## APPENDIX G – GEOTECHNICAL INVESTIGATIONS

Tonkin & Taylor

ENVIRONMENTAL AND ENGINEERING CONSULTANTS

# REPORT

**Ballantyne Road, Wanaka**

**Geotechnical Investigations for Plan Change**

**Report prepared for:**

PATERSON PITTS LTD (WANAKA)

**Report prepared by:**

TONKIN & TAYLOR LTD

**Distribution:**

PATERSON PITTS LTD (WANAKA)

TONKIN & TAYLOR LTD (FILE)

**June 2010**

**Job no: 892097**

# Table of contents

# 1. Introduction

## 1.1. General

This report presents the results of preliminary geotechnical investigations carried out by Tonkin & Taylor Ltd, for a proposed plan change on land adjacent to the previously approved Three Parks Zone, Wanaka.

The work was carried out for Paterson Pitts Ltd (Wanaka) in accordance with a work brief dated 13 May 2010. Tonkin and Taylor Ltd's proposal dated 21 May 2010 outlines the scope of work and conditions of engagement.

## 1.2. Purpose of Report

The land involved in the proposed plan change is currently owned by Ballantyne Investments, Aurora Energy, Robertsons, Gordon/Moseby, Ryton Management Ltd/Canterbury Helicopters Ltd (see Site Plan, Fig 1). This preliminary assessment report covers geotechnical issues, natural hazards and stormwater disposal by soakage.

# 2. Site Description

## 2.1. General

The preliminary study area lies between Ballantyne Road, and the Wanaka Highway (SH 84), immediately to the east of the current Three Parks zone (Fig 1). The Ballantyne Investments land has been used for deer farming, the Aurora Energy land is a transformer substation, and the remaining properties are rural lifestyle blocks with dwellings.

## 2.2. Topography and Surface Drainage

Two distinctive types of topography are found within the plan change area (Fig 1).

To the north-east of Ballantyne Road lies a region of low hummocks and hollows, with up to about 5m of relative vertical relief (Photo 1). This is interpreted as "kame and kettle" topography, associated with fluvio-glacial deposition in contact with glacial ice.

No streams occur within the area. Runoff during heavy rainfall appears to drain internally into hollows or to follow poorly defined channels between the hummocks.

To the north of the hummocky topography lies a region of gently-terraced fluvio-glacial outwash channels (Photo 2). These extend north towards SH84, with a prominent incised channel lying between the back boundary of the Robertson property and the highway. The southern margin of the channel is marked by a terrace riser several metres high.

No streams are present in the outwash channel area.

# 3. Investigations

Aerial photographs of the area were examined and an engineering geological site assessment has been completed to assess geomorphology and surficial conditions within the plan change area.

Eight test pits were excavated to investigate the subsurface geology, with an average spacing of about 250m (see Fig 1). The test pit logs are contained in Appendix B.

# 4. Subsurface Investigations

## 4.1. Geological Setting

The geology of the Three Parks region is dominated by glacial deposits from the last glaciation. These comprise moraine and outwash deposited near Mt Iron during the Mt Iron Advance (23,000 years BP) and above Wanaka township during the Hawea Advance (about 15,000 years BP).

Bedrock in the region is Haast Schist. This is exposed on the slopes of Mt Iron but lies at depth elsewhere.

The active Cardrona Fault lies to the east of Mt Iron, close to the Cardrona River, but is obscured by sediments. The estimated recurrence interval for fault movement is 7500 years, and the seismic risk is thus considered low. A more significant seismic risk exists in this district from potentially strong ground shaking, likely to be associated with a rupture of the Alpine Fault, located along the West Coast of the South Island. There is a high probability that an earthquake with an expected magnitude of up to Richter Magnitude 8 will occur along the Alpine Fault within the next 50 years, which would affect much of the South Island.

## 4.2. Stratigraphy of Plan Change Area

Two distinctive types of topography are present in the area, "kame and kettle" and outwash channel topography. Test pitting reveals they are both underlain by water-deposited outwash gravels, generally similar in composition.

In the "kame and kettle" region, fluvial deposition appears to have occurred in close association with retreating glacial ice from the Mt Iron Advance, with kettle hollows forming as a result of the melting of buried ice.

The outwash channels to the north appear to be carriers of meltwater, largely from the younger Hawea Advance moraines to the east, located above Wanaka township.

