## PUKEKOHE OFFICE
UNIT 2, 4 MANUKAU ROAD, PUKEKOHE
POST: PO BOX 1019, PUKEKOHE, 2120
EMAIL: pukekohe@gcltech.co.nz
TEL: 09 239 2229

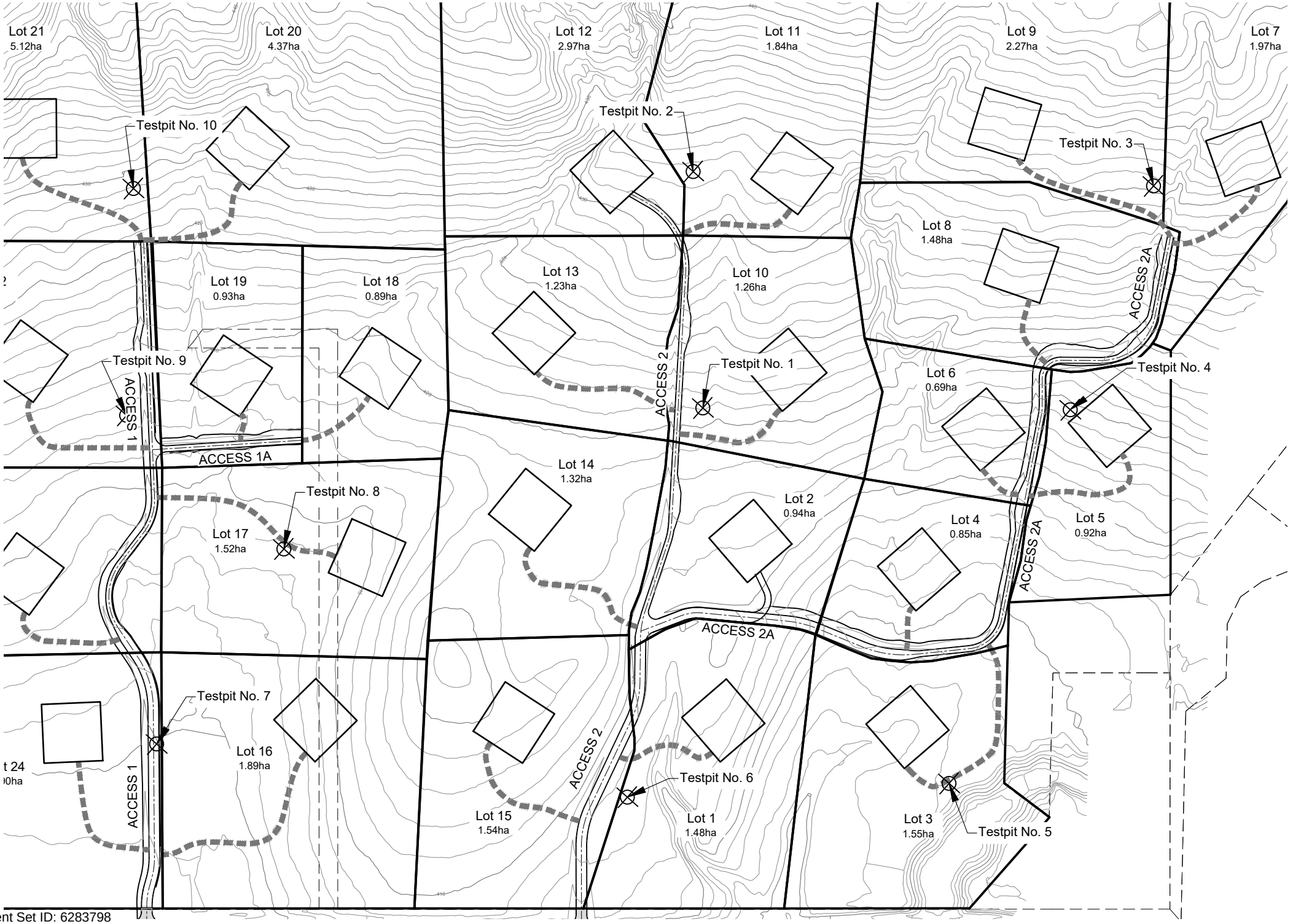
## QUEENSTOWN OFFICE
157 GLENDA DRIVE, FRANKTON
POST: PO BOX 2963, QUEENSTOWN 9349
EMAIL: queenstown@gcltech.co.nz
TEL: 03 442 5700

## AUCKLAND CENTRAL OFFICE
LEVEL 1, KAURI TIMBER BUILDING
104 FANSHAWE STREET, AUCKLAND, 1010
EMAIL: auckland@gcltech.co.nz
TEL: 09 379 0777

## GREAT BARRIER IS. OFFICE
6 MOANA VIEW ROAD, OKUPU
POST: PO BOX 1019, PUKEKOHE, 2120
EMAIL: office@gcltech.co.nz
TEL: 09 239 2229


GCL
Ground Consulting Ltd

# APPENDIX B: CIVILISED LTD PLAN & LOGS



# Test Pit Log

Civilised Ltd

| | | | |
|---|---|---|---|
| Project: | Proposed 24 Lot Subdivision | Project Number: | QV021 |
| Site Location: | Littles Road, Queenstown | Client: | Wakatipu Investments Ltd |
| Tets Pit Number: | Test pit #1 - Fine, sunny, no wind. | | Sheet 1 of 10 |

| Depth (m) | Water Level | Graphic Log | Moisture | Soil Rock Description | Geological Unit | Depth |
|---|---|---|---|---|---|---|
| | | | | TOPSOIL - turf, dark brown, dry | Topsoil | |
| 0.5 | | | | Sandy SILT, LOESS - Light brown, moist | Loess | 0.5 |
| 1.0 | | | | | | 1.0 |
| 1.5 | | | | | | 1.5 |
| 2.0 | | | | Silty, sandy GRAVEL - sub-rounded, light brown, AP20, schist based - Glacial Till | Glacial Till | 2.0 |
| 2.5 | | | | 2.2m bottom of pit, no water ingress.  | | 2.5 |
| 3.0 | | | | | | 3.0 |
| 3.5 | | | | | | |

| | | | |
|---|---|---|---|
| Date Excavated: | 21/03/2019 11:20am | Equipment: | Hitachi 13.5 tonne excavator |
| Logged By: | JFM | Contractor: | Solidbuilt Homes Ltd |

# Test Pit Log

Civilised Ltd

| | | | |
|---|---|---|---|
| Project: | Proposed 24 Lot Subdivision | Project Number: | QV021 |
| Site Location: | Littles Road, Queenstown | Client: | Wakatipu Investments Ltd |
| Tets Pit Number: | Test pit #2 - Fine, sunny, no wind. | | Sheet 2 of 10 |

| Depth (m) | Water Level | Graphic Log | Moisture | Soil Rock Description | Geological Unit | Depth |
|---|---|---|---|---|---|---|
| | | | | TOPSOIL - turf, dark brown, dry | Topsoil | |
| | | | | Sandy SILT, LOESS - Light brown, dry | Loess | |
| 0.5 | | | | Sandy GRAVEL, rounded, light brown, AP20, dry | Gravel | 0.5 |
| 1.0 | | | | Silty, sandy GRAVEL - sub-rounded, light brown, AP20, schist based - Glacial Till | Glacial Till | 1.0 |
| 1.5 | | | | | | 1.5 |
| | | | | SAND - gray, moist, clean | Sand | |
| 2.0 | | | | 1.8m bottom of pit, no water ingress. | | 2.0 |
| 2.5 | | | | | | 2.5 |
| 3.0 | | | | | | |
| 3.5 | | | | | | 3.0 |

| | | | |
|---|---|---|---|
| Date Excavated: | 21/03/2019 11:37am | Equipment: | Hitachi 13.5 tonne excavator |
| Logged By: | JFM | Contractor: | Solidbuilt Homes Ltd |

# Test Pit Log

Civilised Ltd

| | | | |
|---|---|---|---|
| Project: | Proposed 24 Lot Subdivision | Project Number: | QV021 |
| Site Location: | Littles Road, Queenstown | Client: | Wakatipu Investments Ltd |
| Tets Pit Number: | Test pit #3 - Fine, sunny, no wind. | | Sheet 3 of 10 |

| Depth (m) | Water Level | Graphic Log | Moisture | Soil Rock Description | Geological Unit | Depth |
|---|---|---|---|---|---|---|
| | | | | TOPSOIL - turf, dark brown, dry | Topsoil | |
| | | | | Sandy SILT, LOESS - Light brown, dry | Loess | |
| 0.5 | | | | Silty, sandy GRAVEL - sub-rounded, light brown, AP20, schist based - Glacial Till | Glacial Till | 0.5 |
| 1.0 | | | | | | 1.0 |
| | | | | Schist BEDROCK - easily rippable at interface, more solid with depth | Bedrock | |
| 1.5 | | | | | | 1.5 |
| | | | | 1.5m bottom of pit, no water ingress. | | |
| 2.0 | | | | | | 2.0 |
| 2.5 | | | | | | 2.5 |
| 3.0 | | | | | | 3.0 |
| 3.5 | | | | | | |

| | | | |
|---|---|---|---|
| Date Excavated: | 21/03/2019 11:48am | Equipment: | Hitachi 13.5 tonne excavator |
| Logged By: | JFM | Contractor: | Solidbuilt Homes Ltd |

# Test Pit Log

Civilised Ltd

| | | | |
|---|---|---|---|
| Project: | Proposed 24 Lot Subdivision | Project Number: | QV021 |
| Site Location: | Littles Road, Queenstown | Client: | Wakatipu Investments Ltd |
| Tets Pit Number: | Test pit #4 - Fine, sunny, no wind. | | Sheet 4 of 10 |

| Depth (m) | Water Level | Graphic Log | Moisture | Soil Rock Description | Geological Unit | Depth |
|---|---|---|---|---|---|---|
| | | | | TOPSOIL - turf, dark brown, dry | Topsoil | |
| 0.5 | | | | Sandy SILT, LOESS - Light brown, dry | Loess | 0.5 |
| 1.0 | | | | | | 1.0 |
| 1.5 | | | | Silty, sandy GRAVEL - sub-rounded, light brown, AP20, schist based - Glacial Till | Glacial Till | 1.5 |
| 2.0 | | | | | | 2.0 |
| 2.5 | | | | Schist BEDROCK - easily rippable at interface, more solid with depth | Bedrock | 2.5 |
| 3.0 | | | | 2.4m bottom of pit, no water ingress.  | | 3.0 |
| 3.5 | | | | | | |

| | | | |
|---|---|---|---|
| Date Excavated: | 21/03/2019 11:56am | Equipment: | Hitachi 13.5 tonne excavator |
| Logged By: | JFM | Contractor: | Solidbuilt Homes Ltd |

