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WATER RESOURCES

PAVEMENTS

Geotechnical Report for Resource Consent

Ayrburn Screen Hub

1 Ayr Avenue, Arrowtown

Report prepared for:

Waterfall Park Developments Ltd

Report prepared by:

GeoSolve Limited

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GEOTECHNICAL WATER RESOURCES PAVEMENTS

Table of Contents

1 Executive Summary

- This report reviews the geotechnical considerations for the proposed Ayrburn Screen Hub located off Ayr Avenue.
- The development is considered feasible from a geotechnical perspective provided the recommendations of this report are followed.
- The stratigraphy is relatively consistent across the proposed development area. See section 5.2 for further details.
- The risk of liquefaction to the proposed development is assessed as low. The results of the liquefaction analyses indicate that, in general, the subject site is expected to suffer negligible effects under the SLS events and ground deformations within typical structural limits under the ULS event.
- An alluvial fan risk is identified on the QLDC hazard mapping and is assessed in Section 7.10 of this report. The risk to the development from debris flow or flooding associated with the alluvial fan hazard is assessed to be very low. Surface run-off directly from the hills to the north is expected and a small diversion bund to address this issue is recommended. We understand this is being assessed and designed by others as part of the stormwater design.
- A flooding risk is identified on the QLDC hazard maps. We understand the risk of flooding has been assessed separately by others.
- Buildings are proposed close to slope crests in some locations. Preliminary assessment indicates that standard engineering solutions (as described in section 7.7) are available to ensure construction can be completed adjacent to crest areas. In general there are likely to be minimal stability mitigation works required for buildings within 5 m of a slope crest provided the slope is shallower (flatter) than 2.5:1 (H:V).
- Soft silts (loess and alluvial silt) mantel the upper terrace which will provide a reduced bearing capacity as compared to the recommendations of NZS3604:2011. Undercut and replacement with engineered fill can also be used to improve bearing capacity. The final selection of the foundation type for a particular building should be determined during the detailed design stage.
- Soakage testing to assess the suitability of stormwater disposal has been completed in three of the proposed stormwater management areas. Results of the completed testing are provided within Section 8 of this report.
- Further works are recommended at the detailed design phase, as outlined in Section 10.

2 Introduction

2.1 General

This report presents the results of a geotechnical investigation undertaken for the purpose of obtaining resource consent for a proposed film studio and accommodation development. The development is accessed off Ayr Avenue and located in Lot 4 DP 540788, referred to herein as “the subject site” or “site”.

This assessment has been completed for Waterfall Park Developments Limited in accordance with the scope of works and terms and conditions outlined in the contract document dated 17 October 2024 which includes the GeoSolve proposal.

2.2 Development

The general layout of the development is shown on Figure 1b, Appendix A. Earthworks will be required to establish level building platforms and access roads. Cut and fill up to approximately 9 m and 6.5 m in depth is proposed in localised areas to provide level areas for building platforms, courtyards, parking, roads, general access and landscaping.

2.3 Scope of Work

The purpose of this report is to assess the feasibility of the proposed development in the proposed location from a geotechnical perspective and provide recommendations as appropriate. Geotechnical issues or hazards pertaining to the site; specifically liquefaction, slope stability and alluvial fan hazard have been addressed.

Further geotechnical investigation and reporting may be required at the detailed design stage to address specific geotechnical requirements, and to undertake detailed foundation design, as recommended in Section 10 below.

2.4 Credentials

The contributing authors, in their capacity as authors of this report, have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practice Note 2023. Where this report relies on information provided by other experts, this is outlined within the report.

The CVs of the authors of this report detailing their experience relevant to the proposed project are attached within Appendix E of this report.

3 Site Description

3.1 General

The subject site is located approximately 1 km north of Lake Hayes and 350 m to the west of the Arrowtown - Lake Hayes Road from which the site is accessed, as shown on Figure 3.1 below.

Figure 3.1 – Site Location Plan – *ref: QLDC GIS*

The subject site is bound to the south by existing residential developments along Speargrass Flat Road, and to the east by the Ayrburn/Northbrook development site. Undeveloped farmland adjoins the western boundary of the site with Millbrook and associated residential development to the north. An aerial view of the approximate site area is provided on Figure 1b, Appendix A.

3.2 Topography and Surface Drainage

3.2.1 General

Most of the development is located on undulating to gently sloping farmland around the eastern end of the Speargrass Flat Road area. The site is predominately located on a natural terrace (~RL350-355) which is elevated approximately 6-10 meters above the neighbouring Ayrburn development area present immediately to the east/north east. Immediately to the north of the subject site, a hill slope rises up to a level approximately 75 m above the main terrace and most of the site. The lower part of this slope is shown on Cross-Sections A, B and C, Appendix A.

In general overland flow will be from the north towards the south and south east. General run-off from the steep slopes along the northern boundary of the development can be expected however with the exception of the two main overland flow paths described below concentrated flow is not expected. Two prominent overland flow paths are present within or close to the site as follows:

- Mill Creek runs approximately north-south along or close to the eastern boundary of the building development area. The creek is approximately 2 m lower than its immediate surrounding area on the lower terrace, however most of the subject site is 10-12 m above the creek level. We understand flood assessments of Mill Creek have been provided separately;
- An unnamed drainage channel is present to the west of the proposed development area. The channel runs north – south and is approximately 1.5 in depth. Flow from this channel is not consistent and is only active during periods of rainfall. The channel continues along the southern boundary of the site, where it is several metres below the proposed site levels.

Site drainage is discussed further in Sections 7.9 and 7.10 below.

4 Geotechnical Investigations

4.1 General

Site investigations comprising test pits, soakage testing, CPT's, DCP's and Sonic coring have been completed by GeoSolve on the site over several stages of works and are denoted as follows:

4.1.1 Stage 1

Geotechnical site investigations works have been completed by GeoSolve for the purposes of this report (labelled **TP1, CPT1** on site plan):

- A site inspection by an engineering geologist;
- 10 excavator test pits to depths of up to 4.8m;
- 4 cone penetrometer tests (CPT) to depths of up to 14.5m; and
- 1 drill hole to a depth of 15m.

4.1.2 Stage 2

Investigations comprise (labelled **TP1a, DCP1a** on site plan):

- A site inspection by an engineering geologist;
- 6 excavator test pits to depths of up to 4.6m;
- 2 heavy duty dynamic penetration tests (DCP) driven to depths of up to 12.1m

4.1.3 Stage 3

Investigations comprise (labelled **TP1d, DPH1d** on site plan):

- 12 excavator test pits to depths of up to 4.6 m;
- 4 heavy duty dynamic penetration tests (DCP) driven to depths of up to 15 m

4.1.4 Stage 4

Investigations comprise (labelled **SP1** on site plan):

- 2 excavator test pits to depths of up to 4.6 m;
- 3 open pit soakage tests at approximately 1-1.5 m below the proposed finished level.

The investigation locations are show on Figures 1a and b, Appendix A, and the investigation logs are provided in Appendix B.

Soakage testing results are provided in Appendix D.

5 Subsurface Conditions

5.1 Geological Setting

The site is located within the Wakatipu Basin, a feature formed predominately by glacial advances. Published references indicate the last glacial event occurred in the region between 10,000 and 20,000 years ago. The glaciations have left glacial till, glacial outwash and lake sediments over ice-scoured bedrock. Post glacial times have been dominated by erosion of the bedrock and glacial sediments, deposition of alluvial gravels by local watercourses, deposition of lacustrine sediments during periods of high lake levels and the deposition of wind-blown loess.

The site is located in an area where the soil materials comprise windblown, pond, alluvial and glacial deposits overlying schist bedrock.

No active fault traces were observed in the immediate vicinity of the site. However, a significant seismic risk exists in the region from strong ground shaking associated with rupture of the Alpine Fault located along the west coast of the South Island. There is a high probability an earthquake with a magnitude greater than 7.5 will occur on the Alpine Fault within the next 50 years.

5.2 Stratigraphy

The subsurface materials observed during site investigations comprise surficial layers of topsoil, loess and colluvium overlying variably interbedded alluvial deposits which extend to considerable depth.

The main geological units present on the top terrace surface are as follows:

Topsoil comprises black, soft to firm organic SILT with organic rootlets.

Loess comprises light brown, loose to medium dense silty SAND and soft to firm sandy SILT.

Isolated **colluvium** deposits were observed within TP14a, TP6d, TP10d comprising light brown, medium dense, gravelly SAND and silty SAND and firm SILT with minor gravel.

Alluvial deposits comprise interbedded layers of medium dense SAND and GRAVEL and firm to stiff SILT of varying thickness. A 0.7 m thick isolated layer of light brown, firm to stiff clayey SILT was observed within TP21a at 3.0 m bgl.

Schist Bedrock was encountered within TP7d and TP10d located adjacent the northern hill slope. Schist weathering was observed to be variable within the upper meters of the profile comprising; completely weathered (weak to extremely weak) schist within TP10d and slightly weathered (moderately strong) schist in TP7d.

Full details of the observed subsurface stratigraphy can be found within the test pit and borehole logs contained in Appendix B, and the ground model is shown on the cross-sections provided as Figures 2a to 2f, Appendix A.

5.3 Groundwater

Groundwater seepage was identified in TP16a (located on the upper terrace) only within an alluvial sand layer at 3.4 m bgl. Schist was observed within TP7d completed upslope of the TP16a location and therefore it is inferred seepage is likely to be perched on the schist

contact close to the base of TP16a which extended to a depth of 4 m. Proposed cuts in this area are therefore likely to intercept perched groundwater.

The regional groundwater level was confirmed within BH2 within the lower terrace at approx. RL335-337, which is approximately 12-15 m below the ground level of the upper terrace.

5.4 Natural Hazards

On the Queenstown Lakes District Council (QLDC) mapping data base the following potential natural hazards are identified within the development area:

- Alluvial Fan hazard, Regional Scale;
- Flooding associated with Mill Creek.

The extent of these mapped hazards in relation to the development is shown on Figure 1a, Appendix A. Assessment of these hazards is provided below.

6 Liquefaction Analysis

6.1 Design Earthquakes

The site has been mapped in a 2019 liquefaction hazard assessment[1] as belonging to Domain B, which is predominantly underlain by poorly consolidated lake, river or beach sediments with a shallow groundwater table. There is considered to be a low to moderate likelihood of liquefaction-susceptible materials being present in some parts of the areas classified as Domain B1, and there is geotechnical evidence for the presence of liquefaction-susceptible materials in at least some locations at the site. Therefore, we have followed guidance from the Ministry for the Environment, Ministry of Business, Innovation and Employment (MBIE) and Earthquake Commission (EQC) liquefaction planning guidelines[2].

Two earthquake scenarios have been assessed in accordance with NZS 1170.5:2004[3] for an Importance Level 2 (IL2) structure with a 50-year design life.

Peak horizontal ground accelerations and effective magnitudes have been determined using the recommended values within the NZGS/MBIE Module 1 guidelines[4]. Table 1 summarises the scenarios considered.

Table 5.1.1 – Earthquake accelerations and effective magnitudes for liquefaction assessment

Scenario	Performance Requirements	Annual Probability of Exceedance (AEP)	Peak Horizontal Ground Acceleration (PGA)	Effective Magnitude
Serviceability Limit State (SLS)	*Avoid damage that would prevent the structure being used as originally intended without repair*	1/25	0.1 g	6.5
Ultimate Limit State (ULS)	*Avoid collapse of the structural system*	1/500	0.41 g	6.5

6.2 Liquefaction Summary

6.2.1 Analysis Results (Lower Terrace)

Analysis was undertaken on the CPT soundings using the Boulanger & Idriss (2014)[5] to calculate factor of safety against liquefaction and Zhang et al (2002)[6] to calculate liquefaction-induced reconsolidation settlement. As no laboratory testing has been undertaken in this analysis, a soil classification index (I_c) cut off of 2.6 and a fines correction

[1] Barrell, D.J.A. (2019). Assessment of liquefaction hazards in the Queenstown Lakes, Central Otago, Clutha and Waitaki districts of the Otago Region. Lower Hutt (NZ): GNS Science. 99 p. Consultancy Report 2018/67.
[2] Ministry for the Environment, Ministry of Business, Innovation and Employment, Earthquake Commission (2017). Planning and engineering guidance for potentially liquefaction-prone land.
[3] Standards New Zealand (2004). NZS 1170.5:2004 Structural Design Actions. Part 5: Earthquake Actions – New Zealand.
[4] Ministry of Business, Innovation and Employment; New Zealand Geotechnical Society (2021). Earthquake geotechnical engineering practice; Module 1, Overview of the guidelines.

[5] Boulanger, R.W. & Idriss, I.M. (2014). CPT and SPT Based Liquefaction Triggering Procedures. Department of Civil & Environmental Engineering, University of California.
[6] Zhang, G., Robertson, P.K., Brachman, R.W.I. (2002). Estimating liquefaction-induced ground settlements from CPT for level ground.

coefficient (C_{fc}) of 0 has been adopted. No thin layer correction has been applied. The results of the analysis are summarised below:

- No liquefaction is predicted under the site under SLS loading.
- Negligible liquefaction is predicted under ULS loading.

Standard and widely used engineering and foundation solutions are available for the level of liquefaction induced settlement identified in the assessment, see Section 7.3 of this report.

6.2.2 Analysis Results (Upper Terrace)

Groundwater is expected to lie at 12 to 15 m depth below the upper terrace and therefore liquefaction expression and effects at the surface under SLS and ULS are expected to be negligible owing to the thick non liquefiable crust. A total of 6 DCP's were undertaken across the upper terrace and all but one refused in the upper 12 m. Refusal of the HDCP tests is inferred to have occurred on dense gravel.

6.2.3 Liquefaction Discussion

The results of the liquefaction analyses indicate that in general the subject site is expected to suffer negligible effects from an SLS event and ground deformations will be within typical structural limits for a ULS event. Standard foundation options are available and are discussed in section 7 of this report.

7 Engineering Considerations

7.1 General

The recommendations and opinions contained in this report are based upon ground investigation data obtained at discrete locations and historical information held on the GeoSolve database. The nature and continuity of subsoil conditions away from the investigation locations is inferred and cannot be guaranteed.

7.2 Settlement and Foundations

7.2.1 General

All unsuitable materials identified in foundation excavations, particularly those softened by exposure to water, should be undercut and replaced with engineered fill during construction. Any fill that is utilised as bearing for foundations should be placed and compacted in accordance with NZS 4431:2022 and certification provided to that effect.

To minimise the effects of freeze-thaw cycles, all shallow foundations on fine grained soils should be founded a minimum of 0.4 m below the adjacent finished ground surface.

It is recommended the foundation excavations be inspected by a suitably qualified and experienced geotechnical specialist to confirm the conditions are in accordance with the assumptions and recommendations provided in this report.

7.2.2 Foundations

Soft silts (loess and alluvial silt) mantle the upper terrace which are underlain by variable thickness interbedded layers of silt, sand and gravel. The alluvial silt/loess are anticipated to provide approximately half of 'good ground' as defined in NZS3604:2011.

Where present and of sufficient thickness beneath the proposed foundation level, the alluvial gravel is anticipated to provide 'good ground' as defined in NZS3604:2011. The alluvial sand is anticipated to provide a reduced bearing capacity (not Good Ground), although will be greater than the alluvial silt and loess.

The final selection of the foundation for each of the proposed buildings should take into account the information in this report. Bearing capacity should be confirmed on a building specific basis during detailed design and will be largely dependent on the extent of earthworks being undertaken in the particular area. In areas where fill earthworks are being undertaken (utilising a well graded granular fill, placed in accordance with NZS4431)), a standard 3604 foundation is likely to be appropriate.

Due to the scale of the proposed soundstage buildings, these structures are anticipated to be outside the scope of NZS3604:2011 therefore specific bearing capacity/spring stiffness calculations should be completed for these buildings at detailed design once specific plans are further developed.

7.3 Site Preparation

During the earthworks operations all topsoil, organic matter, uncertified fill and other unsuitable materials should be removed from the construction areas in accordance with the recommendations of NZS 3604:2011 and 4431:2022.

Owing to the moderately erodible nature of some of the soils present across the site, sediment control measures should be instigated during earthworks construction.

Water should not be allowed to pond or collect near or under a foundation slab. Positive grading of the subgrade should be undertaken to prevent water ingress or ponding.

All fill that is utilised as bearing for foundations should be placed and compacted in accordance with the recommendations of NZS 4431:2022 and certification provided to that effect. The granular alluvial deposits or schist (following crushing) observed on site could be used as engineered fill (during good weather and in accordance with an earth fill specification). Boulders and cobbles over 75 mm in size will need to be screened from engineered fill sources. An earth fill specification can be provided on request.

We recommend topsoil stripping and subsequent earthworks be undertaken only when a suitable interval of fair weather is expected, or during the earthworks construction season.

7.4 Excavations

7.4.1 General

We recommend that any excavations be inspected by a geotechnical practitioner during earthworks construction.

7.4.2 Permanent Cuts

Cut slopes less than 3 m in height should be constructed with a batter of 3:1 (horizontal to vertical) or flatter, provided these slopes are well drained.

Cut slopes which require to be higher or steeper than those described above should be subject to specific engineering design or structurally retained. Based on plans provided cuts along the north of the proposed development area will be supported by permanent retaining. Further commentary regarding retaining options is provided in Section 7.5 below.

Where cut slopes exceed the recommendations provided above a soil nail system can be considered to allow steeper batter slopes to be utilised. Further assessment can be undertaken at detailed design with respect to specific slope requirements.

7.4.3 Temporary Cuts

Recommendations for temporary batters are as follows:

Table 7.1 Recommended Batter for Temporary Cuts up to 3 m in Height

Material Type	Recommended Maximum Batter for Temporary Cuts Less than 3 m High (horizontal to vertical)	
	Dry Ground	Wet Ground
Loess, Fill, Topsoil, Silty Alluvial Deposits	2 : 1	3 : 1.
Sandy/Granular Alluvial Deposits	1.5 : 1	3 : 1
Schist	1:1 – Provisional*	
*Suitable schist cut angles should be confirmed based on a detailed assessment of the rock using pilot cuts/drill holes at detailed design.		

Temporary batters which are required to be higher or steeper than those described above should be subject to specific design.

Recommended batters for wet ground are provisional only. Any seepage encountered in a cut should be inspected by a geotechnical engineer/engineering geologist to confirm any specific requirements. Installation of drainage, retaining, or regrading, may be required to achieve stability.

Only minor localised seepage was encountered in TP16a at 3.4 m bgl during test pitting at shallow depths and hence the regional groundwater level is unlikely to be encountered during excavations. It is however expected that due to the proposed cut within the north of the site encountering schist that seepage may be encountered in this area. The potential for groundwater seepage to be encountered (including seepages volumes) should be assessed with additional investigations at detailed design.

However, a geotechnical practitioner should inspect any seepage that may be encountered during construction.

7.5 Ground Retention

It is anticipated that retaining will be required to form the proposed cut along the northern extent of the proposed development. The final retaining and slope regrade solution should be assessed at detailed design. Conceptual options for this area include:

- Construction of a temporary retaining wall to form access and allow construction of the building and incorporating the permanent retaining into the building design;
- Constructing a permanent retaining wall offset from the building to support the proposed cut. Due to the retained height and sloping ground associated with the existing hillside a bored and concrete encased steel UC/anchored retaining wall constructed in a top-down methodology is likely to be required.

Any retaining wall should be designed by a chartered professional engineer. Due allowance should be made during the detailed design of all retaining walls for any additional loads upslope of the wall (i.e. rock defects, surcharge due to back-slope, traffic and seismic loading).

See section 7.4.3 for recommended temporary batter slopes.

Perched groundwater was identified in TP16a and has the potential to develop following completion of the earthworks (particularly along the soil/schist contact) in other areas of the development, in particular as a result of heavy or prolonged rainfall. To ensure potential groundwater seeps and flows are properly controlled behind the retaining walls, the following recommendations are provided:

- A minimum 0.3m width of durable free draining granular material should be placed behind all retaining structures;
- A heavy duty non-woven geotextile cloth, such as Bidim A29, should be installed between the natural ground surface and the free draining granular material to prevent siltation and blockage of the drainage media; and
- A heavy-duty (TNZ F/2 Class 500) perforated pipe should be installed within the drainage material at the base of all retaining structures to minimise the risk of excessive groundwater pressures developing. This drainage pipe should be connected to the permanent piped storm water system.

Ultimately any drainage requirements will be determined by the wall designer at the detailed design stage once the retention methodology/solution is confirmed.

7.6 Engineered Fill Slopes

Any engineered fill slopes less than 3 m in height should be constructed with a batter of 3 : 1 (horizontal to vertical) or flatter, provided these slopes are well drained and constructed of well graded granular fill. Fill slopes which are required to be higher or steeper than those described above should be subject to specific engineering design.

It is understood that fill up to approximately 7 m is proposed on the southeastern extent of proposed Soundstage area. The final solution to support the proposed fill should be confirmed at detailed design however feasible standard engineering solutions include:

- Constructing a downslope retaining wall and placing fill behind the wall to achieve the proposed level. Due to the height of the wall, anchors are likely to be required;
- Constructing a geogrid reinforced slope to allow formation of an up to approximately vertical slope (with the inclusion of a facing product).

Specific design will also be required where buildings are located adjacent the slope crests.

7.7 Slope Stability Considerations

Buildings are proposed in close proximity to the crest of the terrance slope that runs along the eastern and southern sides of the development area. GeoSolve have undertaken a preliminary review to assess slope stability. This assessment indicates several standard engineering solutions (as described below) are available to ensure construction can be completed in the platform locations shown on Figure 1b, Appendix A, adjacent to crest areas.

The following techniques could be implemented to address slope stability:

- Deepening of foundation elements;
- Crest setbacks;
- Ground improvement e.g. xxcavation and replacement using reinforced earth;
- Embedded palisade walls;
- Specific design of structural foundations to address any identified movements;
- Earthworks to re grade the terrace slope to a reduced batter, removing the need for a setback.

A detailed stability assessment of the proposed building platforms located adjacent to any slope crest should be undertaken as part of the detailed design phase to determine the most appropriate and cost-effective approach. Slope stability and potential impacts under static and seismic loading should be considered for general infrastructure aspects e.g. access roads, services etc depending on the layout proposed.

In general there are likely to be minimal stability mitigation works required for buildings within 5 m of a slope crest provided the slope is shallower (flatter) than 2.5:1 (H:V).

7.8 Groundwater Considerations

The regional groundwater table is expected to lie below the finished floor levels. Dewatering or other groundwater-related construction issues are therefore unlikely to be required for site earthworks.

Perched groundwater may however be encountered along the schist contact in the proposed excavations along the northern section of the development. To confirm the depth to schist and review potential seepage flows in the vicinity of the proposed northern excavation it is

recommended that further investigations comprising pilot cuts and/or drill holes are completed in this area during detailed design.

A geotechnical practitioner should inspect any seepage if encountered during construction.

7.9 Flooding Risk

Flooding risks associated with Mill Creek are indicated on the QLDC hazard mapping. We understand this hazard has been assessed separately by others and therefore it is not addressed in this report.

7.10 Alluvial Fan Hazard

QLDC hazard mapping identifies parts of the development site as potentially subject to active debris-dominated alluvial fan activity, see Figure 1a, Appendix A. The fan assessment and mapping is at a regional scale (1:50,000) and as such is of relatively coarse resolution, indicating that site-specific assessment is warranted.

Subsequent higher resolution (1:25,000) assessment by ORC of specific alluvial fan areas did not identify any of the site as lying with active fan areas, but noted "…the absence of information on alluvial fan hazard for a certain property or area does not necessarily mean that alluvial fan activity will not affect that property or area", again indicating that site-specific assessment is warranted.

The hill slope to the north of the site shows no sign of instability with gradients generally less than 20° in upper areas increasing to 30-40° in lower areas, with the exception of a small steep rock bluff. No active deep seated land sliding is visible or likely; thus there is negligible sediment/debris supply available for mobilisation. Site sub soils are generally alluvial but not indicative of debris flow or debris flood activity. The risk factors, or geomorphology, for alluvial fan hazard are not present to any significant extent and there is no evidence of previous such activity. The risk from alluvial fan activity is therefore considered very low for the proposed development area.

