ENGEO Limited
24 Rees Street, Queenstown 9371
T: +64 3 328 9012
www.engeo.co.nz

Project Number #22348.000.000

Geotechnical Investigation

29 Hamilton Street, Gore, Southland

Submitted to:
Southbase Construction Limited
165 Glenda Avenue
Five Mile
Queenstown 9300

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Report Title	Geotechnical Investigation - 29 Hamilton Street, Gore			
Project No.	22348.000.001	**Doc ID**	01	
Client	Southbase Construction Ltd	**Client Contact**	Maja Gibowicz	
Distribution (PDF)	maja.gibowicz@southbase.co.nz			
Date	**Revision Details / Status**	**Author**	**Reviewer**	**WP**
07/03/2023	Issued to Client	BH	SM	DF

Executive Summary

The geotechnical investigation undertaken at 29 Hamilton Street Gore in February 2023 by ENGEO shows the site to be underlain by regional bedrock comprising weak siltstone overlain with a 2 to 3 m thick layer of firm silt. At surface, non-certified fill and / or topsoil was encountered across the site at thicknesses ranging from 0.5 to 3.5 m as shown in Appendix 1.

Geotechnical investigation logs of sonic boreholes and hand augers completed as part of the investigation are included in Appendix 2.

ENGEO recommend buildings be founded on timber piles, socketed into the underlying bedrock at approximately 3 to 4 m depth. Alternatively, shallow foundations could be considered for the site but would require significant earthworks to remove the fill / topsoil and replace with an imported granular fill. Design of this fill would require careful consideration at detailed design once building loads are confirmed. Shallow or deep foundations must be designed by a chartered professional engineer.

1 Introduction

ENGEO Ltd have been retained by Southbase Construction Limited to undertake a geotechnical investigation of the property at 29 Hamilton Street, Gore, Southland (herein referred to as 'the site'). This report has been completed in accordance with the Southbase Consultancy Agreement (CP-222, Rev 2, 28.02.2022) provided to us on 8 February 2023.

Kāinga Ora (KO) propose to develop the site by demolishing the existing two structures and constructing 17 new standalone residential dwellings. The purpose of this assessment is to provide geotechnical support to Southbase Construction's Resource and Building Consent Applications (by others) as well as inform Structural and Civil Engineering designs for a new residential development.

The scope of this study comprises:

- Desktop review of relevant publicly available geotechnical data for the site.
- Subsurface investigations to characterise the near and deep surface soils.
- Preparation of this report outlining our findings on the ground conditions and providing geotechnical advice for site development and shallow or timber-piled foundation options.

ENGEO's scope does not include:

- Assessment of surface water flooding, wastewater nor stormwater disposal, typically prepared by civil engineers.
- Detailed design of building foundations and retaining walls. This is anticipated to be completed by structural engineers based on our recommendations herein.
- Design or assessment of ground improvement or other deep foundation options other than timber-pile foundations.

2 Site Description & Proposed Development

The site at 29 Hamilton Street is located on a section of approximately 7,600 m^2 in Gore, Southland. The topography of the site is flat with elevations ranging from 73 to 74 m RL. The site is accessed from Hamilton Street to the west or Oxford Street to the south and is boarded by residential properties and flat undeveloped grass land (Appendix 1). The Mataura River is approximately 200 m to the west and Waikaka Stream is 600 m southeast.

Kāinga Ora have provided a preliminary development plan for the site (Kāinga Ora, 2022). At this stage the development consists of the following:

- Seven, single-storey, one-bedroom houses.
- Ten, single-storey, two-bedroom houses.
- Four, single-storey, three-bedroom houses.
- Two, single-storey, four-bedroom, and

- One, single-storey five-bedroom home.

Given the flat topography of the site, retaining walls are likely not required.

3 Desktop Investigation

3.1 Regional Geology

The site has been regionally mapped to be underlain by fluvial deposits (Q2a) and adjacent to sandstones and siltstones of the regional Murihiku Supergroup (Turnball et al, 2003; Figure 1).

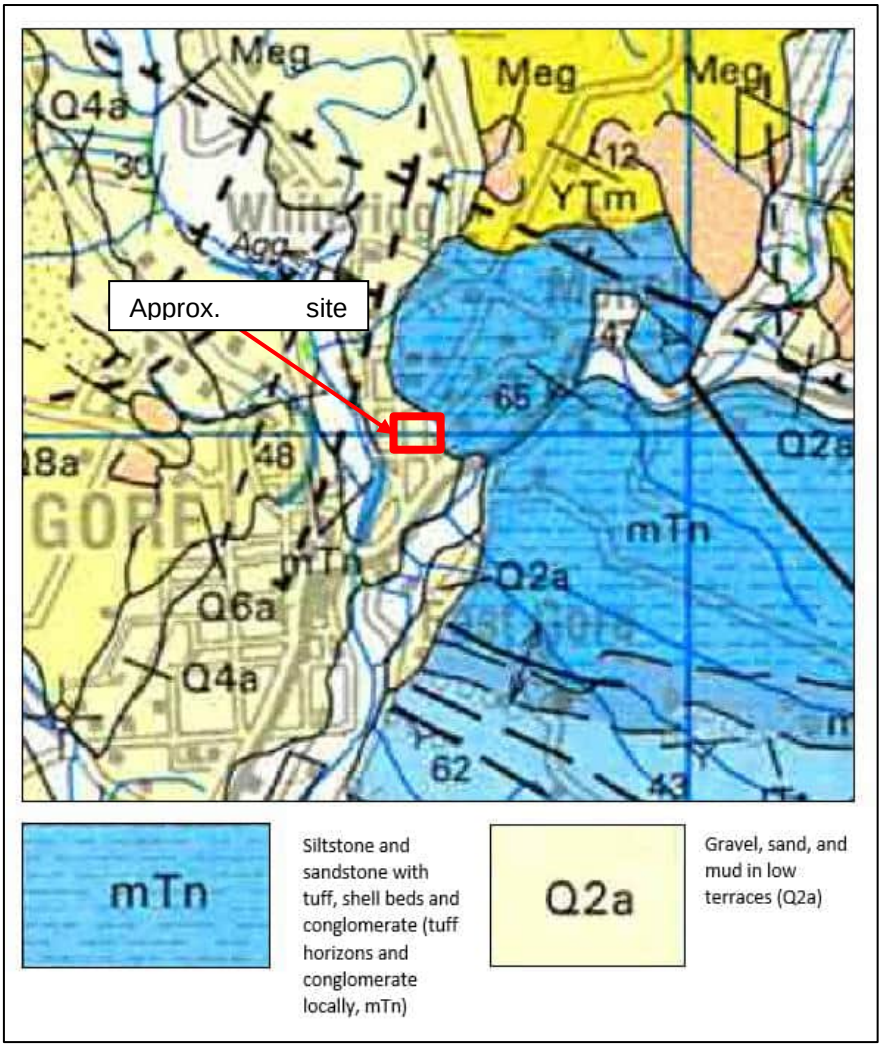


Figure 1: Regional Geological Map. Derived from Turnbull et al (2003).

Siltstone and mudstones are mapped as placed during the Jurassic to Cretaceous and therefore are anticipated to be much denser/harder compared with the younger fluvial deposits.

3.2 Seismicity

The closest active fault to the site is the Blue Mountain No. 1, with the active strand located approximately 22 km northeast of the site. The Blue Mountain No. 1 is an approximately 32 km long, northeast-striking reverse fault system situated at the western foothills of the Blue Mountains and has an estimated recurrence interval of 10,000 to 20,000 years (GNS Active Faults Database).

