Geotechnical Report No. 1184
Mitchell Partnerships

Geotechnical/Natural Hazard Assessment
Three Parks Land, Wanaka

March 2007

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The assessment and judgements given in this report are directed by both the finite data on which they are based and the proposed works to which they are addressed. The data essentially comprised a study of available documented information from various sources together with discussions with relevant authorities and other interested parties. The information reviewed is not exhaustive and has been accepted in good faith as providing representative and true data pertaining to site conditions. If additional information becomes available which might impact on our conclusions, we request the opportunity to review the information, reassess the potential concerns and modify our opinion if warranted.

It should be noted that any risks identified in this report are perceived risks based on the available information.

Executive Summary

Mitchell Partnerships commissioned Opus International Consultants Ltd (Opus) to carry out a Geotechnical Hazards Risk Assessment and limited preliminary contaminated site assessment of the proposed Three Parks Land Development site, Wanaka. Development envisaged includes a layout of mixed use, residential and large format retail areas within the property.

This assessment included both desktop and on site field studies.

Desktop and field studies focussed on the geological history of the site, the potential for land instability (including during seismic events and the risk of liquefaction of the soil), the risk of flooding from the Cardrona River and nearby water sources, and the potential for contamination at the site.

The flood risk to the development site is very low to low from all water sources including the Cardrona River. As an overall conclusion the flood history of the site indicates that residential building on the site with standard foundations would comply with Building Act 2004 flooding provisions. There is also a very low risk to the site from erosion due to the low risk of flooding from the Cardrona River and other watercourses.

There is a very low risk to the site from landslides and rockfalls.

The contaminated land assessment revealed that historical and current land use practice within, and adjacent to the site have included activities that present a risk of contamination to sediment and water (surface and groundwater). Possible issues may be associated with the airstrip and oxidation ponds (and surrounding waste storage).

If the proposed development of this land for a residential subdivision occurs, a Detailed Site Investigation (DSI) is recommended to determine the presence/absence and level of contamination present.

Seismic hazard from the site exists from the Alpine Fault and the Cardrona Fault. The likely size of a seismic event in terms of horizontal acceleration based on the principles of AS/NZS 1170: Part 5, 2003 Earthquake Actions in Wanaka will be around 0.4g (the exact figure will be dependant on building type). There is a low risk of a rupture of the Cardrona Fault affecting the site. There is a low to moderate risk of general structure damage under a seismic event. In terms of structural conditions, the relevant New Zealand Standards and Codes should be used for earthquake loading in accordance with normal practice.

Test pits excavated on site revealed that there is very low to low risk from liquefaction of the soils during a seismic event. The soils are mainly sandy gravels and depth to the groundwater table is between 5-20m.

Material encountered throughout the site is suitable for pavements and shallow foundations based on the requirements of NZS 3604:1999 Timber Framed Buildings. Where loose or soft material is encountered, localised removal and re-compaction of the sediment is recommended.

Contents

1 Introduction

Mitchell Partnerships commissioned Opus International Consultants Ltd (Opus) to carry out a geotechnical hazards risk assessment of the proposed Three Parks Development site (referred to as “site” for the purpose of this report) located as shown in Figure 1.

The brief required a Geotechnical/Natural Hazards Assessment to identify any natural or manmade hazards and/or any subsoil which may not be suitable for certain types of development.

The Geotechnical Hazard Assessment included:

- Flood Hazard Assessment
- Seismic Risk
- Foundation Options (looking at residential, light industrial, retail options in general)
- General comments on pavement construction options through site
- Preliminary Contaminated Site Assessment - review of existing information

Information was gathered from a desktop study, site visit and subsurface geotechnical investigations carried out on site.

The proposed development of the site includes a layout of mixed use, residential and large format retail areas within the Willowridge Property. In addition, extensive landscaping and open space areas have been included along with networking and access for pedestrians and vehicles within the site, and also linkages to the existing town of Wanaka.

2 Site Location and Overview

The site is located southeast of the centre of Wanaka and covers a little over 133 Ha (1.3 km^2). The site is bordered by Ballantyne Rd, Riverbank Rd and State Highway 84 (Figures 1 and 2). The street address (if any), legal description and certificate of title for each location are presented in Table 1. The NZMG UTM coordinate reference for the approximate centre of the area is 2205648E 5604635N, sheet F40.

Table 1 Legal description and Certificate of Title numbers for each of the address's of interest

Street Address	Legal Description	Certificate of Title #
101 Ballantyne Road	Sec 1, SO 17808	150395
None Listed	Lot 2, DP 303207	12731
None Listed	Lot 3 DP 17123	18547
None Listed	Lot 4, DP 15016	12731

Figure 1 – Site location relative to Wanaka.

The site is located on an old alluvial landscape formed during the Last Glacial Advance (15-23ka); an overview of the site is shown in Photo 1. As indicated by the topographical map for the region (NZMG, Sheet F40), as well as a survey of the oxidation pond area, average elevation across the site is roughly 320 m above sea level. The topography across the site is gently rolling between old river channels with slopes generally ranging between 0 - 5°. The Cardrona River is located 150 – 200 m east of the eastern property boundary while land to the west is slightly higher in elevation with similar rolling plains topography. The site is bounded at the north by State Highway 84 and Mt. Iron.

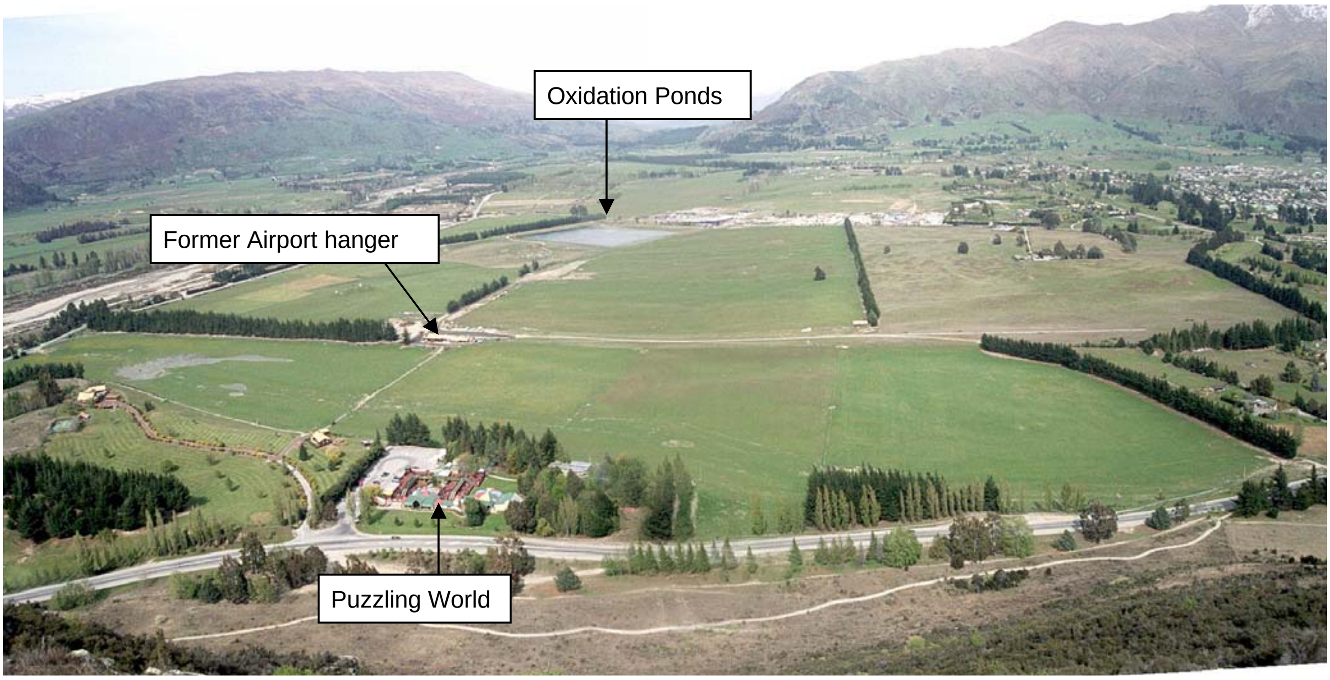

Photo 1 - Overview of site from Mount Iron (October 2006).

The proposed development of the site includes a layout of mixed use, residential and large format retail areas within the Willowridge Property. In addition, extensive landscaping and open space areas have been included along with networking and access for pedestrians and vehicles within the site, and also linkages to the existing town of Wanaka.

Figure 2 - Aerial Photography (2006) and photographic map with the site enclosed within the red boundary (2006 aerial photo modified from image obtained from Google Earth)
Three Parks Land Development

Project #: 6-CWM03.46

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3 Geology and Hydrology

3.1 Regional Geology

New Zealand straddles the boundary of the Australian and Pacific Plates, where relative movement is obliquely convergent across the plate boundary at 30mm/yr in the south (Stirling *et al.*, 1998). The Wakatipu map area is currently being deformed in response to oblique compression within the Pacific Plate to the southeast of the Alpine Fault, with uplift occurring northwest of the fault.

In Central Otago, conjugate northeast and northwest–trending reverse faults and accompanying folds are inferred to be the response to east-west directed compression during the late Pliocene and Quaternary. Reverse faults with slip rates of 0.1-1 mm/yr characterise the style of faulting in Otago and South Canterbury (Stirling *et al.*, 1998). The reverse faults have developed in response to the oblique compression across the plate boundary.

Basement rock consisting of variably schistose to non-schistose quartzo-feldspathic Haast Schist of the Rakia Terrane underlies the Wanaka District (Turnbull, 2000). Overlying the basement schist are moraines and outwash plains that represent the last major glacial advance and these are widespread and well preserved. Tills (Q2t) and outwash gravels (Q2a) are unweathered to slightly weathered. In many places two distinct terminal moraine loops can be recognised, with minor differences in outwash terraces. In the upper Clutha Valley, these deposits are mapped as the Mt Iron (older) and Hawea (younger) advances. The Hawea deposits are more than 15100 ± 200 yrs old, based on a ^{14}C date from peat in an outwash channel (Bell, 1977).

3.2 Local Geology

The majority of the site comprises tills and outwash gravels from the Mount Iron moraine deposit (refer to Figure 3). There is a small area along the eastern margin of the site where deposits represent alluvial deposits associated with the Mt. Iron moraine and glacial advance. The Mt. Iron moraine deposit and related Mt. Iron alluvial deposits are assumed to be approximately 23,000 yrs old (R. Thompson, Pers Comm.). A small slither of land to the south east of the site comprises of alluvial deposits of the Hawea Glacial Advance (~15ka).

Paleo-channels are identified on the aerial photographs and can be determined on site by the rolling landscape. There is a significant paleo-channel at the northern end of the site (the location of the Cardrona Stormwater By-pass); this channel has been interpreted to have drained the Cardrona river system into Lake Wanaka (R. Thompson, Pers. Comm.).

Within close proximity to the Three Parks site is the Cardrona Fault system which runs through Lake Hawea (Turnbull, 2000; Stirling *et al.* 1998). This fault is concealed once it exits the Cardrona Valley and the exact location is unknown, however it is shown on the 1:250,000 map as running parallel to the Cardrona River along the boundary of the site. The significance of this fault will be discussed further in section 6.3.

