Lodestone Haldon Geotechnical Desktop Study

Mackenzie Country

Prepared for Lodestone Energy Ltd
Prepared by Beca Limited

12 September 2024

Contents

Appendices

Revision History

Revision N°	Prepared By	Description	Date
0	Rose Sudworth	Issued to Client for Comment	12/09/2024

Document Acceptance

Action	Name	Signed	Date
Prepared by	Rose Sudworth		12/09/2024
Reviewed by	Nathan McKenzie		12/09/2024
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on behalf of	Beca Limited		

Executive Summary

Geotechnical Desk Study: Haldon, Mackenzie Country	
Methodology	Desk study using publicly available data and site walkover information.
Expected Ground Conditions	Thin surficial layer of topsoil or fill, underlain by glacial outwash deposits (Q2a) on the higher eastern side of the site and river deposits (Q1a) on the lower western side, separated along a rough north-south orientated terrace. Either side may include cobbles or boulders, particularly the eastern side adjacent to the bedrock observed on Mount Maggie.
Expected Seismic Conditions	Nearest active fault is the Ostler Fault approximately 16 km west of the site. PGA for ULS earthquake scenarios (M_w 7.5) are; IL1 (1/100): 0.2g, IL2 (1/25): 0.1 g, IL2 (1/500): 0.4g, Site Subsoil Class C or D
Expected Groundwater	Area of low rainfall but is in close proximity to water bodies and shallow perched water tables are possible.
Potential Hazards	
Geotechnical	Possibility of localised weak soil, and larger cobbles and boulders in gravels.
Earthquake	No active faults have been mapped crossing this site. Liquefaction vulnerability for the west of the site within the river deposits is categorised as 'possible' and low-lying areas, adjacent to Benmore Lake, with shallow groundwater and loose layers may result in a risk which needs to be evaluated through site investigation.
Flood	Flooding may occur across the site in extreme weather events. A flood hazard assessment is being undertaken concurrently to this report.
Other	Wind, slumping towards lakeshore areas, and lacustrine-tsunami risk from landslides to be considered in design.
Preliminary Recommendations for Development	
Solar Foundations	Pile foundations expected to be suitable but note possible presence of cobbles within alluvium. Other foundation concepts could be considered (e.g. screw piles, shallow foundations).
Substation and Power Station Foundations	Shallow foundations likely to be suitable, subject to evaluation of liquefaction and lateral spread risk.
Earthworks	Thin topsoil may be present, requiring undercutting. Imported granular materials for permanent access tracks.
Cables	If shallow groundwater exists, dewatering may be required for trenches up to 2.5 m deep. Groundwater level data to be refined by site investigation to aid in trench design.

Recommendations for Site Investigation

- Service clearance and mark-out of investigation locations.
- 6 boreholes to 10m bgl with SPTs at 1 m intervals (to allow of liquefaction assessment) and installation of standpipe piezometers on completion. An additional 4 boreholes to be completed to 20 m bgl within the substation footprint.
- Approximately 50 mechanically excavated test pits to 4 m bgl with Dynamic Cone Penetrometer (DCP) testing, supplemented by 50 lower priority test pits or Dynamic Probing Super Heavy (DPSH) testing. An additional 2 test pits to be completed to 4 m bgl within the substation footprint.
- Laboratory testing of soils encountered, including soil characterisation, soil corrosivity testing, and thermal resistivity testing (as previously requested by Lodestone).
- Factual reporting of the results of the geotechnical investigation for the entire site and a Site-Specific Hazard Assessment (SSHA) as required by Transpower for the substation location. This deskstudy report will also be updated to reflect evaluation of the liquefaction assessment following the investigation.

1 Introduction

Lodestone Energy (Lodestone) is proposing to build new solar farms on sites around New Zealand and are currently considering an approximately 300 ha site at Haldon Station in the Mackenzie Country. The proposed development will comprise of photovoltaic (PV) solar arrays, power stations (including both an inverter and transformer), reticulation cables and a substation.

Beca Ltd (Beca) have been engaged by Lodestone to provide a geotechnical desktop study, site walkover and recommendations for field testing. This is being undertaken concurrently with a flood risk assessment which will be reported on separately. Other solar farm sites located in South Canterbury being considered by Lodestone have been reported on separately by Beca.

2 Proposed Development

Based on the South Canterbury sites and the solar farm layout shown in Figure 1, Beca expects the proposed development for the Haldon Station site will generally comprise of the following:

- Photovoltaic modules connected to single-axis trackers (Importance Level (IL) 1) which support and orientate the modules. These are expected to be founded on a central line of piles.
- String combiner boxes to consolidate the outputs. Central inverters to convert electricity from the panels from direct current (DC) to alternating current (AC) and transformers to the raise the voltage level from low to medium, both housed within central power stations (IL2).
- Corridors to access the solar site for operation stage inspection and maintenance. Access roads are assumed to be formed at or close to existing ground level.
- 48 power stations plus a substation (IL4 as a Transpower asset) at the locations identified in Figure 1. The size and level of the platform (e.g. any filling needed to lift these areas above flood levels) is currently not known.
- Low voltage cables from string boxes to power stations to be buried in trenches up to 1.0m depth.
- Medium voltage cables from power stations to the substation to be buried in trenches up to 2.5m depth.
- Perimeter fencing along the boundary of the solar farm.

Selected design information for the proposed development (received from Rated Power) is set out in Table 2-1.

Table 2-1 Proposed Development Characteristics (Rated Power, 2024)

Characteristic	Haldon Station
Site Area	~300ha
No. of panels	353,376
Total power	180 MWp
No. of Power Stations (including transformer)	48
No. of Substations (50 MVA)	1

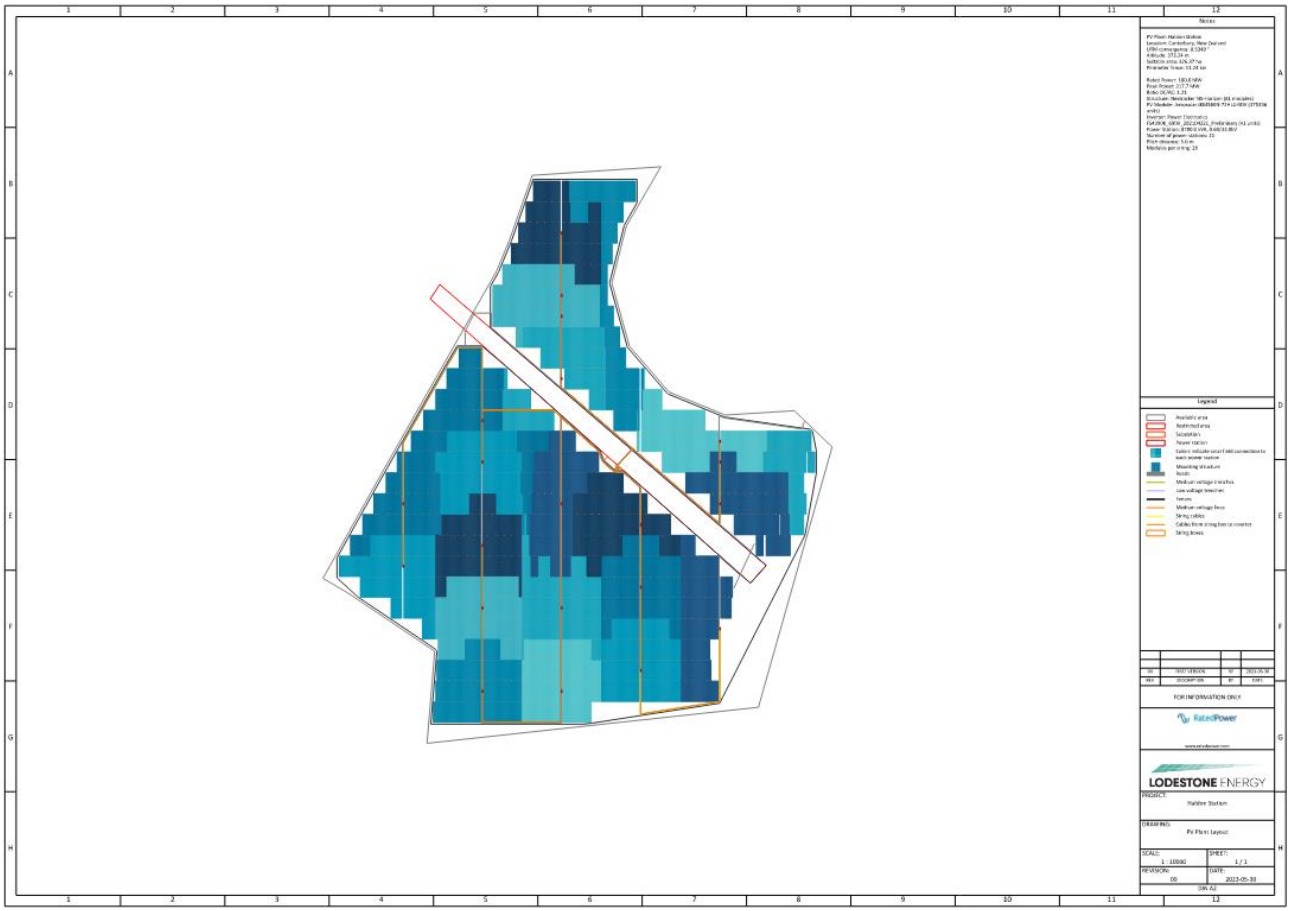

Figure 1: Preliminary Haldon Station solar farm layout (drawing dated 30/05/2023, produced by Rated Power).

3 Desk Study Methodology

The geotechnical desk study was based on a review of publicly available information, as referenced in Section 10. Natural hazard information has been primarily sourced from the Canterbury Maps layers relevant to the Mackenzie District (Canterbury Maps, 2024). Beca did not undertaken any subsurface investigations, however a site walkover was undertaken during preparation of this desk study report.

Lodestone have not provided Beca with a current Land Information Memorandum (LIM) or any other existing geotechnical information or drone photographs and therefore only publicly available information has been reviewed. This report does not cover review of environmental/contaminated land or archaeological information.

4 Site Description

The proposed site is located in the Mackenzie Country approximately 15 km southeast of Twizel, the nearest township, however access to the site is only via Haldon Road approximately 7 km west of Burkes Pass. The property is known as Haldon Station, an operational high-country station and the street address is Haldon Road, Cattle Creek 7999 (Legal Description: Part Reserve 1358, Title Number: CB437/82).

The site is within an irregular shaped area, adjacent to existing farm infrastructure and natural environments. The site is bound by a farm access road and centre pivot irrigation area to the north, the low hills referred to as Mount Maggie immediately east of the site, and the shore of Lake Benmore to the south and west. The site boundary is offset approximately 100 m to 300 m from the shore of Lake Benmore.

The site is approximately 1 km from where the Pukaki River and Twizel River enter the northern extent of Lake Benmore and downstream of several dam structures related to the Waitaki Hydro-Power scheme.

The site is approximately 300 ha in size. Aerial photographs show that no existing structures (such as sheds or other farm infrastructure) are present within the site area although the site is crossed by an overhead transmission line. A brief review of available elevation data shows that the site is generally gently sloping, with elevation decreasing in a southwest direction towards Lake Benmore. It is understood that the site area, as part of the high-country station, is considered un-productive land and has suffered from wind erosion and pest infiltration (Lodestone, 2024). The ground cover appears to be mostly dry grasses and small shrubs, with no large trees present within the site area.

4.1 Services

A ‘before you dig’ (https://www.beforeudig.co.nz) request was undertaken on the 22 August 2024. The only public service noted within the site on the service plans provided is an overhead 220 kV powerline serviced by Transpower that crosses the site, orientated approximately southwest-northeast, as well as three supporting towers. Received data is attached in Appendix A.

4.2 Historical Aerial Imagery

Historical aerial imagery from 1955 to 2019 has been gathered (Canterbury Maps, 2024) and reviewed, which indicates general agricultural use throughout that time, with little change in the layout of the site. However, the area surrounding the site has had some significant changes with the development of the Waitaki Hydro-Power scheme. Earliest available imagery from 1955 indicates the site was located on the eastern banks of the Pukaki River, prior to the construction of the artificial Lake Benmore. By 1965, Lake Benmore is visible in aerial imagery, and the area surrounding the site has remained in a similar configuration since this date, with ongoing agricultural development.

Across all available aerial imagery, surface water channels can be seen meandering across the site which are generally orientated northeast-southwest (parallel to the direction of the Pukaki River). Historical imagery is attached in Appendix B.

4.3 Site Walkover

A walkover by a Beca Engineering Geologist was completed on 26 August 2024 within the site boundary and surrounding area, to gain a greater understanding of the site condition and hazards relevant to the proposed development. A site plan is attached in Appendix C, site photographs taken during the walkover are presented in Figure 2 to Figure 5. A summary of the generalised findings from the site walkover is presented below:

- The ground cover across the site consisted of dry grasses and short shrubs, with gravel and cobbles exposed at the ground surface.
- Within the site, the ground is generally gently sloping, undulating across historical alluvial channels which are spaced approximately 50m to 200 m apart and generally less than 1 m in height difference however up to 2 m in certain areas.
- There is a distinct terrace riser feature down the middle of the site, approximately north to south, where the elevation of the site increases on the eastern side of the terrace. The terrace is most pronounced (up to approximately 3m 4m high) in the northern areas and is less distinct in the south (less than 2 m).
- The high ground connected with Mount Maggie includes slightly metamorphosed sandstone at the surface. Boulders greater than 1 m in diameter are also scattered across the hillsides of Mount Maggie and at the base of the hillside indicating that they could be buried beneath the site as well as the possibility for an extension of the sandstone beneath the eastern side of the site below the alluvial material.
- A small river/creek known as Stony River is located approximately 1 km southeast of the site boundary, on the eastern side of Mount Maggie.
- During the site walkover, the landowner mentioned that the site had received a period of heavy rain the day/night before.

Figure 2: Site overview from Mount Maggie, photograph looking west-southwest.

Figure 3: General ground cover of dry short grasses, with gravel and cobbles at surface.

Figure 4: In situ sandstone and boulders on the lower slopes of Mount Maggie.

Figure 5: Terrace feature that is present across the site (shown in yellow), photograph looking southwest from the northern extent of the site.

