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GEOTECHNICAL

WATER RESOURCES

PAVEMENTS

Preliminary Geotechnical Report

29 Hamilton Street

East Gore, Southland

Report prepared for:

Housing New Zealand Limited

Report prepared by:

GeoSolve Limited

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GEOTECHNICAL WATER RESOURCES PAVEMENTS

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1 Introduction

1.1 General

This report presents the results of geotechnical investigations carried out by GeoSolve Ltd in order to determine subsoil conditions and provide geotechnical inputs for a proposed new residential housing development at 29 Hamilton Street, East Gore.

Photo 1.1 – Proposed building site, 29 Hamilton Street

The investigations were carried out for Housing New Zealand in accordance with GeoSolve Ltd's proposal dated 15 March 2022, which outlines the scope of work and conditions of engagement.

1.2 Development

At this early stage of the project the extent of the development is still unconfirmed, and no concept plans have yet been developed. However, we understand the current intention is to demolish most or all of the existing structures on site and construct up to 25 two to five bedroom units, as one to two storey buildings.

Figure 1, Appendix A illustrates the current site layout.

2 Site Description

2.1 General

The subject property is located at East Gore which is situated approximately 2 km northeast of central Gore, as shown in Figure 1 below.

Figure 2.1 – Site location plan

The property is accessed from Hamilton Street and lies between the Mataura River and the Waikaka Stream, about 2 km from their confluence. The Mataura River is located about 230 m beyond the western boundary of the site, with a stop bank separating the site from the river.

The western half of the site is almost fully covered with hard surfacing (chip seal). The eastern half of the property contains a series of interconnected buildings, with a sealed driveway along the southern boundary. Grassy areas mostly surround the buildings, with a few mature trees north of the buildings. The property is bounded on all sides by residential land, with the exception of the western boundary with Hamilton Street.

2.2 Topography and Surface Drainage

The building site not yet has been surveyed, but appears relatively level. The lowest part of the site appears to be directly south of the existing buildings. Publicly available contour mapping suggests a maximum elevation change of up to 1.5 m across the site, however the actual elevation differences are likely to be less than this based on visual observations. Current buildings and hard surfaces appear to discharge to the Council stormwater main running along the southern part of the site.

3 Geotechnical Investigations

An engineering geological site appraisal has been undertaken with confirmatory subsurface investigations. GeoSolve Ltd visited the subject property on 29 April 2022, undertaking geotechnical investigations comprising three machine auger holes and four test pits which were advanced to a maximum depth of 2.4 m. Dynamic cone (Scala) penetrometer tests were undertaken at each auger/test pit location advancing to 2.4 m or effective refusal.

Auger hole, test pit and Scala penetrometer locations and logs are contained in Appendices A and B respectively.

4 Subsurface Conditions

4.1 Geological Setting

4.1.1 Regional Geology

Gore is located in the Mataura River valley and the site is located on alluvial floodplains adjacent to this river. The valley contains Quaternary-age alluvium (silts to gravels deposited 10,000 years or less ago) that is locally underlain by lignite-bearing sediments of Miocene age (Gore Lignite Measures).

In the vicinity of Gore, the Mataura River has incised through the crystalline basement rocks that form the elevated north limb of the Southland Syncline (known as the Hokonui Hills). These basement rocks comprise the Murihiku Supergroup of Mesozoic age (low grade metamorphosed marine sandstones to mudstones) that are visible in the riverbed and true left bank.

4.1.2 Seismicity

No active faults were identified on site. Active faults have been mapped within 20-30 km of Gore (e.g. the Hillfoot Fault Zone [30 km], Blue Mountain Fault [22 km] and the Spylaw Fault [27 km]).

The above faults are not included in Table 3.6 of NZS 1170.5:2004 as major faults requiring near fault factors when assessing structural design actions.

There are a number of other faults not mapped by GNS Science as “active” that lie within 5 km of the site, with the nearest fault mapped approximately 2.5 km to the northeast of the site. The recent Canterbury earthquakes have highlighted the issue that previously unidentified faults or presumed activity status may be very significant factors in the actual future risk applying to any particular site.

It should be noted the fault terminations shown on fault trace maps are often approximations (owing to lack of data) and the presence of other active faults may be unknown because they may be obscured by overburden soils.

Strong ground shaking throughout the South Island is likely to be associated with a rupture along the current tectonic plate boundary (i.e., the Alpine Fault), located along the West Coast of South Island. Recent research[1] suggests there is a 75% probability of an Alpine Fault earthquake occurring within the next 50 years and an 82% probability that the next earthquake on the Alpine Fault will be of magnitude 8 or greater.

Average return periods for Modified Mercalli shaking intensity scale (MM) events are: MM 6 = 50 years, MM 7 = 300 years and MM 9 = 2,600 years.

[1] Howarth, J.D., *et al.* (2021). Spatiotemporal clustering of great earthquakes on a transform fault controlled by geometry. Nature Geoscience; doi: 10.1038/s41561-021-00721-4

4.2 Stratigraphy

Apart from thin layers of surficial topsoil or asphalt, the site is in most areas underlain by uncontrolled fill averaging ~1.3 m in thickness. The fill is underlain by alluvial sand and silt deposits to a depth of at least 2.2 m below the existing ground surface.

The **uncontrolled fill** is of substantially variable composition across the site, but in most locations tends to be a mixture primarily of loose to medium dense sandy or silty GRAVEL. Occasionally, some rubbish was included with the fill such as brick and concrete fragments, with rare glass fragments. Occasional coal fragments/combustion products were noted at AH1, AH2 and TP5.

While much of the site is covered in chipseal, outside of these areas the fill is capped with **topsoil/fill** typically comprising firm organic SILT with traces of sand and gravel.

Typically underlying the fill and topsoil is **alluvial silt** which typically comprises mottled bluish grey and light brown clayey SILT which is stiff to very stiff. All of the excavations except TP7 were terminated within this deposit.

Markedly different conditions were noted at TP7. No fill was identified, with undisturbed **topsoil** noted in the upper 0.3 m underlain by firm sandy SILT and medium dense gravelly SAND (**alluvial silt** and **alluvial sand**, respectively). Conditions at TP7 are inferred to persist throughout much of the northeastern corner of the site.

Bedrock was not encountered but is expected to lie at moderate depth below the site, probably comprising moderately weathered to unweathered Murihiku Supergroup meta-siltstone bedrock which is expected to extend to substantial depth.

More detailed geotechnical description of soils is provided in the excavation logs contained in Appendix B.

4.3 Groundwater

Generally, no groundwater seepage was observed in the excavations, and the soils observed were predominantly moist in condition. However, some perched groundwater was identified within the uncontrolled fill at TP5 which may be present in isolated locations elsewhere on site, likely developing on the contact between the silty alluvium and the overlying fill during times of high rainfall.

The regional groundwater level is expected to be controlled by water levels in the nearby Mataura River and is likely to undergo fluctuations depending on seasonal or flood conditions in the river flow.

5 Engineering Considerations

5.1 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.

The actual subsurface geotechnical conditions may show some variation from those described and all recommendations and conclusions which are contained in this report are subject to confirmation by inspection during construction.

