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Report

Akaroa Wastewater Disposal Alternatives - Thacker Site Robinsons Bay - Geotechnical Report

Prepared for Christchurch City Council

Prepared by CH2M Beca Ltd

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on behalf of	CH2M Beca		

Executive Summary

The Christchurch City Council (Council) commissioned CH2M Beca Ltd (Beca) to undertake a preliminary geotechnical assessment to inform the option of applying treated wastewater to potential land areas on, and between, Takamatua headland and Takamatua Valley (*Akaroa Wastewater Upgrade Irrigation - Preliminary Geotechnical Assessment Report*, June 2016. Subsequently alternative areas in Takamatua Valley, Robinsons Bay Valley and Pompeys Pillar were investigated (*Akaroa Wastewater Disposal Alternative Sites Stage 2 - Geotechnical Report* in November 2016). This (February 2017) report presents the results of preliminary geotechnical investigations to inform the option of applying treated wastewater to portions of the Thacker property located between Sawmill Road and Robinson Bay Valley Road within the Robinsons Bay valley area. In addition the investigation also looks at potential buffer pond storage sites for the irrigation water.

The Thacker property, at 11 Sawmill Road, which is located on farmland located between Robinsons Bay Valley Road and the valley summit to the east, and by Sawmill Road to the south, covers around 114 hectares and is being considered as an option for drip irrigation beneath trees. The farmland comprises predominately sloping land, being relatively flat in the valley floor, increasing to steep slopes higher in the valley. There are no occupied dwellings on the property.

Geotechnical investigation comprising; a walkover of the land, the excavation and logging of soils from twelve test pits, the preparation of engineering logs, consideration of storage pond locations and a qualitative assessment of the effect of the proposed irrigation on the ground conditions, including identifying any major geotechnical risks, was carried out. In parallel Beca has commissioned PDP to carry out infiltration investigations and assessment, the results of which are reported separately (refer PDP report of February 2017 titled *Infiltration Testing Results for Akaroa Treated Wastewater Disposal Via Irrigation – Thacker Land*).

The ground conditions encountered in the test pits 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 floor of valley, 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. Loess soils can contain low permeability fragipan zones near to the surface that are problematic for the vertical drainage of the soil (i.e. they become a controlling feature for the design of irrigation systems). However no continuous horizontal zones that may interfere with vertical permeability of the soil mass were observed in the test pits.

In the November 2016 investigation groundwater was measured at approximately 2.5m to 3.5m depth below ground level in the valley floor. However, groundwater was not encountered in any of the February 2017 exploratory holes higher up the valley sides. Ongoing monitoring of the piezometers is recommended to confirm these preliminary levels.

To mitigate the effects of exacerbating any historical gullying, shallow erosion and deep seated slope movements, generally areas sloping at greater than 19° were omitted from the irrigation areas.

The risk of inducing instability in the alluvial soils underlying the valley floor is comparatively low, with the exception of local river banks. 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 19° have been used as one of the criteria in selecting the irrigation areas for trees. The dispersive nature of the loess may result in some localised erosion and potential instability in these higher areas as a result of irrigating wastewater to land. It is of note that reworked loess, such as loess colluvium, is more susceptible to erosion and instability than in

situ loess. Localised movement of such silt slopes may be expected to occur following periods of heavy rainfall, or during seismic activity.

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.

Water flow is expected to be predominantly vertical through the loess. If the applied water reaches the bedrock, flow is expected to be controlled by the lithology, fractures and interconnected pore spaces within the Akaroa Volcanic Group. The layered silt and gravel will have anisotropic permeability, with dominant groundwater flow being horizontally through the gravel.

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1 Introduction

1.1 Background

CH2M Beca Ltd (Beca) has been commissioned by the Christchurch City Council (Council) to undertake geotechnical investigations at locations that are under consideration by the Council as potential sites for irrigation to land of treated 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 the Council 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*, February 2017).

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. A preliminary assessment of the suitability of these three areas for irrigation of treated wastewater was carried out and the geotechnical findings reported in the *Akaroa Wastewater Disposal Alternative Sites Stage 2 - Geotechnical Report* in November 2016.

This (February 2017) report presents the results of preliminary geotechnical investigations to inform the option of applying treated wastewater to portions of the Thacker property located between Sawmill Road and Robinson Bay Valley Road within the Robinsons Bay valley area considered in November 2016. In addition the investigation also looks at potential buffer pond storage sites for the irrigation water. The preliminary findings will be subject to further investigation and assessment, which will be required if the Thacker property is selected for wastewater disposal.

The November 2016 report titled *Akaroa Wastewater Disposal Alternative Sites Stage 2 – Geotechnical Report* includes additional investigations that have taken place on the Thacker land, within Robinsons Valley and this should be referred to when reading this (February 2017) report.

1.2 Scope

The scope of geotechnical investigation carried out is as follows:

- A walkover inspection of the property;
- Robinsons Bay Valley – observe the excavation of, and log the soils from twelve test pits, including recording groundwater level (if encountered);
- Prepare engineering logs of the soils encountered;
- 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 Report of February 2017 titled *Infiltration Testing Results for Akaroa Treated Wastewater Disposal Via Irrigation – Thacker Land)*.

1.3 Proposed Development

The Council is considering the option of land disposal as a method of discharging treated wastewater from the Akaroa wastewater treatment plant. Based on the Stage 2 work the indicative total proposed discharge area will need to be approximately 28 hectares, for irrigation to trees.