# Test Pit Log

Civilised Ltd

| | | | |
|---|---|---|---|
| Project: | Proposed 24 Lot Subdivision | Project Number: | QV021 |
| Site Location: | Littles Road, Queenstown | Client: | Wakatipu Investments Ltd |
| Tets Pit Number: | Test pit #5 - Fine, sunny, no wind. | | Sheet 5 of 10 |

| Depth (m) | Water Level | Graphic Log | Moisture | Soil Rock Description | Geological Unit | Depth |
|---|---|---|---|---|---|---|
| | | | | TOPSOIL - turf, dark brown, dry | Topsoil | |
| | | | | Sandy SILT, LOESS - Light brown, dry | Loess | |
| 0.5 | | | | | | 0.5 |
| | | | | Sandy GRAVEL, some silt, cleaner with depth, light brown/gray, subrounded | Gravel | |
| 1.0 | | | | | | 1.0 |
| 1.5 | | | | | | 1.5 |
| 2.0 | | | | | | 2.0 |
| 2.5 | | | | 2.4m bottom of pit, no water ingress.  | | 2.5 |
| 3.0 | | | | | | 3.0 |
| 3.5 | | | | | | |

| | | | |
|---|---|---|---|
| Date Excavated: | 21/03/2019 12:02pm | Equipment: | Hitachi 13.5 tonne excavator |
| Logged By: | JFM | Contractor: | Solidbuilt Homes Ltd |

# Test Pit Log

Civilised Ltd

| | | | |
|---|---|---|---|
| Project: | Proposed 24 Lot Subdivision | Project Number: | QV021 |
| Site Location: | Littles Road, Queenstown | Client: | Wakatipu Investments Ltd |
| Tets Pit Number: | Test pit #6 - Fine, sunny, no wind. | | Sheet 6 of 10 |

| Depth (m) | Water Level | Graphic Log | Moisture | Soil Rock Description | Geological Unit | Depth |
|---|---|---|---|---|---|---|
| | | | | TOPSOIL - turf, dark brown, dry | Topsoil | |
| | | | | Sandy SILT, LOESS - Light brown, dry | Loess | |
| 0.5 | | | | | | 0.5 |
| | | | | Silty, sandy GRAVEL - sub-rounded, light brown, AP20, schist based - Glacial Till | Glacial Till | |
| 1.0 | | | | | | 1.0 |
| 1.5 | | | | | | 1.5 |
| | | | | Schist BEDROCK - solid | Bedrock | |
| 2.0 | | | | 1.9m bottom of pit, no water ingress. | | 2.0 |
| 2.5 | | | | | | 2.5 |
| 3.0 | | | | | | 3.0 |
| 3.5 | | | | | | |

| | | | |
|---|---|---|---|
| Date Excavated: | 21/03/2019 12:13pm | Equipment: | Hitachi 13.5 tonne excavator |
| Logged By: | JFM | Contractor: | Solidbuilt Homes Ltd |

# Test Pit Log

Civilised Ltd

| | | | |
|---|---|---|---|
| Project: | Proposed 24 Lot Subdivision | Project Number: | QV021 |
| Site Location: | Littles Road, Queenstown | Client: | Wakatipu Investments Ltd |
| Tets Pit Number: | Test pit #7 - Fine, sunny, no wind. | | Sheet 7 of 10 |

| Depth (m) | Water Level | Graphic Log | Moisture | Soil Rock Description | Geological Unit | Depth |
|---|---|---|---|---|---|---|
| | | | | TOPSOIL - turf, dark brown, dry | Topsoil | |
| | | | | Sandy GRAVEL, some silt, cleaner with depth, light brown/gray, rounded | Gravel | |
| 0.5 | | | | | | 0.5 |
| 1.0 | | | | | | 1.0 |
| 1.5 | | | | | | 1.5 |
| 2.0 | | | | | | 2.0 |
| 2.5 | | | | | | 2.5 |
| 3.0 | | | | 2.5m bottom of pit, no water ingress. | | 3.0 |
| 3.5 | | | | | | |

| | | | |
|---|---|---|---|
| Date Excavated: | 21/03/2019 12:29pm | Equipment: | Hitachi 13.5 tonne excavator |
| Logged By: | JFM | Contractor: | Solidbuilt Homes Ltd |

# Test Pit Log

Civilised Ltd

| | | | |
|---|---|---|---|
| Project: | Proposed 24 Lot Subdivision | Project Number: | QV021 |
| Site Location: | Littles Road, Queenstown | Client: | Wakatipu Investments Ltd |
| Tets Pit Number: | Test pit #8 - Fine, sunny, no wind. | | Sheet 8 of 10 |

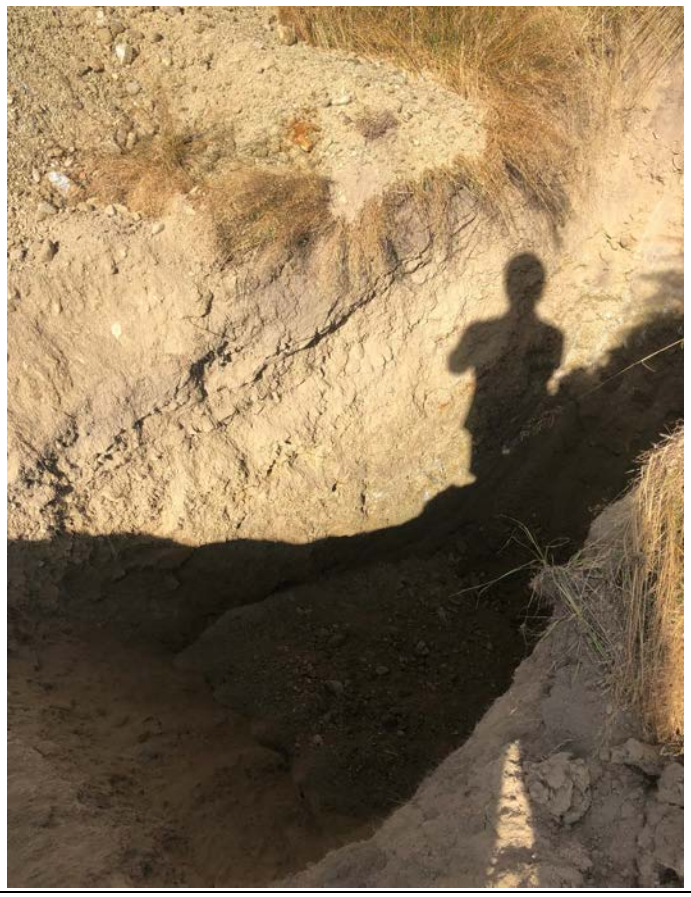
| Depth (m) | Water Level | Graphic Log | Moisture | Soil Rock Description | Geological Unit | Depth |
|---|---|---|---|---|---|---|
| | | | | TOPSOIL - turf, dark brown, moist | Topsoil | |
| | | | | SILT layers - soft, damp, wetter with depth, organic | Silt | |
| 0.5 | | | | | | 0.5 |
| 1.0 | | | | | | 1.0 |
| 1.5 | | | | | | 1.5 |
| | | | | Sandy, silty GRAVEL, light brown/gray, subrounded, saturated, groundwater flows. | Gravel | |
| 2.0 | | | | | | 2.0 |
| 2.5 | | | | | | 2.5 |
| 3.0 | | | | | | 3.0 |
| 3.5 | | | | 3.6m bottom of pit, water ingress at >1.6m depth. | | |

| | | | |
|---|---|---|---|
| Date Excavated: | 21/03/2019 12:23pm | Equipment: | Hitachi 13.5 tonne excavator |
| Logged By: | JFM | Contractor: | Solidbuilt Homes Ltd |

# Test Pit Log

Civilised Ltd

| | | | |
|---|---|---|---|
| Project: | Proposed 24 Lot Subdivision | Project Number: | QV021 |
| Site Location: | Littles Road, Queenstown | Client: | Wakatipu Investments Ltd |
| Tets Pit Number: | Test pit #9 - Fine, sunny, no wind. | | Sheet 9 of 10 |

| Depth (m) | Water Level | Graphic Log | Moisture | Soil Rock Description | Geological Unit | Depth |
|---|---|---|---|---|---|---|
| | | | | TOPSOIL - turf, dark brown, dry | Topsoil | |
| 0.5 | | | | Sandy GRAVEL, some silt, cleaner with depth, light brown/gray, rounded, dry.  | Gravel | 0.5 |
| 1.0 | | | | | | 1.0 |
| 1.5 | | | | | | 1.5 |
| 2.0 | | | | | | 2.0 |
| 2.5 | | | | 2.4m bottom of pit, no water ingress. | | 2.5 |
| 3.0 | | | | | | 3.0 |
| 3.5 | | | | | | |

| | | | |
|---|---|---|---|
| Date Excavated: | 21/03/2019 12:39pm | Equipment: | Hitachi 13.5 tonne excavator |
| Logged By: | JFM | Contractor: | Solidbuilt Homes Ltd |

# Test Pit Log

Civilised Ltd

| | | | |
|---|---|---|---|
| Project: | Proposed 24 Lot Subdivision | Project Number: | QV021 |
| Site Location: | Littles Road, Queenstown | Client: | Wakatipu Investments Ltd |
| Tets Pit Number: | Test pit #10 - Fine, sunny, no wind. | Sheet 10 of 10 | |

| Depth (m) | Water Level | Graphic Log | Moisture | Soil Rock Description | Geological Unit | Depth |
|---|---|---|---|---|---|---|
| | | | | TOPSOIL - turf, dark brown, dry | Topsoil | |
| 0.5 | | | | Sandy SILT, LOESS - Light brown, moist | Loess | 0.5 |
| 1.0 | | | | | | 1.0 |
| 1.5 | | | | Sandy GRAVEL, some silt, cleaner with depth, light brown/gray, subrounded, wet | Gravel | 1.5 |
| 2.0 | | | | | | 2.0 |
| 2.5 | | | | 2.3m bottom of pit, water ingress at 1.8m depth.  | | 2.5 |
| 3.0 | | | | | | 3.0 |
| 3.5 | | | | | | |