A tributary to Mill Creek is located to the west of the development area, see location on Figure 1b, Appendix A. To assess potential for flooding from this flow path, analysis was undertaken by the Rational Method with a 15% increase to allow for future climate change. This analysis indicates a 100-year ARI (average recurrence interval) peak flow of 0.93 m3/s from the 14-hectare catchment area. Based on observed channel dimensions and gradient, it is calculated that in a 100-year flood it will flow no deeper than 300 mm which will be confined well within the channel banks. A small pond exists in the tributary channel, however the volume of water retained is clearly insufficient to pose any danger associated with a potential breach. It is concluded that there is no flooding hazard to the development sites from the western tributary in a 100-year ARI flood.

Moderate cuts are proposed into the hillside in the north of the site. It is recommended a small diversion channel be constructed around the foot of the hill above development areas, to intercept any upslope runoff and convey it into the adjacent watercourse(s) or stormwater system. This channel will also serve to contain any shallow soil instability which may emanate from the hillside. The upslope catchment area is only a few hectares in size and is well vegetated, so the diversion channel is anticipated to be relatively shallow. As an alternative to an excavated channel, similar protection could be achieved by forming a small landscape bund or access way embankment above the building platforms.

Minimum finished floor levels as per standard construction requirements will provide sufficient freeboard against any local runoff or ponding, provided the overall site is well drained by surface contours.

Ultimately, standard engineering solutions exist and can be utilised to address this hazard and slope/stormwater runoff at the site. We understand the design of such measures will be addressed by others as part of the overall stormwater design for the development at the detailed design stage.

7.11 Site Subsoil Category

For detailed design purposes it is recommended the magnitude of seismic acceleration be estimated in accordance with the recommendations provided in NZS 1170.5:2004.

Schist was encountered in TPs 7d and 10d however the schist was not encountered in the remaining investigations completed within the site. Structural design should assume Class D (Deep soil site) in absence of deep drilling data (≈50m depth) to verify the depth to rock. Following additional drilling some buildings in the north of the site may be able to be considered Class C (Shallow soil site).

8 Preliminary Stormwater Soakage Assessment

Three soakage tests were completed in potential stormwater management areas as defined by the environmental design consultant, CKL NZ Ltd (CKL), and as shown on the site investigation plan, Figure 1b, Appendix A.

8.1 General

Soakage testing was completed in the three locations as designated by CKL to assess the suitability of the ground conditions for stormwater disposal. Soakage testing was undertaken at between 1.2 and 3.8 m below existing ground level, which is approximately 1-1.5 m below proposed finished levels.

Soakage testing target depths were approximately 1 m below proposed finished ground level. Testing was completed in SP2 at 1.5 m due to the presence of a SILT with minor to trace sand layer extending to 2.7 m bgl (approximately 1.2 m below proposed ground level).

Prior to undertaking soakage testing, a deep test pit was undertaken adjacent to SPs 1 and 2 to log the subsoil conditions and existing test pit investigation information was reviewed for SP3 and determine a suitable consistent layer for soakage testing. A smaller soakage test pit was then excavated adjacent to the deep pit. The dimensions of the soakage pit were recorded to calculate soakage volume and area.

Before soakage testing was undertaken, the soakage pit was pre-soaked with 4,000 L of water (where moderate drainage was observed) or for a minimum of 4 hours.

Soakage testing was performed by introducing water until the water level of the pit reached the designated testing level. Inflow was then ceased, and the time taken for the water level to drop was recorded, i.e., a falling head test. Testing was then completed to ensure saturated conditions were achieved and until three consistent readings had been achieved for each test.

The regional groundwater level was not encountered in any of the test pits at the site. Groundwater was encountered in two boreholes at approximately 8-9 m below the existing level of the lower terrace (in the east of the proposed development). Given the depth to groundwater below the site it is not expected to influence the long-term infiltration rate however this should be confirmed following confirmation of final soakage management areas.

8.2 Permeability Analysis

Results from the field soakage testing have been analysed to determine indicative infiltration rates which are provided below in Table 8.1.

Table 8.1: Calculated Infiltration Rates

Test	Test Depth (m)	Cut to Proposed Finished Level (m)	Soil type at testing level and test subsoil	Unfactored infiltration rate*	Testing situation*[1]
SP1	1.1	0	Gravelly SAND	800 mm/hr	Falling head test in soil, Quality level 3
SP2	2.9	1.5	Sandy SILT	30 mm/hr	
SP3	1.2	0	Sandy GRAVEL	410 mm/hr	

*Does not include a factor of safety to account for loss of soakage performance over time. A factor of safety is to be calculated by the stormwater management system designer at the detailed design stage.

*[1] Information provided to allow selection of the correct partial factor of safety (F_u) for uncertainty in input data as per Table 4-7 of the proposed 2022 amendments to the QLDC COP[7].

8.3 Preliminary Stormwater Soakage Design Recommendations and Considerations

To ensure suitable disposal during the design life of the system, we recommend that:

- The infiltration rate provided in Table 8.1 should be divided by an appropriate factor of safety by the soak pit designer to account for loss of soakage performance over time as per the recommendations of the QLDC Land Development and Subdivision Code of Practice.
- Soakage devices/areas should not be located close to buildings, retaining walls or slopes such that the foundations, structure or land are likely to be adversely affected. The final soakage device/areas should be confirmed in conjunction with the geotechnical engineer and environmental engineer during detailed design.
- Once the stormwater soakage areas are confirmed further test pitting and soakage testing may be required to finalise the soakage rate for design.
- A geotechnical practitioner who is familiar with the findings of this report should inspect the base of any soakage area during earthworks construction.
- Provision should be included for long-term inspection and routine maintenance of any soakage system.
- An emergency overflow/overland flow path should be designed for extreme storm events where surcharging is possible.

[7] Queenstown Lakes District council (2020), Land Development & Subdivision Code of Practice (2022 proposed amendments)

9 Neighbouring Structures/Hazards

Distances to adjoining structures: No adverse effects are expected on existing structures, on the site, or in neighbouring areas of the site as a result of the earthworks operations provided that the recommendations within this report are followed.

Aquifers: No aquifer resource will be adversely affected as a result of the development. Note that the site is located above the Wakatipu Basin aquifer and consent from the Otago Regional Council is expected to be required if drilling is required as part of future works.

Erosion and Sediment Control: The site presents potential to generate silt runoff. Effective systems for erosion control are runoff diversion drains and contour drains, while for sediment control, options are earth bunds, silt fences, hay bales, vegetation buffer strips and sediment ponds. Only the least amount of subsoil should be exposed at any stage and surfacing established as soon as practical. The QLDC Guidelines for Environmental Management plans should be consulted.

Noise: Conventional earthmoving equipment such as excavators will be required to complete earthworks at the site. Rock-breaking is additionally expected to be required in the northern area of the site where the maximum cut is proposed.

Dust: Regular dampening of soil materials with sprinklers should be effective if required. QLDC guidelines to be followed.

Vibration: Minor vibration induced settlement may occur in these soil types. If appropriate a separate assessment of effects to structures should be carried out during the detailed design stage once foundation solutions have been established. The need for such an assessment will depend on the construction sequence adopted and would apply only to structures within the subject development.

10 Further Work

During the detailed design phase of the project the following geotechnical inputs are recommended:

- Additional investigations comprising boreholes and/or deep test pits/pilot cuts should be undertaken in the vicinity of the proposed northern cut to determine the ground conditions at depth. This should include detailed schist mapping for the retaining wall design and potential seepage volumes along the soil-rock contact.

- A detailed stability assessment of the proposed building platforms which are located adjacent to any slope crest should be undertaken as part of the detailed design phase to determine the most appropriate and cost-effective approach, see Section 7.7 for further details.

- Slope stability and potential impacts under static and seismic loading should be considered for general infrastructure aspects (e.g. roads, services etc) depending on the layout proposed.

- Specific investigation and assessment to confirm foundation design for each building. This should include an assessment of bearing capacity, slope stability and any other requirements depending on the building platform location.

- Specific design of slope batters and design of structural retention where appropriate. Based on plans provided it is expected that moderate retaining will be required in the northern extent of the proposed development as shown within the Patersons earthworks plans and cross-sections A, B and C.

- During construction, foundation excavations should be examined by an inspector or engineer competent to confirm that subsurface conditions encountered throughout are compatible with the findings of this report. It is important that we be contacted if there is any variation in subsoil conditions from those described in this report.

11 Applicability

This report has been prepared for the sole use of our client, Waterfall Park Developments Ltd, with respect to the particular brief and on the terms and conditions agreed with our client. It may not be used or relied on (in whole or part) by anyone else, or for any other purpose or in any other contexts, without our prior review and written agreement.

Investigations have been undertaken at discrete locations in accordance with the brief provided. It must be appreciated that the nature and continuity of subsoil conditions away from the investigation locations cannot be guaranteed.

Report prepared by:

.....

Mike Plunket

Geotechnical Engineer

Reviewed for GeoSolve Ltd by:

.....

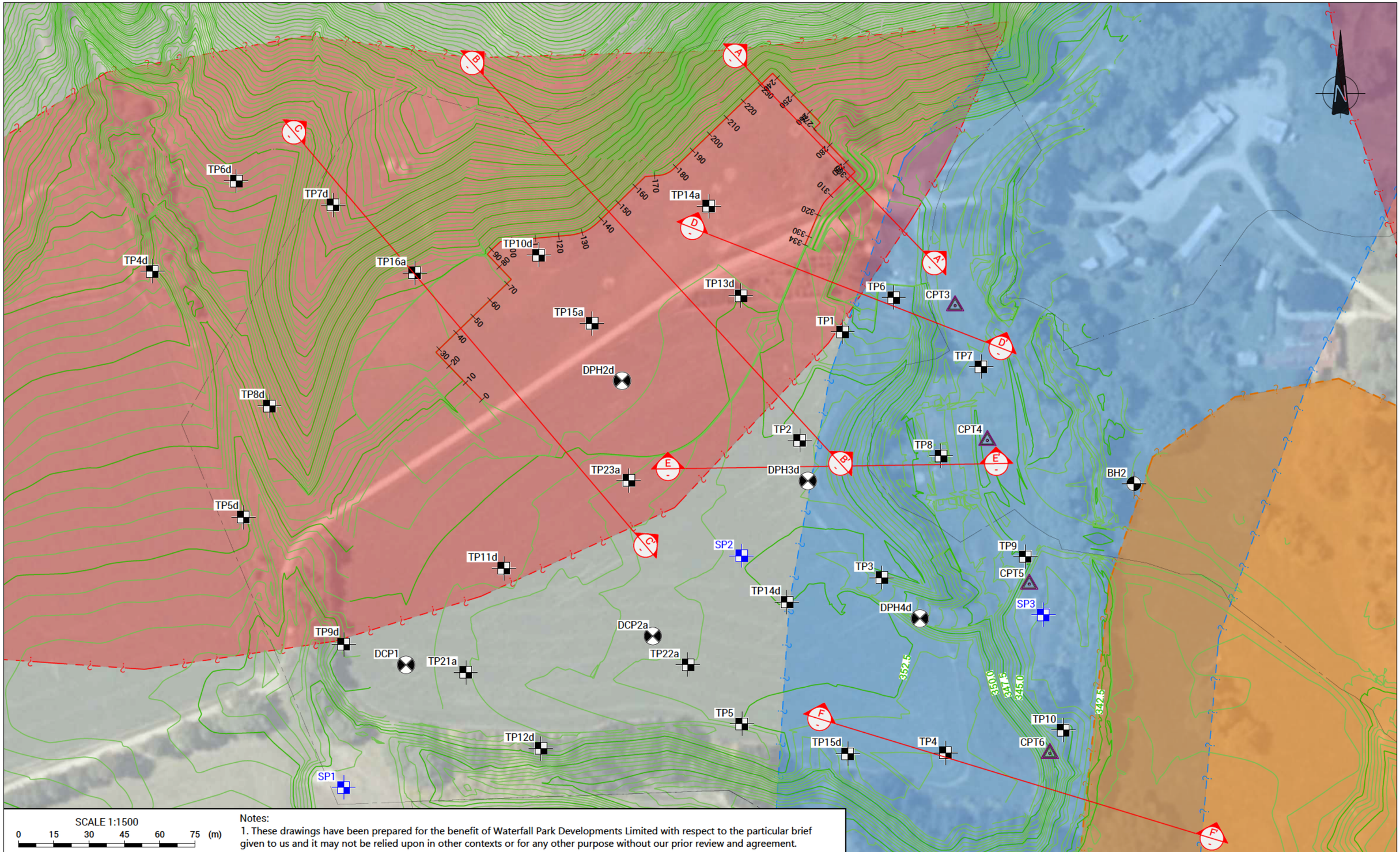
Paul Faulkner

Principal Engineering Geologist

Appendices:

Appendix A – Site Plan & Cross-section
Appendix B – Investigation Data
Appendix C – Liquefaction Analysis
Appendix D – Soakage Results

Appendix A: Site Plan & Cross-section



SCALE 1:1500

0 15 30 45 60 75 (m)

Notes:

1. These drawings have been prepared for the benefit of Waterfall Park Developments Limited with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:

- Test Pit Locations
- Borehole Locations
- DCP Test Locations
- Soakage Test Locations (2024)
- CPT Locations
- Proposed Contours (0.5m intervals)
- LIC2 liquefaction risk area
- Flooding Area
- Regional scale alluvial fan activity

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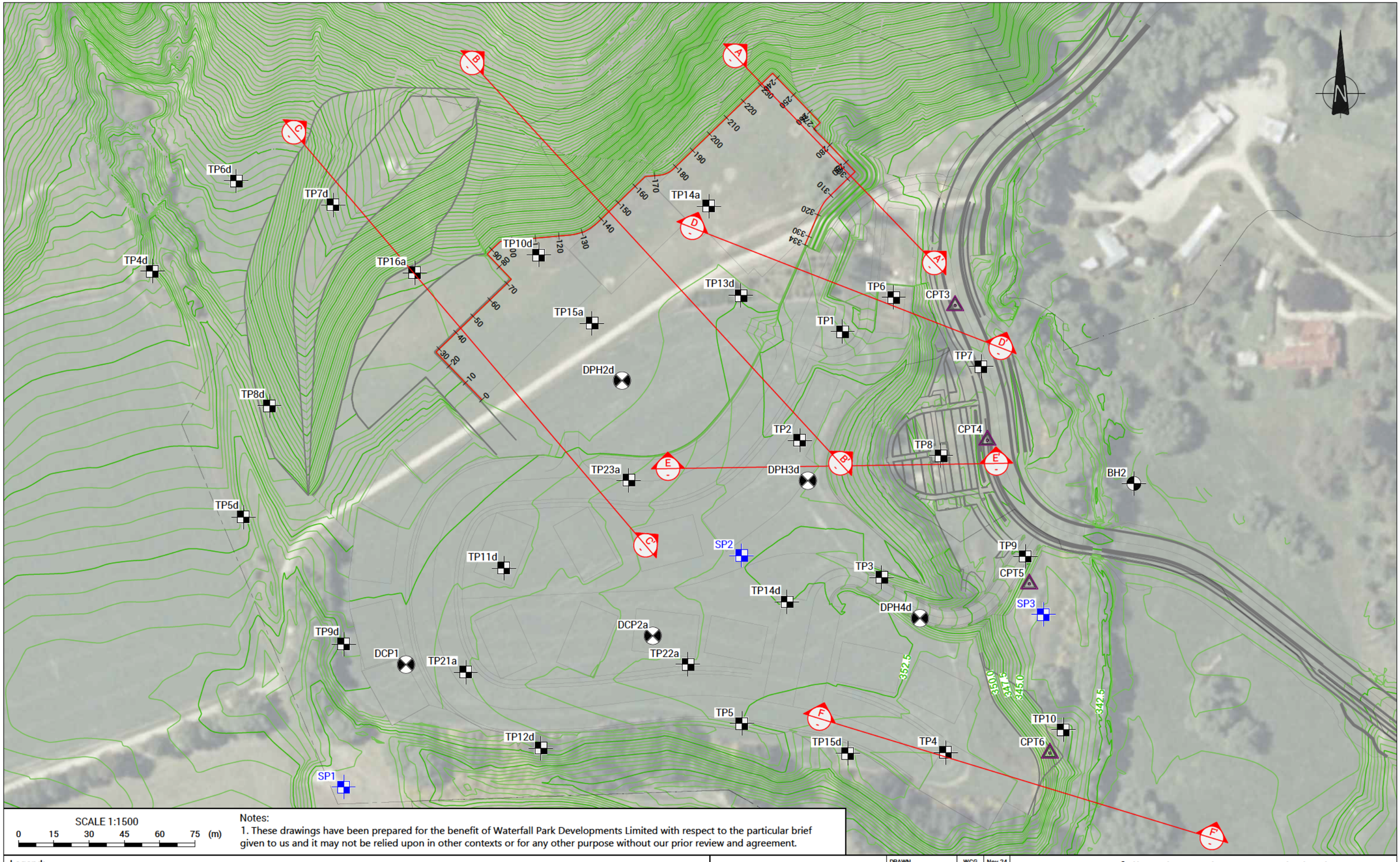
DRAFTING CHECKED		
APPROVED		
CADFILE: 150098.11.dwg		
SCALES (AT A3 SIZE): 1:1500		
PROJECT No: 150098.11	FIG No: Figure 1a	REV. 0

Waterfall Park Developments Limited

Northbrook Arrowtown

Geotechnical Assessment

Investigation Plan



Notes:
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Legend:
- Test Pit Locations
- Borehole Locations
- DCP Test Locations
- Soakage Test Locations (2024)
- CPT Locations
- Proposed Contours (0.5m intervals)

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PROJECT No: 150098.11		

Waterfall Park Developments Limited

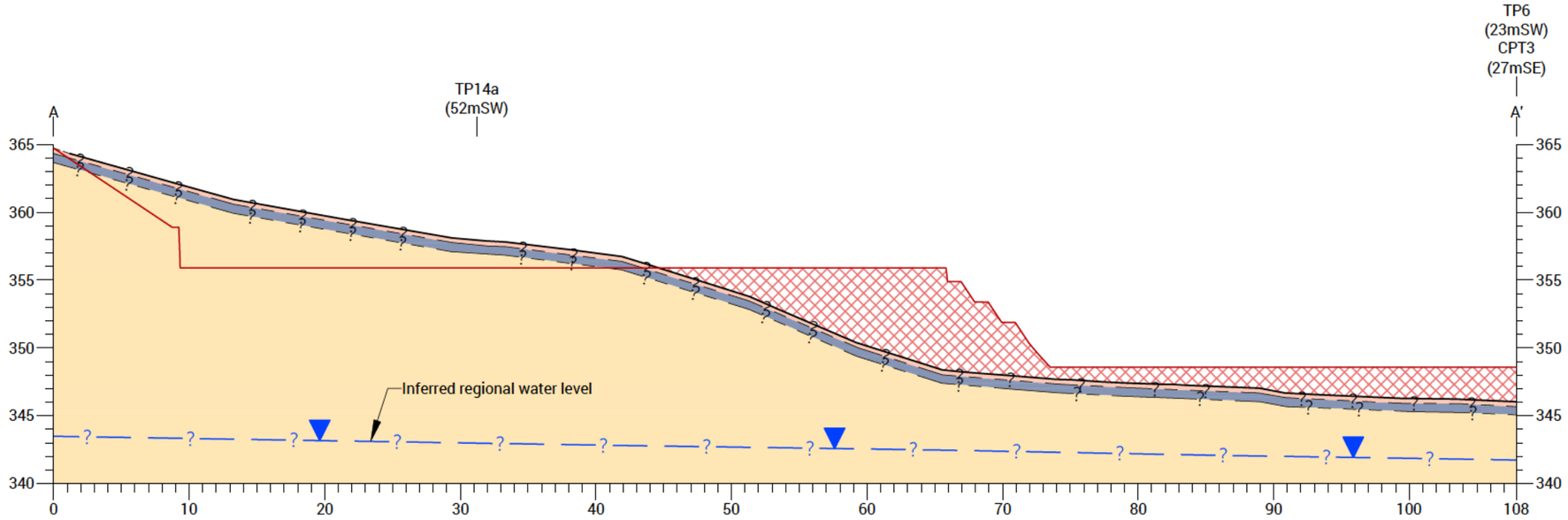
Northbrook Arrowtown

Geotechnical Assessment

Development Plan

FIG No: Figure 1b

REV. 0



SCALE 1:400

0 4 8 12 16 20 (m)

Notes:

1. These drawings have been prepared for the benefit of Waterfall Park Developments Limited with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:

- Topsoil/Fill
- Loess/Colluvium
- Alluvial silt, sand, and gravel
- Schist Bedrock
- Proposed Ground
- Proposed Engineered Fill
- Inferred Regional Water Level
- Inferred Perched Water Level at schist contact

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SCALES (AT A3 SIZE): 1:400		
PROJECT No: 150098.11		

Waterfall Park Developments Limited

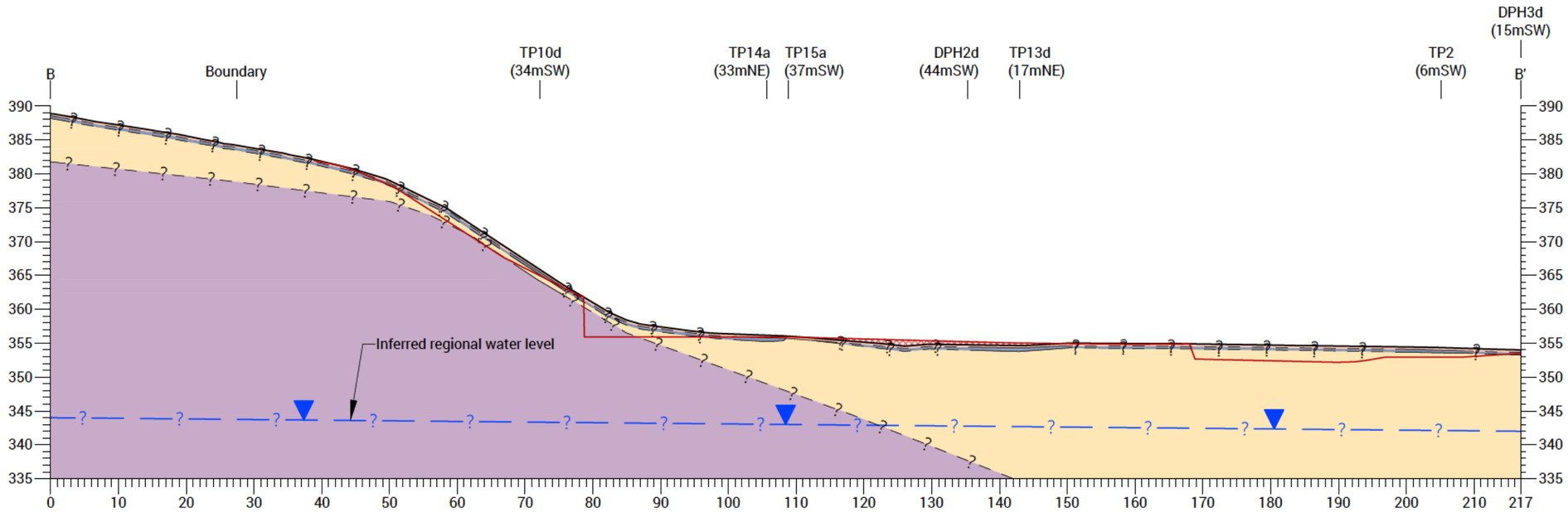
Northbrook Arrowtown

Geotechnical Assessment

Cross Section A

FIG No: Figure 2a

REV. 0



SCALE 1:750

0 7.5 15.0 22.5 30.0 37.5 (m)

Notes:

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Legend:

- Topsoil/Fill
- Loess/Colluvium
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- Schist Bedrock
- Proposed Ground
- Proposed Engineered Fill
- Inferred Regional Water Level
- Inferred Perched Water Level at schist contact