### 4.2.1. Kame and Kettle Area

Test pits 1-4 & 7 were located in this region.

TP 2, 3 & 7 were positioned on the crests of kame hummocks. These encountered approximately 0.3m of topsoil, overlying outwash gravel that extended down to the base of the holes at 3-4m depth.

The outwash gravel typically comprises sandy fine to coarse gravel with some cobbles and boulders up to 0.4 m diameter. The sand is typically medium to coarse. The soils appeared to be in a medium dense condition, but tended to collapse in the

sides of the excavations, due to the lack of fines binding the particles. This limited the depth to which the holes could be practically excavated.

TP 1 &4 were positioned on the floor of kettle hollows, and both found minor infill deposits of fine-grained materials overlying the outwash gravels.

TP1 comprises 0.4 m of topsoil, underlain by 0.4 m of colluvium (loose gravelly silty sand) and 0.4 m of firm, interbedded silt and silty sand, inferred to be outwash silt. TP4 found 0.4 m of topsoil and 1 m of loess (firm silt). The underlying outwash gravels in both holes were similar to those found in the crests of hummocks, apart from the sand component of TP4 being relatively fine.

### 4.2.2. Outwash Channels

Test pits 5, 6 &8 were located in this area.

TP6 & 8 encountered 0.4 m of topsoil, and 1.1 m and 1.5 m respectively of outwash gravel overlying glacial till. TP5 found 3 m of outwash gravel.

The outwash typically comprised sandy fine to coarse gravel with some cobbles and boulders in TP8. The sand was medium to coarse. The materials appeared to be in a medium dense condition, but tended to collapse in the sides of excavations due to the lack of particle binding fines.

The till comprised medium dense gravelly silty sand.

## 5. Groundwater

No groundwater was encountered in the test pits, which were typically 3-4 m deep. All materials were in a moist condition.

The site is located above the Wanaka Basin Aquifer (Wanaka Basin Groundwater Modelling Report; ORC, 2003) and the depth to water table is estimated to be about 15-20m.

## 6. Natural Hazards

### 6.1 Flooding

An assessment of the flooding hazard at the site was made based on the engineering geological field work and examination of the QLDC hazard register. This information indicates that the risk of flooding in the area is low.

Surface runoff following heavy rainfall appears likely to be minor, due to the light soils and the highly pervious outwash gravels beneath. It is possible that temporary minor ponding of runoff could occur in depressions, particularly kettle holes with fine grained infills of loess.

### 6.1. Erosion

There is no credible erosion hazard at the site due to the lack of active watercourses.

## 6.2. Seismic Hazard

The area lies about 1 km west of the inferred concealed trace of the active Cardrona Fault. According to Stirling et al, 1998 (Probabilistic seismic hazard analysis of New Zealand ; NZ J of Geol & Geophysics 41) the fault has a M max of 6.9-7.2, but with a recurrence interval estimated to be 7500 years. The risk of strong shaking from this fault in the next 50 years is considered low, and because the site is remote from the fault trace, the risk of ground rupture is very low.

The main seismic risk to the site is an earthquake of up to Richter Magnitude 8 on the Alpine Fault, with a high probability in the next 50 years that would subject the region to strong ground shaking.

The risk of liquefaction at the site under seismic action is considered to be very low, owing to the deep water table and the nature of the soils found in the test pits. These were predominantly sandy gravels and medium dense gravelly silty sands, with low susceptibility to liquefaction.

## 6.3. Slope Stability

There is no evidence of landslide hazard on the site, which has gentle to moderate slopes in soil types not typically susceptible to slope failures.

# 7. Engineering Considerations

## 7.1. General

Recommendations and opinions in this report are based on the data sources noted above. The nature and continuity of subsoil conditions away from the test pits and soil exposures is inferred, and it must be appreciated that actual conditions could vary from the assumed model.

## 7.2. Site Preparation

Topsoil, loess and any soils weaker than stiff will need to be removed from the building footprints, and foundations should be extended below these soils to bear on competent natural ground (medium dense outwash gravel). Placement of fill should be undertaken in accordance with NZS 4431:1989, in those areas where levels need to be re-established or where elevated building platforms may be required.