5 Ground Conditions

5.1 Geology

Published geological maps (Forsyth, 2001) show the underlying geology of the site is divided between glacial outwash and river deposits, with a boundary orientated roughly northeast-southwest down the centre of the site along a terrace riser as shown in Figure 6. The eastern side of the site is shown to be underlain by Late Pleistocene aged glacial deposits (Q2a), described as outwash gravel. The western side of the site is shown to be underlain by Holocene aged river deposits (Q1a, Springston and Nine Mile Formations) described as generally unweathered, variable mixtures of gravel, sand, silt, and clay forming low-level terraces or abandoned river plains. Adjacent to the eastern boundary of the site is Mount Maggie, a hill features comprised of an anticline and syncline structure of Rakaia Terrane (Tt) sandstone and mudstone. The fold structures (anticline and syncline) and nearby thrust faulting (marked as inactive on published geological maps on east side of Lake Benmore) indicate the surrounding landscape formed under compressional stresses. As noted in Section 4.3, boulders were observed on the slopes of Mount Maggie, which may indicate that sizeable boulders could be buried at depth within the glacial deposits (Q2a) at the base of the slope and the bedrock forming the hills (sandstone) may extend out beneath the site on the eastern side. A cross-section of the interpreted geology at the site is attached in Appendix D.

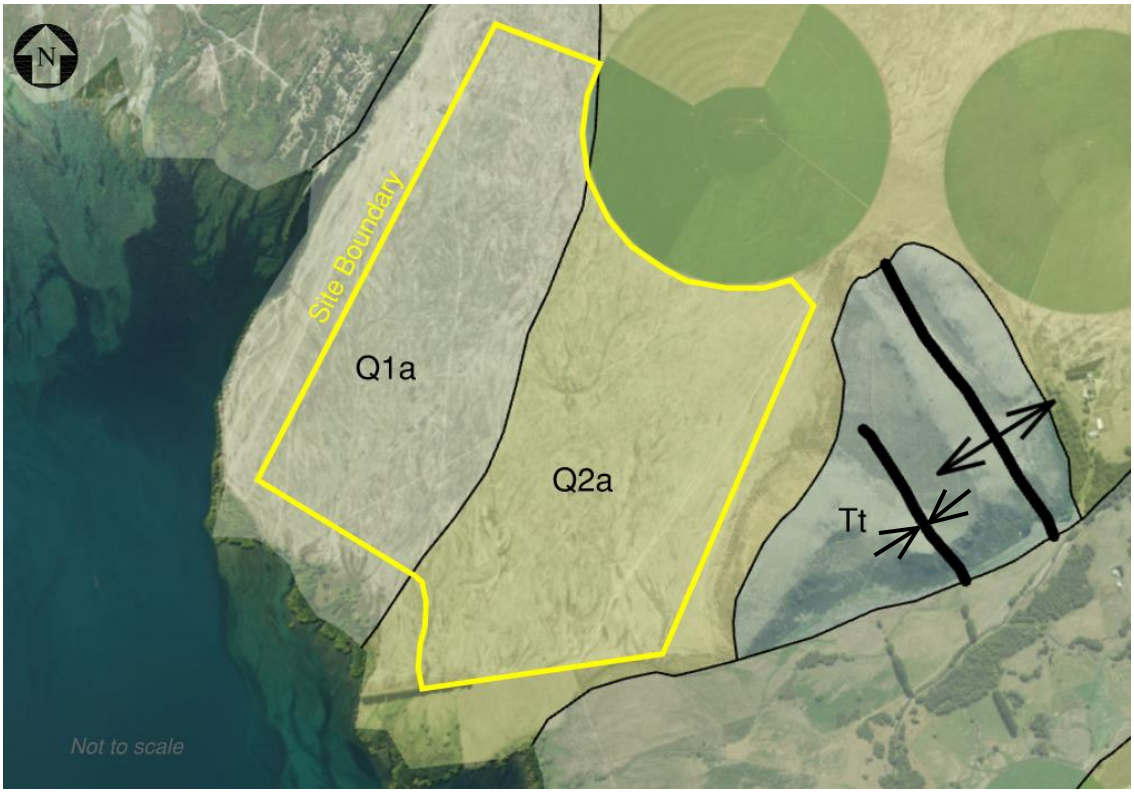

Figure 6: Published geology for the Haldon Station site (Forsyth, 2001) overlain over aerial imagery of site (Land Information New Zealand, captured 2021)

5.2 Ground Conditions

The New Zealand Geotechnical Database (NZGD, https://www.nzgd.org.nz/) shows that there is an absence of publicly available information on the site or close by. The closest investigations approximately 13 km northwest of the site, undertaken in 2020 (by Engineering Design Consultants Ltd) at the location of the Twizel Substation. The investigation comprised of two machine Boreholes to a maximum of 15 metres below ground level (m bgl) and two hand augers combined with DCP tests to a maximum of 0.3 m bgl. The investigations encountered silty, sandy, and clayey gravels to the final investigation depths. No groundwater measurements were recorded in the available logs.

The closest investigations involving a test pit is located 14 km northwest of the site, undertaken in 2019 (by Aurecon Ltd) for a residential development. Underlying topsoil, the test pit encountered sandy gravel to 1.2 m bgl, underlain by sandy gravelly cobbles to the final investigation depth of 1.6 m bgl. The termination reason for the single test pit completed was ‘refusal in very dense gravels’.

Although the existing geotechnical testing is considerable distance away from the site, it is within the same mapped geological unit as the eastern side of the site in the glacial outwash deposits (Q2a).

Environmental Canterbury Well Search (https://www.ecan.govt.nz/data/well-search/) shows four wells immediately adjacent to the site. Although the wells have not been logged by geo-professionals, the logs give an indication of the ground profile, particularly at depth. Of the four wells, three borelogs are available:

- I39/0005 – Gravelly clay encountered to 42 m bgl, underlain by sandy gravelly silt to 64 m bgl, underlain by boulders until rock is encountered at approximately 72 m bgl.
- BZ16/0039 – Sandy gravel with some cobbles to the final depth of 78 m bgl, with minor boulders noted in the upper 43 m of the borelog.
- BZ16/0040 – Topsoil to 0.4 m bgl, underlain by silty gravel to 19 m bgl, underlain by sandy gravel to the final depth of 64 m bgl.

Publicly available investigation logs and Environment Canterbury well logs are attached in Appendix E, and investigation locations shown relative to the site location in Figure 7.

The site is likely to have an altered surficial layer including topsoil, underlain by natural material comprised of silty, sandy, or clayey gravel layers. The gravel layers may contain cobbles and the gravel is expected to extend to considerable depth as suggested by the well logs reviewed above. The implications of these ground conditions are discussed in Section 7.

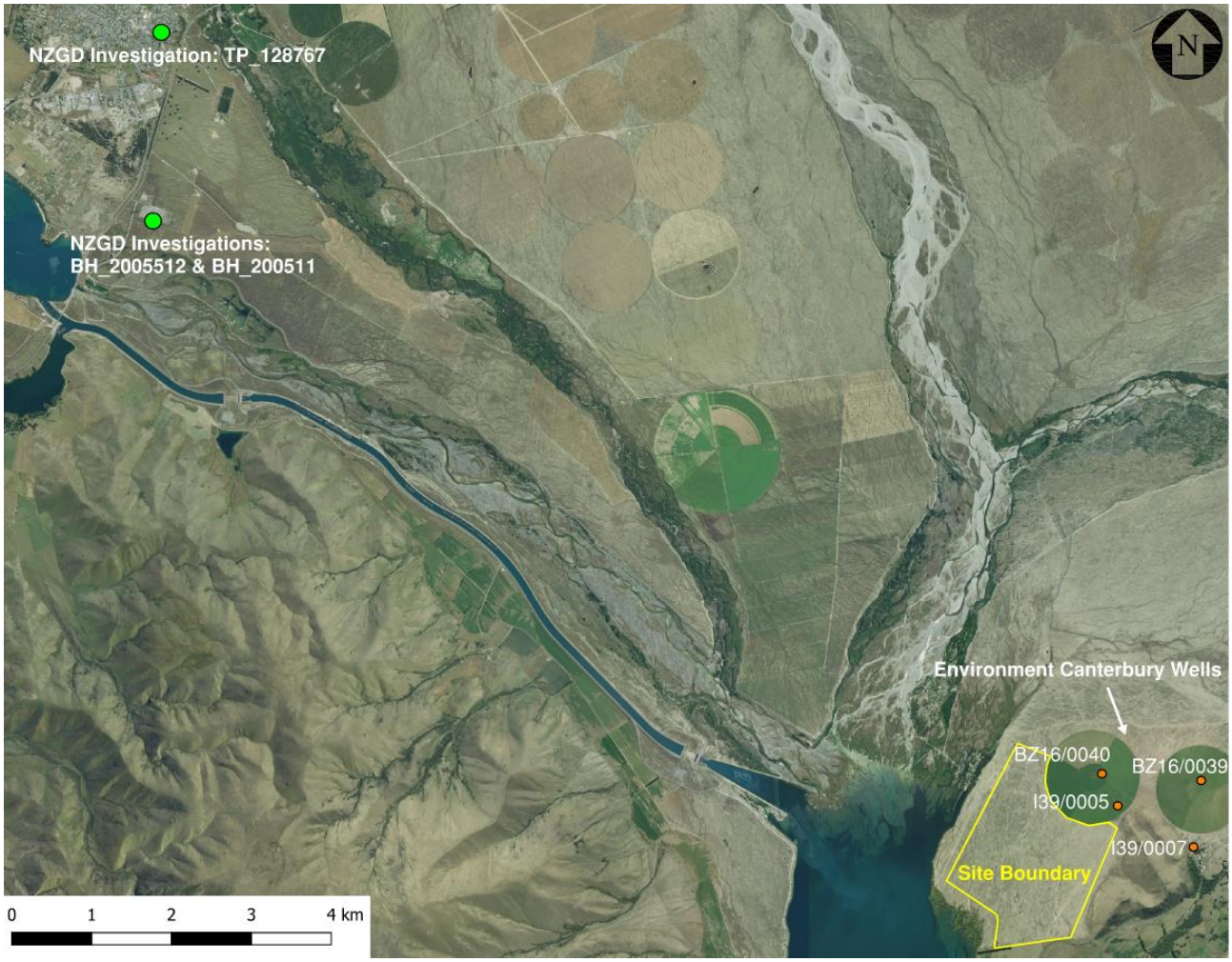

Figure 7: Wider site plan showing locations of investigations from the New Zealand Geotechnical Database and Environment Canterbury Wells, relative to site location.

5.3 Seismic Conditions

5.3.1 Faults

The site will be subject to earthquake shaking in any local event and during an Alpine Fault event. The surface trace of the Alpine Fault is approximately 93 km northwest of the site on the West Coast side of the Southern Alps. The Alpine Fault has been studied extensively and large areas of the South Island have high seismic loads which are routinely designed for. Recent research indicates that there is a 75% probability of an Alpine Fault earthquake occurring in the next 50 years and that there is a 4 out of 5 chance that it will be a Magnitude 8+ event (Howarth, et al., 2018).

The GNS Active Faults Database (GNS, https://data.gns.cri.nz/af/) indicates that the nearest active fault is the Ostler Fault, located approximately 16 km to the west of the site. The Ostler Fault is approximately 50 km

long and crosses the Mackenzie Basin, orientated roughly south-north from Omarama to Twizel (Ghisetti et al., 2007). Revised mapping of the Ostler Fault Zone published by Environment Canterbury (2023) presents an estimated recurrence interval of 2000-4000 years, with the last earthquake on the fault estimated to have occurred 3600 years ago. The locations of the above faults relative to the site location is shown in Figure 8.

Appropriate seismic loading will need to be considered in the design of the solar structures according to the relevant New Zealand standards. The earthquake loads set out in Section 5.3.2 take nearby active faults, including the Alpine Fault, into account.

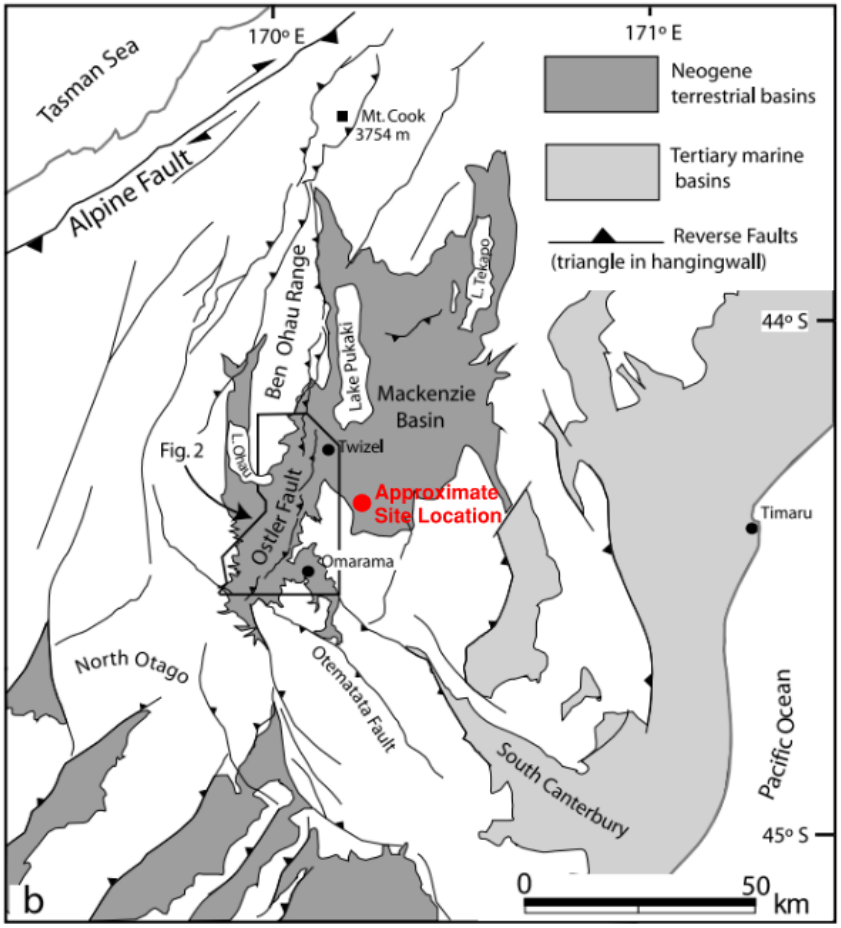

Figure 8: Map of faults within the region of the Mackenzie Basin in the foothills of the Southern Alps. Image taken from Ghisetti et al (2007) annotated with site location.