Test pits excavated on-site revealed alluvial and glacial fan and till deposits, most pits comprised mainly sandy gravels, with some sands and silts. The results of these can be found in Appendix A.

3.3 Hydrogeology

Due to the location of the site in the rain shadow of the Southern Alps it is in a relatively dry area with a median annual rainfall between 651-700 mm (GrowOTAGO). Seasonal precipitation distribution generally involves a wet season in the spring (September to November) and drier periods in February (ORC, 2000).

The site is located in the Wanaka Basin aquifer and, as noted above, is composed of both alluvial outwash gravels and glacial till deposits. These sediments have a relatively high hydraulic conductivity ranging between 50 – 70 m/day across the site resulting in moderately to well-drained sediments (ORC, 2003). Consequently there is little surface water ponding as infiltration through these sediments is reasonably rapid.

Aerial photography from 1997, 2000 and 2003 indicates some water ponding east of the oxidation ponds below a topographical high containing a water reservoir tank. This ponding is believed to be solely related to irrigation at the site and the close proximity to the water reservoir tank.

The aquifer around the site is generally between 30 – 50 m thick and underlain by schist bedrock. The aquifer is principally recharged by infiltration from the Cardrona River with secondary contributions from rainfall and irrigation. As a result, groundwater flow is principally north and west from the Cardrona River toward Lake Wanaka. Groundwater flow direction near the northeastern portion of the site is complicated by the influence of recharging water from Mt. Iron. Mt. Iron provides a southerly and easterly component to groundwater flow in this area.

The water table varies considerably across the site and is highest, ~ 5 mBGS (meters Below Ground Surface), adjacent to the Cardrona River. At the northern end of the site groundwater is much deeper, ~ 20 mBGS, as shown in Figure 4. There are 198 wells located within the Wanaka Basin Aquifer that are currently being used for drinking water supply, irrigation, commercial, scheme water supply and stockwater uses. There are a number of wells (> 5) located within the site with known uses including irrigation and drinking water supply.

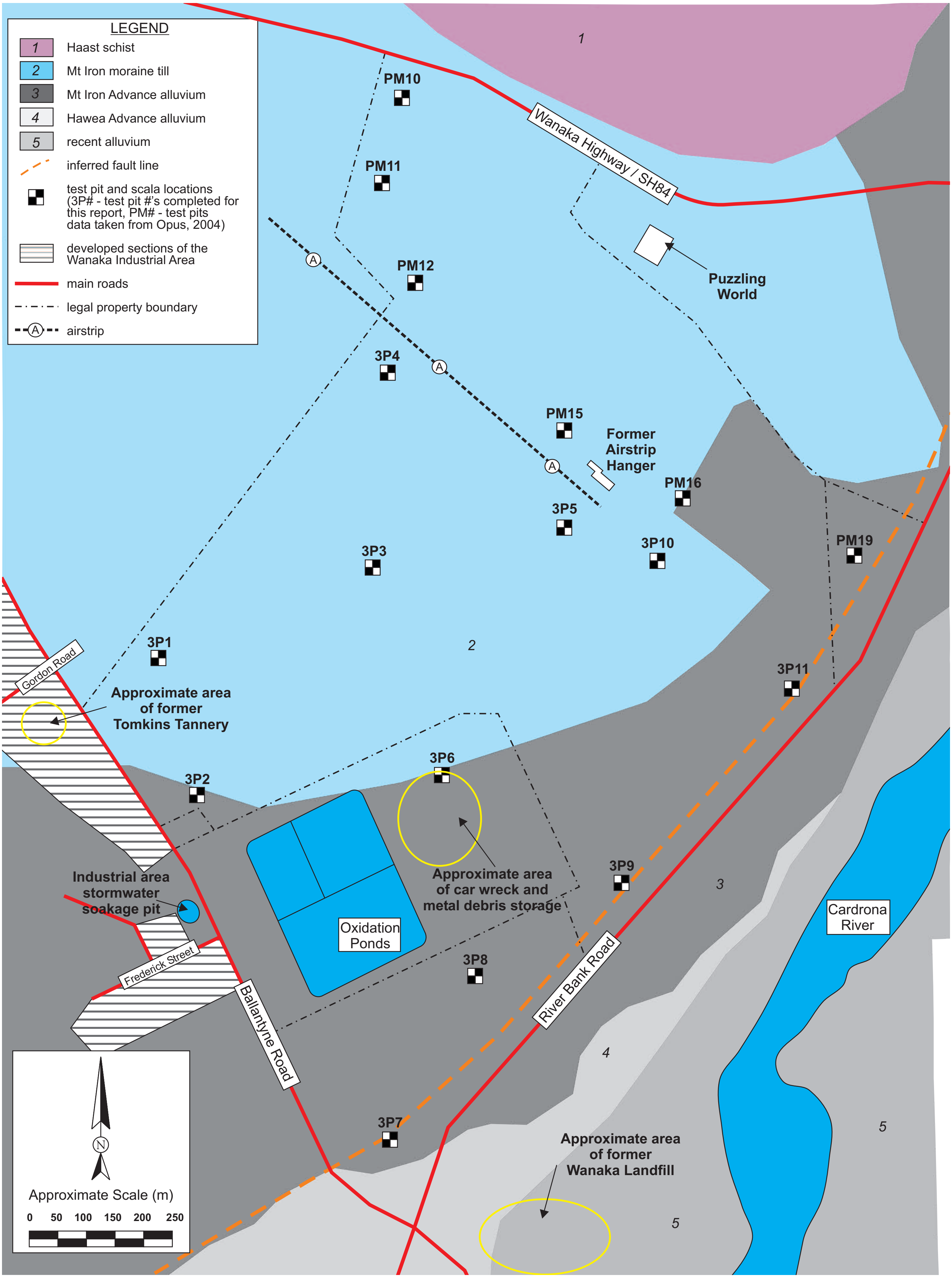

Figure 3 - Regional geology, test pit and land use
(Modified from Turnbull, 2000 & R. Thompson Pers. Comm.,2006)
Three Parks Land Development

Project #: 6-CWM03.46

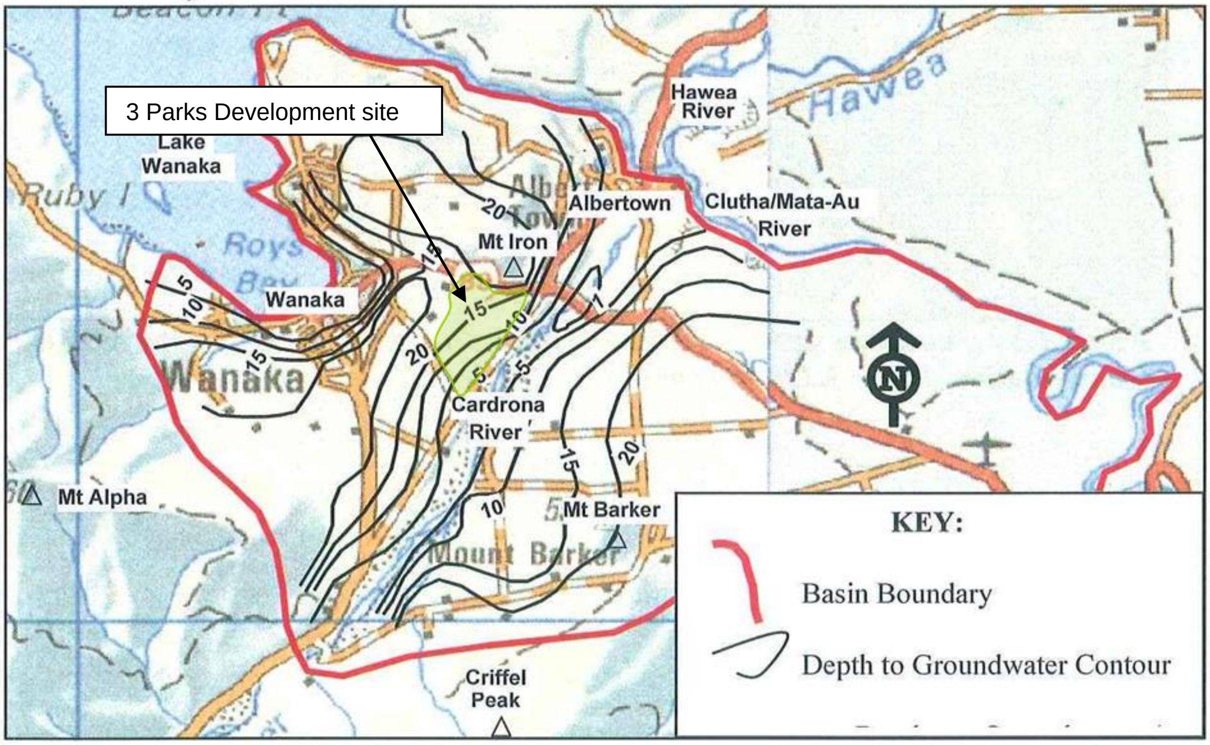

Figure 4 – Depth to water table for the Wanaka Basin in metres below ground level (m BGL) during July 1999. The Three Parks Development Area is highlighted in green. Scale approximately 1:120,000 (ORC, 2003).

4 Site Investigation

4.1 Introduction

An initial visit to the proposed Three Parks Development was undertaken by Opus personnel on 12th October 2006. The main purpose of this site visit was to gather information by way of walkover about the geology, geomorphology and hydrology of the site and to determine the likely hazards to be encountered on site.

4.2 Subsurface investigations

Subsurface investigations consisting of test pits and scala penetrometer tests were undertaken at 11 locations on the site as shown in Figure 3 (test pit logs are presented in Appendix A). The test pits were excavated with a 6 tonne digger to depths of 3 m. In addition, 6 test pits to depths up to 5 m were excavated at the northern end of the site during the Geotechnical investigations into the Queenstown Lakes District Council Cardrona Stormwater Bypass (Opus, 2004).

Sediments observed in the test pits were predominately sandy gravels with minor silt and sand layers. The sediments have been described as glacial tills and alluvial deposits from the last Glaciation. No groundwater or perched water was observed in any of the test pits, however the sediments were damp. As discussed in section 3.3, groundwater can be expected to be encountered from depths of 5 - 20 m across the site. The damp sediments are attributed to rainfall earlier in the week and/or irrigation applied to the land by the farmer.

5 Construction Considerations

5.1 Foundation Options and Pavement Construction Consideration

Subsurface investigation was used to examine the shallow deposits for foundation suitability and ground water conditions. Our findings are useful for consideration of shallow building foundations and general roading subgrade conditions. The extent of our investigation was such that it can be used to broadly characterise the site.

Although at this stage we do not know anticipated foundation loads, it is our expectation they will be relatively light. Our assessment has been based on the requirements of NZS 3604:1999 Timber Framed Buildings. If there are changes to larger loaded areas (multi storey/heavy industrial etc) deeper investigations will be needed and deeper soils testing. All foundations and pavements will need to be designed taking into consideration the seismic influence at the site (refer to section 6.3).

Material encountered throughout the site is suitable for pavements and shallow foundations. Where loose or soft material is encountered, localised removal and re-compaction of the sediment is recommended.

In the northern section of the site, a silt layer was found in the first 0.5m of all test pits (PM10, PM11, PM12, PM15, PM16 and PM19). This silt layer is not suitable for foundations or pavements and we recommend where these soft sediments are encountered, localised removal of material and re-compaction be completed. In addition, site specific investigation and design will be required for all developments.