## 7.3. Excavations and Stability of Faces

Retaining wall design parameters for the plan change area are outlined in the table below:

**Table 7-1. Geotechnical Parameters**

| Unit (see soil descriptions in Section4.2.1) | Thickness (m) | Bulk Density $\gamma$ (kN/m$^3$) | Effective Cohesion c′ (kPa) | Effective Friction $\phi'$ (deg) | Elastic Modulus E (kPa) | Poisson's Ratio v |
|---|---|---|---|---|---|---|
| **Topsoil** - soft SILT | 0.3-0.4 | 16 | N.A. | N.A. | N.A. | N.A. |
| **Loess** - firm SILT | 1.0 | 17 | 0 | 30 | 6,000 | 0.3 |
| **Outwash Gravel**- medium dense sandy GRAVEL variable cobbles and boulders | unknown | 22 | 0 | 38 | 30,000 | 0.3 |
| **Glacial Till**- medium dense gravelly silty sand. | unknown | 19 | 2 | 37 | 25,000 | 0.3 |

Any proposed cuts up to 3 m high in compact till should stand readily at 1:1 to 1.5:1 (horizontal to vertical). Steeper batters could be adopted subject to inspection for cohesionless strata, but establishing vegetation on them would be more difficult. There are cohesionless strata within the outwash gravels and for this reason any cuts should be limited to 1.75:1, unless inspection shows such strata are not present. Compacted fill batters in both materials should be limited to 1.5:1 without specific design.

Cuts higher than 3 m or fills higher than 5 m should be subject to specific design.

## 7.4. Settlement and Foundations

Foundations will be predominantly on medium dense outwash gravels. Scala penetrometer testing was not attempted because of the presence of gravel particles. The gravels should provide good bearing of at least 100 kPa working stresses on footings of 300 mm width and 300 mm embedment (subject to further site specific studies when development plans become available).

Removal of topsoil, loess and other unsuitable deposits (e.g possible colluvium) will be required. If necessary, restoration of levels or preparation of elevated platforms can be achieved by placement of fill in accordance with NZS 4431:1989. Inspection to confirm bearing strengths would be required.

Further foundation investigation is recommended (in accordance with NZS 3604) for each structure, prior to or as part of the building consent process, however this recommendation could be reduced to brief inspections if initial development confirms the expected favourable and uniform subsurface conditions.

## 7.5. Stormwater Disposal by Soakage

The test pits (3-4 m deep) over the plan change area all encountered outwash gravels beneath surficial materials. The outwash is sandy gravel with minimal fines, similar to other deposits in the Wanaka region. These are known to have high permeability values, and have been used successfully for stormwater disposal by soakage, suggesting disposal by soakage is likely to be feasible at the site.

Low permeability till was encountered below the outwash gravel in TP6 & 8, at depths of 1.5 & 1.8 m, but this would not significantly inhibit the use of the overlying gravels for soakage.

## 7.6. Slope Stability

No specific requirements are necessary. The recommendations in Section 7.3 should be noted.

## 7.7. Groundwater

The water table is estimated to be about 15-20m depth. No issues are envisaged.

## 7.8. Neighbouring Structures/Boundaries

**Distances to adjoining structures:** There are no current neighbouring structures. The proposed site is surrounded by farm land.

**Aquifers:** A major aquifer is present at depth (Section 5) requiring particular care to ensure no contamination issues arise.

**Earthworks / Erosion and Sediment Control:** No special provisions apply, but general recommendations are contained in the following link:

http://www.tonkinandtaylor.com.au/otagosi.html#erosion

**Noise:** Rock-breaking and blasting will not be necessary at this site and at the existing RVZ, however the occasional boulder may require removal.

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

**Natural Hazards:** These are discussed in Section 6 above.

# 8. Conclusions and Recommendations

- The proposed plan change area exhibits hummocky fluvio-glacial (kame and kettle) topography to the NE of Ballantyne Rd. This changes to gently terraced glacial outwash channels about midway across to the Wanaka Highway.
- Subsurface soils comprise topsoil, typically underlain by outwash gravels. Thin loess and colluvium may sometimes be present, and glacial till underlies the outwash at two localities.
- No adverse groundwater conditions are expected within the plan change area, with the water table inferred to lie at 15-20m.
- The risk of flooding is considered low and erosion very low.
- There is no evidence of slope instability and the risk is considered low.
- The active Cardrona Fault is inferred to lie about 1km east, but due to the long (7500 year) recurrence interval the risk to the site area in the next 50 years is considered low. The main seismic risk is strong shaking from an Alpine Fault earthquake, with a high probability in the next 50 years.
- The seismic liquefaction risk is considered very low due to the deep water table and the material properties.
- Foundations should be extended below topsoil and loess to bear on competent outwash gravels.
- Placement of fill (if required for building platforms) should be undertaken in accordance with NZS 4431:1989.
- The highly permeable outwash gravels are suitable for stormwater disposal by infiltration.