5.2 Geotechnical Parameters

Table 5.1 provides a summary of the recommended preliminary geotechnical design parameters for the soil materials expected to be encountered during construction of the proposed development. Note these parameters should be checked and revised if needed as further geotechnical data becomes available at later stages of the project.

Table 5.1 – Recommended preliminary geotechnical design parameters

Unit	Thickness (m)	Bulk density γ (kN/m^3)	Effective cohesion c´ (kPa)	Effective friction ϕ´ (deg)	Elastic modulus E (kPa)	Poissons ratio ν
Uncontrolled fill (loose to medium dense sandy or silty GRAVEL)	up to 1.7	16	N/A	N/A	N/A	N/A
Topsoil/fill (firm organic SILT with trace of sand/gravel)	up to 0.7	16	N/A	N/A	N/A	N/A
Alluvial silt (stiff clayey SILT)	not proven	19	2	30	10-15,000	0.3
Alluvial sand (firm sandy SILT)	not proven	17	0	32	5,000	0.3
Alluvial sand (medium dense gravelly SAND)	not proven	18	0	32	5-10,000	0.3

N.B. Topsoil and uncontrolled fill are unsuitable for supporting structures; parameters a provided are for preliminary retention design only.

5.3 Site Preparation

During the earthworks operations all topsoil, organic matter, fill and other unsuitable materials should be removed from the construction areas in accordance with the recommendations of NZS 4431:1989.

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 4431:1989 and certification provided to that effect.

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.

5.4 Excavations

As the site is near horizontal it is anticipated that the only excavations likely to be required will be temporary for foundation construction.

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

Seepage was only encountered within one of the test excavations and hence groundwater is unlikely to be encountered during most foundation excavations. However, a geotechnical practitioner should inspect any seepage, spring flow, voids or under-runners that may be encountered during construction.

If required, dry, permanent batters up to 3 m in height should not exceed 2:1 (horizontal to vertical). Temporary cuts in dry soils may be formed at 1:1 subject to geotechnical advice.

It is possible an earthworks consent may be required and this should be checked with Council once the pre-concept design has been established.

The subsurface materials will be relatively easy to excavate by conventional methods.

5.5 Engineered Fill

Engineered fill may be utilised to replace the existing uncontrolled fill to support foundations, or to establish higher floor levels for flood hazard mitigation if desired.

The alluvial soils could be used as engineered fill on site (during good weather and in accordance with an earthfill specification), however imported hardfill (well graded and ideally from a quarry source) is likely to be more straightforward where required owing to the inherent variability in the silty and sandy alluvium. Boulders and cobbles over 75 mm in size will need to be screened from engineered fill sources. Engineered fill specification and certification to NZS 4431:1989 can be provided on request.

All fill that is utilised as bearing for foundations should be placed and compacted in accordance with the recommendations of NZS 4431:1989 and certification provided to that effect. In the case of granular fill behind foundation walls a specific compaction methodology will need to be prescribed for all areas where fill exceeds 600 mm in thickness and a producer statement is likely to be required to verify adequate fill compaction. Therefore, a fill specification and geotechnical supervision (including laboratory verification) should be sought at an early stage to enable a producer statement to be supplied. Adequate compaction is necessary to carry building loads and to minimise future differential settlement.

All fill slopes less than 3 m in height should be constructed with a maximum batter of 2:1 (horizontal to vertical) or flatter, if well drained. To minimise erosion, effective vegetation cover should be established on fill batters and no water flows should be directed to these slopes. Thicker or steeper fills will require specific engineering assessment and design.

Maintaining the moisture content of any cohesive fill soils to achieve the required compaction will need to be addressed by the contractor. It is recommended that any cut to fill soils (if this method is adopted) be placed and compacted immediately as they are excavated, as stockpiling and reworking is highly likely to degrade the compaction properties of these soils. Such earthworks should only be carried out in the summer or during a period of forecast, prolonged dry weather as cohesive soils are susceptible to becoming excessively moist and could rapidly become unsuitable for placement if they get wet.

5.6 Ground Retention

While the site is mostly flat and we do not anticipate any retention as part of the development, the following comments apply if any retaining walls are proposed.

Any retaining wall proposed should be designed by a chartered professional engineer.

All retaining walls should be designed using the geotechnical parameters recommended in Table 5.1 of this report. Due allowance should be made during the detailed design of all retaining walls for any additional loads upslope of the wall (i.e. surcharge due to backslope or vehicle loading).

All temporary slopes for retaining wall construction should be battered at 1:1 provided these are within dry soils and less than 3 m high.

Groundwater was not identified in most test pits but has the potential to develop following completion of the earthworks, 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 0.3 m width of durable free draining granular material should be placed behind all retaining structures;
- A heavy duty non-woven geotextile cloth, such as Bidim A14, 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.

The safety implications of working under temporary cuts will need to be adequately addressed.

5.7 Groundwater Issues

The regional watertable is expected to lie well below current ground levels, and thus major dewatering or other groundwater-related construction mitigation is unlikely to be required for a typical residential development. It is important that GeoSolve be contacted should there be any seepage, spring flow, voids or under-runners encountered during construction.

5.8 Settlement and Foundations

For one or two-storey dwellings, the most suitable foundation options include concrete slabs on strip footings or proprietary waffle slab systems in conjunction with fill replacement earthworks to prepare the subgrade (where required), or otherwise relatively shallow piles.

As most of the site contains substantial thicknesses of uncontrolled fill, the soils in these areas do not meet the definition of 'Good Ground' as defined in NZS 3604:2011. The existing fill is unsuitable for supporting foundation elements or concrete floor slabs, or for re-placement as engineered fill. General options are to either remove the fill and replace it with engineered fill, or to transfer foundation loads through the fill to the underlying alluvium. Foundation loads should be transferred to the underlying alluvial silts or engineered fill which is likely to provide adequate bearing capacities for the expected range of foundation types.

Additional investigations targeted at specific building platforms are recommended once building platforms have been confirmed to finalise the provision of appropriate geotechnical foundation design parameters; however, the recommendations below are considered suitable for preliminary design purposes.

5.8.1 Fill Replacement

Removal of the uncontrolled fill (and any underlying buried topsoil or soft alluvium) and replacement with engineered fill is likely to be a straightforward solution if concrete slab foundations are preferred, or if any fill soils require removal owing to land contamination. This will facilitate the use of standard (i.e. NZS 3604-type) foundation designs, eliminate the need for foundations to carry floor loads in the case of concrete floors and provide flexibility in terms of the height of the foundation to mitigate flood risk (if desired).

In general, the eastern end of the site was found to have less fill, with uncontrolled fill and buried topsoil extending to a maximum depth of 0.5 m at TP6 and TP7; based on the preliminary ground model, likely excavation depths at this end of the site wouldn't exceed

the fill depth. In other areas the depth of unsuitable soils to be removed and replaced would range between approximately 1.1-1.7 m.

Foundation excavations and the extent of certified fill would need to extend outside the building footprints by a horizontal distance equal to at least the depth of the cut; e.g. if the cut extends to a depth of 1.5 m, it should be extended a horizontal distance outside the building footprint of 1.5 m and replaced with certified fill to achieve design levels.

All unsuitable materials identified in foundation excavations, particularly those softened by exposure to water, should be undercut and replaced with engineered fill during construction (see section 5.5 for requirements).