3.3 Third-party Data

ENGEO reviewed the regional data available through the Environment Southland (Beacon). Key geohazards are summarised below:

- The site is mapped within an area assigned a liquefaction risk of '*Low*'. No definition of low is provided by the report referenced within the Beacon GIS website (Glassey, 2006).
- The site is regionally mapped as having a site subsoil classification of '*Class D – Deep Soils'* in accordance with NZS 1170.5:2004.

ENGEO have also completed a review of historical aerial photographs available via Goggle Earth and Retrolens (Retrolens). Photographs were reviewed from the period 1948 through present day and no observable changes in landform were noted other than the current development that is observed in the 1971 photo (Figure 2). Photo 3 shows the existing building and an apparent change in landform colour.

Figure 2: Historical Imagery of the site (Retrolens)

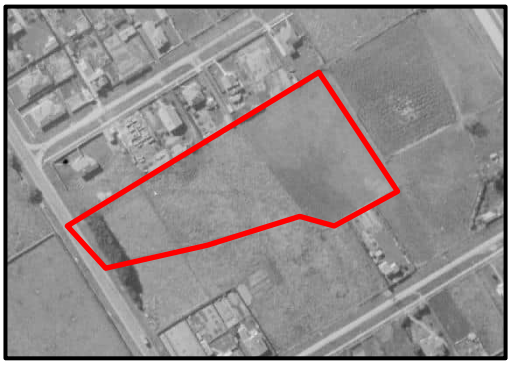


Photo 1: 1948

Photo 2: 1962

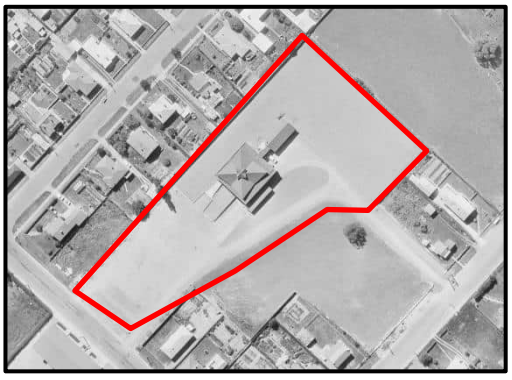


Photo 3: 1971

ENGEO reviewed nearby public site investigation data available on New Zealand Geotechnical Database. Approximately 150 m to the west of the site are two test pits completed on the river side of the flood protection dyke. Both test pits encountered approximately 1 m of silty loess with saturated gravels at depth and a groundwater table at an elevation of approximately 71 m RL.

4 Site Investigation

ENGEO completed a geotechnical site investigation between 13 and 14 February 2023 comprising the following:

- Site walkover to observe and map geomorphological and geological features of interest.
- Completion of three Hand Auger (HA) boreholes to refusal with associated handheld Dynamic Cone Penetrometers (DCPs).
- Monitoring of four sonic boreholes (BH) to 9.5 m bgl with Standard Penetration Tests (SPTs) at 1 m intervals.

ENGEO also completed three short sonic boreholes to 0.9 m bgl for environmental sample collection purposes. Although not part of the geotechnical scope, these were used to inform to the engineering geological model.

Site investigations were observed by an ENGEO Engineering Geologist and logged in accordance with the New Zealand Geotechnical Society (NZGS) field-description of soil and rock guidelines.

Investigation locations are shown in Appendix 1 and investigation logs are included in Appendix 2.

5 Engineering Geological Model

5.1 Site Walkover Results

ENGEO made the following observations during our site walkover:

- The east portion of the site is currently occupied by an approximately 1000 m^2 footprint building. The main portion of the building is double storey with single storey buildings at the front and back of the main building.
- The remaining site area is covered in asphalt with some grassed areas in the northeast corner and southeast corner.
- No surficial indicators for instability were observed by ENGEO nor were any other geological hazards evident.

Typical site photos to provide examples of the landform and existing structures are provided below.

Photo 4: Grassed and asphalt areas of the site looking east.

5.2 Subsurface Geology

ENGEO have characterised three dominant Geological units according to their engineering properties. A summary of these engineering geological units is included in Table 1.

Table 1: Engineering Geological Unit Summary

Geological Unit	Typical Material Description	Density / Consistency[1]	SPT N-Count[2]	Typical thickness (m)
Topsoil / Fill	Organic SILT / Sandy GRAVEL some rubbish, brick and wood fragments	-	-	-[5]
Lacustrine[3]	SILT, some/minor clay	Soft to Stiff	2-10[4]	2.0 – 3.5
Bedrock	Unweathered, weak SILTSTONE / SANDSTONE	Weak	32-50+	-[6]

[1] Consistency / density based on tactile descriptions and SPT N-values.

[2] Minimum and maximum in brackets.

[3] See material description below for explanation of question mark denotation.

[4] The coarse-grained material encountered in HS-ENG23-BH4 between 3.5 to 5.0 m bgl has been disregarded in this assessment.

[5] See Appendix 1 for thickness of fill.

[6] Thickness of bedrock not encountered.

The material encountered in our subsurface investigations is broadly consistent with published mapping (Section 3.1) except for the interpreted Lacustrine which is not mapped at regional scale in this area. Borehole photo logs are provided in Appendix 3, and two interpreted geological cross-sections are provided in Appendix 4.

A brief description of these geological units is as follows:

Topsoil / Fill

This unit typically mantles the site at ground surface. Organic rich topsoil was around 0.2 to 0.3 m below ground surface with fill underneath. Fill was typically observed to be sand and rounded gravels. However, in the northeast corner it was observed to be silt. The Fill was observed by others to contain refuse such as bricks and rubbish (Geosolve, 2022).

Topsoil and Fill have been combined as one material unit as both are deleterious for purposes of the proposed development.

Lacustrine

Underlying the surficial Topsoil / Fill a layer typically 2 – 3.5 m thick of Lacustrine was observed. This unit was typically a firm silt with minor clay. This unit was characterised with a lack of structure and mottling and SPT N-count ranging from 2 - 10. Given the lack of regional characterisation and limited scope of this study, the geological genesis of this unit remains uncertain.

Bedrock

Bedrock was observed in all boreholes underlying the Lacustrine unit but was too deep to be encountered in the previous investigations in 2022 (Geosolve, 2022). Bedrock typically comprised an unweathered weak siltstone with thin disparate layers of fine sand beds. This unit is characterised by its laminated structure and SPT N-counts ranging from 32 to 50+.

5.3 Groundwater

Given the rate of geotechnical investigation drilling and the fine-grained materials observed, stabilised groundwater measurements were not practically achieved in the field as the use of drilling fluids disrupts the localised groundwater regime which takes a significant time to equilibrate. Furthermore, third-party test pitting to 2.3 m bgl did not encounter groundwater. The Mataura River is at approximately elevation 70 – 71 m RL, 150 m to the west of the site and groundwater beneath the site is anticipated be hydraulically connected to the Mataura River. Notwithstanding this, ENGEO have not interpreted a groundwater elevation beneath the site and the local groundwater regime remains uncertain.

6 Geohazard Assessment

Given the results of geotechnical investigations to date ENGEO anticipate the dominant geohazards to the site to be of seismic origin. Seismic hazards resulting from nearby moderate to major earthquakes can generally be classified as primary and secondary. The primary effect is ground rupture, also called surface faulting. The common secondary seismic hazards include ground shaking, regional subsidence or uplift, soil liquefaction, lateral spreading and landslides. The following sections present a discussion of seismic hazards as they apply to the site.

6.1 Ground Rupture

There are no known active faults located within the site. Based on our site walkover and review of relevant publications (Section 3.2) it is our opinion that fault-related ground rupture is unlikely at the site.

6.2 Soil Classification

Based on the investigation results we consider the soil classification in line with NZS 1170.5:2004 to be 'Class C – Shallow Soil' for the purpose of seismic design.