We could not undertake test pitting under the oxidation ponds but excavated a test pit nearby (test pit 6). Depending on how the oxidation ponds are to be remediated, there may be issues in providing a solid foundation for building. The oxidation ponds were lined with a clay liner to create a low permeability basin. The ponds have probably become further sealed by sludge solids that have clogged the soil pores. Consequently the basins form areas of very low permeability that could limit their use for some purposes including residential development.

The sludge and clay layer would need to be removed to restore the natural drainage before development of the area could be undertaken. Further tests would be required to assess the suitability of the material beneath these ponds for foundations and pavements.

6 Natural Hazard Assessment

Information gathered from a desktop study, subsurface investigations and a site visit were used to undertake a hazard assessment on the proposed development area. Hazards that were assessed include:

- Flooding
- Erosion
- Seismicity (general structural consideration, liquefaction and fault rupture)
- Landslide/rockfall
- Contaminated land – preliminary review of existing information only

These hazards have been described in the sections below and a risk assessment carried out in section 8.

6.1 Flooding Hazard

6.1.1 Introduction

An assessment of potential flood risk posed to Lot 2 DP303202 and Lot 3 DP17123 has been undertaken based on the following information sources:

- A full site walkover on 12th October 2006 by an Opus hydrologist.
- Knowledge held by Opus of the Cardrona / Wanaka area affected by the November 1999 flood event.
- A flood hazard map sourced from Otago Regional Council on 22nd June 2006.

6.1.2 Assessment

The above information demonstrates that the flood risk to the area is low. There is no history of the site being flooded even during the extreme November 1999 event when almost all waterways in the area experienced extreme flows.

The fact that the site is situated on a high terrace well above the Cardrona River eliminates a flood risk from this watercourse. The lack of internal watercourses through or bordering the site also suggests flood hazard potential is low. The site has low lying areas which pond and this will need to be managed through stormwater design.

As an overall conclusion, the flood history of the site indicates that residential building on the site with standard foundations would comply with Building Act 2004 flooding provisions. Clause E1.3.2 of the Building Act Regulations provides that surface water resulting from a storm with a 2% probability of occurring annually ("the 50 year flood") shall not enter certain buildings. The Building Act 2004 requirements will still obviously apply to any stormwater design for future subdivision development. These include Clause E1.3.1 which provides that surface water from a 10 year flood which is collected by buildings or site work shall be disposed of in a way that avoids the likelihood of damage to other property.

6.2 Erosion Hazard

Erosion could occur from the undercutting of the river banks/terraces by the Cardrona River affecting the eastern portion of the site however the risk of this occurring is very low. The site is situated on a high terrace well above the Cardrona River eliminating a flood risk (and thus erosion risk) from this watercourse and the lack of internal watercourses through or bordering the site also suggests erosion hazard potential is very low.

6.3 Seismic Hazard

6.3.1 Introduction

Parts of the Wakatipu area are subject to extreme seisomotectonic hazard, due to the presence of the Alpine Fault and the many active faults in Central Otago and northern Southland (see also section 3.2). There is a high probability that an earthquake with an expected magnitude of over 7.5 will occur along the Alpine Fault within the next 50 years.

Within close proximity to the Three Parks site is the Cardrona Fault system (Turnbull, 2000; Stirling *et al.*, 1998, 2000). The Cardrona Fault trace has been observed and mapped in the Cardrona Valley but is concealed (i.e. no active traces are known of the fault and the precise location of the fault is unknown) through the eastern side of Wanaka and through Lake Hawea. On the 1:250,000 Geological Map of the Wakatipu Area the inferred location of the concealed Cardrona Fault runs parallel to the Cardrona River along the eastern boundary of the site. The characteristics of this fault are outlined in Table 2 below:

Table 2: Summary of fault along eastern margin of the site (Stirling *et al*., 1998, Stirling *et al.*, 2000).

Fault	Type	Dip and dip direction	Slip rate (mm/yr)	Single-event displacement (m)	M_{max}	Recurrence interval (yrs)
Cardrona	Oblique/ reverse	30-70° NW	0.25	1-3	6.9-7.2	7500

Seismic hazard will be assessed in terms of general structural considerations, liquefaction and fault rupture damage.

6.3.2 Assessment

General Structural Considerations

The likely size of a seismic event in terms of horizontal acceleration based on the principles of AS/NZS 1170: Part 5, 2003 Earthquake Actions in Wanaka will be around 0.4g. This figure was based on soil information obtained from test pits excavated on the site and by considering an earthquake with a return period (R) of 1/500. The calculated horizontal acceleration for this site is relatively high.

Due to the presence of the Alpine Fault and other active faults in and near to the Wanaka region (including the Cardrona Fault), the risk of general structure damage is low to moderate. The relevant New Zealand Standards and Codes should be used for earthquake loading in accordance with normal practice.

Liquefaction

To establish the risk of liquefaction at the site, 11 test pits were excavated throughout the proposed development site. Sediments encountered in the test pits consisted mainly of sandy gravels with some silt and sand. Some of the test pit sides started to collapse due to the uniform clean gravels encountered.

As discussed in section 3.3 and 4.2, no groundwater or perched water were observed in any test pits excavated on site. Information gathered from the Wanaka Basin Groundwater Modelling Report (ORC, 2003) show that the groundwater table on site varies from between 5 and 20 m below ground level (Figure 4). Liquefaction is unlikely to occur in sediments where the groundwater table is at depths >12m

Given the free-draining nature of the materials and the depth to the groundwater table, liquefaction of the soil under a seismic event is unlikely. Further investigation and laboratory testing would be needed to fully define the risk, but our assessment is that this is not required. In terms of other general structural conditions, the relevant New Zealand Standards and Codes should be used for earthquake loading in accordance with normal practice.

Fault Rupture

Likely fault rupture calculated for the Cardrona Fault system is to be between 1 and 3m (see table 2). The zone of influence is generally taken to be within 200m of an active fault or boundary of an active fault. Due to the presence of sedimentary deposits at this locality, the rupture could affect a wide area, but would cause smaller displacement at any one point at the surface. Such surface deformation could also cause significant damage to any development in the rupture area.

The recurrence interval for a seismic event to occur on the Cardrona Fault is large (7,500 years) in comparison to that of the Alpine fault (300-1200 years) and therefore a rupture occurring on the Alpine Fault is more likely to affect the site than that of the Cardrona Fault.

6.4 Landslide/Rockslide Hazard

Due to the relatively flat topography, there are no landslide/rockslide/fall hazards on site. The Northern-most portion of the site, which is bounded by the State Highway, is located approximately 100m from Mt Iron (Photo 2).

An assessment of aerial photography and information gathered from the site visit was made to assess the landslide and/or rockfall/slide hazard posed to the development site from Mt Iron. The schist outcrop that makes up Mt Iron is well vegetated and historic aerial photographs do not show any evidence of instability of the slope. There is also no evidence of rock surrounding the slope on the side of the Wanaka State Highway. The whole schist outcrop is dipping away from the site 15° to the North-west. Landslide and/or rockfall/slide risk to the site from Mt Iron is very low.

Photo 2 - Mt Iron to the North of the proposed development site (October 2006).

7 Preliminary Contaminated Land Assessment

The preliminary contaminated land assessment primarily involved a desk study to assess site history, potential historical sources of contamination and review the MWH document entitled, “Remediation of the oxidation ponds site in Ballantyne Road”.

7.1 Site History

The site history described below is based on the compilation of data obtained from aerial photography, interviews with regional and local councils/authorities and a review of available documentation relating to the site (eg. LIM reports). Locations referred to below are indicated on Figure 3 and photograph locations and orientation provided in Figure 2.

7.1.1 Historical and Current Land Use

Airstrip

According to aerial photography, with the exception of a small airstrip, the site area consisted entirely of unoccupied land and farmland/pasture prior to 1966. In 1966 the airstrip located on the site did not contain any visible infrastructure. Aerial photography from 1976 shows a small building and what appears to be a fence at the northwest end of the airstrip.

The airstrip once served as the main airport for Wanaka with a hanger constructed for the airport in the late 1970’s – early 1980’s at the southeast end of the airstrip (Figure 3 and Photo 1). This building is still present today and is currently used as an operations base for Capell Construction Ltd and Nichols Landscaping. These businesses use the area for storage, maintenance, and servicing of vehicles and machinery. The former hanger also contains two 9000L tanks that had historically been used to store diesel and fuel for airplanes and airport vehicles. The tanks are owned by Mobil and presently contain diesel for the business at the site.

Oxidation ponds

The oxidation ponds were constructed in the mid to late 1970’s but in November 1976 were not yet installed. The system consists of three oxidation ponds that receive wastewater from Wanaka via a pipeline along Ballantyne Road (Photo 3). The treated water is then piped along Riverbank Road and discharged into the Clutha River near Albert Town.

Photo 3 - Looking southwest over the largest of the oxidation ponds (October 2006).

It had been recognized that water quality at the discharge point does not always comply with consent conditions. Given this and other land development pressures at the current oxidation pond site, a Joint Working Party Group was formed in March 2003 to investigate alternative options and locations for Wanaka's waste treatment under an initiative entitled, "Project Pure". The final report by this working party indicated that the preferred option involves moving treatment elsewhere while the existing oxidation ponds are to be decommissioned and the site rehabilitated.

It has been observed that the area east of the oxidation ponds has historically contained a number of car wrecks, large drums/tanks, rubbish and other metal debris. The use of this area for storage of these types of materials continues today as observed during the site walkover inspection (Photo 4).

Photo 4 - Looking east over car wrecks, metal debris and other rubbish to the east of the oxidation ponds (October, 2006).

Adjacent Land

The majority of the land adjacent to the site has, and continues to be principally farmland and residential property. Adjacent land uses of concern include developments within the Wanaka Industrial Area and the former Wanaka Landfill.

The Wanaka Industrial Area consists of a strip of industrially zoned property extending along the west side of Ballantyne Road with the majority of development centred on Gordon Road. Recent development has extended to the south and along Frederick Street. Historical and current developments of note include the Tomkins Tannery, car wreckers, engineering workshops, concrete contractors, property management and professional offices (Eg. Lakes Contract Services, Fulton Hogan, Allied Concrete).

The former Wanaka Landfill is located south of Riverbank Road at its intersection with Ballantyne Road (Figure 3). Although it is not certain how long the landfill operated, aerial photography indicates it was at least as far back as 1976 until its closure in September 1999. The landfill received a variety of Municipal waste which may have included hazardous waste.

7.2 Potential Contamination Associated with Historical Land Use

The description of potential historical sources of contamination presents an indication of contaminants commonly associated with the identified historical land use but does not necessarily indicate that these contaminants exist at the site today.

Airstrip

As indicated in the "Contaminated Land Management Guidelines, Schedule A & B (2004)", potential contaminants commonly associated with airstrips include hydrocarbons and metals associated with fuel storage, workshops, washdown areas and stormwater runoff from hardstand. Airstrips have a HAIL (Hazardous Activities and Industries List) code of #4. The servicing and storage of the vehicles and machinery used currently at the site also provide a potential for the above contaminants to exist at the site.