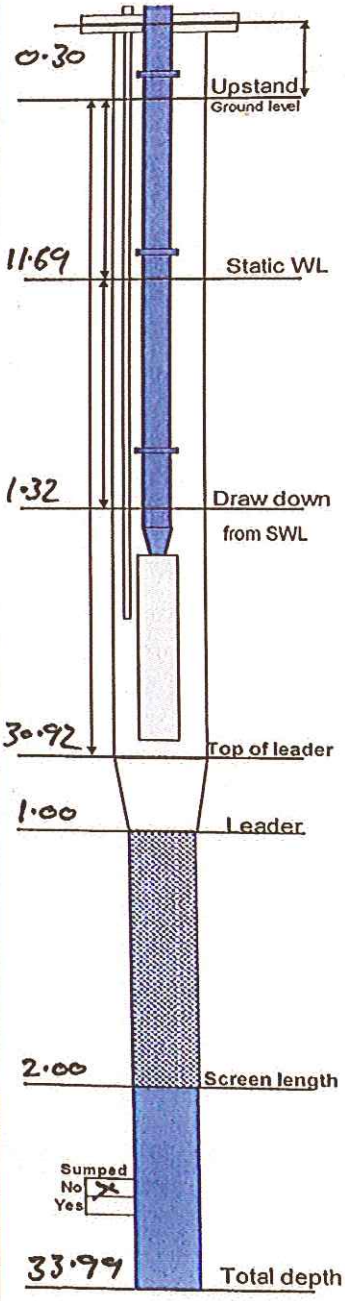
| | | | |
|---|---|---|---|
| Date Excavated: | 21/03/2019 12:46pm | Equipment: | Hitachi 13.5 tonne excavator |
| Logged By: | JFM | Contractor: | Solidbuilt Homes Ltd |

mcneill DRILLING | DISTRIBUTION | PUMPING SINCE 1918

| | | | |
|---|---|---|---|
| Client Name: | Urban collective | Home No. | |
| | Hole 2 | Cell No. | |
| Address | Littles Rd | Consent No. | |
| | Queenstown | | |
| Grid Reference | E- 1262472 | N- 5010257 | |
| Driller | N Simmons | | |
| Machine/Rig: | DR24 | Fleet No. 232 | |
| Drill Method: | Diesel rotary | | |
| Bore diameter mm | 150 mm | | |
| Start date: | 10-5-17 | Finish Date: 11-5-17 | |
| Development Hours: | 2.5 | Development Method: ~~air~~ Surge | |
| Screen Slot: | 2.5 mm | ID 128 mm | OD 138 mm |
| PVC slotted | Top m | Bottom m | |
| Total casing used: | 32.32 m m | Total Depth: 33.99 m | |
| Sump length: | N/A m | Sump Diameter: mm | |
| Test Pumping | Air lifted | Pumped ✓ | Rate: 6.25 LPS |
| Test Pump period | 5 Hrs | Pump intake: 20 m | |
| Bacterial Water test | Yes ✓ | No | |
| Chemical Water test | Yes ✓ | No | |
| Casing top sealed | Yes ✓ | No | |
| Impervious seal at ground | Yes | No ✓ | |
| Over Drilled | Yes ✓ | No | 0.5 m |

Comments:

0 - 0.7 Soil
0.7 - 3.9 Small Sandy Gravel
3.9 - 9.9 Silt
9.9 - 20.9 Very ~~Sandy~~ Silty Gravel
20.9 - 23.9 ~~Sandy~~ Very Silty Gravel
23.9 - 27.3 Sand
27.3 - 34.00 Sandy Gravel
34.00 - 34.5 Schist rock




Version: 1, Created 16 October 2014

# WAKATIPU INVESTMENTS LTD

LITTLES ROAD SUBDIVISION
DALEFIELD

## GEOTECHNICAL ASSESSMENT FOR PROPOSED RURAL SUBDIVISION

REF: R5119-2A
DATE: 31 AUGUST 2019

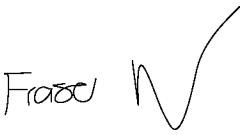
GCL Ground Consulting Ltd

# REPORT QUALITY CONTROL

REPORT PREPARED BY: **GROUND CONSULTING LIMITED (GCL)**


## QUEENSTOWN OFFICE

157 GLENDA DRIVE, FRANKTON
POST: PO BOX 2963, QUEENSTOWN 9349
EMAIL: queenstown@gcltech.co.nz
TEL: 03 442 5700


| DOCUMENT CONTROL | | | | |
|---|---|---|---|---|
| REPORT TITLE | | GEOTECHNICAL ASSESSMENT FOR PROPOSED RURAL SUBDIVISION | | |
| REPORT REFERENCE | | R5119-2A | PROJECT NUMBER | 5119 |
| CLIENT | | WAKATIPU INVESTMENTS LIMITED | | |
| REV | DATE | REVISION STATUS | AUTHOR | REVIEWER |
| A | 31 AUGUST 2019 | ISSUED TO CLIENT | PETER FORREST | FRASR WALSH |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| APPROVAL | | | | |
| AUTHOR SIGNATURE | |  | REVIEWER SIGNATURE |  |
| NAME | | PETER FORREST | NAME | FRASER WALSH |
| TITLE | | PRINCIPAL ENGINEERING GEOLOGIST | TITLE | DIRECTOR |

# EXECUTIVE SUMMARY

| | | |
|---|---|---|
| Scope of Work | | GCL has been engaged to conduct a geotechnical investigation of the ground conditions at Lot 10 LT518523, Littles Road, Dalefield, and make appropriate recommendations for resource consent conditions with respect to natural hazards, earthworks and foundation conditions. |
| Current Site Status | | The site remains open pasture accept the preliminary construction of an access road. |
| Development Proposals | | 20 Lot rural subdivision, with Lot sizes ranging from 0.69 to 8.85ha. Single building platform area for each lot. |
| Site Details | Location | Lot 10 LT518523, Littles Road, Dalefield. |
| | History | Open pasture, with no history or previous development. |
| Ground Conditions | Published Geology | Late Pleistocene Glacial Till Deposits comprising generally unweathered, unsorted to sorted, loose sandy gravel silt and sand (till) in terminal and ground moraines. |
| | Previous Investigations | An Infrastructure Report was prepared by Civilised Ltd that covers off on the basic infrastructure requirements, including earthwork volumes, stormwater and effluent disposal. |
| | Hydrogeology | Depressed groundwater at the building platform. A number of open gulleys are situated in the north of the property that trend into overland flow paths. The eastern section of the lower portion of the property also contains incised gulley features. |
| | Environmental Condition | No environmental hazards are expected. |
| Natural Hazards | Liquefaction | Site investigations have proven rock at shallow depth and soils not prone to liquefaction. |
| | Alluvial landforms | QLDC and ORC mapping does not identify the area as alluvial in nature. However, a number of gulleys and overland flow paths are apparent across the site that will impact on a number of the lots in terms of drainage and stability. |
| | Seismic characteristics | Seismic Soil Class B and C (site specific) considered appropriate. No active faults in proximity but design should be cognisant of NZS1170.5. |
| Geotechnical Considerations | Slope Stability | No stability issues other than Lot 11 that has a building platform in close proximity to a gulley bank. |
| | Building Platform | Earthworks required to form a cut to fill platform. |
| | Foundations | NZS3604 "good ground' present which will provide an ultimate bearing capacity of 300kPa for traditional shallow foundations or waffle slab-on-ground solutions. |
| | Earthworks | Standard conditions apply to align with QLDC Code of practice. Site won material is suitable for reuse subject to appropriate screening. |
| Infrastructure | By others. | |

# TABLE OF CONTENTS

# LIST OF DRAWINGS



# LIST OF TABLES



# APPENDICES

# 1 INTRODUCTION

## 1.1 PROJECT BRIEF

A geotechnical assessment has been undertaken by GCL for a proposed rural residential subdivision of Lot 10 LT518523, Littles Road, Dalefield at the request of the Urban Collective on behalf of the clients Wakatipu Investments Ltd. The site location is presented in Drawing 001.

This geotechnical assessment has been prepared for the purpose of obtaining resource consent with Queenstown Lakes District Council (QLDC).

This report includes a summary of the investigations undertaken and provides an assessment of:

- Site details.
- Ground conditions.
- Groundwater conditions.
- Natural hazards.
- Building platform stability.
- Foundation conditions.
- Other pertinent constraints and issues identified with the site.

## 1.2 PROPOSED SITE DEVELOPMENT

A scheme plan showing the indicative layout of the proposed subdivision is contained in Appendix A.

The proposed subdivision will comprise 20 lots with designated building platforms, access roads and driveways. The land is currently zoned Rural General under the Queenstown Lakes District Council (QLDC) District Plan and is zoned Wakatipu Basin Lifestyle Precinct under the QLDC Proposed District Plan. All building platform areas are to the south of the boundary between the Wakatipu Basin Amenity Zone and Lifestyle Precinct, although some Lots have land area situated across the boundary.

The new building platforms are to be created on flat to gently sloping ground within each allotment. All of the proposed lots are intended for rural lifestyle development with incorporation of building restriction and landscape covenant areas to preserve as much of the existing rural landscape as possible. The lots vary in size from 0.69ha to 8.85ha, with each building platform measuring approximately 60m x 60m.

The property will require on-site stormwater and effluent disposal systems, which are subject to assessment by Civilised Ltd.

# 2 DESK TOP STUDY

## 2.1 PREVIOUS INVESTIGATIONS

GCL has reviewed the QLDC eDocs facility, which provided limited site investigation documentation for the immediate area. GCL has undertaken recent site investigations on nearby properties and are therefore familiar with the ground conditions of the Little Road and Fitzpatrick Road area.

In addition, an Infrastructure Report was prepared by Civilised Ltd for Wakatipu Investments Ltd for the Dalefield Subdivision in support of resource consent application RM190656, referenced QV021. The report covers off on the basic infrastructure requirements of the then 24-lot development, including stormwater and effluent disposal. With the latter, a total of ten test pits were excavated across the subdivision in order to determine ground conditions for soakage and effluent disposal. No geotechnical parameters were measured during this exercise. A copy of the test pit location plan and the test pit logs from Civilised are reproduced in Appendix B.

The Civilised report also provides information on potable water supply and includes within its Appendix C a copy of a borehole record drilled by McNeills Drilling for the purposes of developing a water well. The borehole 'drillers' log is also presented in Appendix B. Its location is south of Little Road however, so can only provide indicative ground conditions – see Section 2.2 below also.

## 2.2 NEW ZEALAND GEOTECHNICAL DATABASE

The New Zealand Geotechnical Database (NZGD) has been viewed and no geotechnical investigations have been identified in the immediate vicinity of the proposed dwelling.