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. So that the individual subgrades are protected, the foundation excavations should be covered in a minimum 50 mm layer of site concrete or a 100 mm layer of compacted granular hardfill following the recommended inspections.

Figure 5.1 summarises the recommended provisional working stresses for shallow footings which bear upon stiff alluvial silt. It should be noted the foundation working stresses presented in Figure 5.1 are governed by bearing capacity in the case of narrow footings and settlement in the case of wide footings.

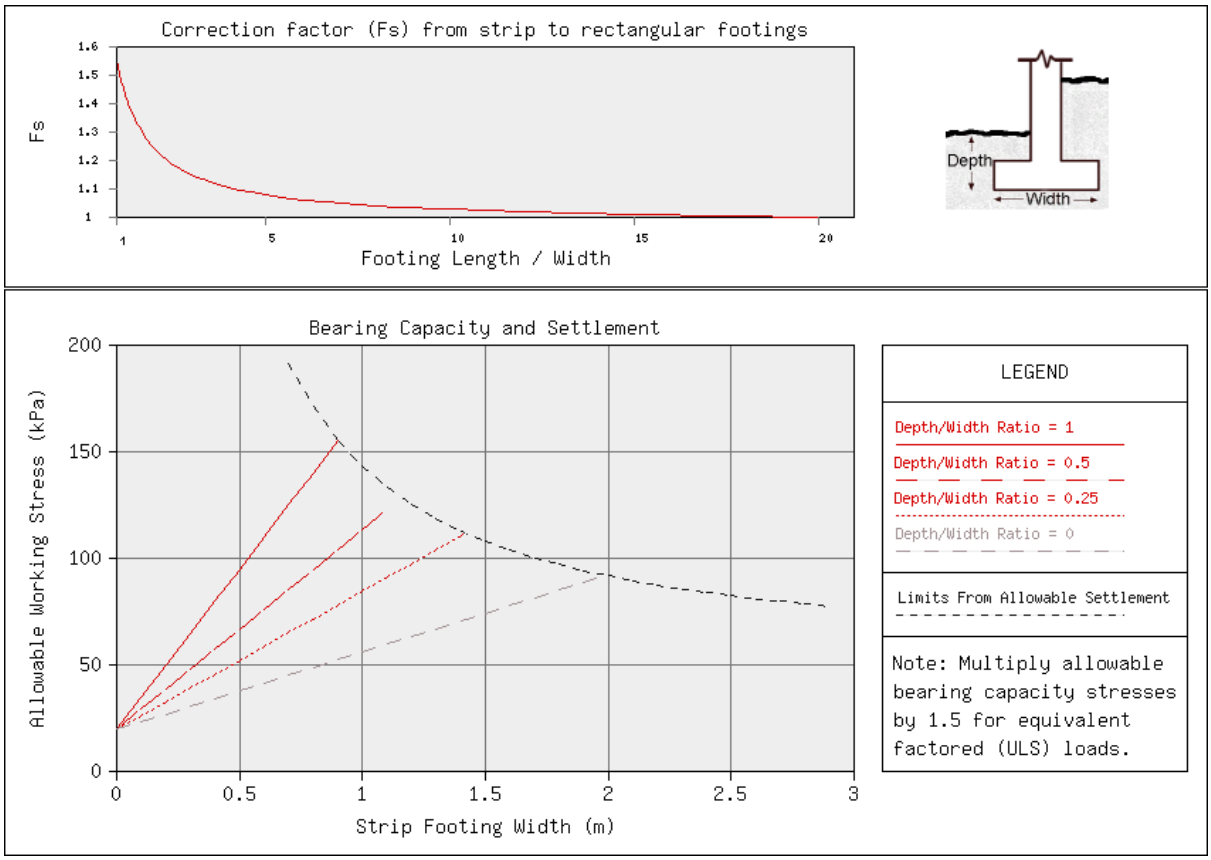

Figure 5.1 – Provisional recommended bearing for shallow footings on stiff alluvial silt

From Figure 5.1 it can be seen an allowable working stress of approximately 95 kPa is recommended for a 500 mm wide by 500 mm deep strip footing founded within stiff alluvial silt. This corresponds to a factored (ULS) bearing capacity of approximately 142 kPa and an ultimate geotechnical bearing capacity of 285 kPa.

It should be noted that the bearing capacities presented above assume that the loads are vertical with no horizontal loads or moments applied to the foundations. Reduction factors to account for eccentric and/or horizontal loads can be provided during detailed design once loads are finalised.

Higher bearing capacities may be able to be achieved when allowing for the placement of engineered fill as part of the removal of unsuitable soils. If shallow foundation systems are preferred GeoSolve can provide targeted advice to suit the ground conditions at individual building platforms.

5.8.2 Piled Foundations

If piled foundations are preferred (e.g. if timber subfloors are required or if issues such as fill contamination favour minimal cuts), then construction of bored and cast piles is likely to be successful in this setting.

A piled foundation which fully supports all loads (including floor loads) will likely minimise the excavation required during construction, thus enabling some of the uncontrolled fill to remain on site. This may be optimal to minimise soil disturbance or the quantity of soils which require disposal off-site.

Moderate end bearing is expected to be available in the stiff alluvium beyond approximately 0.5-1.7 m depth (subject to construction inspection). All floors should be designed to span between piles (where applicable) so that the floors are fully supported. If timber subfloors are not desired, then specifically designed structurally engineered concrete floor slabs could also be supported by piles if preferred.

Table 5.3 summarises the recommended provisional parameters for vertical pile capacity design for piles embedded into stiff alluvial silt. Note that this assumes a circular pile with a minimum pile diameter of 300 mm and minimum embedment of 1 m into natural soils. We note the investigations show fill and other unsuitable soils have been encountered between depths of 0.3 and 1.7 m. Therefore, pile depths could be more than 2 m in places.

Table 5.2 – Provisional ultimate pile design parameters in stiff alluvial silt (bored piles)

Ultimate end bearing (kPa)	Ultimate skin friction (kPa)
650	0[†]

[†] Provisionally we recommend that skin friction in natural soils on the pile is not considered in the design to counteract any down-drag effects from the uncontrolled fill.

A strength reduction factor should be applied to the above when comparing to factored structural loadings. A maximum strength reduction factor (SRF) of 0.5 is recommended for both static and seismic load cases.

If higher capacities are required, deeper piles could be considered. GeoSolve can provide further advice if required once provisional building loads have been calculated by the structural engineer.

The floor slab should be designed to span fully unsupported between piles. The uncontrolled fill will be able to take some lateral loads; we recommend that a passive coefficient of earth pressure, k_P, of 2.5 and a unit weight of 16 kN/m^3 is considered for both long term and short term loadings. It is possible that higher lateral capacities will be able to be achieved on parts of the site; GeoSolve can provide further advice if required once provisional building loads are available.

Driven timber piles may also be suitable for this site providing the resulting vibrations and noise can be adequately controlled. There may be some obstructions in the fill which could impede embedment. Driven pile design parameters can be provided once indicative loadings are available. This option may be preferable if disposal of site soils is to be minimised.

5.9 Pavements

The subgrade under any surfaced areas is likely to comprise fill in most locations. Fill is not ideal subgrade for surfaced areas, however the fill appears to have been in place for many decades and hence performance is likely to be adequate. Falling Weight Deflectometer (FWD) testing could be considered to better define subgrade CBR, however due to the variability of the fill at the site an in-situ design (10 percentile) CBR value of 2% is considered appropriate for this material. Increased values may be applicable after inspection once stripping is carried out.