Recent work completed earlier this year by URS consultants involving subsurface investigation has been completed at the site around the 2 fuel storage tanks. The results of this assessment have not yet been reported.

Oxidation Ponds and Waste Storage

As outlined in the MWH report entitled, "Project Pure: Remediation of the oxidation ponds site in Ballantyne Road (2005)", potential contaminants associated with the oxidations ponds include various metals as well as both harmless and pathogenic bacteria. Metals such as copper, lead and zinc are likely to be present as a result of corrosion of old waste pipes transporting wastewater to the oxidation ponds. Most of these contaminants will be contained within the sludge although some leaching to the underlying sediments may have occurred as a result of slow water infiltration through the clay liner.

In addition to the issues related directly to the oxidation ponds there is also potential for contamination of the sediment to the east of the site where car wrecks and other rubbish has traditionally been stored. Potential contaminants mainly include hydrocarbons and metals. The most applicable HAIL code for activity at, and around the oxidation ponds is #49 (waste storage).

Adjacent Land

Potential contaminants from adjacent properties mainly include hydrocarbons, metals, alkalis and organic acids. These contaminants are associated with the various industrial activities and storage units within the Wanaka Industrial Area as well as from the former Wanaka Landfill area.

7.3 Site characterisation

The following utilises information presented in the previous sections to characterise potential contamination, transportation pathways and risk to the surrounding environment at the site. This characterisation is an assessment based on the preliminary investigation completed to date. Should additional information become available this characterisation should be updated.

7.3.1 Hypothetical Exposure Pathways and Populations at Risk

Wanaka Basin Aquifer

If contamination exists and reaches the groundwater table there is potential for transportation to occur through the Wanaka Basin Aquifer along groundwater flow paths through advection and diffusion processes. As outlined in section 3.3, groundwater flow beneath the site is principally from the Cardrona River north towards Lake Wanaka but will become more complicated by recharge from Mt. Iron at the northeast end of the site. Contamination reaching the groundwater table has the potential to dissipate over a larger area due to the relatively high hydraulic conductivity of the aquifer.

The major population at risk, if potential contamination travelled along this exposure pathway, would be groundwater users, both human and animals (eg. stock). The risk would be greatest near the source of contamination as dilution of contaminants will occur with increasing distance from the site. Migration of potential contaminants, if any, through the aquifer will depend on contaminant concentration, solubility and the ability of the aquifer to act as a filtering system.

Groundwater flow in the Wanaka Basin Aquifer also represents a pathway for potential contaminants to be transported to the site. For example, contaminants, if any, occurring beneath the industrial zone, within stormwater transported to the soaking pit north of Frederick Road, of from the former Wanaka landfill site could potentially be transported beneath the site by this mechanism.

Contaminated Sediment

Exposure to contaminants, if any, within sediment may occur through direct or indirect means. Direct contact by humans and/or animals using the site could occur via surficial contamination or during excavation of sediment. Indirect contamination could occur through plants growing at the site that are ingested by humans and animals.

Surface Water

If there is any contaminated surface water there is a risk of direct exposure in the event of flooding or ponding of water over contaminated sediments. In addition to direct contact contaminated surface water, may also act as a transportation mechanism for contamination across the site. Potential exposure populations are similar to those of contaminated sediment.

7.3.2 Likelihood of Potential Environmental Contamination

During the course of the desk study there was no direct evidence revealing significant contamination within the site. The following section outlines the likelihood of potential contamination specifically associated with areas outlined in section 7.2.

Airstrip

It has been indicated that the two 9000L Underground Storage Tanks (USTs) located near the old airport hanger have been in operation at the site since the hanger was constructed in the late 1970's – early 1980's. Over such a prolonged time frame there is risk that slow leakage from corrosion of the tanks or from spillage at the surface has caused hydrocarbon contamination of the sediments beneath this area.

The recent investigation by URS for Mobile Oil around the site may provide additional insight on potential contamination and should be reviewed when the report becomes available.

In addition to potential contamination from the two USTs, it is also probable that the upper sediments around the old airstrip, principally the hanger, are contaminated with metals and hydrocarbons. The operation of any former and current workshops and washdown areas are possibly sources for such contamination.

Oxidation Ponds

The three oxidation ponds that comprise part of the Wanaka wasterwater treatment system have been in operation at the site since the mid to late 1970's. As indicated in the MWH report (2005), the ponds are lined with clay. However, it is probable that some contaminants have leached from the sludge through this clay liner and into the sediments directly beneath the oxidation ponds.

Another possible source of contamination from the oxidation ponds is related to waste sludge that has accumulated at the bottom of the ponds. This sludge is likely to contain metals (eg. copper, zinc, lead, chromium), high bacteria concentrations, and possibly viral microbes.

In addition, the area directly adjacent to the east side of the oxidation ponds has historically and continues to be used as a storage/disposal area for old car bodies and wrecks, metal debris as well as other rubbish. Due to the longstanding use of this location for this activity it is probable that localized contamination of sediment by metals and hydrocarbons has occurred.

Wanaka Industrial Area

The close proximity of the Wanaka Industrial Area to the western extent of the site presents a risk for contamination migration. A possible source of contamination is stormwater drainage transported from the industrial activities along Ballantyne road to a small soaking pit ~ 20 – 30 meters from the western property boundary (Figure 3). However, the likelihood of significant contamination from the Wanaka Industrial Area is unlikely.

Former Wanaka Landfill

The former landfill received a variety of municipal wastes over a long time frame (at least 23 years) and it is located upstream of local groundwater flow. Consequently contamination of the land beneath the landfill is probable and there is a potential that this has been transported beneath the site. Preliminary examination of available groundwater analysis provided by the ORC for monitoring wells located at the landfill site indicate that contamination to groundwater beneath the landfill is not of concern.

7.4 Recommended Further Work

Historical and current land use practice within, and adjacent to the site have included activities that could conceivably have presented a risk of contamination to sediment and water (surface and groundwater). Potential contaminants from these activities mainly include hydrocarbons, metals, bacteria and viral microbes. If the proposed development of this land to a residential subdivision occurs a Detailed Site Investigation (DSI) is recommended to quantify the presence/absence and level of contamination present.

Implementation of a detailed site investigation should include, but may not be limited to the following scope of work;

- Additional, specific background investigation into existence and extent of potential contaminants (eg. landfill).
- Surficial sampling of sediments around the airstrip hanger, UST's, oxidation ponds (including sludge), and car wreck/metal debris storage site to determine presence and extent of contamination.
- Investigation and sampling of subsurface sediments around the above locations to determine presence and extent of contamination.
- Sampling of nearby water wells (upgradient and downgradient).

Potential On-Site Remedial Options

The DSI will provide a comprehensive assessment of potential contamination and define the best approach for the creation of a Site Remedial Action Plan if necessary. Required remedial actions will ultimately depend on proposed land use (eg. residential, parkland) and the results of the DSI. The following remedial options are based only on this preliminary investigation and are meant to be indicative options only:

Airstrip

- UST removal
- Removal of contaminated sediment, if any, to a certified landfill followed by validation testing

Oxidation Ponds

- Complete removal of sludge, clay liner and contaminated sediment, if any to a certified landfill. Validation testing necessary.
- Modify drainage and cover the oxidation ponds with clean fill.
- Stabilize oxidation sludge with lime or by sun drying followed by cover with clean fill.

Car Wreck/Metal Debris Area

- Removal of car wrecks, metal debris and other rubbish to a certified landfill.
- Removal of contaminated sediment, if any, to a certified landfill. Validation testing necessary.

Contaminated Sediment from Adjacent Land Use

- Removal of contaminated sediment, if any, to a certified landfill. Validation testing necessary.

8 Risk Assessment

In this report the risks associated with the Three Parks Development site have been assessed using qualitative risk assessment methodology based on the principles of AS/NZS 4360:2004 Risk Management and Landslide Risk Management Concepts and Guidelines and further developed by the Australian Geomechanics Society (AGS).

Risk level is defined by rating the likelihood and consequence of an event occurring that affects a site with potential loss of life. Risks are summarised and presented in Table 3. We have also included recommendations for risk management which will require specific risk treatment plans.

We have presented what is effectively a snapshot in time of risks based on our current state of knowledge and used this to present our assessment of what we anticipate in the future.

Table 3 - Risk Assessment Summary Table for Three Parks Development, Wanaka

Hazard Type	Likelihood	Consequences	Risk Level	Comments and recommendations regarding Risk Management
Flooding	Rare	Medium	Very Low to Low	Site visit and background research carried out. Flood history of the site indicates that residential building on the site with standard foundations would comply with Building Act 2004 flooding provisions.
Erosion	Rare	Insignificant	Very Low	No specific additional mitigation measures needed.
Seismic General structure	Unlikely	Medium	Low to Moderate	Desktop study carried out, followed by analysis of design earthquake. The calculated horizontal acceleration for this site is relatively high. In terms of structural conditions, the relevant New Zealand Standards and Codes should be used for earthquake loading in accordance with normal practice.
Seismic Liquefaction	Rare	Medium	Very Low to Low	Test pits carried out on site, followed by analysis of design earthquake. Due to the depth of the groundwater and the sediments located on site, liquefaction of the soil under seismic event is unlikely however in terms of structural conditions, the relevant New Zealand Standards and Codes should be used for earthquake loading in accordance with normal practice.
Seismic Cardrona Fault rupture	Rare	Major	Low to Moderate	Desktop study carried out. Active Fault line running through (or close to) the proposed subdivision. In terms of structural conditions, the relevant New Zealand Standards and Codes should be used for earthquake loading in accordance with normal practice.
Foundation Failure	Rare	Minor	Very Low	Limited and Generalized Scala Penetrometer Tests and Test Pitting. Site specific investigation and design needed for all developments.
Rockfall/slide	Inconceivable	Insignificant	Very Low	No specific additional mitigation measures needed. Recommended observation of Mt Iron after large seismic events, severe storms or isolated rockfall events.
Landslide	Rare	Insignificant	Very Low	No specific additional mitigation measures needed.

Table 3 cont.

Hazard Type	Likelihood	Consequences	Risk Level	Comments and recommendations regarding Risk Management
Contaminated Land Airstrip	Likely	Minor	Moderate	Desktop research carried out. Surficial sampling of sediments is required to determine presence and extent of contamination; investigation and sampling of subsurface sediments to determine presence and extent of contamination; sampling of nearby water wells (upgradient and downgradient).
Contaminated Land Oxidation Ponds	Possible	Minor	Low to Moderate	Same as above
Contaminated Land Waste Storage	Possible	Insignificant	Very Low to Low	Same as above
Contaminated Land Adjacent Land - Wanaka Industrial Area	Unlikely	Insignificant	Very Low	Desktop research carried out. Additional background research needed to identify specifics of potentially contaminating activities.
Contaminated Land Adjacent Land - Former Wanaka Landfill	Unlikely	Minor	Low	Desktop research carried out. Additional background research needed to examine landfill history and available monitoring information (e.g. monitoring wells).

9 Summary and Recommendations

Mitchell Partnerships commissioned Opus to carry out a Geotechnical Hazards Risk Assessment of the proposed Three Parks Development site, Wanaka. Development envisaged includes a layout of mixed use, residential and large format retail areas within the property. In addition, extensive landscaping and open space areas have been included along with networking and access for pedestrians and vehicles within the site, and also linkages to the existing town of Wanaka.

