Before the Independent Commissioners

Under	the Resource Management Act 1991
In the matter of	a hearing on submissions on the proposed Te Tai o Poutini Plan Topic 20: Settlement Zone and its Precincts Submitter: **Russell Robinson** and **Brunner Builders Limited (S515)**

Statement of Evidence of Helen Christina Kellett

(Geotechnical Assessment)

18 March 2024

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Qualifications and experience

1 My full name is Helen Christina Kellett.

2 I have 11 years' experience as a professional Engineering Geologist and 4.5 years' experience as a professional Environmental Scientist.

3 I am currently employed as Environmental Scientist and Senior Engineering Geologist at Wiley Geotechnical Ltd. (**WGL**) and have held that position since 1 November 2019.

4 My previous work experience includes Geotechnical Site Investigations and Hazard Assessments for land developments of a similar scale to that proposed by the rezoning at Lot 1 DP2820 and Pt RS3806, Arnold Valley Road, Moana (**Site**).

5 This evidence is provided in support of the submission by Russell Robinson and Brunner Builders Limited seeking to rezone the Site from notified Settlement Zone and Rural Residential Precinct to a mix of Settlement Zone and Settlement Zone with Settlement Centre Precinct, subject to an Outline Development Plan (**ODP**), through the Proposed Te Tai o Poutini Plan (**TTPP**).

6 My role has been to provide geotechnical investigation and assessment of the site in relation to the proposed residential and commercial development.

7 I have visited the site and am familiar with the site and area.

8 In preparing this statement of evidence I have considered the following documents:

(a) Submission of Russell Robinson and Brunner Builders Limited;

(b) New Zealand Active Fault Database, maintained by Institute of Geological and Nuclear Sciences Limited (**GNS**), retrieved from https://data.gns.cri.nz/af/

(c) Nathan, S.; Rattenbury, M.S.; Suggate, R.P. (compilers) 2002: Geology of the Greymouth area: scale 1:250,000. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences 1:250,000 geological map 12. 58 p

(d) New Zealand Geotechnical Society and The Ministry of Business, Innovation, and Employment (2016). Earthquake geotechnical engineering practice. Module 1: Overview of the guidelines. Rev0. Issue date March 2016.;

(e) Standards Association of New Zealand (2004). Structural Design Actions, Part 5: Earthquake Actions – New Zealand, NZS 1170.5:2004. Standards New Zealand, Wellington.

9 In preparing this statement of evidence I have considered the following planning provisions:

(a) Te Tai o Poutini District Plan (notified June 2022) (**TTPP**)

(b) The Resource Management Act 1991 (**RMA**)

(c) The proposed minor amendments to the TTPP to accommodate the Moana North ODP and area specific provisions attached at Attachment 1 to the Statement of Evidence of Craig Barr dated 18 March 2024.

Code of Conduct for Expert Witnesses

10 While this is not a hearing before the Environment Court, I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court of New Zealand Practice Note 2023 and that I have complied with it when preparing my evidence. Other than when I state I am relying on the advice of another person, this evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Scope of evidence

11 I have prepared evidence in relation to the geotechnical suitability of the site for the proposed rezoning from notified Settlement Zone and Rural Residential Precinct to a mix of Settlement Zone and Settlement Zone with Settlement Centre Precinct, subject to an ODP.

Summary of Assessment

12 I was requested by Brunner Builders Ltd to provide a Geotechnical Investigation Report including geotechnical hazard assessment to accompany a re-zoning plan change request made on the Grey District Plan (**Attachment 1**). That plan change request sought rezoning from rural to residential, while the rezoning through this TTPP process seeks an increased residential density, with some allowance for commercial activity. The conclusions in my report remain relevant to the rezoning sought in this process. In summary my report states the following:

(a) The geotechnical site investigation indicates that the general stratigraphy of the ground underlying the site comprises topsoil,

underlain by silty and sandy gravel up to 1.6 m below existing ground level (bgl), further underlain by sandy gravel to at least 2.5 m bgl. Based on my observations and the geological map published by GNS (Nathan et al. 2002) the site is underlain by sand and gravel glacial till deposits overlying the O'Keefe Formation, which is part of the Blue Bottom Group.

(b) Standing water was encountered between 1.4 m and 1.7 m bgl in four out of 18 test locations. Given the location of the site and its elevation above Lake Brunner and the Arnold Valley, it is considered that the standing water encountered is likely to be perched water and that true groundwater level is likely to be at a similar elevation to Lake Brunner and the Arnold River.

(c) Based on published geologic mapping and nearby and on-site soil testing, in line with NZS 1170.5:2004, we consider the soil classification to be 'Class D – Deep or Soft Soil'.

(d) The risk of land damage as a result of liquefaction occurring at the site in a future severe earthquake event is assessed to be low. The reasons for this include:

    (i) The composition and density of the gavel layers underlying topsoil generally indicates the material is unlikely to be liquefiable. Glacial till sediments, similar to those encountered in our on-site test locations, have a low probability of liquefaction;

    (ii) Groundwater is indicated to be relatively deep, generally the soil material above the groundwater table is non-liquefiable.

(e) The site is assessed to be at low risk of geotechnical hazards. The reasons for this include:

    (i) As under the Grey Operative District Plan, there are no natural hazard overlays that apply to the site. Mapped natural hazards include earthquake, landslide and flood hazards. I have also reviewed the notified TTPP mapping and note that there are no notified natural hazard overlays applying to the site either. The notified TTPP includes various 'Hazards and Risks' overlays

relating to tsunami,[1] floods,[2] Land Instability, coastal,[3] earthquakes[4] and specific overlays for Westport and Hokitika Hazards.

(ii) Based on aerial photography and our site observations, there is no obvious land instability at the site. Slopes and are well vegetated which helps to maintain the stability of steep slopes.

(iii) I expect minimal, if any, land surface settlement within the former landfill area. Owing to the length of time since landfill operations ceased, I expect the majority of land surface settlement to have already occurred. However, owing to the nature of the fill material in the landfill area, it is considered prudent to restrict building and earthworks activities over the landfill area. This matter would be considered at subdivision stage in accordance with NZS 4404: 2010 Land Development and Subdivision infrastructure.

(iv) The GNS New Zealand Active Fault Database, indicates there are no known active faults on or near the site. The current nearest active fault is the Alpine Fault located approximately 13.2 km to the east of the site. Further to the south, the Hope Fault is an active fault located approximately 17.5 km from the site. Since there are no known active faults crossing the property, it is our opinion that ground rupture is unlikely at the site.

(v) Based on the findings of the geotechnical investigation, the current ground surface is not considered to be presently subject to erosion, subsidence, falling debris, slippage or inundation by soil or rock in accordance with the provision of Section 106 of the Resource Management Act 1991.

13 Geotechnical recommendations provided in the attached report are based on ground conditions indicated from published sources, site observations and subsurface investigations described in this report, based on accepted normal methods of site investigations. Variations in ground conditions may exist between test locations and therefore have not been taken into account

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[1] Coastal Tsunami Hazard and Lake Tsunami.

[2] Flood Plain, Flood Hazard Susceptibility, Flood Hazard Severe.

[3] Coastal Hazard Severe, Coastal Hazard Alert, Coastal Setback.

[4] Earthquake Hazard Overlay 20m, 50m, 100m, 150m and 200m.

in the report. Additional investigation and analysis should be undertaken at building consent stage to confirm soil conditions are as expected. I consider these matters can be dealt with at the time of subdivision and residential development.