# 9. Applicability

This report has been prepared for the benefit of Paterson Pitts (Wanaka) with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

During construction, excavations should be examined by an inspector or engineer competent to confirm that subsurface conditions encountered are compatible with the inferred conditions on which this report has been based and assess any support requirements. It is important that we be contacted if there is any variation in subsoil conditions from those described in this report.

Report prepared by:

Graeme Halliday

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Graeme Halliday

SENIOR ENGINEERING GEOLOGIST

Authorised for Tonkin & Taylor by:

Graham Salt

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Graham Salt

GEOTECHNICAL GROUP COORDINATOR

MTW

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## Appendix A: Site Plan and Photographs

**Photo 1 -** Hummocky 'kame and kettle' topography in fluvio-glacial gravels.

**Photo 2 -** Outwash channel area, looking NE towards Mt Iron from margin of hummocks.


OUTWASH CHANNELS

KAME & KETTLE TOPOGRAPHY (hummocks & hollows)

TP 1 Test Pits

**Tonkin & Taylor**
Environmental and Engineering Consultants
Level 1, 70 MacAndrew Road, South Dunedin
www.tonkin.co.nz

| | | |
|---|---|---|
| DRAWN | HY | 11/05/10 |
| DRAFTING CHECKED | | |
| APPROVED | | |
| CADFILE : \\Figure 1 – Site Plan 1.dwg | | |
| SCALES (AT A3 SIZE) | AS SHOWN | |
| PROJECT No. | 892097 | |

Paterson Pitts Partners Ltd (Wanaka)
Geotechnical Investigation
Ballantyne Road, Wanaka
Site Plan

FIG. No. Figure 1

REV. 0

## Appendix B: Test Pit Logs

Tonkin & Taylor

# TONKIN & TAYLOR LTD
# EXCAVATION LOG

EXCAVATION NUMBER: **TP 1**

| | | | |
|---|---|---|---|
| PROJECT: Ballantyne Rd | | | Job Number: 892097 |
| LOCATION: See Site Plan | Inclination: | Vertical | Direction: |

| | | | | | |
|---|---|---|---|---|---|
| EASTING: | mE | EQUIPMENT: 12T Excavator | | OPERATOR: | |
| NORTHING: | mN | INFOMAP NO. | | COMPANY: | Diverse Works |
| ELEVATION: | m | DIMENSIONS: | | HOLE STARTED: | 10-Jun-10 |
| METHOD: | | EXCAV. DATUM: GL | | HOLE FINISHED: | 10-Jun-10 |

| PENETRATION | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG | ENGINEERING DESCRIPTION: SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS | WATER CONTENT | GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
|---|---|---|---|---|---|---|
| | | 0.4 | | Black, SILT. | Moist | TOPSOIL |
| | | 0.8 | | Brown, gravelly silty SAND. Gravel is fine. Loose. | Moist | COLLUVIUM |
| | | 1.2 | | Grey, interbedded silty SAND and SILT. Silt is non plastic. Firm and medium dense. | Moist | OUTWASH SILT |
| | | 1.6 | | Grey, sandy GRAVEL with minor cobbles and rare boulders. Gravel is fine to coarse. Sand is medium to coarse. Boulders max size 1.0m. Medium dense. Pit walls collapsing. High permeability. | Moist | OUTWASH GRAVEL |
| | | 2.0 | | | | |
| | | 2.4 | | | | |
| | | 2.8 | | | | |
| | | 3.2 | | | | |
| | | 3.6 | | | | |
| | NO SEEPAGE | 4.0 | | | | |
| | | 4.4 | | Total Depth = 4 m | | |
| | | 4.8 | | | | |
| | | 5.2 | | | | |
| | | 5.6 | | | | |
| | | 6.0 | | | | |
| | | 6.4 | | | | |

| | |
|---|---|
| COMMENT: Pit located in hollow 25m from fenceline | Logged By: GSH |
| | Checked Date: |
| PHOTO REF.: | Sheet: 1 of 1 |