6.3 Ground Shaking

As depicted in the conceptual plans (Kāinga Ora, 2022), ENGEO consider the proposed development structures to be classified under NZS1170.0:2004 as Importance Level 2 buildings. The design peak ground accelerations (PGA) for the site under both ULS SLS design load cases have been adopted from the updated site specific probabilistic seismic hazard assessment (Cubrinovski et al. 2021) Appendix A in MBIE / NSGS Module 1 (2021) and provided in Table 2.

Table 2: Peak Ground Acceleration for Gore

Location	Serviceability Limit State (SLS) $a_{max}(g)$	Ultimate Limit State (ULS) $a_{max}(g)$
Gore	Return Period[1]	
	25 - Year	500 - Year
	0.07	0.27

The effective earthquake magnitude for the Gore area is 6.2.

ENGEO consider the potential for seismic liquefaction to be low due to the fine-grained materials observed to mantle shallow bedrock. This is supported by the regional scale liquefaction assessment (Section 3.3). As such, ENGEO do not consider further investigation of seismic liquefaction to be required.,

7 Geotechnical Recommendations

Based on geotechnical investigation results to date we consider the site located at 29 Hamilton Street, Gore to be suitable for the proposed development from a geotechnical perspective, subject to the recommendations discussed below.

Based on our assessment and subject to the geotechnical recommendations provided in this report being adhered to, we consider that the proposed development is unlikely to be subject to the natural hazards listed under Section 71 of the Building Act, excluding inundation which is to be advised by others.

7.1 Foundation Recommendations

Deep foundations in the form of piles are suitable for the site. Piles can be designed in accordance with NZ Building Code B1/VM4 provided:

- Piles terminate a minimum 3 x pile diameter into Bedrock in accordance with clause 4.1.3 of B1/VM4. Based on the Interpreted Geological Cross Section in Appendix 4. Bedrock is anticipated across the site between 69 and 70 m RL.
- Design adopts the material parameters in Table 3 (Section 7.2).
- It is designed by a Chartered Professional Engineer with experience in deep foundation design.
- Logs of encountered ground conditions are provided by the drilling contractor and are reviewed by the design engineer against assumed design values.

Alternatively, shallow foundations may be suitable for the site subject to further geotechnical input. The main constraints for shallow foundations, should they be progressed, are:

- Unknown extent of Topsoil / Fill across the site. Appendix 1 contains an interpolated depth of Topsoil / Fill, however this should be used with caution as its based upon limited point data. For shallow foundations to be used on site, all uncertified fill or organic material must be removed beneath their footprints.
- The Lacustrine has been logged by ENGEO as soft to stiff which indicates this unit provides less than 100 kPa of Geotechnical Ultimate Bearing Capacity[1]. Standard NZS3604 footings require 300 kPa GUBC and typically proprietary waffle rafts require 200 kPa GUBC, albeit some can withstand as low as 140 kPa[2].

Based on those constraints, should shallow foundations be elected across the site, an engineered gravel raft will be required under building platforms which is subject to detailed geotechnical design once building loads are further understood.

7.2 Geotechnical Design Parameters

We recommend the following geotechnical parameters be used in design of shallow or deep foundations.

[1] Equation 3 of Harwood (2012)

[2] Firth RibRaft Technical Manual (FIR0667). Accessed 21 February 2023.

Table 3: Recommended Geotechnical Parameters for Foundation Design

Geological Unit	Unit Weight (kN/m^3)	Undrained Shear Strength *Su* (kPa)[1]	Youngs Modulus *E* (MPa)[2]
Lacustrine[2]	17	25	4
Bedrock	20	200	17

[1] Estimated based on tactile description in logs, SPTs and Table 5.3 within Look (2007). Lower value used given soft material encountered in HS-ENG23-BH3.

[2] Estimated using Table 5-6 within Bowles (1988) using typical SPT values of each unit.

The geotechnical recommendations summarised above are based on our current understanding of the inferred geological units. These should be re-evaluated based on future data should this become available or during construction should observations differ from those made herein.

7.3 Earthworks

ENGEO anticipates earthworks may be required at the site in the case of:

- Deep foundations - bulk filling of the topographical low point where the existing building is located to achieve a flat level site (see the February 2023 survey in Appendix 1); or
- Shallow foundations - structural engineered fill for filling both the topographical low point (as above) and the proposed gravel rafts (as per Section 7.1).

Requirements of each are detailed below.

7.3.1 Deep Foundations

If deep foundations are elected for the site, then bulk filling does not need to be placed and certified under NZS4431:2022 and undocumented fill may remain in place (from a geotechnical perspective). However, where bulk filling is placed beneath internal roadways forming the subgrade etc., then we recommend this fill be placed in accordance with TNZ F/1:1997.

7.3.2 Shallow Foundations

If shallow foundations are elected for the site, then all earthworks under proposed building foundations shall be completed and certified under the guidance of a suitably qualified and Chartered Engineer in accordance with NZS4431:2022. Requirements for site preparation and fill suitability & compaction will be provided once further assessments are carried out (see Section 7.1), however at this stage we envisage among other requirements (yet to be scoped) that:

- All topsoil and any other unsuitable material shall be over-excavated from beneath the building platforms to exposure *in situ* natural materials and be observed by a suitably qualified geo-professional.
- Fill must be placed and tested under the observation and direction of a suitably qualified geo-professional. The replacement fill must be free of organics, and should be placed, spread and compacted in controlled 200 mm (loose) lifts.

- Earthworks compaction criteria should be adopted based on the fill material used. Cohesive soils should adopt a compaction criterion based on shear strength and air voids. If granular soils are to be adopted, a percentage of Maximum Dry Density (MDD) compaction specification will be required. Subject to final confirmation by the Geotechnical Engineer, normal acceptance criteria is typically 95% of the MDD.

7.4 Temporary Stormwater Control

Control measures should be undertaken to control and treat stormwater runoff, with silt and erosion controls complying with local authority guidelines for erosion and sediment control.

Surface cut-off drains or appropriate stormwater flow paths should be maintained across the site. Drains and impervious surfaces will divert water away from any buildings. Stormwater from paved areas shall be taken in a piped system and disposed of into an approved stormwater system.

7.5 Safety in Design

ENGEO anticipate the primary safety in design considerations are due to the potential for earthworks, required if shallow foundations are to be constructed. Specifically, the dominant hazard is the stability of temporary cuts. This hazard can be eliminated if piles are selected as the foundation concept as bulk earthworks are not required. We can provide safety in design advice as part of the detailed design stages once foundation concepts have been confirmed and earthworks requirements identified.

8 Sustainability

We encourage you to consider sustainability when assessing the options available for your project.

The use of timber pile foundations will reduce earthworks requirements and may significantly reduce the environmental cost of the project. If considering shallow foundation options, minimising the use of concrete, particularly reinforced concrete, is typically the most environmentally friendly option due to the significant amount of carbon released in the manufacturing of cement and processing of steel.

9 Limitations

i. We have prepared this report in accordance with the brief as provided. This report has been prepared for the use of our client, Southbase Construction Limited, their professional advisers and the relevant Territorial Authorities in relation to the specified project brief described in this report. No liability is accepted for the use of any part of the report for any other purpose or by any other person or entity.

ii. The recommendations in this report are based on the ground conditions indicated from published sources, site assessments and subsurface investigations described in this report based on accepted normal methods of site investigations. Only a limited amount of information has been collected to meet the specific financial and technical requirements of the client's brief and this report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it should be appreciated that actual conditions could vary from the assumed model.

iii. Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes.

iv. This Limitation should be read in conjunction with the Engineering NZ / ACENZ Standard Terms of Engagement.

v. This report is not to be reproduced either wholly or in part without our prior written permission.