5.3.2 Earthquake Loads

Beca understand that Lodestone is adopting 50 year design life and the following Importance Level (IL) in accordance with AS/NZS 1170.0.2002:

- PV Modules as IL1.
- Power Stations as IL2.
- Substation as IL2.

Should a greater importance level be adopted for the Transpower substation, earthquake loads can be provided for that specific structure. Earthquake loads for IL1/IL2 structures were determined in accordance with Section 5.1 of MBIE Module 1 and the seismic hazard values presented in Appendix A of MBIE Module 1, using the nearest region of Twizel (NZGS & MBIE, 2021).

Table 5-1 Peak ground acceleration (PGA) and earthquake magnitude at Haldon Station site

Importance Level	Limit State Load	Annual Probability Exceedance	Design Life	Peak Ground Acceleration (PGA)	Moment Magnitude M_w
IL1	SLS	-	50 years	-	-
	ULS	1/100		0.20	6.1
IL2	SLS	1/25	50 years	0.10	6.1
	ULS	1/500		0.40	6.1

5.3.3 Site Subsoil Class

For the derivation of structural demands in accordance with NZS1170.5, the site subsoil class has been preliminarily assessed based on the nearby geotechnical investigations and Environment Canterbury well borelogs reviewed in Sections 5.2. Based on the guidance presented in NZS1170.5 Section 3.1.3 (and Table 3.2 specifically), the site subsoil class is likely between Class C (shallow soil) and Class D (deep or soft soil). This has been informed by the nearby well borelogs (L38/0005 and BZ16/0039), showing gravel, clay, silt, and sand to as shallow as 64 m bgl, underlain by boulders until rock is encountered at approximately 72 m bgl. It is recommended that both Class C and Class D are considered by structural engineers for subsequent earthquake design and that the more conservate value is adopted.

NZS1170.5 is currently being revised including a proposed change to evaluate the earthquake response of the site using shear wave velocity over 30m depth rather than the Site Subsoil Class. The earthquake site response characteristics for the site may require a revision to suite the expected change in approach when the next revision of NZS1170.5 is released for use.

5.4 Groundwater

In areas of the Mackenzie Basin close to active riverbeds, a shallow groundwater table is present within the post-glacial alluvial gravels which is recharged from rivers and rainfall (Cooksey, 2008). With the sites proximity to Pukaki River and Lake Benmore, a shallow groundwater table is therefore possible. The shallow groundwater tables are thought to be perched on lower alluvial gravels, that have higher silt and clay content than the gravels in the upper ground profile. Overall groundwater flow in the areas is towards Lake Benmore (Cookey, 2008).

NIWA's map of median annual total rainfall (NIWA, 2012) indicates that the site and surrounding area at the northern end of Lake Benmore is one of the dryest locations in Canterbury with less than 400 mm per year based on data from 1981-2010.

Based on the Meridian Energy website (accessed September 2024), the operational lake levels of Lake Benmore are bound between the minimum consented level of 354.9 m RL, and 361.1 m RL (NZVD2016) above which the lake is subject to outflow requirements. As of September 2024, the lake level was measured at 360.9 m RL (NZVD2016) and therefore relatively high. Based on a review of LiDAR, the site elevation is approximately 362 to 372 m RL (NZVD2016), indicating a 1m to 11m elevation difference between the site elevation and current lake level. Beca will be undertaking a survey of the site shortly and will be able to confirm the difference in site elevation following that.

There are three active Environment Canterbury Wells (https://www.ecan.govt.nz/data/well-search/) either on the site or in proximity which provide recent groundwater information as summarised in Table 5-2. The locations of these wells are also shown on Figure 7 and we note that all three wells are located at higher elevations than the site. Well I39/0007 presents groundwater depths significantly shallower than the other two active wells in the area, however it is located on the eastern side of Mount Maggie so may be subject to different geological controls. Also as noted in Section 4.3, during the month of August there was a significant

rainfall and if the top of the well is not well sealed, water could be infiltrating from the surface. BZ16/0039 is also some distance from the site, meaning it may not be representative of site groundwater conditions.

I39/0005 is likely the most representative (although still at a higher elevation) and indicates groundwater from 4.3 m bgl. From the data available it is difficult to make assumptions about the groundwater particularly because the site is in an area of low rainfall but is in close proximity to water bodies and shallow perched water tables are possible. Groundwater is likely to vary seasonally and laterally across the large site. Investigation using test pits and standpipe piezometers installed in boreholes are recommended to confirm groundwater levels within the site.

Table 5-2: Groundwater measurements in ECan Wells

Well ID	Location	Elevation at Well Location (m RL, NZVD2016)	Depth to groundwater (m bgl)	Depth of groundwater (m RL, NZVD2016)	Date of measurement
I39/0005	Outside NE corner of site (near/within irrigated area)	375.8	4.3	371.5	Aug 2024
I39/0007	1 km east of site (on far side of Mt Maggie)	377.9	1.6	376.3	Aug 2024
BZ16/0039	1 km NE of site, within irrigated area	383.6	6.0	377.6	Aug 2024

Notes:

Metres below ground level (m bgl).

Metres relative to vertical datum (m RL).

Groundwater depths and levels have been rounded to 1 decimal place.

6 Potential Hazards

Hazards with the potential to impact the site are discussed in the following sections. Those hazards which are unlikely to affect the site due to the characteristics of the site and surrounding land (such as volcanic and geothermal activity) have been omitted for simplicity. A geotechnical site investigation will provide more insight into potential hazards affecting the site and this hazard assessment may require updating following future site activities.

6.1 Geotechnical Hazards

Surficial soft or unsuitable soils (i.e., deep topsoil, non-engineered fill, buried organic material) may be encountered on the site due to historical agricultural use of the site. Expansive soils, subject to high seasonal ground movement, are not expected to be present. Layers of loose soil may exist within the alluvial deposits which could be affected by earthquake shaking.

Slope instability hazards are not expected at this site, other than potentially local instability risks near any existing farm drains or areas of higher elevation (such as the terrace slope).

The gravelly soils expected at the site may include large cobbles or boulders and shallow sandstone bedrock is possible on the eastern side of the site adjacent to Mount Maggie which could be difficult to penetrate for pile foundations. Geotechnical site investigations will help confirm the hazard relevant to foundation design.

6.2 Earthquake Related Hazards

As discussed in Section 5.3, the site (and New Zealand in general) is within a seismically active area. Within the Mackenzie Basin, evidence of past fault rupture may be hidden by the action of braided river systems. No faults have been mapped crossing this site to date, however the hill feature of Mount Maggie is located directly east of the site and is mapped as an anticline and syncline structure which would have formed under compressional stress. Within the site boundary, the generally flat to gently sloping topography suggests that no obvious surface expressions are present and the terrace riser is most likely connected to river erosion. The site is not specifically mapped within the Ostler Fault Hazard Area (2023 layer, available on Canterbury Maps) however this does not rule out the effect of earthquake related hazards.

The Mackenzie Liquefaction Vulnerability Categories (2023 layer, available on Canterbury Maps) shows the liquefaction risk varies across the site with the change corresponding with the geological boundary between the Late Pleistocene Glacial deposits (Q2a) to the east, and Holocene River deposits (Q1a) to the west (as discussed in Section 5.1). The liquefaction risk is described as ‘Liquefaction damage is possible’ for the Holocene River deposits to the west, and ‘Liquefaction damage is unlikely’ for the Late Pleistocene Glacial Deposits to the east. For this to occur loose sandy or silty material and high groundwater would need to be present. As noted in Section 5.4, from the limited data available it is difficult to make assumptions about the groundwater but the close proximity to water bodies and possible shallow perched water tables, indicates that liquefaction may be a risk in any loose layers within the river deposits on the western side of the site and will need be confirmed through site investigation. The Mackenzie Liquefaction Vulnerability Categories are based on a report produced by Environment Canterbury (Jack, 2023) of Revised Liquefaction Information for the Mackenzie District, which has utilised existing geological information for the surrounding area so is an indication of liquefaction vulnerability not a site-specific liquefaction assessment.

With the geological units identified within the site area and their variation in liquefaction vulnerability, liquefaction induced differential settlement should also be considered as an earthquake related hazard for the site. Lateral spreading requires a free face towards which the ground can move during a moderate to large earthquake event. The historic terraces, river channels and lakeshore extents of the site may present a lateral spread hazard. There is limited available information to further investigate the risk of differential settlement and

lateral spreading, though site testing and liquefaction checks are recommended to be completed to assess this.

6.3 Flood (inundation) Hazards

Review of the Mackenzie Operative District Plan (Canterbury Maps, 2024) shows that the southern extent of the site is within the Hydro-Electricity Inundation Hazard Area, as well as the area surrounding the site to the west and north. There are three power stations of the Waitaki Hydro-Power Scheme between Lake Ohau and Lake Benmore, the closets of which to the site is Ohau C power station approximately 3.5 km northwest of the site boundary.

No further information or maps on flood inundation hazard are available for the site, and hydrological modelling is required to confirm site-specific flood risk which is currently being undertaken.

6.4 Other Hazards

The sites proximity to the shores of Lake Benmore may present the hazard of slumping/slipping at lake edges as a result of undercutting by wave action, or excess groundwater and surface water flows, as listed in Section 18 of the Mackenzie District Plan (Mackenzie District Council, 2011). Other hazards to consider as listed in the Mackenzie District Plan are drought, fire, and wind.

As detailed by Lodestone Energy (2024), the site has suffered from wind erosion due to the dry ground and pest infiltration, so it is expected that that wind erosion is a hazard within the site area due to the limited vegetation and topsoil cover. Appropriate wind loads will also need to be considered in the design of the solar structures according to the relevant New Zealand standards.

Existing research has shown that lacustrine-tsunami risk from landslides is a potential hazard for nearby Lake Tekapo, due to the slopes surrounding the lake having high landslide potential as a result of steep slope angles, proximity to active faulting, and high sedimentation rates (Mountjoy et al., 2018). Human settlement and hydropower infrastructure around the lakeshore mean the impact of a tsunami could be significant. Literature that suggests Lake Benmore may also be subject to this hazard could not be found, however Lake Benmore's proximity to Lake Tekapo and similar surrounding environment suggest this hazard may need to be considered. A review of aerial imagery shows the slopes directly opposing the site appear to be alluvial fan structures, with generally gently inclined slopes entering Lake Benmore. There are steeper slopes that enter Lake Benmore further south that may have landslide potential, leading to hazard of lacustrine tsunami.

7 Preliminary Recommendations for Development

7.1 Solar Development Area

Much of the site is expected to be suitable for development based on the completed assessment.

Liquefaction is possible at the site with potential for lateral spreading to occur in low-lying areas adjacent to Lake Benmore. Liquefaction effects further back from the lake are expected to reduce due to deeper groundwater levels. Site investigations and liquefaction assessment is recommended to be completed to evaluate this hazard.

Flooding may also affect the extent of development. This hazard is being evaluated in a separate study.

Refer to the following sections for preliminary development recommendations for specific infrastructure.

7.2 Solar Foundations

Pile foundations are likely to be suitable to support the solar arrays. The expected gravelly soils may include cobbles, buried boulders and sandstone bedrock on the eastern side of the site. These could cause shallow refusal of a proportion of driven or screw piles. The size and proportion of the coarse grain size material and presence of shallow bedrock will be established through the field investigation spread across the site.

Shallow foundations are also expected to be suitable, if considered as an economic alternative.

The height of Photovoltaic modules will need to be checked for adequate freeboard above flood levels within any channels where flooding may occur, plus consideration of water flow loading.

Proposed geotechnical investigations will provide site specific information on the ground conditions and presence of larger cobble/boulders or presence of shallow bedrock which could affect foundation construction. Pre-construction pile testing will also help to assess constructability.

7.3 Substation and Power Station Foundations

Shallow foundations are likely to be suitable for substations and power station foundations, subject to confirmation of the risk of liquefaction. Seismic design considerations may define the foundation type, and confirmation of foundation type will be identified after site specific investigations have been completed to assess the shallow soil profile. Poor ground (e.g., deep weak/organic soils or loose sandy soils) could require localised excavation and replacement with better materials.

The location of this infrastructure is recommended to avoid any channels running across the site that may be identified in the hydrological modelling to reduce the risk of flooding, subject to confirming flood levels. This hazard can also be mitigated by raising the founding levels using engineered fill platforms sufficient to provide an adequate freeboard.

The substation will need to meet any requirements and standards specific to Transpower assets, and advice on required finished floor level for any buildings on the site should be sought from the council.

7.4 Access Roads and Earthworks

Minor earthworks may be required at the substation and power stations to remove organic (topsoil) soils, if they are encountered during geotechnical investigations. Allowances should be made to undercut this material for access roads and in the location of any structures.

Access roads crossing existing channels (if identified) on the site will need to consider potential flooding effects. Roads traversing channels may be designed to allow any flood waters to locally flow over them during flood events and to not alter existing drainage patterns.

Onsite materials are expected to be suitable for reuse in construction, other than screening out any oversize cobble/boulder size material. Imported granular materials are likely needed to form unsealed granular pavements for permanent site access tracks.

7.5 Buried Cables

The near surface soils are expected to be suitable for conventional cable construction, potentially comprising silty, sandy, or clayey gravels. Imported backfill maybe be required for areas trenched through gravels containing cobbles/boulders. Groundwater levels may be as shallow as 1.6 m bgl based on the nearby Environment Canterbury wells, as discussed in Section 5.4. The proposed development specifications (Rated Power, 2024) indicate that medium voltage trenched may be as deep as 2.5 m deep suggesting that dewatering during installation may be required. Groundwater data will be refined by site investigations detailed in Section 8, to aid in trench design for buried cables.