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SCALES (AT A3 SIZE): 1:750		
PROJECT No: 150098.11		

Waterfall Park Developments Limited

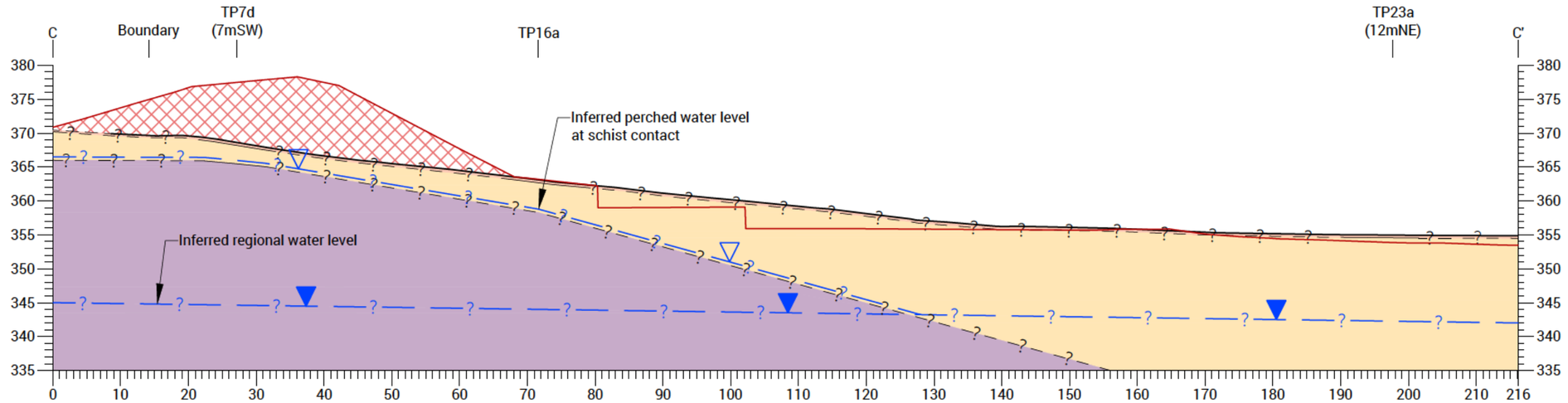
Northbrook Arrowtown

Geotechnical Assessment

Cross Section B

FIG No: Figure 2b

REV. 0



SCALE 1:750

0 7.5 15.0 22.5 30.0 37.5 (m)

Notes:

1. These drawings have been prepared for the benefit of Waterfall Park Developments Limited with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:

- Topsoil/Fill
- Loess/Colluvium
- Alluvial silt, sand, and gravel
- Schist Bedrock
- Proposed Ground
- Proposed Engineered Fill
- Inferred Regional Water Level
- Inferred Perched Water Level at schist contact

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PROJECT No: 150098.11		

Waterfall Park Developments Limited

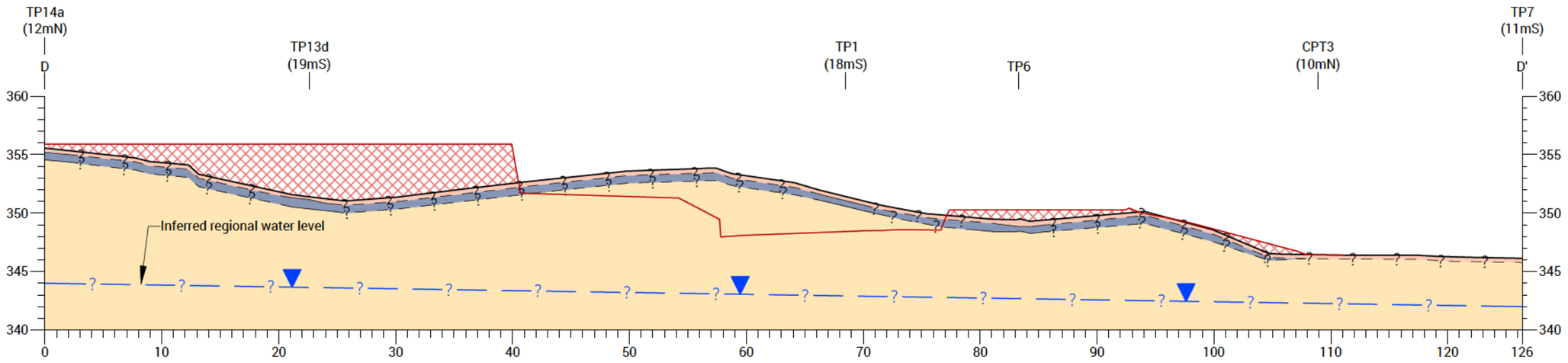
Northbrook Arrowtown

Geotechnical Assessment

Cross Section C

FIG No: Figure 2c

REV. 0



SCALE 1:400

0 4 8 12 16 20 (m)

Notes:

1. These drawings have been prepared for the benefit of Waterfall Park Developments Limited with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:

- Topsoil/Fill
- Loess/Colluvium
- Alluvial silt, sand, and gravel
- Schist Bedrock
- Proposed Ground
- Proposed Engineered Fill
- Inferred Regional Water Level
- Inferred Perched Water Level at schist contact

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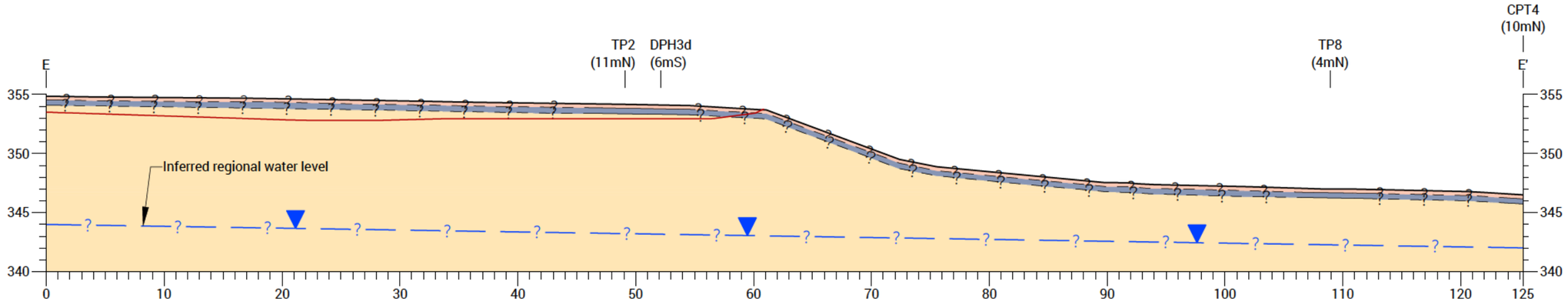
SCALES (AT A3 SIZE): 1:400		
PROJECT No: 150098.11	FIG No: Figure 2d	REV. 0

Waterfall Park Developments Limited

Northbrook Arrowtown

Geotechnical Assessment

Cross Section D



SCALE 1:400

0 4 8 12 16 20 (m)

Notes:

1. These drawings have been prepared for the benefit of Waterfall Park Developments Limited with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:

- Topsoil/Fill
- Loess/Colluvium
- Alluvial silt, sand, and gravel
- Schist Bedrock
- Proposed Ground
- Proposed Engineered Fill
- Inferred Regional Water Level
- Inferred Perched Water Level at schist contact

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SCALES (AT A3 SIZE): 1:400		
PROJECT No: 150098.11		

Waterfall Park Developments Limited

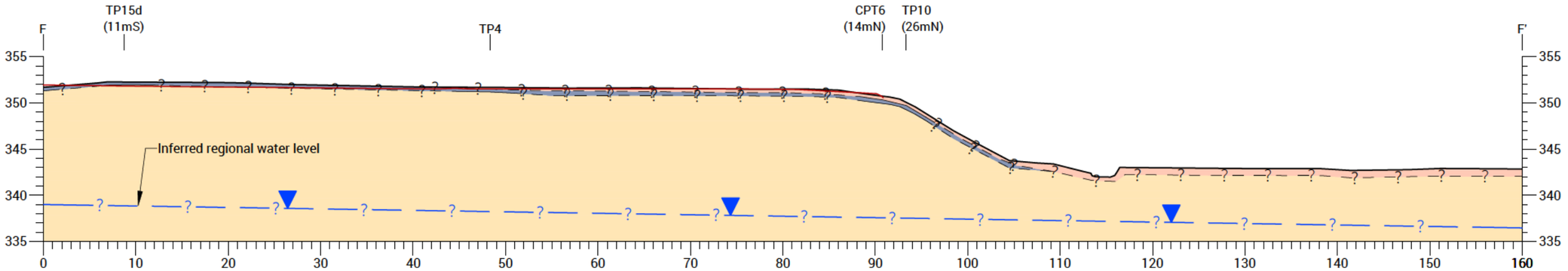
Northbrook Arrowtown

Geotechnical Assessment

Cross Section E

FIG No: Figure 2e

REV. 0



SCALE 1:500

0 5 10 15 20 25 (m)

Notes:

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Legend:

- Topsoil/Fill
- Loess/Colluvium
- Alluvial silt, sand, and gravel
- Schist Bedrock
- Proposed Ground
- Proposed Engineered Fill
- Inferred Regional Water Level
- Inferred Perched Water Level at schist contact

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CADFILE: 150098.11.dwg		
SCALES (AT A3 SIZE): 1:500		
PROJECT No: 150098.11		

Waterfall Park Developments Limited

Northbrook Arrowtown

Geotechnical Assessment

Cross Section F

FIG No: Figure 2f

REV. 0

Appendix B: Investigation Data

DRILL HOLE LOG

DRILL HOLE No: BH2
Hole Location: SEE PLAN

SHEET 1 OF 1

PROJECT: AYRBURN FARM. LOCATION: LAKE HAYES – ARROWTOWN JOB No: 150098

CO-ORDINATES mN
mE

DIRECTION: N/A °

ANGLE FROM HORIZ.: 90°

DRILL TYPE: SONIC 3"

DATUM: N/A

R.L. GROUND: N/A m

R.L. COLLAR: N/A m

HOLE STARTED: 23-4-15

HOLE FINISHED: 23-4-15

DRILLED BY: McNEILL

LOGGED BY: PGF CHECKED:

DESCRIPTION OF CORE

GEOLOGICAL UNIT	ROCK OR SOIL TYPE, WEATHERING, HARDNESS, STRENGTH, COLOUR, LITHOLOGICAL FEATURES (bedding, cement, foliation, mineralogy, texture, etc...);	DEPTH (m)	PIEZOMETER DETAILS	SPT RESULTS
ALLUVIAL DEPOSITS	TOPSOIL.	0	CAP	
	SILT with minor sand, Grey brown, moist none plastic.		BENTONITE SEAL 0 – 1.0m	SPT AT 1.0m 2, 3, 3, 2, 4, 7 N = 16
	SAND, fine with minor silt, Grey brown	1	1.0m	
	sandy GRAVEL with minor silt, orange-brown, gravel sub-rounded to sub-angular, fine to medium, moist, bedded.	2	GRAVEL 1.0 – 6.0m	SPT AT 2.5m 5, 8, 9, 10, 13, 12 N = 44
	SILT with some sand, grey, moist none plastic	3	PIEZOMETER SOLID PIPE 0 – 9.0m.	
	sandy GRAVEL with minor silt, orange-brown, gravel sub-rounded to sub-angular, fine to medium, moist bedded	4		
	silty SAND, fine, grey-brown.	5		
	sandy GRAVEL, orange-brown, gravel sub-rounded to sub-angular, fine to medium, moist, bedded.	6	6.0m	
	silty SAND, fine, grey-brown.			
	sandy GRAVEL, orange brown, sub-round -sub angular, moist, bedded.	7	BENTONITE SEAL 6.0 – 8.0m.	
	silty SAND, fine, grey-brown.			
	SILT with some sand, grey-brown, moist non-plastic	8	8.0m	SPT AT 8.5m 5, 11, 10, 11, 11, 10 N = 42
	SAND, fine to coarse, grey-brown		▽	
	Very sandy GRAVEL with some sandy + silty lenses, grey-brown, gravel is sub-rounded to sub-angular, fine to medium, moist, bedded.	9	9.0m	
			SAND 8.0 – 12.0m.	
		10		
		11	PIEZOMETER SLOTTED PIPE 9.0 – 12.0m.	SPT AT 11.5m 8, 6, 6, 7, 7, 7 N = 27
		12	BASE OF PIEZOMETER. 12.0m	
	SAND with minor silt, grey-brown, fine to medium	13		
		14		SPT AT 14.5m 4, 6, 6, 6, 7, 8 N = 27
	BOREHOLE COMPLETE FINAL DEPTH 15m.	15m		

CORE LOSS / LIFT (%): 3, 10, 30, 100

METHOD, CORE & CASING: SONIC 3"

TEST SYMBOL

GRAPHIC LOG

PIEZOMETER

DATE / DEPTH: HOLE STARTED & COMPLETED 23-4-15.

WATER: ▽ GROUNDWATER AT 8.7m DEPTH

CORE BOX RL (m)

GeoSolve Ltd
EXCAVATION LOG

EXCAVATION NUMBER:

TP 1

PROJECT: Ayrburn Farm			Job Number: 150098
LOCATION: See Site Plan		Inclination: VERTICAL	Direction:

EASTING:	mE	EQUIPMENT: 13 Tonne Excavator		OPERATOR: Tony Brookes	
NORTHING:	mN	INFOMAP NO.		COMPANY: Earthworks and Drainage	
ELEVATION:	m	DIMENSIONS:		HOLE STARTED: 22-Apr-15	
METHOD:		EXCAV. DATUM:		HOLE FINISHED: 22-Apr-15	

SCALA PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.3		Dark brown, sandy organic SILT with rootlets and traces of clay. Soft.	Moist	TOPSOIL
		0.8		Yellow grey, SILT with some fine sand. Firm to stiff.	Moist	LOESS
		2.4		Grey brown, gravelly SAND with minor silt and gravel lenses. Gravel is fine with sub-rounded to rounded clasts. Medium dense. Sub-horizontal bedding.	Moist	ALLUVIAL SAND
	NO SEEPAGE	4.0		Grey brown, sandy GRAVEL with minor silt and cobbles. Gravel is fine with sub-rounded to rounded clasts. Medium dense. Sub-horizontal bedding.	Moist	ALLUVIAL GRAVEL

Total Depth = 4 m

COMMENT: Test pit was dry and sides were stable.	Logged By: PGF
	Checked Date:
	Sheet: 1 of 1

GeoSolve Ltd
EXCAVATION LOG

EXCAVATION NUMBER:

TP 2

PROJECT: Ayrburn Farm			Job Number: 150098
LOCATION: See Site Plan		Inclination: VERTICAL	Direction:

EASTING:	mE	EQUIPMENT: 13 Tonne Excavator	OPERATOR: Tony Brookes
NORTHING:	mN	INFOMAP NO.	COMPANY: Earthworks and Drainage
ELEVATION:	m	DIMENSIONS:	HOLE STARTED: 22-Apr-15
METHOD:		EXCAV. DATUM:	HOLE FINISHED: 22-Apr-15

SCALA PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.3		Dark brown, sandy organic SILT with rootlets and traces of clay. Soft.	Moist	TOPSOIL
		0.7		Yellow grey, SILT with some fine sand. Firm to stiff.	Moist	LOESS
		1.0		Grey brown, sandy GRAVEL with minor silt and cobbles. Gravel is fine with sub-rounded to rounded clasts. Medium dense. Sub-horizontal bedding.	Moist	ALLUVIAL GRAVEL
		2.3		Grey brown, gravelly SAND with minor silt and gravel lenses. Gravel is fine with sub-rounded to rounded clasts. Medium dense. Sub-horizontal bedding.	Moist	ALLUVIAL SAND
	NO SEEPAGE	4.1		Grey brown, sandy GRAVEL with minor silt and cobbles. Gravel is fine with sub-rounded to rounded clasts. Medium dense. Sub-horizontal bedding.	Moist	ALLUVIAL GRAVEL

Total Depth = 4.1 m

COMMENT: Test pit was dry and sides were stable.	Logged By: PGF
	Checked Date:
	Sheet: 1 of 1

GeoSolve Ltd
EXCAVATION LOG

EXCAVATION NUMBER:

TP 3

PROJECT: Ayrburn Farm			Job Number: 150098
LOCATION: See Site Plan		Inclination: VERTICAL	Direction:

EASTING:	mE	EQUIPMENT: 13 Tonne Excavator		OPERATOR: Tony Brookes	
NORTHING:	mN	INFOMAP NO.		COMPANY: Earthworks and Drainage	
ELEVATION:	m	DIMENSIONS:		HOLE STARTED: 22-Apr-15	
METHOD:		EXCAV. DATUM:		HOLE FINISHED: 22-Apr-15	

SCALA PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.3		Dark brown, sandy organic SILT with rootlets and traces of clay. Soft.	Moist	TOPSOIL
		0.6		Yellow grey, SILT with some fine sand. Firm to stiff.	Moist	LOESS
	NO SEEPAGE	4.0		Grey brown, gravelly SAND with minor silt and gravel lenses. Gravel is fine with sub-rounded to rounded clasts. Medium dense. Sub-horizontal bedding.	Moist	ALLUVIAL SAND
		4.2		Grey brown, sandy GRAVEL with minor silt and cobbles. Gravel is fine with sub-rounded to rounded clasts. Medium dense. Sub-horizontal bedding.	Moist	ALLUVIAL GRAVEL

Total Depth = 4.2 m

COMMENT: Test pit was dry and sides were stable.

Logged By: PGF

Checked Date:

GeoSolve Ltd
EXCAVATION LOG

EXCAVATION NUMBER: **TP 4**

PROJECT: Ayrburn Farm			Job Number: 150098
LOCATION: See Site Plan		Inclination: VERTICAL	Direction:

EASTING:	mE	EQUIPMENT: 13 Tonne Excavator	OPERATOR: Tony Brookes
NORTHING:	mN	INFOMAP NO.	COMPANY: Earthworks and Drainage
ELEVATION:	m	DIMENSIONS:	HOLE STARTED: 22-Apr-15
METHOD:		EXCAV. DATUM:	HOLE FINISHED: 22-Apr-15

SCALA PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.2		Dark brown, sandy organic SILT with rootlets and traces of clay. Soft.	Moist	TOPSOIL
		0.4		Yellow grey, SILT with some fine sand. Firm to stiff.	Moist	LOESS
		0.8		Grey brown, sandy GRAVEL with minor silt and cobbles. Gravel is fine with sub-rounded to rounded clasts. Medium dense. Sub-horizontal bedding.	Moist	ALLUVIAL GRAVEL
	NO SEEPAGE	4.4		Grey brown, silty SAND with some fine gravel and thin bed of laminated sandy silt at 4.2m. Medium dense.	Moist	ALLUVIAL SAND

Total Depth = 4.4 m

COMMENT: Test pit was dry and sides were stable.

Logged By: PGF

Checked Date:

GeoSolve Ltd
EXCAVATION LOG

EXCAVATION NUMBER:
TP 5

PROJECT: Ayrburn Farm			Job Number: 150098
LOCATION: See Site Plan		Inclination: VERTICAL	Direction:

EASTING:	mE	EQUIPMENT: 13 Tonne Excavator	OPERATOR: Tony Brookes
NORTHING:	mN	INFOMAP NO.	COMPANY: Earthworks and Drainage
ELEVATION:	m	DIMENSIONS:	HOLE STARTED: 22-Apr-15
METHOD:		EXCAV. DATUM:	HOLE FINISHED: 22-Apr-15

SCALA PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.6		Dark brown, sandy SILT with organic rootlets. Soft.	Moist	FILL
		0.9		Dark brown, organic SILT with traces of clay and sand. Soft.	Moist	HISTORIC TOPSOIL
		1.3		Yellow grey, SILT with some fine sand. Firm to stiff.	Moist	LOESS
		2.4		Grey brown, sandy gravelly SILT. Firm. Massive.	Moist	ALLUVIAL FAN
	NO SEEPAGE	4.2		Grey brown, sandy GRAVEL with minor silt and cobbles. Gravel is fine with sub-rounded to rounded clasts. Medium dense. Sub-horizontal bedding.	Moist	ALLUVIAL GRAVEL

Total Depth = 4.2 m

COMMENT: Test pit was dry and sides were stable.	Logged By: PGF
	Checked Date:
	Sheet: 1 of 1

GeoSolve Ltd
EXCAVATION LOG

EXCAVATION NUMBER: **TP 6**

PROJECT: Ayrburn Farm			Job Number: 150098
LOCATION: See Site Plan	Inclination:	VERTICAL	Direction:

EASTING:	mE	EQUIPMENT: 13 Tonne Excavator		OPERATOR: Tony Brookes	
NORTHING:	mN	INFOMAP NO.		COMPANY: Earthworks and Drainage	
ELEVATION:	m	DIMENSIONS:		HOLE STARTED: 22-Apr-15	
METHOD:		EXCAV. DATUM:		HOLE FINISHED: 22-Apr-15	

SCALA PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.3		Dark brown, sandy organic SILT with rootlets and traces of clay. Soft.	Moist	TOPSOIL
		0.7		Grey brown, sandy SILT. Soft.	Moist	FILL
		1.0		Yellow grey, SILT with some fine sand. Firm to stiff.	Moist	LOESS
		2.5		Grey brown, sandy GRAVEL with minor silt and cobbles. Gravel is fine with sub-rounded to rounded clasts. Medium dense. Sub-horizontal bedding.	Moist	ALLUVIAL GRAVEL
	NO SEEPAGE	4.8		Yellow grey, silty SAND. Loose to medium dense. Massive.	Moist	ALLUVIAL SAND

Total Depth = 4.8 m

COMMENT: Test pit was dry and sides were stable.

Logged By: PGF
Checked Date:
Sheet: 1 of 1

GeoSolve Ltd
EXCAVATION LOG

EXCAVATION NUMBER: **TP 7**

PROJECT: Ayrburn Farm			Job Number: 150098
LOCATION: See Site Plan	Inclination:	VERTICAL	Direction:

EASTING:	mE	EQUIPMENT: 13 Tonne Excavator		OPERATOR: Tony Brookes	
NORTHING:	mN	INFOMAP NO.		COMPANY: Earthworks and Drainage	
ELEVATION:	m	DIMENSIONS:		HOLE STARTED: 22-Apr-15	
METHOD:		EXCAV. DATUM:		HOLE FINISHED: 22-Apr-15	

SCALA PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.3		Dark brown, sandy organic SILT with rootlets and traces of clay. Soft.	Moist	TOPSOIL
	NO SEEPAGE	4.4		Grey brown, sandy GRAVEL with cobbles and boulders up to 350 mm. Gravel is fine to coarse and sub-rounded to rounded. Loose to medium dense. Bedded.	Moist	ALLUVIAL GRAVEL

Total Depth = 4.4 m

COMMENT: Test pit was dry, minor instability of pit sides.

Logged By: PGF

Checked Date:

GeoSolve Ltd
EXCAVATION LOG

EXCAVATION NUMBER: **TP 8**

PROJECT: Ayrburn Farm			Job Number: 150098
LOCATION: See Site Plan		Inclination: VERTICAL	Direction:

EASTING:	mE	EQUIPMENT: 13 Tonne Excavator		OPERATOR: Tony Brookes	
NORTHING:	mN	INFOMAP NO.		COMPANY: Earthworks and Drainage	
ELEVATION:	m	DIMENSIONS:		HOLE STARTED: 22-Apr-15	
METHOD:		EXCAV. DATUM:		HOLE FINISHED: 22-Apr-15	

SCALA PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.3		Dark brown, sandy organic SILT with rootlets and traces of clay. Soft.	Moist	TOPSOIL
		0.7		Yellow grey, SILT with some fine sand. Firm to stiff.	Moist	LOESS
	NO SEEPAGE	4.2		Grey brown, sandy GRAVEL with cobbles and boulders up to 350 mm. Gravel is fine to coarse and sub-rounded to rounded. Loose to medium dense. Bedded.	Moist	ALLUVIAL GRAVEL

Total Depth = 4.2 m

COMMENT: Test pit was dry, minor instability of pit sides.