We have carried out a risk assessment using qualitative risk assessment methodology based on the principles of AS/NZS 4360:2004 Risk Management and Landslide Risk Management Concepts and Guidelines and further developed by the Australian Geomechanics Society (AGS).

The following sections summarise the main points of each hazard identified and makes recommendations as to what further work is likely to be needed.

Flood Risk

As an overall conclusion the flood history of the site indicates that residential building on the site with standard foundations would comply with Building Act 2004 flooding provisions.

Clause E1.3.2 of the Building Act Regulations provides that surface water resulting from a storm with a 2% probability of occurring annually (“the 50 year flood”) shall not enter certain buildings.

The Building Act 2004 requirements will still obviously apply to any stormwater design for future subdivision development. These include Clause E1.3.1 which provides that surface water from a 10 year flood which is collected by buildings or site work shall be disposed of in a way that avoids the likelihood of damage to other property.

Erosion

There is a very low risk to the site from erosion due to the low risk of flooding from the Cardrona and other watercourses.

Seismic

The likely size of a seismic event in terms of horizontal acceleration based on the principles of AS/NZS 1170: Part 5, 2003 Earthquake Actions in Wanaka will be around 0.4g (this will depend on what buildings will be established). This figure was based on soil information obtained from test pits excavated on the site and a return period of 1/500. The calculated horizontal acceleration for this site is relatively high and there is a low to moderate risk of general structure failure under a seismic event.

In terms of structural conditions, the relevant New Zealand Standards and Codes should be used for earthquake loading in accordance with normal practice.

Seismic – Liquefaction

Test pits carried out on site, followed by analysis of design earthquake. Due to the depth of the groundwater and the type of sediments located on site, liquefaction of the soil under seismic event is low. However in terms of structural conditions, the relevant New Zealand Standards and Codes should be used for earthquake loading in accordance with normal practice.

Seismic – Fault rupture

The recurrence interval for a seismic event to occur on the Cardrona Fault is large (7,500 years) in comparison to that of the Alpine fault (300-1200 years) and therefore a rupture occurring on the Alpine Fault is more likely to affect the site than that of the Cardrona Fault. The risk from fault rupture to the site is low to moderate.

Landslide/Rockfall

There is no evidence of landslides or rockfalls affecting the area from Mt. Iron. We recommend that the slope be observed following major seismic event, severe storm or incidence of rockfall.

Other Natural Hazards

There is no risk to the site from snow avalanches, tsunami or volcanic eruptions.

Contaminated Land

At this stage desktop work has been carried out. Historical and current land use practice within, and adjacent to the site have included activities that present a risk of contamination to sediment and water (surface and groundwater). Potential contaminants from these activities mainly include hydrocarbons, metals, bacteria and viral microbes. If the proposed development of this land to a residential subdivision occurs a Detailed Site Investigation (DSI) is recommended to determine the presence/absence and level of contamination present.

Foundation and Pavement Considerations

Material encountered throughout the site is suitable for pavements and shallow foundations based on the requirements of NZS 3604:1999 Timber Framed Buildings. Where loose or soft material is encountered, localised removal and re-compaction of the sediment is recommended.

10 References

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Appendix A – Test Pit Logs

INVESTIGATION PIT LOG
TEST REPORT

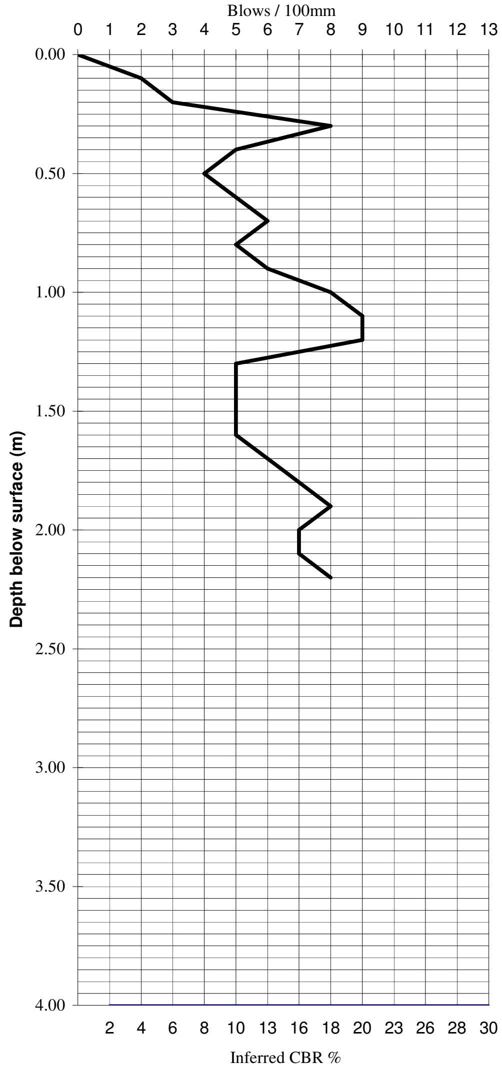
Project : 3 Parks Development
Location : Wanaka
Client : Mitchell Partnerships
Contractor : Nichols Landscaping
Sampled by : Mark Darcy and Kim Martelli
Date Sampled : 12/10/06
Pit number : Test Pit 1

Project No : 6CWM03.46 006DD
Lab Ref No : OPU.D6/14
Client Ref No :

Depth (mm)	Geological Description
0-200	Light brown silty Topsoil with some gravel
200-400	Fine to medium GRAVEL; grey. Loosely packed; rounded to sub-rounded schist gravel.
400-500	Coarse GRAVEL; grey. Loosely packed; rounded to sub-rounded schist gravel.
500-1000	Medium GRAVEL; grey. Loosely packed; rounded to sub-rounded schist gravel.
1000-3000	Medium to coarse GRAVEL; grey. Loosely packed; rounded to sub-rounded, with schist slabs up to 300mm in size
3000	end of test pit - hole collapsed No groundwater observed, hole damp

Sample recovered at :
Depth at which scala penetrometer started : 0 metres

Scala Penetrometer



Test Methods
Determination of Penetration Resistance of a Soil, NZS 4402 : 1988, Test 6.5.2
Inferred CBR values taken from Austroads pavement design manual 1992
Sampling Method: NZS 4407 :1991,Part 2.4.2

Notes
IANZ Accreditation does not apply to inferred CBR values or depths gretaer than 1.5 metres

Date tested : 12/10/06
Date reported : 14/11/06

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INVESTIGATION PIT LOG
TEST REPORT

Project :	**3 Parks Development**
Location :	**Wanaka**
Client :	**Mitchell Partnerships**
Contractor :	**Nichols Landscaping**
Sampled by :	**Mark Darcy and Kim Martelli**
Date Sampled :	**12/10/06**
Pit number :	**Test Pit 1**

Project No :	**6CWM03.46 006DD**
Lab Ref No :	**OPU.D6/14**
Client Ref No :	

Date tested : 12/10/06
Date reported : 14/11/06

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INVESTIGATION PIT LOG
TEST REPORT

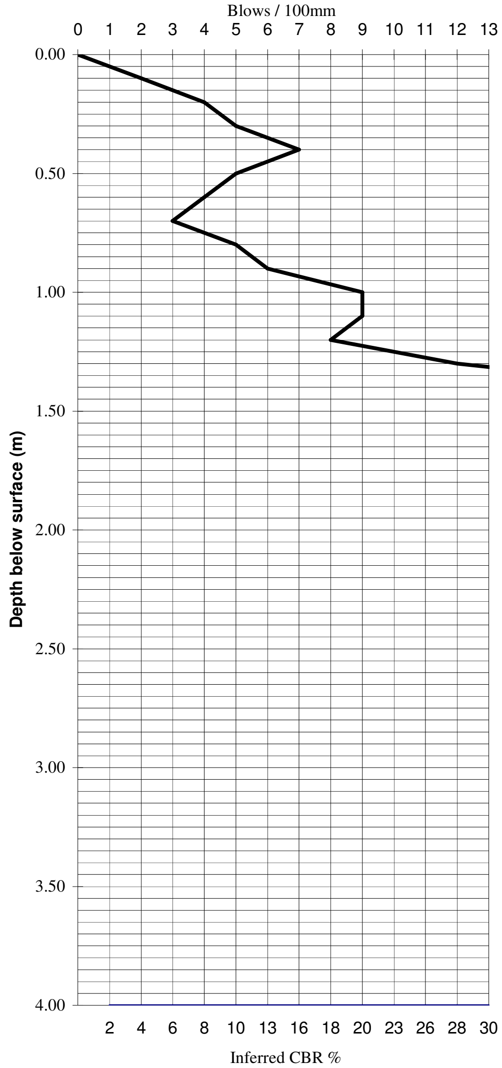
Project : 3 Parks Development
Location : Wanaka
Client : Mitchell Partnerships
Contractor : Nichols Landscaping
Sampled by : Mark Darcy and Kim Martelli
Date Sampled : 12/10/06
Pit number : Test Pit 2

Project No : 6CWM03.46 006DD
Lab Ref No : OPU.D6/14
Client Ref No :

Depth (mm)	Geological Description
0-100	Dark brown topsoil
100-900	Sandy fine to medium GRAVEL. Loosely packed; sub-rounded to angular schist gravel.
900-1200	Sandy coarse GRAVEL. Loose packed; sub-rounded to angular schist gravel.
1200-3000	Sandy coarse GRAVEL. Dense and compactly packed; with angular and sub-rounded schist slabs up to 1000mm (slabs unbreakable with digger, one 2000mm).
	End of test pit - holes collapsing in No groundwater observed, hole damp

Sample recovered at :
Depth at which scala penetrometer started : 0 metres

Scala Penetrometer



Test Methods
Determination of Penetration Resistance of a Soil, NZS 4402 : 1988, Test 6.5.2
Inferred CBR values taken from Austroads pavement design manual 1992
Sampling Method: NZS 4407 :1991,Part 2.4.2

Notes
IANZ Accreditation does not apply to inferred CBR values or depths gretaer than 1.5 metres

Date tested : 12/10/06
Date reported : 14/11/06

Sampling and testing is covered by IANZ Accreditation
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INVESTIGATION PIT LOG
TEST REPORT

Project :	**3 Parks Development**
Location :	**Wanaka**
Client :	**Mitchell Partnerships**
Contractor :	**Nichols Landscaping**
Sampled by :	**Mark Darcy and Kim Martelli**
Date Sampled :	**12/10/06**
Pit number :	**Test Pit 2**

Project No :	**6CWM03.46 006DD**
Lab Ref No :	**OPU.D6/14**
Client Ref No :	

Date tested : 12/10/06
Date reported : 14/11/06

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INVESTIGATION PIT LOG
TEST REPORT