# TONKIN & TAYLOR LTD
# EXCAVATION LOG

EXCAVATION NUMBER: **TP 2**

| | | | |
|---|---|---|---|
| PROJECT: Ballantyne Rd | | | Job Number: 892097 |
| LOCATION: See Site Plan | Inclination: | Vertical | Direction: |

| | | | | | |
|---|---|---|---|---|---|
| EASTING: | mE | EQUIPMENT: 12T Excavator | | OPERATOR: | |
| NORTHING: | mN | INFOMAP NO. | | COMPANY: Diverse Works | |
| ELEVATION: | m | DIMENSIONS: | | HOLE STARTED: 10-Jun-10 | |
| METHOD: | | EXCAV. DATUM: GL | | HOLE FINISHED: 10-Jun-10 | |

| PENETRATION | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG | ENGINEERING DESCRIPTION: SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS | WATER CONTENT | GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
|---|---|---|---|---|---|---|
| | | 0.4 | | Brown, SILT. | Moist | TOPSOIL |
| | | 0.8 | | Brown, sandy GRAVEL with minor silt and roots. Gravel is fine to coarse. Sand is coarse. Medium dense. Pit walls collapsing. | Moist | OUTWASH GRAVEL |
| | | 1.2 | | Grey, sandy GRAVEL with open textured gravel lenses and minor boulders. Gravel is fine to coarse. Boulders max size 0.4m. Medium dense. Pit walls collapsing. High permeability. | Moist | OUTWASH GRAVEL |
| | | 1.6 | | | | |
| | | 2.0 | | | | |
| | | 2.4 | | | | |
| | | 2.8 | | | | |
| | NO SEEPAGE | 3.2 | | | | |
| | | 3.6 | | Total Depth = 3.5 m | | |
| | | 4.0 | | | | |
| | | 4.4 | | | | |
| | | 4.8 | | | | |
| | | 5.2 | | | | |
| | | 5.6 | | | | |
| | | 6.0 | | | | |
| | | 6.4 | | | | |

| | |
|---|---|
| COMMENT: Pit located on top of hummock | Logged By: GSH |
| | Checked Date: |
| PHOTO REF.: | Sheet: 1 of 1 |

# TONKIN & TAYLOR LTD
# EXCAVATION LOG

EXCAVATION NUMBER: **TP 3**

| | | | |
|---|---|---|---|
| PROJECT: Ballantyne Rd | | | Job Number: 892097 |
| LOCATION: See Site Plan | Inclination: | Vertical | Direction: |

| | | | |
|---|---|---|---|
| EASTING: | mE | EQUIPMENT: 12T Excavator | OPERATOR: |
| NORTHING: | mN | INFOMAP NO. | COMPANY: Diverse Works |
| ELEVATION: | m | DIMENSIONS: | HOLE STARTED: 10-Jun-10 |
| METHOD: | | EXCAV. DATUM: GL | HOLE FINISHED: 10-Jun-10 |

| PENETRATION | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG | ENGINEERING DESCRIPTION: SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS | WATER CONTENT | GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
|---|---|---|---|---|---|---|
| | | 0.4 | | Brown, SILT. | Moist | TOPSOIL |
| | | 0.8 | | Brown, sandy GRAVEL with some cobbles and boulders. Gravel is fine to coarse. Sand is medium to coarse. Boulders max size 0.4m. Medium dense. Pit walls collapsing. High permeability. | Moist | OUTWASH GRAVEL |
| | | 1.2 | | | | |
| | | 1.6 | | | | |
| | | 2.0 | | Grey, sandy GRAVEL. Gravel is fine to medium. Sand is medium to coarse. Medium dense. Pit walls collapsing. | Moist | OUTWASH GRAVEL |
| | | 2.4 | | | | |
| | | 2.8 | | | | |
| | | 3.2 | | | | |
| | | 3.6 | | | | |
| | NO SEEPAGE | 4.0 | | | | |
| | | 4.4 | | Total Depth = 4 m | | |
| | | 4.8 | | | | |
| | | 5.2 | | | | |
| | | 5.6 | | | | |
| | | 6.0 | | | | |
| | | 6.4 | | | | |

| | |
|---|---|
| COMMENT: Pit located on top of hummock | Logged By: GSH |
| | Checked Date: |
| PHOTO REF.: | Sheet: 1 of 1 |