Logged By: PGF
Checked Date:
Sheet: 1 of 1

GeoSolve Ltd
EXCAVATION LOG

EXCAVATION NUMBER: **TP 9**

PROJECT: Ayrburn Farm			Job Number: 150098
LOCATION: See Site Plan	Inclination:	VERTICAL	Direction:

EASTING:	mE	EQUIPMENT: 13 Tonne Excavator		OPERATOR: Tony Brookes	
NORTHING:	mN	INFOMAP NO.		COMPANY: Earthworks and Drainage	
ELEVATION:	m	DIMENSIONS:		HOLE STARTED: 22-Apr-15	
METHOD:		EXCAV. DATUM:		HOLE FINISHED: 22-Apr-15	

SCALA PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.3		Dark brown, sandy organic SILT with rootlets and traces of clay. Soft.	Moist	TOPSOIL
		0.6		Yellow grey, SILT with some fine sand. Firm to stiff.	Moist	LOESS
		3.0		Grey brown, sandy GRAVEL with minor silt and cobbles. Gravel is fine with sub-rounded to rounded clasts. Medium dense. Sub-horizontal bedding.	Moist	ALLUVIAL GRAVEL
	NO SEEPAGE	4.3		Grey brown, silty SAND with some fine gravel and thin bed of laminated sandy silt at 4.2m. Medium dense.	Moist	ALLUVIAL SAND

Total Depth = 4.3 m

COMMENT: Test pit was dry and sides were stable. M

Logged By: PGF

Checked Date:

GeoSolve Ltd
EXCAVATION LOG

EXCAVATION NUMBER: **TP 10**

PROJECT: Ayrburn Farm			Job Number: 150098
LOCATION: See Site Plan	Inclination:	VERTICAL	Direction:

EASTING:	mE	EQUIPMENT: 13 Tonne Excavator		OPERATOR: Tony Brookes	
NORTHING:	mN	INFOMAP NO.		COMPANY: Earthworks and Drainage	
ELEVATION:	m	DIMENSIONS:		HOLE STARTED: 22-Apr-15	
METHOD:		EXCAV. DATUM:		HOLE FINISHED: 22-Apr-15	

SCALA PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.3		Dark brown, sandy organic SILT with rootlets and traces of clay. Soft.	Moist	TOPSOIL
		0.7		Yellow grey, SILT with some fine sand. Firm to stiff.	Moist	LOESS
	NO SEEPAGE	3.6		Grey brown, sandy GRAVEL with minor silt, sand and gravel bands. Gravel is fine to coarse and sub-rounded to rounded. Loose. Bedded.	Moist	ALLUVIAL GRAVEL

Total Depth = 3.6 m

COMMENT: Test pit was dry. Alluvial gravel collapsing into pit.

Logged By: PGF
Checked Date:
Sheet: 1 of 1

GeoSolve Ltd
EXCAVATION LOG

EXCAVATION NUMBER:
TP 14a

PROJECT: Waterfall Park Subdivision, Lake Hayes			Job Number: 150098.01
LOCATION: See Site Plan	Inclination:	Vertical	Direction:

EASTING:	mE	EQUIPMENT: 8T excavator	OPERATOR: Tony
NORTHING:	mN	INFOMAP NO.	COMPANY: Earthworks and Drainage
ELEVATION:	m	DIMENSIONS:	HOLE STARTED: 5-Aug-16
METHOD:		EXCAV. DATUM:	HOLE FINISHED: 5-Aug-16

SCALA PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.3		Black, organic SILT with roots. Soft.	Moist	TOPSOIL
		0.65		Light brown, silty SAND with a trace of gravel and rootlets. Sand is fine. Gravel is fine. Uniformly graded. Loose to medium dense. Massive.	Moist	LOESS
		0.95		Light brown, gravelly SAND. Sand is fine to coarse. Gravel is fine to medium. Poorly graded. Medium dense. Massive.	Moist	COLLUVIUM
		2.1		Grey, SAND with some gravel. Sand is fine to medium. Gravel is fine to medium, angular. Poorly graded. Medium dense. Massive.	Moist	ALLUVIAL SAND
		2.6		Grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to medium. Poorly graded. Medium dense. Bedded.	Moist	ALLUVIAL GRAVEL
	NO SEEPAGE	4.0		Grey, gravelly SAND and SAND with some gravel. Sand is fine to coarse. Gravel is fine to medium. Poorly graded. Medium dense. Massive.	Moist	ALLUVIAL SAND

Total Depth = 4 m

COMMENT: Minor slumping of test pit walls.	Logged By: JAS
	Checked Date:
	Sheet: 1 of 1

GeoSolve Ltd
EXCAVATION LOG

EXCAVATION NUMBER:
TP 15a

PROJECT: Waterfall Park Subdivision, Lake Hayes			Job Number: 150098.01
LOCATION: See Site Plan	Inclination:	Vertical	Direction:

EASTING:	mE	EQUIPMENT: 8T excavator	OPERATOR: Tony
NORTHING:	mN	INFOMAP NO.	COMPANY: Earthworks and Drainage
ELEVATION:	m	DIMENSIONS:	HOLE STARTED: 5-Aug-16
METHOD:		EXCAV. DATUM:	HOLE FINISHED: 5-Aug-16

SCALA PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.25		Black, organic SILT with roots. Soft.	Moist	TOPSOIL
		0.35		Light brown, silty SAND. Sand is fine. Uniformly graded. Loose to medium dense. Massive.	Moist	LOESS
		1.1		Brown grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to medium schist clasts. Poorly graded. Medium dense. Bedded.	Moist	ALLUVIAL GRAVEL
	NO SEEPAGE	3.7		Light grey, gravelly SAND and sandy GRAVEL. Sand is fine to coarse. Gravel is fine to medium. Poorly graded. Medium dense. Bedded.	Moist	ALLUVIAL SAND/GRAVEL

Total Depth = 3.7 m

COMMENT: Significant slumping of test pit walls.	Logged By: JAS
	Checked Date:
	Sheet: 1 of 1

GeoSolve Ltd
EXCAVATION LOG

EXCAVATION NUMBER: **TP 16a**

PROJECT: Waterfall Park Subdivision, Lake Hayes			Job Number: 150098.01
LOCATION: See Site Plan		Inclination: Vertical	Direction:

EASTING:	mE	EQUIPMENT: 8T excavator	OPERATOR: Tony
NORTHING:	mN	INFOMAP NO.	COMPANY: Earthworks and Drainage
ELEVATION:	m	DIMENSIONS:	HOLE STARTED: 5-Aug-16
METHOD:		EXCAV. DATUM:	HOLE FINISHED: 5-Aug-16

SCALA PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.25		Black, organic SILT with roots. Soft.	Moist	TOPSOIL
		0.45		Light brown, silty SAND. Sand is fine. Gravel is fine. Uniformly graded. Loose to medium dense. Massive	Moist	LOESS
		1.0		Grey brown, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to medium, angular to subrounded. Poorly graded. Medium dense. Bedded.	Moist	ALLUVIAL GRAVEL
		2.7		Grey, sandy GRAVEL and gravelly SAND. Sand is fine to coarse. Gravel is fine to coarse, angular to subrounded. Poorly graded. Medium dense. Bedded.	Moist	ALLUVIAL SAND/GRAVEL
	Minor inflow <5L/min	4.0		Grey, SAND with minor to some gravel and a trace of cobbles. Sand is fine to medium. Gravel is fine to medium. Poorly graded. Medium dense. Bedded.	Moist. Saturated from 3.4m	ALLUVIAL SAND

Total Depth = 4 m

COMMENT: Test pit walls stood well - no slumping.	Logged By: JAS
	Checked Date:
	Sheet: 1 of 1

GeoSolve Ltd
EXCAVATION LOG

EXCAVATION NUMBER: **TP 21a**

PROJECT: Waterfall Park Subdivision, Lake Hayes			Job Number: 150098.01
LOCATION: See Site Plan	Inclination:	Vertical	Direction:

EASTING:	mE	EQUIPMENT: 8T excavator	OPERATOR: Tony
NORTHING:	mN	INFOMAP NO.	COMPANY: Earthworks and Drainage
ELEVATION:	m	DIMENSIONS:	HOLE STARTED: 8-Aug-16
METHOD:		EXCAV. DATUM:	HOLE FINISHED: 8-Aug-16

SCALA PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.25		Black, organic SILT with roots. Soft.	Moist	TOPSOIL
		1.7		Grey, sandy SILT and SILT with minor to trace of gravel. Sand is fine. Gravel is fine to medium. Poorly graded. Stiff. Massive.	Moist	ALLUVIAL SILT
		2.8		Grey, silty SAND and sandy SILT with a trace of gravel. Sand is fine. Gravel is fine. Uniformly graded. Medium dense. Massive.	Moist	ALLUVIAL SAND/SILT
		3.0		Light brown grey, gravelly SAND. Sand is fine to coarse. Gravel is fine to medium. Poorly graded. Medium dense. Massive.	Moist	ALLUVIAL SAND
		3.7		Light brown grey, clayey SILT interbedded with silty SAND horizons. Sand is fine. Highly micaceous. Low plasticity. Dilatant. Uniformly graded. Firm to stiff. Bedded.	Moist	ALLUVIAL SILT
		3.9		Light brown, SAND. Sand is fine. Uniformly graded. Medium dense. Bedded.	Moist	ALLUVIAL SAND
		4.2		Brown grey, gravelly SAND and SAND. Sand is fine to coarse. Gravel is fine to medium. Poorly graded. Medium dense. Bedded.	Moist	ALLUVIAL SAND
	NO SEEPAGE	4.6		Brown grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse. Well graded. Medium dense. Bedded.	Moist	ALLUVIAL GRAVEL

Total Depth = 4.6 m

COMMENT: Test pit walls stood well - no slumping.	Logged By: JAS
	Checked Date:
	Sheet: 1 of 1

GeoSolve Ltd
EXCAVATION LOG

EXCAVATION NUMBER:
TP 22a

PROJECT: Waterfall Park Subdivision, Lake Hayes			Job Number: 150098.01
LOCATION: See Site Plan	Inclination:	Vertical	Direction:

EASTING:	mE	EQUIPMENT: 8T excavator	OPERATOR: Tony
NORTHING:	mN	INFOMAP NO.	COMPANY: Earthworks and Drainage
ELEVATION:	m	DIMENSIONS:	HOLE STARTED: 8-Aug-16
METHOD:		EXCAV. DATUM:	HOLE FINISHED: 8-Aug-16

SCALA PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.35		Black, organic SILT with roots. Soft.	Moist	TOPSOIL
		0.65		Light brown, sandy SILT with some gravel. Sand is fine. Gravel is fine to medium. Non-plastic. Poorly graded. Firm to stiff. Massive.	Moist	ALLUVIAL SILT
		0.8		Grey, sandy SILT. Sand is fine. Non-plastic. Uniformly graded. Stiff. Massive.	Moist	ALLUVIAL SILT
		1.4		Dark grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to medium, subangular to subrounded. Well graded. Medium dense. Bedded.	Moist	ALLUVIAL GRAVEL
		3.1		Dark grey, silty SAND and sandy SILT. Sand is fine. Uniformly graded. Medium dense/firm. Massive.	Moist	ALLUVIAL SAND/SILT
		3.8		Light grey, SAND. Sand is fine to medium. Uniformly graded. Medium dense. Massive.	Moist	ALLUVIAL SAND
	NO SEEPAGE	4.6		Grey, SILT. Micaceous. Low plasticity. Dilatant. Uniformly graded. Firm. Massive.	Moist	ALLUVIAL SILT

Total Depth = 4.6 m

COMMENT: Test pit walls stood well - no slumping.	Logged By: JAS
	Checked Date:
	Sheet: 1 of 1

GeoSolve Ltd
EXCAVATION LOG

EXCAVATION NUMBER: **TP 23a**

PROJECT: Waterfall Park Subdivision, Lake Hayes			Job Number: 150098.01
LOCATION: See Site Plan	Inclination:	Vertical	Direction:

EASTING:	mE	EQUIPMENT: 8T excavator	OPERATOR: Tony
NORTHING:	mN	INFOMAP NO.	COMPANY: Earthworks and Drainage
ELEVATION:	m	DIMENSIONS:	HOLE STARTED: 8-Aug-16
METHOD:		EXCAV. DATUM:	HOLE FINISHED: 8-Aug-16

SCALA PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.25		Black, organic SILT with roots. Soft.	Moist	TOPSOIL
		1.3		Brown grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to medium, subangular to subrounded. Well graded. Medium dense. Bedded.	Moist	ALLUVIAL GRAVEL
		3.0		Grey, interbedded sandy SILT, SAND and silty SAND. Sand is fine. Silt is non-plastic. Medium dense/firm. Massive.	Moist	ALLUVIAL SAND/SILT
		3.9		Grey, SILT with sand horizons. Sand is fine. Micaceous. Low plasticity. Dilatant. Uniformly graded. Firm. Massive.	Moist	ALLUVIAL SILT
	NO SEEPAGE	4.5		Brown grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to medium, subrounded. Iron and manganese staining. Poorly graded. Medium dense. Bedded.	Moist	ALLUVIAL GRAVEL

Total Depth = 4.5 m

COMMENT: Test pit walls stood well - no slumping.	Logged By: JAS
	Checked Date:
	Sheet: 1 of 1

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EXCAVATION LOG

EXCAVATION NUMBER:

PIT 4D

PROJECT: WaterfallParkRetirement		Job Number: 150098.06
LOCATION: Waterfall Park	Inclination: Vertical	Direction:

EASTING: 168.816796	EQUIPMENT: 21T	OPERATOR: Aaron
NORTHING: -44.949362	INFOMAP NO.	COMPANY: Wilson Contractors
ELEVATION: 0.00	DIMENSIONS:	HOLE STARTED: 23-Sep-2019
METHOD:	EXCAV. DATUM: Ground level	HOLE FINISHED: 23-Sep-2019

SCALE PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.10		Dark brown, organic SILT. Soft.	Moist	TOPSOIL
		0.90		Light brownish grey, SILT with trace sand and trace gravel. Massive. Firm. Low plasticity.	Moist	LOESS
		1.20		Grey, gravelly SAND. Gravel is fine to medium and sub-angular to sub-rounded. Sand is fine to coarse. Bedded. Medium dense. Bedding is sub-horizontal.	Moist	ALLUVIAL SAND
		1.40		Grey, SILT with minor sand. Massive. Firm. Low plasticity.	Moist	ALLUVIAL SILT
	NO SEEPAGE	4.60		Grey, SAND with some gravel and minor silt. Massive. Medium dense.	Moist	ALLUVIAL SAND

Total Depth = 4.60 m

COMMENT:

Logged by: Josh

Checked Date:

Sheet: 1 of 1

GeoSolve

EXCAVATION LOG

EXCAVATION NUMBER:

PIT 5D

PROJECT: WaterfallParkRetirement		Job Number: 150098.06
LOCATION: Waterfall Park	Inclination: Vertical	Direction:

EASTING: 168.807245	EQUIPMENT: 21T	OPERATOR: Aaron
NORTHING: -44.958133	INFOMAP NO.	COMPANY: Wilson Contractors
ELEVATION: 0.00	DIMENSIONS:	HOLE STARTED: 23-Sep-2019
METHOD:	EXCAV. DATUM: Ground level	HOLE FINISHED: 23-Sep-2019

SCALE PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.20		Dark brown, organic SILT. Soft.	Moist	TOPSOIL
		0.70		Light brownish grey, SILT with trace sand and trace roots. Massive. Firm.	Moist	LOESS
		1.10		Grey, gravelly SAND. Gravel is fine. Sand is fine to coarse. Bedded. Medium dense. Bedding is sub-horizontal.	Moist	ALLUVIAL SAND
		2.70		Grey, sandy SILT. Massive. Firm. Low plasticity.	Moist	ALLUVIAL SILT
	NO SEEPAGE	4.30		Brownish grey, gravelly SAND. Gravel is fine to medium and sub-rounded to rounded. Sand is fine to coarse. Bedded. Medium dense. Bedding is sub-horizontal. Occasional 100 mm thick sand lense.		ALLUVIAL GRAVEL

Total Depth = 4.30 m

COMMENT:	Logged by: Josh
	Checked Date:
	Sheet: 1 of 1

GeoSolve

EXCAVATION LOG

EXC A V A TIO N NUMBER:

PIT 6D

PROJECT: WaterfallParkRetirement		Job Number: 150098.06
LOCATION: Waterfall Park	Inclination: Vertical	Direction:

EASTING: 0.000000	EQUIPMENT: 21T	OPERATOR: Aaron
NORTHING: 0.000000	INFOMAP NO.	COMPANY: Wilson Contractors
ELEVATION: 0.00	DIMENSIONS:	HOLE STARTED: 24-Sep-2019
METHOD:	EXCAV. DATUM: Ground level	HOLE FINISHED: 24-Sep-2019

SCALE PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.20		Dark brown, organic SILT.	Moist	TOPSOIL
		0.50		Brownish grey, silty SAND with minor gravel and trace roots. Sand is fine. Bedded. Loose. Bedding is gently inclined.	Moist	COLLUVIUM
		2.90		Grey, SAND with minor silt. Sand is fine to medium. Bedded. Medium dense. Bedding is gently inclined. Occasional gravel lenses.	Moist	ALLUVIAL SAND
	NO SEEPAGE	4.30		Grey, sandy SILT with trace gravel. Sand is fine. Bedded. Firm to stiff. Bedding is sub-horizontal.	Moist	ALLUVIAL SILT

Total Depth = 4.30 m

COMMENT:

Logged by: Josh

Checked Date:

GeoSolve

EXCAVATION LOG

EXCAVATION NUMBER:

PIT 7D

PROJECT: WaterfallParkRetirement		Job Number: 150098.06
LOCATION: Waterfall Park	Inclination: Vertical	Direction:

EASTING: 168.806783	EQUIPMENT: 21T	OPERATOR: Aaron
NORTHING: -44.959971	INFOMAP NO.	COMPANY: Wilson Contractors
ELEVATION: 0.00	DIMENSIONS:	HOLE STARTED: 23-Sep-2019
METHOD:	EXCAV. DATUM: Ground level	HOLE FINISHED: 23-Sep-2019

SCALE PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.20		Dark brown, organic SILT. Soft.	Moist	TOPSOIL
	NO SEEPAGE	3.10		Light grey, SAND with some silt and trace gravel. Sand is fine to medium. Massive. Medium dense.	Moist	ALLUVIAL SAND
		3.30		Slightly weathered, grey, foliated, SCHIST. Moderately strong.		SCHIST BEDROCK

Total Depth = 3.30 m

COMMENT:

Logged by: Josh

Checked Date:

Sheet: 1 of 1

GeoSolve

EXCAVATION LOG

EXCAVATION NUMBER:

PIT 8D

PROJECT: WaterfallParkRetirement		Job Number: 150098.06
LOCATION: Waterfall Park	Inclination: Vertical	Direction:

EASTING: 168.807356	EQUIPMENT: 21T	OPERATOR: Aaron
NORTHING: -44.956648	INFOMAP NO.	COMPANY: Wilson Contractors
ELEVATION: 0.00	DIMENSIONS:	HOLE STARTED: 23-Sep-2019
METHOD:	EXCAV. DATUM: Ground level	HOLE FINISHED: 23-Sep-2019

SCALE PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.20		Dark brown, organic SILT. Soft.	Moist	TOPSOIL
		0.50		Grey, sandy GRAVEL. Sand is fine to medium. Gravel is fine to medium and sub-angular to sub-rounded. Bedded. Medium dense. Bedding is sub-horizontal.	Moist	ALLUVIAL GRAVEL
	NO SEEPAGE	4.30		Grey, sandy SILT with trace gravel. Sand is fine. Bedded. Firm. Bedding is sub-horizontal. Non-plastic. Occasional gravel lense up to 100 mm thick.	Moist	ALLUVIAL SILT

Total Depth = 4.30 m

COMMENT:	Logged by: Josh
	Checked Date:
	Sheet: 1 of 1

GeoSolve

EXCAVATION LOG

EXCAVATION NUMBER:

PIT 9D

PROJECT: WaterfallParkRetirement		Job Number: 150098.06
LOCATION: Waterfall Park	Inclination: Vertical	Direction:

EASTING: 168.745787	EQUIPMENT: 21T	OPERATOR: Aaron
NORTHING: -45.008347	INFOMAP NO.	COMPANY: Wilson Contractors
ELEVATION: 0.00	DIMENSIONS:	HOLE STARTED: 22-Sep-2019
METHOD:	EXCAV. DATUM: Ground level	HOLE FINISHED: 22-Sep-2019

SCALE PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.30		Dark brown, organic SILT. Soft.	Moist	TOPSOIL
		2.70		Light brownish grey, sandy SILT with trace gravel. Sand is fine. Massive. Firm to stiff. Occasional 50 mm thick gravel lense.	Moist	ALLUVIAL SILT
		3.30		Light grey, SAND with minor silt. Sand is fine to medium. Bedded. Medium dense.	Moist	ALLUVIAL SAND
	NO SEEPAGE	4.20		Light grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse and sub-rounded to rounded. Bedded. Medium dense to dense. Bedding is sub-horizontal. Iron and manganese staining.	Moist	ALLUVIAL GRAVEL

Total Depth = 4.20 m

COMMENT:

Logged by: Josh

Checked Date:

Sheet: 1 of 1

GeoSolve

EXCAVATION LOG

EXCAVATION NUMBER: **PIT 10D**

PROJECT: WaterfallParkRetirement		Job Number: 150098.06
LOCATION: Waterfall Park	Inclination: Vertical	Direction:

EASTING: 168.816796	EQUIPMENT: 21T	OPERATOR: Aaron
NORTHING: -44.949362	INFOMAP NO.	COMPANY: Wilson Contractors
ELEVATION: 0.00	DIMENSIONS:	HOLE STARTED: 23-Sep-2019
METHOD:	EXCAV. DATUM: Ground level	HOLE FINISHED: 23-Sep-2019

SCALE PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.20		Dark brown, organic SILT. Soft.	Moist	TOPSOIL
		0.80		Light brown, SILT with minor gravel and trace roots. Massive. Firm. Non-plastic.	Moist	COLLUVIUM
		1.70		Light grey, SAND with trace gravel and trace cobbles. Sand is fine to medium. Bedded. Loose to medium dense. Bedding is gently inclined.	Moist	ALLUVIAL SAND
	NO SEEPAGE	4.00		Completely weathered, grey, foliated, SCHIST. Extremely weak to weak.		SCHIST BEDROCK

Total Depth = 4.00 m

COMMENT:

Logged by: Josh

Checked Date:

Sheet: 1 of 1

GeoSolve

EXCAVATION LOG

EXC A V A TIO N NUMBER:
PIT 11D

PROJECT: WaterfallParkRetirement		Job Number: 150098.06
LOCATION: Waterfall Park	Inclination: Vertical	Direction:

EASTING: 168.806783	EQUIPMENT: 21T	OPERATOR: Aaron
NORTHING: -44.959971	INFOMAP NO.	COMPANY: Wilson Contractors
ELEVATION: 0.00	DIMENSIONS:	HOLE STARTED: 22-Sep-2019
METHOD:	EXCAV. DATUM: Ground level	HOLE FINISHED: 22-Sep-2019

						GEOLOGICAL
SCALE PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.30		Dark brown, organic SILT. Soft.	Moist	TOPSOIL
		0.50		Light brownish grey, gravelly SILT with minor sand. Gravel is fine to medium and sub-angular . Massive. Firm.	Moist	OVERBANK DEPOSIT
		2.10		Light grey, SILT with minor sand. Massive. Firm to stiff. Low plasticity.	Moist	ALLUVIAL SILT
	NO SEEPAGE	4.00		Light grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse and sub-rounded to rounded. Bedded. Medium dense. Well graded. Bedding is sub-horizontal. Iron and manganese staining.	Moist	ALLUVIAL GRAVEL

Total Depth = 4.00 m

COMMENT:

Logged by: Josh
Checked Date:
Sheet: 1 of 1

GeoSolve

EXCAVATION LOG

EXCAVATION NUMBER:

PIT 12D

PROJECT: WaterfallParkRetirement		Job Number: 150098.06
LOCATION: Waterfall Park	Inclination: Vertical	Direction:

EASTING: 168.808660	EQUIPMENT: 21T	OPERATOR: Aaron
NORTHING: -44.959637	INFOMAP NO.	COMPANY: Wilson Contractors
ELEVATION: 0.00	DIMENSIONS:	HOLE STARTED: 22-Sep-2019
METHOD:	EXCAV. DATUM: Ground level	HOLE FINISHED: 22-Sep-2019

						GEOLOGICAL
SCALE PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.20		Dark brown, organic SILT. Soft.	Moist	TOPSOIL
		0.60		Light greyish brown, SILT with minor gravel. Massive. Firm.	Moist	LOESS
		1.50		Light brownish grey, sandy SILT with trace roots. Sand is fine. Massive. Firm.	Moist	ALLUVIAL SILT
		3.20		Light grey, SAND. Sand is fine to medium. Bedded.	Dry	ALLUVIAL SAND
	NO SEEPAGE	4.10		Light grey, sandy GRAVEL. Gravel is fine to coarse and sub-rounded to rounded. Bedded. Well graded. Bedding is sub-horizontal. Iron and manganese staining.	Moist	ALLUVIAL GRAVEL

Total Depth = 4.10 m

COMMENT:

Logged by: Josh

Checked Date:

Sheet: 1 of 1

GeoSolve

EXCAVATION LOG

EXCAVATION NUMBER:

PIT 13D

PROJECT: WaterfallParkRetirement		Job Number: 150098.06
LOCATION: Waterfall Park	Inclination: Vertical	Direction:

EASTING: 168.810212	EQUIPMENT: 21T	OPERATOR: Aaron
NORTHING: -44.958330	INFOMAP NO.	COMPANY: Wilson Contractors
ELEVATION: 0.00	DIMENSIONS:	HOLE STARTED: 23-Sep-2019
METHOD:	EXCAV. DATUM: Ground level	HOLE FINISHED: 23-Sep-2019

SCALE PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.20		Dark brown, organic SILT. Soft.	Moist	TOPSOIL
		0.90		Light greyish brown, SILT with trace roots. Massive. Firm to stiff. Non-plastic.	Moist	LOESS
		2.00		Light grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse and sub-rounded to rounded. Bedded. Medium dense. Iron and manganese staining.	Moist	ALLUVIAL GRAVEL
	NO SEEPAGE	4.00		Light grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to medium and sub-angular to sub-rounded. Bedded. Loose to medium dense.	Moist	ALLUVIAL GRAVEL

Total Depth = 4.00 m

COMMENT:	Logged by: Josh
	Checked Date:
	Sheet: 1 of 1

GeoSolve

EXCAVATION LOG

EXCAVATION NUMBER: **PIT 14D**

PROJECT: WaterfallParkRetirement		Job Number: 150098.06
LOCATION: Waterfall Park	Inclination: Vertical	Direction:

EASTING: 168.810490	EQUIPMENT: 21T	OPERATOR: Aaron
NORTHING: -44.958534	INFOMAP NO.	COMPANY: Wilson Contractors
ELEVATION: 0.00	DIMENSIONS:	HOLE STARTED: 22-Sep-2019
METHOD:	EXCAV. DATUM: Ground level	HOLE FINISHED: 22-Sep-2019

SCALE PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.20		Dark brown, organic SILT. Soft.	Moist	TOPSOIL
		0.50		Light brownish grey, SILT with minor gravel and minor sand. Massive. Firm.	Moist	OVERBANK DEPOSIT
		1.50		Grey, sandy SILT. Sand is fine. Massive. Firm.	Moist	ALLUVIAL SILT
		1.90		Light brownish grey, gravelly SAND. Gravel is fine and sub-angular . Sand is fine to coarse. Bedded. Medium dense. Iron staining.	Moist	ALLUVIAL SAND
		3.70		Dark grey, SILT with trace sand. Massive. Non-plastic.	Moist	ALLUVIAL SILT
	NO SEEPAGE	4.30		Light grey, SAND. Sand is fine to medium. Bedded. Medium dense.	Moist	ALLUVIAL SAND

Total Depth = 4.30 m

COMMENT:

Logged by: Josh

Checked Date:

Sheet: 1 of 1

GeoSolve

EXCAVATION LOG

EXCAVATION NUMBER:

PIT 15D

PROJECT: WaterfallParkRetirement		Job Number: 150098.06
LOCATION: Waterfall Park	Inclination: Vertical	Direction:

EASTING: 168.816796	EQUIPMENT: 21T	OPERATOR: Aaron
NORTHING: -44.949362	INFOMAP NO.	COMPANY: Wilson Contractors
ELEVATION: 0.00	DIMENSIONS:	HOLE STARTED: 22-Sep-2019
METHOD:	EXCAV. DATUM: Ground level	HOLE FINISHED: 22-Sep-2019

SCALE PENETRATION	GROUNDWATER / SEEPAGE	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	WATER CONTENT	GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
		0.20		Dark brown, organic SILT. Soft.	Moist	TOPSOIL
		0.40		Grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to medium and sub-angular to sub-rounded. Bedded. Loose.	Moist	ALLUVIAL GRAVEL
		3.90		Light grey, SAND with minor silt and trace roots. Sand is fine to medium. Bedded. Medium dense. Bedding is sub-horizontal.	Moist	ALLUVIAL SAND
	NO SEEPAGE	4.10		Light brownish grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse and sub-rounded to rounded. Bedded. Medium dense. Iron staining.	Moist	ALLUVIAL GRAVEL
		4.30		Dark grey, SILT. Massive. Firm. Low plasticity.	Moist	ALLUVIAL SILT

Total Depth = 4.30 m

COMMENT:

Logged by: Josh

Checked Date:

Sheet: 1 of 1

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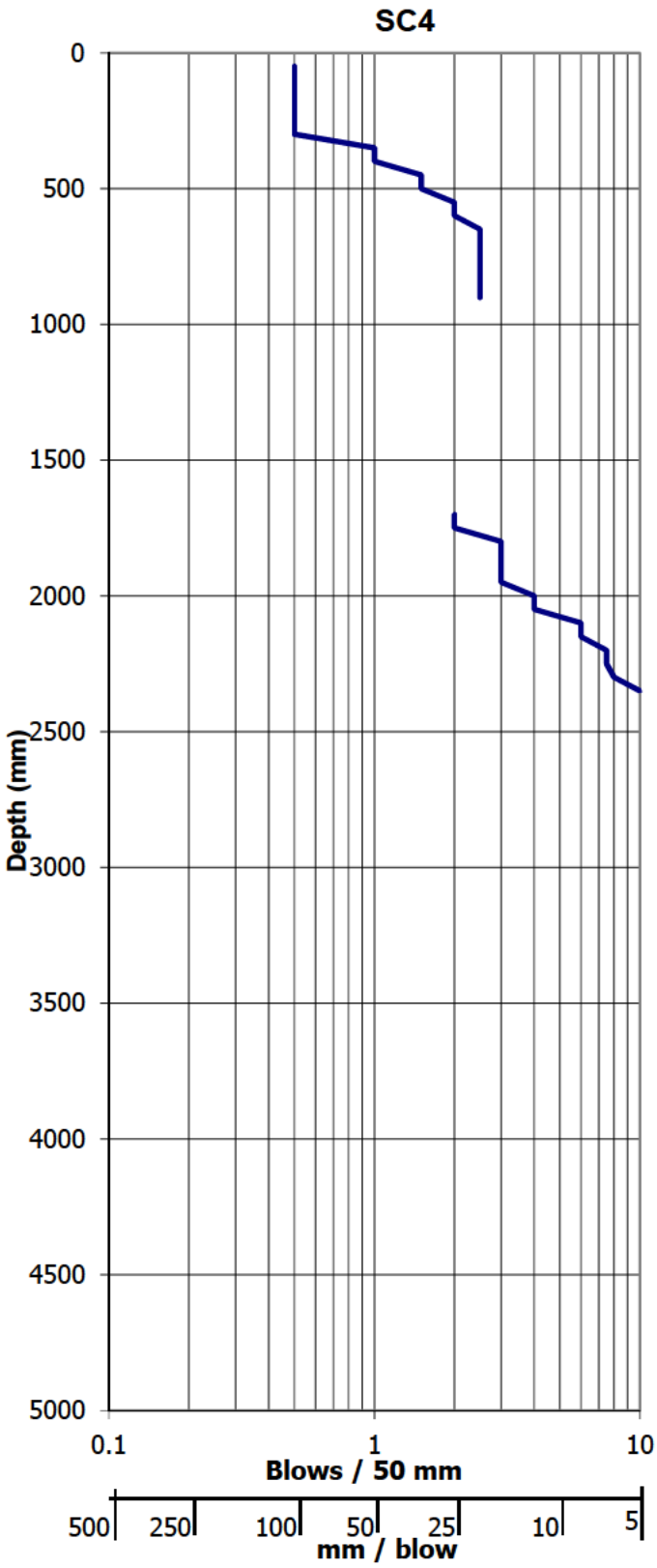
SCALA PENETROMETER LOG

Job No: *150098.06*	Date: *23/09/2019*	**Test No.**	***SC4***
Project: *Ayrburn Retirement*	Operated by: *JM*		
Location: *TP4D*	Logged by: *JM*	**Sheet**	***4***
RL:	Inferred Soil Type:	**of**	***15***

SC4	
mm Driven	No. of Blows
50	0.5
100	0.5
150	0.5
200	0.5
250	0.5
300	0.5
350	1
400	1
450	1.5
500	1.5
550	2
600	2
650	2.5
700	2.5
750	2.5
800	2.5
850	2.5
900	2.5
950	
1000	
1050	
1100	
1150	
1200	
1250	
1300	
1350	
1400	
1450	
1500	
1550	
1600	
1650	
1700	2
1750	2
1800	3
1850	3
1900	3
1950	3
2000	4
2050	4
2100	6
2150	6
2200	7.5
2250	7.5
2300	8
2350	10
2400	
2450	
2500	

SC4 cont...	
mm Driven	No. of Blows
2550	
2600	
2650	
2700	
2750	
2800	
2850	
2900	
2950	
3000	
3050	
3100	
3150	
3200	
3250	
3300	
3350	
3400	
3450	
3500	
3550	
3600	
3650	
3700	
3750	
3800	
3850	
3900	
3950	
4000	
4050	
4100	
4150	
4200	
4250	
4300	
4350	
4400	
4450	
4500	
4550	
4600	
4650	
4700	
4750	
4800	
4850	
4900	
4950	
5000	



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

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SCALA PENETROMETER LOG

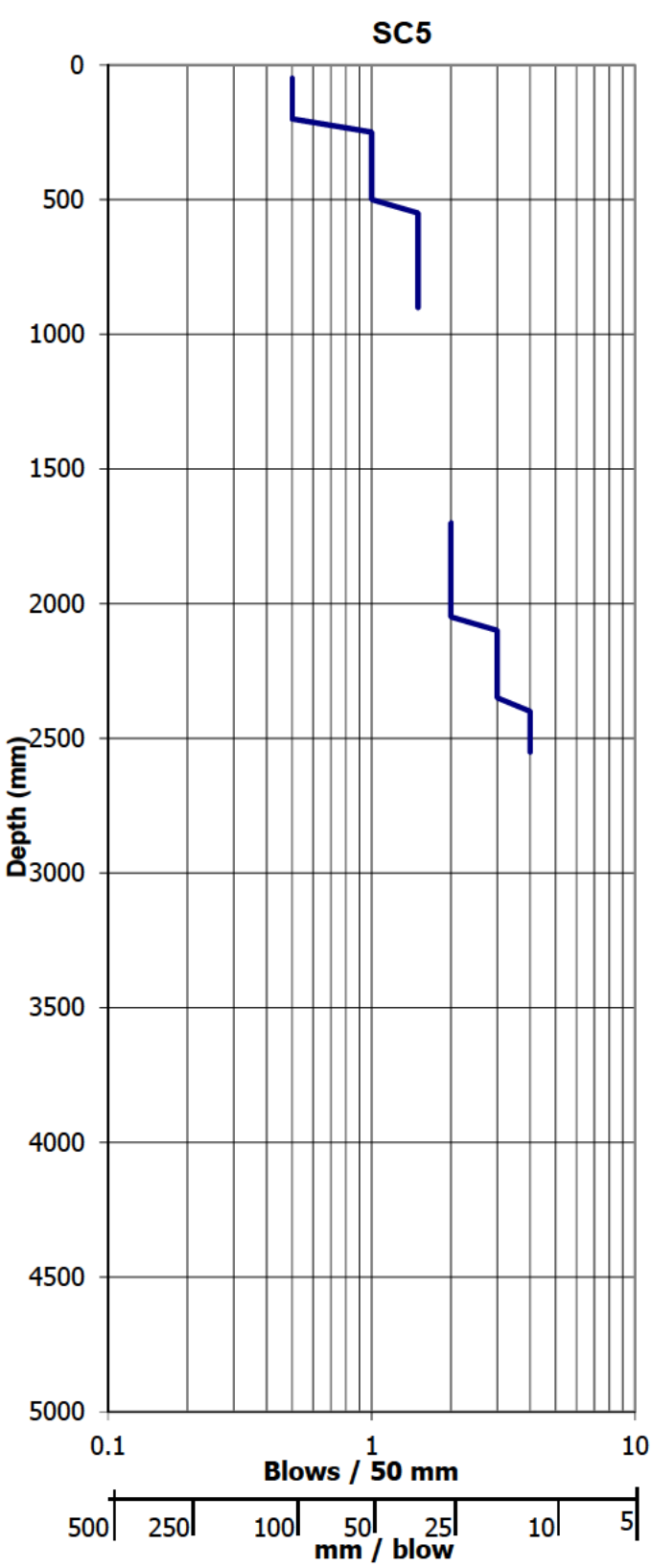
Job No: *150098.06*
Project: *Ayrburn Retirement*
Location: *TP5D*
RL:

Date: *23/09/2019*
Operated by: *JM*
Logged by: *JM*
Inferred Soil Type:

Test No. *SC5*
Sheet *5*
of *15*

SC5	
mm Driven	No. of Blows
50	0.5
100	0.5
150	0.5
200	0.5
250	1
300	1
350	1
400	1
450	1
500	1
550	1.5
600	1.5
650	1.5
700	1.5
750	1.5
800	1.5
850	1.5
900	1.5
950	
1000	
1050	
1100	
1150	
1200	
1250	
1300	
1350	
1400	
1450	
1500	
1550	
1600	
1650	
1700	2
1750	2
1800	2
1850	2
1900	2
1950	2
2000	2
2050	2
2100	3
2150	3
2200	3
2250	3
2300	3
2350	3
2400	4
2450	4
2500	4

SC5 cont...	
mm Driven	No. of Blows
2550	4
2600	
2650	
2700	
2750	
2800	
2850	
2900	
2950	
3000	
3050	
3100	
3150	
3200	
3250	
3300	
3350	
3400	
3450	
3500	
3550	
3600	
3650	
3700	
3750	
3800	
3850	
3900	
3950	
4000	
4050	
4100	
4150	
4200	
4250	
4300	
4350	
4400	
4450	
4500	
4550	
4600	
4650	
4700	
4750	
4800	
4850	
4900	
4950	
5000	



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

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SCALA PENETROMETER LOG

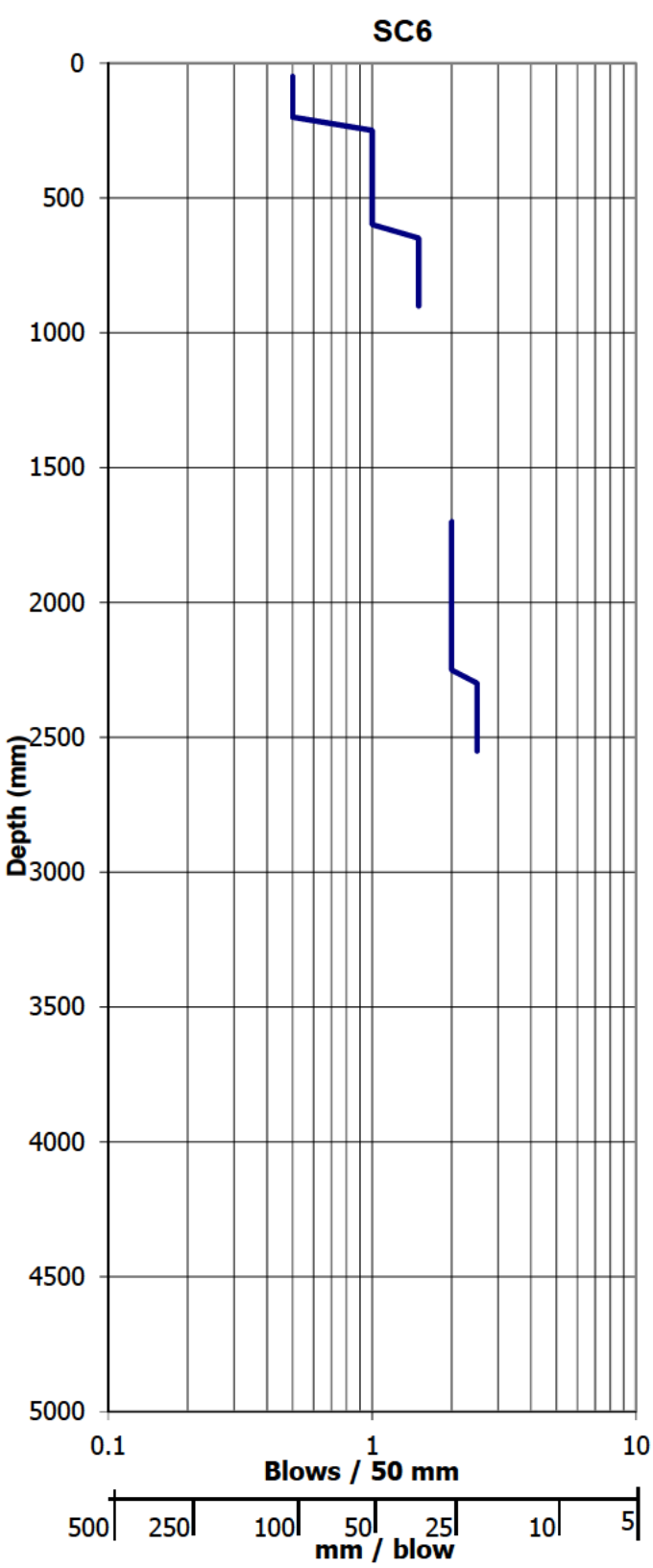
Job No: *150098.06*
Project: *Ayrburn Retirement*
Location: *TP6D*
RL:

Date: *23/09/2019*
Operated by: *JM*
Logged by: *JM*
Inferred Soil Type:

Test No. *SC6*
Sheet *6*
of *15*

SC6	
mm Driven	No. of Blows
50	0.5
100	0.5
150	0.5
200	0.5
250	1
300	1
350	1
400	1
450	1
500	1
550	1
600	1
650	1.5
700	1.5
750	1.5
800	1.5
850	1.5
900	1.5
950	
1000	
1050	
1100	
1150	
1200	
1250	
1300	
1350	
1400	
1450	
1500	
1550	
1600	
1650	
1700	2
1750	2
1800	2
1850	2
1900	2
1950	2
2000	2
2050	2
2100	2
2150	2
2200	2
2250	2
2300	2.5
2350	2.5
2400	2.5
2450	2.5
2500	2.5

SC6 cont...	
mm Driven	No. of Blows
2550	2.5
2600	
2650	
2700	
2750	
2800	
2850	
2900	
2950	
3000	
3050	
3100	
3150	
3200	
3250	
3300	
3350	
3400	
3450	
3500	
3550	
3600	
3650	
3700	
3750	
3800	
3850	
3900	
3950	
4000	
4050	
4100	
4150	
4200	
4250	
4300	
4350	
4400	
4450	
4500	
4550	
4600	
4650	
4700	
4750	
4800	
4850	
4900	
4950	
5000	



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

GEOSOLVE

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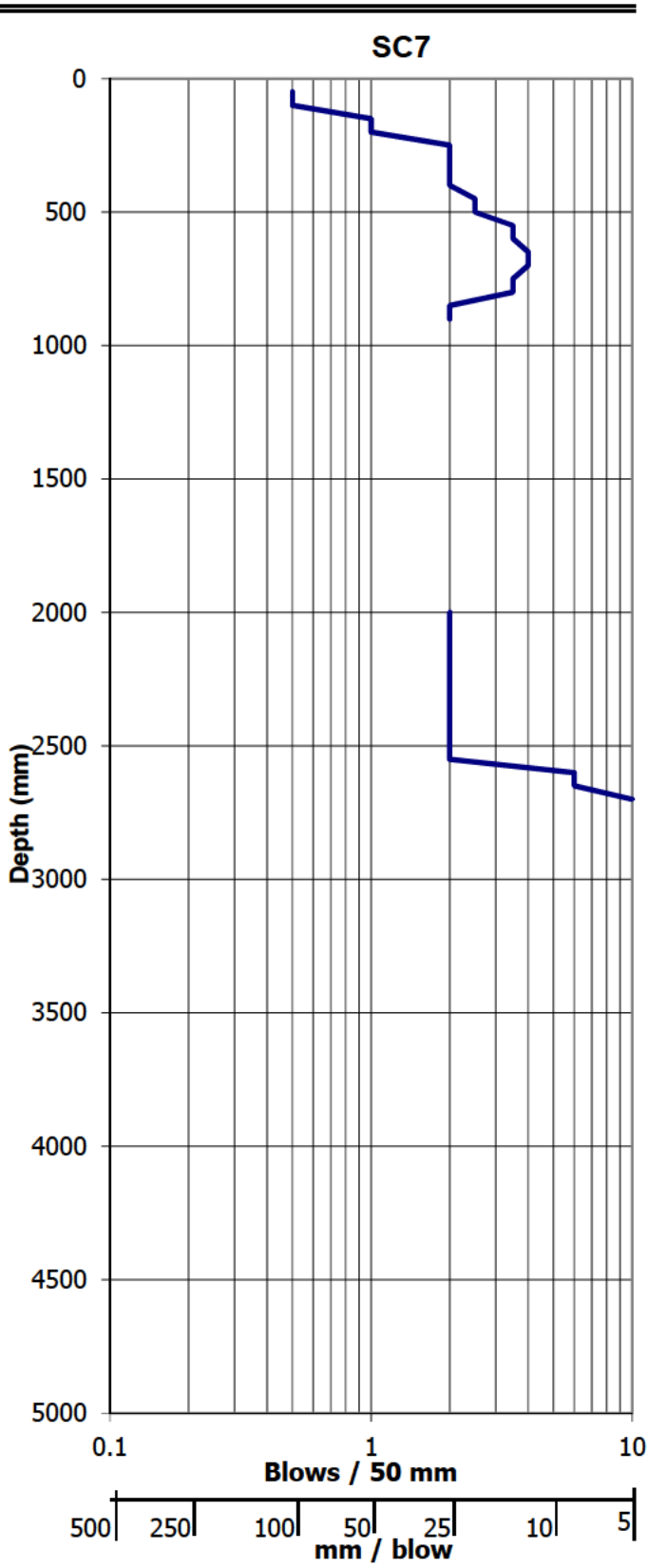
SCALA PENETROMETER LOG

Job No: *150098.06*	Date: *23/09/2019*	**Test No.**	***SC7***
Project: *Ayrburn Retirement*	Operated by: *JM*		
Location: *TP7D*	Logged by: *JM*	**Sheet**	***7***
RL:	Inferred Soil Type:	**of**	***15***

SC7	
mm Driven	No. of Blows
50	0.5
100	0.5
150	1
200	1
250	2
300	2
350	2
400	2
450	2.5
500	2.5
550	3.5
600	3.5
650	4
700	4
750	3.5
800	3.5
850	2
900	2
950	
1000	
1050	
1100	
1150	
1200	
1250	
1300	
1350	
1400	
1450	
1500	
1550	
1600	
1650	
1700	
1750	
1800	
1850	
1900	
1950	
2000	2
2050	2
2100	2
2150	2
2200	2
2250	2
2300	2
2350	2
2400	2
2450	2
2500	2