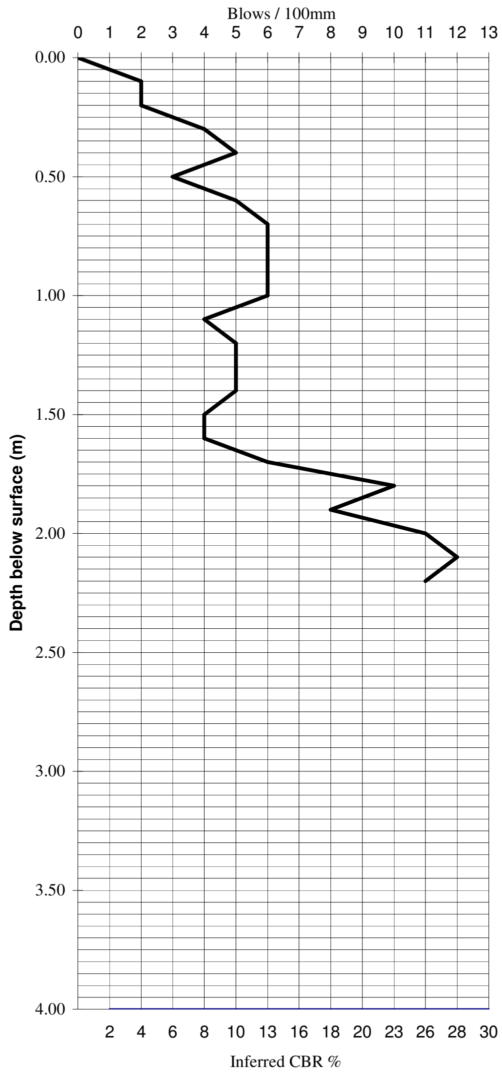
Project : 3 Parks Development
Location : Wanaka
Client : Mitchell Partnerships
Contractor : Nichols Landscaping
Sampled by : Mark Darcy and Kim Martelli
Date Sampled : 12/10/06
Pit number : Test Pit 3

Project No : 6CWM03.46 006DD
Lab Ref No : OPU.D6/14
Client Ref No :

Depth (mm)	Geological Description
0-100	Sandy fine TOPSOIL brown.
100-2000	Fine to coarse GRAVEL. Loosely packed; well graded; bedded; rounded to sub-rounded schist gravel.
	End of test pit - hole collapsing No groundwater observed, hole damp

Sample recovered at :
Depth at which scala penetrometer started : 0 metres

Scala Penetrometer



Test Methods	Notes
Determination of Penetration Resistance of a Soil, NZS 4402 : 1988, Test 6.5.2 Inferred CBR values taken from Austroads pavement design manual 1992 Sampling Method: NZS 4407 :1991,Part 2.4.2	IANZ Accreditation does not apply to inferred CBR values or depths gretaer than 1.5 metres

Date tested : 12/10/06
Date reported : 14/11/06

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INVESTIGATION PIT LOG
TEST REPORT

Project : 3 Parks Development
Location : Wanaka
Client : Mitchell Partnerships
Contractor : Nichols Landscaping
Sampled by : Mark Darcy and Kim Martelli
Date Sampled : 12/10/06
Pit number : Test Pit 3

Project No :	**6CWM03.46 006DD**
Lab Ref No :	**OPU.D6/14**
Client Ref No :	

Date tested : 12/10/06
Date reported : 14/11/06

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INVESTIGATION PIT LOG
TEST REPORT

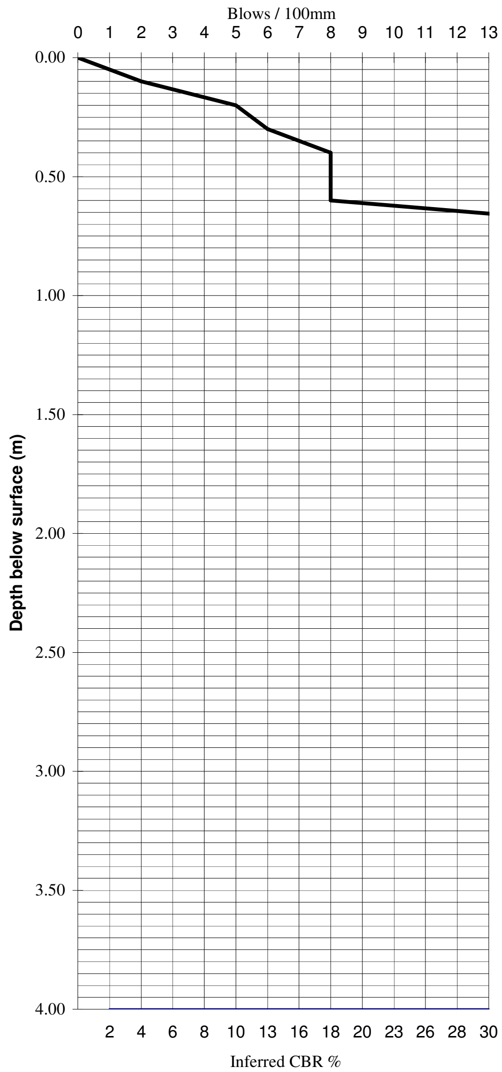
Project : 3 Parks Development
Location : Wanaka
Client : Mitchell Partnerships
Contractor : Nichols Landscaping
Sampled by : Mark Darcy and Kim Martelli
Date Sampled : 12/10/06
Pit number : Test Pit 4

Project No : 6CWM03.46 006DD
Lab Ref No : OPU.D6/14
Client Ref No :

Depth (mm)	Geological Description
0-500	Sandy topsoil, brown. With some gravel.
500-1000	Sandy coarse GRAVEL; dark brown. Loosely packed, rounded.
100-1300	Very fine SAND; grey. Densely packed.
1300-1600	Medium to coarse SAND; grey. Densely packed; with coarse gravel; rounded.
1600-2900	Sandy GRAVEL of various sizes. Most 100-150mm.
	end of test pit No groundwater observed, hole damp

Sample recovered at :
Depth at which scala penetrometer started : 0 metres

Scala Penetrometer



Test Methods	Notes
Determination of Penetration Resistance of a Soil, NZS 4402 : 1988, Test 6.5.2 Inferred CBR values taken from Austroads pavement design manual 1992 Sampling Method: NZS 4407 :1991,Part 2.4.2	IANZ Accreditation does not apply to inferred CBR values or depths gretaer than 1.5 metres

Date tested : 12/10/06
Date reported : 14/11/06

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INVESTIGATION PIT LOG
TEST REPORT

Project :	**3 Parks Development**
Location :	**Wanaka**
Client :	**Mitchell Partnerships**
Contractor :	**Nichols Landscaping**
Sampled by :	**Mark Darcy and Kim Martelli**
Date Sampled :	**12/10/06**
Pit number :	**Test Pit 4**

Project No :	**6CWM03.46 006DD**
Lab Ref No :	**OPU.D6/14**
Client Ref No :	

Date tested : 12/10/06
Date reported : 14/11/06

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INVESTIGATION PIT LOG
TEST REPORT

Project :	**3 Parks Development**
Location :	**Wanaka**
Client :	**Mitchell Partnerships**
Contractor :	**Nichols Landscaping**
Sampled by :	**Mark Darcy and Kim Martelli**
Date Sampled :	**12/10/06**
Pit number :	**Test Pit 5**

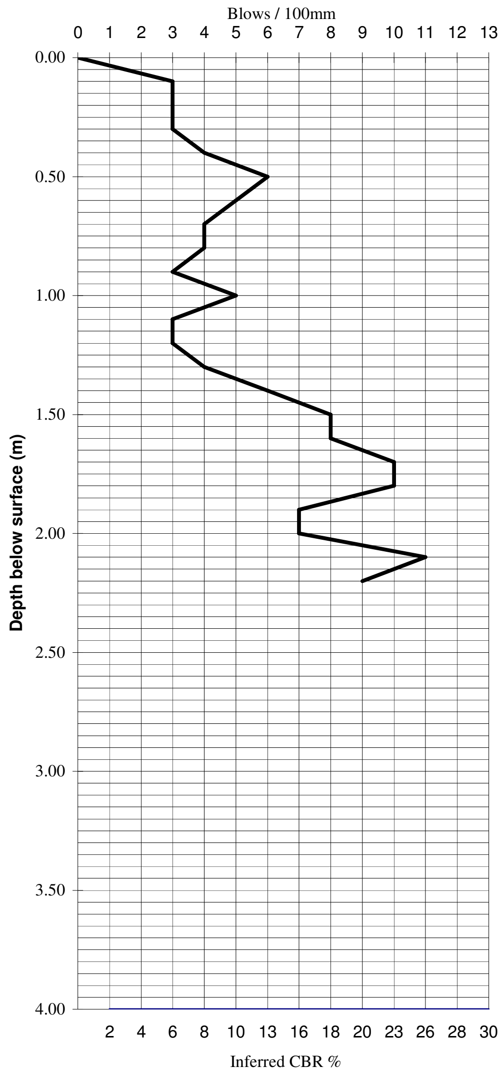
Project No :	**6CWM03.46 006DD**
Lab Ref No :	**OPU.D6/14**
Client Ref No :	

Depth (mm)	Geological Description
0-200	Sandy topsoil; brown. With some gravel.
200-2700	Medium to coarse GRAVEL, grey. Loosely packed; clean; uniform; well-sorted; bedding. Some larger schist boulders up to 200mm. End of test pit - hole collapsing No groundwater observed, hole damp

Sample recovered at :

Depth at which scala penetrometer started : 0 metres

Scala Penetrometer



Test Methods	**Notes**
Determination of Penetration Resistance of a Soil, NZS 4402 : 1988, Test 6.5.2 Inferred CBR values taken from Austroads pavement design manual 1992 Sampling Method: NZS 4407 :1991,Part 2.4.2	IANZ Accreditation does not apply to inferred CBR values or depths gretaer than 1.5 metres

Date tested : 12/10/06
Date reported : 14/11/06

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INVESTIGATION PIT LOG
TEST REPORT

Project :	**3 Parks Development**
Location :	**Wanaka**
Client :	**Mitchell Partnerships**
Contractor :	**Nichols Landscaping**
Sampled by :	**Mark Darcy and Kim Martelli**
Date Sampled :	**12/10/06**
Pit number :	**Test Pit 5**

Project No :	**6CWM03.46 006DD**
Lab Ref No :	**OPU.D6/14**
Client Ref No :	

Date tested : 12/10/06
Date reported : 14/11/06

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INVESTIGATION PIT LOG
TEST REPORT

Project :	**3 Parks Development**
Location :	**Wanaka**
Client :	**Mitchell Partnerships**
Contractor :	**Nichols Landscaping**
Sampled by :	**Mark Darcy and Kim Martelli**
Date Sampled :	**12/10/06**
Pit number :	**Test Pit 6**

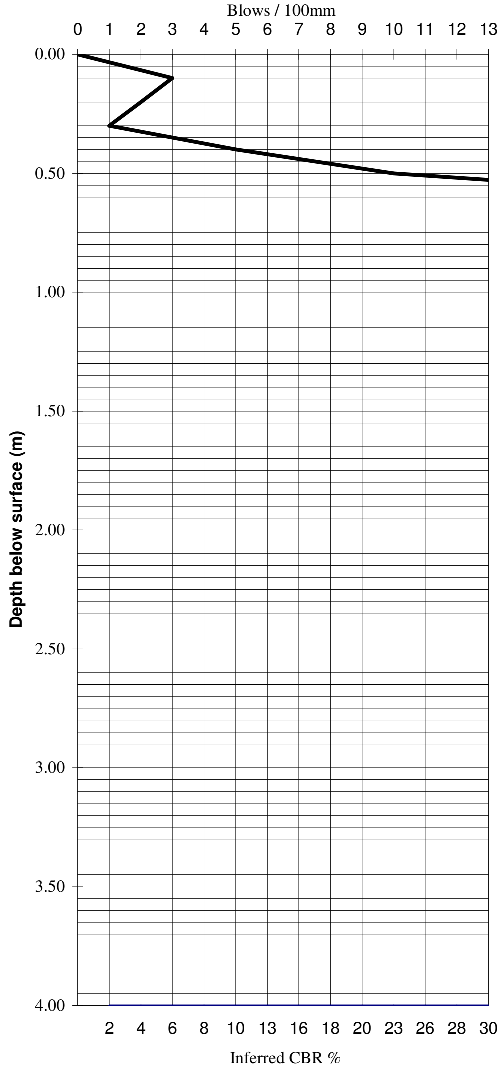
Project No :	**6CWM03.46 006DD**
Lab Ref No :	**OPU.D6/14**
Client Ref No :	