Tonkin & Taylor

# TONKIN & TAYLOR LTD
# EXCAVATION LOG

EXCAVATION NUMBER: **TP 4**

| | | | |
|---|---|---|---|
| PROJECT: Ballantyne Rd | | | Job Number: 892097 |
| LOCATION: See Site Plan | | Inclination: Vertical | Direction: |

| | | | | | |
|---|---|---|---|---|---|
| EASTING: | mE | EQUIPMENT: 12T Excavator | | OPERATOR: | |
| NORTHING: | mN | INFOMAP NO. | | COMPANY: Diverse Works | |
| ELEVATION: | m | DIMENSIONS: | | HOLE STARTED: 10-Jun-10 | |
| METHOD: | | EXCAV. DATUM: GL | | HOLE FINISHED: 10-Jun-10 | |

| PENETRATION | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG | ENGINEERING DESCRIPTION: SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS | WATER CONTENT | GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
|---|---|---|---|---|---|---|
| | | 0.2 | | Brown, SILT. | Moist | TOPSOIL |
| | | 0.4 | | | | |
| | | 0.6 | | Brown, SILT with fine roots. Non plastic. Firm. Low permeability. | Moist | LOESS |
| | | 0.8 | | | | |
| | | 1.0 | | | | |
| | | 1.2 | | | | |
| | | 1.4 | | | | |
| | | 1.6 | | Grey, sandy GRAVEL with some cobbles and boulders. Gravel is fine to coarse. Sand is fine. Boulders max size 0.5m. Medium dense. Pit walls standing well. High permeability. | Moist | OUTWASH GRAVEL |
| | | 1.8 | | | | |
| | | 2.0 | | | | |
| | | 2.2 | | | | |
| | | 2.4 | | | | |
| | NO SEEPAGE | 2.6 | | | | |
| | | 2.8 | | Total Depth = 2.7 m | | |
| | | 3.0 | | | | |
| | | 3.2 | | | | |

| | |
|---|---|
| COMMENT: Pit located in adjacent channel/depression | Logged By: GSH |
| | Checked Date: |
| PHOTO REF.: | Sheet: 1 of 1 |

# TONKIN & TAYLOR LTD
# EXCAVATION LOG

EXCAVATION NUMBER: **TP 5**

| | | | |
|---|---|---|---|
| PROJECT: Ballantyne Rd | | | Job Number: 892097 |
| LOCATION: See Site Plan | Inclination: | Vertical | Direction: |

| | | | | | |
|---|---|---|---|---|---|
| EASTING: | mE | EQUIPMENT: 12T Excavator | | OPERATOR: | |
| NORTHING: | mN | INFOMAP NO. | | COMPANY: Diverse Works | |
| ELEVATION: | m | DIMENSIONS: | | HOLE STARTED: 10-Jun-10 | |
| METHOD: | | EXCAV. DATUM: GL | | HOLE FINISHED: 10-Jun-10 | |

| PENETRATION | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG | ENGINEERING DESCRIPTION: SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS | WATER CONTENT | GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
|---|---|---|---|---|---|---|
| | | | | Brown, SILT. | Moist | TOPSOIL |
| | | 0.2 | | Brown and grey, sandy GRAVEL. Gravel is fine to coarse. Sand is coarse. Medium dense. Pit walls collapsing easily. | Moist | OUTWASH GRAVEL |
| | | 0.4 | | | | |
| | | 0.6 | | | | |
| | | 0.8 | | | | |
| | | 1.0 | | | | |
| | | 1.2 | | | | |
| | | 1.4 | | | | |
| | | 1.6 | | | | |
| | | 1.8 | | | | |
| | | 2.0 | | | | |
| | | 2.2 | | | | |
| | | 2.4 | | | | |
| | | 2.6 | | | | |
| | NO SEEPAGE | 2.8 | | | | |
| | | 3.0 | | | | |
| | | 3.2 | | Total Depth = 3 m | | |

| | |
|---|---|
| COMMENT: | Logged By: GSH |
| | Checked Date: |
| PHOTO REF.: | Sheet: 1 of 1 |

