS							
FLUID LOSS	DAILY WATER LEVEL	CORE RECOVERY	METHOD	CASING	RQD	SV	τ (kPa)	SPT 'N'	SAMPLES	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	R L (m)
		100 %	Sonic							0		Soft SILT, minor fine sand, minor organics some clay; dark brown; moist; high plasticity. Organics: amorphous, roots. [topsoil].		31
												Soft fine sandy SILT, some clay, trace organics; dark brown; wet; high plasticity. Organics: rootlets, charcoal.		
										1		Firm fine sandy SILT, some clay; dark brown; moist; brown; low plasticity.	ALLUVIAL DEPOSITS	32
		100 %	Sonic							2		Loosely packed fine to coarse GRAVEL, trace fine cobbles, trace fine to coarse sand, trace silt, trace clay; brown and grey; moist to dry; low plasticity (matrix). Gravel: SW to CW, subangular, basalt. Baked due to drilling in places.		33
										3		END OF LOG @ 3.04 m		34
										4				35
										5				36
										6				37
										7				

DATE STARTED: 29/9/16 — DRILLED BY: McMillans Drilling

DATE FINISHED: 29/9/16 — EQUIPMENT: Sonic Rig

LOGGED BY: LB — DRILL METHOD: Sonic

SHEAR VANE No: N/A — DRILL FLUID: Water

DIAMETER/INCLINATION: 123 mm/ -90°

COMMENTS:
Co-ordinates and elevation obtained from the ECan GIS viewer. Borehole dry on 29/09/2016 2:00 pm.

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:40

CH2M BECO

BOREHOLE No: BH5

MACHINE BOREHOLE LOG

SHEET 1 of 1

PROJECT: Akaroa Wastewater Disposal Alternatives — JOB NUMBER: 6517986

SITE LOCATION: Akaroa — CLIENT: Christchurch City Council

CIRCUIT: NZTM — BOREHOLE LOCATION: Takamatua Valley

COORDINATES: N 5,152,227 m — R L: 9 m — COORDINATE ORIGIN: MAP

E 1,597,794 m — DATUM: LVD — ACCURACY: ±1m

DRILLING: FLUID LOSS	DRILLING: DAILY WATER LEVEL	DRILLING: CORE RECOVERY	DRILLING: METHOD	DRILLING: CASING	DRILLING: RQD	IN-SITU TESTS: SV	IN-SITU TESTS: τ (kPa)	IN-SITU TESTS: SPT 'N'	SAMPLES	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	R L (m)
	29/09/2016 12:00:00 p.m.	100 %	HA							0		Soft fine to medium gravelly SILT, some organics, trace clay; brown; wet; low plasticity. Gravel: SW, subrounded to subangular basalt. Organics: peat, roots. [topsoil].		10
										1		Firm clayey SILT, minor gravel, some fine sand; light brown; wet; high plasticity. Gravel: SW, subrounded to subangular basalt.		
		100 %	Sonic							2		1.52 - 1.95 m: gravel absent.	ALLUVIAL DEPOSITS	11
												Loosely packed medium to coarse GRAVEL, trace fine to coarse sand, trace silt; dark grey; wet; non plastic. Gravel: SW - MW, subrounded to subangular basalt.		
		100 %	Sonic							3		Firm to stiff fine gravelly SILT, some fine to coarse sand, some clay, trace medium gravel; dark brown; saturated; low plastiscity. Gravel: SW, subrounded to aubagular, basalt.		12
										4				13
										5		END OF LOG @ 4.56 m		14
										6				15
										7				16

DATE STARTED: 28/9/16 — DRILLED BY: McMillans Drilling

DATE FINISHED: 28/9/16 — EQUIPMENT: Sonic Rig

LOGGED BY: LB — DRILL METHOD: HA/Sonic

SHEAR VANE No: N/A — DRILL FLUID: Water

DIAMETER/INCLINATION: 123 mm/ -90°

COMMENTS:
Co-ordinates and elevation obtained from the ECan GIS viewer. Static groundwater observed at 0.47 mbgl on 29/09/2016 12:00 pm.

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:40

BOREHOLE No: BH6

CH2M BECO

MACHINE BOREHOLE LOG

SHEET 1 of 1

PROJECT: Akaroa Wastewater Disposal Alternatives — JOB NUMBER: 6517986

SITE LOCATION: Akaroa — CLIENT: Christchurch City Council

CIRCUIT: NZTM — BOREHOLE LOCATION: Takamatua Valley

COORDINATES: N 5,151,907 m — R L: 34.4 m — COORDINATE ORIGIN: MAP

E 1,598,527 m — DATUM: LVD — ACCURACY: ±1m

DRILLING: FLUID LOSS	DRILLING: DAILY WATER LEVEL	DRILLING: CORE RECOVERY	DRILLING: METHOD	DRILLING: CASING	DRILLING: RQD	IN-SITU TESTS: SV	IN-SITU TESTS: τ (kPa)	IN-SITU TESTS: SPT 'N'	SAMPLES	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	R L (m)
		50 %	HA							0		Soft SILT, minor fine to medium gravel, some clay, some fine to coarse sand; brown; saturated; low plasticity. Gravel: SW, subrounded to subangular, basalt. (Sample disturbed by hand augering).	FILL	35
	28/09/2016 4:00:00 p.m.									1		0.75 - 1.52 m: no recovery.	ALLUVIAL DEPOSITS	
		61 %	Sonic							2		Soft fine to medium gravelly SILT, minor clay, some coarse sand; brown; saturated; high plasticity. Gravel: SW, subrounded to subangular, basalt.		36
										3		2.44 - 3.04 m: no recovery.		37
		100 %	Sonic									Soft fine to medium gravelly SILT, minor clay, some coarse sand; brown; saturated; high plasticity. Gravel: SW, subrounded to subangular, basalt.		
												COBBLE (150 mm): SW, basalt.		
												Very stiff fine sandy SILT, some coarse sand, trace fine gravel; dark grey; moist; non plastic. Gravel: SW, subangular, basalt.		38
										4		Stiff fine to coarse gravelly SILT, some fine to medium sand; dark brown; wet; non plastic. Gravel: SW-CW, subrounded to subangular basalt.		
												END OF LOG @ 4.56 m		39
										5				
														40
										6				
														41
										7				