The Thacker property size is around 114 hectares. The currently proposed irrigation for the Thacker property would be carried out by drip irrigation beneath trees. The design land application rates being considered for land irrigation under trees are given in the PDP Report of February 2017 titled *Infiltration Testing Results for Akaroa Treated Wastewater Disposal Via Irrigation – Thacker Land.*

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

2 Area Description and Observations

2.1 Location

The Thacker property is farmland located between Robinsons Bay Valley Road and the valley summit to the east, and by Sawmill Road to the south (refer to Borehole Location Plan in Appendix A). The farmland comprises predominately sloping land, being relatively flat in the valley floor, increasing to steep slopes higher in the valley. There are no occupied dwellings on the property. This area is located approximately 5.3km north of Old Coach Road proposed WWTP site, and ranges in elevation from around 30m to 400m above mean sea level.

2.2 Area Geology

The published geological map (Forsyth *et. al.*, 2008) shows that 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.

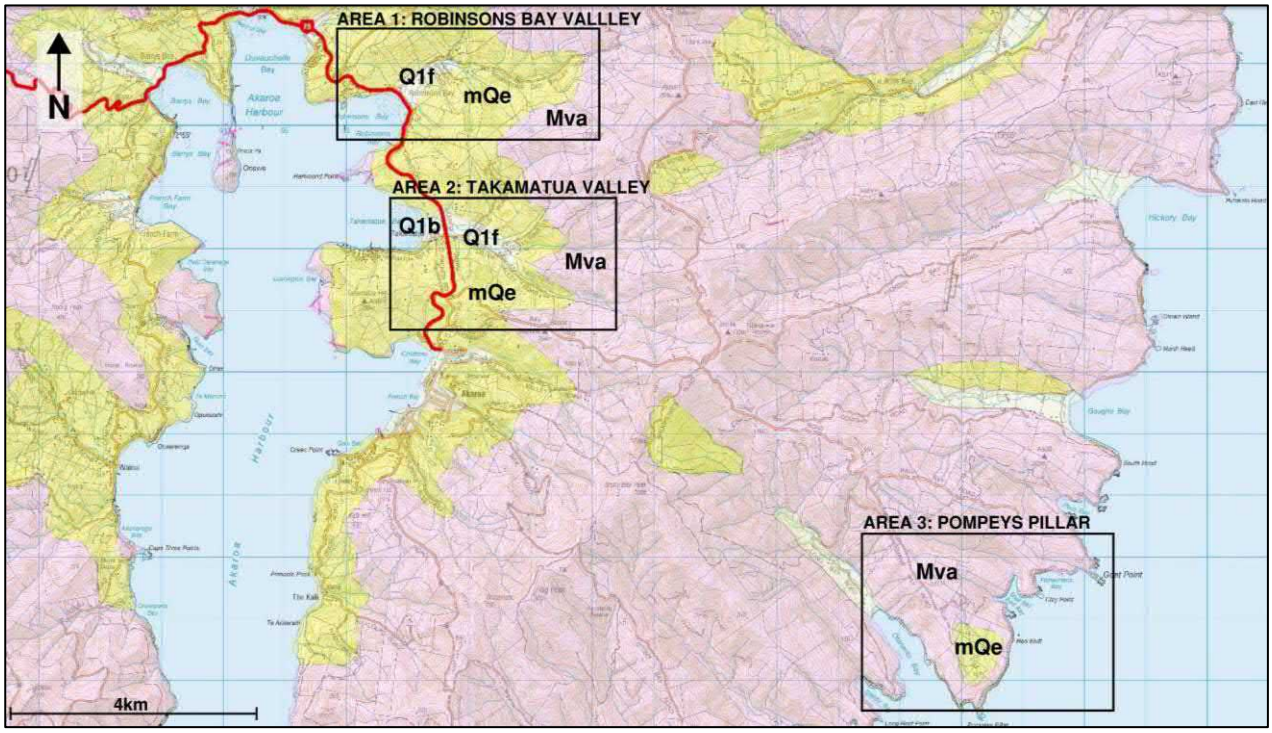

Figure 1. Robinson Bay Valley Location and Geology

2.3 Previous Assessments

A report by Tonkin and Taylor (2008) identified areas of land instability in the Robinsons Bay Valley area. However the study area only extended part way up the valley (to the east) and did not cover the Thacker land.

2.4 Site Walkover Observations

As noted above the published geology of the area indicates a likely composition of Quaternary loess, loess colluvium/ fans and alluvium overlying the Akaroa Volcanic Group. Visual observations are that the loess is thinner higher on the slopes, thickening with decreasing elevation, although the depth is likely to vary based on the underlying bedrock profile. Loess colluvium/fans are composed of reworked loess and miscellaneous pieces of bedrock that have accumulated on the lower slopes as a result of various gravity induced geological processes. The alluvium is expected to be limited to the valley bottoms.

Generally on the lower elevation slopes the land surface is undulating with little or no evidence of instability away from the steeper gullies. There is evidence of shallow instability and/or erosion locally on the gully boundaries and next to the banks of Robinsons Bay Valley Stream. The surface expression of these features indicates shallow translational movement, typically in the range of 1m to 2m deep, occurring where the slopes/banks have been over-steepened. The movement is limited to the loess and loess colluvium/fans, except adjacent to the main creek, where they occur in the alluvium. Based on visual observations it appears that the loess or loess colluvium/fans are less stable than the alluvium.

On the mid-slopes, typically of elevations between approximately 100m and 200m above mean sea level (ASL), the ground rises and the inclination of the slopes increases. In the gully areas the ground surface is often hummocky (indicative of ground movement), with this being particularly noticeable towards the eastern boundary of the Thacker property.

On the higher slopes, above an approximate elevation of 200m ASL there is evidence that the bedrock is at shallow depth, being exposed on some of the steeper slopes. The flatter areas, between the steeper slopes, suggest terraces or other geological features within the bedrock, influencing the surface morphology. The scale of these features are not expected to relate to deep seated instability. However where the surficial soils are thicker, typically in the gully areas, there is evidence of shallow ground movement and locally there is evidence of debris flows.