8 Recommendations for Further Work

Beca recommend that a broad scale geotechnical investigation is undertaken to provide ground condition information to the solar supplier and enable the risk of liquefaction to be evaluated. The Transpower substation will require site specific investigation which are included in our recommendations but will be reported on separately. We propose to undertake a comparable density of testing for the South Canterbury Lodestone sites already reported on but scaled for the size of the Haldon Station site. A site plan is provided in Appendix C showing approximate testing locations to illustrate the density of testing. The proposed testing will assist to better characterise site constraints and provide site-specific data for design:

- Service clearance and mark-out of geotechnical investigation locations. Due to the size of the site and its lack of landmarks, locations will need to be surveyed or GPS located ahead of the field investigation.
- 6 boreholes to 10m bgl with Standard Penetration Tests (SPTs) at 1 m intervals (to allow of liquefaction assessment) and installation of standpipe piezometers on completion for long term monitoring.
- Approximately 100 mechanically excavated test pits (1 per approximately 3ha) to 4m bgl with Dynamic Cone Penetrometer (DCP) testing. Beca recommend that 50 of these test pits are prioritised to be completed, while the remaining 50 as secondary priority. The secondary test pits could potentially be replaced by Dynamic Probing Super Heavy (DPSH) testing or only utilised if site conditions are found to be inconsistent between adjacent locations. An additional two test pits are to be completed within the substation footprint (total of four test pits within substation footprint) as part of the site-specific investigation for the substation.
- As part of a site-specific investigation for the substation, an additional 4 boreholes to 20 m bgl and 4 test pits to 4 m bgl are recommended within the substation footprint. Standpipe piezometers should be installed in two of the boreholes, with SPTs at 1 m in all four of the boreholes.
- The number of test pits can be reviewed during the start of the investigation once an understanding of the consistency of the ground conditions has been gained. Test pits will be mechanically excavated using at least a 20-tonne excavator and we have assumed that the priority 1 test pits will take up to 2 weeks to complete with a further 2 weeks required for the secondary test pits.
- Laboratory testing of soils encountered, including soil characterisation, soil corrosivity testing, and thermal resistivity testing (as previously requested by Lodestone).
- Factual reporting of the results of the geotechnical investigation for the entire site and a Site-Specific Hazard Assessment (SSHA) as required by Transpower for the substation location. This desk study report will also be updated to reflect evaluation of the liquefaction assessment following the investigation.

The field testing techniques proposed reflects gravelly soils being encountered, making Cone Penetration Tests (CPTs) impractical. Borehole data will be used to evaluate the liquefaction susceptibility.

Pile load tests would ideally be undertaken after the result of the geotechnical investigation have been analysed and recommendations made regarding the most suitable foundation option. The pile testing will also provide additional constructability feedback on driven piles (if the preferred foundation concept for the solar arrays) within the gravelly soils expected.

Electrical resistivity field testing can be undertaken as part of this geotechnical investigation or once the location of the substation has been confirmed.

If any unexpected or unsuitable ground conditions are encountered during the field investigation, additional testing may be required. Additional testing may also be required to confirm ground conditions at specific locations (such as power stations/substations and any other structures) and potentially to support resource or building consent applications.

Under Section 5.104 of the Canterbury Land and Water Regional Plan (Environment Canterbury, 2023), boreholes for geotechnical investigations are a permitted activity so do not require resource consent given that

monitoring bores are constructed as detailed in the document, and information on bore location and bore installation (i.e., investigation logs) are provided to Canterbury Regional Council within 40 days of carry out the works.

The recommended work is currently outside of the Beca scope of work, but we would be pleased to provide Lodestone with a proposal to commission the appropriate contractors, supervise the work onsite and prepare the required reporting (as currently being undertaken for the other South Canterbury sites).

9 Applicability Statement

This report has been prepared by Beca Limited (Beca) on the specific instructions of Lodestone Energy (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 Beca has not given its prior written consent, is at that person's own risk.

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.

In preparing this report Beca has relied on key information including the following: Canterbury Maps, GNS Science QMaps and Active Faults Database, NZGD, ECan, the Mackenzie District Council website, Rated Power layout dated 30/05/2023 and any other references (as noted in Section 10). Unless specifically stated otherwise in this report, Beca has relied on the accuracy, completeness, currency and sufficiency of all information provided to it by, or on behalf of, the Client, including the information listed above, and has not sought independently to verify the information provided. This report should be read in full, having regard to all stated assumptions, limitations and disclaimers. No part of this report shall be taken out of context, and, to the maximum extent permitted by law, no responsibility is accepted by Beca for the use of any part of this report in any context, or for any purpose, other than that stated herein.

10 References

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A
Appendix A – Service Plans

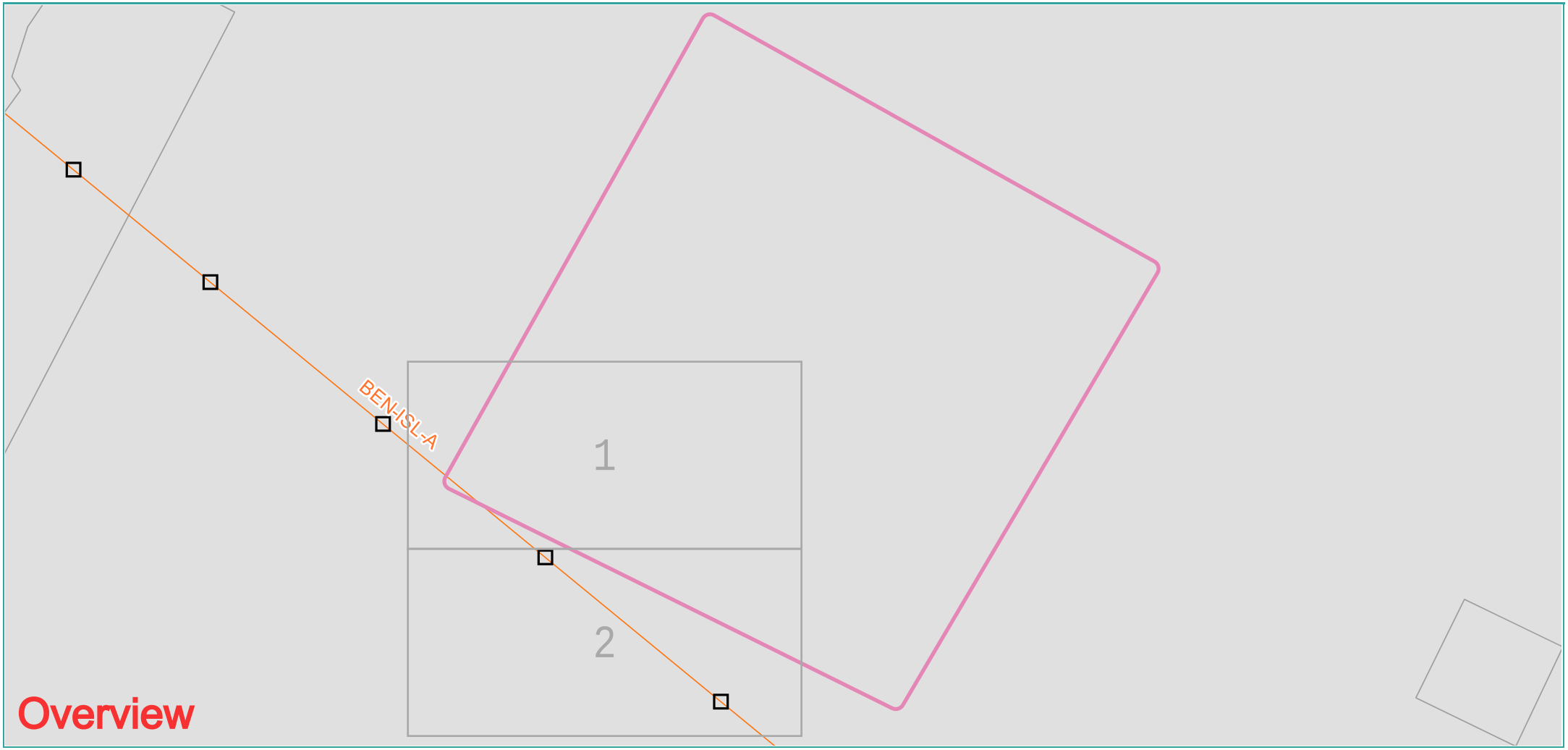
TRANSPOWER

OVERHEAD TRANSMISSION LINES

Site Location: Section 2 Haldon Arm Rd, Tekapo, Canterbury 7999

Sequence No: 13101248

Job No: 2453011



Disclaimer: This map shows current known assets as at the date shown. Contractors must update location information for each new job. This information is provided for reference purposes to assist contractors when determining the approximate location of Transpower's assets. Any graphical information may not be to scale and may not depict the entire asset. Direct field observations/mark-outs are required to determine the precise location of assets. Contractors undertaking excavation works are responsible for protecting underground equipment and rely on these plans at their own risk. No excavation should proceed without locating Transpower's underground assets. Transpower does not accept liability for the accuracy and completeness of this information. While reasonable measures have been taken to ensure the accuracy of the information contained in this plan response, neither Transpower or PelicanCorp shall have any liability whatsoever in relation to any loss, damage, cost or expense arising from the use of this plan response or the information contained in it or the completeness or accuracy of such information. Use of such information is subject to and constitutes acceptance of these terms.

N

Scale: 1:9881

Date: 22/08/2024

- BeforeUdig Enquiry
- < 66kv Overhead
- 110kv Overhead
- 220kv Overhead
- 400kv Overhead
- Pole
- Tower

Only Transpower assets are shown. Please consult local power companies for other electricity asset locations.

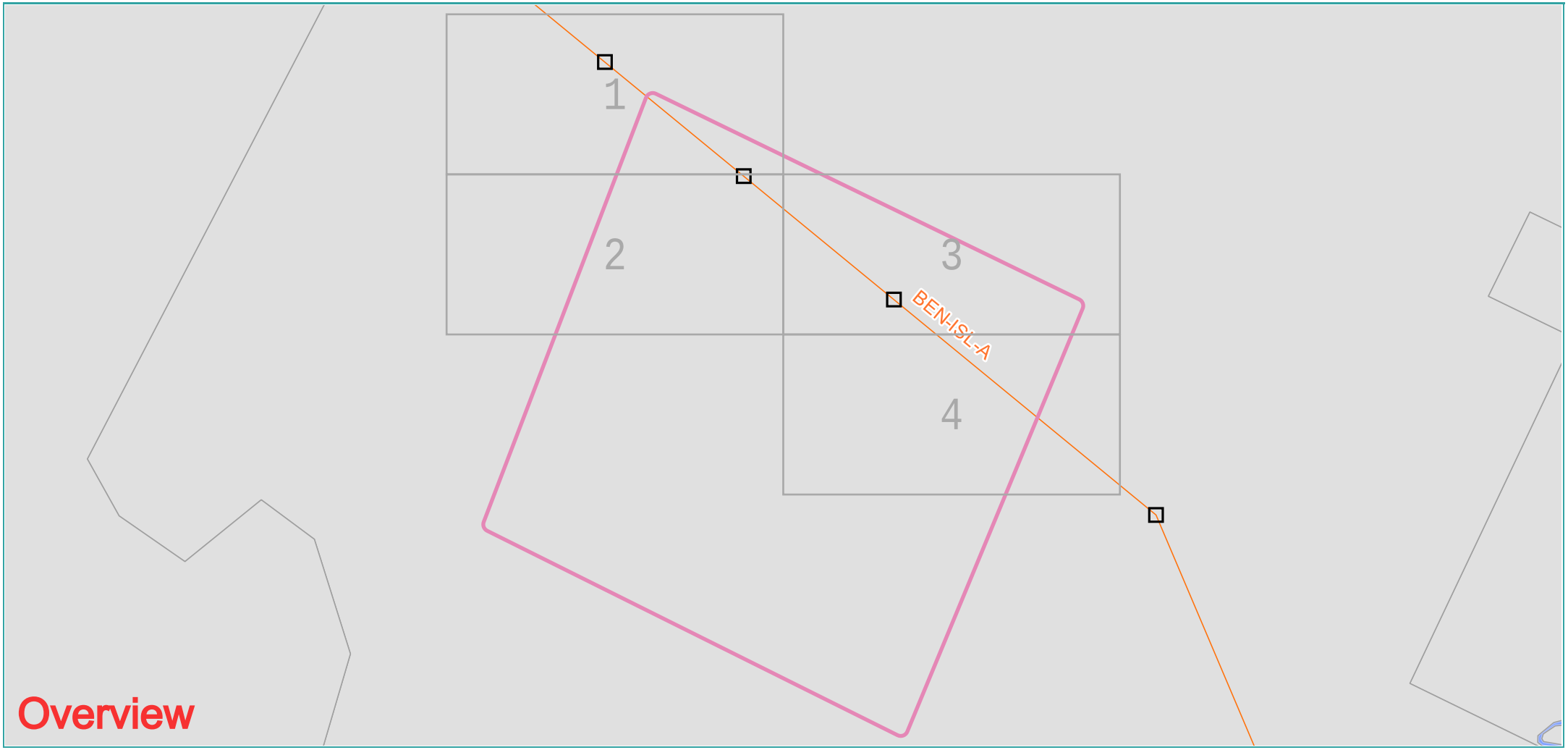
TRANSPOWER

OVERHEAD TRANSMISSION LINES

Site Location: Section 3 Haldon Arm Rd, Tekapo, Canterbury 7999

Sequence No: 13101308

Job No: 2453016



Disclaimer: This map shows current known assets as at the date shown. Contractors must update location information for each new job. This information is provided for reference purposes to assist contractors when determining the approximate location of Transpower's assets. Any graphical information may not be to scale and may not depict the entire asset. Direct field observations/mark-outs are required to determine the precise location of assets. Contractors undertaking excavation works are responsible for protecting underground equipment and rely on these plans at their own risk. No excavation should proceed without locating Transpower's underground assets. Transpower does not accept liability for the accuracy and completeness of this information. While reasonable measures have been taken to ensure the accuracy of the information contained in this plan response, neither Transpower or PelicanCorp shall have any liability whatsoever in relation to any loss, damage, cost or expense arising from the use of this plan response or the information contained in it or the completeness or accuracy of such information. Use of such information is subject to and constitutes acceptance of these terms.

N

Scale: 1:11552

Date: 22/08/2024

- BeforeUdig Enquiry
- < 66kv Overhead
- 110kv Overhead
- 220kv Overhead
- 400kv Overhead
- Pole
- Tower

Only Transpower assets are shown. Please consult local power companies for other electricity asset locations.