Depth (mm)	Geological Description
0-200	Sandy, fine topsoil; dark brown.
200-1000	Fine SAND; brown. Loosely packed; poorly sorted; rounded to sub-rounded schist gravel up to 20mm. Some large angular schist boulders up to 500mm in size.
1000-3000	Silty SAND; grey/brown. Densely packed; with rounded gravel and some schist slabs.
	End of test pit No groundwater observed, hole damp

Sample recovered at :

Depth at which scala penetrometer started : 0 metres

Scala Penetrometer



Test Methods

Determination of Penetration Resistance of a Soil, NZS 4402 : 1988, Test 6.5.2
Inferred CBR values taken from Austroads pavement design manual 1992
Sampling Method: NZS 4407 :1991,Part 2.4.2

Notes

IANZ Accreditation does not apply to inferred CBR values or depths gretaer than 1.5 metres

Date tested : 12/10/06
Date reported : 14/11/06

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INVESTIGATION PIT LOG
TEST REPORT

Project :	**3 Parks Development**
Location :	**Wanaka**
Client :	**Mitchell Partnerships**
Contractor :	**Nichols Landscaping**
Sampled by :	**Mark Darcy and Kim Martelli**
Date Sampled :	**12/10/06**
Pit number :	**Test Pit 6**

Project No :	**6CWM03.46 006DD**
Lab Ref No :	**OPU.D6/14**
Client Ref No :	

Date tested : 12/10/06
Date reported : 14/11/06

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INVESTIGATION PIT LOG
TEST REPORT

Project :	**3 Parks Development**
Location :	**Wanaka**
Client :	**Mitchell Partnerships**
Contractor :	**Nichols Landscaping**
Sampled by :	**Mark Darcy and Kim Martelli**
Date Sampled :	**12/10/06**
Pit number :	**Test Pit 7**

OPUS

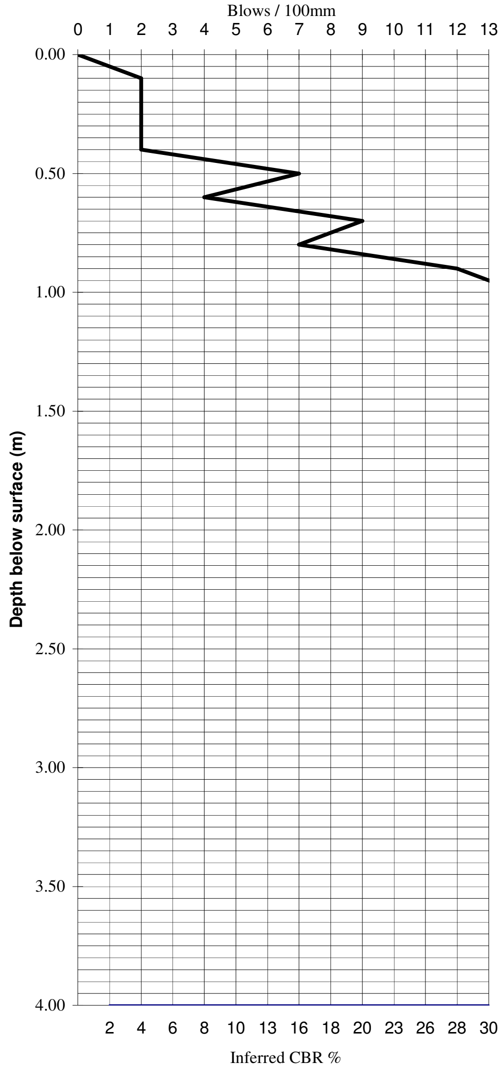
Project No :	**6CWM03.46 006DD**
Lab Ref No :	**OPU.D6/14**
Client Ref No :	

Depth (mm)	Geological Description
0-200	Sandy silty Topsoil; Dark brown.
200-1800	Coarse GRAVEL; grey. Loosely packed; bedding; rounded, mostly 20mm in size.
1800-2850	Medium GRAVEL; grey. Loosely packed; clasts up to 200mm.
	End of test pit No groundwater observed, hole damp

Sample recovered at :

Depth at which scala penetrometer started : 0 metres

Scala Penetrometer



Test Methods	Notes
Determination of Penetration Resistance of a Soil, NZS 4402 : 1988, Test 6.5.2 Inferred CBR values taken from Austroads pavement design manual 1992 Sampling Method: NZS 4407 :1991,Part 2.4.2	IANZ Accreditation does not apply to inferred CBR values or depths gretaer than 1.5 metres

Date tested : 12/10/06
Date reported : 14/11/06

This report may only be reproduced in full

INVESTIGATION PIT LOG
TEST REPORT

Project :	**3 Parks Development**
Location :	**Wanaka**
Client :	**Mitchell Partnerships**
Contractor :	**Nichols Landscaping**
Sampled by :	**Mark Darcy and Kim Martelli**
Date Sampled :	**12/10/06**
Pit number :	**Test Pit 7**

Project No :	**6CWM03.46 006DD**
Lab Ref No :	**OPU.D6/14**
Client Ref No :	

Date tested : 12/10/06
Date reported : 14/11/06

INVESTIGATION PIT LOG
TEST REPORT

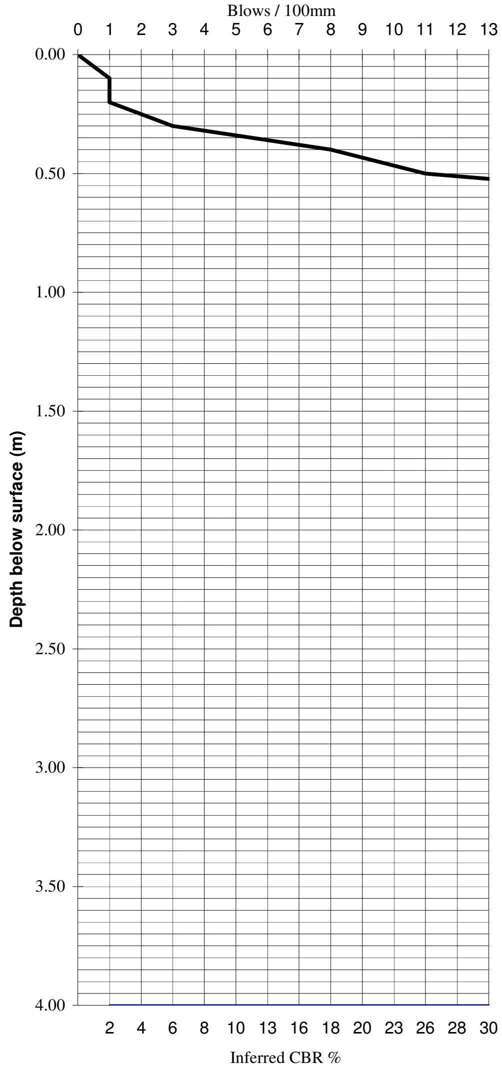
Project : 3 Parks Development
Location : Wanaka
Client : Mitchell Partnerships
Contractor : Nichols Landscaping
Sampled by : Mark Darcy and Kim Martelli
Date Sampled : 12/10/06
Pit number : Test Pit 8

Project No : 6CWM03.46 006DD
Lab Ref No : OPU.D6/14
Client Ref No :

Depth (mm)	Geological Description
0-150	Sandy topsoil; dark brown.
150-700	Coarse to medium GRAVEL; grey. Loosely packed; with some large rounded to sub-rounded boulders 500-100mm across. Some schist slabs up to 200mm.
700-3100	Coarse GRAVEL; grey. Moderately packed; sub-rounded up to 200mm in size
	End of test pit No groundwater observed, hole damp

Sample recovered at :
Depth at which scala penetrometer started : 0 metres

Scala Penetrometer



Test Methods	Notes
Determination of Penetration Resistance of a Soil, NZS 4402 : 1988, Test 6.5.2 Inferred CBR values taken from Austroads pavement design manual 1992 Sampling Method: NZS 4407 :1991,Part 2.4.2	IANZ Accreditation does not apply to inferred CBR values or depths gretaer than 1.5 metres

Date tested : 12/10/06
Date reported : 14/11/06

This report may only be reproduced in full

INVESTIGATION PIT LOG
TEST REPORT

Project :	**3 Parks Development**
Location :	**Wanaka**
Client :	**Mitchell Partnerships**
Contractor :	**Nichols Landscaping**
Sampled by :	**Mark Darcy and Kim Martelli**
Date Sampled :	**12/10/06**
Pit number :	**Test Pit 8**

Project No :	**6CWM03.46 006DD**
Lab Ref No :	**OPU.D6/14**
Client Ref No :	

Date tested : 12/10/06
Date reported : 14/11/06

INVESTIGATION PIT LOG
TEST REPORT

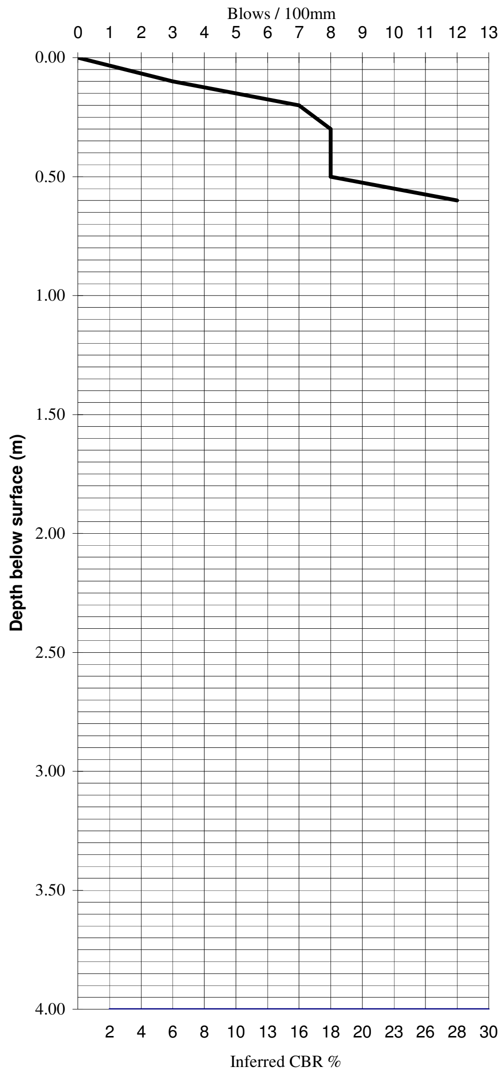
Project : 3 Parks Development
Location : Wanaka
Client : Mitchell Partnerships
Contractor : Nichols Landscaping
Sampled by : Mark Darcy and Kim Martelli
Date Sampled : 12/10/06
Pit number : Test Pit 9