TTPP Provisions

14 I consider that the proposed re-zoning is geotechnically suitable for compliance with Subdivision Policies Clause SUB- P1 to SUB - P9. Should an application for subdivision of the site be submitted, I would expect that subdivision plans including the proposed earthworks plans would be reviewed by a Geotechnical Engineer, who is familiar with the geological conditions of the site. The TTPP requires this via matter of control (e) which adopts the requirements of NZS 4404: 2010 Land Development and Subdivision infrastructure, in Rule SUB-R6 which will also apply to subdivision and development of the Site under the Moana North ODP.

15 Should the proposed re-zoning proceed, and the proposed TTPP amendment (Attachment 1 to Mr Barr's evidence) be accepted and implemented, I consider that the TTPP provisions are sufficient to provide controls over the following geotechnically relevant matters of subdivision development, as set out in clauses SUB – R6 e., SUB – R7 c. and SUB – S2:

(a) NZS 4404: 2010 Land Development and Subdivision Infrastructure,

(b) natural hazards in accordance with the provision of Section 106 of the Resource Management Act 1991,

(c) subdivision earthworks,

(d) and the stated requirements for building platforms.

Conclusion

16 Based on available published geotechnical data and my on-site observations and testing, I consider the site to be geotechnically suitable for re-zoning from notified Settlement Zone and Rural Residential Precinct to a mix of Settlement Zone and Settlement Zone with Settlement Centre Precinct, subject to an ODP, and for future subdivision accordance with the provision of Section 106 of the Resource Management Act 1991.

Helen Christina Kellett

Dated this 18th day of March 2024

Geotechnical Investigation Report

Lot 1 DP2820 and Pt RS 3806
Arnold Valley Road
Moana

Submitted to:

Brunner Builders Ltd.
100 Main South Road
Karoro
Greymouth 7805

Wiley Geotechnical Ltd.
Level 1, 61 Cambridge Terrace, Christchurch
PO Box 21171, Edgeware, Christchurch 8143

Contents

1 Executive Summary

Wiley Geotechnical Limited (WGL) was requested by Brunner Builders Ltd. to provide a geotechnical investigation at Lot 1 DP2820 and Pt RS 3806, Arnold Valley Road, Moana, West Coast, for the proposed Plan Change from Rural to Residential land zoning. The results of our desktop study and geotechnical assessment are documented in this report. Our findings and conclusions are summarised in the table below:

Table 1: Summary of Findings

Site Sub-soil Conditions			
GNS mapped geology:	Glacial Till	**Soil Classification (NZS 1170.5:2004)**	Class 'D'
Groundwater Level:	Varies across the site. Standing / perched water encountered from 1.3 m depth.		
Natural Hazards			
Flooding and Coastal Erosion:	Located outside known flood hazard and coastal erosion hazard areas.		
Land Instability:	No obvious land instability at the site.		
Seismicity:	No active faults on site. The nearest active fault is the Alpine Fault, 13.2 km east of the site.		
Seismic Assessment			
Liquefaction Risk Potential:	Low		
Lateral Spread Risk:	Low		
Design PGA (ULS)	0.46 g	**Design PGA (SLS)**	0.12 g
Effective Earthquake Magnitude (ULS)	M_w 6.8	**Effective Earthquake Magnitude (SLS)**	M_w 6.2
Geotechnical Recommendations			
The site is considered geotechnically suitable for the proposed re-zoning from Rural to Residential. If the site is to be subdivided, a Subdivision Plan and proposed earthworks plans should be reviewed by the Project Geotechnical Engineer.			

2 Introduction

At the instruction of Brunner Builders Ltd, we have undertaken a site-specific geotechnical investigation at Lot 1 DP2820 and Pt RS 3806, Arnold Valley Road, Moana. The purpose of this report is to support your application for a Plan Change to change the zoning of the land from Rural to Residential.

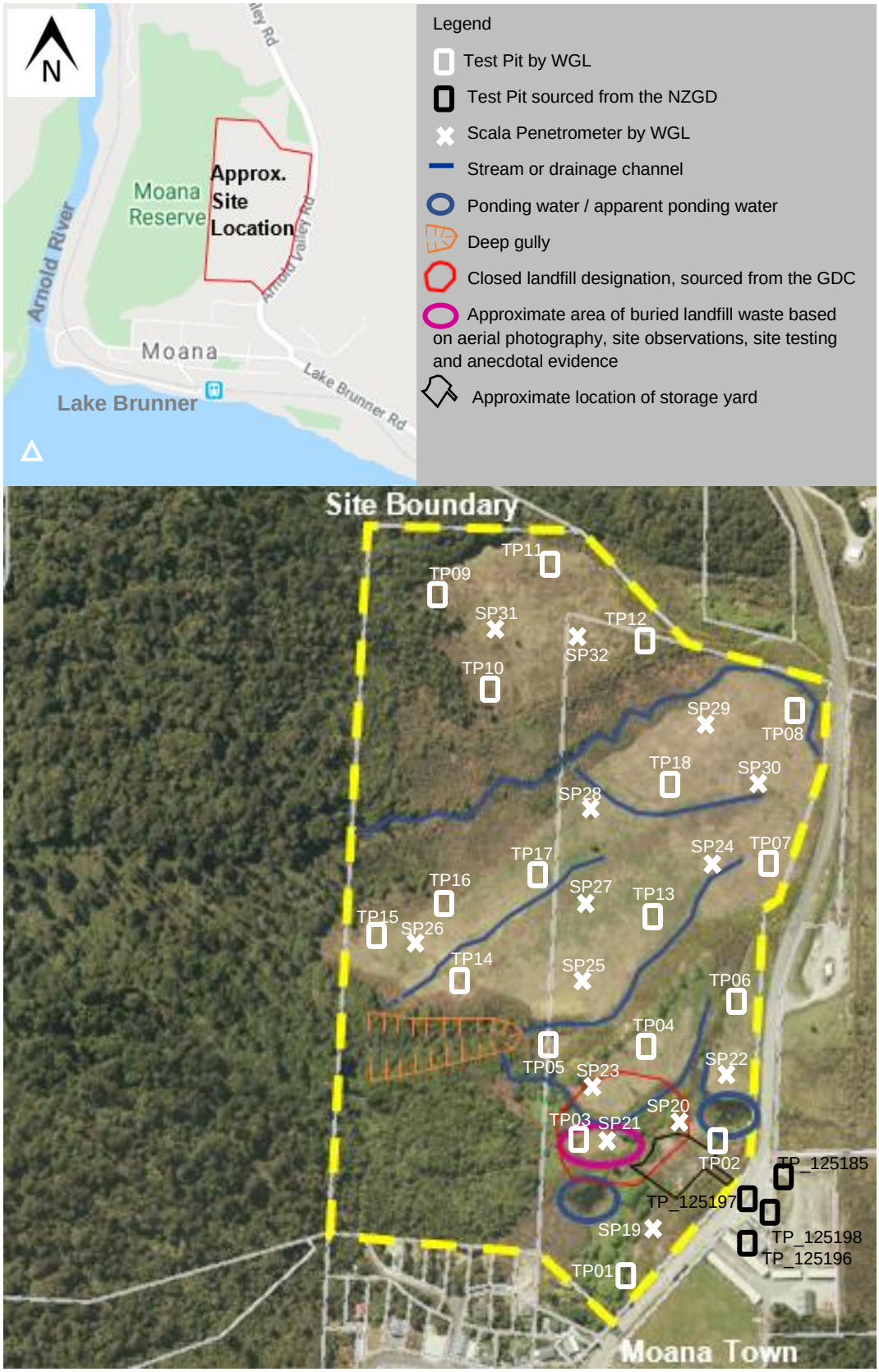
3 Site Layout

Table 2: Site Layout Summary

Site Area:	26.7 Ha
Topography:	Terraced – the majority of the site is made up of flat to gentle (0^0 to 5°) terraces of differing elevations. There is one steep gully of an unknown slope angle (owing to limited access) on the south western side of the site. A second, apparent (based on aerial photography), steep gully of an unknown slope angle (owing to no access) appears to be present on the north western side of the site.
Site/Area Description:	The site is located immediately north of Moana township, approximately 480 m north of Lake Brunner and approximately 500 m east of the Arnold River.

A site location plan is presented in figure 1.

Figure 1: Site Location Plan



Images sourced from Google Maps and Westmaps

4 Local Geotechnical Information

4.1 Geology

The GNS map (Nathan et al. 2002) for the site indicates that it is underlain by dominantly gravel and sand glacial till deposits overlying the O'Keefe Formation, which is part of the Blue Bottom Group.

4.2 New Zealand Geotechnical Database

WGL has reviewed nearby subsurface data available on the New Zealand Geotechnical Database (NZGD), listed in table 3 and presented in figure 1.

Table 3: Nearby sub-surface data

NZGD Identifier	Distance from site	Depth (m)
TP_125185	40 m east	2.2
TP_125196	45 m east	1.8
TP_125197	21 m east	1.7
TP_125198	45 m east	2.0

The nearby Test Pits located to the east of the site indicate medium dense to very dense gravel fill and asphalt overlay from the surface to 0.6 m depth, underlain by medium dense to dense gravel with occasional sand layers to 2.2 m depth. Test Pit TP_125196 encountered peat material immediately below the surficial fill layer from 0.4 m to 0.9 m depth, underlain by medium dense to very dense gravel to between 1.7 m and 2.2 m depth.

5 Historic Aerial Photographs

We have reviewed historical aerial photographs, through Retrolens.nz and Google Earth, dating back to 1943. These photographs were viewed with the intention of identifying changes to landform and structures at the site. We have summarised our observations related to the geotechnical aspects of site development in Table 1:

Table 1: Summary of Historical Aerial Photographs

Date	Description
1943	The site and surrounding area were largely undeveloped, with the western edges and south western portion of Lot 1 DP2820 being heavily vegetated with forest. Development related to Moana township begins approximately 250 m south of the site.
1953	The site and surrounding area were largely undeveloped. A north trending, linear section of land has been cleared to the north of the north eastern corner of lot Pt RS 3806.
1962	Straightening of Arnold Valley Road had begun at the north eastern boundary of the site and an access road had been driven east to west across the site into the edge to the forest, on the north west side of Lot 1 DP2820, where material removed for road construction appears to have been stockpiled. A line of trees had been planted adjacent to a northeast to south west trending terrace, approximately 350 m from the south boundary of the site, across Pt RS 3806, with land cleared of vegetation to the south of the trees, and an east to west access track had been driven across the south side of Pt RS 3806.
1968	Developments relating to Moana township appear to begin adjacent to the site. There is a small excavation to the north of the north eastern site boundary. This may have been a small quarry.
1973	Earthworks and/or clearing of vegetation had been undertaken on the south eastern side of Pt RS 3806 between the south boundary and a south east to north west trending gully, approximately 180 m from the south boundary, adjacent to a bend in Arnold Valley Road. There may have been a building constructed at the site, on the south eastern side of Pt RS 3806. The remainder of the site appears undeveloped.
1982	Several ancillary buildings were present on the south side of Pt RS 3806 and a cattle stop or similar appears to have been installed. Further vegetation clearance had taken place, back to the eastern edge of a south east to north west trending gully, approximately 180 m from the south boundary, on the south side of Pt RS 3806. An unknown material had been stockpiled on the south eastern side of the site adjacent to the gully; this may be landfill material. Earthworks and/or clearing of vegetation had also taken place north of the gully, however; the extent of this clearance is unknown as imagery of the north eastern side of Pt RS 3806 was unavailable. Lot 1 DP2820 appears undeveloped. The site immediately to the east has been developed with a shed and yard.
2013, 2014, 2015, 2019	Two buildings remain on the site, on the south side of Pt RS 3806, with a roughly square cleared yard area to the west of the buildings. To the south and west of the yard area there appears to be a water body. The south east to north west trending gully, approximately 180 m from the south boundary, on the south side of Pt RS 3806, and now to the west of the existing yard, appears to have been partially filled; this is the approximate location of a closed landfill. The extent of former land clearance on Pt RS 3806 is visible, with an area of low vegetation growth present on the south side of the lot extending past the landfill area, in a linear strip, approximately 350 m from the south boundary, to the tree lined terrace edge.

6 Field Exploration and Subsurface Conditions

6.1 Site Observations

Wiley Geotechnical visited the site on 26 February 2020 and made the following observations:

- The site is relatively flat and terraced (photos 1 and 2).
- There is a storage yard on the south eastern side of the site comprising gravel fill material, housing mostly vehicles (Photo 3).
- Two disused sheds are present on the site, the larger of the two is located adjacent to the storage yard, and is a light weight building with a light weight roof on a concrete slab foundation.
- The south western side of the site and the western edge of the site are heavily vegetated with forest and could not be accessed. There is a heavily forested, deep gully on the south western side of the site (photo 4). There also appears to be a second heavily forested, gully on the north western side of the site, draining one of the streams, but this could not be confirmed owing to no access.
- Approximately six streams or natural drainage channels run through the site from east to west. The majority of these are vegetated with little access available. Where access was found, the base and banks of the streams / drainages were vegetated with grasses and mosses with approximately 5 mm to 20 mm of water in the base.
- We did not observe ground cracks or any clear evidence to indicate lateral spread or ground subsidence during our visit.

	
Photo 1: North east side of site, looking south east	Photo 2: West site of site, looking south
	
Photo 3: Storage yard, south east side of site, looking west	Photo 4: Deep gully, looking south west

6.2 Test Pits and Scala Penetrometer Testing

WGL carried out a shallow subsurface investigation consisting of 18 test pits and 15 Scala penetrometer (Scala) tests within the site boundary.

All of the test pits met target depth between 1.5 m and 2.5 m depth, except one which met practical refusal at 1.6 m depth, owing to a large boulder at least 1 m wide. Scala penetrometer tests met practical refusal at between 0.2 m and 1.3 m depth. One Scala penetrometer test was undertaken in the landfill, (in TP03) between 1.5 m and 3.3 m depth. Test locations are presented in figure 1 and a summary of ground conditions is presented in table 5. Test pit logs and Scala penetrometer results are presented as an attachment to this report and are written in general accordance with the New Zealand Geotechnical Society field classification guidelines (NZGS, 2005).

Groundwater was variable across the site owing to the size of the site, terracing, vegetation and locations of streams and drainage channels. Standing water was encountered in 4 test locations at between 1.3 m and 1.7 m depth. Four out of 18 test pits, excavated to between 1.5 m and 2.5 m depth, encountered standing water. The highest standing water level encountered at the site was 1.3 m depth below ground level in two locations on the south eastern side of the site, to the east of the closed landfill, close to a body of ponded surface water. Standing water was encountered at 1.6 m depth in two further locations, one near an apparent area of ponded water, south of the closed landfill,

on the south side of the site, and one near a stream on the north western side of the site. Given the location of the site and its elevation above lake Brunner and the Arnold Valley, we consider that the standing water encountered may be perched water and that true groundwater level is likely to be somewhat deeper.

Table 5: Summary of Subsurface Conditions

Depth (m)	Soil Description	Consistency/Density
0 up to 0.6	SILT (Topsoil)	Soft to Firm
0.6 up to 1.6	Silty GRAVEL and Sandy GRAVEL	Medium Dense to Dense
1.6 to 2.5	Sandy GRAVEL	Medium Dense to Dense

Based on nearby and on-site subsurface data, it is our opinion that the material encountered in our subsurface investigation is broadly consistent with published geologic mapping.

6.3 Soil Classification

Based on published geologic mapping and nearby and on-site soil testing, in line with NZS 1170.5:2004, we consider the soil classification to be 'Class D – Deep or Soft Soil'.

7 Geotechnical Assessment

7.1 Liquefaction and Lateral Spreading

The ground conditions encountered in our test locations comprise medium dense to dense gravel from at least 0.6 m to 2.5 m depth. Nearby test pits also comprise up to 2.2 m of medium dense to dense gravel. This gravel has been deposited by glaciers that once covered the land. Youd (1998), provides guidance on the likelihood of liquefaction in sediments during strong seismic shaking, indicating that glacial till deposits have a low to very low susceptibility to liquefaction.

Given the nature of the type of soil encountered in our test pits and in nearby test locations, and its density, we consider the risk of liquefaction of the soils underlying the site to be low. As a result, we consider the likelihood of liquefaction induced settlement to be low.

As per section 6.2, based on aerial photography and our site observations, there is no obvious land instability at the site. Given the well vegetated banks and bases of gullies, streams and drainages, and the nature of the medium dense to dense gravel soils beneath the site, we consider the likelihood of lateral spreading to be low.

7.2 Grey District Plan Natural Hazards

Grey District Council (GDC) have issued a district plan which includes policies relating to natural hazards.

7.2.1 Flooding and Coastal Erosion

With reference to the GDC district plan, the site is not located in areas of known flood hazard mentioned in the District Plan, specifically south or east of Lake Brunner. Flood hazard maps,

published by the WCRC and referred to in the Grey District Plan, were unavailable at the time of our investigation. WCRC has advised that the only maps currently held are unpublished informal maps identifying the flood extents from the 1988 floods.

The site is located inland, and therefore is not at risk of Coastal Erosion.

7.2.2 Land Instability

The majority of the site is terraced, with generally flat areas of differing elevations. A steep, heavily vegetated, deep gully is present on the south western side of the site, while a second steep gully appears to be present on the north western side of the site (based on aerial photography). The steep gullies were unable to be accessed owing to thick vegetation cover. No mining or other subsurface activity is known to have taken place at the site.

There is a former landfill on the south side of the site. The location of the landfill area is presented in figure 1. Landfill material is undocumented but anecdotal evidence collected for a Preliminary Site Investigation, by Wiley Geotechnical (Ref: 20001.000.002), indicates that the landfill comprises general household waste and farm rubbish.

Based on aerial photography and our site observations, there is no obvious land instability at the site. The majority of the site, including the closed landfill and steep gully areas, is well vegetated with forest or rough pasture, which traps silt and helps to prevent surface erosion. Vegetation also helps to maintain the stability of steep slopes.

We expect minimal, if any, land surface settlement within the former landfill area. If settlement of the land surface occurs, under static conditions, we expect settlement to be negligible. In line with MfE (2001), it has been more than 10 years since landfill operations ceased and therefore, we expect the majority of land surface settlement to have already occurred.

7.2.3 Seismicity

We have reviewed the GNS New Zealand Active Fault Database, which indicates there are no known active faults on or near the site. The current nearest active fault is the Alpine Fault located approximately 13.2 km to the east of the site. The Alpine Fault dips to the east and is a dextral strike -slip fault. Further to the south, the Hope Fault is an active fault located approximately 17.5 km from the site. The Hope Fault dips to the north west and is a dextral strike-slip fault.

The nearest known inactive faults are the Hohonu Fault (located approximately 2.7 km to the south east of the site) and the Fraser Fault (located approximately 10 km southeast of the site).

Since there are no known active faults crossing the property, it is our opinion that ground rupture is unlikely at the subject property. Granular soils, such as sand and some sandy gravels, are susceptible to liquefaction in the event of future earthquakes, however glacial till sediments, similar to those encountered in our on-site test locations, have a low probability of liquefaction. Based on the regional earthquake risk (discussed further below) and depth to groundwater, it is our opinion that there is a relatively low risk of liquefaction induced settlement or lateral movement such that specific liquefaction design is not required.

We recommend that the future structures and improvements are designed to account for seismic shaking and ground motions. In accordance with NZS 1170.5:2004, Importance Level 2 buildings are required to be designed to resist earthquake shaking with an annual probability of exceedance of 1 / 500 (i.e. A 500 year return period) This is the ultimate limit state (ULS) design seismic loading.

Structures are expected to retain their structural integrity during a ULS earthquake, and not collapse or endanger life. Furthermore, Importance Level 2 buildings should sustain little or no structural damage under a serviceability limit state (SLS) design load, which is based on earthquake shaking with a 25 year return period.

The corresponding design peak ground accelerations (PGA) for the site have been calculated from NZS1170.5:2004 using the recommendations of the New Zealand Geotechnical Society; and Peak horizontal ground accelerations (a_{max}) have been calculated in accordance with MBIE / NZGS Module 1 (2016) using the following formula:

a_{max} = $C_{0,1000}$ R f g / 1.3

$C_{0,1000}$ = 0.6 for Class D sites in Moana (MBIE / NZGS Module 1 (2016), Figure A.2, from NZTA Bridge Manual, 2014)

R = 1.0 for a 500 year return period event (NZS1170.5) (ULS)

= 0.25 for a 25 year return period event (NZS1170.5) (SLS)

f = 1.0 for Class D

Thus, the design PGA at the site is given as:

ULS: a_{max} = 0.6 x 1.0 x 1.0 x 1.0 g / 1.3 = 0.46 g

SLS: a_{max} = 0.6 x 0.25 x 1.0 x 1.0 g / 1.3 = 0.12 g

In accordance with MBIE / NZGS Module 1 (2016), Figure A.7 (from NZTA Bridge Manual, 2014), the effective earthquake magnitude (M_w) can be taken as 6.8 under ULS conditions and 6.2 under SLS conditions.

8 Assessment Against RMA Section 106

Assessment against Section 106 of the Resource Management Act is a requirement for potential future subdivision.

We have assessed the natural hazards associated with the site in accordance with Section 106 of the Resource Management Act. We consider the current ground surface not to be presently subject to erosion, subsidence, falling debris, slippage or inundation by soil or rock in accordance with the provision of Section 106 of the Resource Management Act 1991. We have not considered the risk of inundation by water. Furthermore, we do not consider that future residential use of the land is likely to accelerate, worsen or result in material damage to the land provided that the proper engineering practices are followed during any development, including those recommended in this report.

9 Geotechnical Recommendations

Based on available published geotechnical data and our on-site observations and testing, we consider the site to be geotechnically suitable for re-zoning from Rural to Residential and for future subdivision in accordance with the provision of Section 106 of the Resource Management Act 1991, and that standard earthwork and construction practice will not result significant increase or risk of erosion, subsidence, falling debris, slippage or inundation by soil or rock.

Should an application for subdivision of the site be submitted, we recommend subdivision plans including the proposed earthworks plans are reviewed by WGL as the project Geotechnical Engineer, who is familiar with the geological conditions of the site.

10 References

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Youd, T. L. (1998). Screening Guide for Rapid Assessment of Liquefaction Hazard at Highway Bridge Sites. Bringham Young University. Technical Report MCEER-98-0005.

Limitations

(i) This report has been prepared for the use of our client, Brunner Builders Ltd., and their professional advisers and the relevant Regional 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) Assessments made in this report are based on the ground conditions indicated from published sources, site inspections and subsurface investigations described in this report, based on accepted normal methods of site investigations. Variations in ground conditions may exist

between test locations and therefore have not been taken into account in the report. If variations are found during excavation or at foundation preparation stage WGL should be notified immediately so we can amend our recommendations.

(iii) This Limitation should be read in conjunction with the IPENZ/ACENZ Standard Terms of Engagement.

We trust that this information meets your current requirements. Please do not hesitate to contact the undersigned on 021 0399 385 or helen@wileygeotechnical.co.nz if you require any further information.

Yours Sincerely

Helen Kellett

Senior Engineering Geologist

Raymond Su

Associate Geotechnical Engineer

Matt Wiley, CPEng, CMEngNZ

Principal Engineer

Attachments:

- Test Pit Logs and Scala Penetrometer Test Results

WILEY GEOTECHNICAL LTD

Test Pit No. TP01

SITE: Arnold Valley Road, Moana

REF: 20001

Sheet 1 of 18

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	Water Level	Excavatability (Relative Scale)	Vane Shear Strength Peak/Remolded (kPa)	SCALA PENETROMETER BLOWS / 100 mm (5, 10, 15)
FILL	SW	Gravelly, fine to coarse SAND with minor silt and trace rootlets and concrete; grey. Well graded, subrounded to subangular. Gravel, fine to coarse, well graded, subrounded to subangular. [FILL]			MD to D	W				
GLACIAL TILL	SW	Gravelly, fine to coarse SAND with trace silt, cobbles and boulders; grey. Well graded, subrounded to subangular. Gravel, fine to coarse, well graded, subrounded to subangular. Boulders up to 330 mm diameter.		1	D	W				
	GW	Sandy, fine to coarse GRAVEL with trace cobbles; grey. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Cobbles up to 130 mm diameter.		2	D	S	V			
		EOH:2.2 m depth		3						

NOTES: Standing water encountered at 1.7 m depth.

Test Pit met target depth at 2.2 m.

LOGGED BY: HK

DATE EXCAVATED: 10-Mar-20

METHOD: Sumito SH200 digger, 29T. 6 tooth bucket, 1.3 m wide.

WILEY GEOTECHNICAL LTD

Test Pit No. TP02

SITE: Arnold Valley Road, Moana

REF: 20001

Sheet 2 of 18

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	Water Level	Excavatability (Relative Scale)	Vane Shear Strength Peak/Remolded (kPa)	SCALA PENETROMETER BLOWS / 100 mm (5 10 15)
FILL	SW	Sandy, fine to coarse GRAVEL with trace cobbles; grey. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Cobbles up to 120 mm diameter. [FILL]			L to MD	M				
BTS	ML	SILT with some rootlets and wood; brown. Low plasticity.			S to F	W				
GLACIAL TILL	GM	Silty fine to coarse GRAVEL, with trace sand and cobbles; reddish brown.			MD	W				
	SW	Gravelly fine to coarse SAND; brownish grey with orangey brown limonite cemented layers.		1	MD	W				
	GW	Sandy, fine to coarse GRAVEL with trace cobbles; grey with orangey brown limonite cemented layers. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Cobbles up to 130 mm diameter.		2	D	S	V			
		EOH:2.2 m depth		3						

NOTES: Standing water encountered at 1.3 m depth.

Test Pit met target depth at 2.2 m.

BTS = Buried Topsoil

LOGGED BY: HK

DATE EXCAVATED: 10-Mar-20

METHOD: Sumito SH200 digger, 29T. 6 tooth bucket, 1.3 m wide.

WILEY GEOTECHNICAL LTD

Test Pit No. TP03

SITE: Arnold Valley Road, Moana

REF: 20001

Sheet 3 of 18

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	Water Level	Excavatability (Relative Scale)	Vane Shear Strength Peak/Remolded (kPa)	SCALA PENETROMETER BLOWS / 100 mm
FILL	SW	Gravelly fine to coarse SAND with trace rootlets, cobbles and boulders; brownish grey. Well graded, subrounded to subangular. Gravel, fine to coarse, well graded, subrounded to subangular. Boulders up to 220 mm diameter. [FILL]			L to MD	M				1
FILL	ML	Gravelly SILT with trace sand; grey. Low plasticity. Gravel, fine to coarse, well graded, subrounded to subangular. [CAPPING FILL]			F to St	M				
FILL	GW	Sandy fine to coarse GRAVEL; grey. Well graded, subrounded to sub angular. Sand, medium to coarse, poorly graded, subrounded to subangular. [FILL]			MD	M				
LANDFILL	GW	Sandy, fine to coarse GRAVEL with trace cobbles, plastic, wood, ceramics, fabric, glass, metal and other domestic rubbish; grey. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Cobbles up to 130 mm diameter. [LANDFILL]		1	L to MD	M				0
		EOH:1.5 m depth		2						1 3 5 6 4 9 6 7 5 3 4 5 4 5 12
				3						12

NOTES: Standing water not encountered.

Test Pit met target depth at 1.5 m.

Scala Penetrometer met target depth at 3.3 m. Result also included in Scala Logs. No Scala data between 0.2 m and 1.5 m depth owing to practical refusal on dense gravel and gravelly silt fill material.

LOGGED BY: HK

DATE EXCAVATED: 10-Mar-20

METHOD: Sumito SH200 digger, 29T. 6 tooth bucket, 1.3 m wide.

WILEY GEOTECHNICAL LTD

Test Pit No. TP04

SITE: Arnold Valley Road, Moana

REF: 20001

Sheet 4 of 18

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	Water Level	Excavatability (Relative Scale)	Vane Shear Strength Peak/Remolded (kPa)	SCALA PENETROMETER BLOWS / 100 mm (5, 10, 15)
TOPSOIL	ML	SILT with trace gravel, sand and rootlets; dark brown. Low plasticity. [TOPSOIL]			F to St	W				
A	ML	SILT with trace gravel, sand and cobbles; yellowish brown. Cobbles up to 100 mm diameter.			F to St	W				
GLACIAL TILL	GM	Silty fine to coarse GRAVEL, with trace sand and cobbles; brownish grey. Cobbles up to 130 mm diameter, some iron stained.			D	S				
	GW	Sandy, fine to coarse GRAVEL with trace cobbles; grey with orangey brown limonite cemented layers. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Cobbles up to 130 mm diameter.		1	D	S				
				2						
		EOH:2.2 m depth		3						

NOTES: Standing water not encountered. Surface water migrating down through the soil.

Test Pit met target depth at 2.2 m.

A = Alluvium

LOGGED BY: HK

DATE EXCAVATED: 10-Mar-20

METHOD: Sumito SH200 digger, 29T. 6 tooth bucket, 1.3 m wide.

WILEY GEOTECHNICAL LTD

Test Pit No. TP05

SITE: Arnold Valley Road, Moana

REF: 20001

Sheet 5 of 18

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	Water Level	Excavatability (Relative Scale)	Vane Shear Strength Peak/Remolded (kPa)	SCALA PENETROMETER BLOWS / 100 mm (5, 10, 15)
TOPSOIL	ML	SILT with trace gravel, sand and rootlets; dark brown. Low plasticity. [TOPSOIL]			S to F	W				
ALLUVIUM	ML	SILT with trace gravel, sand and cobbles; yellowish brown. Cobbles up to 100 mm diameter.			F to St	W				
	ML	SILT with trace rootlets, tree roots, organics, gravel, sand, and cobbles; light brown. Cobbles up to 100 mm diameter.			F	W				
GLACIAL TILL	GM	Silty fine to coarse GRAVEL, with trace sand and cobbles; reddish brown. Cobbles up to 130 mm diameter,			MD	S				
	GW	Sandy, fine to coarse GRAVEL with trace cobbles and boulders; brownish grey with orangey brown limonite cemented layers. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Cobbles up to 130 mm diameter. Becomes grey at 1.2 m depth.		1	MD to D	S				
		EOH:2.0 m depth		2						
				3						

NOTES: Standing water not encountered.

Test Pit met target depth at 2.0 m.

LOGGED BY: HK

DATE EXCAVATED: 10-Mar-20

METHOD: Sumito SH200 digger, 29T. 6 tooth bucket, 1.3 m wide.

WILEY GEOTECHNICAL LTD

Test Pit No. TP06

SITE: Arnold Valley Road, Moana

REF: 20001

Sheet 6 of 18

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	Water Level	Excavatability (Relative Scale)	Vane Shear Strength Peak/Remolded (kPa)	SCALA PENETROMETER BLOWS / 100 mm (5, 10, 15)
TOPSOIL	ML	SILT with trace gravel, sand and rootlets; dark brown. Low plasticity. [TOPSOIL]			S to F	W				
GLACIAL TILL	GW	Sandy, fine to coarse GRAVEL with trace tree roots, rootlets, silt and cobbles, brown. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Cobbles up to 100 mm diameter.			L to MD					
		No organic material present from 0.7 m depth.		1	D	W				
		Fine to coarse GRAVEL with trace sand; brown. Well graded, subrounded to subangular.			D	S	V			
		Sandy, fine to coarse GRAVEL with trace cobbles and boulders; grey. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Boulders up to 600 mm diameter.		2	D	S				
		EOH:2.0 m depth		3						

NOTES: Standing water encountered at 1.6 m depth.

Test Pit met target depth at 2.0 m.

LOGGED BY: HK

DATE EXCAVATED: 10-Mar-20

METHOD: Sumito SH200 digger, 29T. 6 tooth bucket, 1.3 m wide.

WILEY GEOTECHNICAL LTD

Test Pit No. TP07

SITE: Arnold Valley Road, Moana

REF: 20001

Sheet 7 of 18

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	Water Level	Excavatability (Relative Scale)	Vane Shear Strength Peak/Remolded (kPa)	SCALA PENETROMETER BLOWS / 100 mm (5 10 15)
TOPSOIL	ML	SILT with trace gravel, sand and rootlets; dark brown. Low plasticity. [TOPSOIL]			S to F	W				
GLACIAL TILL	GM	Silty fine to coarse GRAVEL, with trace rootlets, tree roots, sand, cobbles and boulders; brown. well graded, subrounded to subangular. Boulders up to 500 mm diameter. Occasional dark grey sand lenses.		1	MD to D	S				
	GW	Sandy, fine to coarse GRAVEL with trace cobbles and boulders; grey. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Boulders up to 600 mm diameter.		2	MD to D	S				
		EOH:2.0 m depth		3						

NOTES: Standing water not encountered.

Test Pit met target depth at 2.0 m.

LOGGED BY: HK

DATE EXCAVATED: 10-Mar-20

METHOD: Sumito SH200 digger, 29T. 6 tooth bucket, 1.3 m wide.

WILEY GEOTECHNICAL LTD

Test Pit No. TP08

SITE: Arnold Valley Road, Moana

REF: 20001

Sheet 8 of 18

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	Water Level	Excavatability (Relative Scale)	Vane Shear Strength Peak/Remolded (kPa)	SCALA PENETROMETER BLOWS / 100 mm (5, 10, 15)
TOPSOIL	ML	SILT with trace gravel, sand, cobbles, tree roots and rootlets; dark brown. Low plasticity. [TOPSOIL]			S to F	M				
GLACIAL TILL	GM	Silty fine to coarse GRAVEL, with trace rootlets, sand and cobbles; brown. Well graded, subrounded to subangular. Cobbles up to 90 mm diameter. No organics below 0.7 m depth. Limonite cemented layer at 0.95 m depth.		1	D	W				
	GW	Sandy, fine to coarse GRAVEL with trace cobbles; brownish grey. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Cobbles up to 130 mm diameter.		2	D	M				
		EOH:2.3 m depth		3						

NOTES: Standing water not encountered.

Test Pit met target depth at 2.3 m.

LOGGED BY: HK

DATE EXCAVATED: 10-Mar-20

METHOD: Sumito SH200 digger, 29T. 6 tooth bucket, 1.3 m wide.

WILEY GEOTECHNICAL LTD

Test Pit No. TP09

SITE: Arnold Valley Road, Moana

REF: 20001

Sheet 9 of 18

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	Water Level	Excavatability (Relative Scale)	Vane Shear Strength Peak/Remolded (kPa)	SCALA PENETROMETER BLOWS / 100 mm (5, 10, 15)
TOPSOIL	ML	SILT with trace gravel, sand and rootlets; dark brown. Low plasticity. [TOPSOIL]			S to F	W				
GLACIAL TILL	GM	Silty fine to coarse GRAVEL, with trace rootlets, sand and cobbles; brown. Well graded, subrounded to subangular. Cobbles up to 90 mm diameter.		1	MD to D	S				
	GW	Sandy, fine to coarse GRAVEL with trace and cobbles; grey with orangey brown limonite cemented layers. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Cobbles up to 130 mm diameter.		2	MD to D	W				
		EOH:2.0 m depth		3						

NOTES: Standing water not encountered.

Test Pit met target depth at 2.0 m.

LOGGED BY: HK

DATE EXCAVATED: 10-Mar-20

METHOD: Sumito SH200 digger, 29T. 6 tooth bucket, 1.3 m wide.

WILEY GEOTECHNICAL LTD

Test Pit No. TP10

SITE: Arnold Valley Road, Moana

REF: 20001

Sheet 10 of 18

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	Water Level	Excavatability (Relative Scale)	Vane Shear Strength Peak/Remolded (kPa)	SCALA PENETROMETER BLOWS / 100 mm (5, 10, 15)
TOPSOIL	ML	SILT with trace gravel, sand and rootlets; dark brown. Low plasticity. [TOPSOIL]			S to F	W				
	GM	Silty fine to coarse GRAVEL, with trace rootlets, tree roots, sand, cobbles and boulders; brown. well graded, subrounded to subangular. Boulders up to 300 mm diameter.			L to MD	S				
GLACIAL TILL	GW	Sandy, fine to coarse GRAVEL with trace cobbles; grey with orangey brown limonite cemented layers. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Cobbles up to 130 mm diameter.		1	MD to D	W				
		EOH:1.9 m depth		2						
				3						

NOTES: Standing water not encountered.

Test Pit met target depth at 1.9 m.

LOGGED BY: HK

DATE EXCAVATED: 10-Mar-20

METHOD: Sumito SH200 digger, 29T. 6 tooth bucket, 1.3 m wide.

WILEY GEOTECHNICAL LTD

Test Pit No. TP11

SITE: Arnold Valley Road, Moana

REF: 20001

Sheet 11 of 18

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	Water Level	Excavatability (Relative Scale)	Vane Shear Strength Peak/Remolded (kPa)	SCALA PENETROMETER BLOWS / 100 mm (5, 10, 15)
TOPSOIL	ML	SILT with trace gravel, sand and rootlets; dark brown. Low plasticity. [TOPSOIL]			S to F	W				
GLACIAL TILL	GW	Sandy, fine to coarse GRAVEL with trace cobbles and boulders; grey with orangey brown limonite cemented layers. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Boulders up to 250 mm diameter.		1 2	MD to D	W				
		EOH:2.1 m depth		3						

NOTES: Standing water not encountered.

Test Pit met target depth at 2.1 m.

LOGGED BY: HK

DATE EXCAVATED: 10-Mar-20

METHOD: Sumito SH200 digger, 29T. 6 tooth bucket, 1.3 m wide.

WILEY GEOTECHNICAL LTD

Test Pit No. TP12

SITE: Arnold Valley Road, Moana

REF: 20001

Sheet 12 of 18

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	Water Level	Excavatability (Relative Scale)	Vane Shear Strength Peak/Remolded (kPa)	SCALA PENETROMETER BLOWS / 100 mm (5, 10, 15)
TOPSOIL	ML	SILT with trace gravel, sand and rootlets; dark brown. Low plasticity. [TOPSOIL]			S to F	W				
GLACIAL TILL	GM	Silty fine to coarse GRAVEL, with trace sand; reddish brown. Well graded, subrounded to subangular.			L to MD	S				
	SW	Fine to coarse SAND with trace gravel; grey. Well graded, subrounded to subangular.			L to MD	W				
	GW	Sandy, fine to coarse GRAVEL with trace cobbles and boulders; brownish grey with orangey brown limonite cemented layers. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Cobbles up to 200 mm diameter.		1	MD to D	M				
		EOH:1.8 m depth		2 3						

NOTES: Standing water not encountered.

Test Pit met target depth at 1.8 m.

LOGGED BY: HK

DATE EXCAVATED: 10-Mar-20

METHOD: Sumito SH200 digger, 29T. 6 tooth bucket, 1.3 m wide.

WILEY GEOTECHNICAL LTD

Test Pit No. TP13

SITE: Arnold Valley Road, Moana

REF: 20001

Sheet 13 of 18

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	Water Level	Excavatability (Relative Scale)	Vane Shear Strength Peak/Remolded (kPa)	SCALA PENETROMETER BLOWS / 100 mm (5, 10, 15)
TOPSOIL	ML	SILT with trace gravel, sand and rootlets; dark brown. Low plasticity. [TOPSOIL]			S to F	W				
GLACIAL TILL	GW	Sandy, fine to coarse GRAVEL with trace cobbles and boulders; grey with orangey brown limonite cemented layers. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Boulders up to 1 m+ diameter.		1	MD to D	S / W				
		EOH:0.6 m depth		2						
				3						

NOTES: Standing water not encountered.

Test Pit met practical refusal at 1.6 m depth owing to a large boulder.

LOGGED BY: HK

DATE EXCAVATED: 11-Mar-20

METHOD: Sumito SH200 digger, 29T. 6 tooth bucket, 1.3 m wide.

WILEY GEOTECHNICAL LTD

Test Pit No. TP14

SITE: Arnold Valley Road, Moana

REF: 20001

Sheet 14 of 18

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	Water Level	Excavatability (Relative Scale)	Vane Shear Strength Peak/Remolded (kPa)	SCALA PENETROMETER BLOWS / 100 mm (5, 10, 15)
TOPSOIL	ML	SILT with trace gravel, sand and rootlets; dark brown. Low plasticity. [TOPSOIL]			S to F	W				
GLACIAL TILL	GM	Silty fine to coarse GRAVEL, with trace rootlets, sand and cobbles; yellowish brown. Well graded, subrounded to subangular. Cobbles up to 100 mm diameter, iron stained.			MD	W				
	GW	Sandy, fine to coarse GRAVEL with trace cobbles and boulders; grey with orangey brown limonite cemented layers. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Boulders up to 500 mm diameter.		1 2	MD to D	W				
		EOH:2.3 m depth		3						

NOTES: Standing water not encountered.

Test Pit met target depth at 2.3 m.

LOGGED BY: HK

DATE EXCAVATED: 11-Mar-20

METHOD: Sumito SH200 digger, 29T. 6 tooth bucket, 1.3 m wide.

WILEY GEOTECHNICAL LTD

Test Pit No. TP15

SITE: Arnold Valley Road, Moana

REF: 20001

Sheet 15 of 18

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	Water Level	Excavatability (Relative Scale)	Vane Shear Strength Peak/Remolded (kPa)	SCALA PENETROMETER BLOWS / 100 mm (5, 10, 15)
TOPSOIL	ML	SILT with trace gravel, sand and rootlets; dark brown. Low plasticity. [TOPSOIL]			S to F	W				
GLACIAL TILL	GM	Silty fine to coarse GRAVEL, with trace rootlets, tree roots, sand, cobbles and boulders; brown. well graded, subrounded to subangular. Boulders up to 700 mm diameter.			MD	W				
	GW	Sandy, fine to coarse GRAVEL with trace cobbles; grey with orangey brown limonite cemented layers. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Cobbles up to 200 mm diameter.		1 2	MD to D	M				
		EOH:2.2 m depth		3						

NOTES: Standing water not encountered.

Test Pit met target depth at 2.2 m.

LOGGED BY: HK

DATE EXCAVATED: 11-Mar-20

METHOD: Sumito SH200 digger, 29T. 6 tooth bucket, 1.3 m wide.

WILEY GEOTECHNICAL LTD

Test Pit No. TP16

SITE: Arnold Valley Road, Moana

REF: 20001

Sheet 16 of 18

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	Water Level	Excavatability (Relative Scale)	Vane Shear Strength Peak/Remolded (kPa)	SCALA PENETROMETER BLOWS / 100 mm (5, 10, 15)
TOPSOIL	ML	SILT with trace gravel, sand, cobbles and rootlets; dark brown. Low plasticity. Cobbles up to 90 mm diameter. [TOPSOIL]			S to F	W				
GLACIAL TILL	GM	Silty fine to coarse GRAVEL, with trace rootlets, sand and cobbles; yellowish brown. Well graded, subrounded to subangular. Cobbles up to 130 mm diameter, iron stained.			MD	W				
	GW	Sandy, fine to coarse GRAVEL with trace cobbles and boulders; grey with orangey brown limonite cemented layers. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Boulders up to 300 mm diameter.		1	MD to D	W	V			
		Becomes grey at 1.7 m depth.		2		S				
		EOH:2.5 m depth		3						

NOTES: Standing water encountered at 1.3 m depth.

Test Pit met target depth at 2.5 m.

LOGGED BY: HK

DATE EXCAVATED: 11-Mar-20

METHOD: Sumito SH200 digger, 29T. 6 tooth bucket, 1.3 m wide.

WILEY GEOTECHNICAL LTD

Test Pit No. TP17

SITE: Arnold Valley Road, Moana

REF: 20001

Sheet 17 of 18

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	Water Level	Excavatability (Relative Scale)	Vane Shear Strength Peak/Remolded (kPa)	SCALA PENETROMETER BLOWS / 100 mm (5, 10, 15)
TOPSOIL	ML	SILT with trace gravel, sand, cobbles and rootlets; dark brown. Low plasticity. Cobbles up to 90 mm diameter. [TOPSOIL]			S to F	W				
GLACIAL TILL	GM	Silty fine to coarse GRAVEL, with trace rootlets, sand and cobbles; yellowish brown. Well graded, subrounded to subangular. Cobbles up to 150 mm diameter.			MD	W				
	GW	Sandy, fine to coarse GRAVEL with trace cobbles and boulders; grey with orangey brown limonite cemented layers. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Boulders up to 550 mm diameter.		1	MD to D	W				
		EOH:2.0 m depth		2						
				3						

NOTES: Standing water not encountered.

Test Pit met target depth at 2.0 m.

LOGGED BY: HK

DATE EXCAVATED: 11-Mar-20

METHOD: Sumito SH200 digger, 29T. 6 tooth bucket, 1.3 m wide.