We trust that this information meets your current requirements. Please do not hesitate to contact the undersigned on (03) 328 9012 if you require any further information.

Report prepared by

Blake Hoare

Engineering Geologist

Report reviewed by

Sam Murray, CMEngNZ (CPEng)

Associate Geotechnical Engineer

10 References

Bowles, J. E. (1988). *Foundation analysis and design (fifth edition).*\

Environment Southland Beacon GIS (https://maps.es.govt.nz/index.aspx?app=natural-hazards&ext=1279478,4883499,1294909,4891076) accessed, 27 February 2023.

Harwood (2012). A Review of Shallow Foundation Design Practice in New Zealand. Inaugural SESOC Biennial Conference *From Theory to Practice, 2-3 November 2012, Auckland.*

GNS Science, New Zealand Geology Web Map, Retrieved 2021, from Geonet: https://data.gns.cri.nz/geology/

GNS Science. Active Faults Database Retrieved 2022, from Geonet: https://data.gns.cri.nz/af/

Geosolve (2022). Preliminary Geotechnical Report, 29 Hamilton Street, East Gore, Southland (220222), dated May 2022.

Kāinga Ora. (2022). Redevelopment Simple Track Brief for 43 – 29 Hamilton Street, East Gore, Gore – 30 September 2022 (Draft Final Version 1.3).

Look, B. G. (2007). *Handbook of geotechnical investigation and design tables*. Taylor & Francis.

Ministry of Business, Innovation, and Employment (2016). New Zealand Geotechnical Database. Retrieved February 2023, from https://www.nzgd.org.nz

Ministry of Business, Innovation, and Employment (2021). Overview of the Geotechnical Guidelines – Earthquake Geotechnical Engineering Practice. Version 1.

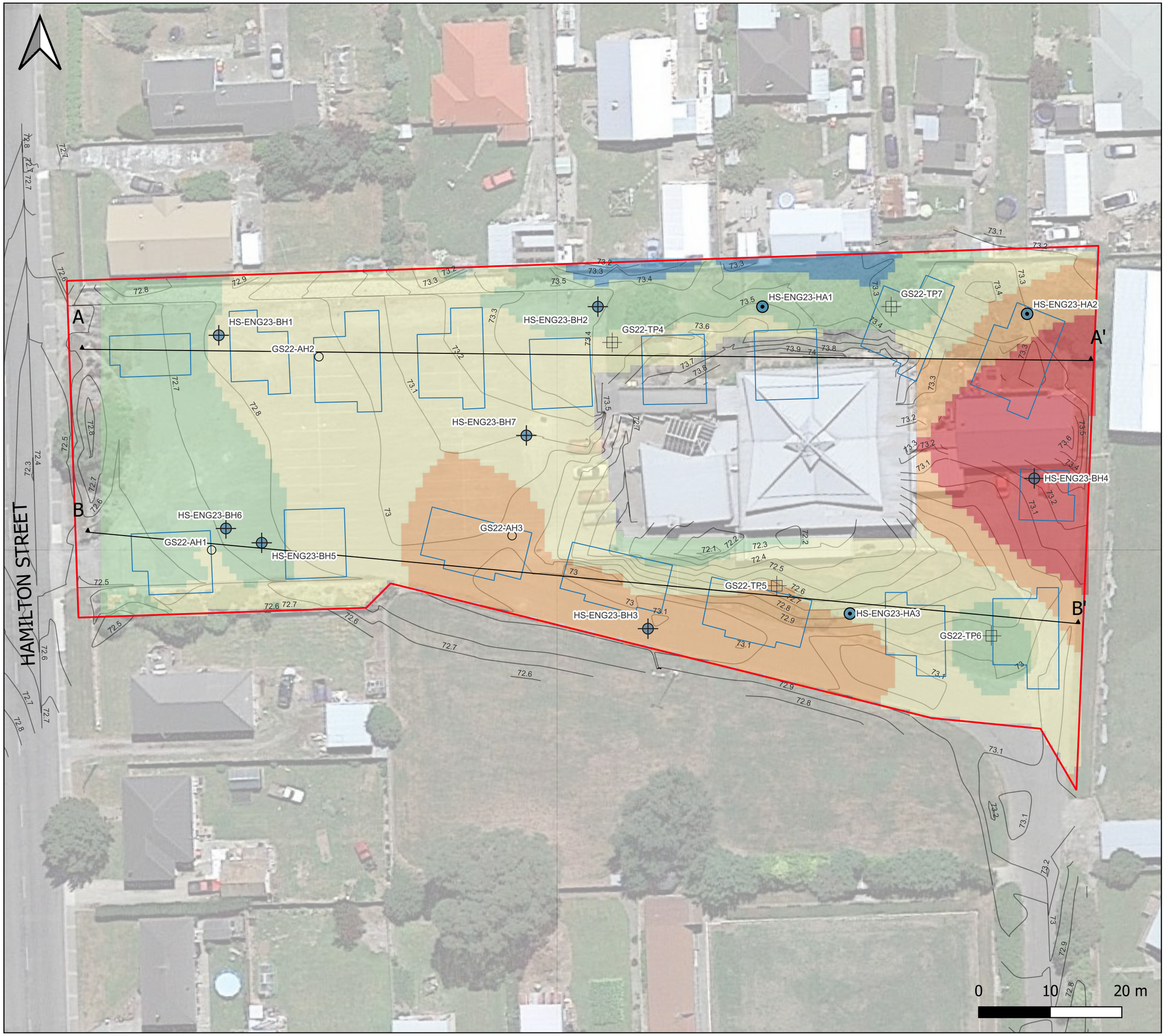
NZS 1170:5:2004: Structural Design Actions – Part 5: Earthquake Actions – New Zealand.

NZS 4431:2022: Engineering Fill Construction for Lightweight Structures.

TNZ F/1:1997. Specification for Earthworks Construction, Transit New Zealand (SP/SF1:970128)

APPENDIX 1:

Test Location Plan



LEGEND

- Interpreted Geological Cross Sections (See Appendix 3)
- Contours (0.5m, Terramark 22/02/2023)
- Proposed Development Layout (Simple Track Brief 30/9/22)
- Site Cadastrial Boundary

Geotechnical Investigation Locations

- Borehole ENGEO
- Hand Auger ENGEO
- Test Pit Others
- Auger Hole Others

Depth of Uncertified Fill (interpolation)

- < 0.5 m
- 0.5 - 1.0 m
- 1.0 - 1.5 m
- 1.5 - 2.0 m
- > 2.0 m

Notes:
There is increased uncertainty with the interpreted thickness of uncertified fill under the existing building, therefore it has been removed. Uncertified fill heatmap more accurate near ground investigation locations.

ENGEO

Background: Google Satelite Imagery

Site Location Plan

Client: Southbase Construction		Appendix No. 1 Size: A3
Project: 29 Hamilton	Drawn: BH	
Date: 06/03/2023	Checked: SM	
Proj No: 21517	Scale: 1:500 @ A3	Version: 1.0

APPENDIX 2:

Investigation Logs

Geotechnical Soil Logging Key

ENGEO borehole and test pit logs are written in general accordance with the New Zealand Geotechnical Society field classification guidelines (2005).
Please refer to this document for the methods of field classification and description for engineering purposes.