# TONKIN & TAYLOR LTD
# EXCAVATION LOG

EXCAVATION NUMBER: **TP 6**

| | | | |
|---|---|---|---|
| PROJECT: Ballantyne Rd | | | Job Number: 892097 |
| LOCATION: See Site Plan | Inclination: | Vertical | Direction: |

| | | | |
|---|---|---|---|
| EASTING: mE | EQUIPMENT: 12T Excavator | OPERATOR: | |
| NORTHING: mN | INFOMAP NO. | COMPANY: Diverse Works | |
| ELEVATION: m | DIMENSIONS: | HOLE STARTED: 10-Jun-10 | |
| METHOD: | EXCAV. DATUM: GL | HOLE FINISHED: 10-Jun-10 | |

| PENETRATION | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG | ENGINEERING DESCRIPTION: SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS | WATER CONTENT | GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
|---|---|---|---|---|---|---|
| | | 0.2 | | Brown, SILT. | Moist | TOPSOIL |
| | | 0.4 | | | | |
| | | 0.6 | | Brown, sandy GRAVEL. Gravel is fine to coarse. Sand is medium to coarse. Medium dense. Pit walls collapsing. High permeability. | Moist | OUTWASH GRAVEL |
| | | 0.8 | | | | |
| | | 1.0 | | | | |
| | | 1.2 | | | | |
| | | 1.4 | | | | |
| | | 1.6 | | Yellow grey, gravelly silty SAND. Gravel is fine to coarse. Sand is fine to coarse. Silt is non plastic. Medium dense. Low permeability. | Moist | TILL |
| | | 1.8 | | | | |
| | | 2.0 | | | | |
| | | 2.2 | | | | |
| | | 2.4 | | | | |
| | | 2.6 | | | | |
| | | 2.8 | | | | |
| | | 3.0 | | | | |
| | NO SEEPAGE | 3.2 | | | | |

Total Depth = 3.2 m

| | |
|---|---|
| COMMENT: | Logged By: GSH |
| | Checked Date: |
| PHOTO REF.: | Sheet: 1 of 1 |

# TONKIN & TAYLOR LTD
# EXCAVATION LOG

EXCAVATION NUMBER: **TP 7**

| | | | |
|---|---|---|---|
| PROJECT: Ballantyne Rd | | | Job Number: 892097 |
| LOCATION: See Site Plan | Inclination: | Vertical | Direction: |

| | | | | | |
|---|---|---|---|---|---|
| EASTING: | mE | EQUIPMENT: 12T Excavator | | OPERATOR: | |
| NORTHING: | mN | INFOMAP NO. | | COMPANY: | Diverse Works |
| ELEVATION: | m | DIMENSIONS: | | HOLE STARTED: | 10-Jun-10 |
| METHOD: | | EXCAV. DATUM: GL | | HOLE FINISHED: | 10-Jun-10 |

| PENETRATION | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG | ENGINEERING DESCRIPTION: SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS | WATER CONTENT | GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
|---|---|---|---|---|---|---|
| | | | | Brown, SILT. | Moist | TOPSOIL |
| | | 0.2 | | Brown, sandy GRAVEL with minor silt and fine roots. Gravel is fine to coarse. Sand is medium to coarse. Medium dense. Pit walls collapsing. High permeability. | Moist | OUTWASH GRAVEL |
| | | 0.4 | | | | |
| | | 0.6 | | | | |
| | | 0.8 | | Grey, sandy GRAVEL. Gravel is fine to medium. Sand is medium to coarse. Medium dense. Pit walls collapsing. Cross stratified, dipping towards Mt Iron. High permeability. | Moist | OUTWASH GRAVEL |
| | | 1.0 | | | | |
| | | 1.2 | | | | |
| | | 1.4 | | | | |
| | | 1.6 | | | | |
| | | 1.8 | | | | |
| | | 2.0 | | | | |
| | | 2.2 | | | | |
| | | 2.4 | | | | |
| | | 2.6 | | | | |
| | | 2.8 | | | | |
| | NO SEEPAGE | 3.0 | | | | |
| | | 3.2 | | Total Depth = 3 m | | |

| | |
|---|---|
| COMMENT: Pit located on ridge behind prominent knob, 70m from fenceline | Logged By: GSH |
| | Checked Date: |
| PHOTO REF.: | Sheet: 1 of 1 |