All unsuitable soft or organic fill should be removed from beneath the access road footprints prior to commencement of pavement construction.

All soft and/or unsuitable materials which are exposed during preparation of pavement subgrade should be excavated and replaced with engineered fill.

Inspections of the pavement subgrade should be completed during construction by a suitably qualified geotechnical practitioner.

5.10 Site Subsoil Category

The following geotechnical information has been used to characterise the site subsoil class in respect of NZS 1170.5:2004 Structural Design Actions:

- Test pit and auger hole investigations across the site identified interbedded silts, sand and gravels to a minimum 2.2 m depth;
- Geological interpretation of the wider geomorphology of the area indicates that the depth to rock with an unconfined compressive strength in excess of 1 MPa in this area is likely to be in the order of several meters.

Based on the best available information, we consider the site subsoil class in terms of NZS 1170.5:2004 Clause 3.1.3 to be **Class C (Shallow Soil Sites)**.

The structural engineer should determine how sensitive the proposed structure is to different soil classes, in which case further investigations may be justified to gain more assurance. Further testing may involve drilling deep boreholes to confirm rock and/or shear wave velocity testing.

6 Neighbouring Structures/Hazards

6.1 Flood Hazard

This location is protected by existing stopbanks. Thus it is not in a defined floodway which might be subject to frequent flooding, and therefore unlikely to require significant mitigation. Local discussions to date indicate no knowledge of any previous flooding of the site.

The District Plan classifies the site as prone to flooding subsequent to a stopbank breach or stopbank overtopping which would be a very rare scenario. Further, we understand Environment Southland is currently upgrading the Gore stopbank system which will further increase the flood protection standard to this area – scheduled for completion next year.

Realistically, the actual risk of stopbank failure and consequent flooding is not readily quantifiable but likely to be very low.

Planning advice should be sought regarding any consenting issues associated with flood hazard. Mitigation, if any, would probably involve modest elevation of floor levels by filling or piling (cost probably not prohibitive).

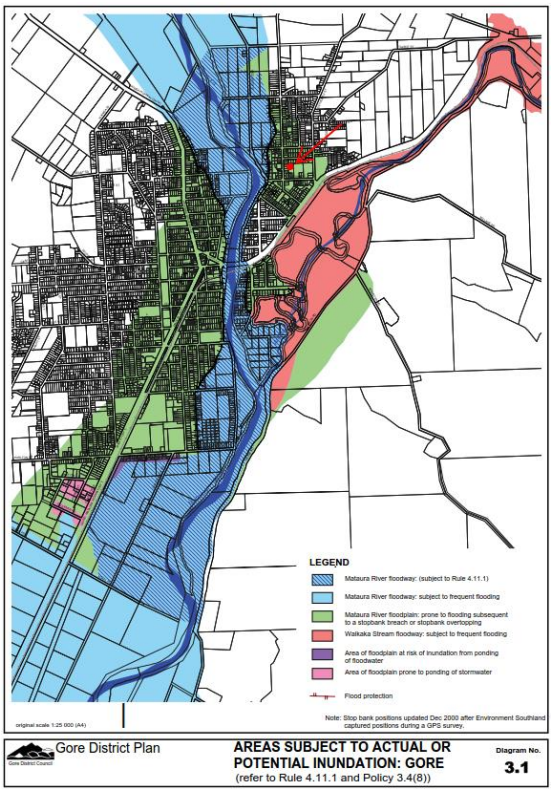

Figure 6.1 – Site location relative to mapped flood hazard zones in Gore District Plan

6.2 Other Hazards

Natural hazards: The site has been mapped in a broad-scale 2006 liquefaction hazard assessment[2] as of 'Negligible' liquefaction risk. The stiff condition of the shallow natural soils, the soil type/plasticity and the lack of shallow groundwater indicate the likelihood of damaging liquefaction occurring on site to be low.

A risk of seismic activity has been identified for the region as a whole and appropriate allowance should be made for seismic loading during detailed design of the proposed development, but there are no site-specific constraints.

The recommendations of this report should be followed in order to mitigate risks associated with landslip and subterranean erosion.

[2] Glassey, P.J. (2006). Geological Hazards: Southland District Council Lifelines Study. GNS Science Consultancy Report 2006/100.

Distances to adjoining structures: No adverse geotechnical implications apply for neighbouring properties during construction of the development provided the above excavation considerations are noted. This should be reassessed once conceptual design plans are available.

Aquifers: No aquifer resource will be adversely affected by the development.

Erosion and Sediment Control: The site presents some potential to generate silt runoff and this would naturally drain downslope. Only the least amount of subsoil should be exposed at any stage and surfacing established as soon as practical. Silt runoff should not be permitted to enter any watercourse.

We recommend advice be sought from a qualified specialist where compliance with local and regional erosion and sediment control regulations is uncertain.

Noise: Rock-breaking and/or blasting is unlikely to be required, however pile driving would create noise if used.

Dust: Regular dampening of soil materials with sprinklers should be effective if required.

Vibration: No vibration induced settlement is expected in these soil types; however, any works that create vibrations (e.g. fill compaction, pile driving) should be subject to geotechnical advice. Any structures to remain following demolition works and all neighbouring structures should be considered by the contractor with respect to vibration effects and further advice sought if there is any uncertainty.

7 Conclusions and Recommendations

- The site is in most areas underlain by uncontrolled fill averaging ~1.3 m in thickness. The fill is underlain by alluvial sand and silt deposits to a depth of at least 2.2 m below the existing ground surface.
- In general, fill thicknesses increase towards the west with uncontrolled fill and buried topsoil extending to a maximum depth of 0.5 m at TP6 and TP7 (eastern end of the site). In other areas the depth of unsuitable soils range between approximately 1.1-1.7 m in depth.
- Generally, no groundwater seepage was observed in the excavations; however, some perched groundwater was identified within the uncontrolled fill at TP5 which may be present in isolated locations elsewhere on site.
- If required, dry, permanent batters up to 3 m in height should not exceed 2:1 (horizontal to vertical). Temporary cuts in dry soils less than 3 m in depth may be formed at 1:1 subject to geotechnical advice.
- Engineered fill may be utilised to replace the existing uncontrolled fill to support foundations, or to establish higher floor levels for flood hazard mitigation if desired. Any fill that is utilised as bearing for foundations should be placed and compacted in accordance with NZS 4431:1989 and certification provided to that effect.
- The alluvial soils could be used as engineered fill on site; however, well graded imported hardfill is likely to be more straightforward where required owing to the inherent variability in the silty and sandy alluvium.
- For one or two-storey dwellings, the most suitable foundation options include waffle slabs, concrete slabs on strip footings in conjunction with fill replacement earthworks (where required), or otherwise relatively shallow piles.
- The majority of the site is underlain by substantial thicknesses of uncontrolled fill; these areas do not meet the definition of 'Good Ground' as defined in NZS 3604:2011.
- The existing fill is unsuitable for supporting foundation elements or concrete floor slabs, or for re-placement as engineered fill. General options are to either remove the fill and replace it with engineered fill (including a sufficient margin of engineered fill outside the building perimeter), or to transfer foundation loads through the fill to the underlying alluvium.
- Foundation loads should be transferred to the underlying alluvial silts or engineered fill which is likely to provide adequate bearing capacities for the expected range of foundation types.
- Removal of the uncontrolled fill (and any underlying buried topsoil or soft alluvium) and replacement with engineered fill is likely to be a straightforward solution if concrete slab foundations are preferred, or if any fill soils require removal owing to land contamination.