Grain Size (mm)

0.06	0.2	0.6	2	6	20	60	200

SILT and CLAY	SAND			GRAVEL			COBBLE	BOULDER
	Fine	Medium	Coarse	Fine	Medium	Coarse		

Additional Info

▼	Standing water level
UTP	Unable to Penetrate
NA	Not Assessed

Graphic Logs

The graphic log shows soil types and their corresponding UCS classification

Granular Soil (>65% of soil >0.06 mm)		Cohesive Soil (>35% of soil <0.06 mm)	
GW	Well graded GRAVEL	MH	High plasticity SILT
GP	Poorly graded GRAVEL	ML	Low plasticity SILT
GM	Silty GRAVEL	CH	High plasticity CLAY
GC	Clayey GRAVEL	CL	Low plasticity CLAY
SW	Well graded SAND		**Organic Soil**
SP	Poorly graded SAND	OH	High Plasticity organic SILT or CLAY
SM	Silty SAND	OL	Low plasticity organic SILT or CLAY
SC	Clayey SAND	PT	Peat
Other Soils			
TS/BTS	Topsoil/ Buried Topsoil	F	Fill

G = Gravel W = Well Graded P = Poorly Graded C = Clay S = Sand M = Silt H = High Plasticity L = Low Plasticity O = Organic

Cohesive Soils - Consistency Index

		Undrained shear strength (kPa)	Field Diagnostic Features
VS	Very Soft	<12	Easily exudes between fingers when squeezed
S	Soft	12 – 25	Easily indented by fingers
F	Firm	25 – 50	Indented by strong finger pressure and can be indented by thumb pressure
St	Stiff	50 – 100	Cannot be indented by thumb pressure
VSt	Very Stiff	100 – 200	Can be indented by thumb nail
H	Hard	200+	Difficult to indent by thumb nail

Moisture Content

D	Dry	Looks and feels dry
M	Moist	Feels cool and darkened in colour and granular soils tend to be cohere
W	Wet	Feels cool and darkened in colour. Granular soils tend to cohere and free water forms when remoulding cohesive soils
S	Saturated	Feels cool, darkened in colour and free water present on the sample

Granular Soils - Density Index

		SPT 'N' Value (blows /300mm)	Scala Penetrometer (blows/100 mm)
VL	Very loose	<4	0 - 2
L	Loose	4 – 10	1 – 3
MD	Medium Dense	10 - 30	3 - 7
D	Dense	30 - 50	7 – 17
VD	Very Dense	<50	>17

Proportional Terms Definition

Fraction	Term	% of Soil	Example
Major	(UPPERCASE)	>50	GRAVEL
Subordinate	(lowercase)y	20 - 50	Sandy
Minor	With some....	12 - 20	With some sand
	With minor....	5 - 12	With minor sand
	With trace....	<5	With trace sand

Soil Structure

Zoning		Cementing	
Layers	Continuous across exposure or sample	Weakly Cemented	Easily broken up by hand in air or water
Lenses	Discontinuous layers of lenticular shape	Moderately cemented	Effort is required to break up the soil by hand in air or water
Pockets	Irregular inclusions of different material		

LOG OF BORING HS-ENG23-BH1

29 Hamilton Street
29 Hamilton Street Gore

22348

Client : Southbase Construction
Date : 15/2/2023
Hole Depth : 9.42 m
Drilling Method : Sonic
Drilling Contractor : Speight

Core Diameter : mm
Energy Transfer Ratio : %
Logged By/Reviewed By : JJ/BH / SM
Latitude : 1287443
Longitude : 4887913

Depth (m BGL)	Material	Sample Type	USCS Symbol	DESCRIPTION	Log Symbol	Elevation (mRL)	Water Level	Moisture	Consistency/ Density Index	SPT N-Value	Torvane Shear (kPa)	Total Core Recovery (%)	Installation
0.0	FILL			SILT with some fine gravel, dark brown, non plastic [FILL]									
0.5				Fine to coarse GRAVEL, with some sand, light grey, homogenous, well graded, rounded. Sand: fine to coarse [FILL]									
1.0	LACUSTRINE?		ML	SILT with some clay, light grey mottled orange, homogenous, firm, high plasticity [LACUSTRINE?]		72		M	Firm	SPT@1.5m 1,1,1,2,2,2 N=7			
1.5													
2.0						71							
2.5													
3.0			ML	SILT, minor organics, trace clay, dark brown, firm, low plasticity. Organics: fibrous wood fragments [LACUSTRINE?]		70			Firm	SPT@3m 0,0,0,0,1,10 N=11			
3.5	BEDROCK			Unweathered, dark brown, laminated, SILTSTONE, very weak [BEDROCK]				D	Hard				
4.0				At 3.70m: thin fine sand band		69							
4.5				At 4.30m: 900 mm of fine to medium SAND, trace silt.				M	Very Dense	SPT@4.5m 3,6,8,8,10,15 N=41			
5.0						68							
5.5													
6.0						67				SPT@6m 3,7,12,18,20 N=50			
6.5													
7.0				At 6.80m: thin band of fine sand		66		D	Hard				
7.5				At 7.30m: laminations faint.						SPT@7.5m 7,7,8,16,20,6 N=50			
8.0						65							
8.5				At 8.60m: Moderately thick layer of fine to medium SAND, trace silt.					Very Dense				
9.0				At 8.80m: Moderately thin layer of organic SILT, trace fine sand. Organics: fibrous wood fragments		64		M	Soft	SPT@9m 10,9,16,10,13,11 N=50			
				At 8.90m: Moderately thick layer of silty fine SAND, greeenish grey, homogenous.					Very Dense				
				End of Hole Depth: 9.42 m Termination: Target depth									

Groundwater observed at collar immediately after drilling, likely drilling water.

Water Level | Date : Time | Hole Depth
1)
2)
3)
4)

ENGEO MACHINE BOREHORE LOG (SOIL) 21517 - GINT MASTER.GPJ NZ DATA TEMPLATE 2.GDT 2/3/23

LOG OF BORING HS-ENG23-BH2

29 Hamilton Street
29 Hamilton Street Gore

22348

Client : Southbase Construction
Date : 15/2/2023
Hole Depth : 9.45 m
Drilling Method : Sonic
Drilling Contractor : Speight

Core Diameter : mm
Energy Transfer Ratio : %
Logged By/Reviewed By : JJ/BH / SM
Latitude : 1287496
Longitude : 4887917

Depth (m BGL)	Material	Sample Type	USCS Symbol	DESCRIPTION	Log Symbol	Elevation (mRL)	Water Level	Moisture	Consistency/ Density Index	SPT N-Value	Torvane Shear (kPa)	Total Core Recovery (%)	Installation
0.0	FILL			SILT, with some fine to medium gravel, some fine sand, brown. Non-plastic [FILL]									
0.5	LACUSTRINE?		ML	SILT, with minor clay, grey mottled orange, homogenous, firm, low plasticity [LACUSTRINE?]		73		M	Firm	SPT@1.5m 1,1,1,2,1,3 N=7			
1.0													
1.5													
2.0						72							
2.5				At 2.70m: becomes clayey SILT, high plasticity, very soft.					Very Soft	SPT@3m 0,0,0,0,4,6 N=10			
3.0						71							
3.5			GW	Fine to coarse GRAVEL, with some sand, grey, homogenous, 'loose', well graded, rounded. Sand: fine to coarse [LACUSTRINE?]		70			'Loose'				
4.0				Unweathered, dark brown with grey banding, laminated, SILTSTONE, very weak [BEDROCK]						SPT@4.5m 3,4,8,9,15,16 N=48			
4.5	BEDROCK					69							
5.0				At 5.20m: moderately thick layer of cemented clasts inclusions									
5.5													
6.0						68				SPT@6m 4,2,8,8,7,9 N=32			
6.5													
7.0						67		D	Hard				
7.5										SPT@7.5m 1,3,3,9,14,22 N=48			
8.0						66							
8.5													
9.0						65				SPT@9m 1,1,6,9,17,18 N=50			

End of Hole Depth: 9.45 m
Termination: Target depth

Hole dipped immediately after 1 hour and two hours after drilling all at 2.1m below collar likely drilling water.