A number of seeps and springs were noted across the area which are expected to be controlled by the hydrogeology of the bedrock.

A preliminary assessment is that the increased risk of instability caused by irrigation of preferred areas within the site is low. This is based on applying dripper irrigation to the lower areas and mid-areas as shown in Appendix A, where the application is set back from steeper features such as gullies and away from hummocky ground above steeper slopes.

2.5 Pond Storage Options

The Appendix A plan shows pond sites viewed during the walkover. The selected sites all conform to the proposed minimum dwelling buffer distance of 100m. A commentary on the visual observations and recommendations of these potential pond sites is set out below.

The volume of storage required for the pond system has been previously reported at around 12,000m^3. However, based on further assessment work by PDP in February 2017 it is recommended to increase the pond storage to 17,500m^3 to provide a more conservative irrigation application rate, and to give the option to include for a volume of 2,500m^3 to account for direct rainfall onto the pond. The storage volume remains indicative at this stage and can only be confirmed accurately once the irrigation area has been identified in terms of specific land parcels and the infiltration characteristics of these areas has been fully investigated.

Assuming a pond water depth of 3.0m and a basal rainfall storage depth of 0.5m then an active storage of 2.5m would be provided. A total water depth of 3m is considered well suited to meeting the storage requirement while also assisting to maintain the pond dissolved oxygen levels to full depth. Based on this depth, for an active storage volume of 17,500m^3, a square pond would need to be around 90m in length. Detailed investigations and design will be required to better define these figures.

2.5.1 Site 1 (T1): Elevation 40m

This site is the one of the more favourable viewed on the property. Although it is not flat, which would assist with optimising the earthworks required for the pond, it is relatively gently sloping and falls around 8m down the slope (over a distance of 130m). Depending on the pond volume required and the depth to bedrock, it is possible that one, two or three ponds would contain the necessary volume (multiple ponds cascading down the hill). The geomorphology of the site indicates that the landform is relatively stable with limited to no stability issues.

At this location there appears to be thick deposits of loess/surficial soils as witnessed in adjacent stream cuttings. Provided that there are many meters of loess/surficial soils at this location, the loess/surficial soils could be used in a cut and fill process to form the structural foundation of a lined pond system. If the volcanic bedrock was present at relatively shallow depths then this would make the pond location more problematic and lead to higher construction costs and potentially a greater cumulative pond area. An alternative would be to have the pond sit on the slope and use nearby borrow soil to form the pond. This option would likely be more visually intrusive. The site has an upstream catchment, so the stormwater would need to be diverted in a shallow swale around the pond site.

2.5.2 Sites 2 (T2): Elevation 140m

This site is located at the top of a gully and immediately below site T3. It could be developed as a ‘dam’ positioned across the upper gully in order to minimise the earthworks required. The site has limited upstream stormwater catchment and small diversion swales could divert water around them. Site T2 is in close proximity to the adjacent trees which can be hazardous for pond systems (either if they were to fall in a wind storm or their roots hunt out the water source).

2.5.3 Site 3 (T3): Elevation 150m

This site is situated on a knoll at the head of the main irrigation area, directly adjacent to the property to the south. The neighbouring property has mature eucalypt and other exotic trees directly on the boundary, which is not favourable for the positioning of a storage pond. Notwithstanding this, the site is relatively flat over a wide area. The site has virtually no upstream catchment and consequently limited stormwater issues. There is no indication of the depth of loess at this location, but is expected to be favourable for the construction of shallow ponds. It is noted that this site is at an elevation of 150m, which is around 40m higher that the wastewater treatment plant site at Akaroa. Consequently, this site and higher ones would require pumping from the plant to fill the pond (whereas lower pond systems may be fed by gravity flow from the treatment plant, but would then need to be pumped up the irrigation fields).

2.5.4 Site 4 (T4): Elevation 220m

This is a relatively small site and may only be of use for a distributed pond system. No investigations were undertaken at this site.

2.5.5 Site 5 (T5): Elevation 206m

Anecdotally the land directly to the north of this site is reported to be continuously wet in the winter. Given the hummocky nature of this area, and its wet nature the area is not likely to be used for irrigation. Nonetheless the ridge to the northwest is more favourable as a possible irrigation area, hence this site may be of some use in a distributed pond system. The geomorphology of the area is uncertain and would require detailed examination to determine the stability of the site. No investigations were undertaken at this site.

2.5.6 Site 6 (T6): Elevation 314m

This site is a relatively flat, large, amphitheatre like area towards the top of the property. The site is very steep both upslope and downslope. Upslope of the site, and within it, there are areas of active rock sliding (scree). Much of the floor of the amphitheatre is covered in rock. Interestingly from a geomorphology perspective there is no obvious rock accumulation on the floor of the amphitheatre. It is unlikely that there are suitable soils for the construction of a pond at this location and soils would need to be hauled upslope to this location to create a pond. While possible to build a pond here, rock fall issues would need to be addressed and cartage costs for fill from downslope are likely to be prohibitive. No investigations were undertaken at this site.

2.5.7 Site 7 (T7): Elevation 316m

This is a large site in a transition zone between a steep ridge above and hummocky land below to the northwest. It is a long thin site that contours around the slope directly adjacent to the property boundary. This site is likely to be underlain by a thin layer of volcanic colluvium based on the small cuttings observed. Rock fall appears to be relatively limited in this area. The location on the property is not suitable for the irrigation system which is likely to be situated on the lower slopes. No investigations were undertaken at this site.

3 Scope of Investigation

3.1 Field Investigations

The geotechnical investigations on the Thacker property comprised twelve test pits (TP 100 through TP 111). The test pit locations are shown on the figures in Appendix A. Additional infiltration pits and hand augers were undertaken by PDP (report of February 2017 titled *Infiltration Testing Results for Akaroa Treated Wastewater Disposal Via Irrigation – Thacker Land)*.

The test pit site investigation commenced on 1st February 2017 and was completed on 3rd February 2017. The geotechnical site investigations were observed by a Beca geotechnical engineer. Unless otherwise stated, all soil and rock logging has been undertaken by a Beca geotechnical engineer in general accordance with New Zealand Geotechnical Society Guidelines (NZGS, 2005). All logs have been verified by a Beca Senior Engineering Geologist.

3.2 Test Pits

Peninsula Excavations Ltd were contracted to excavate test pits using a 2.5 tonne excavator. The pits were approximately 1.5 by 1.0m in plan area and ranged up to 4.1m depth. Beyond around 1m depth the pits were excavated using a machine auger attachment on the excavator. Ground water was not encountered in any of the pits.

The test pit logs and photographs are presented in Appendix B.

Table 1: Summary of Test Pit (TP)

TP No.	Northing (m)	Easting (m)	R.L. ground (m)	Total Depth (m)
TP 100	5,154,843	1,598,389	76	1.2
TP 101	5,154,794	1,598,491	88	3.8
TP 102	5,154,145	1,598,670	196	3.8
TP 103	5,154,469	1,598,796	158	4.0
TP 104	5,154,344	1,598,557	152	4.0
TP 105	5,154,355	1,598,494	148	4.0
TP 106	5,154,488	1,598,380	126	3.6
TP 107	5,154,598	1,598,416	116	3.9
TP 108	5,154,800	1,598,091	63	4.0
TP 109	5,154,893	1,597,803	45	4.0
TP 110	5,154,923	1,597,731	40	4.1
TP 111	5,154,581	1,598,879	149	4.0

3.3 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 Report of February 2017 titled *Infiltration Testing Results for Akaroa Treated Wastewater Disposal Via Irrigation – Thacker Land* for the details).

4 Conceptual Ground Model

4.1 Geological Setting

The ground conditions encountered in the test pits 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 floor of valley, 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. Towards the bottom of the alluvium, nearer to the contact with bedrock, the sediments become more gravelly. Underlying these terrestrial sediments is expected to be the Akaroa Volcanic Group (although not proven).

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

Within the valleys and at higher elevations, colluvium, loess colluvium and reworked loess are present, typically above 60m RL. These materials are generally thicker at lower elevations, becoming thinner at higher levels.

4.2 Thacker Property Soils

Table 2 summarises the ground conditions encountered in the February 2017 test pits on the Thacker land in the Robinsons Bay Valley, which were typically at a higher elevation.

Table 2: Ground conditions at Robinsons Bay Valley based on February 2017 Test Pits

Unit	Approximate Depth (m)	Approximate Layer thickness (m)	Typical Description	Geological Unit
-	0	0.12	Topsoil	N/A
0[1]	0.1	2.4	SILT, trace clay, trace sand	Loess Colluvium
1	0.12	4m+	SILT, trace clay, trace sand	Loess

Notes: 1. Only encountered in TP 100 and TP 101

Table 3 has been taken from the November 2016 report and summarises the ground conditions encountered in the Robinsons Bay Valley based on information from the boreholes in the base of the valley on Thacker land.

Table 3: Ground conditions at Robinsons Bay Valley based on November 2016 boreholes and test pits

Unit	Approximate Depth (m)	Approximate Layer thickness (m)	Typical Description	Geological Unit
-	0	0.15	Topsoil	N/A
1	0.15	1.5	Sandy SILT, some to trace clay, trace gravel	Alluvium
2[1]	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[1]	5.6	> 0.5	GRAVEL, some sand, trace silt	Alluvium

Notes: 1. Absent in TP5 (inland)

The investigations indicate a broadly consistent pattern of a thin layer of poorly developed topsoil overlying deep deposits of loess silt within ten of the twelve test pits excavated (TP 102 to TP 111). The base of the silt layer was not encountered, nor was the ground water table in these test pits. Within Test pits TP 100 and 101 and the November 2016 exploratory holes mixed deposits of loess colluvium and alluvial gravels (inferred to lie at the base of the pit) were encountered. Test Pit TP 100 was located on the alluvial plain adjacent to the valley stream and was terminated short of target depth due to the presence of cobbles/boulders. The interbedded gravel underlying the upper silt in the central valley floor is consistent with the geological model indicating alluvial deposition of more granular deposits at lower elevations. TP 101 was located within an active gully region within hummocky ground and was interpreted to be colluvium material.

In the November 2016 investigation groundwater was measured at approximately 2.5m to 3.5m in the valley floor. 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.

The Thacker property is located within a Zone of Loessial deposition. In this zone the fragipan appears less developed and gammation (refer below) of the soils occurs with greater predominance. Fragipan is a zone near to the surface that is compact and provides a low permeability zone that is extensive, such zones are problematic for the vertical drainage of the soil (i.e. they become a controlling feature for the design of irrigation systems). Fragipan and gammation zones develop with time as weathering processes.

The gammation zone consists of features around blocky discontinuities within the matrix of the loess. The discontinuities were found to be typically moderately widely spaced (i.e. 200mm to 600mm). At the discontinuities, horizontal through to vertical in orientation, the soil gets leached of iron and this results in grey zones around the discontinuities and often orange staining at the fringe of the grey. No continuous horizontal gammation zones that may interfere with vertical permeability of the soil mass were observed in the test pits. The gammation development was present in most of the test pits encountered within the parent loess soil, but were more pronounced in test pits TP 109 and TP 100 on the gentler slopes towards the base of the property. In these lower elevation pits the grey zones were becoming thin (20mm to 60mm thick), whereas they were very thin (6mm to 20mm) higher on the hill side. As depth increased within the test pits the gammation presentation transitioned from mottled orange soils to the greyed veins shown in Figure 2.