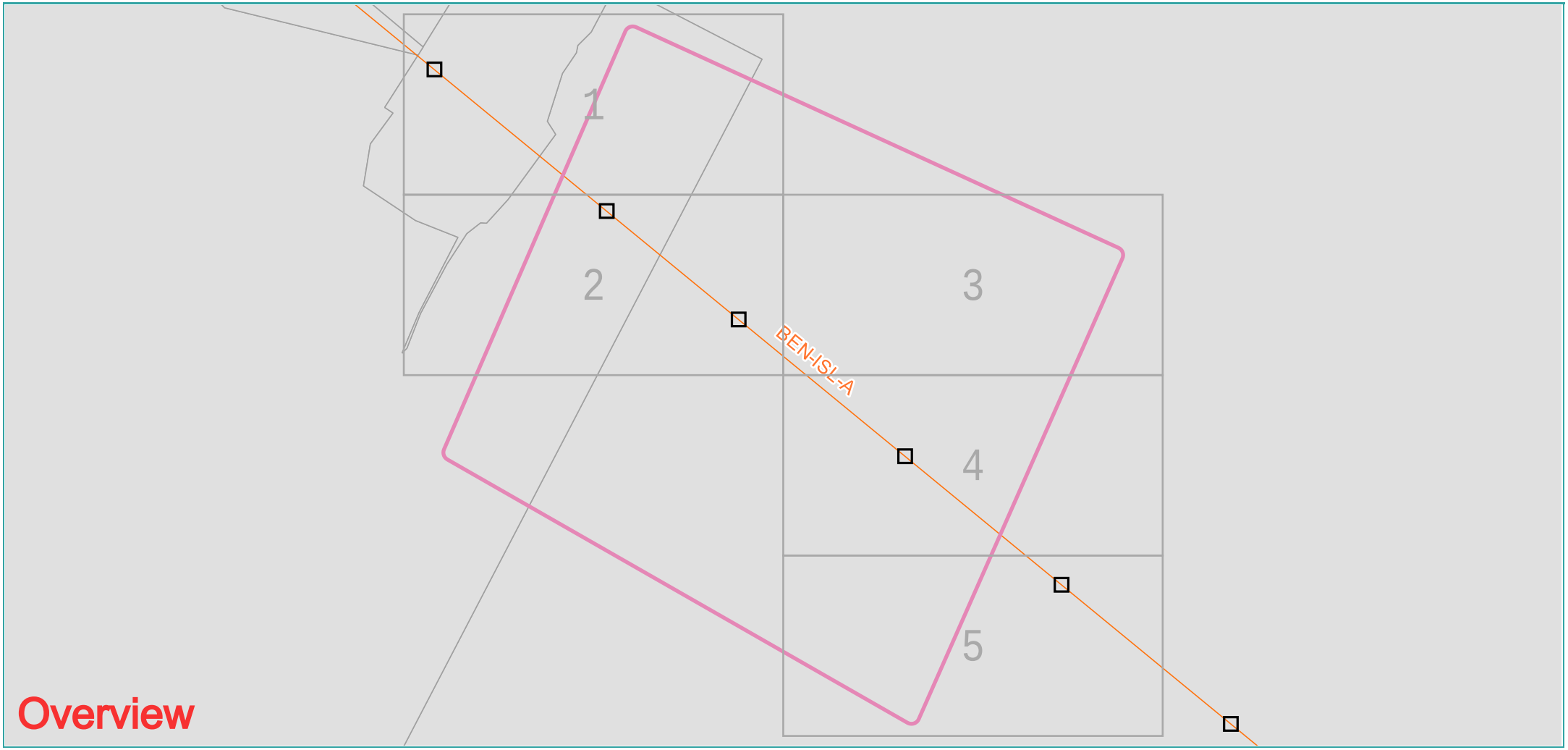
TRANSPOWER

OVERHEAD TRANSMISSION LINES

Site Location: Section 4 Haldon Arm Rd, Tekapo, Canterbury 7999

Sequence No: 13101363

Job No: 2453020



Overview

Disclaimer: This map shows current known assets as at the date shown. Contractors must update location information for each new job. This information is provided for reference purposes to assist contractors when determining the approximate location of Transpower's assets. Any graphical information may not be to scale and may not depict the entire asset. Direct field observations/mark-outs are required to determine the precise location of assets. Contractors undertaking excavation works are responsible for protecting underground equipment and rely on these plans at their own risk. No excavation should proceed without locating Transpower's underground assets. Transpower does not accept liability for the accuracy and completeness of this information. While reasonable measures have been taken to ensure the accuracy of the information contained in this plan response, neither Transpower or PelicanCorp shall have any liability whatsoever in relation to any loss, damage, cost or expense arising from the use of this plan response or the information contained in it or the completeness or accuracy of such information. Use of such information is subject to and constitutes acceptance of these terms.

N

Scale: 1:10250

Date: 22/08/2024

- BeforeUdig Enquiry
- < 66kv Overhead
- 110kv Overhead
- 220kv Overhead
- 400kv Overhead
- Pole
- Tower

Only Transpower assets are shown. Please consult local power companies for other electricity asset locations.

B

Appendix B – Historical Imagery

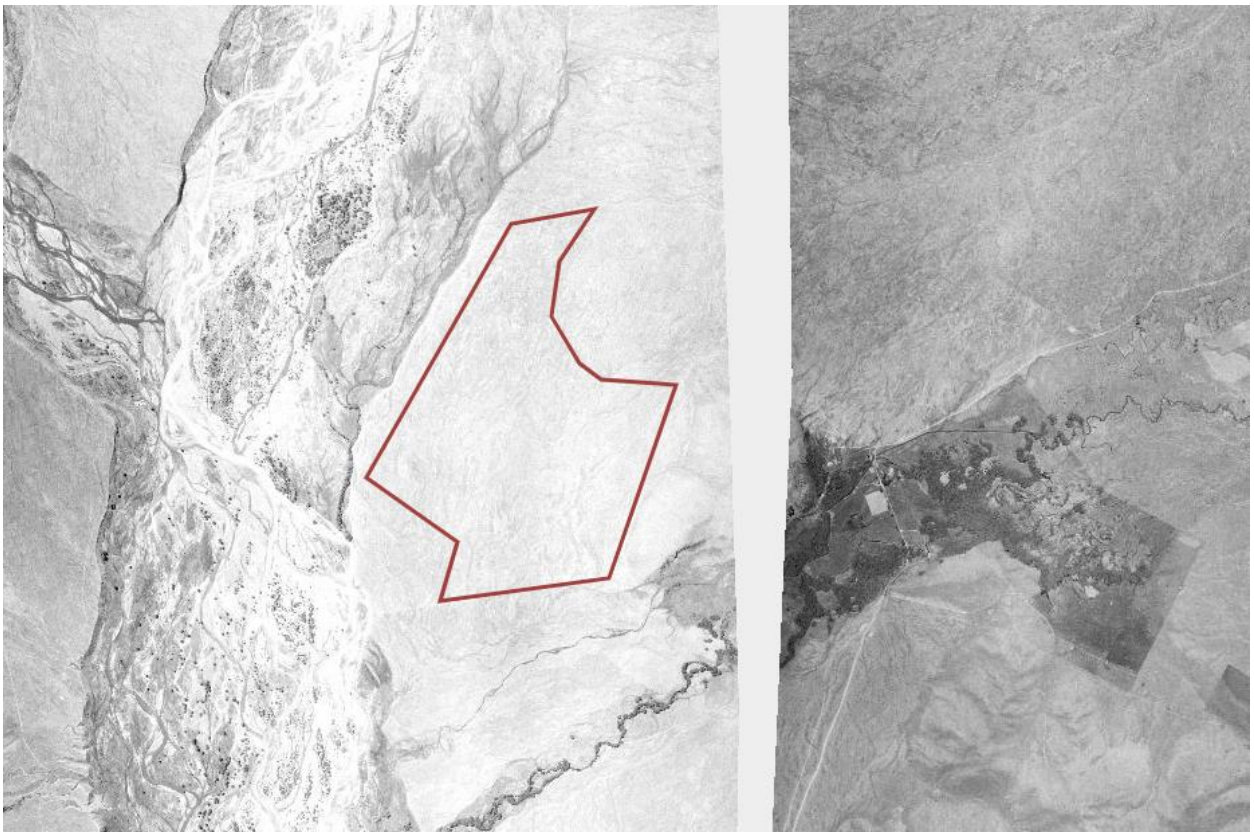


Figure A1 – Aerial imagery dating from 1955 to 1959, approximate site outline shown in red, scale unknown (source: https://apps.canterburymaps.govt.nz/CanterburyHistoricAerialImagery/).

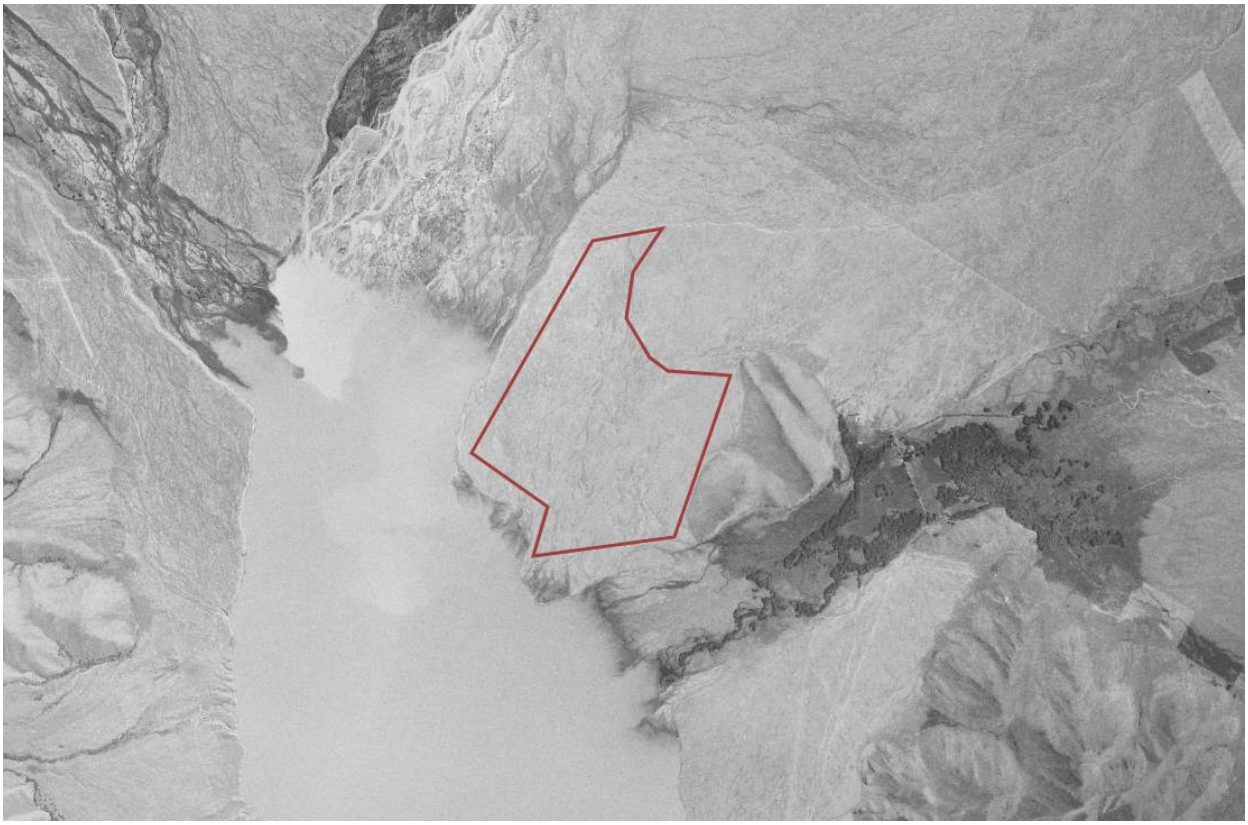


Figure A2 – Aerial imagery dating from 1965 to 1969, approximate site outline shown in red, scale unknown (source: https://apps.canterburymaps.govt.nz/CanterburyHistoricAerialImagery/).

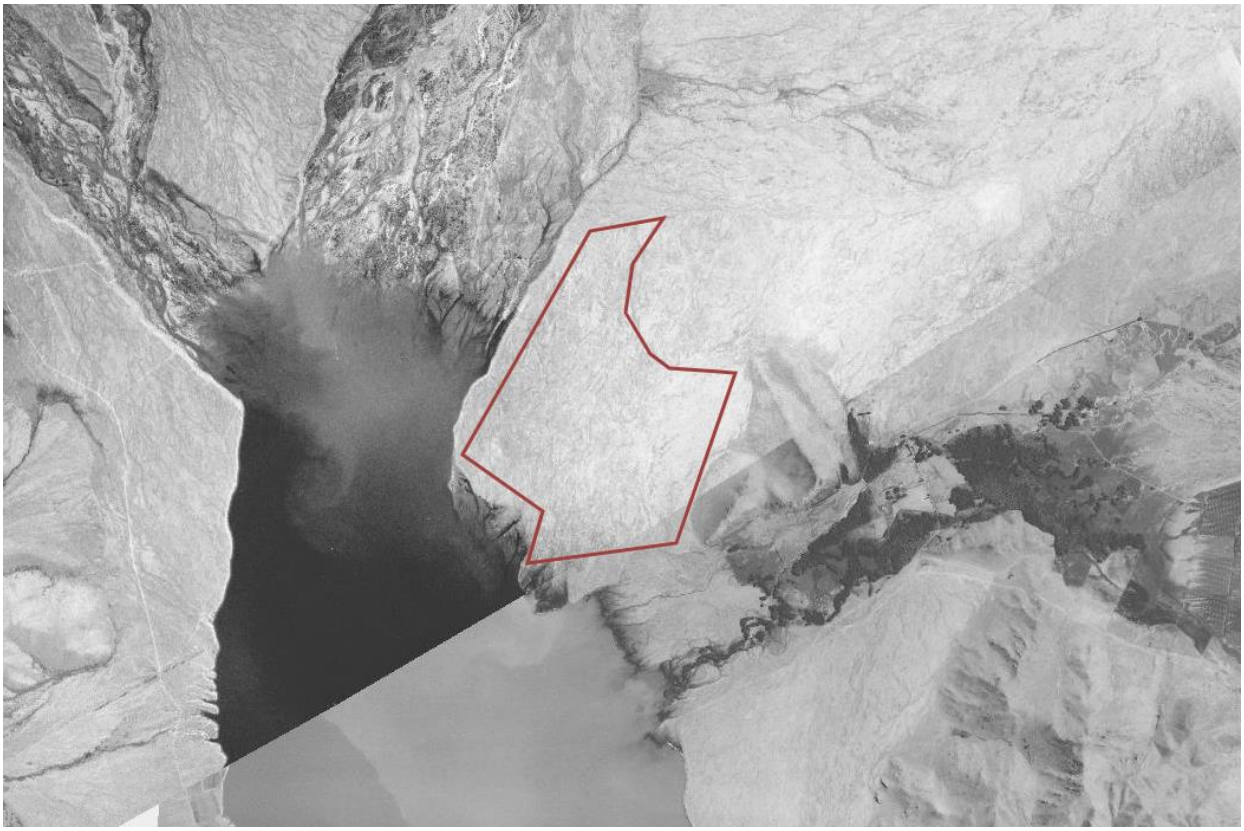


Figure A3 – Aerial imagery dating from 1975 to 1979, approximate site outline shown in red, scale unknown (source: https://apps.canterburymaps.govt.nz/CanterburyHistoricAerialImagery/).