However, three boreholes have been drilled in lower lying areas approximately 550m to the southeast of the proposed site on Fitzpatrick Road properties. The boreholes were drilled as water wells, noting standing groundwater levels at approximately 10m, and deep rock head. Given the distance and differing geomorphology these are not considered relevant to the proposed site.

## 2.3 HISTORICAL AERIAL PHOTOGRAPHS

Aerial photographs available from the Google Earth Images and Retrolens.nz dating from 1956 to 2016 were studied to observe the site over time and assess the geomorphological setting. The review of historic aerial photography indicates that there has been no significant modification of the site and surrounding area, which remains open pasture.

## 2.4 PUBLISHED GEOLOGY

The Geological Map of New Zealand, Sheet 18 (Wakatipu), at a scale of 1:250,000 maps the site as being underlain by Late Pleistocene Glacial Till Deposits comprising generally unweathered, unsorted to sorted, loose sandy gravel silt and sand (till) in terminal and ground moraines.

### 2.5 SITE SERVICES

The property is not serviced by reticulated public stormwater or wastewater services. Utilities will be developed as part of the subdivision infrastructure.

# 3 SITE CONDITIONS

### 3.1 SITE DETAILS

The site comprises Lot 10 LT518523 situated on the north side of Littles Road, Dalefield.

The site is located within a predominantly rural/farming landscape, that has been identified for rural subdivision development within the district of Dalefield. The property comprises an undeveloped lot with a specific building platform and is currently surrounded by undeveloped land and residential development in various stages of construction and completion.

At the time of our investigations, the easterly access road was in the early stage of construction.

### 3.2 SITE TOPOGRAPHY

The site consists of a large gently to moderately sloping southeast facing paddocks currently used for stock grazing.

The northern property boundary is situated on a southwest to northeast trending ridge, with steeper grade slopes falling directly off the ridge to the southeast, before shallowing towards the areas of the proposed building platforms. Grades in the vicinity of the building platforms on Lots 1 to 20 can be described as flat to gently sloping.

A number of sub parallel gulleys are clearly evident from both aerial photographs and from the site walkover. The gulleys are reasonably incised on the upper slopes, before shallowing out on the lower slopes and morphing in to ephemeral overland flow paths. The exception is a 3m deep, 10m wide gulley situated in the north eastern section of the subdivision. Drawings 002a and 002b attempt to map gulleys and overland flow paths (002a) based on site walkover information and Google Earth imagery (002b).

Vegetation patterns is also another indicator of the gulley features and overland flow paths. The latter are quite evident on the 2018 Google Earth imagery (DRW002b) where the grass cover is much darker and more verdant where coincidental with the flow paths.

### 3.3 SITE SURFACE WATER FEATURES

Whilst there are no surface water features marked on the topographical maps for the area, as discussed above, the aerial photographs suggest that a number of ephemeral surface water features or previous stream lines are evident running off the ridge feature. These are delineated by typical meandering lines of greener and heavier vegetation than the surrounding paddocks and slight variation in shadows suggesting shallow gulleys (Drawing 002b).

A minor gulley runs from the ridge to the southeast in the eastern section of the subdivision passing through Lots 6 to 11 to varying degrees. The gulley is not seen to interfere with any of the building platforms, but does pass close to the building platform of Lot 11.

Surface water from the project site will drain off the land via sheet flow, from the northwest to the southeast.

## 3.4 SLOPE INSTABILITY FEATURES

The site contains no observed slope instability features.

## 3.5 NATURAL HAZARDS

### 3.5.1 Tonkin & Taylor (T&T) Liquefaction Hazard Assessment for QLDC

In 2012, T&T published their Queenstown Lakes District Liquefaction Hazard Assessment Report, a summary of which is usually attached to the LIM for any property. The report indicates that the site does not lie within mapped liquefaction zones. This is interpreted to mean that the site has a low to nil perceived risk for liquefaction.

In addition, good engineering practice promotes site investigation to satisfy the requirements of NZS3604 and determine 'good ground' is available and that there are no saturated fine-grained soils present that are prone to liquefaction.

### 3.5.2 ORC Liquefaction Hazard Zoning

The ORC hazard mapping relies on the Opus report provided to the Council titled Seismic Risk in the Otago Region (2005). This study identifies the lower two thirds of the property area as 'possibly susceptible', based on the presence of very loose to medium dense sediments where liquefaction or settlement are possible with seismic shaking of sufficient intensity.

### 3.5.3 GIS Hazard Mapping

With reference to the ORC and QLDC GIS and hazard mapping, the site area has the following characteristics:

- Alluvial fan processes or landscapes do not affect the site. Whilst the aerial surveys suggest a number of sub parallel gulleys coming of the ridge along the northern property boundary, the catchment is very small with no evidence of recent alluvial activity.
- The site is not in a flood hazard zone.
- The site is not in an area associated with active fault zones.
- The site is not in an area of known active landslides.
- The site area is mapped as being possibly susceptible to liquefaction due to the likely presence of loose fine-grained sediments.
- A 1:2500-year seismic event will cause significant shaking and damage to inappropriately designed structures.
- The seismic soil classification for the area is Class B for shallow soils (less than 3m) in the upper regions of the property (where no building is anticipated) and Class D for deeper soils situated in the lower portions of the property.

### 3.5.4 Discussion on the Gulley Features

Despite the GIS and hazard mapping not identifying the area as subject to alluvial activity or landscape, the gulley features running of the northern ridge of the property are considered to be 'active' in that water was seen to be flowing at low volumes through them during the site walkover and investigation period. The depth of the gulley features reflects more the erodibility of the upper surface soils rather than volume of flow. There is also no evidence to suggest that debris flow is a hazard associated with the gulleys, primarily because the catchment is small, comprising mainly paddock underlain by competent rock. I.e. there is little source material available.

The gulleys themselves are stable in so far as there is no evidence of any slumping or landslip type features on their banks. Nor is there evidence of any tension cracks propagating away from the crest of the banks.

However, it is clear that their ephemeral flow and their transition to more overland flow paths needs to be considered on a lot by lot basis when considering the position of the building platforms to their surface expression. Table 1 below summarises the Lots that are potentially impacted by the overland flows and gulleys.

Table 1: Overland Flow Impact per Lot

| Lot | Feature Present | Potential Impact | Potential Mitigation |
|---|---|---|---|
| 1 | Gulley to the immediate west of the building platform | South west corner of building platform coincides with top of bank | Move the building platform to the north east. |
| 2 | None mapped | NA | NA |
| 3 | Two merging overland flow paths at the position of the building platform. | Wet ground and interference of overland flow path. | Use access ROW to capture upstream overland flow and divert away from the Lot. |
| 4 | Overland flow path. | Negligible | Ensure Building Platform away from flow path. |
| 5 | Overland flow path. Boggy ground noted during site investigation. | Wet ground and interference of overland flow path. | Use access ROW to capture upstream overland flow and divert away from the Lot. |
| 6 | Gulley to the immediate west of the building platform. | Proximity to the top of bank. | Rotate building platform to increase distance from bank. |
| 7 | Small gulley to the immediate west of the building platform | Proximity to the top of bank. | Rotate building platform to increase distance from bank. |
| 8 | Overland flow path to the west of the building platform. | Negligible. | NA |
| 9 | Overland flow path to the west of the building platform. | Negligible. | NA |
| 10 | Overland flow path to the west of the building platform. | Negligible. | NA |
| 11 | Gulley feature adjacent to the south east corner of the building platform. | Stability of foundations and bank. | Move the building platform at least 10m from the top of the bank. |
| 12 | Gulley feature and flow path to the north west of the building platform, with confluence of other flow paths to the north of the platform. | Potential for surface water to encroach on the building platform. | Specific assessment of the hazards and potentially raise the building platform level or hard engineer drainage solutions. |
| 13 | None mapped | NA | NA |

| Lot | Feature Present | Potential Impact | Potential Mitigation |
|---|---|---|---|
| 14 | None mapped | NA | NA |
| 15 | None mapped | NA | NA |
| 16 | None mapped | NA | NA |
| 17 | Gulley feature and flow path to the north west of the building platform, with confluence of other flow paths to the north of the platform. | Potential for surface water to encroach on the building platform. | Move the building platform to the north east. |
| 18 | Building platform situated between two overland flow paths. | Negligible. | Ensure Building Platform away from flow path. |
| 19 | North east corner of the building platform cuts across an overland flow path. | Wet ground and interference of overland flow path. | Move building platform to the south west. |
| 20 | Building platform situated south and down slope of an overland flow path. | Potential for surface water to encroach on the building platform. | Specific assessment of the hazards and potentially raise the building platform level or hard engineer drainage solutions. |

It should also be noted that the main access road to the subdivision which runs between Lots 1-4, 6, and 8-11 inclusive is coincident with an overland flow path. This has been mitigated during construction with the installation of a field drain running along the side of the access road, together with a number of soak pits.

# 4 SUB SURFACE CONDITIONS

## 4.1 FIELD INVESTIGATIONS

Sub-surface investigations have been undertaken in the vicinity of the proposed building platforms with a single test pit located to provide appropriate information for the potential building platform. A suitably qualified engineering geologist from GCL undertook the investigations, with locations determined with a hand-held GPS device and the use of QLDC GIS viewer and Google Maps.

The sub-surface investigations have comprised twenty mechanically excavated test pits, with a maximum depth of 3.4m; excavation ceased once geology had been established.

The locations of all sub-surface ground investigations are shown relative to the identified building platform in Drawing 002.

## 4.2 INVESTIGATION LOGGING

Soils recovered from the test pits have been logged and are presented in Appendix C. Logging of the soil encountered has been undertaken in accordance with NZ Geotechnical Society Guidelines for the Field Classification and Description of Soil and Rock for Engineering Purposes.

Scala penetrometer testing has not been undertaken for the purpose of this exercise, with strength parameters being derived based on the test pit observations and assessment of the soils' relative density through engineering logging and description.

## 4.3 GROUND CONDITIONS

A summary of the sub-surface conditions identified in the investigations undertaken is presented below in order of depth from the ground surface. The sub-surface conditions have been extrapolated between the investigations undertaken. Whilst care has been taken to provide sufficient sub-surface information, following best practice for the purposes of resource consent, no guarantee can be given on the validity of the inference made. As such, it should be appreciated that ground conditions may vary between the investigations undertaken.

### 4.3.1 Soil Type Summary

Table 2 below summarises the different soil types encountered during the investigation together with their depth range and measured thickness (m) within each test pit. The soil types are presented in stratigraphical order from left to right across the table.