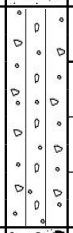
WILEY GEOTECHNICAL LTD

Test Pit No. TP18

SITE: Arnold Valley Road, Moana

REF: 20001

Sheet 18 of 18

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	Water Level	Excavatability (Relative Scale)	Vane Shear Strength Peak/Remolded (kPa)	SCALA PENETROMETER BLOWS / 100 mm (5, 10, 15)
TOPSOIL	ML	SILT with trace gravel, sand, cobbles and rootlets; dark brown. Low plasticity. Cobbles up to 90 mm diameter. [TOPSOIL]			S to F	W				
GLACIAL TILL	GM	Silty fine to coarse GRAVEL, with trace rootlets, tree roots, sand, cobbles and boulders; yellowish brown. Well graded, subrounded to subangular. Boulders up to 500 mm diameter.			MD	S				
	GW	Sandy, fine to coarse GRAVEL with trace cobbles and boulders; grey with orangey brown limonite cemented layers. Well graded, subrounded to subangular. Sand, fine to coarse, well graded, subrounded to subangular. Boulders up to 300 mm diameter.		1	MD to D	W				
		EOH:2.0 m depth		2						
				3						

NOTES: Standing water not encountered. Surface water migrating down through the soil.

Test Pit met target depth at 2.0 m.

LOGGED BY: HK

DATE EXCAVATED: 11-Mar-20

METHOD: Sumito SH200 digger, 29T. 6 tooth bucket, 1.3 m wide.

WILEY GEOTECHNICAL

Scala Penetrometer Testing

Client: Brunner Builders Ltd. **Ref:** C20001

Site address: Arnold Valley Road, Moana **Date:** 11/03/2020

Location: See Site location Plan **By:** HK

Test No.	SP19	Test No.	SP20	Test No.	SP21	Test No.	SP22
Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows
100	1	100	1	100	5	100	1
200	1	200	6	200	20+	200	0
300	5	300	15	300		300	0
400	12	400	8	400		400	0
500	20+	500	8	500		500	2
600		600	7	600		600	3
700		700	6	700		700	11
800		800	6	800		800	20+
900		900	6	900		900	
1000		1000	7	1000		1000	
1100		1100	10	1100		1100	
1200		1200	12	1200		1200	
1300		1300	15	1300		1300	
1400		1400	18	1400		1400	
1500		1500	20+	1500		1500	
1600		1600		1600		1600	
1700		1700		1700		1700	
1800		1800		1800		1800	
1900		1900		1900		1900	
2000		2000		2000		2000	
2100		2100		2100		2100	
2200		2200		2200		2200	
2300		2300		2300		2300	
2400		2400		2400		2400	
2500		2500		2500		2500	
2600		2600		2600		2600	
2700		2700		2700		2700	
2800		2800		2800		2800	
2900		2900		2900		2900	
3000		3000		3000		3000	
3100		3100		3100		3100	
3200		3200		3200		3200	
3300		3300		3300		3300	
3400		3400		3400		3400	
3500		3500		3500		3500	
3600		3600		3600		3600	
3700		3700		3700		3700	
3800		3800		3800		3800	
3900		3900		3900		3900	
4000		4000		4000		4000	

WILEY GEOTECHNICAL

Scala Penetrometer Testing

Client: Brunner Builders Ltd. **Ref:** C20001

Site address: Arnold Valley Road, Moana **Date:** 11/03/2020

Location: See Site location Plan **By:** HK

Test No.	SP23	Test No.	SP24	Test No.	SP25	Test No.	SP26
Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows
100	1	100	0	100	1	100	1
200	3	200	2	200	0	200	0
300	4	300	1	300	0	300	2
400	4	400	1	400	0	400	1
500	4	500	1	500	0	500	20+
600	9	600	1	600	6	600	
700	12	700	7	700	20+	700	
800	20+	800	20+	800		800	
900		900		900		900	
1000		1000		1000		1000	
1100		1100		1100		1100	
1200		1200		1200		1200	
1300		1300		1300		1300	
1400		1400		1400		1400	
1500		1500		1500		1500	
1600		1600		1600		1600	
1700		1700		1700		1700	
1800		1800		1800		1800	
1900		1900		1900		1900	
2000		2000		2000		2000	
2100		2100		2100		2100	
2200		2200		2200		2200	
2300		2300		2300		2300	
2400		2400		2400		2400	
2500		2500		2500		2500	
2600		2600		2600		2600	
2700		2700		2700		2700	
2800		2800		2800		2800	
2900		2900		2900		2900	
3000		3000		3000		3000	
3100		3100		3100		3100	
3200		3200		3200		3200	
3300		3300		3300		3300	
3400		3400		3400		3400	
3500		3500		3500		3500	
3600		3600		3600		3600	
3700		3700		3700		3700	
3800		3800		3800		3800	
3900		3900		3900		3900	
4000		4000		4000		4000	

Scala Penetrometer Testing

Client: Brunner Builders Ltd. **Ref:** C20001

Site address: Arnold Valley Road, Moana **Date:** 11/03/2020

Location: See Site location Plan **By:** HK

Test No.	SP27	Test No.	SP28	Test No.	SP29	Test No.	SP30
Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows
100	1	100	0	100	0	100	1
200	1	200	1	200	1	200	0
300	3	300	1	300	0	300	0
400	12	400	3	400	2	400	0
500	15	500	2	500	20+	500	0
600	20+	600	3	600		600	0
700		700	5	700		700	1
800		800	11	800		800	2
900		900	20+	900		900	2
1000		1000		1000		1000	5
1100		1100		1100		1100	6
1200		1200		1200		1200	18
1300		1300		1300		1300	20+
1400		1400		1400		1400	
1500		1500		1500		1500	
1600		1600		1600		1600	
1700		1700		1700		1700	
1800		1800		1800		1800	
1900		1900		1900		1900	
2000		2000		2000		2000	
2100		2100		2100		2100	
2200		2200		2200		2200	
2300		2300		2300		2300	
2400		2400		2400		2400	
2500		2500		2500		2500	
2600		2600		2600		2600	
2700		2700		2700		2700	
2800		2800		2800		2800	
2900		2900		2900		2900	
3000		3000		3000		3000	
3100		3100		3100		3100	
3200		3200		3200		3200	
3300		3300		3300		3300	
3400		3400		3400		3400	
3500		3500		3500		3500	
3600		3600		3600		3600	
3700		3700		3700		3700	
3800		3800		3800		3800	
3900		3900		3900		3900	
4000		4000		4000		4000	

WILEY GEOTECHNICAL

Scala Penetrometer Testing

Client: Brunner Builders Ltd. **Ref:** C20001

Site address: Arnold Valley Road, Moana **Date:** 11/03/2020

Location: See Site location Plan **By:** HK

Test No.	SP31	Test No.	SP32	Test No.	TP03	Test No.	
Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows
100	1	100	0	100	1	100	
200	3	200	1	200	20+	200	
300	2	300	0	300		300	
400	3	400	0	400		400	
500	10	500	6	500		500	
600	20+	600	2	600		600	
700		700	4	700		700	
800		800	6	800		800	
900		900	16	900		900	
1000		1000	20+	1000		1000	
1100		1100		1100		1100	
1200		1200		1200		1200	
1300		1300		1300		1300	
1400		1400		1400		1400	
1500		1500		1500	0	1500	
1600		1600		1600	1	1600	
1700		1700		1700	3	1700	
1800		1800		1800	5	1800	
1900		1900		1900	6	1900	
2000		2000		2000	4	2000	
2100		2100		2100	9	2100	
2200		2200		2200	6	2200	
2300		2300		2300	7	2300	
2400		2400		2400	5	2400	
2500		2500		2500	3	2500	
2600		2600		2600	4	2600	
2700		2700		2700	5	2700	
2800		2800		2800	4	2800	
2900		2900		2900	5	2900	
3000		3000		3000	12	3000	
3100		3100		3100	12	3100	
3200		3200		3200	7	3200	
3300		3300		3300	7	3300	
3400		3400		3400		3400	
3500		3500		3500		3500	
3600		3600		3600		3600	
3700		3700		3700		3700	
3800		3800		3800		3800	
3900		3900		3900		3900	
4000		4000		4000		4000	