- Construction of bored and cast piles are also likely to be successful in this setting. A piled foundation which fully supports all loads (including floor loads) will likely minimise the excavation required during construction, thus enabling some of the uncontrolled fill to remain on site. This may be optimal to minimise soil disturbance or the quantity of soils which require disposal off-site.
- Driven timber piles may also be suitable for this site providing the resulting vibrations and noise can be adequately controlled. There may be some obstructions in the fill which could impede embedment.
- The subgrade under areas where surfacing may be proposed is likely to comprise fill in most locations. Fill is not ideal subgrade for surfaced areas, however the fill appears to have been in place for many decades and hence performance is likely to be adequate. A preliminary in-situ design (10 percentile) CBR value of 2% is considered appropriate for this material.
- Based on the best available information, we consider the site subsoil class in terms of NZS 1170.5:2004 Clause 3.1.3 to be Class C (Shallow Soil Sites).
- The site is protected from flooding of the Mataura River by existing stopbanks. Thus it is not in a defined floodway which might be subject to frequent flooding, and therefore unlikely to require significant mitigation. Environment Southland is currently upgrading the Gore stopbank system which will further increase the flood protection standard to this area (scheduled for completion next year).
- Realistically, the actual risk of stopbank failure and consequent flooding is not readily quantifiable but likely to be very low.
- Planning advice should be sought regarding any consenting issues associated with flood hazard. Mitigation, if any, would probably involve modest elevation of floor levels by filling or piling.
- The site has been mapped in a broad-scale 2006 liquefaction hazard assessment as of 'Negligible' liquefaction risk. The stiff condition of the shallow natural soils, the soil type/plasticity and the lack of shallow groundwater indicate the likelihood of damaging liquefaction occurring on site to be low.
- All unsuitable materials identified in foundation excavations, particularly those softened by exposure to water, should be undercut and replaced with engineered fill during construction.
- A geotechnical practitioner should inspect all excavations and additionally any seepage, spring flow or under-runners that may be encountered during construction.
- A geotechnical practitioner should inspect all foundation excavations prior to placement of reinforcing and concrete pour.
- Additional investigations targeted at specific building platforms are recommended once building platforms have been confirmed to finalise the provision of appropriate geotechnical foundation design parameters.

8 Applicability

This report has been prepared for the sole use of our client, Housing New Zealand Limited, 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. While the density of the investigations undertaken to date is considered sufficient for preliminary characterisation, further investigations are recommended at a later stage of the project. The nature and continuity of subsoil conditions away from the investigation locations cannot be guaranteed.

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.

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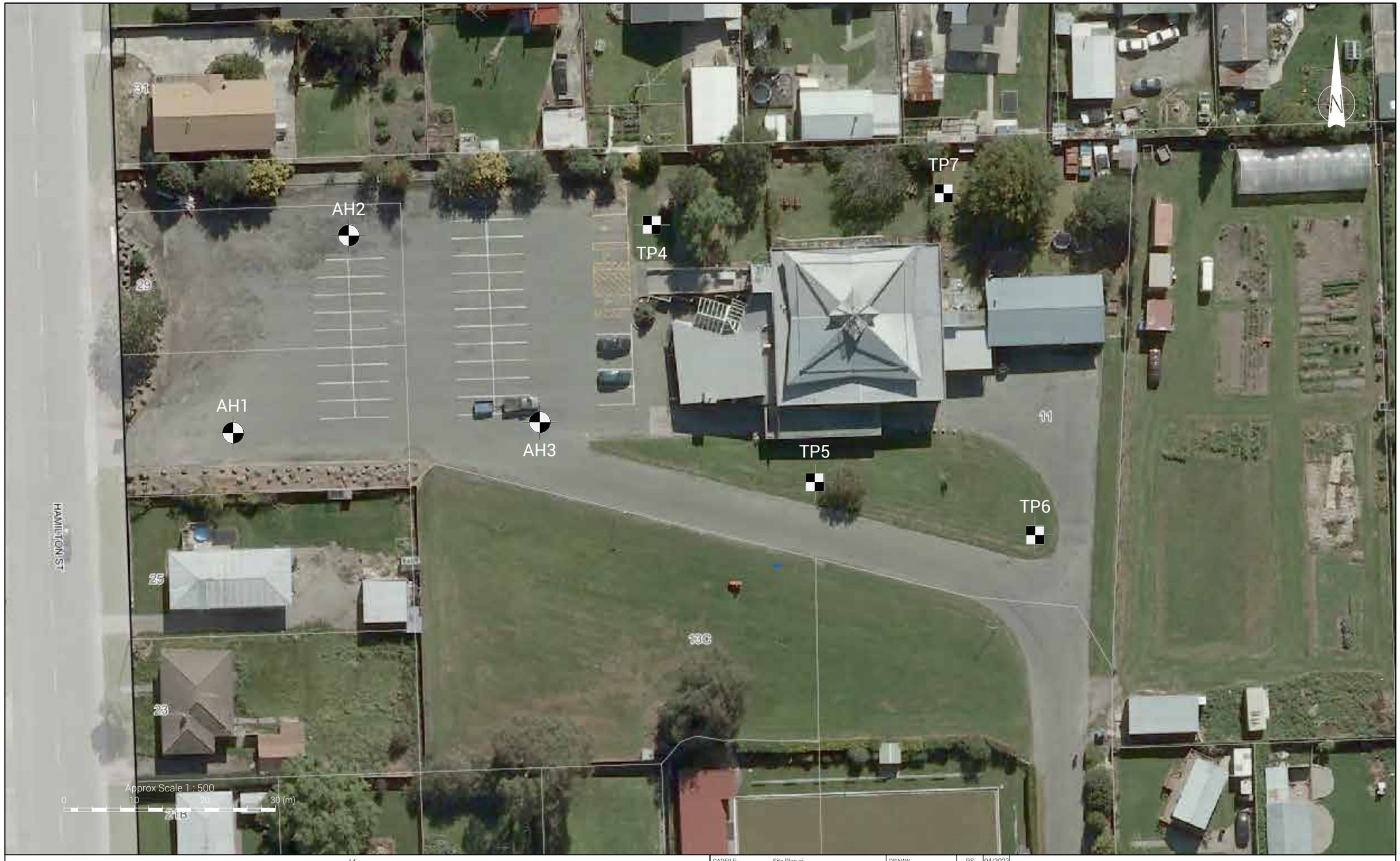
Appendices: Appendix A – Site Plan [1p]
Appendix B – Investigation Data - AH1-AH3 and TP4-TP7 [7p]

Appendix A: Site Plan



Key

= Machine auger/Scala penetrometer location

= Test pit/Scala penetrometer location

CADFILE:	Site Plan.ai	DRAWN	RS	04/2022
SCALE (AT A3 SIZE):	AS SHOWN	DRAFTING CHECKED	RS	05/2022
PROJECT No:	220222	APPROVED	MTW	05/2022