Table 2: Lithology Summary

| TP | Lot | Topsoil | Loess | Colluvium | Alluvium | Glacial Till | Schist |
|---|---|---|---|---|---|---|---|
| 101 | 12 | 0-0.4m (0.4) | 0.4-0.8m (0.4) | - | 0.8-0.9m (0.1) | 1.9-2.7m (0.8) | - |
| 102 | 13 | 0-0.4m (0.4) | - | 0.4-0.7m (0.3) | 0.7-2.5m (1.8) | 2.5-3.2m (0.7) | - |
| 103 | 14 | 0-0.2m (0.2) | - | 0.2-0.4m (0.2) | - | 0.4-2.1m (1.7) | - |
| 104 | 15 | 0-0.4m (0.4) | - | 0.2-0.9m (0.7) | - | 0.9-2.5m (1.6) | - |
| 105 | 1 | 0-0.3m (0.3) | - | 0.3-0.7m (0.4) | - | 0.7-2.1m (1.5) | - |
| 106 | 2 | 0-0.2m (0.2) | - | - | 0.2-1.5m (1.3) | 1.5-2.4m (0.9) | - |
| 107 | 10 | 0-0.3m (0.3) | - | - | 0.3-1.7m (1.4) | - | 1.7-3.2m (1.5) |
| 108 | 11 | 0-0.3m (0.3) | 0.3-0.4m (0.1) | - | 0.4-2.9m (2.5) | - | 2.9-3.3m (0.4) |
| 109 | 4 | 0-0.3m (0.3) | - | 0.3-1.4m (1.1) | 1.4-1.8m (0.4) | 1.8-2.4m (0.6) | 2.4-2.9m (0.5) |
| 110 | 6 | 0-0.2m (0.2) | - | - | 0.2-1.1m (0.9) | - | 1.1-1.5m (0.4) |
| 111 | 8 | 0-0.2m (0.2) | - | - | 0.2-1.3m (1.1) | - | 1.3-1.5m (0.2) |
| 112 | 9 | 0-0.3m (0.3) | - | - | 0.1-1.3m (1.0) | - | 1.3-1.5m (0.2) |
| 113 | 7 | 0-0.3m (0.3) | - | 0.3-0.6m (0.3) | - | 0.6-3.1m (2.5) | 3.1-3.2m (0.1) |
| 114 | 5 | 0-0.3m (0.3) | - | - | 0.3-0.5m (0.2) | 0.5-1.2m (0.7) | 1.2-1.3m (0.1) |
| 115 | 3 | 0-0.3m (0.3) | 0.3-0.5m (0.2) | - | 0.5-2.9m (2.4) | - | - |
| 116 | 17 | 0-0.3m (0.3) | - | - | 0.3-0.6m (0.3) | 0.6-2.5m (1.9) | - |
| 117 | 18 | 0-0.3m (0.3) | - | 0.3-0.7m (0.4) | 0.7-2.5m (1.8) | - | 2.5-3.1m (0.6) |
| 118 | 19 | 0-0.4m (0.4) | - | - | 0.4-1.7m (1.3) | 1.7-2.8m (1.1) | - |
| 119 | 20 | 0-0.3m (0.3) | - | 0.3-0.7m (0.4) | 0.7-2.4m (1.7) | 2.4-3.0m (0.6) | - |
| 120 | # | 0-0.3m (0.3) | 0.3-0.7m (0.4) | - | - | 0.7-3.4m (2.7) | - |

### 4.3.2 Topsoil

Topsoil, gravelly in places, mantles the site to a depth of between 0.3 and 0.4m but is generally 300mm thick.

### 4.3.3 Loess

Both the GCL and Civilised investigations identified loess materials across the property. Typically comprising a clayey SILT or silty fine SAND, the material presents as yellowish brown and firm to stiff with occasional rootlets extending from the topsoil and measuring up to 400mm thick. Loess is not uncommon in the Dalefield and Lower Shotover districts.

### 4.3.4 Colluvium

Colluvium (recent soils derived from shallow slope wash and weathering processes) was encountered in several pits particularly around the gully feature in the eastern section of the site.

The colluvial soils are generally described as clayey SILT or silty SAND with an orange discolouration and varying volumes of gravel and rootlets. The soils extend to a maximum depth of 1.4m but are generally circa 500mm thick where present. The relative density varies from form to stiff.

### 4.3.5 Alluvial Deposits

Alluvial deposits were encountered across the majority of test pits presenting as a gravelly SAND with cobbles and occasional boulders being greyish brown in colour. The relative density varies across the property from moderately dense to dense.

Groundwater inflow and or saturated soils were also a common feature of the alluvial deposits.

### 4.3.6 Glacial Till

Glacial deposits were encountered generally below the colluvium or alluvium and extended to a maximum depth of 3.4m and up to 2.7m in thickness. The soils are generally described as dense and very dense silts, sands and gravels with varying volumes of cobbles and boulders. The glacial deposits are all reported to be dry, indicating the high level of relative density hindering perched groundwater.

### 4.3.7 Schist Bedrock

Schist bedrock was encountered in nine of the test pits excavated from as shallow as 1.1m below ground level. The rock often describes a completely or heavily weathered mantle that results in blue grey clayey silt being present above the more competent foliated moderately strong rock, typical of the district.

## 4.4 GROUNDWATER CONDITIONS

Groundwater inflow and saturated soils are associated with the alluvial deposits only, indicating a perched and non-continuous water table across the site. This is also consistent with the observations made by Civilised Ltd.'s investigation also.

With reference to the boreholes drilled in the area for water supply, logs would suggest that the water table is approximately 10m below ground level at the topographical height of Littles Road. This would suggest slightly deeper groundwater for the project site.

Given the nature and topography of the site, it is unlikely that a coherent groundwater table would rise significantly to the extent that it would interfere with shallow foundations.

# 5 NATURAL HAZARD RISK ASSESSMENT

## 5.1 GENERAL

In accordance with Section 106 of the Resource Management Act, we have undertaken a qualitative natural hazards risk assessment for the proposed subdivision. The natural hazard consequence and likelihood of occurrence has been assessed by means of the overall risk matrix as shown in Table 3, with the risk classifications defined in Table 4.

Table 3: Risk Matrix

| POTENTIAL CONSEQUENCES | LIKELIHOOD | | | | |
|---|---|---|---|---|---|
| | VERY UNLIKELY (0 – 5%) | UNLIKELY (5 – 45%) | POSSIBLE (45 – 55%) | LIKELY (55 – 95%) | ALMOST CERTAIN (95 – 100%) |
| SEVERE | Low | Low | Moderate | High | Very high |
| MODERATE | Negligible | Low | Moderate | Moderate | High |
| MINOR | Negligible | Low | Low | Moderate | Moderate |
| NEGLIGIBLE | Negligible | Negligible | Negligible | Low | Low |

Table 4: Summary of Risk Classification

| RATING SCALE | SECTION 106 COMLIANCE | DISCUSSION |
|---|---|---|
| VERY HIGH | Non-compliant | There is a high probability that severe damage to the proposed house site could arise from an identified source without appropriate remedial action |
| HIGH | Non-compliant | The proposed house site is likely to experience significant damage from an identified source without remedial action |
| MODERATE | Non-compliant | It is possible that damage could arise to the proposed house site, but it is unlikely that such damage would be significant |
| LOW | Compliant | It is possible that damage could arise to the proposed house site from an identified source though this is likely to be mild or unlikely |
| NEGLIGIBLE | Compliant | The presence of the identified source does not give rise to the potential to cause significant damage to the proposed house site |

## 5.2 SUBDIVISION ASSESSMENT

Table 5 shows a risk register for the proposed subdivision and appropriate mitigation measures if applicable based on Tables 2 & 3.

Table 5: Risk Register

| RISK | POTENTIAL CONSEQUENCES | LIKELIHOOD | RISK CLASSIFICATION | COMMENT | MITIGATION MEASURES |
|---|---|---|---|---|---|
| SLOPE INSTABILITY | Moderate | Very unlikely | Negligible | Remote from any active landslide. No geomorphological expression of recent activity. | n/a |
| GROUND SUBSIDENCE | Moderate | Very unlikely | Negligible | Competent ground conditions | n/a |
| SOIL SHRINK/SWELL | Moderate | Very unlikely | Negligible | See Section 8.4 | Engineered foundations designed for Class S soil expansivity |
| EARTHQUAKE | Severe | Possible | Moderate | Remote from active fault, but in a seismically active region. | Appropriately designed structure in accordance with NZS1170. |
| LIQUEFACTION | Severe | Very unlikely | Low | Course and relatively dense ground conditions with rock likely to be shallow across the subdivision. | Be vigilant in further site investigations at detailed design stage. |
| DEBRIS FLOW | Moderate | Unlikely | Low | No evidence of any debris flow activity or source of material identified. Gulleys are deep and would contain any debris flow. | n/a |
| FLOODING | Moderate | Very unlikely | Negligible | No water courses on site. Flooding not identified as a risk by QLDC or ORC. | n/a |
| TSUNAMI | Minor | Very unlikely | Negligible | Elevated site remote from lake | n/a |
| VOLCANIC ERRUPTION / ASH FALL | Moderate | Very unlikely | Negligible | Remote from active volcanic centre | n/a |

Table 5 indicates the risk classification for the identified natural hazards is low to negligible for all risks apart from "Earthquakes" where appropriate mitigation measures can be reasonably

provided. As such, we consider the proposed house site fulfils Section 106 of the Resource Management Act.

# 6 GROUND MODEL

## 6.1 GENERAL

We have developed a ground model for the site based on the investigations undertaken to date including a desktop study, site mapping and sub-surface tests. A summary of the ground model is provided as follows:

- The site is presently undeveloped and does not appear to have been significantly modified in recent history aside from the establishment of the current access road being built.
- The site is located on moderately sloping topography, which shallows to the south east. The site does not display any slope instability features. In addition, the site is remote from steeper slopes and/or slopes prone to the development of slope instability features.
- The site is underlain by competent ground conditions consisting of loess, colluvium, alluvium, glacial deposits and shallow rock head. The loess and colluvium may be unsuitable for earthworks and to accommodate foundations depending on site specific investigations. However, the alluvium and glacial till are general dense materials that will provide site won material suitable for earthworks and foundation embedment.
- Aerial imagery together with site walkover observations suggests that the gulley features in the north of the property trend into overland flow paths and or ephemeral streams. A number of gulley features also extend on to the lower slopes of the property, particularly in the eastern section. There is little evidence from the test pit logs or on site of any recent alluvial activity associated with the gulleys other than the presence of small volumes of flow..
- Seepage and inflow within the granular alluvial materials was reported in the test pits but the underlying glacial till proved to be dry. Consequently, perched groundwater may be present on site within the granular alluvial materials, but not to the extent that they would interfere with shallow foundations.
- The site is not located in the vicinity of an active fault zone but should be considered as seismically active in line with the wider Otago region.
- The site is not considered susceptible to liquefaction due to the presence of shallow rock head and generally depressed groundwater levels across the site.
- There are no apparent environmental hazards associated with the site.