DATE STARTED: 27/9/16 — DRILLED BY: McMillans Drilling

DATE FINISHED: 27/9/16 — EQUIPMENT: Sonic Rig

LOGGED BY: LB — DRILL METHOD: HA/Sonic

SHEAR VANE No: N/A — DRILL FLUID: Water

DIAMETER/INCLINATION: 123 mm/ -90°

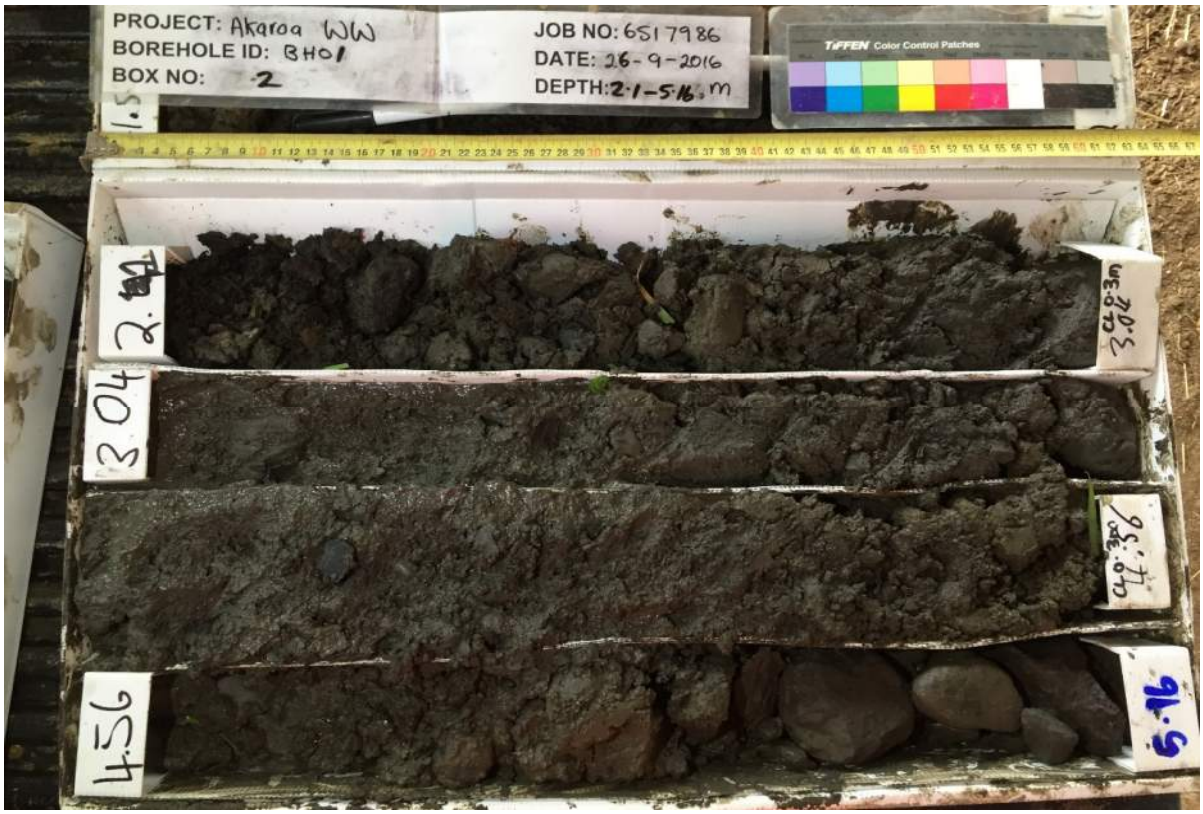
COMMENTS:

Co-ordinates and elevation obtained from the ECan GIS viewer. Static groundwater observed at 1.3 mbgl on 28/09/2016 4:00 pm.

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:40

BOX: 1/3 **DEPTH: 0.0 to 2.1 m**



BOX: 2/3 **DEPTH: 2.1 to 5.16 m**

BOX: 3/3 **DEPTH: 5.16 to 6.08 m**

BH01

BOX: 1/3 **DEPTH: 0 to 3.04 m**

BH02

BOX: 2/3 **DEPTH: 3.04 to 3.94 m**

BOX: 3/3 **DEPTH: 3.94 to 6.08 m**

BOX: 1/3 **DEPTH: 0.0 to 3.04 m**

BOX: 2/3 **DEPTH: 3.04 to 4.86 m**

BOX: 3/3 **DEPTH: 4.56 to 6.08 m**

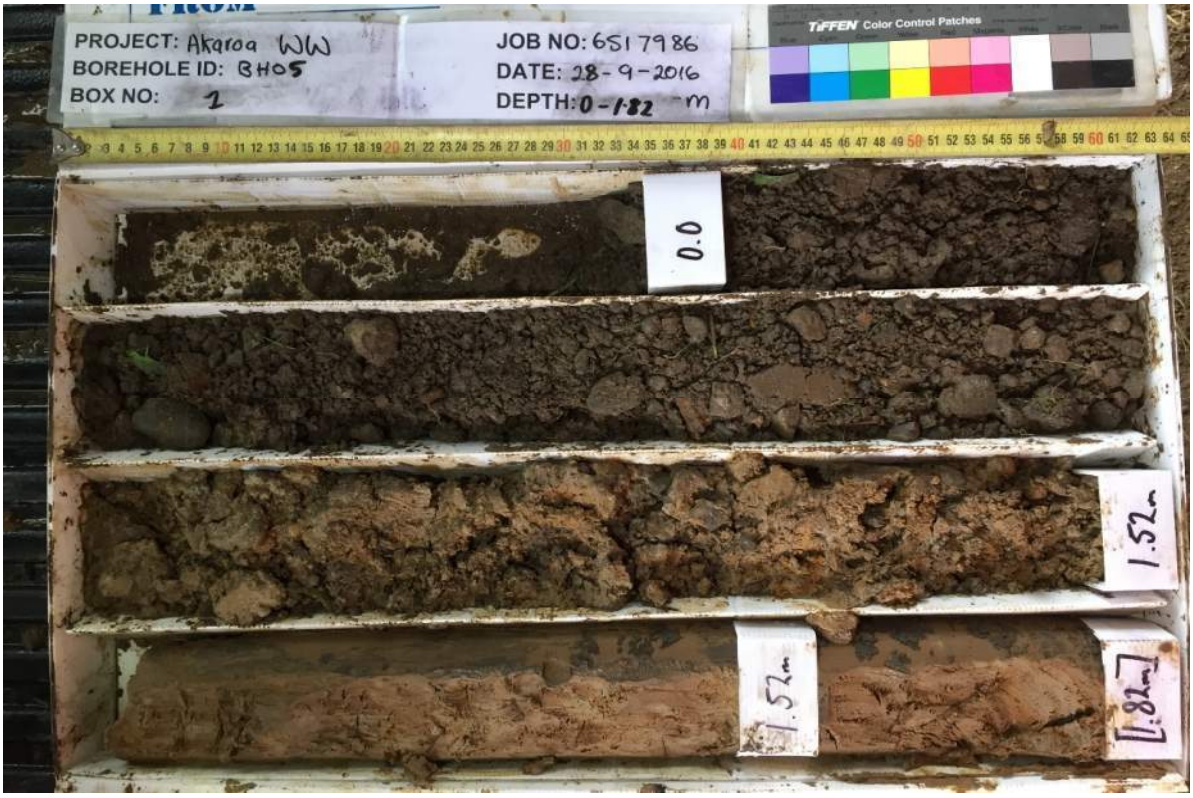
BH3

BOX: 1/2 **DEPTH: 0.0 to 2.42 m**

BH4

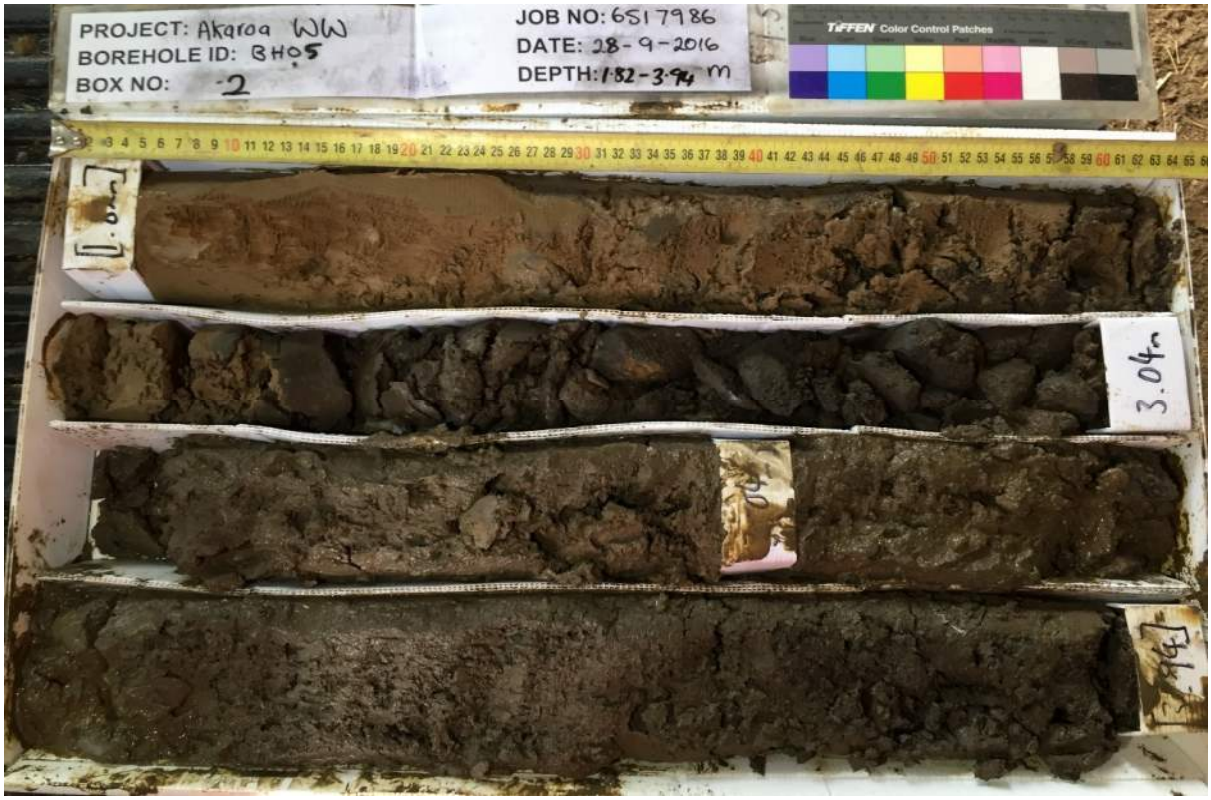
BOX: 2/2 **DEPTH: 2.42 to 3.04 m**

BH4



BOX: 1/3 **DEPTH: 0.0 to 1.82 m**

BH5



BOX: 2/3 **DEPTH: 1.82 to 3.94 m**

BOX: 3/3 **DEPTH: 3.94 to 4.56 m**

BOX: 1/2 **DEPTH: 0.0 to 3.94 m**

BOX: 2/2 **DEPTH: 3.94 to 4.56 m**

BH6

Appendix C

Piezometer Details

Bore Log

McMILLAN Drilling GROUP

Client: Pattle Delamore Partners

Project: Akaroa Wastewater Upgrade

Bore No.: BH001

Job No.: 16343

Site Location: Robinsons Bay Valley Road, Robinsons Bay
Grid Reference: 1596984.63mE 5154569.36mN NZTM
Rig Operator: K. Morris
Rig Model & Mounting: Geoprobe 8140LC - track

Date Commenced: 26/09/2016
Date Completed: 26/09/2016
Elevation (m): 0.00
Datum: Ground

Description	Method	Drivability (1–5)	Recovery (25–75)	Depth	Graphic Log	SPT N-value (Uncorrected) (10–50)	In-Situ Tests (Uncorrected)	Samples - Permeability tests	Installation & Resources
TOPSOIL.	Sonic core drilling	1–2	100%	0.5					Stand-up Protective Surround; Cement (2 bags) 0.40m; Sand (0.5 bags) 1.00m
SILT; light brown. 0.50m				1.0					
Silty PEAT with some gravel and trace of cobbles; dark brown. Gravel, fine to coarse. 1.52m		2–3	80%	1.5					Bentonite (1.2 bags) 2.70m; 50 mm Blank pipe (3.0m)
				2.0					
				2.5					
		3–4	80%	3.0					3.00m
				3.5					
				4.0					Filter sand (2 bags); 50 mm Slotted pipe (3.0m)
		4–5	80%	4.5					
				5.0					
				5.5					
				6.0					6.0m

EOH: 6.08m

Remarks

Geotechnical investigation borehole BH001

Static water levels:
1.40m bgl at casing depth of 6.08m; 26/9/2016

300 liters water added

Drivability

1 Easy Push - No Hammer \ Fast Penetration
2 Relatively Easy Push - Light Hammer \ Relatively Fast
3 Medium Push - Consistent Hammer \ Medium
4 Hard Push - Full Hammer \ Somewhat Slow
5 Very Hard Push - Full Hammer \ Very Slow

Additional Resources:

Plastic Liner / PVC Splits	m	-
Core boxes	no.	3
Flush Mounted Toby Box		
- Standard	ea	
- Environmental	ea	
Above Ground Protective Surround	ea	✔
Geotextile Sock	m	-
Hand Clear Location	ea	
Decontaminate Equipment	ea	

120 High Street, Southbridge 7602, Canterbury, New Zealand ph: (03) 324 2571 fax: (03) 324 2431 web: www.drilling.co.nz

Hole Depth: 6.08m

Created: 4/10/2016 12:09:23 p.m.

Bore Log

McMILLAN Drilling GROUP

Client: Pattle Delamore Partners

Project: Akaroa Wastewater Upgrade

Bore No.: BH002

Job No.: 16343

Site Location: Robinsons Bay Valley Road, Robinsons Bay
Grid Reference: 1597347.56mE 5154775.47mN NZTM
Rig Operator: K. Morris
Rig Model & Mounting: Geoprobe 8140LC - track

Date Commenced: 26/09/2016
Date Completed: 27/09/2016
Elevation (m): 0.00
Datum: Ground

Description	Method	Drivability (1 2 3 4 5)	Recovery (25 50 75)	Depth	Graphic Log	SPT N-value (Uncorrected) (10 20 30 40 50)	In-Situ Tests (Uncorrected)	Samples - Permeability tests	Installation & Resources
TOPSOIL.	Sonic core drilling		50%	0.5					Stand-up Protective Surround; Cement (2.2 bags); 0.40m; Bentonite (1.5 bags); 50 mm Blank pipe (1.4m); 1.10m
Clayey GRAVEL with trace of peat. 1.40m			80%	1.0 1.5					1.40m
			100%	2.0 2.5 3.0 3.5					50 mm Slotted pipe (3.0m); Filter sand (3.5 bags)
			100%	4.0 4.5 5.0 5.5 6.0					4.40m

EOH: 6.08m

Remarks

Geotechnical investigation borehole BH002

Static water levels:
1.10m bgl at casing depth of 4.56m; 26/9/2016

No water added

Drivability

1 Easy Push - No Hammer \ Fast Penetration
2 Relatively Easy Push - Light Hammer \ Relatively Fast
3 Medium Push - Consistent Hammer \ Medium
4 Hard Push - Full Hammer \ Somewhat Slow
5 Very Hard Push - Full Hammer \ Very Slow

Additional Resources:

Plastic Liner / PVC Splits	m	-
Core boxes	no.	3
Flush Mounted Toby Box		
- Standard	ea	
- Environmental	ea	
Above Ground Protective Surround	ea	✔
Geotextile Sock	m	-
Hand Clear Location	ea	
Decontaminate Equipment	ea	

120 High Street, Southbridge 7602, Canterbury, New Zealand ph: (03) 324 2571 fax: (03) 324 2431 web: www.drilling.co.nz

Hole Depth: 6.08m

Created: 4/10/2016 12:09:23 p.m.

Bore Log

McMILLAN Drilling GROUP

Client: Pattle Delamore Partners

Project: Akaroa Wastewater Upgrade

Bore No.: BH003

Job No.: 16343

Site Location: Robinsons Bay Valley Road, Robinsons Bay
Grid Reference: 1597795.4mE 5154878.11mN NZTM
Rig Operator: K. Morris
Rig Model & Mounting: Geoprobe 8140LC - track

Date Commenced: 28/09/2016
Date Completed: 28/09/2016
Elevation (m): 0.00
Datum: Ground

Description	Method	Drivability (1–5)	Recovery (25–75)	Depth	Graphic Log	SPT N-value (Uncorrected) (10–50)	In-Situ Tests (Uncorrected)	Samples - Permeability tests	Installation & Resources
TOPSOIL.	Sonic core drilling	1–2	80%	0.5					Stand-up Protective Surround; Cement (2 bags)
CLAY; light brown. 0.50m				1.0					0.40m
				1.5					Bentonite (2.5 bags)
Clayey GRAVEL. 1.80m		3–4	100%	2.0					50 mm Blank pipe (3.6m)
				2.5					
				3.0					
			100%	3.5					3.38m
				4.0					3.58m
				4.5					Filter sand (2 bags)
		5	100%	5.0					50 mm Slotted pipe (2.5m)
				5.5					
				6.0					6.08m

EOH: 6.08m

Remarks

Geotechnical investigation borehole BH003

Static water levels:
3.86m bgl at casing depth of 6.08m; 28/9/2016

500 liters water added

Drivability

1 Easy Push - No Hammer \ Fast Penetration
2 Relatively Easy Push - Light Hammer \ Relatively Fast
3 Medium Push - Consistent Hammer \ Medium
4 Hard Push - Full Hammer \ Somewhat Slow
5 Very Hard Push - Full Hammer \ Very Slow

Additional Resources:

Plastic Liner / PVC Splits	m	-
Core boxes	no.	3
Flush Mounted Toby Box		
- Standard	ea	
- Environmental	ea	
Above Ground Protective Surround	ea	✔
Geotextile Sock	m	-
Hand Clear Location	ea	
Decontaminate Equipment	ea	

120 High Street, Southbridge 7602, Canterbury, New Zealand ph: (03) 324 2571 fax: (03) 324 2431 web: www.drilling.co.nz

Hole Depth: 6.08m

Created: 4/10/2016 12:09:23 p.m.

Bore Log

McMILLAN Drilling GROUP

Client: Pattle Delamore Partners

Project: Akaroa Wastewater Upgrade

Bore No.: BH003B

Job No.: 16343

Site Location: Robinsons Bay Valley Road, Robinsons Bay
Grid Reference: 1597796.94mE 5154876.9mN NZTM
Rig Operator: K. Morris
Rig Model & Mounting: Geoprobe 8140LC - track

Date Commenced: 29/09/2016
Date Completed: 29/09/2016
Elevation (m): 0.00
Datum: Ground

Description	Method	Drivability	Recovery	Depth	Graphic Log	SPT N-value (Uncorrected)	In-Situ Tests (Uncorrected)	Samples - Permeability tests	Installation & Resources
TOPSOIL.	Sonic core drilling	1 2 3 4 5	25 50 75	0.5 1.0 1.5 2.0 2.5 3.0		10 20 30 40 50			Stand-up Protective Surround; Cement (2 bags) 0.40m; 50 mm Blank pipe (1.0m); Bentonite (1 bags) 0.84m; 1.04m; Filter sand (2 bags); 50 mm Slotted pipe (2.0m); 3.04m
CLAY; light brown. 0.50m			100%						
Clayey GRAVEL. 1.80m			100%						

EOH: 3.04m

Remarks

Geotechnical investigation borehole BH003B

Static water levels:
Dry at casing depth of 3.04m; 29/9/2016

No water added

Drivability

1 Easy Push - No Hammer \ Fast Penetration
2 Relatively Easy Push - Light Hammer \ Relatively Fast
3 Medium Push - Consistent Hammer \ Medium
4 Hard Push - Full Hammer \ Somewhat Slow
5 Very Hard Push - Full Hammer \ Very Slow

Additional Resources:

Plastic Liner / PVC Splits	m	-
Core boxes	no.	2
Flush Mounted Toby Box		
- Standard	ea	
- Environmental	ea	
Above Ground Protective Surround	ea	✔
Geotextile Sock	m	-
Hand Clear Location	ea	
Decontaminate Equipment	ea	

120 High Street, Southbridge 7602, Canterbury, New Zealand ph: (03) 324 2571 fax: (03) 324 2431 web: www.drilling.co.nz

Hole Depth: 3.04m

Created: 4/10/2016 12:09:23 p.m.

Bore Log

McMILLAN Drilling GROUP

Client: Pattle Delamore Partners

Project: Akaroa Wastewater Upgrade

Bore No.: BH005

Job No.: 16343

Site Location: Takamatua Valley Road, Takamatua
Grid Reference: 1597794.83mE 5152227.37mN NZTM
Rig Operator: K. Morris
Rig Model & Mounting: Geoprobe 8140LC - track

Date Commenced: 28/09/2016
Date Completed: 28/09/2016
Elevation (m): 0.00
Datum: Ground

Description	Method	Drivability (1 2 3 4 5)	Recovery (25 50 75)	Depth	Graphic Log	SPT N-value (Uncorrected) (10 20 30 40 50)	In-Situ Tests (Uncorrected)	Samples - Permeability tests	Installation & Resources
Silty GRAVEL.	Hand auger		100%	0.5					Environmental Flush Toby Box; Cement (2.5 bags) 0.40m; 50 mm Blank pipe (1.0m); Bentonite (1.5 bags) 0.77m; 0.97m
FILL. 0.60m				1.0					
Silty CLAY; brownish orange. 0.90m				1.5					
	Sonic core drilling		100%	2.0					Filter sand (3 bags); 50 mm Slotted pipe (3.5m)
Clayey GRAVEL. 3.00m				2.5					
			100%	3.0					
				3.5					
				4.0					4.47m; 4.47m; Surrounding ground collapse
EOH: 4.56m				4.5					

Remarks

Geotechnical investigation borehole BH005

Static water levels:
1.40m bgl at casing depth of 4.56m; 28/9/2016

No water added

Drivability

1 Easy Push - No Hammer \ Fast Penetration
2 Relatively Easy Push - Light Hammer \ Relatively Fast
3 Medium Push - Consistent Hammer \ Medium
4 Hard Push - Full Hammer \ Somewhat Slow
5 Very Hard Push - Full Hammer \ Very Slow

Additional Resources:

Plastic Liner / PVC Splits	m	-
Core boxes	no.	3
Flush Mounted Toby Box		
- Standard	ea	
- Environmental	ea	✔
Above Ground Protective Surround	ea	
Geotextile Sock	m	-
Hand Clear Location	ea	✔
Decontaminate Equipment	ea	

120 High Street, Southbridge 7602, Canterbury, New Zealand ph: (03) 324 2571 fax: (03) 324 2431 web: www.drilling.co.nz

Hole Depth: 4.56m

Created: 4/10/2016 12:09:23 p.m.

Bore Log

McMILLAN Drilling GROUP

Client: Pattle Delamore Partners

Project: Akaroa Wastewater Upgrade

Bore No.: BH006

Job No.: 16343

Site Location: Old Le Bons Track, Takamatua
Grid Reference: 1598548.03mE 5151907.07mN NZTM
Rig Operator: K. Morris
Rig Model & Mounting: Geoprobe 8140LC - track

Date Commenced: 27/09/2016
Date Completed: 27/09/2016
Elevation (m): 0.00
Datum: Ground

Description	Method	Drivability (1 2 3 4 5)	Recovery (25 50 75)	Depth	Graphic Log	SPT N-value (Uncorrected) (10 20 30 40 50)	In-Situ Tests (Uncorrected)	Samples - Permeability tests	Installation & Resources
TOPSOIL.	Hand auger		100%	0.5					Environmental Flush Toby Box; Cement (2 bags) 0.40m; Bentonite (1.5 bags) 0.80m; 50 mm Blank pipe (1.0m) 1.00m; Filter sand (3 bags); 50 mm Slotted pipe (2.0m) 3.00m; 4.25m Surrounding ground collapsed
Clayey GRAVEL; light brown. 1.00m				1.0					
Silty GRAVEL with trace of peat; dark brown. 1.52m	Sonic core drilling		75%	1.5					
				2.0					
				2.5					
				3.0					
			100%	3.5					
				4.0					
EOH: 4.56m				4.5					

Remarks

Geotechnical investigation borehole BH006

2.30m bgl at casing depth of 4.56m; 27/9/2016

300 liters water added

Drivability

1 Easy Push - No Hammer \ Fast Penetration
2 Relatively Easy Push - Light Hammer \ Relatively Fast
3 Medium Push - Consistent Hammer \ Medium
4 Hard Push - Full Hammer \ Somewhat Slow
5 Very Hard Push - Full Hammer \ Very Slow

Additional Resources:

Plastic Liner / PVC Splits	m	-
Core boxes	no.	2
Flush Mounted Toby Box		
- Standard	ea	
- Environmental	ea	✔
Above Ground Protective Surround	ea	
Geotextile Sock	m	-
Hand Clear Location	ea	✔
Decontaminate Equipment	ea	

120 High Street, Southbridge 7602, Canterbury, New Zealand ph: (03) 324 2571 fax: (03) 324 2431 web: www.drilling.co.nz

Hole Depth: 4.56m

Created: 4/10/2016 12:09:23 p.m.

Appendix D

Test Pit Logs and Photographs

Log Key Sheet

WATER

Water level on date shown

METHOD *(shows drilling method)*

OB	open barrel
Wash	wash boring
TT	triple tube
UT	thin walled undisturbed tube
SPT	standard penetration test – open nose sampler
Nc	standard penetration test – solid nose sampler
MA	machine auger
PS	piston sample
PCT	percussion – top drive
PCB	percussion – bottom drive
Conc	concentrics
Sonic	sonic
HA	hand auger
VE	vacuum excavation

SAMPLES

Dx	Disturbed sample, number x
Bx	Bulk sample, number x
Ux(d)	Undisturbed sample, number x, tube diameter d in mm
Wx	Water sample, number x

MOISTURE

Dry, looks and feels dry
Moist, no free water on hand when remoulding
Wet, free water on hand when remoulding
Saturated, soil below water table

SOIL AND ROCK DESCRIPTIONS

Soil and Rock Descriptions are generally as described in the NZ Geotechnical Society "Field Description of Soil and Rock – Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes", dated December 2005.
Vane Shear Strength measurements in accordance with the NZ Geotechnical Society "Guideline for hand held shear vane test" dated August 2001.

IN SITU TESTS

SV	= 40/10	In situ shear strength and remoulded shear strength respectively, as measured by Geotechnics/ Pilcon Shear Vane
τ	= 50/12	Vane shear strength and remoulded vane shear strength respectively, corrected to BS1377
UTP	=	Unable To Penetrate with Shear Vane
N	= 15	SPT uncorrected blow count for 300mm penetration
N_c	= 50+	SPT uncorrected blow count for 300 mm penetration using solid nose sampler

★	**Laboratory Test(s) carried out:**
AL	Atterberg limits
UU	Unconsolidated undrained triaxial
PSD	Particle size
CU	Consolidated undrained triaxial
CONS	Consolidation
COMP	Compaction
UCS	Unconfined compression

WEATHERING

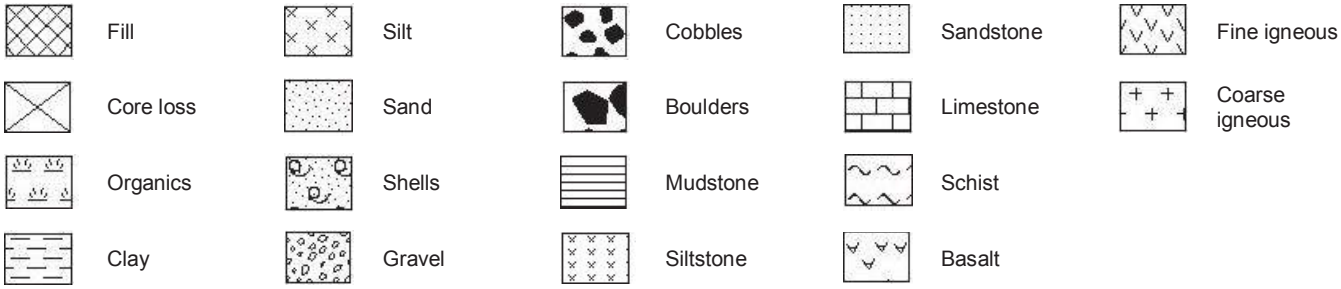
CW	Completely weathered
HW	Highly weathered
MW	Moderately weathered
SW	Slightly weathered
UW	Unweathered

CONSISTENCY

Cohesive Soils	Undrained Shear Strength (kPa)
Very soft	<12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	>200

Non-cohesive Soils	SPT – Uncorrected
Very loose	0 to 4
Loose	4 to 10
Medium dense	10 to 30
Dense	30 to 50
Very dense	>50

GRAPHIC LOG (1 or a combination of the following)



ORGANIC SOILS

Von Post Degree of Humification

H1	Completely unconverted and mud-free peat, when pressed gives clear water and plant structure is visible.
H2	Practically unconverted and mud-free peat, when pressed gives almost clear water and plant structure is visible.
H3	Very slightly decomposed or very slightly muddy peat, when pressed gives marked muddy water, no peat substance passes through the fingers and plant structure is less visible.
H4	Slightly decomposed or slightly muddy peat, when pressed gives marked muddy water and plant structure is less visible.
H5	Moderately decomposed or very muddy peat with growth structure evident but slightly obliterated.
H6	Moderately decomposed or very muddy peat with indistinct growth structure.
H7	Fairly well decomposed or very muddy peat but the growth structure can just be seen.
H8	Well decomposed or very muddy peat with very indistinct growth structure.
H9	Practically decomposed or mud-like peat in which almost no growth structure is evident
H10	Completely decomposed or mud peat where no growth structure can be seen, entire substance passes through the fingers when pressed.

CH2M BECO

TEST PIT No: TP5

TEST PIT LOG

SHEET 1 of 1

PROJECT: Akaroa Wastewater Disposal Alternatives — JOB NUMBER: 6517986

SITE LOCATION: Akaroa — CLIENT: Christchurch City Council

CIRCUIT: NZTM — TEST PIT LOCATION: Robinsons Valley

COORDINATES: N 1,599,198 m, E 5,154,726 m — R L: 160 m — DATUM: LVD — COORDINATE ORIGIN: hhGPS — ACCURACY: ±5m

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	SV	τ (kPa)	WATER LEVEL	R L (m)
			Soft SILT, some fine sand, trace clay; dark brown; moist; low plasticity. [TOPSOIL].					
			Stiff SILT, minor clay, trace fine sand, trace organics, trace fine to coarse gravels, trace fine to coarse cobbles; brown; moist; high plasticity. Gravel & Cobbles: SW, subangular, basalt. Organics: rootlets.	LOESS COLLUVIUM				
			0.35 m: cobbles absent.					
0.5			0.5 m: brown speckled black. Organics: charcoal.					159.5
			Stiff Clayey SILT, some fine sand, trace organics; light brown, mottled light grey; moist; high plasticity. Organics: rootlets.					
1.0								159.0
			1.45 m: Greyish white, mottled orange.					
1.5								158.5
			1.8 m: wet.	LOESS				
2.0								158.0
			2.4 m: moist.					
2.5								157.5
3.0								157.0
3.5			END OF LOG @ 3.5 m					156.5

DATE EXCAVATED: 28/9/16 — CONTRACTOR: Local

LOGGED BY: LB — EQUIPMENT: 2.5t Excavator

SHEAR VANE No: N/A — METHOD: Excavator

COMMENTS:
Co-ordinates by handheld GPS; Elevation from the ECan GIS viewer.

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:20

CH2M BECO

TEST PIT No: IP5

TEST PIT LOG

SHEET 1 of 1

PROJECT:	Akaroa Wastewater Disposal Alternatives	JOB NUMBER:	6517986
SITE LOCATION:	Akaroa	CLIENT:	Christchurch City Council

CIRCUIT: NZTM
COORDINATES: N 1,599,198 m
E 5,154,726 m

TEST PIT LOCATION: Robinsons Valley
R L: 160 m
DATUM: LVD

COORDINATE ORIGIN: hhGPS
ACCURACY: ±5m

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	SV	τ (kPa)	WATER LEVEL	R L (m)
			Soft SILT, minor organics, some fine sand, some clay; dark brown; moist; low plasticity. Organics: amorphous, roots. [TOPSOIL].					
			Stiff SILT, some clay, trace coarse sand, trace medium to coarse gravel, trace fine to medium cobbles; brown; moist; low plasticity. Gravel & cobbles: SW to MW, subangular to subrounded, basalt.	LOESS COLLUVIUM				
0.5			END OF LOG @ 0.43 m					159.5
1.0								159.0
1.5								158.5
2.0								158.0
2.5								157.5
3.0								157.0
3.5								156.5

DATE EXCAVATED:	28/9/16	CONTRACTOR:	Local
LOGGED BY:	LB	EQUIPMENT:	2.5t Excavator
SHEAR VANE No:	N/A	METHOD:	Excavator

COMMENTS:
Co-ordinates by handheld GPS; Elevation from the ECan GIS viewer. Excavated to perform subsurface infiltration ring test.

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:20

CH2M BECO

TEST PIT No: IP8

TEST PIT LOG

SHEET 1 of 1

PROJECT:	Akaroa Wastewater Disposal Alternatives	JOB NUMBER:	6517986
SITE LOCATION:	Akaroa	CLIENT:	Christchurch City Council

CIRCUIT: NZTM
COORDINATES: N 1,605,690 m
E 5,146,116 m
TEST PIT LOCATION: Pompeys Pillar
R L: 235 m
DATUM: LVD
COORDINATE ORIGIN: hhGPS
ACCURACY: ±5m

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	SV	τ (kPa)	WATER LEVEL	R L (m)
			Soft SILT, some fine sand, some organics, trace clay, trace fine cobbles; dark brown; wet; low plasicity. Cobbles: SW, subangular, basalt. Organics: amorphous, rootlets. [TOPSOIL].	LOESS COLLUVIUM				
			Firm SILT, some fine sand, trace fine cobbles, trace clay, dark brown, mottled light brown; wet; low plasticity. Cobbles: SW, subangular, basalt.					
			Stiff SILT, minor clay, trace fine to medium sand; light brown, mottled dark brown; wet; high plasticity.					
0.5			END OF LOG @ 0.4 m					234.5
1.0								234.0
1.5								233.5
2.0								233.0
2.5								232.5
3.0								232.0
3.5								231.5

DATE EXCAVATED:	27/9/16	CONTRACTOR:	McMillans Drilling
LOGGED BY:	LB	EQUIPMENT:	1.8t Excavator
SHEAR VANE No:	N/A	METHOD:	Excavator

COMMENTS:
Co-ordinates by handheld GPS; Elevation from the ECan GIS viewer. Excavated to perform subsurface infiltration ring test.

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:20

CH2M BECO

TEST PIT No: IP9

TEST PIT LOG

SHEET 1 of 1

PROJECT:	Akaroa Wastewater Disposal Alternatives	JOB NUMBER:	6517986
SITE LOCATION:	Akaroa	CLIENT:	Christchurch City Council

CIRCUIT: NZTM
COORDINATES: N 1,606,009 m
E 5,145,295 m
TEST PIT LOCATION: Pompeys Pillar
R L: 160 m
DATUM: LVD
COORDINATE ORIGIN: hhGPS
ACCURACY: ±5m

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	SV	τ (kPa)	WATER LEVEL	R L (m)
			Soft SILT, some fine sand, some organics, trace clay; dark brown; moist; low plasicity. Organics: amorphous, rootlets. [TOPSOIL].					
			Firm SILT, some fine sand, trace clay, light brown, mottled dark brown; moist; low plasticity.					
0.5			Stiff SILT, some clay, some fine sand, trace coarse sand; light brown, mottled orange; moist; low plasticity. Coarse sand: MW-HW, subrounded, orange. Limoite.	LOESS COLLUVIUM				159.5
			END OF LOG @ 0.48 m					
1.0								159.0
1.5								158.5
2.0								158.0
2.5								157.5
3.0								157.0
3.5								156.5

DATE EXCAVATED:	27/9/16	CONTRACTOR:	McMillans Drilling
LOGGED BY:	LB	EQUIPMENT:	1.8t Excavator
SHEAR VANE No:	N/A	METHOD:	Excavator

COMMENTS:
Co-ordinates by handheld GPS; Elevation from the ECan GIS viewer. Excavated to perform subsurface infiltration ring test.

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:20

CH2M BECO

TEST PIT No: IP10

TEST PIT LOG

SHEET 1 of 1

PROJECT:	Akaroa Wastewater Disposal Alternatives	JOB NUMBER:	6517986
SITE LOCATION:	Akaroa	CLIENT:	Christchurch City Council

CIRCUIT: NZTM
COORDINATES: N 1,606,373 m
E 5,145,113 m
TEST PIT LOCATION: Pompeys Pillar
R L: 105 m
DATUM: LVD
COORDINATE ORIGIN: hhGPS
ACCURACY: ±5m

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	SV	τ (kPa)	WATER LEVEL	R L (m)
			Firm SILT, some fine sand, some organics, trace clay; dark brown; moist; low plasicity. Organics: amorphous, rootlets. [TOPSOIL].	LOESS COLLUVIUM				
			Firm SILT, some fine sand, trace clay, trace organics; brown; moist; low plasticity. Organics: rootlets.					
			Firm SILT, some fine sand, some clay; greyish brown; moist; low plasticity.					
			0.38 m: greyish brown, mottled orange.					
0.5			Stiff SILT, some clay, some fine sand; light brown, mottled orange; moist; high plasticity. END OF LOG @ 0.46 m					104.5
1.0								104.0
1.5								103.5
2.0								103.0
2.5								102.5
3.0								102.0
3.5								101.5

DATE EXCAVATED:	27/9/16	CONTRACTOR:	McMillans Drilling
LOGGED BY:	LB	EQUIPMENT:	1.8t Excavator
SHEAR VANE No:	N/A	METHOD:	Excavator

COMMENTS:
Co-ordinates by handheld GPS; Elevation from the ECan GIS viewer. Excavated to perform subsurface infiltration ring test.

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:20

Akaroa Wastewater Disposal Alternatives Test Pits

TP05

View E

DEPTH: 0.0 to 2.0 m

IP05 view W

DEPTH: 0.0 to 0.43 m

Akaroa Wastewater Disposal Alternatives Test Pits

View W **DEPTH: 0.0 to 0.4 m**

Outer ring = 800 mm **Top down view**

IP08

CH2M Beca

6517986/606/008

Test Pit Photos

IP09

DEPTH: 0.0 to 0.48 m

View SW

View W

DEPTH: 0.0 to 0.46 m

IP10