Water Level | Date : Time | Hole Depth
1)
2)
3)
4)

ENGEO MACHINE BOREHORE LOG (SOIL) 21517 - GINT MASTER.GPJ NZ DATA TEMPLATE 2.GDT 2/3/23

LOG OF BORING HS-ENG23-BH3

29 Hamilton Street
29 Hamilton Street Gore

22348

Client : Southbase Construction
Date : 14/2/2023
Hole Depth : 9.45 m
Drilling Method : Sonic
Drilling Contractor : Speight

Core Diameter : mm
Energy Transfer Ratio : %
Logged By/Reviewed By : JJ/BH / SM
Latitude : 1287503
Longitude : 4887872

Depth (m BGL)	Material	Sample Type	USCS Symbol	DESCRIPTION	Log Symbol	Elevation (mRL)	Water Level	Moisture	Consistency/ Density Index	SPT N-Value	Torvane Shear (kPa)	Total Core Recovery (%)	Installation
0.0	FILL			Gravelly fine to coarse SAND, with minor silt, grey, homogenous, well graded. Gravel: fine to coarse, subrounded to sub angular [FILL]		73		M				25 50 75	
1.0						72				SPT@1.5m 1,0,1,1,1,1 N=4			
1.5	LACUSTRINE?		ML	SILT, with some clay, grey, very soft to soft, homogenous, highly plastic [LACUSTRINE?]									
2.0						71		M	Very Soft				
3.0						70				SPT@3m 0,0,0,0,0,2 N=2			
3.5	BEDROCK			Unweathered, dark brown with grey banding, laminated, SILTSTONE, weak [BEDROCK]									
4.0						69		D		SPT@4.5m 2,5,8,8,14,20 N=50			
4.5													
5.0				At 5.20m: thick bed of dark brown / black silt, with medium gravel cemented clast inclusions.		68			Hard				
5.5													
6.0						67		M		SPT@6m 1,1,7,5,15,28 N=50			
6.5													
7.0				Unweathered, grey speckled dark brown, massive, SANDSTONE, very weak. Sand: fine. [BEDROCK]		66							
7.5										SPT@7.5m 2,4,8,12,16,14 N=50			
8.0						65		D	Very Dense				
8.5													
9.0						64				SPT@9m 3,7,11,12,13,14 N=50			

End of Hole Depth: 9.45 m
Termination: Target depth

Groundwater dipped immediately after drilling at 2m below collar - likely drilling water. Collapsed next morning.

Water Level | Date : Time | Hole Depth
1)
2)
3)
4)

ENGEO MACHINE BOREHORE LOG (SOIL) 21517 - GINT MASTER.GPJ NZ DATA TEMPLATE 2.GDT 2/3/23

LOG OF BORING HS-ENG23-BH4

29 Hamilton Street
29 Hamilton Street Gore

22348

Client : Southbase Construction
Date : 14/2/2023
Hole Depth : 9.45 m
Drilling Method : Sonic
Drilling Contractor : Speight

Core Diameter : mm
Energy Transfer Ratio : %
Logged By/Reviewed By : JJ/BH / SM
Latitude : 1287557
Longitude : 4887893

Depth (m BGL)	Material	Sample Type	USCS Symbol	DESCRIPTION	Log Symbol	Elevation (mRL)	Water Level	Moisture	Consistency/ Density Index	SPT N-Value	Torvane Shear (kPa)	Total Core Recovery (%)	Installation
0.5	FILL			Gravelly fine to medium SAND, with minor silt, grey, homogenous. Gravel: fine to coarse, subrounded to sub angular [FILL]		73		D					
1.0													
1.5				Fine to coarse GRAVEL with some sand dark grey. Well graded homogenous. Gravel: sub rounded to sub angular [FILL]		72				SPT@1.5m 2,3,2,2,2,4 N=10			
2.0													
2.5				At 2.8m: becomes red brown		71		M					
3.0										SPT@3m 5,8,9,7,7,7 N=30			
3.5						70							
4.0	LACUSTRINE?		GW	Fine to coarse sandy fine to coarse GRAVEL, with some silt, light grey, homogenous, well-graded. Gravel sub rounded to sub-angular [LACUSTRINE?]				W	Dense				
4.5						69				SPT@4.5m 6,8,9,8,8,8 N=33			
5.0	BEDROCK			Unweathered, grey, massive, SILTSTONE, very weak [BEDROCK]									
5.5						68							
6.0										SPT@6m 6,6,10,18,20,2 N=50			
6.5						67							
7.0								M	Hard				
7.5						66				SPT@7.5m 2,5,8,12,20,10 N=50			
8.0													
8.5						65							
9.0										SPT@9m 2,4,6,14,19,7 N=50			

End of Hole Depth: 9.45 m
Termination: Target depth

Groundwater dipped immediately after drilling at 1.8m below collar - likely drilling water. Collapsed next morning

Water Level | Date : Time | Hole Depth
1)
2)
3)
4)

ENGEO MACHINE BOREHORE LOG (SOIL) 21517 - GINT MASTER.GPJ NZ DATA TEMPLATE 2.GDT 2/3/23

LOG OF BORING HS-ENG23-BH5

29 Hamilton Street
29 Hamilton Street Gore

22348

Client : Southbase Construction
Date : 15/2/2023
Hole Depth : 0.9 m
Drilling Method : Sonic
Drilling Contractor : Speight

Core Diameter : mm
Energy Transfer Ratio : %
Logged By/Reviewed By : JJ/BH / SM
Latitude : 1287449
Longitude : 4887884

Depth (m BGL)	Material	Sample Type	USCS Symbol	DESCRIPTION	Log Symbol	Elevation (mRL)	Water Level	Moisture	Consistency/ Density Index	SPT N-Value	Torvane Shear (kPa)	Total Core Recovery (%) 25 50 75	Installation
	FILL			Silty fine to coarse SAND, minor fine to medium gravel, grey. Gravel: rounded. [FILL]				D					
0.5				0.50m: brick fragments.									
	LACUSTRINE?		ML	SILT, some clay, grey, homogenous, 'firm', high plasticity [LACUSTRINE?]				M	Very Soft to Soft				
				End of Hole Depth: 0.9 m Termination: Target depth									

Groundwater not encountered.

Water Level | Date : Time | Hole Depth
1)
2)
3)
4)

LOG OF BORING HS-ENG23-BH6

29 Hamilton Street
29 Hamilton Street Gore

22348

Client : Southbase Construction
Date : 15/2/2023
Hole Depth : 0.9 m
Drilling Method : Sonic
Drilling Contractor : Speight

Core Diameter : mm
Energy Transfer Ratio : %
Logged By/Reviewed By : JJ/BH / SM
Latitude : 1287444
Longitude : 4887886

Depth (m BGL)	Material	Sample Type	USCS Symbol	DESCRIPTION	Log Symbol	Elevation (mRL)	Water Level	Moisture	Consistency/ Density Index	SPT N-Value	Torvane Shear (kPa)	Total Core Recovery (%) 25 50 75	Installation
0	FILL			Silty fine to coarse SAND, minor fine to medium gravel, grey. Gravel: rounded [FILL]				D					
0.5				0.50m: brick fragments.									
	LACUSTRINE?		ML	SILT, some clay, grey, homogenous, 'firm', high plasticity [LACUSTRINE?]				M	Very Soft to Soft				

End of Hole Depth: 0.9 m
Termination: Target depth

Groundwater not encountered.