GEOSOLVE
ENGINEERING CONSULTANTS
GEOTECHNICAL
WATER RESOURCES
PAVEMENTS

Kāinga Ora
Preliminary Geotechnical Investigations
29 Hamilton Street, East Gore, Southland
Site Plan

FIG No: FIGURE 1

REV. 1

Appendix B: Investigation Data

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AUGER HOLE LOG

EXCAVATION NUMBER: **AH 1**

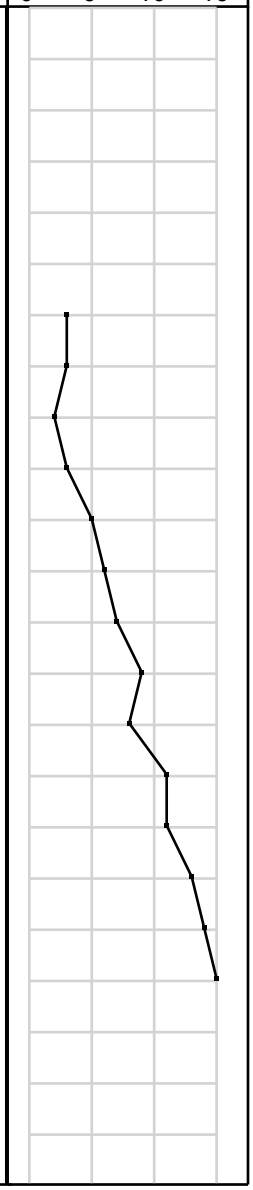
PROJECT:	KO-HAMILTON29			JOB NUMBER:	220222
LOCATION:	See Site Plan	INCLINATION:	Vertical		

EASTING:	1287438 m	EQUIPMENT:	5.5t excavator/450 mm auger	OPERATOR:	Robin
NORTHING:	4887883 m	COORD. SYSTEM:	NZTM2000	COMPANY:	Croydon Contracting
ELEVATION:	73 m	EXCAV. DATUM:	Existing ground level	HOLE STARTED:	29/04/2022
METHOD:	Aerial Photography	ACCURACY:	± 4 m	HOLE FINISHED:	29/04/2022

Soil / Rock Type	Description		Graphic Log	Depth (m)
FILL	Sandy fine to coarse GRAVEL with trace of cobbles; grey. Dense; dry; well graded; gravel, rounded, slightly weathered greywacke or quartz; sand, fine to coarse; cobbles, rounded. Capped by 20 mm of chip seal.	0m		0.0
FILL	Sandy fine to coarse GRAVEL with some silt; brown. Dense; moist; well graded; gravel, rounded, slightly weathered greywacke or quartz; sand, fine to coarse. Some rubbish including brick and timber fragments, rare coal fragments.	0.3m		0.3
FILL	Silty fine to coarse GRAVEL with some sand and minor clay; brown. Medium dense; moist; gravel, rounded, slightly weathered greywacke or quartz; sand, fine to coarse. Some rubbish including brick and timber fragments, rare coal fragments.	0.6m		0.6
FILL	SILT with some clay and trace organics; brownish grey. Firm to stiff; moist; non-plastic; organics, fine, rare fibrous wood fragments.	0.9m		0.9
ALLUVIAL SILT	SILT with minor clay and trace of gravel; bluish grey. Stiff to very stiff; moist; low plasticity; gravel, fine to coarse, rounded. Occasional greenish brown flecks/spots.	1.1m 2.3m		1.1 2.3

Groundwater / Seepage: NO SEEPAGE

Scala Penetrometer (Blows per 100mm)



Total Excavation Depth = 2.3 m

COMMENT:	Target depth reached. Scala from 500 mm owing to very dense pavement subgrade.	LOGGED BY:	RS
		CHECKED DATE:	13/05/2022
		SHEET:	1 of 1

GEOSOLVE
ENGINEERING CONSULTANTS

AUGER HOLE LOG

EXCAVATION NUMBER: **AH 2**

PROJECT:	KO-HAMILTON29			JOB NUMBER:	220222
LOCATION:	See Site Plan	INCLINATION:	Vertical		

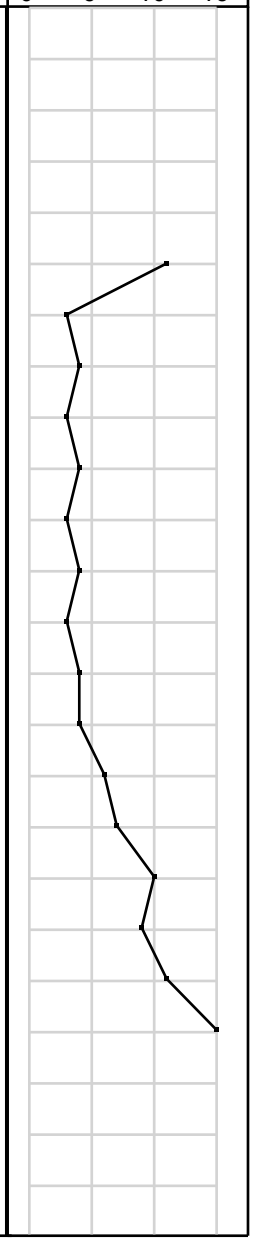
EASTING:	1287455 m	EQUIPMENT:	5.5t excavator/450 mm auger	OPERATOR:	Robin
NORTHING:	4887912 m	COORD. SYSTEM:	NZTM2000	COMPANY:	Croydon Contracting
ELEVATION:	73 m	EXCAV. DATUM:	Existing ground level	HOLE STARTED:	29/04/2022
METHOD:	Aerial Photography	ACCURACY:	± 4 m	HOLE FINISHED:	29/04/2022

Soil / Rock Type	Description	Depth (m)
FILL	Sandy fine to coarse GRAVEL with trace of cobbles; grey. Dense; dry; well graded; gravel, rounded, slightly weathered greywacke or quartz; sand, fine to coarse; cobbles, rounded. Capped by 20 mm of chip seal.	0m – 0.5m
FILL	Sandy fine to coarse GRAVEL with some silt; brown. Dense; moist; well graded; gravel, rounded, slightly weathered greywacke or quartz; sand, fine to coarse. Some rubbish including brick and timber fragments, rare coal fragments.	0.5m – 0.8m
FILL	Silty fine to coarse GRAVEL with some sand and minor clay; brown. Medium dense; moist; gravel, rounded, slightly weathered greywacke or quartz; sand, fine to coarse. Some rubbish including brick and timber fragments, rare coal fragments.	0.8m – 1.2m
FILL	SILT with some clay and trace organics; brownish grey. Firm to stiff; moist; non-plastic; organics, fine, rare fibrous wood fragments.	1.2m – 1.4m
ALLUVIAL SILT	SILT with minor clay and trace of gravel; bluish grey. Stiff to very stiff; moist; low plasticity; gravel, fine to coarse, rounded. Occasional greenish brown flecks/spots.	1.4m – 2.4m

Graphic Log

Groundwater / Seepage: NO SEEPAGE

Scala Penetrometer (Blows per 100mm)



Total Excavation Depth = 2.4 m

COMMENT:	Target depth reached. Scala from 400 mm owing to very dense pavement subgrade.	LOGGED BY:	RS
		CHECKED DATE:	13/05/2022
		SHEET:	1 of 1

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AUGER HOLE LOG

EXCAVATION NUMBER: **AH 3**

PROJECT:	KO-HAMILTON29			JOB NUMBER:	220222
LOCATION:	See Site Plan	INCLINATION:	Vertical		

EASTING:	1287481 m	EQUIPMENT:	5.5t excavator/450 mm auger	OPERATOR:	Robin
NORTHING:	4887886 m	COORD. SYSTEM:	NZTM2000	COMPANY:	Croydon Contracting
ELEVATION:	73 m	EXCAV. DATUM:	Existing ground level	HOLE STARTED:	29/04/2022
METHOD:	Aerial Photography	ACCURACY:	± 4 m	HOLE FINISHED:	29/04/2022

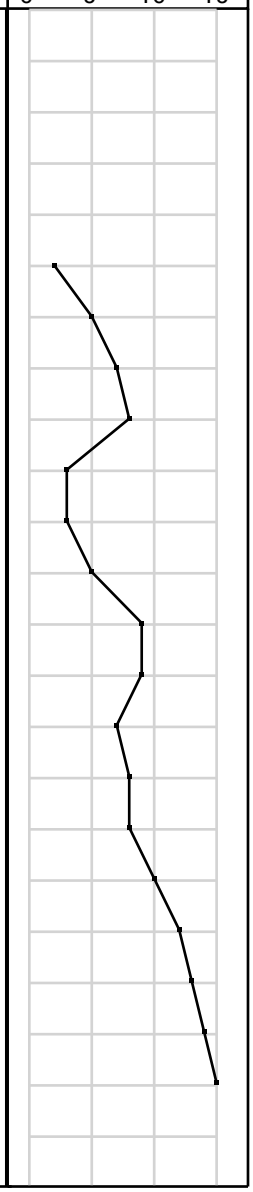
Soil / Rock Type	Description	
FILL	Sandy fine to coarse GRAVEL with trace of cobbles; grey. Dense; dry; well graded; gravel, rounded, slightly weathered greywacke or quartz; sand, fine to coarse; cobbles, rounded. Capped by 20 mm of chip seal.	0m
FILL	Sandy fine to coarse GRAVEL with some silt; brown. Dense; moist; well graded; gravel, rounded, slightly weathered greywacke or quartz; sand, fine to coarse.	0.3m 1m
FILL	SILT with some gravel and sand, with trace of organics; brownish and bluish grey. Stiff; moist; low plasticity; organics include timber/wood fragments.	1.6m
FILL	SILT with some clay and trace organics; brownish grey. Firm to stiff; moist; non-plastic; organics, fine, rare fibrous wood fragments.	1.7m
ALLUVIAL SILT	SILT with minor clay and trace of gravel; bluish grey. Stiff to very stiff; moist; low plasticity; gravel, fine to coarse, rounded. Occasional greenish brown flecks/spots.	2.3m

Graphic Log

Depth (m): 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3

Groundwater / Seepage: NO SEEPAGE

Scala Penetrometer (Blows per 100mm)



Total Excavation Depth = 2.3 m

COMMENT:	Target depth reached. Scala from 400 mm owing to very dense pavement subgrade - 2nd attempt.	LOGGED BY:	RS
		CHECKED DATE:	13/05/2022
		SHEET:	1 of 1

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TEST PIT LOG

EXCAVATION NUMBER: **TP 4**

PROJECT:	KO-HAMILTON29			JOB NUMBER:	220222
LOCATION:	See Site Plan	INCLINATION:	Vertical		

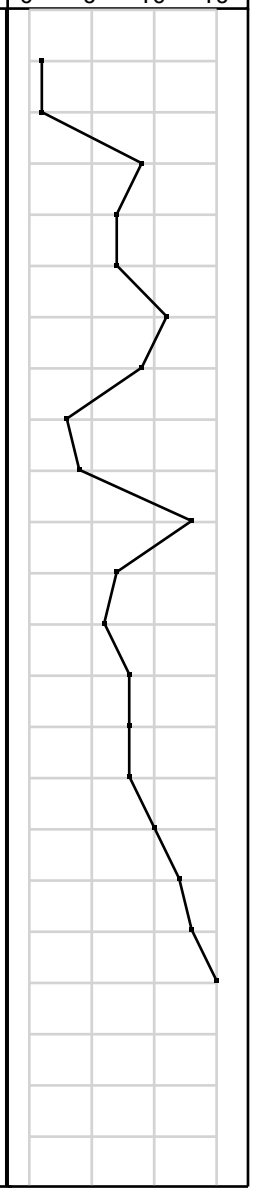
EASTING:	1287497 m	EQUIPMENT:	5.5t excavator/450 mm auger	OPERATOR:	Robin
NORTHING:	4887912 m	COORD. SYSTEM:	NZTM2000	COMPANY:	Croydon Contracting
ELEVATION:	73 m	EXCAV. DATUM:	Existing ground level	HOLE STARTED:	29/04/2022
METHOD:	Aerial Photography	ACCURACY:	± 4 m	HOLE FINISHED:	29/04/2022

Soil / Rock Type	Description	
TOPSOIL/FILL	Organic SILT with trace of sand and gravel; brown. Firm; moist; non-plastic; sand, fine to coarse; gravel, fine to coarse, rounded, slightly weathered greywacke or quartz. Frequent rootlets.	0m
FILL	Silty GRAVEL with some sand; greyish brown. Medium dense; moist; well graded; sand, fine to coarse; gravel, fine to coarse, rounded, slightly weathered greywacke or quartz.	0.2m
FILL	Gravelly SILT with minor sand and trace of organics; greyish brown. Firm to stiff; moist; low plasticity; sand, fine to coarse; gravel, fine to coarse, rounded, slightly weathered greywacke or quartz. Organics are fibrous, tend to be found in pockets. Rare rubbish including glass and brick fragments.	0.6m
ALLUVIAL SILT	Clayey SILT with trace of gravel; bluish grey, becoming mottled light brown. Stiff to very stiff; moist; low plasticity; gravel, fine to coarse, rounded. Occasional greenish brown flecks/spots.	1.2m
		2.3m

Graphic Log

Depth (m): 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3

Groundwater / Seepage: NO SEEPAGE



Total Excavation Depth = 2.3 m

COMMENT:	Target depth reached.	LOGGED BY:	RS
		CHECKED DATE:	13/05/2022
		SHEET:	1 of 1

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TEST PIT LOG

EXCAVATION NUMBER: **TP 5**

PROJECT:	KO-HAMILTON29			JOB NUMBER:	220222
LOCATION:	See Site Plan	INCLINATION:	Vertical		

EASTING:	1287521 m	EQUIPMENT:	5.5t excavator/450 mm auger	OPERATOR:	Robin
NORTHING:	4887877 m	COORD. SYSTEM:	NZTM2000	COMPANY:	Croydon Contracting
ELEVATION:	73 m	EXCAV. DATUM:	Existing ground level	HOLE STARTED:	29/04/2022
METHOD:	Aerial Photography	ACCURACY:	± 4 m	HOLE FINISHED:	29/04/2022

Soil / Rock Type	Description	Depth
TOPSOIL/FILL	Organic SILT; brown. Firm; moist; non-plastic; rare rubbish including brick fragments.	0m – 0.7m
FILL	Silty fine to coarse GRAVEL with some sand and minor clay; bluish grey. Medium dense; moist, wet to saturated in patches; gravel, rounded, slightly weathered greywacke or quartz, tends to be segregated in some zones; sand, fine to coarse. Frequent rubbish including large timber fragments, occasional combustion products.	0.7m – 1.4m
BURIED TOPSOIL	Organic SILT; dark brown. Firm to stiff; moist; non-plastic; organics are fine/fibrous.	1.4m – 1.6m
ALLUVIAL SILT	Clayey SILT with trace of gravel; bluish grey. Stiff to very stiff; moist; low plasticity; gravel, fine to coarse, rounded. Occasional greenish brown flecks/spots.	1.6m – 2.2m
-	-	2.2m – 2.4m

Graphic Log

Depth (m): 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4

Groundwater / Seepage: ~1 L/min

Scala Penetrometer (Blows per 100mm): 0, 5, 10, 15

Total Excavation Depth = 2.2 m

COMMENT:	Target depth reached. Perched groundwater confined to within patches of gravelly fill.	LOGGED BY:	RS
		CHECKED DATE:	13/05/2022
		SHEET:	1 of 1

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TEST PIT LOG

EXCAVATION NUMBER: **TP 6**

PROJECT:	KO-HAMILTON29			JOB NUMBER:	220222
LOCATION:	See Site Plan	INCLINATION:	Vertical		

EASTING:	1287552 m	EQUIPMENT:	5.5t excavator/450 mm auger	OPERATOR:	Robin
NORTHING:	4887868 m	COORD. SYSTEM:	NZTM2000	COMPANY:	Croydon Contracting
ELEVATION:	73 m	EXCAV. DATUM:	Existing ground level	HOLE STARTED:	29/04/2022
METHOD:	Aerial Photography	ACCURACY:	± 4 m	HOLE FINISHED:	29/04/2022

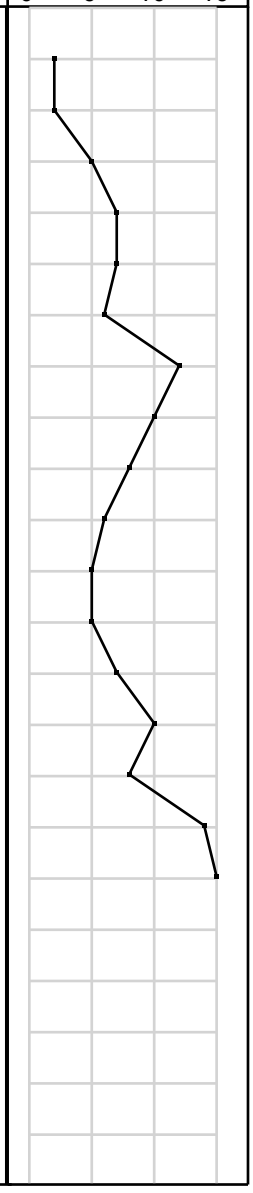
Soil / Rock Type	Description	Depth
TOPSOIL/FILL	Organic SILT; dark brown. Firm; moist; non-plastic; frequent rootlets.	0m – 0.2m
FILL	Sandy fine to coarse GRAVEL with some silt; brown. Medium dense; moist; well graded; gravel, rounded, slightly weathered greywacke or quartz; sand, fine to coarse. Rare rubbish including ceramic fragments.	0.2m – 0.5m
ALLUVIAL SILT	Clayey SILT with trace of gravel; bluish grey, becoming mottled light brown. Stiff to very stiff; moist; low plasticity; gravel, fine to coarse, rounded. Occasional greenish brown flecks/spots.	0.5m – 2.3m

Graphic Log

Depth (m): 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3

Groundwater / Seepage: NO SEEPAGE

Scala Penetrometer (Blows per 100mm)



Total Excavation Depth = 2.3 m

COMMENT:	Target depth reached.	LOGGED BY:	RS
		CHECKED DATE:	13/05/2022
		SHEET:	1 of 1

GEOSOLVE
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TEST PIT LOG

EXCAVATION NUMBER:
TP 7

PROJECT:	KO-HAMILTON29			JOB NUMBER:	220222
LOCATION:	See Site Plan	INCLINATION:	Vertical		

EASTING:	1287539 m	EQUIPMENT:	5.5t excavator/450 mm auger	OPERATOR:	Robin
NORTHING:	4887918 m	COORD. SYSTEM:	NZTM2000	COMPANY:	Croydon Contracting
ELEVATION:	74 m	EXCAV. DATUM:	Existing ground level	HOLE STARTED:	29/04/2022
METHOD:	Aerial Photography	ACCURACY:	± 4 m	HOLE FINISHED:	29/04/2022

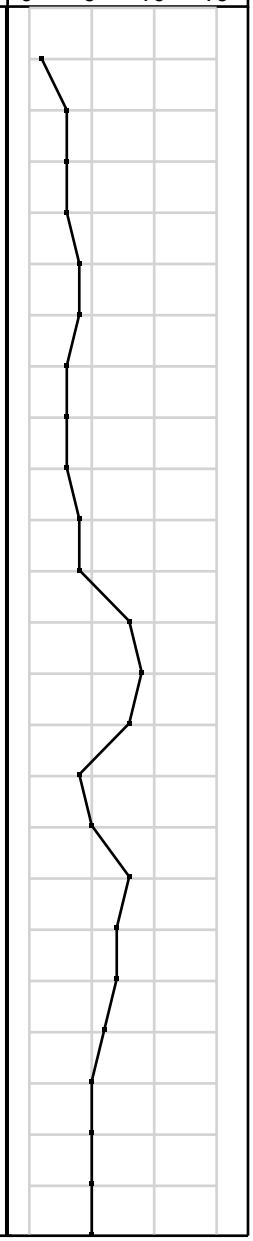
Soil / Rock Type	Description	Depth (m)
TOPSOIL	Organic SILT; dark brown. Firm; moist; non-plastic; rare rubbish including ceramic fragments. Frequent roots and rootlets.	0m – 0.3m
ALLUVIAL SILT	Sandy SILT; brown. Firm; moist; non-plastic; sand is fine.	0.3m – 0.95m
ALLUVIAL SAND	Gravelly fine to coarse SAND with trace of cobbles; grey and brown. Medium dense; moist; poorly graded; gravel, fine to medium, rarely coarse, rounded, slightly weathered greywacke or quartz; cobbles, rounded.	0.95m – 1.9m
ALLUVIAL SAND	Gravelly fine to coarse SAND with minor silt and trace of cobbles; grey and brown. Medium dense; moist; poorly graded; gravel, fine to medium, rarely coarse, rounded, slightly weathered greywacke or quartz; cobbles, rounded.	1.9m – 2.3m
-	-	2.3m – 2.4m

Graphic Log

Depth (m): 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4

Groundwater / Seepage: NO SEEPAGE

Scala Penetrometer (Blows per 100mm)



Total Excavation Depth = 2.3 m

COMMENT:	Target depth reached.	LOGGED BY:	RS
		CHECKED DATE:	13/05/2022
		SHEET:	1 of 1