Figure 2: Soil gammation encountered within TP 108 at around 1m depth (soil fragment is approximately 200mm long)

Another feature of the loess soils was the presence of vesicles (small holes) within the soil matrix, these being typically less than 1mm in diameter. These vesicles can also been seen in Figure 2 (small black spots). Such holes may assist with the passage of water through the silt soils, even though their continuity throughout the soil mass could not be determined.

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 Thacker assessment have been screened to exclude land sloping at greater than 19°. Hence the issues identified in the Stage 1 assessment, whilst still having the potential to occur, are expected to have a lower risk profile for the areas in this assessment.

5.2 Thacker Property, Robinson's Bay Valley

The November 2016 report *Akaroa Wastewater Disposal Alternative Sites Stage 2 – Geotechnical Report* noted that 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.

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 19° have been used as one of the criteria in selecting the irrigation areas for trees. However the dispersive nature of the loess is likely to result in some localised 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.

Water flow is expected to be predominantly vertical through the loess, but will likely be influenced by the gammation zones deeper in the soil. However locally, cemented layers or fragipans within the loess may lead to lateral flow above the pans. Root structures for planted forest areas are likely to break up the fragipan zones if they were to exist. If the applied water reaches the bedrock, flow is expected to be controlled by the lithology, fractures and interconnected pore spaces within the Akaroa Volcanic Group.

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.

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Appendix A

Site Plan and Locations of Investigations

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Legend

- Stage 1 Bore Hole Locations
- Stage 1 Test Locations
- Proposed Stage 2 Test Locations
- Potential Pond Sites
- Approximate boundary of preferred area with slope generally < 19 (30.71 ha)
- Approximate boundary of less preferred area with slope generally < 19 (1.49 ha)
- Thacker Property
- River 25m Buffer
- Stream 10m Buffer
- 200m Contour

Slope 0º - 19º (62 ha)

- < 15º
- 15º - 19º

Note: Discharge Area Calculated using 15m LINZ DEM
Building Footprints used from LINZ Topo 50, 2005

Kingstons Hill
Robinsons Bay Valley Road
Sawmill Road
Christchurch Akaroa Road

T1 T2 T3 T4 T5 T6 T7

Author: BDJ Date: 17/02/2017

File: \\Beca.net\projects\6517986\TGI\01 Map\6517986-20-31_AkaroaNewWWTP_ThackerProperty_DripperIrrigation_10.3.mxd

Map Scale @ A3: 1:8,000
0 80 160 320
Metres

1 Ha @ 1:10,000

N

Revision	Author	Verified	Approved	Date
4	BDJ	JAF2	GO	17/02/2017
3	BDJ	DRAFT	DRAFT	31/01/2017
2	BDJ	DRAFT	DRAFT	27/01/2017
1	BDJ	DRAFT	DRAFT	09/01/2017

Title: **Thacker Property, 11 Sawmill Rd, Robinsons Bay**
Preliminary Assessment of Irrigable Areas and Provisional Test Pit Locations

Client: **Christchurch City Council**

Project: **Akaroa Wastewater Upgrade**

CH2M Beca

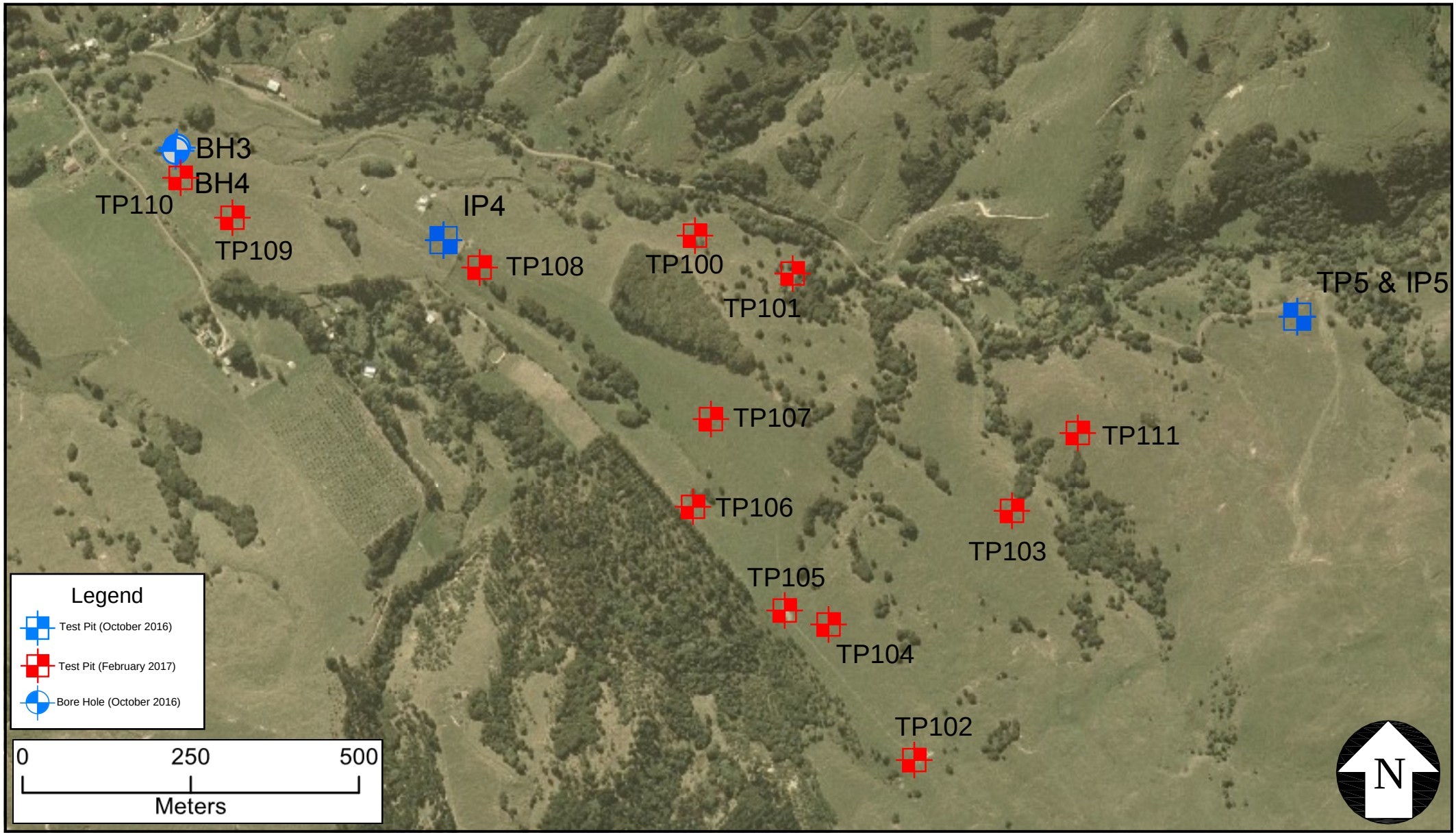
Discipline: **GIS**

Drawing No: **GIS-6517986-20-31**

Appendix B

Test Pit Logs and Photographs

Robinsons Bay Valley - Thacker Property



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No.	Revision	By	Chk	Appd	Date	Drawing Originator: CH2M Beca	Original Scale (A1) / Reduced Scale (A3)	Design / Drawn / Dsg Verifier / Dwg Check	Approved For Construction* Date	Client: Christchurch City Council	Project: Akaroa Wastewater Disposal Alternative Sites Stage 3	Title: Robinsons Bay Valley Thacker Property	Discipline: Site Map	Job Number: 6517986 / Rev.: 0

* Refer to Revision 1 for Original Signature

DO NOT SCALE

IF IN DOUBT ASK.

BLUEBEAM

CH2M Beca

TEST PIT No: 100

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 Bay Valley

COORDINATES: N 5,154,843 m — R L: 76 m — COORDINATE ORIGIN: hhGPS

E 1,598,389 m — DATUM: MSL — ACCURACY: ±5m

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	SV	τ (kPa)	WATER LEVEL	R L (m)
			SILT, minor clay, trace organics; light brown; dry; high plasticity (when wetted). Organics: rootlets. [TOPSOIL].					
			Very stiff, SILT, trace fine sand, trace clay, trace organics, trace fine to coarse angular gravel/cobbles; light brown mottled grey; dry; high plasticity (when wetted). Organics: rootlets.	LOESS COLLUVIUM	138/30	199/48		
0.5			SILT, minor coarse sub-angular gravel/cobbles; light brown/ brown; moist. Gravel/cobbles: sub-angular basalt.		126/31	183/48		75.5
1.0			1.0m some gravel/cobbles.					75.0
			END OF LOG @ 1.2 m					
1.5								74.5
2.0								74.0
2.5								73.5
3.0								73.0
3.5								72.5
4.0								72.0
4.5								71.5

DATE EXCAVATED: 1/2/17 — CONTRACTOR: Peninsula Excavations

LOGGED BY: SC — EQUIPMENT: 2.5t Excavator

SHEAR VANE No: Geo1211 — METHOD: E

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

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:25

CH2M BECA

TEST PIT No: 101

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 5,154,794 m
E 1,598,491 m
TEST PIT LOCATION: Robinsons Bay Valley
R L: 88 m
DATUM: MSL
COORDINATE ORIGIN: hhGPS
ACCURACY: ±5m

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	SV	τ (kPa)	WATER LEVEL	R L (m)
			Stiff, SILT, trace fine sand, trace to minor clay, trace organics; light brown; high plasticity. Organics: rootlets. [TOPSOIL]					
			Stiff, SILT, trace fine sand, trace clay; mottled grey, orange, brown.	LOESS	UTP			
0.5			0.4m. Becomes soft; moist.		60/8	89/16		87.5
1.0					50/10	74/20		87.0
1.5								86.5
2.0								86.0
2.5								85.5
3.0								85.0
3.5								84.5
			END OF LOG @ 3.8 m					
4.0								84.0
4.5								83.5

DATE EXCAVATED:	1/2/17	CONTRACTOR:	Peninsula Excavations	COMMENTS: Co-ordinates by handheld GPS; Elevation from the ECan GIS viewer.
LOGGED BY:	SC	EQUIPMENT:	2.5t Excavator	
SHEAR VANE No:	Geo1211	METHOD:	E	

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:25

CH2M Beca

TEST PIT No: 102

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 5,154,145 m
E 1,598,670 m
TEST PIT LOCATION: Robinsons Bay Valley
R L: 196 m
DATUM: MSL
COORDINATE ORIGIN: hhGPS
ACCURACY: ±5m

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	SV	τ (kPa)	WATER LEVEL	R L (m)
			Stiff, SILT, trace fine sand, trace clay, trace organics; light brown; dry. Organics: rootlets. [TOPSOIL]					
			Stiff, SILT, trace fine sand, trace clay, trace organics; light brown, speckled grey, orange; dry. Organics: rootlets. 0.2m. Very stiff to hard.	LOESS	80/10 UTP	114/20		
0.5			0.6m. Becoming hard.					195.5
			0.8m. Mottled orange; moist.					
1.0								195.0
			1.2m. Orange mottling absent; becoming wet.					
1.5								194.5
2.0								194.0
2.5								193.5
3.0								193.0
			3.3m Stiff; occasional thin bands of orangish brown; otherwise brown.					
3.5								192.5
			END OF LOG @ 3.8 m					
4.0								192.0
4.5								191.5

DATE EXCAVATED:	1/2/17	CONTRACTOR:	Peninsula Excavations
LOGGED BY:	SC	EQUIPMENT:	2.5t Excavator
SHEAR VANE No:	Geo1211	METHOD:	E

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

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:25

CH2M Beca

TEST PIT No: 103

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 5,154,469 m
E 1,598,796 m
TEST PIT LOCATION: Robinsons Bay Valley
R L: 158 m
DATUM: MSL
COORDINATE ORIGIN: hhGPS
ACCURACY: ±5m

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	SV	τ (kPa)	WATER LEVEL	R L (m)
			Hard, SILT, trace fine sand, trace clay, trace organics; light brown; dry. Organics: rootlets. [TOPSOIL]					
			Very Stiff, SILT, trace clay; mottled grey, orange and brown; dry; high plasticity (when wetted).					
0.5			0.5m. mottled orange; moist.		140	202		157.5
1.0			1.0m. Ocassional thin grey veins.					157.0
1.5								156.5
2.0				LOESS				156.0
2.5								155.5
3.0								155.0
3.5								154.5
4.0			END OF LOG @ 4 m					154.0
4.5								153.5

DATE EXCAVATED:	1/2/17	CONTRACTOR:	Peninsula Excavations	COMMENTS: Co-ordinates by handheld GPS; Elevation from the ECan GIS viewer.
LOGGED BY:	SC	EQUIPMENT:	2.5t Excavator	
SHEAR VANE No:	Geo1211	METHOD:	E	

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:25

CH2M BECA

TEST PIT No: 104

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 Bay Valley		
COORDINATES:	N 5,154,344 m	R L:	152 m	COORDINATE ORIGIN:	hhGPS
	E 1,598,557 m	DATUM:	MSL	ACCURACY:	±5m

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	SV	τ (kPa)	WATER LEVEL	R L (m)
			Stiff, SILT, trace fine sand, trace clay, trace organics; light brown; dry. Organics: rootlets. [TOPSOIL].					
			Hard, SILT, minor fine sand, trace clay; light brown mottled orange, grey, brown; dry.		UTP			
0.5			0.5m. Moist.		UTP			151.5
					UTP			
1.0								151.0
1.5								150.5
2.0				LOESS				150.0
2.5								149.5
3.0								149.0
3.5								148.5
4.0			END OF LOG @ 4 m					148.0
4.5								147.5

DATE EXCAVATED:	1/2/17	CONTRACTOR:	Peninsula Excavations	COMMENTS:
LOGGED BY:	SC	EQUIPMENT:	2.5t Excavator	Co-ordinates by handheld GPS; Elevation from the ECan GIS viewer.
SHEAR VANE No:	Geo1211	METHOD:	E	

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:25

CH2M BECA

TEST PIT No: 105

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 5,154,355 m
E 1,598,494 m
TEST PIT LOCATION: Robinsons Bay Valley
R L: 148 m
DATUM: MSL
COORDINATE ORIGIN: hhGPS
ACCURACY: ±5m

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	SV	τ (kPa)	WATER LEVEL	R L (m)
0			Hard, SILT, trace fine sand, trace clay, trace organics; light brown; dry. Organics: rootlets. [TOPSOIL]					
			Hard, SILT, trace fine sand, trace clay; light brown, mottled orange grey; dry.					
0.5					UTP			147.5
1.0								147.0
1.5			1.5m. Moist.					146.5
2.0				LOESS				146.0
2.5								145.5
3.0								145.0
3.5								144.5
4.0			END OF LOG @ 4 m					144.0
4.5								143.5

DATE EXCAVATED:	1/2/17	CONTRACTOR:	Peninsula Excavations
LOGGED BY:	SC	EQUIPMENT:	2.5t Excavator
SHEAR VANE No:	Geo1211	METHOD:	E

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

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:25

CH2M Beca

TEST PIT No: 106

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 5,154,488 m
E 1,598,380 m
TEST PIT LOCATION: Robinsons Bay Valley
R L: 126 m
DATUM: MSL
COORDINATE ORIGIN: hhGPS
ACCURACY: ±5m

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	SV	τ (kPa)	WATER LEVEL	R L (m)
			Hard, SILT, trace fine sand, trace clay, trace organics; brown; dry; high plasticity (when wetted). Organics: roots (50mm). [TOPSOIL].					
			Hard, SILT, trace fine sand, trace clay, trace organics; light brown, mottled orangish grey; dry.		UTP			
0.5			0.5m. Roots to 500mm depth.					125.5
1.0								125.0
1.5								124.5
2.0				LOESS				124.0
2.5								123.5
3.0			2.9m. Moist.					123.0
3.5								122.5
			END OF LOG @ 3.6 m					
4.0								122.0
4.5								121.5

DATE EXCAVATED:	2/2/17	CONTRACTOR:	Peninsula Excavations
LOGGED BY:	SC	EQUIPMENT:	2.5t Excavator
SHEAR VANE No:	Geo1211	METHOD:	E

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

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:25

CH2M Beca

TEST PIT No: 107

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 Bay Valley

COORDINATES: N 5,154,598 m, E 1,598,416 m — R L: 116 m — DATUM: MSL — COORDINATE ORIGIN: hhGPS — ACCURACY: ±5m

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	SV	τ (kPa)	WATER LEVEL	R L (m)
			Hard, SILT, trace fine sand, trace clay, trace organics; brown; dry; high plasticity (when wetted). Organics: rootlets. [TOPSOIL].					
			SILT, trace fine sand, trace clay; light brown, mottled orange, grey, white.		UTP			
0.5								115.5
			0.9m. Moist.					
1.0								115.0
1.5								114.5
2.0				LOESS				114.0
2.5								113.5
3.0								113.0
3.5								112.5
			END OF LOG @ 3.9 m					
4.0								112.0
4.5								111.5