The ground model developed above has been utilised to consider the various geotechnical aspects of the proposed development which is presented in Section 7 of this report.

### 6.2 GEOTECHNICAL RISK

The ground model presented in this report is based on the investigations undertaken to date and it should be appreciated that there is inherent risk with the formulation of a ground model. In particular we note the following:

- Ground conditions can vary between investigations undertaken and there is always some natural variability in ground conditions.
- Discrete sub-surface investigations may not identify small-scale ground irregularities, particularly associated with human disturbance such as offal pits, drainage line back-fills and landscaping works.
- Ground strength varies with changes in water content, soil type and ground loading. As such, it should be appreciated that weaker ground conditions may develop over that measured due to periods of wet weather and/or during the winter months.
- The potential geotechnical effects of climate change are not well understood to date. Effects may include changes in groundwater levels, soil saturation and surface water characteristics, which may have an effect on site development.

Given the potential risk profile provided above, we have adopted a conservative approach when considering the geotechnical aspects of the proposed development provided in Section 7 of this report.

# 7 GEOTECHNICAL CONSIDERATIONS

### 7.1 GENERAL

The geotechnical aspects of the proposed subdivision have been considered principally with the aim of demonstrating that safe and stable conditions for the proposed building platforms and future dwellings are presently available or are achievable with appropriate remedial works/constraints. This in particular has been considered with respect to the following information, standards, guidelines and codes:

- The ground model developed in Section 6 of this report.
- NZS 3604:2011: 'Timber-framed buildings'.
- AS 2870:2011: 'Residential slabs and footings'.
- NZS 1170:2004: 'Structural design actions'.
- New Zealand Building Code: Clauses B1, E1, G12 & G13.
- District and Regional Plan provisions on residential development.
- Council development codes, standards and guides on residential development.

Of note, is NZS 3604:2011 and the New Zealand Building Code which provide a set of criteria for determining whether safe and stable conditions or "good ground" are achieved, whereby "good ground" allows for the design of standard foundations in accordance with the provisions of the standards. In summary, "good ground" defines conditions where the risk of

foundation failure is considered to be low to nil. Foundation failure is possible via the following mechanisms, which are addressed in this report as follows:

- Slope instability: This includes foundation failure associated with slope derived instability and is addressed in Section 7.2 of this report.
- Weak ground: This includes foundation failure associated with poor bearing capacity and is addressed in Section 7.4 of this report.
- Ground settlement/consolidation. This includes ground consolidation associated with building loads, earthworks load, and dewatering and is addressed in Section 7.5 of this report.
- Soil expansiveness: This includes soil shrink/swell associated with drying and wetting of the soil profile and is addressed in Section 7.6 of this report.
- Seismicity: This includes the effects of ground shaking associated with a seismic event and is addressed in section 7.7 of this report.

## 7.2 SLOPE STABILITY

The proposed subdivision is located on gently to moderately sloping topography, which is underlain by competent ground conditions and is remote from steeper slopes and/or slopes prone to the development of slope instability features.

The modest overall slope angles and underlying competent ground conditions in the vicinity of the proposed building platforms should provide a safe and stable ground with respect to slope stability conditions. The only variation from this would be Lot 11, where the current platform is in close proximity to the top of a gulley bank.

A safe and stable building platform is defined as having a low to negligible risk of failure over the lifetime of the dwelling and is assessed as a factor of safety where a quantitative slope stability assessment is undertaken. Given the modest slope angles in the vicinity of the site, we consider that a qualitative assessment of slope stability (as provided above) is acceptable for defining risk for this site and that a more rigorous quantitative analysis is not required.

Site earthworks will likely be required to some extent on each building platform to provide a suitable level area within the existing topography, and we consider that appropriate site development constraints are required in order to maintain safe and stable conditions. This is addressed in Section 8 of this report.

## 7.3 BUILDING PLATFORM DEVELOPMENT

Each building platform will be site specific in terms of the amount of development they will need in order to form the level area required. This may well require cut to fill in some instances.

The use of site won material will be subject to confirmation on site. Materials considered unsuitable will be the topsoil and to a lesser extent the loess and colluvium materials. Loess generally comprises a clayey silt that is typically very sensitive to change in moisture content and can be difficult to rework when too wet. The colluvium is likely to be more conducive to being reused, but in both cases would be suitable for non-structural landscaping. Suitable site won material is considered appropriate for placement as fill provided the following measures are taken:

- Fill areas to be benched/tied in;

- Free draining material and drainage system placed immediately behind and retaining walls;
- Appropriate lift height, compaction and certification for fill greater than 600mm.

## 7.4 BEARING CAPACITY

### 7.4.1 General

Bearing capacity is discussed in this report in terms of ultimate limit state design methods outlined in AS/NZS 1170. As such, in accordance with AS/NZS 1170, we have provided "ultimate" bearing capacity values and an appropriate "dependable" bearing capacity for foundation design. The dependable bearing capacity has been determined from a strength reduction factor of 0.5 (i.e. a factor of safety of 2), which is in general accordance with the requirements of AS/NZS 1170.

In addition, the 'Allowable Bearing Capacity', where the ultimate is factored by a safety of 3, is included for reference.

The bearing capacity has been determined from our interpretation of the engineering description of the soil conditions, observations from the test pits on the soil behaviour and relative density measurements based on the site-specific testing undertaken. The values presented take into consideration natural variability of ground strength likely between investigations undertaken and potential strength reduction associated with saturated soil conditions.

It is also assumed that engineering fill will be placed to specification to provide an ultimate bearing capacity of 300kPa.

### 7.4.2 Shallow Foundation Solutions

Table 6 outlines design bearing capacities for a shallow pad/strip footing solution. The design capacities are based on a minimum foundation embedment depth of 450mm into competent ground. Competent ground will need to be determined on a site by site basis but is likely to consist of alluvial or glacial deposits, unless the loess and or colluvium is determined to provide sufficient strength.

Table 6: Shallow Pad/Strip Footing Design Parameters

| LOAD CASE | ULTIMATE BEARING CAPACITY | STRENGTH REDUCTION FACTOR | DEPENDABLE BEARING CAPACITY | (ALLOWABLE BEARING CAPACITY) |
|---|---|---|---|---|
| ULTIMATE LIMIT STATE DESIGN | 300kPa | 0.5 | 150kPa | 100kPa |

The embedment depth requirement for this foundation will be subject to formal engineering design and in general accordance to AS 2870 which is outlined in Section 7.5 of this report.

### 7.4.3 Shallow Pile Foundations

Table 7 outlines design bearing capacities for a shallow pile foundation solution for lightweight timber structures and appurtenant structures. The design capacities are based on a minimum foundation embedment depth of 450mm into competent ground. In addition, were piles to

be used, it is likely they would be taken to rock head where far greater bearing capacities could be achieved. Specific engineering design would be recommended if this were the solution adopted.

Table 7: Shallow Pile Foundation Design Parameters

| END BEARING CASE | | | | |
|---|---|---|---|---|
| LOAD CASE | ULTIMATE BEARING CAPACITY | STRENGTH REDUCTION FACTOR | END DEPENDABLE BEARING CAPACITY | (END ALLOWABLE BEARING CAPACITY) |
| ULTIMATE LIMIT STATE DESIGN | 300kPa | 0.5 | 150kPa | 100kPa |
| | | | | |
| AUGURED PILE SKIN FRICTION | | | | |
| LOAD CASE | - | STRENGTH REDUCTION FACTOR | DEPENDABLE SKIN FRICTION | (ALLOWABLE SKIN FRICTION) |
| ULTIMATE LIMIT STATE DESIGN | - | 0.5 | 20kPa | 15kPa |

The embedment depth requirement for this foundation will be subject to formal engineering design and in general accordance to AS 2870 which is outlined in Section 7.5 of this report.

### 7.4.4 Foundation Service Bridging

We recommend that where a service line and associated backfilled trench are located within a 45° loading line taken from the base of a load bearing structure foundation bridging is required.

Service line trenching and backfilling should be in accordance with recommendations provided in Section 8 of the report.

### 7.4.5 Retaining Walls

Engineered retaining walls will be required on site under the following circumstances:

- Where the retention height is greater than 1.5m;
- Where retaining wall supports any surcharged loads such as sloping ground and structure/traffic loads; and
- Where retaining wall failure will affect the stability and integrity of adjacent structures and neighbouring properties.

Table 8 provides geotechnical parameters for the engineered retaining wall design as required:

Table 8: Retaining Wall Design Parameters

| MATERIAL | COHESION (c') | FRICTION ANGLE (ϕ') | ULTIMATE BEARING CAPACITY | UNIT WEIGHT (γ) |
|---|---|---|---|---|
| Loess | 0kPa | 24° | 200kPa | 17kN/m$^3$ |
| Colluvium | 0kPa | 24° | 240kPa | 18kN/m$^3$ |
| Alluvium | 0kPa | 32° | 300kPa | 18kN/m$^3$ |
| Glacial Till | 0kPa | 34° | 300kPa | 18kN/m$^3$ |
| Schist | 100kPa | 26° (0° on foliations) | 900kPa | 26kN/m$^3$ |

All retaining walls should be constructed with appropriate toe drainage and backfilled to their full height with lightly compacted free draining granular material or other appropriate drainage solution. Toe drainage should be discharged at a point that will not impact or influence the construction works on site or alternatively be connected to the reticulated stormwater system.

### 7.5 SOIL EXPANSIVENESS

Provided clayey SILT immediately below the topsoil is removed, the site soil is not considered expansive according to AS 2870 based on the logging of recovered test pit samples.

There is no specific engineered foundation design required to resist shrink/swell associated with non-expansive soil.

### 7.6 SEISMIC CONSIDERATIONS

#### 7.6.1 Seismic Soil Class

Site investigations in the vicinity of the building platforms have proven rock head at varying depths across the property. Therefore, without specific investigation for each building platform a seismic soil class cannot be readily assigned.

However, in general, where rockhead was encountered within 3m of surface, a site sub soil class B is appropriate according to NZS1170.5.

Where rock is in excess of 3m depth, a sub soil class C is appropriate according to NZS1170.5.