SC7 cont...	
mm Driven	No. of Blows
2550	2
2600	6
2650	6
2700	10
2750	
2800	
2850	
2900	
2950	
3000	
3050	
3100	
3150	
3200	
3250	
3300	
3350	
3400	
3450	
3500	
3550	
3600	
3650	
3700	
3750	
3800	
3850	
3900	
3950	
4000	
4050	
4100	
4150	
4200	
4250	
4300	
4350	
4400	
4450	
4500	
4550	
4600	
4650	
4700	
4750	
4800	
4850	
4900	
4950	
5000	



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

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SCALA PENETROMETER LOG

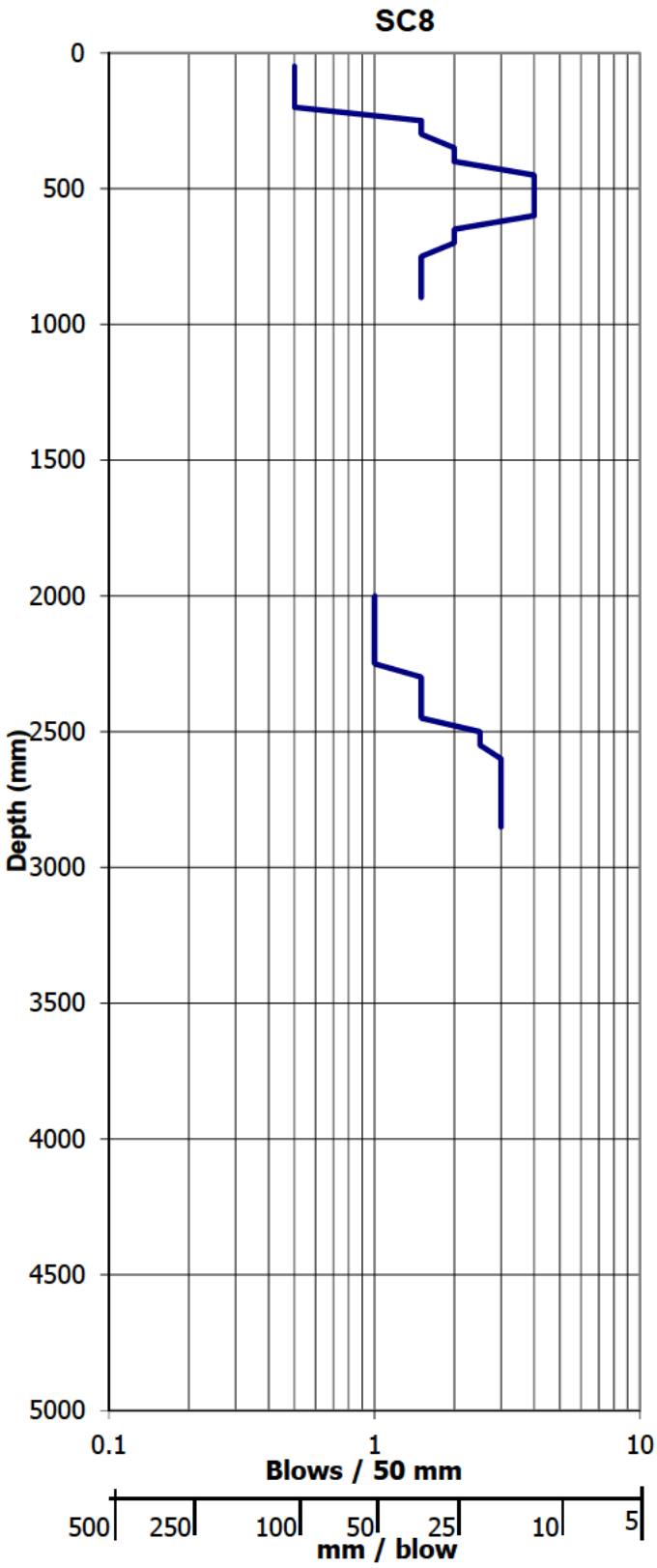
Job No: *150098.06*
Project: *Ayrburn Retirement*
Location: *TP8D*
RL:

Date: *23/09/2019*
Operated by: *JM*
Logged by: *JM*
Inferred Soil Type:

Test No. *SC8*
Sheet *8*
of *15*

SC8	
mm Driven	No. of Blows
50	0.5
100	0.5
150	0.5
200	0.5
250	1.5
300	1.5
350	2
400	2
450	4
500	4
550	4
600	4
650	2
700	2
750	1.5
800	1.5
850	1.5
900	1.5
950	
1000	
1050	
1100	
1150	
1200	
1250	
1300	
1350	
1400	
1450	
1500	
1550	
1600	
1650	
1700	
1750	
1800	
1850	
1900	
1950	
2000	1
2050	1
2100	1
2150	1
2200	1
2250	1
2300	1.5
2350	1.5
2400	1.5
2450	1.5
2500	2.5

SC8 cont...	
mm Driven	No. of Blows
2550	2.5
2600	3
2650	3
2700	3
2750	3
2800	3
2850	3
2900	
2950	
3000	
3050	
3100	
3150	
3200	
3250	
3300	
3350	
3400	
3450	
3500	
3550	
3600	
3650	
3700	
3750	
3800	
3850	
3900	
3950	
4000	
4050	
4100	
4150	
4200	
4250	
4300	
4350	
4400	
4450	
4500	
4550	
4600	
4650	
4700	
4750	
4800	
4850	
4900	
4950	
5000	



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

GEOSOLVE

GEOSOLVE LTD

SCALA PENETROMETER LOG

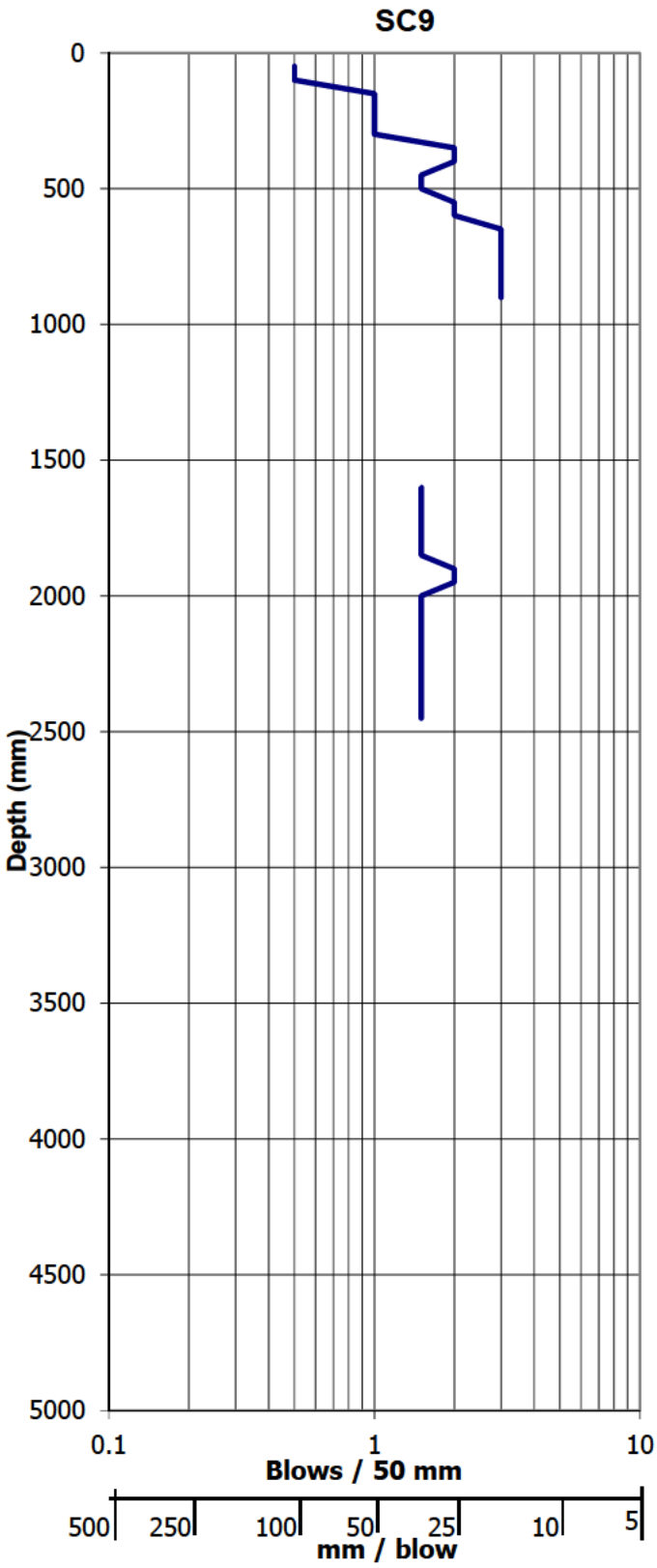
Job No: *150098.06*
Project: *Ayrburn Retirement*
Location: *TP9D*
RL:

Date: *23/09/2019*
Operated by: *JM*
Logged by: *JM*
Inferred Soil Type:

Test No. *SC9*
Sheet *9*
of *15*

SC9	
mm Driven	No. of Blows
50	0.5
100	0.5
150	1
200	1
250	1
300	1
350	2
400	2
450	1.5
500	1.5
550	2
600	2
650	3
700	3
750	3
800	3
850	3
900	3
950	
1000	
1050	
1100	
1150	
1200	
1250	
1300	
1350	
1400	
1450	
1500	
1550	
1600	1.5
1650	1.5
1700	1.5
1750	1.5
1800	1.5
1850	1.5
1900	2
1950	2
2000	1.5
2050	1.5
2100	1.5
2150	1.5
2200	1.5
2250	1.5
2300	1.5
2350	1.5
2400	1.5
2450	1.5
2500	

SC9 cont...	
mm Driven	No. of Blows
2550	
2600	
2650	
2700	
2750	
2800	
2850	
2900	
2950	
3000	
3050	
3100	
3150	
3200	
3250	
3300	
3350	
3400	
3450	
3500	
3550	
3600	
3650	
3700	
3750	
3800	
3850	
3900	
3950	
4000	
4050	
4100	
4150	
4200	
4250	
4300	
4350	
4400	
4450	
4500	
4550	
4600	
4650	
4700	
4750	
4800	
4850	
4900	
4950	
5000	



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

GEOSOLVE

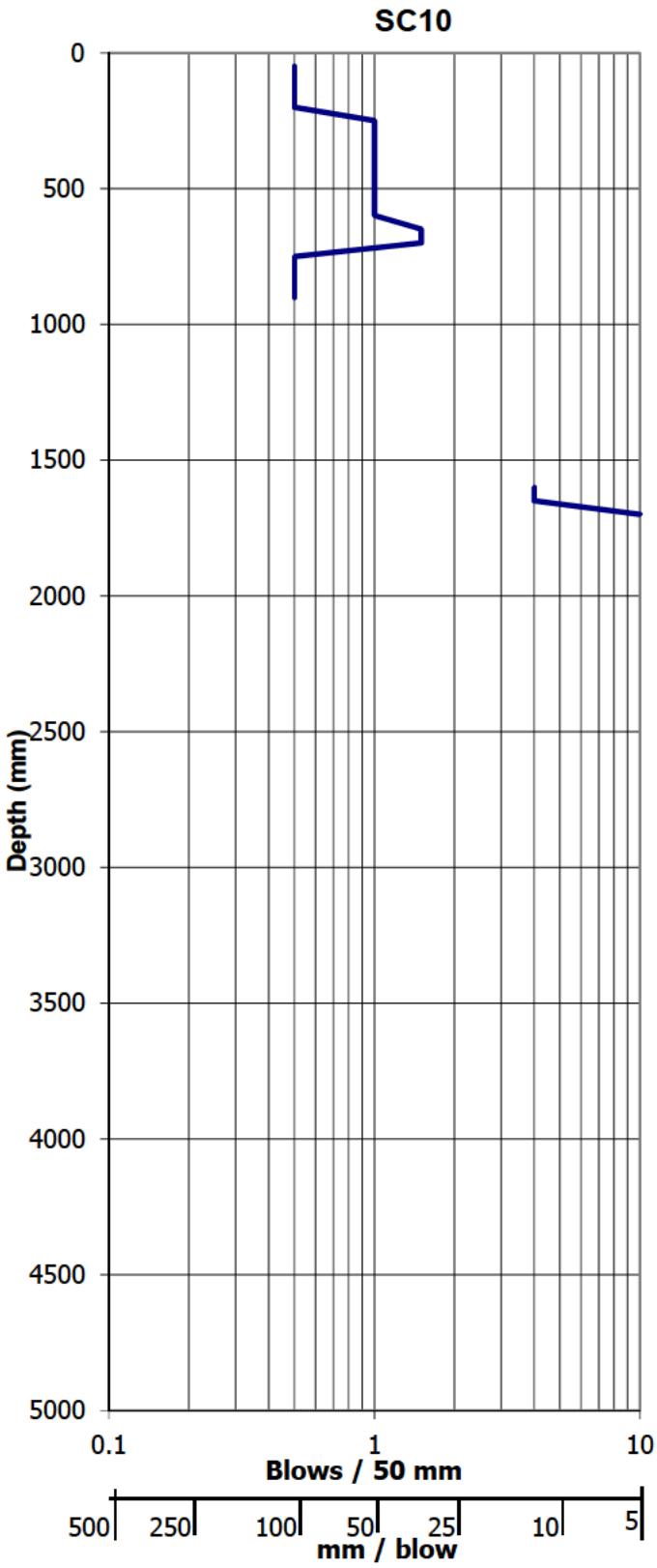
GEOSOLVE LTD

SCALA PENETROMETER LOG

Job No: *150098.06*	Date: *23/09/2019*	**Test No.**	***SC10***
Project: *Ayrburn Retirement*	Operated by: *JM*		
Location: *TP10D*	Logged by: *JM*	**Sheet**	***10***
RL:	Inferred Soil Type:	**of**	***15***

SC10	
mm Driven	No. of Blows
50	*0.5*
100	*0.5*
150	*0.5*
200	*0.5*
250	*1*
300	*1*
350	*1*
400	*1*
450	*1*
500	*1*
550	*1*
600	*1*
650	*1.5*
700	*1.5*
750	*0.5*
800	*0.5*
850	*0.5*
900	*0.5*
950	
1000	
1050	
1100	
1150	
1200	
1250	
1300	
1350	
1400	
1450	
1500	
1550	
1600	*4*
1650	*4*
1700	*10*
1750	
1800	
1850	
1900	
1950	
2000	
2050	
2100	
2150	
2200	
2250	
2300	
2350	
2400	
2450	
2500	

SC10 cont...	
mm Driven	No. of Blows
2550	
2600	
2650	
2700	
2750	
2800	
2850	
2900	
2950	
3000	
3050	
3100	
3150	
3200	
3250	
3300	
3350	
3400	
3450	
3500	
3550	
3600	
3650	
3700	
3750	
3800	
3850	
3900	
3950	
4000	
4050	
4100	
4150	
4200	
4250	
4300	
4350	
4400	
4450	
4500	
4550	
4600	
4650	
4700	
4750	
4800	
4850	
4900	
4950	
5000	



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

GEOSOLVE

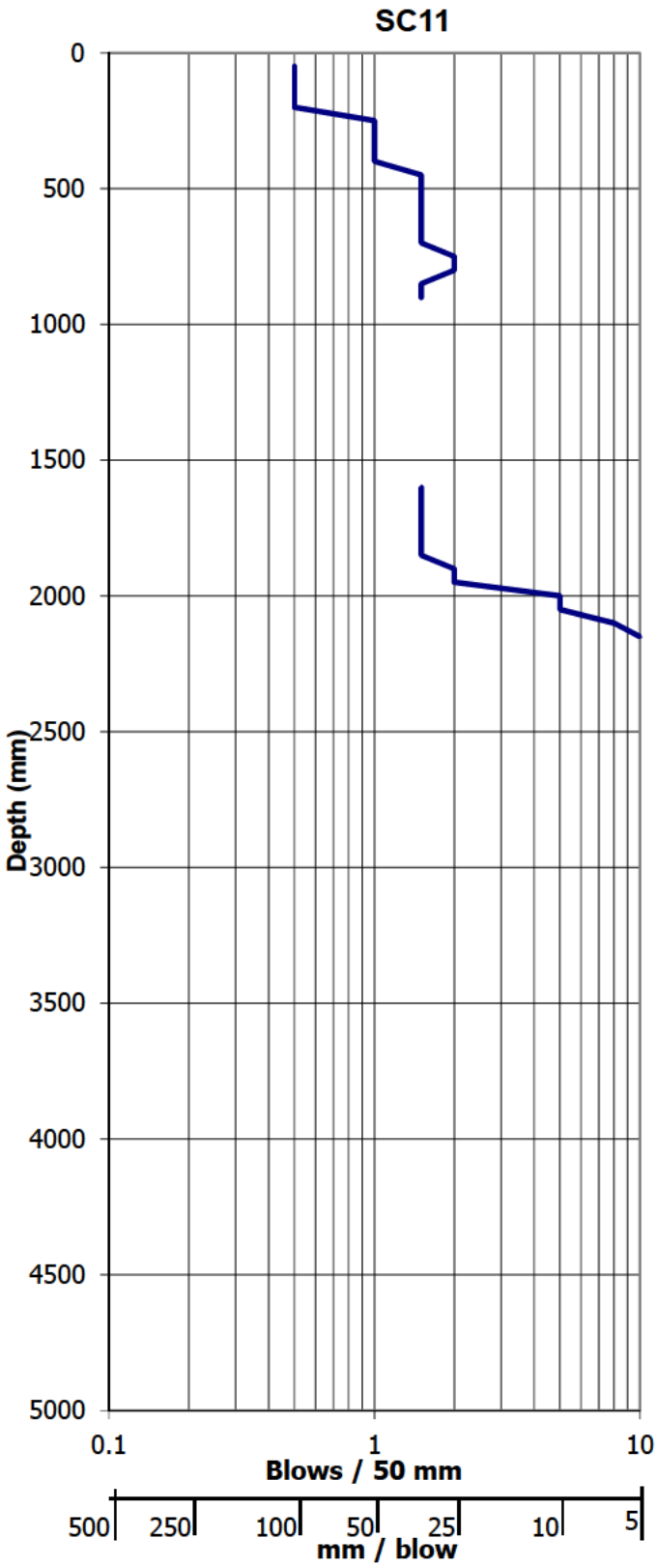
GEOSOLVE LTD

SCALA PENETROMETER LOG

Job No: *150098.06*	Date: *23/09/2019*	**Test No.**	***SC11***
Project: *Ayrburn Retirement*	Operated by: *JM*		
Location: *TP11D*	Logged by: *JM*	**Sheet**	***11***
RL:	Inferred Soil Type:	**of**	***15***

SC11	
mm Driven	No. of Blows
50	0.5
100	0.5
150	0.5
200	0.5
250	1
300	1
350	1
400	1
450	1.5
500	1.5
550	1.5
600	1.5
650	1.5
700	1.5
750	2
800	2
850	1.5
900	1.5
950	
1000	
1050	
1100	
1150	
1200	
1250	
1300	
1350	
1400	
1450	
1500	
1550	
1600	1.5
1650	1.5
1700	1.5
1750	1.5
1800	1.5
1850	1.5
1900	2
1950	2
2000	5
2050	5
2100	8
2150	10
2200	
2250	
2300	
2350	
2400	
2450	
2500	

SC11 cont...	
mm Driven	No. of Blows
2550	
2600	
2650	
2700	
2750	
2800	
2850	
2900	
2950	
3000	
3050	
3100	
3150	
3200	
3250	
3300	
3350	
3400	
3450	
3500	
3550	
3600	
3650	
3700	
3750	
3800	
3850	
3900	
3950	
4000	
4050	
4100	
4150	
4200	
4250	
4300	
4350	
4400	
4450	
4500	
4550	
4600	
4650	
4700	
4750	
4800	
4850	
4900	
4950	
5000	



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

GEOSOLVE

GEOSOLVE LTD

SCALA PENETROMETER LOG

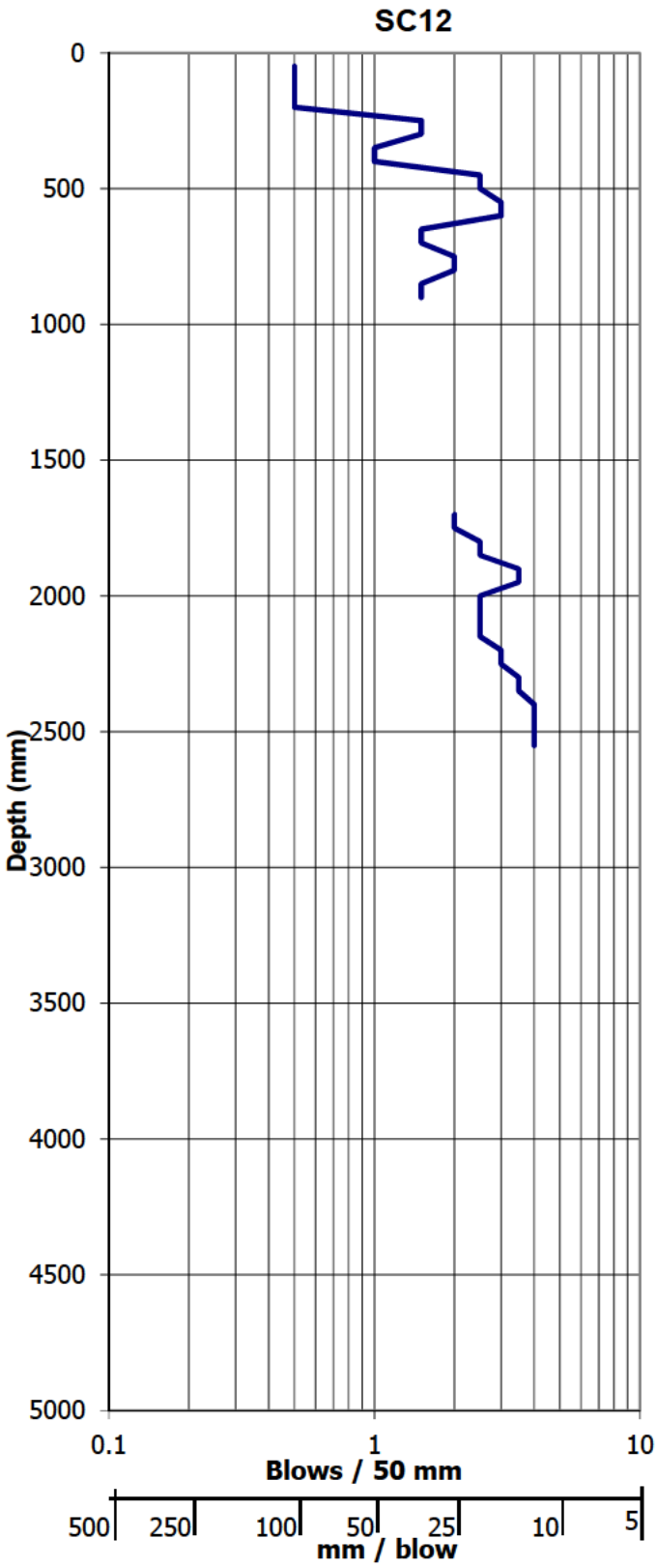
Job No: *150098.06*
Project: *Ayrburn Retirement*
Location: *TP12D*
RL:

Date: *23/09/2019*
Operated by: *JM*
Logged by: *JM*
Inferred Soil Type:

Test No. *SC12*
Sheet *12*
of *15*

SC12	
mm Driven	No. of Blows
50	0.5
100	0.5
150	0.5
200	0.5
250	1.5
300	1.5
350	1
400	1
450	2.5
500	2.5
550	3
600	3
650	1.5
700	1.5
750	2
800	2
850	1.5
900	1.5
950	
1000	
1050	
1100	
1150	
1200	
1250	
1300	
1350	
1400	
1450	
1500	
1550	
1600	
1650	
1700	2
1750	2
1800	2.5
1850	2.5
1900	3.5
1950	3.5
2000	2.5
2050	2.5
2100	2.5
2150	2.5
2200	3
2250	3
2300	3.5
2350	3.5
2400	4
2450	4
2500	4

SC12 cont...	
mm Driven	No. of Blows
2550	4
2600	
2650	
2700	
2750	
2800	
2850	
2900	
2950	
3000	
3050	
3100	
3150	
3200	
3250	
3300	
3350	
3400	
3450	
3500	
3550	
3600	
3650	
3700	
3750	
3800	
3850	
3900	
3950	
4000	
4050	
4100	
4150	
4200	
4250	
4300	
4350	
4400	
4450	
4500	
4550	
4600	
4650	
4700	
4750	
4800	
4850	
4900	
4950	
5000	



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

GEOSOLVE

GEOSOLVE LTD

SCALA PENETROMETER LOG

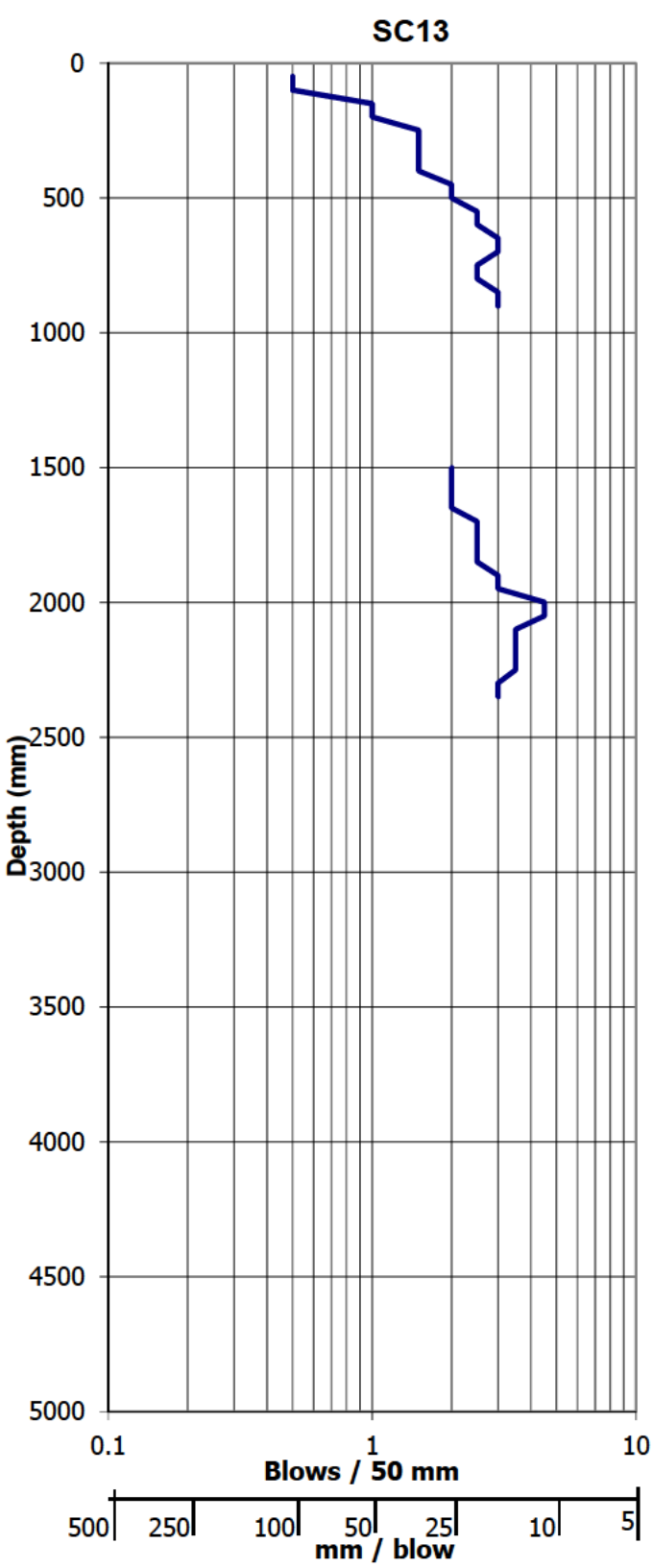
Job No: *150098.06*
Project: *Ayrburn Retirement*
Location: *TP13D*
RL:

Date: *23/09/2019*
Operated by: *JM*
Logged by: *JM*
Inferred Soil Type:

Test No. *SC13*
Sheet *13*
of *15*

SC13	
mm Driven	No. of Blows
50	0.5
100	0.5
150	1
200	1
250	1.5
300	1.5
350	1.5
400	1.5
450	2
500	2
550	2.5
600	2.5
650	3
700	3
750	2.5
800	2.5
850	3
900	3
950	
1000	
1050	
1100	
1150	
1200	
1250	
1300	
1350	
1400	
1450	
1500	2
1550	2
1600	2
1650	2
1700	2.5
1750	2.5
1800	2.5
1850	2.5
1900	3
1950	3
2000	4.5
2050	4.5
2100	3.5
2150	3.5
2200	3.5
2250	3.5
2300	3
2350	3
2400	
2450	
2500	

SC13 cont...	
mm Driven	No. of Blows
2550	
2600	
2650	
2700	
2750	
2800	
2850	
2900	
2950	
3000	
3050	
3100	
3150	
3200	
3250	
3300	
3350	
3400	
3450	
3500	
3550	
3600	
3650	
3700	
3750	
3800	
3850	
3900	
3950	
4000	
4050	
4100	
4150	
4200	
4250	
4300	
4350	
4400	
4450	
4500	
4550	
4600	
4650	
4700	
4750	
4800	
4850	
4900	
4950	
5000	



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

GEOSOLVE

GEOSOLVE LTD

SCALA PENETROMETER LOG

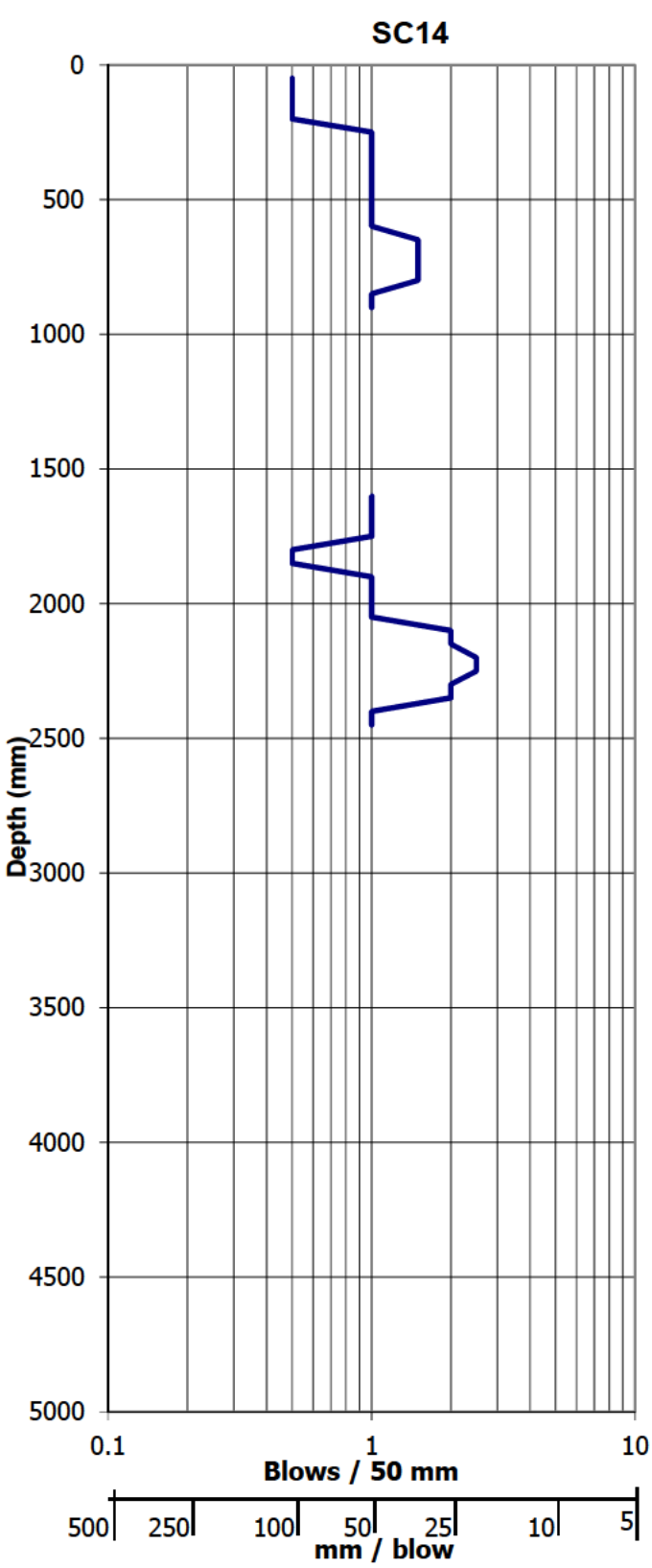
Job No: *150098.06*
Project: *Ayrburn Retirement*
Location: *TP14D*
RL:

Date: *23/09/2019*
Operated by: *JM*
Logged by: *JM*
Inferred Soil Type:

Test No. *SC14*
Sheet *14*
of *15*

SC14	
mm Driven	No. of Blows
50	0.5
100	0.5
150	0.5
200	0.5
250	1
300	1
350	1
400	1
450	1
500	1
550	1
600	1
650	1.5
700	1.5
750	1.5
800	1.5
850	1
900	1
950	
1000	
1050	
1100	
1150	
1200	
1250	
1300	
1350	
1400	
1450	
1500	
1550	
1600	1
1650	1
1700	1
1750	1
1800	0.5
1850	0.5
1900	1
1950	1
2000	1
2050	1
2100	2
2150	2
2200	2.5
2250	2.5
2300	2
2350	2
2400	1
2450	1
2500	

SC14 cont...	
mm Driven	No. of Blows
2550	
2600	
2650	
2700	
2750	
2800	
2850	
2900	
2950	
3000	
3050	
3100	
3150	
3200	
3250	
3300	
3350	
3400	
3450	
3500	
3550	
3600	
3650	
3700	
3750	
3800	
3850	
3900	
3950	
4000	
4050	
4100	
4150	
4200	
4250	
4300	
4350	
4400	
4450	
4500	
4550	
4600	
4650	
4700	
4750	
4800	
4850	
4900	
4950	
5000	



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

GEOSOLVE

GEOSOLVE LTD

SCALA PENETROMETER LOG

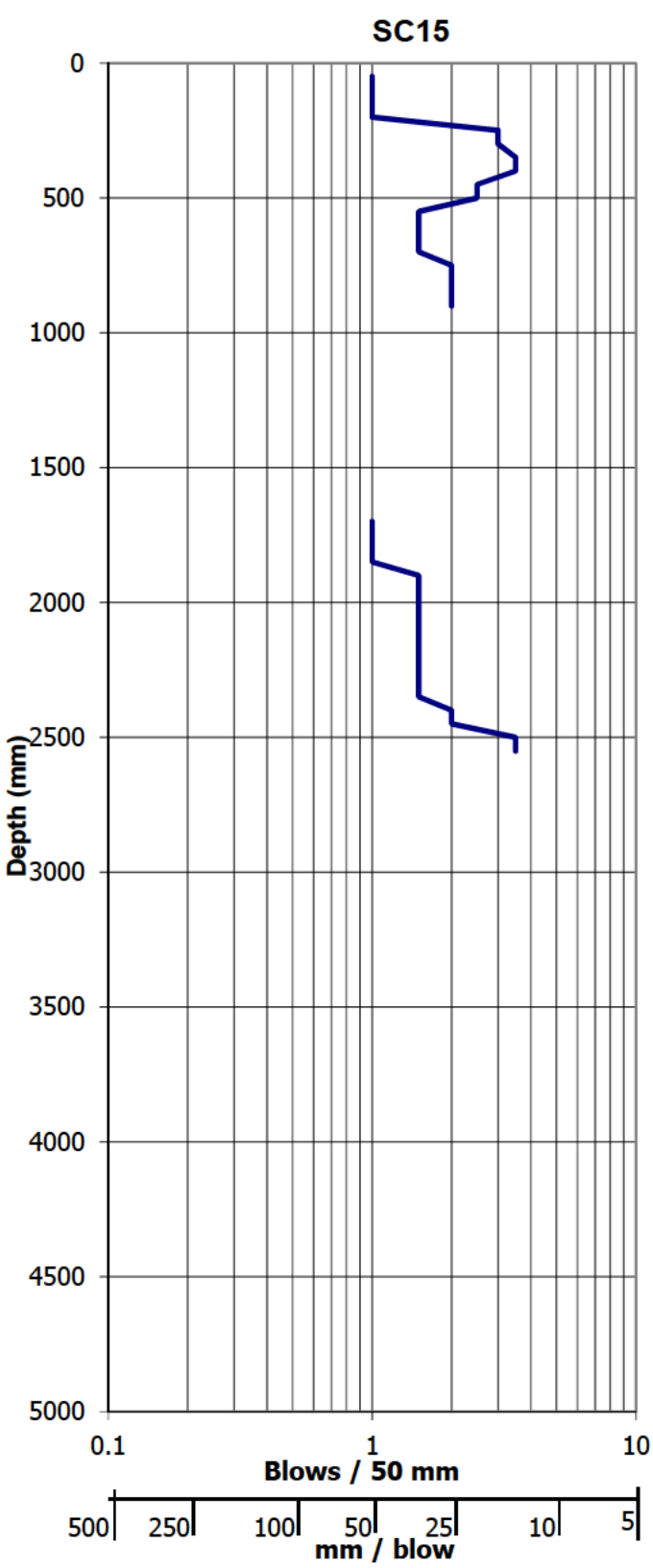
Job No: *150098.06*
Project: *Ayrburn Retirement*
Location: *TP15D*
RL:

Date: *23/09/2019*
Operated by: *JM*
Logged by: *JM*
Inferred Soil Type:

Test No. *SC15*
Sheet *15*
of *15*

SC15	
mm Driven	No. of Blows
50	1
100	1
150	1
200	1
250	3
300	3
350	3.5
400	3.5
450	2.5
500	2.5
550	1.5
600	1.5
650	1.5
700	1.5
750	2
800	2
850	2
900	2
950	
1000	
1050	
1100	
1150	
1200	
1250	
1300	
1350	
1400	
1450	
1500	
1550	
1600	
1650	
1700	1
1750	1
1800	1
1850	1
1900	1.5
1950	1.5
2000	1.5
2050	1.5
2100	1.5
2150	1.5
2200	1.5
2250	1.5
2300	1.5
2350	1.5
2400	2
2450	2
2500	3.5

SC15 cont...	
mm Driven	No. of Blows
2550	3.5
2600	
2650	
2700	
2750	
2800	
2850	
2900	
2950	
3000	
3050	
3100	
3150	
3200	
3250	
3300	
3350	
3400	
3450	
3500	
3550	
3600	
3650	
3700	
3750	
3800	
3850	
3900	
3950	
4000	
4050	
4100	
4150	
4200	
4250	
4300	
4350	
4400	
4450	
4500	
4550	
4600	
4650	
4700	
4750	
4800	
4850	
4900	
4950	
5000	



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

TEST PIT LOG

HOLE NO.: SP01

CLIENT: Justine Hollows
PROJECT: Ayrburn Studio
JOB NO.: 150098.11

SITE LOCATION:
CONTRACTOR:
START DATE: 21/10/2024
COORDINATES:
EQUIPMENT:
END DATE: 21/10/2024
LOCATION METHOD: Total Station\Surveyed
ACCURACY: ± 1 m
LOGGED BY: MP
ELEVATION: Existing ground level
OPERATOR:
CHECKED DATE:

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND	SCALA PENETROMETER (Blows / 0 mm)	SHEAR STRENGTH (kPa) Vane: Values	WATER
TOPSOIL	Gravelly organic SILT with minor rootlets, brown. 0.20 m			TS TS TS	1 2 3 4 5 6 7 8 9 10 11 12 13 14	50 100 150 200	Groundwater Not Encountered
UNCONTROLLED FILL	Sandy GRAVEL trace rootlets, brownish grey, dipping 5-10 degrees to 013. Sand, fine to coarse; gravel, fine to coarse. 0.40 m						
ALLUVIAL SAND	Gravelly SAND, light grey. Bedded, sand, fine to coarse, mostly medium to coarse; gravel, fine to coarse, mostly fine, subrounded to rounded. 2.20 m		0.5 1.0 1.5 2.0 2.5 3.0 3.5				
	End Of Hole: 2.20 m						

PHOTO(S)

REMARKS

WATER

- Standing Water Level
- Out flow
- In flow

TEST PIT LOG

HOLE NO.: SP02

CLIENT: Justine Hollows
PROJECT: Ayrburn Studio
JOB NO.: 150098.11

SITE LOCATION:
CONTRACTOR:
START DATE: 21/10/2024
COORDINATES:
EQUIPMENT:
END DATE: 21/10/2024
LOCATION METHOD: Total Station\Surveyed
ACCURACY: ± 1 m
LOGGED BY: MP
ELEVATION: Existing ground level
OPERATOR:
CHECKED DATE:

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND
TOPSOIL	Gravelly organic SILT with minor rootlets, brown. 0.10 m			
OVERBANK DEPOSITS	Sandy GRAVEL with minor silt, orange grey. Sand, fine to coarse; gravel, fine to medium, subrounded to angular. 0.40 m			
ALLUVIAL SILT	Sandy SILT, orange grey. Sand, fine. 0.70 m		0.5	
ALLUVIAL GRAVEL	Sandy GRAVEL & gravelly SAND, grey, interbedded siltier beds. Bedded, sand, fine to coarse; gravel, fine to medium, subrounded to subangular. 1.20 m		1.0	
ALLUVIAL SILT	SILT with minor to trace sand, grey orange banding, interbedded siltier beds. Bedded, sand, fine. 2.70 m		1.5 2.0 2.5	
	Sandy SILT, light grey, interbedded siltier beds. Loosely bedded, sand, fine. 3.80 m		3.0 3.5	
	End Of Hole: 3.80 m			

SCALA PENETROMETER (Blows / 0 mm): 1 2 3 4 5 6 7 8 9 10 11 12 13 14

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

WATER

- Standing Water Level
- Out flow
- In flow

TEST PIT LOG

HOLE NO.: SP03

CLIENT: Justine Hollows
PROJECT: Ayrburn Studio
JOB NO.: 150098.11

SITE LOCATION:
CONTRACTOR:
START DATE: 21/10/2024
COORDINATES:
EQUIPMENT:
END DATE: 21/10/2024
LOCATION METHOD: Total Station\Surveyed
ACCURACY: ± 1 m
LOGGED BY: MP
ELEVATION: Existing ground level
OPERATOR:
CHECKED DATE:

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND
TOPSOIL	Organic SILT with minor rootlets, brown. 0.10 m			TS
LOESS	Sandy SILT, dark brownish grey. 0.60 m		0.5	
ALLUVIAL GRAVEL	Sandy GRAVEL trace cobbles, orange grey, interbedded sand beds. Bedded, sand, fine to coarse; gravel, fine to coarse. 1.20 m		1.0	
	End Of Hole: 1.20 m		1.5 2.0 2.5 3.0 3.5	

SCALA PENETROMETER (Blows / 0 mm): 1 2 3 4 5 6 7 8 9 10 11 12 13 14

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER: Groundwater Not Encountered

PHOTO(S)

REMARKS

WATER

- Standing Water Level
- Out flow
- In flow

Appendix C: Liquefaction Analysis

Appendix C - Liquefaction Analysis

General

Liquefaction occurs when susceptible, saturated soils attempt to move to a denser state under cyclic shearing. In this report, liquefaction is defined as when pore pressures rise to reach the overburden stress. When this occurs, the following effects can happen at flat sites:

- loss of strength;
- ejection of material under pressure to the ground surface; and
- post-liquefaction volumetric densification as the materials reconsolidate.

In addition, sloping sites or sites with a 'free face' may experience lateral spreading or movement.

Liquefaction Susceptibility

Soils susceptible to liquefaction have the following characteristics:

- Saturated. Below the ground water level;
- Have "sand like" behaviour[8]; and
- Are in loose or medium dense condition.

Soils which are susceptible to liquefaction require a certain level of earthquake shaking (trigger) to cause them to liquefy. Denser soils require more intense and/or longer duration of shaking (higher trigger) than less dense soil.

Analysis Method

Liquefaction analyses were undertaken on the test data using the Boulanger & Idriss (2014)[7] deterministic method.

Assessment of Consequences of Liquefaction

The following can be assessed to estimate the consequences of liquefaction at this site:

- Crust thickness
- Liquefaction severity index
- Free field settlements
- Lateral spread

Crust Thickness

The non-liquefiable upper layer of soils (crust) provides some protection against ground surface damage as a result of liquefaction. The thicker the crust, the less ground surface damage is expected with significant protection provided by thicknesses of more than 5 m.

Empirical correlations have been developed by Ishihara[9] to quantify the thickness of non-liquefiable crust required to prevent the formation of sand boils resulting from the liquefaction of underlying soil layers. These correlations indicate that for a given thickness of liquefiable soil, as the peak ground acceleration increases a greater thickness of non-liquefiable soil is required to prevent liquefaction damage from manifesting on the surface.

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[8] "Geotechnical earthquake engineering practice: Module 1 Guideline for the identification, assessment and mitigation of liquefaction hazards", Rev 0, July 2010. New Zealand Geotechnical Society. This document states that soil with: Fc <30%, or; Fc >30% and PI < 7% (where Fc= percent passing a 0.075mm sieve and PI=plasticity index) is considered as "sand-like" and is susceptible to liquefaction.

[9] Ishihara, K. (1985). "Stability of natural deposits during earthquakes," Theme lecture, Proc. 11th Int. Conf. On Soil Mechanics and Foundation Engineering, San Francisco, 2, 321-376pp.

Liquefaction Severity Number

Liquefaction severity number (LSN) is a single value which can be calculated from a liquefaction assessment considering the thickness density and depth of liquefiable layers and the intensity of earthquake shaking. Based on observations of ground surface damage in Christchurch an indicative correlation has been developed between ground surface damage from liquefaction and LSN as described below.

As the LSN increases, so does the risk of severe effects on the land and structure. In general, the following surface effects are considered likely at sites with various LSN values.

Table 1C - Liquefaction Severity Number[10]

	Effects from excess porewater pressure and liquefaction	**Characteristic LSN**	**Characteristics of liquefaction and its consequences**
L0	Insignificant	< 10	No significant excess pore water pressures (no liquefaction)
L1	Mild	5 – 15	Limited excess pore water pressures; negligible deformation of the ground and small settlements.
L2	Moderate	10 – 25	Liquefaction occurs in layers of limited thickness (small proportion of the deposit, say 10 percent or less) and lateral extent; ground deformation results in relatively small differential settlements.
L3	High	15 – 35	Liquefaction occurs in significant portion of the deposit (say 30 percent to 50 percent) resulting in transient lateral displacements, moderate-to-large differential movements, and settlement of the ground in the order of 100 mm to 200 mm.
L4	Severe	> 30	Complete liquefaction develops in most of the deposit resulting in large lateral displacements of the ground, excessive differential settlements and total settlement of over 200 mm.
L5	Very severe		Liquefaction resulting in lateral spreading (flow), large permanent lateral ground displacements and/or significant ground distortion (lateral strains/stretch, vertical offsets and angular distortion).

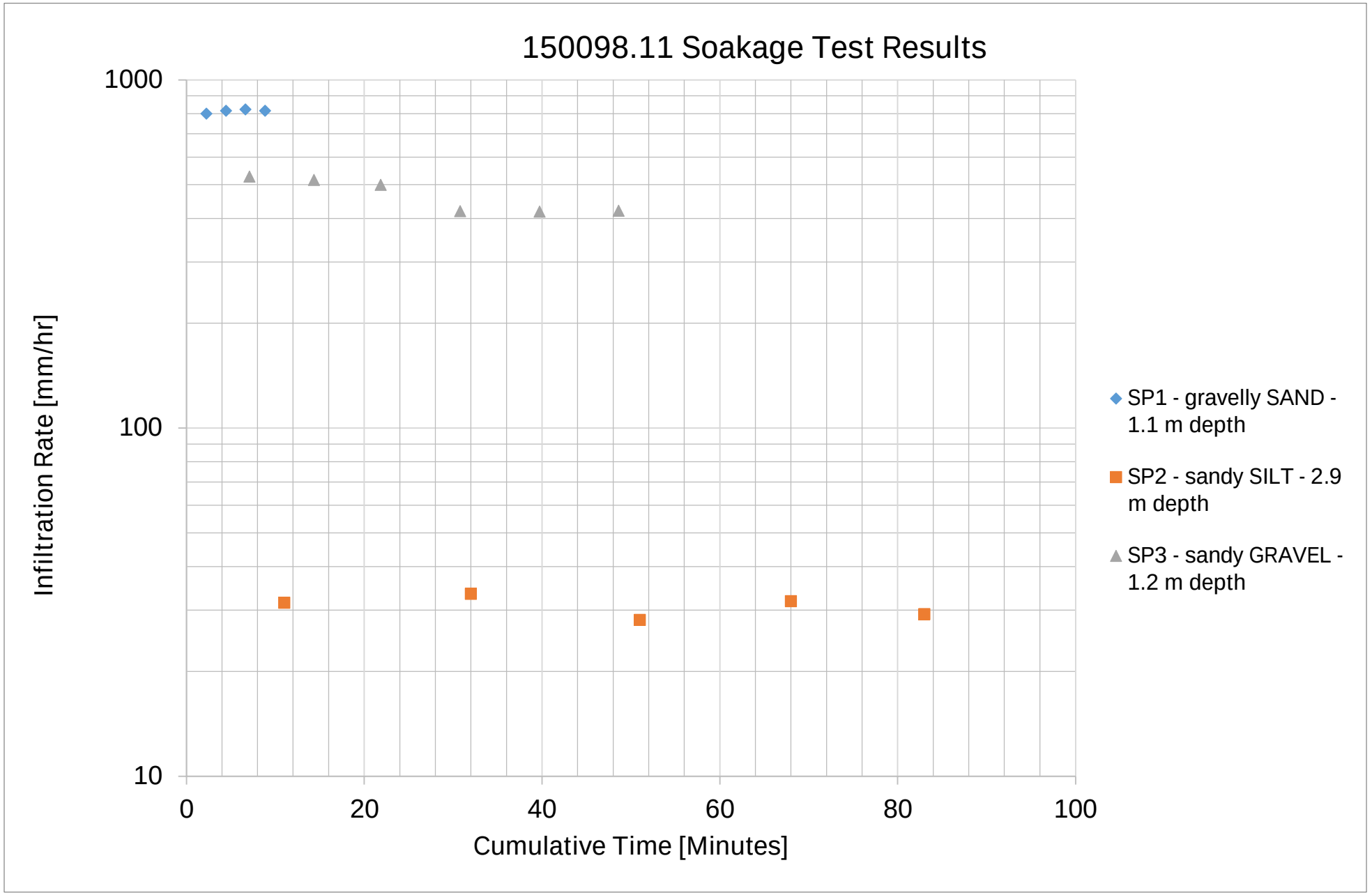
Free Field Settlements

This describes the settlement of ground not occupied by a building, occurring due to dissipation of excess pore water pressure generated during earthquake shaking. Where appropriate, we have estimated reconsolidation settlement of any potentially liquefiable layers using the methodology recommended by Idriss & Boulanger (2014)[7].

A component of building settlement may also occur due to yield of any liquefied founding soils. This component of settlement is very difficult to predict and depends on the interaction of the building and the soil it is founded on.

[10] New Zealand Geotechnical Society [NZGS] and Ministry of Business, Innovation and Employment [MBIE] (2021). Earthquake geotechnical engineering practice in New Zealand. Module 3: Identification, assessment and mitigation of liquefaction hazards. Rev 1.

Appendix D: Soakage Testing Results


150098.11 Soakage Test Results
1000
100
10
Infiltration Rate [mm/hr]
0
20
40
60
80
100
Cumulative Time [Minutes]
SP1 - gravelly SAND - 1.1 m depth
SP2 - sandy SILT - 2.9 m depth
SP3 - sandy GRAVEL - 1.2 m depth

Appendix E: GeoSolve Project Personnel Curriculum Vitae

GEOSOLVE
ENGINEERING CONSULTANTS

Curriculum Vitae

Mike Plunket – *Geotechnical Engineer*
mplunket@geosolve.co.nz
Cell: 0273710803

Mike is a chartered professional geotechnical engineer with over 9 years of experience in the Central Otago area. Based in Wanaka, Mike has primarily worked on geotechnical projects involving managing geotechnical investigation, assessment and design in the Central Otago area. He also has experience in projects within the greater Otago, and Southland area.

Mike's current role involves managing geotechnical projects around the greater Queenstown Lakes/Central Otago region as well as undertaking building foundation and retaining wall designs in the greater Otago area. He works closely with the other specialists within the GeoSolve team and a range of other engineers/specialists consultants outside GeoSolve.

Mike has worked on several major projects, including, Skyline, Northlake Residential Subdivision and Retirement Village, Five Mile Development, Brunswick Street Hotel, Marina Terraces Apartments, Ayrburn Precinct, Northbrook Arrowtown and Mount Cardrona Station.

Qualifications	BE (Hons) Civil, University of Canterbury, 2015
Professional Affiliations	Chartered Member and Chartered Professional Engineer, Engineering NZ (CPEng/CMEngNZ)
Software Familiarity	Slope/w, Wallap, RSPile, Allpile, Cliq, Slide, Gabion, Plaxis.

Employment Record

Geosolve Ltd
2016 to Current

Geotechnical Engineer - *Central Otago, NZ*

- Geotechnical consulting on a variety of residential, commercial and local government projects including site feasibility and appraisal, intrusive investigation co-ordination and supervision (deep: CPT, borehole and DPH; shallow: hand-auger, scala penetrometer, test pitting and soakage testing), hazard assessments and analysis of data including liquefaction assessment.
- Geotechnical design and analysis for retaining wall, slope stability remediation and foundations.
- Construction supervision following geotechnical assessment for residential, subdivision, commercial and local government developments within central Otago.

Selected Project Description

Subdivisions

- **Northlake Residential Subdivision and Retirement Village, Wanaka** – Large subdivision and Retirement Village in Wanaka. Work involved undertaking geotechnical investigation and reporting to provide inputs into subdivision design, stormwater infiltration testing for stormwater basins, assessments for requirement of current roading improvements, settlement assessments for proposed water storage tanks and construction supervision of earthworks to provide geotechnical sign off for residential lots and water storage tanks. Design of soil nail slope to allow earthworks 2017-.
- **Mount Cardrona Station Residential Subdivision, Cardrona Valley** – Residential subdivision within the Cardrona Valley. Work involved undertaking geotechnical investigation and reporting to provide input into subdivision design, design of subdivision infrastructure including wastewater plant, water and wastewater

main feeding existing Cardrona township to new wastewater treatment plant through subdivision. Water reservoir, water treatment plants, water intake structures and associated infrastructure for water to be transported to the water treatment plant including up an approximately 30 m high terrace, stormwater storage basins to store and slowly release the increased runoff from the subdivision. Retaining wall design. Construction supervision, monitoring and sign of the above elements. – 2020-2024.

- **Parkins Bay, Glendhu Bay, Wanaka** – Residential subdivision within Wanaka. Construction supervision, monitoring and sign off of the above elements – 2017-2025.

Buildings

- **Ayrburn Precinct, Arrowtown** – Undertaking geotechnical investigation, geotechnical assessment including liquefaction assessment and retaining wall design for various buildings within the Ayrburn Hospitality Precinct outside Arrowtown – 2022-2025
- **Northbrook Arrowtown** – Undertaking geotechnical assessment to provide structural design inputs for proposed 5 storey retirement village apartment building with basement parking – 2024-2025.
- **Watersports Building, Wanaka** – Undertaking geotechnical investigation, geotechnical assessment including liquefaction assessment and providing input for structural design for a building on the shoreline of Lake Wanaka. Undertaking construction supervision to confirm design requirements. 2018-2019
- **The Precinct, Wanaka** – Undertaking geotechnical investigations and assessment for new three storey commercial development in Central Wanaka. Given the calculated liquefaction risk this involved working with structural engineers and other stakeholders to develop a robust foundation system. Undertaking construction supervision to confirm design requirements. 2018-2019
- **Building 8, 5 Mile Development, Queenstown** – Undertaking geotechnical investigations and assessment for five storey commercial development. Providing foundation options for concept design then undertaking further geotechnical analysis to refine the foundation system for proposed building. Then undertaking construction supervision to confirm design requirements and fill certification of fill placed below the building. Detailed input into crane pad loading during construction. 2016-2017.
- **17-19 Man Street Hotel Development, Queenstown** – Undertaking geotechnical investigations and assessment for proposed five storied hotel development in Queenstown. Providing foundation options then working with structural engineers to refine the foundation systems. 2017-2021
- **Marina Terraces Apartments, Wanaka –** Construction observations to verify earthworks construction including under building gravel raft and drainage was constructed in accordance with the design for 5 storey apartment buildings in close proximity to Lake Wanaka. Supervision of construction of double anchored sheet pile wall and dewatering works. 2018-2022.
- **Mount Aspiring College Redevelopment, Wanaka** – Large multi storey new block over part of the current school site due to large increase in number of students at the Wanaka high school. This involved undertaking geotechnical investigations across the proposed footprint, assisting with foundation solution optioneering, calculating foundation inputs for structural analysis to refine chosen shallow foundation systems and pile design for proposed buildings. Also undertaking construction supervision to confirm design requirements and fill certification of soils placed below buildings. 2017-2022
- **Kitea Hotel, Wanaka** – Multi-storey hotel within Central Wanaka. This involved undertaking a geotechnical investigation and reporting in 2016 for a previously proposed development then undertaking a review of the existing investigation data to undertake detailed foundation analysis to provide structural design inputs into the superstructure. Supervision of construction to confirm design assumptions. 2016-2021.
- **Roys Bay Estate, Wanaka** – Retirement Village Development within Wanaka. This involved reviewing a preliminary geotechnical assessment and then undertaking more detailed liquefaction testing to provide detailed design inputs to the development. Approximately 20 buidlings with between 4 and 5 units proposed as part of the development. Construction supervision including fill earthworks monitoring to confirm design assumptions – 2018-2022.
- **Northbrook Wanaka –** Geotechnical assessment to inform detailed design of Retirement Village comprising approximately 25 blocks (4x units per block) and central wellness and care buildings. Detailed design inputs to aid structural design. Construction observations to certify fill compaction and design assumptions.
- **Wanaka Yacht Club –** Geotechnical assessment to inform preliminary planning for new Yacht Club building on edge of Lake Wanaka. Geotechnical investigation identified that the existing building occupied reclamation fill that extends below the current lake level. Optioneering study to allow further planning for the proposed building.
- **Cardrona Distillery Warehouses** – Geotechnical assessment to inform design of 3 large warehouse buildings located on gold mining tailings. Investigation identified gold tailings below the proposed warehouse footprint, sonic drilling was then required to determine the thickness of the gold tailings to inform detailed foundation design.
- **Scapegrace Distillery, Bendigo** – Geotechnical assessment to inform detailed design of Distillery development adjacent to Lake Dunstan. Provision of foundation design inputs to allow detailed design of large buildings.

- **Silverlight Studio, Wanaka** – Geotechnical assessment to inform preliminary design and resource consenting for large scale movie studio development including large scale cut and fill earthworks.
- **Queenstown Views Apartments, Queenstown** – Geotechnical assessment to inform planning and detailed design of 5 storey hotel with basement in central Queenstown. Detailed foundation and retaining input and construction observations to verify design assumptions.
- **Marram Man Street Development, Queenstown -** Geotechnical assessment to inform planning and detailed design of 4 storey hotel with basement in central Queenstown.
- **Riverside Apartments, Wanaka –** Geotechnical assessment to inform detailed design of apartment development. Construction observations to verify fill compaction and verify design assumptions.

Retaining Wall / Slope Stability Design

- **Cardona Alpine Resort, Willows Reinforced Slope, Cardona** – Undertaking investigations and design for a geogrid reinforced slope below the bottom station of the Willows Basin lift tower. Involved a detailed slope stability assessment and remediation design then preparation of construction drawings and specifications for consent/construction. Undertook construction supervision during construction. 2021-2022
- **Cardrona Alpine Resort, Halfpipe Remediation, Cardrona**
- **Crichton Lane Dwelling Extension, Queenstown** – Designing retaining walls to create access for upslope access to the proposed dwelling extension, design of rock bolts to support defects in the schist bedrock within the batter slope directly above the dwelling extension and design of a 6 m high temporary anchored universal column wall to allow construction of the dwelling on the site. 2018-2019
- **Brunswick Street Hotel, Queenstown** – Design of a perimeter retaining wall around the site toa allow construction of a proposed hotel development. Retaining walls up to 13 m high. Final design involved a series of single and double anchored bored pile walls. Retaining wall was peer reviewed by another consultant. Construction inspections to verify the retaining wall and anchors had been constructed in accordance with the design 2020-2024.
- **Skyline Development** – Design of Anchored Bored Pile Retaining Wall and Reinforced Slope to allow for construction of new upper gondola terminal. Bored pile wall and Reinforced Slope up to 5 m and 6 m high respectively. Plaxis modelling of global stability of retaining wall considering multiple retaining walls and building anchor loads with high pre-stress loads adjacent to proposed bored pile wall – 2019-2022.
- **Lowburn Terraces Reinforced Slope** – Design of up to approximately 6 m high 45 degree geogrid reinforced slope to allow construction of dwelling within sloping site.
- **Pinnacle Place Rock Stability** – Design of rock bolts and dowels to support up to 10 m high steep cuts to form a building platform within sloping terrain. Detailed rock defect analysis and calculations to confirm bolt/dowel sizing and spacing.
- **Aspiring Terrace, Wanaka – Soil Nail Remediation** – Construction supervision of slope nail reinforced slope below an existing council road reserve to stabilise an existing poorly constructed geogrid reinforced slope.
- **Northbrook, Wanaka – Soil Nail Slope Design –** Detailed design of up to 50 degree 10 m high slope nail reinforced slope including geotechnical investigations and anchor testing to confirm inputs for detailed design. Construction inspections to verify design solution had been constructed in accordance with requirements.
- **Willow Place, Queenstown – Anchored UC Retaining Wall Design** – Design of retaining solution to remedy failing timber crib wall on steep site in Queenstown. The solution of an anchored UC retaining wall was selected to ensure stability of the dwelling directly upslope during construction. Wall designed in conjunction with structural engineer who specified the waler beam and piles.
- **Peninsula Road – Reinforced Slope** – Design of duramesh/geogrid reinforced slope to allow construction of residential dwelling in close proximity to crest of steep slope.
- **The Tiers – Anchored UC Retaining Wall Design** – design of anchored UC wall to allow construction of dwelling into side of steep hill below existing road alignment.
- **Waterfall Park, Retaining Wall and Soil Nail Reinforcement, Arrowtown** – design of cantilevered UC walls up to 3 m high with up to 20 m high driven and grouted soil nail reinforced slope above the retaining wall. Construction supervision during construction to verify design solution had been constructed in accordance with requirements.

Infrastructure

- **Mount Cardona Station Water Treatment Buildings, Cardona** – Undertaking geotechnical investigation and assessment for proposed waste water treatment plant and water treatment reservoirs, water intake and pipeline alignment within an historic quarry and gold mining area. Undertaking construction supervision to confirm design requirements. 2019-2022.
- **Stage 3, Wanaka Lakefront Boardwalk Redevelopment, Wanaka** – Undertaking geotechnical investigations and assessment for proposed Queenstown Lakes District Council boardwalk redevelopment near the edge of Lake Wanaka. Providing foundation options then design for the boardwalk and retaining walls within the

redevelopment area. Construction supervision to confirm the design requirements had been met. 2019-2021.

- **QLDC North Wanaka Pump Station Assessment** – Undertaking a geotechnical assessment to inform detailed design of a new pump station located in close proximity to Lake Wanaka. Liquefaction analysis and foundation analysis to inform preliminary design.
- **Northlake Reservoir** – Geotechnical assessment for water storage reservoir located upslope of future residential development area. Detailed foundation calculations to provide inputs for tank designer. Construction observations to confirm the design requirrements as presented in geotechnical report had been achieved during tank construction.
- **Kane Road Quarry Assessment** – Geotechnical assessment to review suitability of site soils for use within aggregate quarry operation. Sampling and organisation of lab testing to assess properties of aggregate relative to standard NZ aggregate specifications.
- **Hawea Wastewater Treatment Plant Upgrade** – Undertaking a geotechnical assessment to inform detailed design of a proposed sidestream reactor to increase efficiency of the existing wastewater treatment plant. The site comprised moderately thick variable fill directly adjacent to the existing pond. The reactor was constructed on piles to bear within a suitable substrate. Construction supervision was undertaken to inspect the piles and verify geotechnical design assumptions.
- **Awarua Wastewater Treatment Plant Upgrade** – Undertaking a geotechnical assessment to inform detailed design of a Lamella Clarifier to increase efficiency of the existing wastewater treatment plant. The site comprised moderate uncontrolled fill overlying saturated loose sand and peat overlying a dense sand. Detailed foundation analysis considering liquefaction effects on the piles was competed to inform structural design. Construction supervision was undertaken to inspect the piles and verify geotechnical design assumptions.

GEOSOLVE
ENGINEERING CONSULTANTS

Curriculum Vitae

Paul Faulkner – Senior Engineering Geologist
pfaulkner@geosolve.co.nz
Phone: 021 579 261

Paul is a senior engineering geologist with 25 years professional experience and is based in the Geosolve Queenstown office. His particular interests are assessing geological hazards, remediating rock and soils slopes and construction in unfavourable ground conditions. He has experience with large commercial, high value private residential developments, infrastructure, tourist operations, deep excavations and rock slope engineering. He has provided emergency response services for rock-soil instability incidents in the Lakes District Region and completed risk to life assessments for developments exposed to natural hazards.

Education	MSc, Engineering Geology, Leeds University UK, 1998 BSc, Geological Science, Leeds University, UK, 1997
Professional Affiliations	Member Engineering New Zealand, The New Zealand Geotechnical Society, the International Association of Enginerering Geologists and the Geological Society of London

Employment Record

GeoSolve Ltd
2013 to Current

Senior Engineering Geologist (Geotechnical)

- Project management and project representative;
- Geotechnical and civil construction inspections and monitoring;
- Geological modelling;
- Rockfall and debris flow assessment;
- Liquefaction analyses;
- Geotechnical assessment and reporting;
- Foundation design inputs, and;
- Earthworks and subdivision consent and sign-off reporting.

Tonkin & Taylor
2006-2013

Senior Engineering Geologist (Geotechnical)

- Similar scope as Geosolve employment above;

UK, Various Companies
1998 to 2006

Engineering Geologist/Geotechnical Engineer

- Numerous geotechnical investigations, reporting and design inputs for highway and rail projects and commercial developments nationwide

Rock Deformation Research, South Africa, 1997

Geologist

- Geological structural interpretations, underground mapping and mineralogy studies

Queenstown Project Experience

Key Projects	
Skyline Re-development Queenstown	• *Geotechnical investigation and reporting for the top terminal, lower terminal and gondola replacement and car park buildings;* • *Detailed debris flow and rock fall risk assessments including estimates of Annual Individual Fatality Risk. Project included 3D and 2D rock fall modelling to determine run out locations, bounce heights and boulder energies, suitable barrier locations (fence and Bund), and extent of remedial measures.* • *Debris Flow assessment, probability, volume, run out locations and Annual Individual Fatality Risk* • *Environment Court evidence preparations, mediation and attendance.* • *Working with the contractor to determine suitable bluff remediation options.*
Skyline tree removal and rock fall risk Ben Lomond Reserve	• *Assessment to determine the risk of rock fall associated with tree removal for the gondola corridor.* • *Working with a specialist rope access contractor to remediate key bluff areas, methods included Drill and blast, rock fall mesh installation, bolting and temporary catch fences. Work ongoing.*
QLDC tree removal and rock fall risk Ben Lomond Reserve	• *Assessment to determine the risk of rock fall associated with tree removal for an area of the Ben Lomond Reserve. Key areas identified which will require remediation.* • *Work progressing into detailed assessment of remedial options and calculations of Annual Individual Fatality Risk for this area of the slope following completion of the works.*
QLDC, Glenorchy Road	• *Recommendations and supervision of preliminary remedial works at Wyuna Cut, including rock defect mapping and analysis, scaling and large block removal.* • *Multiple assessments and reports for bluffs at 12- mile, Bennetts bluff, Wyuna Bluff and other lower rock exposures along the corridor.* • *Emergency attendance and inputs for a large rock fall event at 12-mile bluffs that blocked the road for approximately 2 days in 2010.*
Lakes Edge Subdivision, Frankton Queenstown	• *Geotechnical assessment for a complex subdivision comprising variable ground conditions from weak liquefiable soils to sub vertical rock sites. Project involved ground improvement (stone columns), engineered fill and reinforced earth design and construction, rock mapping and rock stability assessments.* • *The project was taken through consent, engineering approval, construction and sign off.*
QLDC - Lakes District Region, liquefaction assessment	• *Review of geotechnical investigation data for the district and development of a Liquefaction risk category system with recommendations for investigation for development requirements. This data now forms part of the QLDC hazard mapping.*
Queenstown Lakes District Reservoirs, various	• *Geotechnical assessments and inputs for several lakes district reservoir, including Quail Rise, Kelvin Heights, Arrowtown, lake Hayes, Beacon Point, Wynyard and Middleton Road. For Arrowtown slope stability analysis and estimation of seismic ground displacement was undertaken which followed into detailed design of slope stabilisation measures, construction and sign -off of a reinforced earth buttress.*
Trails Trust, Queenstown	• *Geotechnical design and construction inputs for the Arthurs Point to Arrowtown and Arthurs Point to Tuckers Beach Trails.*
Waterfall Park Hotel Development, Queenstown	• *Management and senior engineering Geology review for consent and detailed engineering design for a multi building hotel development with liquefaction, lateral spreading, rock fall and low strength soils.*
The Tiers sub-division and residential development area, Frankton Road, Queenstown	• *Detailed geological assessment of a sloping site with displaced schist bedrock and design inputs for a 15 m deep permanent rock cut stabilised by rock anchors and shotcrete.* • *Resource consent, building consent and Geotechnical completion reporting;*

Shotover Country Residential sub-division, Queenstown	• *Management and Senior engineering geology review for a liquefaction assessment of the lower terrace area of Shotover Country. Construction inspections and geotechnical completion reporting for Stage 16.* • *Geotechnical inputs for the proposed QLDC water treatment plant.*
Coneburn Subdivision, Kingston Road, Queenstown	• *Project manager and senior engineering geologist for an approximate 600+ lot subdivision resource consent. Ground conditions comprise soft saturated soils with liquefaction potential. A rock fall assessment and protection bund design was also completed.*
Remarkables Park Developments, Queenstown	• *Management of detailed geotechnical investigations and assessments for several buildings and areas of the Remarkables Park development, including liquefaction and slope stability analysis, preliminary inputs for the proposed Gondola, geotechnical inputs for foundation design.*
Residential development Multiple Sites	• *Geotechnical investigations and assessments for multiple residential and commercial developments across the Lakes District Region. Geotechnical issues such as rock and soil slope instability, ground bearing, liquefaction, settlement and engineered fill certification, hearing attendance and evidence preparation.*
Publications	• *A Practical Seismic Liquefaction Zoning System for Risk Management of Urban Development (co-author). New Zealand Geotechnical Society Symposium 2013.*

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