DATE EXCAVATED: 2/2/17 — CONTRACTOR: Peninsula Excavations

LOGGED BY: SC — EQUIPMENT: 2.5t Excavator

SHEAR VANE No: Geo1211 — METHOD: E

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

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:25

CH2M BECA

TEST PIT No: 108

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 5,154,800 m
E 1,598,091 m
TEST PIT LOCATION: Robinsons Bay Valley
R L: 63 m
DATUM: MSL
COORDINATE ORIGIN: hhGPS
ACCURACY: ±5m

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	SV	τ (kPa)	WATER LEVEL	R L (m)
			Stiff, SILT, trace sand, trace clay, trace organics; brown; dry; high plasticity (when wetted). Organics: rootlets. [TOPSOIL].					
			Hard, SILT; light brown, mottled orange, grey; moist.					
0.5			0.4m. Mottled light grey (for 50mm) vertical to horizontal veins.		UTP			62.5
1.0								62.0
1.5								61.5
2.0				LOESS				61.0
2.5								60.5
3.0								60.0
3.5			3.5m. Wet.					59.5
4.0			END OF LOG @ 4 m					59.0
4.5								58.5

DATE EXCAVATED:	2/2/17	CONTRACTOR:	Peninsula Excavations	COMMENTS: Co-ordinates by handheld GPS; Elevation from the ECan GIS viewer.
LOGGED BY:	SC	EQUIPMENT:	2.5t Excavator	
SHEAR VANE No:	Geo1211	METHOD:	E	

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:25

CH2M BECA

TEST PIT No: 109

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 5,154,893 m
E 1,597,803 m
TEST PIT LOCATION: Robinsons Bay Valley
R L: 45 m
DATUM: MSL
COORDINATE ORIGIN: hhGPS
ACCURACY: ±5m

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	SV	τ (kPa)	WATER LEVEL	R L (m)
			Stiff, SILT, trace clay, trace organics; brown; dry; high plasticity (when wetted). Organics: rootlets. [TOPSOIL].					
			Hard, SILT, trace fine sand, trace clay; light brown, mottled orange, grey; damp; high plasticity.		UTP			
0.5								44.5
1.0			1.0m. 50mm thick grey bands.					44.0
1.5								43.5
2.0				LOESS				43.0
2.5			2.5m. Wet.					42.5
3.0								42.0
3.5								41.5
4.0			END OF LOG @ 4 m					41.0
4.5								40.5

DATE EXCAVATED:	2/2/17	CONTRACTOR:	Peninsula Excavations
LOGGED BY:	SC	EQUIPMENT:	2.5t Excavator
SHEAR VANE No:	Geo1211	METHOD:	E

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

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:25

CH2M BECA

TEST PIT No: 110

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 Bay Valley

COORDINATES: N 5,154,923 m, E 1,597,731 m — R L: 40 m — DATUM: MSL — COORDINATE ORIGIN: hhGPS — ACCURACY: ±5m

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	SV	τ (kPa)	WATER LEVEL	R L (m)
			Hard, SILT, trace fine sand, trace clay, trace organics; brown; dry. Organics: roots. [TOPSOIL].					
			Hard, SILT, trace clay; light brown, mottled orange, grey; moist.					
0.5					UTP			39.5
			0.8m. Grey bands of fine SILT.					
1.0								39.0
1.5								38.5
2.0			2.0m. Wet.	LOESS				38.0
2.5								37.5
3.0								37.0
3.5								36.5
4.0								36.0
			END OF LOG @ 4.1 m					
4.5								35.5

DATE EXCAVATED: 2/2/17 — CONTRACTOR: Peninsula Excavations

LOGGED BY: SC — EQUIPMENT: 2.5t Excavator

SHEAR VANE No: Geo1211 — METHOD: E

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

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:25

CH2M BECA

TEST PIT No: 111

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 Bay Valley		
COORDINATES:	N 5,154,581 m	R L:	149 m	COORDINATE ORIGIN:	hhGPS
	E 1,598,879 m	DATUM:	MSL	ACCURACY:	±5m

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	SV	τ (kPa)	WATER LEVEL	R L (m)
			Hard, SILT, trace fine sand, trace clay, trace organics/rootlets; brown; dry; high plasticity (when wetted), [TOPSOIL].					
			Hard, SILT, trace clay; light brown, mottled orange, grey; dry.					
0.5					UTP			148.5
			0.75m. Thin grey veins; moist.					
1.0								148.0
			1.3m. Wet.					
1.5								147.5
2.0				LOESS				147.0
2.5								146.5
3.0			3.0m. Orangish brown.					146.0
3.5								145.5
4.0			END OF LOG @ 4 m					145.0
4.5								144.5

DATE EXCAVATED:	3/2/17	CONTRACTOR:	Peninsula Excavations	COMMENTS:
LOGGED BY:	SC	EQUIPMENT:	2.5t Excavator	Co-ordinates by handheld GPS; Elevation from the ECan GIS viewer.
SHEAR VANE No:	Geo1211	METHOD:	E	

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

A4 Scale 1:25

Akaroa Wastewater Disposal Alternatives Test Pits

TP100

TP101

Akaroa Wastewater Disposal Alternatives Test Pits

TP102

TP103

Akaroa Wastewater Disposal Alternatives Test Pits

TP104

TP105

Akaroa Wastewater Disposal Alternatives Test Pits

TP106

TP107

Akaroa Wastewater Disposal Alternatives Test Pits

TP108

TP109

Akaroa Wastewater Disposal Alternatives Test Pits

TP110

TP111