#### 7.6.2 Liquefaction

The building platforms are not considered to be at any risk from liquefaction due to the shallow depth to rock head, the density of the sand and silt-based soils, the granular nature of the alluvial soils and the depressed groundwater regime.

#### 7.6.3 Earthquakes

The Queenstown Lakes region, as for most of New Zealand has been identified as being prone to seismic activity and as such, an appropriate allowance for seismic loading should be made during detailed design of the proposed building, foundations, retaining structures and earthworks.

# 8 SITE DEVELOPMENT CONSTRAINTS

### 8.1 GENERAL EARTHWORKS DISCUSSION

The proposed site development works will likely require excavation and or temporary batters prior to the construction of formal retaining structures and building platforms as well as access roads and driveways. As such, there is the risk of collapse of soil batters during construction especially if left unsupported for an extended period of time and or left exposed during prolonged period of rainfall.

The topsoil is considered unsuitable for reuse as an engineered fill, the site won glacial till is likely to provide a source of suitable non-cohesive material for fill placement subject to its performance in context of NZS4431.

## 8.2 SITE PREPARATION

During the earthworks operations all topsoil and organic matter and other unsuitable materials should be removed from the construction areas in accordance with the recommendations of NZS 4431:1989. The subgrade should be inspected prior to fill being placed and or foundations being constructed to establish it has suitable bearing capacity and is clear of unsuitable materials.

Appropriate shallow graded sediment control measures should be installed during construction where rainwater and drainage run-off over exposed soils is likely. If slope gradients in excess of 5% are proposed in soils then the construction and lining of drainage channels is recommended, e.g. with geotextile and suitably graded granular material, or similarly effective armouring.

Exposure to the elements should be limited for all soils and covering the soils with polythene sheeting will reduce degradation due to wind, rain and surface run-off. Under no circumstances should water be allowed to pond or collect near or under a foundation or slab. This can be avoided with shaping of the subgrade to prevent water ingress or ponding.

If fill is utilised as bearing for foundations it should be placed and compacted in accordance with the recommendations of NZS 4431:1989 and certification provided to that effect.

The upper soils present at the site are prone to erosion, both by wind and water, and should be protected by hardfill capping or re-topsoiled/mulched and re-vegetated as soon as the finished batter or subgrade levels are achieved.

## 8.3 EXCAVATIONS

Recommendations for temporary and permanent slope batters are provided in Table 9 below. Slopes that are required to be steeper than those described below should be structurally retained or subject to specific geotechnical design.

All slopes should be periodically monitored during construction for signs of instability and excessive erosion, and, where necessary, corrective measures should be implemented to the satisfaction of a Geotechnical Engineer or Engineering Geologist. Should construction and earthworks be undertaken during the winter period, the frequency of the inspections should increase, with site inspections being made after any significant weather event.

Seepages are common in excavations completed in hillside areas and drainage measures, such as horizontal drains, may be required if excessive groundwater seepages are encountered during excavation. This may well be the case in the deeper excavations where groundwater is anticipated to be near or just above rockhead or at the contact between the glacial till and alluvial soils. The final design and location of all sub-soil drainage works should be confirmed during construction by a suitably qualified and experienced Geotechnical Engineer or Engineering Geologist.

Recommended temporary and permanent batter angles for cut slopes up to a maximum of 3.0m in both wet and dry conditions are presented below. The batters provided should be adhered to where more than one soil type is present within the slope or defaulted to the

shallower angle where appropriate. The height of any permanent batter should be cognisant of QLDC's District Plan Section 22 – see Section 8.5 below.

Table 9: Batter angles for soil slopes

| Material Type | Recommended Maximum Batter Angles for Temporary Cut Slopes Formed in Soils | | Recommended Maximum batter Angles for Permanent Cut Slopes Formed in Dry (Drained) Slopes |
|---|---|---|---|
| | Wet Ground | Dry Ground | |
| Topsoil | 3H:1V | 2.5H:1V | 2H:1V (grassed/planted) |
| Engineered Fill | 2H:1V | 1H:1V | 2H:1V (unretained, drained) |
| Loess[1] | 3H:1V | 1H:1V to sub vertical | 1H:1V |
| Colluvium | 3H:1V | 2H:1V | 2H:1V |
| Alluvium | 2H:1V | 1H:1V | 2H:1V or by assessment |
| Glacial Till | 2H:1V | 0.5H:1V | 2H:1V or by assessment |

Notes:

1: Loess can perform well when cut vertically for batters <1.5m in height as surface flow is less likely to rill the material.

Inspections of soil cuts will be required during construction to confirm the above recommendations and based on the site observations a reduction in batter angles from those provided above may be required and conversely, if materials are preforming, may be steepened if site conditions and construction sequencing/programme are favourable.

## 8.4 ENGINEERED FILL SLOPES

As recommended in Table 8 above, unretained engineered fill slopes should be formed at 2H:1V (or flatter) providing they are well drained and compacted to the appropriate specification based on NZS4431. If steeper grades are required, the fill will require geogrid reinforcement to form slopes up to 45° but subject to specific engineering design from a chartered professional engineer.

## 8.5 QLDC SECTION 22

We recommend the following constraints for the construction of permanent and long-term site earthworks carried out the vicinity of the proposed dwelling in line with QLDC's District Plan Section 22 Earthworks Rules:

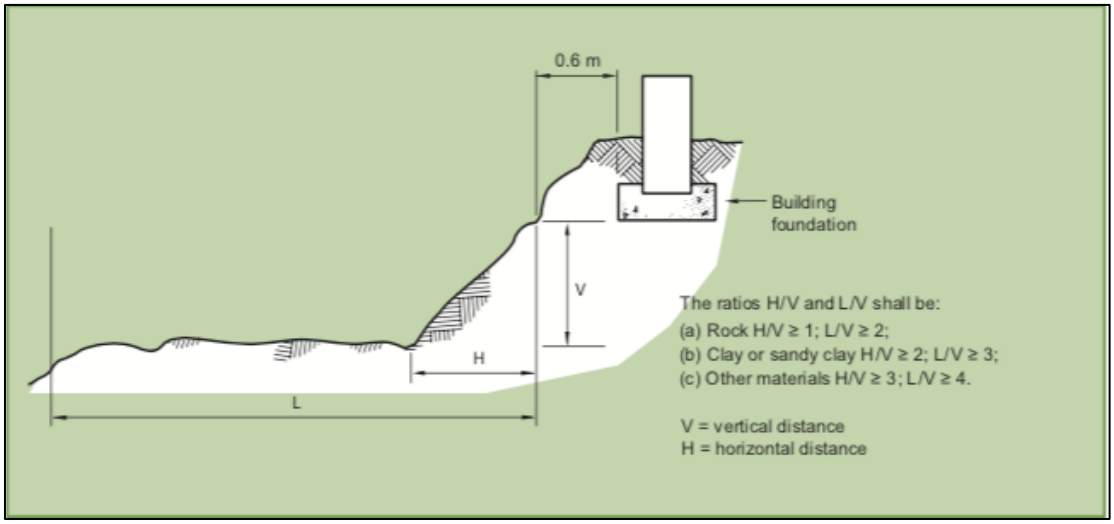
- The maximum height of any cut shall not exceed 2.4 metres.
- The maximum height of any fill shall not exceed 2 metres.
- The vertical height of any cut or fill shall not be greater than the distance of the top of the cut or the toe of the fill from the site boundary (see Interpretative Diagram 6 of Section 22), except where the cut or fill is retained, in which case it may be located up to the boundary, if less or equal to 0.5 metre in height.

## 8.6 FOUNDATION PROVISIONS (NZS3604)

With reference to NZS3604, Section 3.1.2 (b), any foundation for a building erected at the top of a bank, shall be 600mm behind the ground line as shown in the figure below. The horizontal

distance (H) from the top to the bottom shall not exceed 3m. The slope beyond the bank shall not exceed 10° degrees for a distance of 10m.

Figure 3.1 After NZS3604




With reference to NZS3604, Section 3.1.2 (c) fill, including hard fill, placed over undisturbed ground or certified fill, shall not exceed 600mm in depth above natural ground level, if within 3m of a foundation. Where this condition cannot be met, the fill shall be tested and certified to be of appropriate density/strength.

## 8.7 CONSTRUCTION MONITORING AND CERTIFICATION

Given the extent of the earthworks and the volume of cut and fill required for the subdivision including the building platforms, the earthworks and placement of fill should be undertaken in general accordance of Queenstown Lakes District Council's Land Development and Subdivision Code of Practice (incorporating NZS4404) and NZS4431.

Of particular importance are the inspection and certification of the following:

- Subgrade inspection.
- Suitability of site won material for reuse and engineered fill.
- Performance of temporary cut batters.
- Foundation inspections.
- Fill >600mm depth or built as a slope >2H:1V.

## 8.8 SERVICES

We recommend that all underground services are backfilled with adequately compacted backfill to minimise the risk of significant trench consolidation and settlement.

Trench excavations should be shored or battered appropriately in accordance with the OSH/DOL Approved Code of Practice for Safety in Excavations and Shafts for Foundations (April 2000).

The contractor is expected to employ the appropriate plant and machinery to undertake the excavation and retaining wall construction.

### 8.9 UNSUITABLE MATERIALS

Recommendations for foundation design provided in Section 7 of this report are based on foundations embedded within "good ground" according to NZS 3604:2011. In order to achieve "good ground" we recommend the following:

- A suitably qualified person should inspect all foundation excavations.
- Care should be taken to ensure that all unsuitable material such as the topsoil layer, weak ground, areas of non-engineered fill and or hard spots are removed from the building platform prior to building construction.
- The undercut for the building footprint should extend for a horizontal distance equivalent to the undercut depth beyond the footprint. The undercut should be backfilled with engineered fill up to the required formation level unless specified otherwise by a suitably qualified person.

# 9 LIMITATIONS

### 9.1 GENERAL

Ground Consulting Ltd has undertaken this assessment in accordance with the brief as provided, based on the site and location as shown on Drawing 002. This report has been provided for the benefit of our client, and for the authoritative council to rely on for the purpose of processing the consent for the specific project described herein. No liability is accepted by this firm or any of its directors, servants or agents, in respect of its use by any other person, and any other person who relies upon information contained herein does so entirely at their own risk.