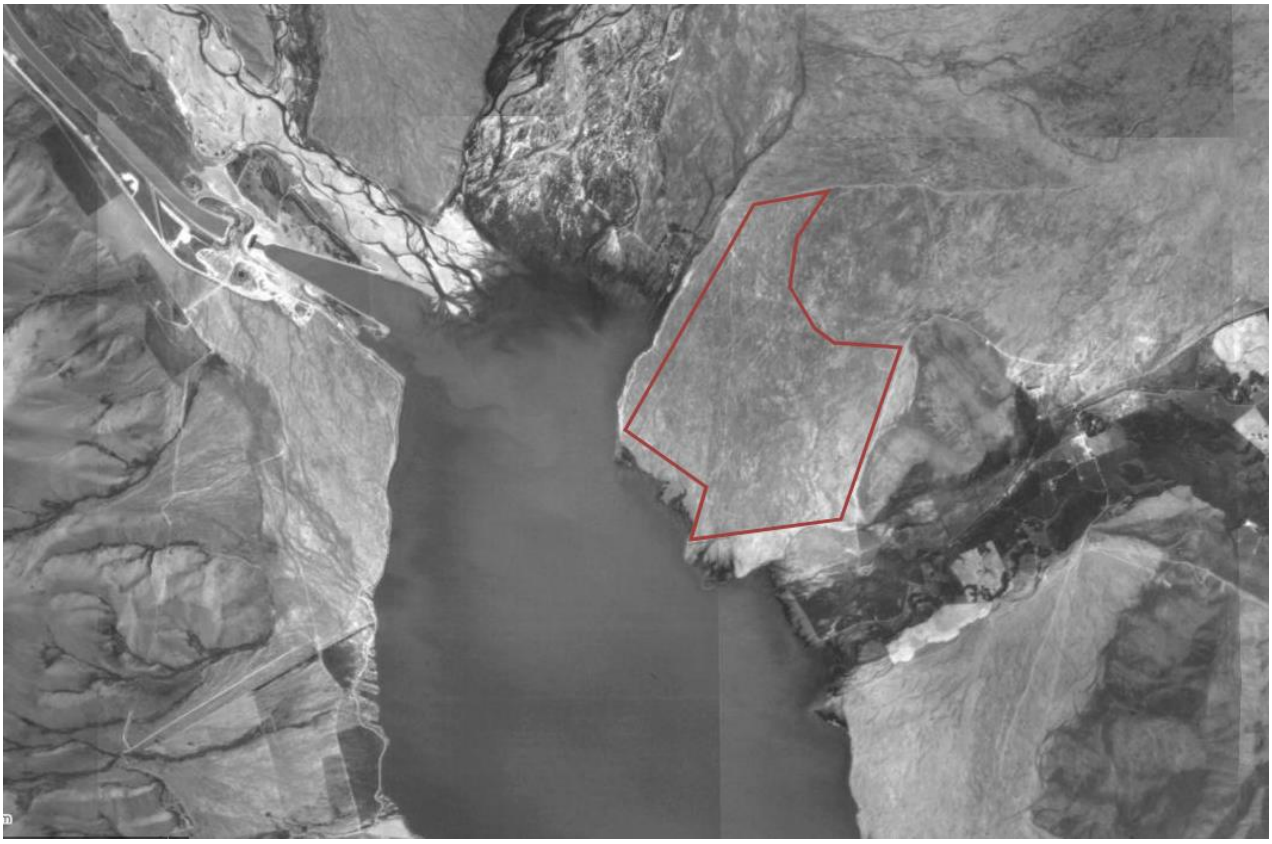


Figure A4 – Aerial imagery dating from 1985 to 1989, approximate site outline shown in red, scale unknown (source: https://apps.canterburymaps.govt.nz/CanterburyHistoricAerialImagery/).

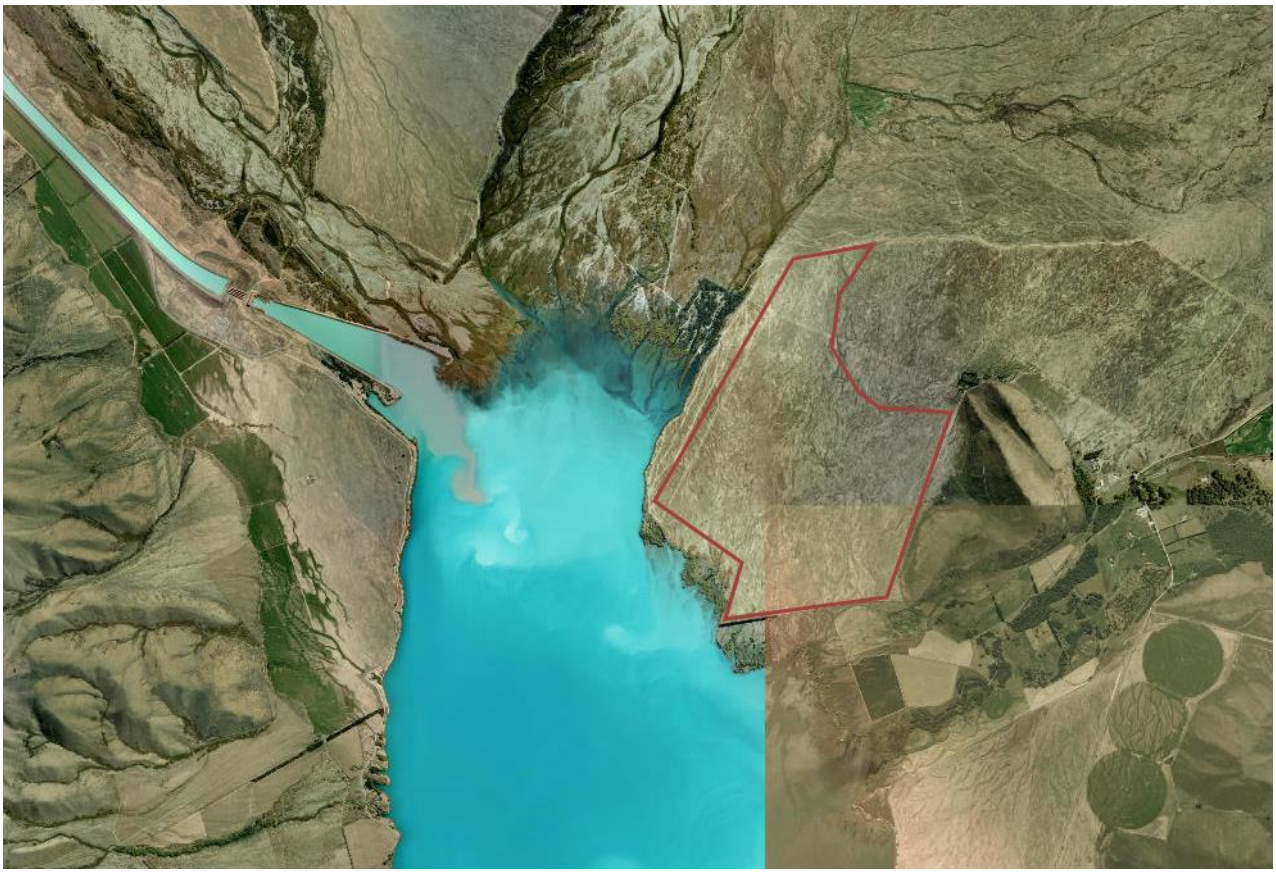


Figure A5 – Aerial imagery dating from 2004 to 2010, approximate site outline shown in red, scale unknown (source: https://apps.canterburymaps.govt.nz/CanterburyHistoricAerialImagery/).

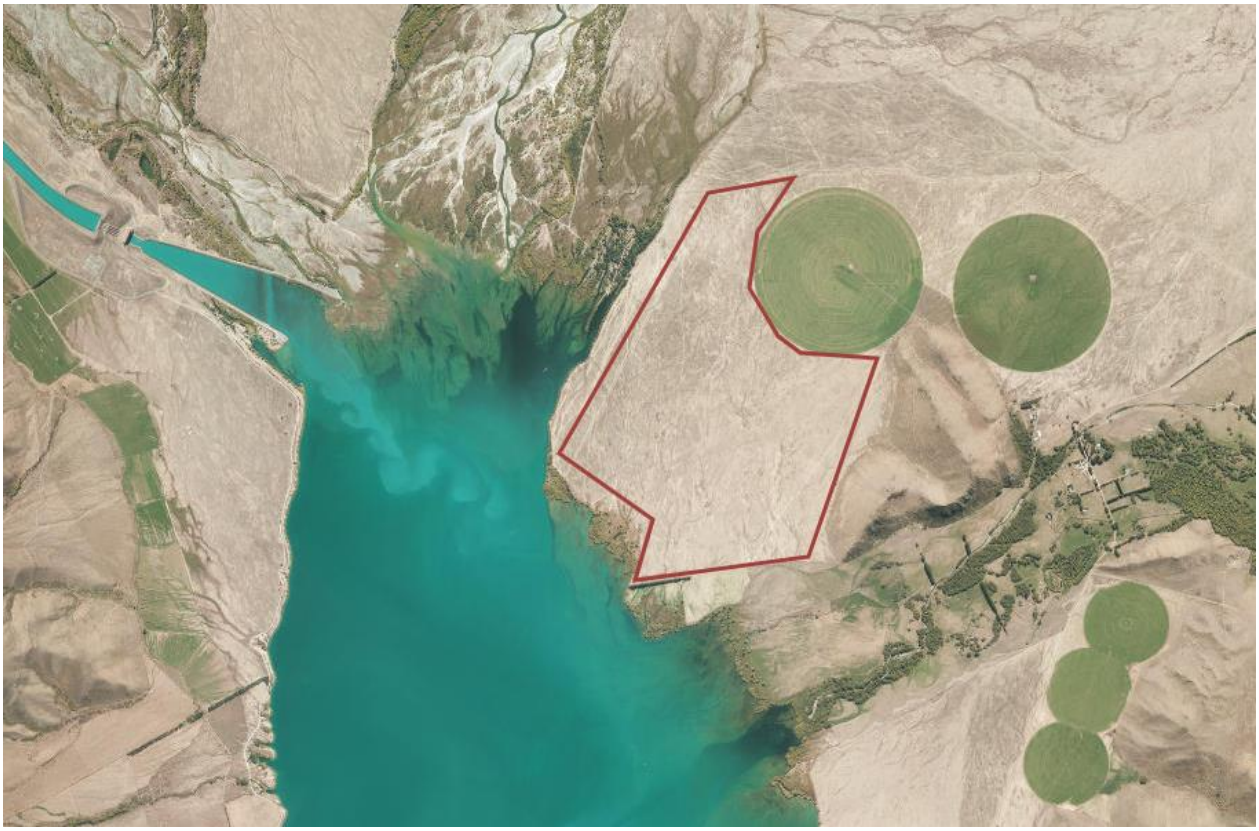
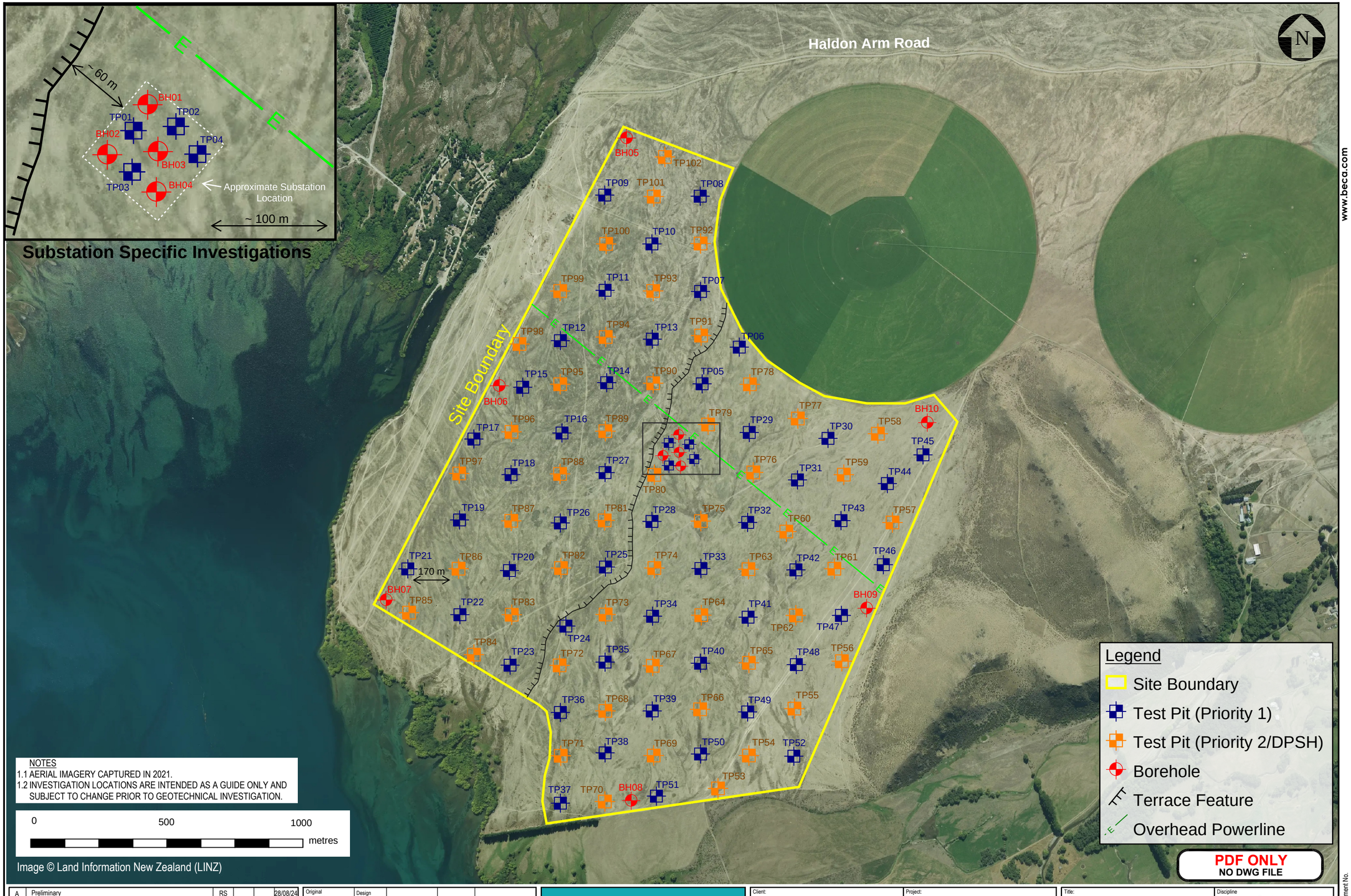


Figure A6 – Aerial imagery dating from 2010-2014, approximate site outline shown in red, scale unknown (source: https://apps.canterburymaps.govt.nz/CanterburyHistoricAerialImagery/).