Project No : 6CWM03.46 006DD
Lab Ref No : OPU.D6/14
Client Ref No :

Depth (mm)	Geological Description
0-500	Topsoil; brown/grey
500-1000	Medium to coarse GRAVEL; grey. Moderately to densely packed; well-sorted; rounded to sub-rounded schist gravel.
1000-2750	Medium to coarse GRAVEL; grey. Well packed; well sorted, with sub-rounded schist boulders up to 400mm in size, more commonly 100-200mm.
	End of test pit - hole fretting No groundwater observed, hole damp

Sample recovered at :
Depth at which scala penetrometer started : 0 metres

Scala Penetrometer



Test Methods	Notes
Determination of Penetration Resistance of a Soil, NZS 4402 : 1988, Test 6.5.2 Inferred CBR values taken from Austroads pavement design manual 1992 Sampling Method: NZS 4407 :1991,Part 2.4.2	IANZ Accreditation does not apply to inferred CBR values or depths gretaer than 1.5 metres

Date tested : 12/10/06
Date reported : 14/11/06

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INVESTIGATION PIT LOG
TEST REPORT

Project :	**3 Parks Development**
Location :	**Wanaka**
Client :	**Mitchell Partnerships**
Contractor :	**Nichols Landscaping**
Sampled by :	**Mark Darcy and Kim Martelli**
Date Sampled :	**12/10/06**
Pit number :	**Test Pit 9**

Project No :	**6CWM03.46 006DD**
Lab Ref No :	**OPU.D6/14**
Client Ref No :	

Date tested : 12/10/06
Date reported : 14/11/06

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INVESTIGATION PIT LOG
TEST REPORT

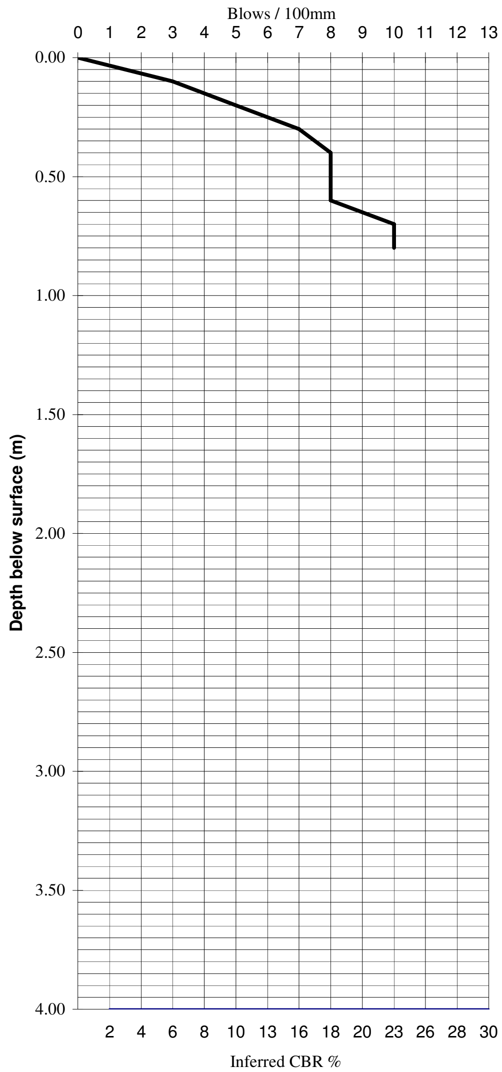
Project : 3 Parks Development
Location : Wanaka
Client : Mitchell Partnerships
Contractor : Nichols Landscaping
Sampled by : Mark Darcy and Kim Martelli
Date Sampled : 12/10/06
Pit number : Test Pit 10

Project No : 6CWM03.46 006DD
Lab Ref No : OPU.D6/14
Client Ref No :

Depth (mm)	Geological Description
0-100	Topsoil; dark brown.
100	Very coarse SAND; yellow/white. Bedding, wavy, 2-5mm thick.
100-600	Coarse GRAVEL with some brown silt. Densely packed; rounded to sub-rounded schist gravels.
600-1200	Fine to medium GRAVEL; grey. Moderately packed; rounded to sub-rounded schist gravels.
1200-2100	Medium to coarse GRAVEL, grey. Moderately packed; sub-rounded to angular schist gravels with some 300mm sub-rounded to angular schist.
2100	fine to medium SILT; grey; with some medium, rounded to sub-rounded gravel.
	end of test pit No groundwater observed, hole damp

Sample recovered at :
Depth at which scala penetrometer started : 0 metres

Scala Penetrometer



Test Methods	Notes
Determination of Penetration Resistance of a Soil, NZS 4402 : 1988, Test 6.5.2 Inferred CBR values taken from Austroads pavement design manual 1992 Sampling Method: NZS 4407 :1991,Part 2.4.2	IANZ Accreditation does not apply to inferred CBR values or depths gretaer than 1.5 metres

Date tested : 12/10/06
Date reported : 14/11/06

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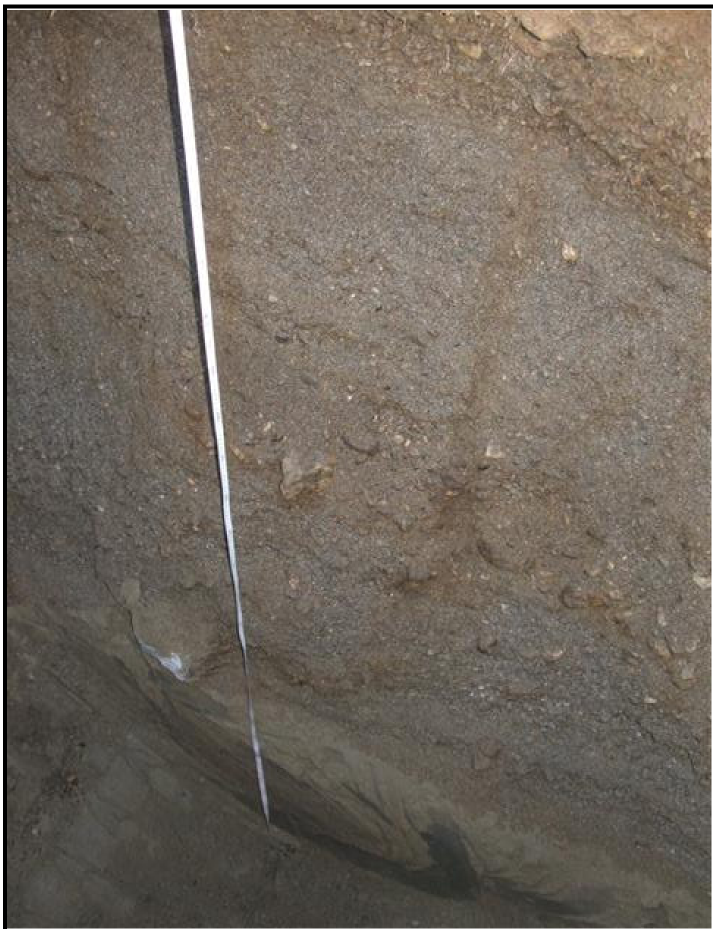
INVESTIGATION PIT LOG
TEST REPORT

Project :	**3 Parks Development**
Location :	**Wanaka**
Client :	**Mitchell Partnerships**
Contractor :	**Nichols Landscaping**
Sampled by :	**Mark Darcy and Kim Martelli**
Date Sampled :	**12/10/06**
Pit number :	**Test Pit 10**

Project No :	**6CWM03.46 006DD**
Lab Ref No :	**OPU.D6/14**
Client Ref No :	



Date tested : 12/10/06
Date reported : 14/11/06

INVESTIGATION PIT LOG
TEST REPORT

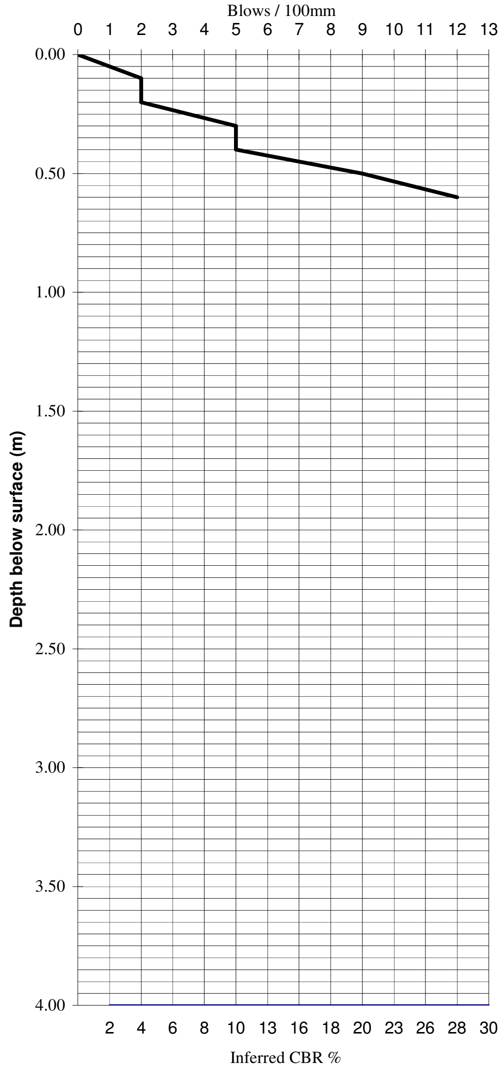
Project : 3 Parks Development
Location : Wanaka
Client : Mitchell Partnerships
Contractor : Nichols Landscaping
Sampled by : Mark Darcy and Kim Martelli
Date Sampled : 12/10/06
Pit number : Test Pit 11

Project No : 6CWM03.46 006DD
Lab Ref No : OPU.D6/14
Client Ref No :

Depth (mm)	Geological Description
0-200	Sandy, silty topsoil; dark brown with some schist derived gravel
200-700	Sandy coarse GRAVEL; grey. Moderately packed; rounded..
700-2800	Fine to coarse GRAVEL; grey. Moderately packed, rounded with some 200-300mm sub-rounded schist boulders, some up to 800mm
	End of test pit - hole collapsing No groundwater observed, hole damp

Sample recovered at :
Depth at which scala penetrometer started : 0 metres

Scala Penetrometer



Test Methods	Notes
Determination of Penetration Resistance of a Soil, NZS 4402 : 1988, Test 6.5.2 Inferred CBR values taken from Austroads pavement design manual 1992 Sampling Method: NZS 4407 :1991,Part 2.4.2	IANZ Accreditation does not apply to inferred CBR values or depths gretaer than 1.5 metres

Date tested : 12/10/06
Date reported : 14/11/06

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INVESTIGATION PIT LOG
TEST REPORT

Project : 3 Parks Development
Location : Wanaka
Client : Mitchell Partnerships
Contractor : Nichols Landscaping
Sampled by : Mark Darcy and Kim Martelli
Date Sampled : 12/10/06
Pit number : Test Pit 11

Project No :	**6CWM03.46 006DD**
Lab Ref No :	**OPU.D6/14**
Client Ref No :	

Date tested : 12/10/06
Date reported : 14/11/06

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