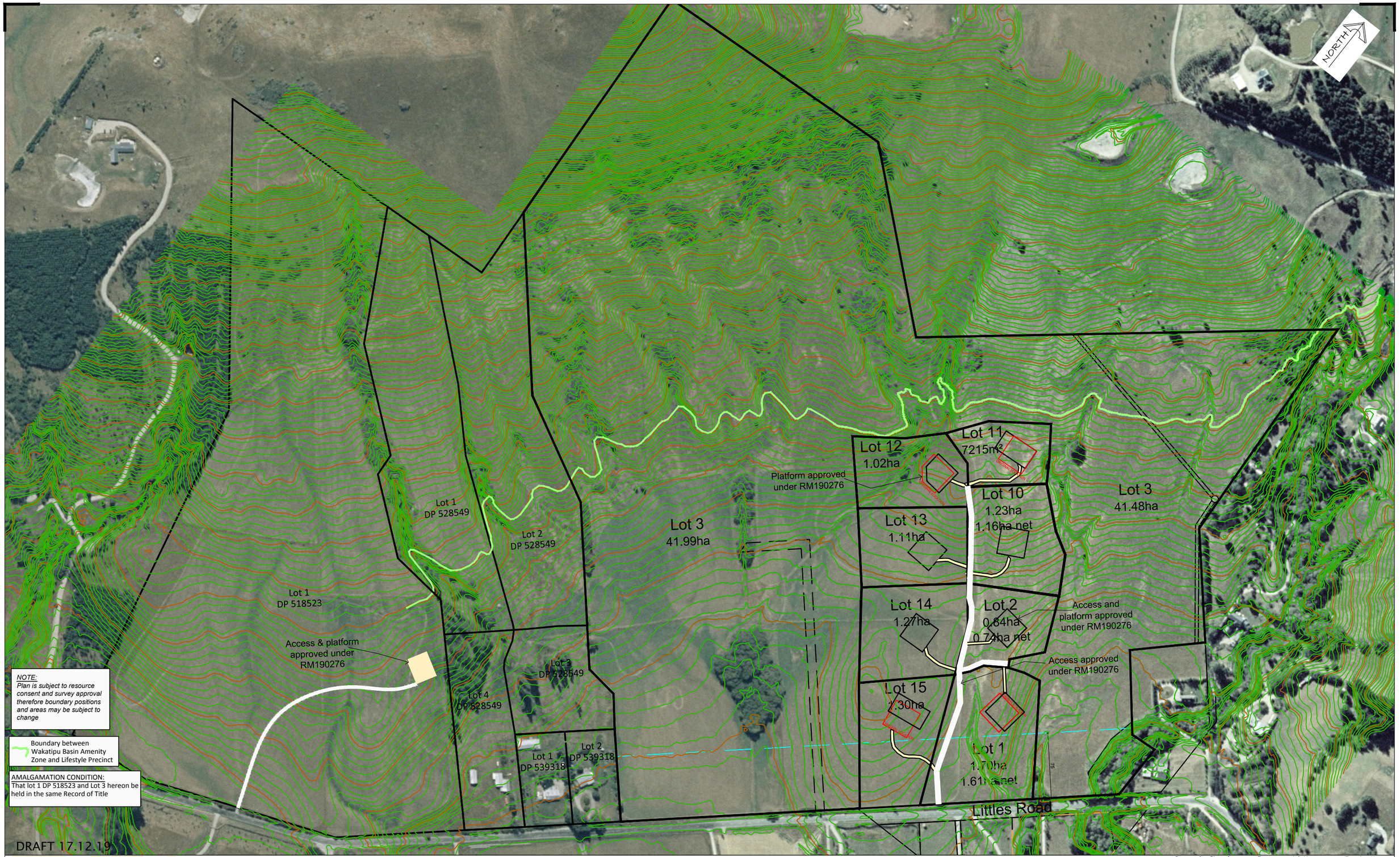


The sub-surface conditions have been extrapolated between the investigations undertaken. Whilst care has been taken to provide sufficient sub-surface information following best practice, no guarantee can be given on the validity of the inference made and it must be appreciated that actual conditions could vary from the assumed model.

### 9.2 FURTHER INVESTIGATIONS REQUIRED

This assessment has been undertaken for the proposed site development to date. Any structural changes, alterations and additions made to the proposed development should be checked by a suitably qualified person and may require further investigations and analysis.

Geotechnical inspections will be required during construction to assess site slopes, foundation excavations, retaining walls and other geotechnical aspects of the development. This is to ensure ground conditions encountered are in accordance with the findings of this assessment. If ground conditions differ from those presented in this report, advice on design and construction modifications should be sought from a suitably qualified person.




Shotover Design Limited trading as
Clark Fortune McDonald & Associates
Licensed Cadastral Surveyors - Land Development - Planning Consultants
309 Lower Shotover Road, P.O.Box 553 Queenstown
Tel. (03)441-6044, Fax (03)442-1066, Email admin@cfma.co.nz
21 Reece Crescent, P.O.Box 550, Wanaka
Tel. (03)443-4448, Fax (03)443-4445, Email admin@cfma.co.nz
Level 1, Bracken Court, 480 Moray Place, P.O. Box 5960
Tel. (03)470-1582, Fax (03)470-1583, Email admin@cfma.co.nz

| Rev. | Date | Revision Details | By |
|---|---|---|---|
| C | April19 | Amend driveway location for lot 17 | ED |
| D | Aug19 | Amend platforms on lots 10 and 11 | ED |
| E | Sep19 | Amend BPs on lots 1,6,7,11,12,17,19 as per geotech report | ED |
| F | Dec19 | Delete lot 7, include in lot 9 | ED |
| G | Dec19 | Amend BP locations on lots 1 & 15 & delete a number of lots | ED |

# LOTS 1, 2 AND 10-15 BEING A PROPOSED SUBDIVISION OF LOT 10 DP 518523

| | | | | | |
|---|---|---|---|---|---|
| Client | Surveyed | Signed | Date | Job No. | Drawing No. |
| WAKATIPU INVESTMENTS LTD | --- | | --- | 12628 | 13 |
| | Drawn | Signed | Date | Scale | 1:2000 @ A1 |
| | ED | | 10.12.18 | | 1:4000 @ A3 |
| | Designed | Signed | Date | Datum & Level | Rev. |
| | | | | MT NIC 2000 | G |

Notes:
All dimensions shown are in meters unless shown otherwise.
Any person using Clark Fortune McDonald drawings and other data accepts the risk of:
- Using the drawings and other data in electronic form without requesting and checking them for accuracy against the original hard copy versions.
- Ensuring the information is the most recent issue.


Shotover Design Limited trading as
Clark Fortune McDonald & Associates
Licensed Cadastral Surveyors - Land Development - Planning Consultants
309 Lower Shotover Road, P.O.Box 553 Queenstown
Tel. (03)441-6044, Fax (03)442-1066, Email admin@cfma.co.nz
21 Reece Crescent, P.O.Box 550, Wanaka
Tel. (03)443-4448, Fax (03)443-4445, Email admin@cfma.co.nz
Level 1, Bracken Court, 480 Moray Place, P.O. Box 5960
Tel. (03)470-1582, Fax (03)470-1583, Email admin@cfma.co.nz

| Rev. | Date | Revision Details | By |
|---|---|---|---|
| A | Feb 19 | Amend platform and boundary locations | ED |
| B | March 19 | Amend platform locations | ED |
| C | April19 | Amend driveway location for lot 17 | ED |
| D | Aug19 | Amend platforms for lots 10 and 11 | ED |
| E | Sep19 | Amend platforms on lots 1,6,11,12,17,19 as per geotech report | ED |
| F | Dec19 | Delete lot 7, include in lot 9 | ED |
| G | Dec19 | Amend BP locations on lots 1 & 15 & delete a number of lots | ED |

# LOTS 1 & 2 & 10-15 BEING A PROPOSED SUBDIVISION OF LOT 10 DP 518523

| Client | Surveyed | Signed | Date | Job No. | Drawing No. |
|---|---|---|---|---|---|
| WAKATIPU INVESTMENTS LTD | --- | | --- | 12628 | 13 |
| | Drawn | Signed | Date | Scale | |
| | ED | | 10.12.18 | 1:2000 @ A1<br>1:4000 @ A3 | |
| | Designed | Signed | Date | Datum & Level | Rev. |
| | | | | MT NIC 2000 | G |

Notes:
All dimensions shown are in meters unless shown otherwise.
Any person using Clark Fortune McDonald drawings and other data accepts the risk of:
- Using the drawings and other data in electronic form without requesting and checking them for accuracy against the original hard copy versions.
- Ensuring the information is the most recent issue.


**NOTES REGARDING PROPOSED VEGETATION**

***TREE PLANTING***

Tree planting to consist of a mix of Alnus cordata, Quercus robur, Quercus robur fastigiata, Populus nigra x euramericana, Platanus x acerifolia, Fraxinus excelsior, Picea omorika, Picea sitchensis, Ulmus 'Louis van Houtte', Fagus sylvatica. Trees are to be located individually as shown on this plan and are to be container grown and a minimum of 1.5 metres in height at the time of planting. Trees shall be planted in accordance with best arboricultural practice and shall be double staked and tied for support. All trees shall be automatically irrigated by drippers or sprinklers for the first three years following planting

***RIPARIAN VEGETATION***

These planting areas shall be a mix of the following species:

| | | |
|---|---|---|
| Carex buchannii | Carex petrei | Carex secta |
| Chionocloa conspicua | Chionocloa rigida | Chionocloa rubra |
| Cortaderia richardii | Griselinia lucida | Juncus edgariae |
| Kunzea ericoides | Phormuim cookianum | Phormium tenax |
| Pittosporum tenuifolium | Poa cita | Polystichum vestitum |

Each area of riparian planting shall be a mix of some or all of the above species. Individual plants shall be placed so as to suit conditions. Each area of riparian planting shown on the plan must include an average of 1 plant per 1.5m$^2$. All plants shall be 35F (0.25l pot size) at the time of planting, as a minimum.

***GENERAL NOTES REGARDING VEGETATION***

Grass cover within 0.5m of new plant location shall be removed prior to planting. This area around each plant shall be cleared of weeds and other vegetation twice yearly. Each new plant shall be protected from animal pest using a plastic sheath or guard. Ecowool reinforced mulch mats or similar shall be pinned around the base of each new plant. All new plants will be automatically irrigated by sprinklers or drippers for the first three years following planting.

N

REF: 1426-03 SLP
DATE: 28.01.20
SCALE: 1:2000 @ A3

# Structural Landscape Plan

## Wakatipu Investment Ltd Subdivision - Littles Road, Queenstown

vivian+espie
resource management and landscape planning
**vivian+espie Limited** Resource Management and Landscape Planning
**PO Box** 2514
**Physical Address** 1/2118 Glenda Drive Frankton, Queenstown
**Tel** +64 3 441 4189 **Fax** +64 3 441 4190 **Web** www.vivianespie.co.nz