# TONKIN & TAYLOR LTD
# EXCAVATION LOG

EXCAVATION NUMBER: **TP 8**

| | | | |
|---|---|---|---|
| PROJECT: Ballantyne Rd | | | Job Number: 892097 |
| LOCATION: See Site Plan | Inclination: | Vertical | Direction: |

| | | | |
|---|---|---|---|
| EASTING: | mE | EQUIPMENT: 12T Excavator | OPERATOR: |
| NORTHING: | mN | INFOMAP NO. | COMPANY: Diverse Works |
| ELEVATION: | m | DIMENSIONS: | HOLE STARTED: 10-Jun-10 |
| METHOD: | | EXCAV. DATUM: GL | HOLE FINISHED: 10-Jun-10 |

| PENETRATION | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG | ENGINEERING DESCRIPTION: SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS | WATER CONTENT | GEOLOGICAL: SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
|---|---|---|---|---|---|---|
| | | 0.2 | | Brown, SILT. | Moist | TOPSOIL |
| | | 0.4 | | Brown and grey, sandy GRAVEL with some cobbles and boulders. Gravel is fine to coarse. Boulders max size 0.4m. Medium dense. Pit walls collapsing. High permeability. | Moist | OUTWASH GRAVEL |
| | | 0.6 | | | | |
| | | 0.8 | | | | |
| | | 1.0 | | | | |
| | | 1.2 | | | | |
| | | 1.4 | | | | |
| | | 1.6 | | | | |
| | | 1.8 | | | | |
| | NO SEEPAGE | 2.0 | | Yellow brown, gravelly silty SAND. Gravel is fine to medium. Silt is non plastic. Medium dense. Massive. Low permeability. | Moist | TILL |
| | | 2.2 | | | | |
| | | 2.4 | | | | |
| | | 2.6 | | | | |
| | | 2.8 | | | | |
| | | 3.0 | | | | |
| | | 3.2 | | Total Depth = 3 m | | |

| | |
|---|---|
| COMMENT: | Logged By: GSH |
| | Checked Date: |
| PHOTO REF.: | Sheet: 1 of 1 |

www.tonkin.co.nz

Tonkin & Taylor

T&T Ref: 892097
15 December 2010

Paterson Pitts Partners
PO Box 283
Wanaka 9343

Attention: Mike Botting

Dear Mike

# North Three Parks Geotechnical Issues

QLDC have asked for additional information on:

1. "the actual ground shaking due to the quake compared to the New Zealand Standard" and,
2. "the impacts of that"

We respond as follows:

Our geotechnical report was not intended to imply that earthquake induced shaking at the site would be other than already prescribed for this area by the standard (NZS 1170.5:2004 Structural design actions Part 5: Earthquake actions- NZ), i.e. structures here should be designed conventionally, to the standard seismic provisions.

Given that the above code is followed, the impacts of the SLS earthquake can be expected to be no structural damage to the building and, as regards the land itself, as stated in our report, the risk of liquefaction is considered to be very low, owing to the deep watertable.

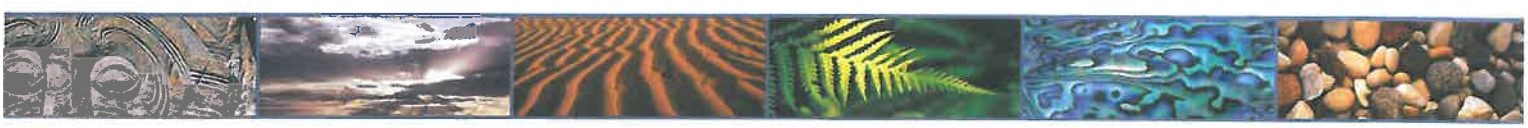
In summary, the site has no features that present significant seismic risk. This is in keeping with much of the flat land in Wanaka (with the exception of perhaps the likes of some of the low lying land around the lakeshore west of Beacon Pt). Even in a major earthquake, liquefaction (as in the recent Darfield earthquake that affected Canterbury recently) is not expected to be widespread in Wanaka.

Yours sincerely

Graham Salt

Graham Salt
DUNEDIN GROUP MANAGER

12-Jan-11
document2



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