Water Level | Date : Time | Hole Depth
1)
2)
3)
4)

LOG OF BORING HS-ENG23-BH7

29 Hamilton Street
29 Hamilton Street Gore

21517

Client : Southbase Construction
Date : 15/2/2023
Hole Depth : 0.9 m
Drilling Method : Sonic
Drilling Contractor : Speight

Core Diameter : mm
Energy Transfer Ratio : %
Logged By/Reviewed By : JJ/BH / SM
Latitude : 1287486
Longitude : 4887899

Depth (m BGL)	Material	Sample Type	USCS Symbol	DESCRIPTION	Log Symbol	Elevation (mRL)	Water Level	Moisture	Consistency/ Density Index	SPT N-Value	Torvane Shear (kPa)	Total Core Recovery (%) 25 50 75	Installation
0.5	FILL			Silty fine to coarse SAND, minor fine to medium gravel, grey. Gravel: rounded [FILL]		73		D					

End of Hole Depth: 0.9 m
Termination: Target depth

Groundwater not encountered.

Water Level | Date : Time | Hole Depth
1)
2)
3)
4)

ENGEO

Hand Auger Log

Client: Southbase Construction
Project: 29 Hamilton Street
Location: 29 Hamilton Street Gore
Project Number: 22348

Hole I.D:
HS-ENG23-HA1

Method: Hand Auger
Contractor: ENGEO
Operator: ENGEO
Equipment: Hand Auger/Shovel
Hole Size: 50 mm
Vane Number: n/a

Coordinates E: 1287519
(NZTM) N: 4887917
Elevation (mRL): 73.8
Elevation Datum: NZTM

Total Depth: 0.5 m
Survey Method: Gore 0.5 urban Contours
Start Date: 14/2/2023
Finish Date: 14/2/2023
Logged By: JJ/BH
Reviewed By: SM

Elevation (mRL)	Geological Unit	DESCRIPTION (SOIL: Classification, colour, consistency / density, moisture, plasticity, additional features (grain size, roundness, composition etc. as applicable))	Depth (m BGL)	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density	Sample	Testing / Additional Comments
	FILL/TOPSOIL	SILT, minor fine sand, minor organics, light brown, non plastic. Organics: rootlets [TOPSOIL]							
73.5		SILT, some fine to medium gravels, tracet rootlets, brown, non plastic [FILL]				D			
		SILT, minor fine sand, light brown mottled orange, non plastic [FILL]							
		End of Hole Depth: 0.5 m Termination Condition: Practical refusal	0.5						

Dynamic Cone Penetrometer

Blows per 100mm

2 4 6 8 10 12

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>>
>>
>>
>>

Groundwater not encountered.

ENGEO

Hand Auger Log

Client: Southbase Construction
Project: 29 Hamilton Street
Location: 29 Hamilton Street Gore
Project Number: 22348

Hole I.D:
HS-ENG23-HA2

Method: Hand Auger
Contractor: ENGEO
Operator: ENGEO
Equipment: Hand Auger/Shovel
Hole Size: 50 mm
Vane Number: n/a

Coordinates E: 1287556
(NZTM) N: 4887916
Elevation (mRL): 73.8
Elevation Datum: NZTM

Total Depth: 0.5 m
Survey Method: Gore 0.5 urban Contours
Start Date: 14/2/2023
Finish Date: 14/2/2023
Logged By: JJ/BH
Reviewed By: SM

Elevation (mRL)	Geological Unit	DESCRIPTION (SOIL: Classification, colour, consistency / density, moisture, plasticity, additional features (grain size, roundness, composition etc. as applicable))	Depth (m BGL)	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density	Sample	Testing / Additional Comments
		SILT, minor fine sand, minor organics, light brown, non plastic. Organics: rootlets [TOPSOIL]							
73.5	FILL/TOPSOIL	Fine sandy SILT, brown, homogenous, non plastic [FILL]				D			
			0.5						
		End of Hole Depth: 0.5 m Termination Condition: Practical refusal							

Dynamic Cone Penetrometer

Blows per 100mm

2 4 6 8 10 12

>>
>>
>>
>>

Groundwater not encountered.

ENGEO

Hand Auger Log

Client: Southbase Construction
Project: 29 Hamilton Street
Location: 29 Hamilton Street Gore
Project Number: 22348

Hole I.D:
HS-ENG23-HA3

Method: Hand Auger Contractor: ENGEO Operator: ENGEO Equipment: Hand Auger/Shovel Hole Size: 50 mm Vane Number: n/a	Coordinates E: 1287531 (NZTM) N: 4887874 Elevation (mRL): 73 Elevation Datum: NZTM	Total Depth: 0.5 m Survey Method: Gore 0.5 urban Contours Start Date: 14/2/2023 Finish Date: 14/2/2023 Logged By: JJ/BH Reviewed By: SM

Elevation (mRL)	Geological Unit	DESCRIPTION SOIL: Classification, colour, consistency / density, moisture, plasticity, additional features (grain size, roundness, composition etc. as applicable)	Depth (m BGL)	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density	Sample	Testing / Additional Comments	Dynamic Cone Penetrometer Blows per 100mm 2 4 6 8 10 12
	FILL/TOPSOIL	SILT, minor fine sand, minor organics, light brown, non plastic. Organics: rootlets [TOPSOIL]								
		Fine sandy SILT, brown, homogenous, non plastic [FILL]				D				
		At 0.45m: brown mottled orange.								
72.5		End of Hole Depth: 0.5 m Termination Condition:	0.5							

No DCP undertaken due to proximity of underground services.

Groundwater not encountered.

APPENDIX 3:

Borehole Photo Logs

HS-ENG23-BH1, Box 1 : 0.0 – 2.7 m

HS-ENG23-BH1, Box 2 : 2.7 – 5.6 m

ENGEO Expect Excellence	**Geotechnical Investigation** **Borehole Photos** **HS-ENG23-BH1**	Client: Southbase Construction		Page No: 1
		Project: 29 Hamilton Road, Gore Date Drilled: 14/2/2023	Drawn: BH	
			Checked:	Size: A4
		Proj No: 22348	Scale: NTS	Revision: 0

HS-ENG23-BH1, Box 3 : 5.6 – 8.6 m

HS-ENG23-BH1, Box 4 : 8.6 –9.42 m

ENGEO Expect Excellence	**Geotechnical Investigation** **Borehole Photos** **HS-ENG23-BH1**	Client: Southbase Construction		Page No: 2
		Project: 29 Hamilton Road, Gore Date Drilled: 14/2/2023	Drawn: BH Checked:	Size: A4
		Proj No: 22348	Scale: NTS	Revision: 0

HS-ENG23-BH2, Box 1 : 0 – 3.45 m

HS-ENG23-BH2, Box 2 : 3.45 – 5.76 m

ENGEO Expect Excellence	**Geotechnical Investigation** **Borehole Photos** **HS-ENG23-BH2**	Client: Southbase Construction	Page No: 1
		Project: 29 Hamilton Road, Gore Date Drilled: 14/2/2023	Drawn: BH Checked:
		Proj No: 22348	Scale: NTS
			Size: A4 Revision: 0

HS-ENG23-BH2, Box 3 : 5.75 – 8.3 m

HS-ENG23-BH2, Box 4 : 8.3 –9.45 m

ENGEO Expect Excellence	**Geotechnical Investigation** **Borehole Photos** **HS-ENG23-BH2**	Client: Southbase Construction	Page No: 2
		Project: 29 Hamilton Road, Gore Date Drilled: 14/2/2023	Drawn: BH Checked:
		Proj No: 22348	Scale: NTS
			Size: A4 Revision: 0

HS-ENG23-BH3, Box 1 : 0 to 3.45m

HS-ENG23-BH3, Box 2 : 3.45 to 6.0 m

ENGEO Expect Excellence	**Geotechnical Investigation** **Borehole Photos** **HS-ENG23-BH3**	Client: Southbase Construction	Page No: 1
		Project: 29 Hamilton Road, Gore Date Drilled: 13/2/2023	Drawn: BH Checked:
		Proj No: 22348	Scale: NTS
			Size: A4 Revision: 0