Figure A7 – Aerial imagery dating from 2015-2019, approximate site outline shown in red, scale unknown (source: https://apps.canterburymaps.govt.nz/CanterburyHistoricAerialImagery/).

C

Appendix C – Site and Testing Plan



NOTES
1.1 AERIAL IMAGERY CAPTURED IN 2021.
1.2 INVESTIGATION LOCATIONS ARE INTENDED AS A GUIDE ONLY AND SUBJECT TO CHANGE PRIOR TO GEOTECHNICAL INVESTIGATION.

PDF ONLY
NO DWG FILE

No.	Revision	By	Chk	Appd	Date
A	Preliminary	RS			28/08/24
B	Preliminary Rev 2	RS			29/08/24

Original Scale (A3): 1 : 12,500 m

Design			
Drawn			
Dsg Verifier			
Drg Check			

* Refer to Revision 1 for Original Signature

Client: LODESTONE ENERGY LTD

Project: HALDON STATION SOLAR FARM

Title: PROPOSED GEOTECHNICAL INVESTIGATION SITE PLAN

Discipline: Geotech

Drawing No.: GEO-1

Rev.: A

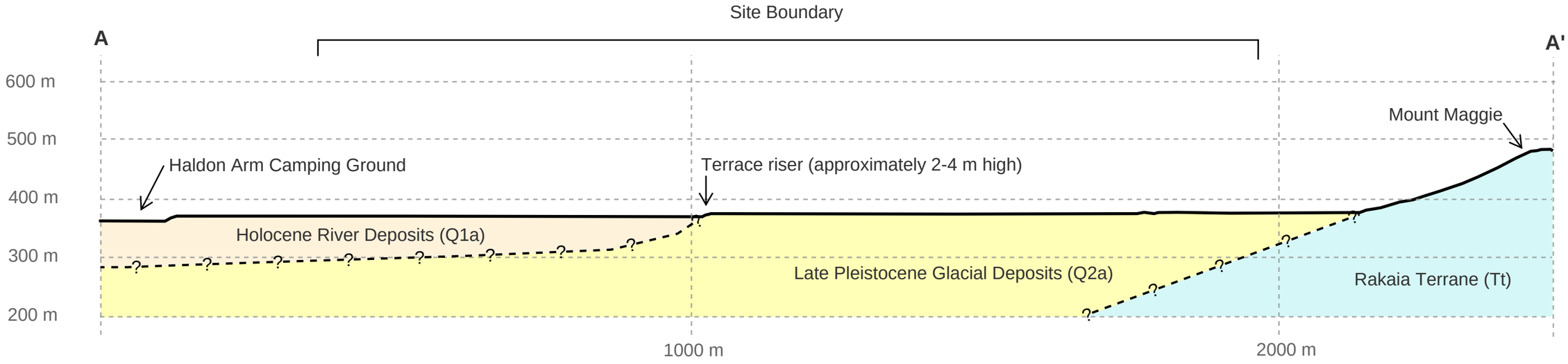
www.beca.com

BLUEBEAM Document No.

DO NOT SCALE FOR SET OUT DIMENSIONS

D

Appendix D – Geological Cross Section



PDF ONLY
NO DWG FILE

No.	Revision	By	Chk	Appd	Date
A	Preliminary	RS			4/09/24

Original Scale (A3)

Design			
Drawn			
Dsg Verifier			
Drg Check			

* Refer to Revision 1 for Original Signature

Client: LODESTONE ENERGY LTD

Project: HALDON STATION

Title: GEOLOGICAL CROSS SECTION

Discipline: Geotech

Drawing No.: GEO-1

Rev.: A

DO NOT SCALE FOR SET OUT DIMENSIONS

E

Appendix E – Publicly Available Investigation Logs

aurecon
www.aurecongroup.com

TEST PIT RECORD

HOLE NO. **TP01**

PROJECT NO. **505949**

PROJECT **South Island Motel Developments - Twizel Geotechnical Investigation**
13-17 Ruataniwha Road

METHOD **TP/Excavator**

MACHINE & NO. **Hitachi 130W Wheeled Excavator**

CO-ORDINATES (NZTM)
E 1368655
N 5095330

DATE from **14/08/2019** to **14/08/2019**

GROUND-LEVEL **+462.00** m RL

Water level (m)	PID (ppm)	Samples Type / Ref / Depth	Reduced Level	Depth (m) 0.00	Legend	STRATA DESCRIPTION (SUBORDINATE FRACTION, MAJOR FRACTION, MINOR FRACTION, COLOUR, STRUCTURE, STRENGTH, MOISTURE CONDITION, GRADING, BEDDING, PLASTICITY, ETC.... *(NZ GEOTECHNICAL SOCIETY - FIELD DESCRIPTION OF SOIL AND ROCK)*)
			+461.55	0.45		SILT with minor sand and trace rootlets; dark brown. "Firm", moist, non-plastic; Sand, fine. (TOPSOIL)
			+460.80	1.20		Sandy GRAVEL with minor cobbles; yellowish brown. "Dense to very dense", moist, fine to coarse, sub-rounded to rounded, imbricated; Sand, medium to coarse.
			+460.40	1.60		Sandy gravelly COBBLES with minor boulders; yellowish brown. "Very dense", sub-rounded to rounded, poorly imbricated; Gravel, fine to coarse, sub-rounded to rounded; Sand, fine to coarse.
						End of Test pit/Excavator at 1.60m, on 14/08/2019 *Termination Reason:* Refusal in very dense gravels.

- Small Disturbed Sample
- Large Disturbed Sample
- SPT Liner Sample
- Thin Wall Undisturbed Sample
- U100 Undisturbed Sample
- Pocket Penetrometer Test
- Piston Sample
- Water Level
- Impression Packer Test
- Standard Penetration Test
- Permeability Test
- Piezometer / Standpipe Tip
- Packer Test
- In-situ Vane Shear Test

REMARKS

Located in the field with handheld GPS receiver, accurate to +/- 10m.

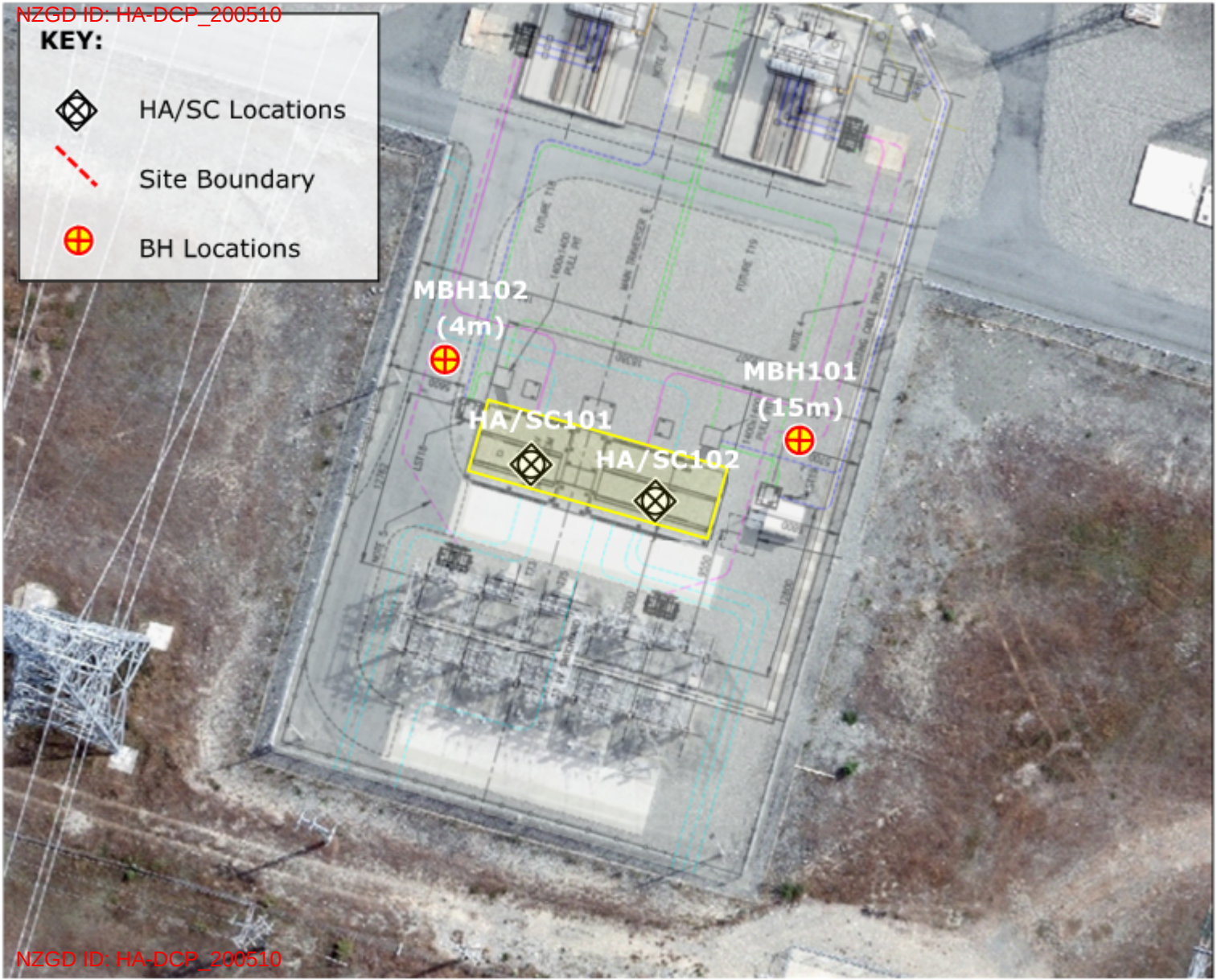
No groundwater encountered in excavations.

LOGGED **F. MONTEITH** CHECKED **C. WILSON**

DATE **14/08/2019** DATE **22/08/2019**

Aurecon, Level 2 Iwikau Building, 93 Cambridge Terrace, Christchurch 8013. Tel: 03 366 0821 Fax: christchurch@aurecongroup.com

NZGD ID: TP_128767


KEY:
HA/SC Locations
Site Boundary
BH Locations
MBH102
(4m)
MBH101
(15m)
HA/SC101
HA/SC102

ENGINEERING DESIGN CONSULTANTS

DRILLED: 25/02/2020 **FILE: 49202**

HAND AUGER NO.:
HA101

SHEET 1 OF 1

PROJECT: Geotechnical Investigation **CLIENT: Mitton Electronet**

LOGGED	PROCESSED	CHECKED
DP	DP	GL

ADDRESS: Twizel Substation, Old Iron Bridge Road, Twizel

BH LOCATION: COORDS: RL GROUND: SHEAR VANE ID#: -

DEPTH (m) GL	SOIL DESCRIPTION — Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments	LEGEND	GROUND WATER	SHEAR STRENGTH (kPa) ○Residual ●Peak 40 80 120 160	SOIL SENSITIVITY	SCALA BLOWS (PER 50 mm) 5 10 15
	FILL - Loose, light grey medium to coarse GRAVEL, dry					
	Dense, light brown sandy GRAVEL with trace cobbles, dry to moist. Sand is fine to coarse					
0.2	End of hand auger (target depth)	EOH @ 0.25 m				

NOTES:

Groundwater was not encountered during hand auger drilling.
Hand auger terminated due to refusal at 0.25m.

Groundwater not encountered.

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PO BOX 118 ALBANY, AUCKLAND 0755

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FAX (09) 415 1280

1st FLOOR, UNIT 1, 100 BUSH ROAD, ALBANY, AUCKLAND

PH (09) 451 9044

Printed: 17/04/2020 8:50:47 AM

NZGD ID: HA-DCP_200510

ENGINEERING DESIGN CONSULTANTS

DRILLED: 25/02/2020 **FILE: 49202**

HAND AUGER NO.:
HA102

SHEET 1 OF 1

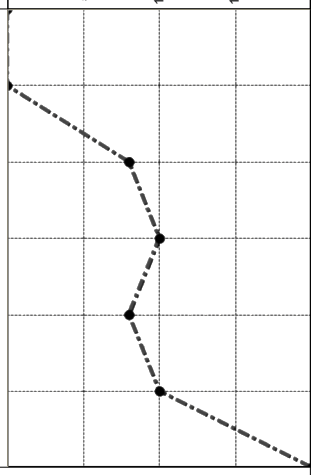
PROJECT: Geotechnical Investigation **CLIENT: Mitton Electronet**

ADDRESS: Twizel Substation, Old Iron Bridge Road, Twizel

LOGGED	PROCESSED	CHECKED
DP	DP	GL

BH LOCATION: COORDS: RL GROUND: SHEAR VANE ID#: -

DEPTH (m) GL	SOIL DESCRIPTION (Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments)	LEGEND	GROUND WATER	SHEAR STRENGTH (kPa) ○Residual ●Peak 40 80 120 160	SOIL SENSITIVITY	SCALA BLOWS (PER 50 mm) 5 10 15
	FILL - Loose, light grey medium to coarse GRAVEL, dry					
0.2	Dense, light brown silty GRAVEL with some sand trace cobbles, dry to moist. Sand is fine to coarse					
	End of hand auger (target depth)	EOH @ 0.30 m				



NOTES:
Groundwater was not encountered during hand auger drilling.
Hand auger terminated due to refusal at 0.30m.

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CIVIL, STRUCTURAL, ENVIRONMENTAL, GEOTECHNICAL AND FIRE ENGINEERS

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PH (09) 451 9044

Printed: 17/04/2020 8:50:47 AM

NZGD ID: HA-DCP_200510

ENGINEERING DESIGN CONSULTANTS

DRILLED: 25/02/2020 **FILE: 49202**

BORE HOLE NO.: MBH101

SHEET 1 OF 2

PROJECT: Geotechnical Investigation **CLIENT: Mitton Electronet**

ADDRESS: Twizel Substation, Old Iron Bridge Road, Twizel

LOGGED	PROCESSED	CHECKED
DP	DP	GL

BH LOCATION: COORDS: RL GROUND:

DEPTH (m) GL	SOIL DESCRIPTION (Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments)	LEGEND	GROUND WATER	TEST DEPTH	SAMPLE TYPE	SPT "N" VALUE	COMMENTS
	FILL - Loose, light grey medium to coarse GRAVEL, dry						
	Dense, light grey silty fine to coarse GRAVEL with trace fine to medium sand and cobbles						
1	with some fine to medium sand			1.00		50	3, 11/ 16, 20, 14 for 65mm N=50
2	becoming clayey GRAVEL with some fine to medium sand, wet			2.00		50	7, 17/ 20, 18, 12 for 30mm N=50
3	becoming sandy fine to coarse GRAVEL with some silt, moist			3.00		50	14, 12/ 32, 18 for 40mm N=50
4				4.00		50	6, 13/ 14, 18, 14, 14 for 65mm N=50
				4.50		50	8, 9/ 15, 18, 17 for 60mm N=50
5	becoming silty GRAVEL, moist						
6				6.00		50	14, 14/ 33, 17 for 70mm N=50
7							
				7.50		50	9, 18/ 33, 17 for 35mm N=50
8	becoming sandy GRAVEL, sand is fine to coarse						

BORING PROGRESS & WATER OBSERVATIONS

Date / Time	Hole Depth	Casing Depth	Water Depth	Water Type	Remarks

GENERAL REMARKS

3 Inch Sonic Borehole drilled with 5 inch casing. SPT hammer 4522 TB, average energy transfer ratio of 89.4%.

All dimensions in metres	DRILLING COMPANY	METHOD / PLANT USED	Sonic core drilling

ENGINEERING DESIGN CONSULTANTS LTD

CIVIL, STRUCTURAL, ENVIRONMENTAL, GEOTECHNICAL AND FIRE ENGINEERS

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15B LESLIE HILLS DRIVE
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BORE HOLE NO.: MBH101

SHEET 2 OF 2

PROJECT: Geotechnical Investigation **CLIENT: Mitton Electronet**

ADDRESS: Twizel Substation, Old Iron Bridge Road, Twizel

LOGGED	PROCESSED	CHECKED
DP	DP	GL

BH LOCATION: COORDS: RL GROUND:

DEPTH (m) GL	SOIL DESCRIPTION — Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments	LEGEND	GROUND WATER	TEST DEPTH	SAMPLE TYPE	SPT "N" VALUE	COMMENTS
10	becoming sandy GRAVEL, sand is fine to coarse			9.00		50	15, 16/ 25, 22, 3 for 5mm N=50
	becoming silty GRAVEL with some fine to medium sand, dry to moist			10.50		50	21, 29 N=50
11							
12				12.00		50	6, 5/ 8, 10, 14, 18 for 15mm N=50
13							
				13.50		50	4, 18/ 35, 15 for 30mm N=50
14	becoming dry						
15	End of Borehole (target depth)	EOH @ 15.00 m		15.00		50	50 N=50

BORING PROGRESS & WATER OBSERVATIONS

Date / Time	Hole Depth	Casing Depth	Water Depth	Water Type	Remarks

GENERAL REMARKS

3 Inch Sonic Borehole drilled with 5 inch casing. SPT hammer 4522 TB, average energy transfer ratio of 89.4%.

All dimensions in metres	DRILLING COMPANY	METHOD / PLANT USED	Sonic core drilling

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ENGINEERING DESIGN CONSULTANTS

DRILLED: 25/02/2020 **FILE: 49202**

BORE HOLE NO.: MBH102

SHEET 1 OF 1

PROJECT: Geotechnical Investigation **CLIENT: Mitton Electronet**

ADDRESS: Twizel Substation, Old Iron Bridge Road, Twizel

LOGGED	PROCESSED	CHECKED
DP	DP	GL

BH LOCATION: COORDS: RL GROUND:

DEPTH (m) GL	SOIL DESCRIPTION — Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments	LEGEND	GROUND WATER	TEST DEPTH	SAMPLE TYPE	SPT "N" VALUE	COMMENTS
	FILL - Loose, light grey medium to coarse GRAVEL, dry						
	Dense, light brown sandy GRAVEL with some silt and trace cobbles, dry. Sand is fine to coarse						
	becoming silty GRAVEL with some fine to coarse sand						
1	becoming sandy GRAVEL with some silt. Sand is fine to coarse			1.00		50	10, 14/ 12, 16, 17, 5 for 20mm N=50
2	becoming light brownish grey silty GRAVEL with some fine to coarse sand			2.00		50	7, 8/ 14, 17, 19 for 65mm N=50
3	becoming light brown clayey GRAVEL with some silt and trace sand. Sand is fine			3.00		50	22, 28 N=50
	becoming dark grey, moist						
	becoming light grey, silty GRAVEL, dry						
4	End of Borehole (target depth)	EOH @ 4.00 m		4.00		50	21, 17/ 14, 16, 13, 2 for 5mm N=50

BORING PROGRESS & WATER OBSERVATIONS

Date / Time	Hole Depth	Casing Depth	Water Depth	Water Type	Remarks

GENERAL REMARKS

3 Inch Sonic Borehole drilled with 5 inch casing. SPT hammer 4522 TB, average energy transfer ratio of 89.4%.

Groundwater not encountered.

All dimensions in metres | DRILLING COMPANY | METHOD / PLANT USED: Sonic core drilling

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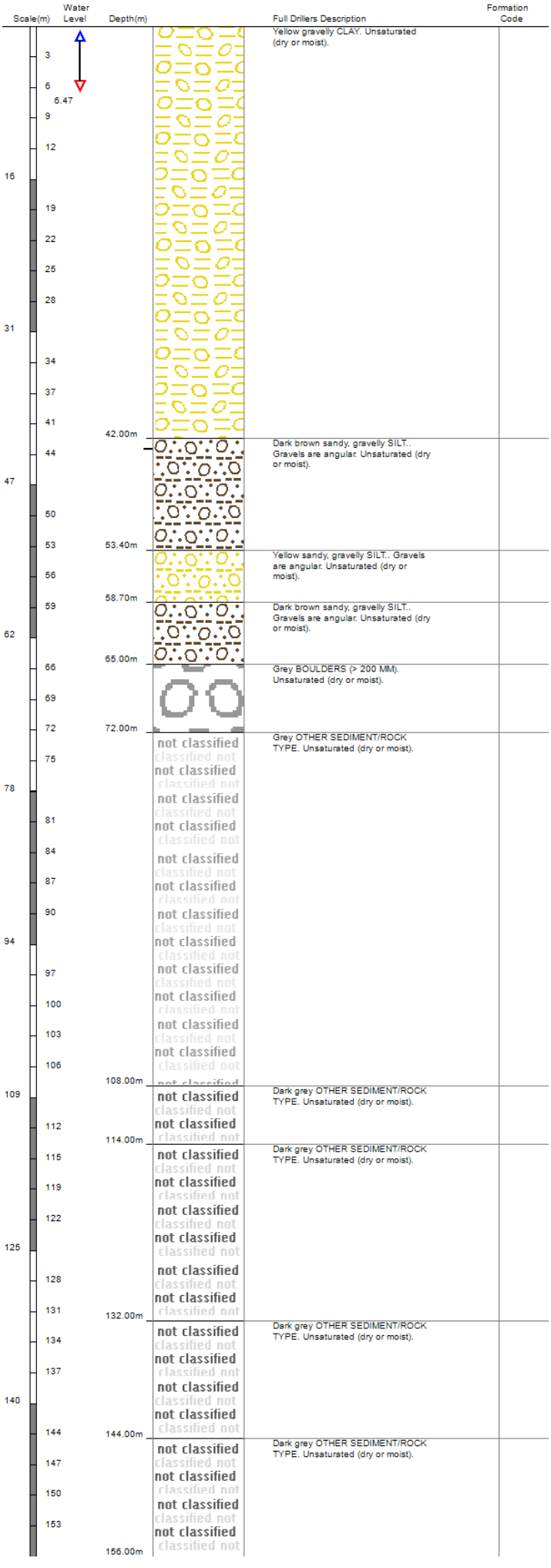
NZGD ID: BH_200512

Borelog for well I39/0005

Grid Reference (NZTM): 1380664 mE, 5085634 mN
Location Accuracy: 2 - 15m
Ground Level Altitude: 376.1 m +MSD Accuracy: < 0.5 m
Driller: Washington Drilling and Exploration
Drill Method: Rotary Rig
Borelog Depth: 156.0 m Drill Date: 16-Feb-2004

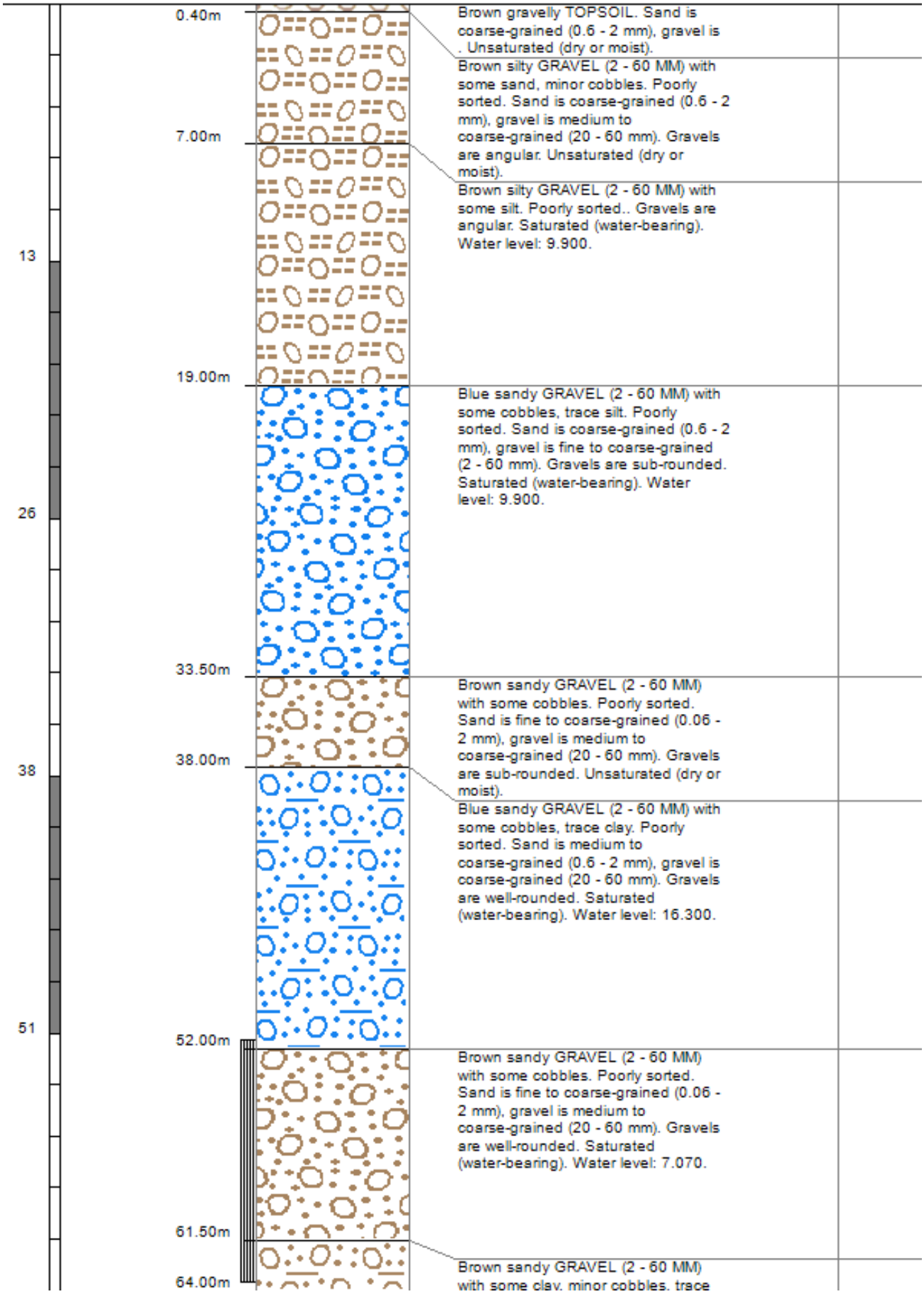
Environment Canterbury Regional Council
Kaunihera Taiao ki Waitaha



Borelog for well BZ16/0040

Grid Reference (NZTM): 1380449 mE, 5086090 mN
Location Accuracy: 10 - 50m
Ground Level Altitude: 377.9 m +MSD Accuracy: < 2.5 m
Driller: Barber Drilling Ltd
Drill Method: Dual Rotary
Borelog Depth: 64.0 m Drill Date: 16-May-2013

Environment Canterbury Regional Council
Kaunihera Taiao ki Waitaha



Borelog for well BZ16/0039

Grid Reference (NZTM): 1381704 mE, 5086012 mN
Location Accuracy: 10 - 50m
Ground Level Altitude: 384.0 m +MSD Accuracy: < 2.5 m
Driller: Barber Drilling Ltd
Drill Method: Dual Rotary
Borelog Depth: 78.0 m Drill Date: 10-May-2013

Environment Canterbury Regional Council
Kaunihera Taiao ki Waitaha