HS-ENG23-BH3, Box 3 : 6.0 to 8.6 m

HS-ENG23-BH3, Box 4 : 8.6 to 9.45 m

ENGEO Expect Excellence	**Geotechnical Investigation** **Borehole Photos** **HS-ENG23-BH3**	Client: Southbase Construction		Page No: 2
		Project: 29 Hamilton Road, Gore Date Drilled: 13/2/2023	Drawn: BH Checked:	Size: A4
		Proj No: 22348	Scale: NTS	Revision: 0

HS-ENG23-BH4, Box 1 : 0.0 – 2.65 m

HS-ENG23-BH4, Box 2 : 2.65 – 4.95 m

ENGEO Expect Excellence	**Geotechnical Investigation** **Borehole Photos** **HS-ENG23-BH4**	Client: Southbase Construction	Page No: 1
		Project: 29 Hamilton Road, Gore Date Drilled: 13/2/2023	Drawn: BH Checked:
		Proj No: 22348	Scale: NTS
			Size: A4 Revision: 0

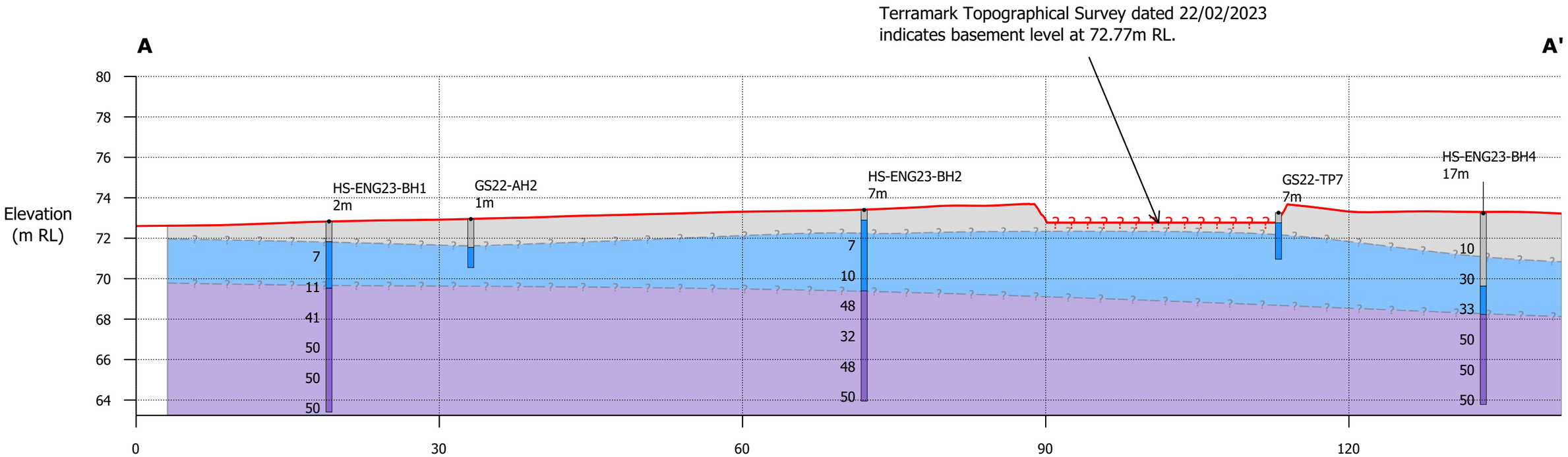
HS-ENG23-BH4, Box 3 : 4.95 – 7.05 m

HS-ENG23-BH4, Box 4 : 7.05 to 9.45 m

ENGEO Expect Excellence	**Geotechnical Investigation** **Borehole Photos** **HS-ENG23-BH4**	Client: Southbase Construction	Page No: 2
		Project: 29 Hamilton Road, Gore Date Drilled: 13/2/2023	Drawn: BH Checked:
		Proj No: 22348	Scale: NTS
			Size: A4 Revision: 0

APPENDIX 4:

Interpreted Geological Cross Sections



Legend

Existing Ground Surface (Terramark 22/2/2023)

Interpreted Geological Units

BEDROCK
LACUSTRINE?
FILL/TOPSOIL

Surfaces

Inferred Geological Boundary

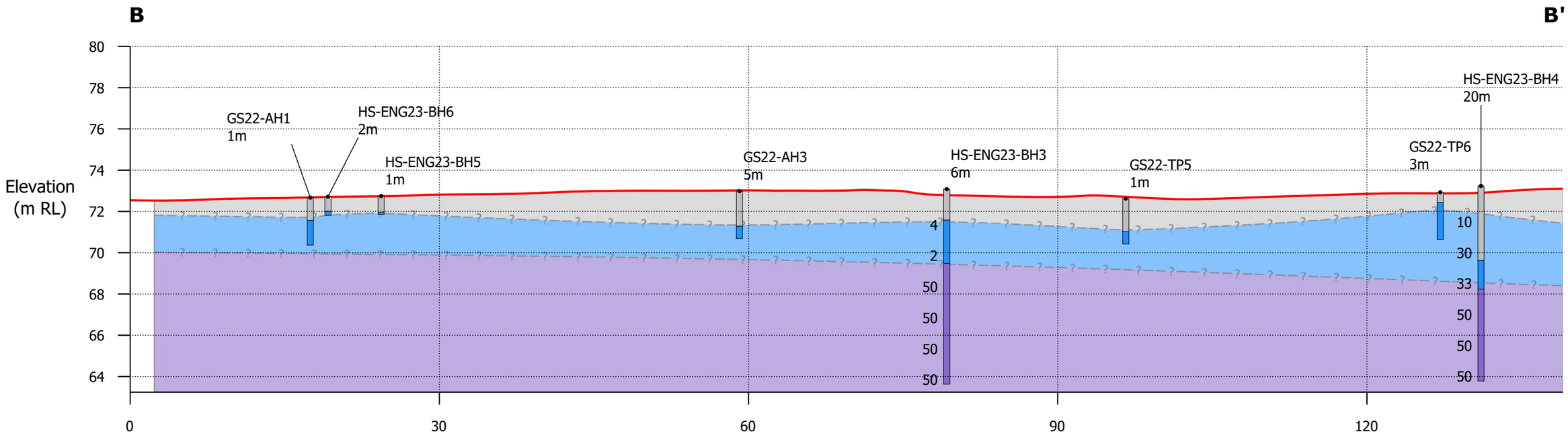
Note:
1. SPTs N numbers shown on left of boreholes

Scale: 1:400

Vertical exaggeration: 2x

0m 50m

Responsible dept.	Technical reference	Creator	Approved by	
Queenstown	22348	BLH	SM	
Legal owner: ENGEO		Document type: Cross Section	Document status: Issue	
		Title: Interpreted Geological Cross Section A-A'	Identification number: Appendix 4	
			Rev.: 0 / Date of issue: 02/03/2023	Sheet



Legend

Existing Ground Surface (Terramark 22/2/2023)

Interpreted Geological Units

- BEDROCK
- LACUSTRINE?
- FILL/TOPSOIL

Surfaces

Inferred Geological Boundary

Note:
1. SPTs N-values shown on left of boreholes

Scale: 1:400

Vertical exaggeration: 2x

0m 50m

Responsible dept.	Technical reference	Creator	Approved by	
Queenstown	22348	BLH	SM	

Legal owner	Document type	Document status	
ENGEO	Cross Section	Issue	
	Title: Interpreted Geological Cross Section B-B'	Identification number: Appendix 4	
		Rev.: 0	Date of issue: 02/03/2023	Sheet: