REPORT

Queenstown Lakes District Council

Wanaka Region GIS Hazard Map

Report prepared for:

Queenstown Lakes District Council

Report prepared by:

Tonkin & Taylor Ltd

Distribution:

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Tonkin & Taylor Ltd (FILE)

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Executive summary

This study consisted of both collation of existing hazard data and fieldwork to provide hazard data accurate enough for use on a lot by lot basis. The primary goal was to update and convert to electronic form the existing QLDC Hazard Register Maps to both produce a set of stand-alone maps and data for use within a wider GIS system.

The primary sources of data were:

- Field mapping
- High resolution geo-referenced colour aerial photography provided by QLDC
- Topological contour data provided by QLDC and also gathered for previous site investigations
- GNS QMAP
- Local knowledge and experience of senior geologists and information available from previous site investigations
- QLDC Hazard Register Maps (2007)

The data is presented primarily as AutoCAD DWG files but ArcView SHP shape files are also provided for the layers containing our defined hazard areas and location of sites for which we may have additional information available. All data is provided using the NZMG coordinate system for convenience.

The following layers are included:

- Topographic contours
- Combined high resolution aerial photography
- Geological hazard areas with attributes associated providing classification, description, date of survey, source of data and relevant job number and RDUC
- Active faults
- Cadastral information including lot boundaries and roads
- Site specific investigations performed by Tonkin and Taylor for which further detail and subsurface investigations may be available in reports filed with QLDC or from the respective property owners

1 Introduction

This report presents the results from a hazard mapping study of Wanaka and the surrounding area carried out by Tonkin & Taylor Ltd. It also includes the methods, some considerations for viewing, using and interpreting the data, and recommendations for further study.

1.1 Background

Prior to this study the QLDC Hazard Register Maps were available at a set of hardcopy sheets. In 2008 the QLDC Hazard Register Maps were updated in a similar but more in depth fashion for Queenstown and its surrounding area. One of the outcomes of this study was a recommendation that the Wanaka area Hazard Register Maps be updated.

1.2 Scope of Work

The study covered Wanaka, Albert Town and surrounding areas. More detailed mapping was carried out in identified priority areas depending on the extent of existing and proposed development.

1.3 Hazard Zoning Level of Detail

The study comprised updating the current Hazard Register so that the inventory of existing landslides may be classified as “Intermediate” level using AGS terminology (Reference [1] Table 1). Field mapping was carried out a scale of 1:5000 to more accurately define hazards to individual properties. Characterisation of potential landslides is to the “Basic” level and reliance on it should be to this level only.

Table 1 - AGS Definition of Zoning Levels

Type of Zoning	Risk Zoning						
	Hazard Zoning						
	Susceptibility Zoning						
	Inventory Mapping						
Zoning Level	Inventory of existing landslides	Characteriz-ation of potential landslides	Travel distance and velocity	Frequency assessment	Temporal spatial probability	Elements at risk	Vulnerability
Preliminary	Basic [1,2]	Basic [1,2]	Basic [1] Intermediate [2]	Basic [1,2]	Basic [1,2]	Basic [1,2]	Basic [1,2]
Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate to Basic
Advanced	Sophisticated	Sophisticated to Intermediate	Intermediate to Sophisticated	Intermediate to Sophisticated	Sophisticated	Sophisticated	Intermediate to Sophisticated

Notes:

1. For qualitative zoning
2. For quantitative zoning

2 GIS

2.1 Introduction

A Geographical Information System (GIS) is a system for collating, storing, analysing and managing data and associated attributes which are geographically referenced.

2.2 Software Packages

A variety of software packages are available and each has specific uses in the assimilation of data into a GIS system. All packages read shapefiles and can manipulate and store associated attributes.

2.2.1 AutoCAD Civil3D 2011

AutoCAD Civil 3D is a package for drafting and design. It includes AutoCAD Map 3D, used for creating and managing spatial GIS data in addition to the powerful digital terrain modelling tools of Civil3D used to manipulate contour data.

2.2.2 Global Mapper 12

Global Mapper (GM) is a software package designed for quickly viewing and converting geo-referenced data of many kinds in multiple coordinate systems and different formats. The aerial photography provided by QLDC was combined to cover the area of investigation using Global Mapper for convenience. Contour data can quickly be re-projected and converted from ArcView SHP format to AutoCAD DXF or DWG format using GM.

3 Hazard Mapping System

3.1 Photography

QLDC provided ortho-rectified colour photography of the area of investigation which was combined into a single file for convenience. Higher resolution aerial photography for Wanaka and Albert Town had been gathered for previous jobs and was also used.

3.2 Geology

Geological information was sourced primarily from the Wakatipu geological map published by the Institute of Geological and Nuclear Science (IGNS) (now known as GNS Science) which contains details of surficial geology. The map was recently (2000) published as part of the wider QMAP 1:250 000 geological mapping project that covers all of New Zealand.

This was combined with information from local site investigations carried out over recent decades, and was subsequently reviewed by engineering geologists with long experience in the region to verify the accuracy of the content.

3.3 Hazards

All existing landslide boundaries, including those from the previous hazard map, recent mapping of alluvial fans commissioned by the Otago Regional Council and local site investigations, were collated and reviewed by senior engineering geological staff. Each component was assembled and, where practicable, was verified by the field staff involved with the original fieldwork.

Areas of with piping potential in the artesian portion of the Cardrona Aquifer were also included as a form of instability with significant potential for associated landsliding.

The metadata associated with each landslide polygon follow the existing QLDC format, with the hazard type and hazard code attached to each landslide feature to categorise the activity level of the slide and other information, namely:

- Hazard Code (HAZ_CODE) – see Table 1 below (page 5)
- Register Data Usage Categories (RDUC) – see Table 2 below (page 6)
- USGS Category (Flows/Slides/Falls)
- Description/Status (Dormant/Active/Potentially Active)
- Date of survey
- Company/organisation involved or holding data for the site
- Company/organisation job number (if available)

Table 1 - Hazard Code (HAZ_CODE)

Code	Title	Explanation
A	Active Schist Debris Landslides	Active slides in debris derived from schist bedrock with known or apparent episodic activity in historical times (last 150 yrs).
B	Schist Debris Landslides (Activity Unknown)	Slides in debris derived from schist bedrock, with activity unknown due to lack of information.
C	Dormant or Very Slowly Creeping Schist Debris Landslides	Slides in schist bedrock, with no known activity in historical times (last 150 years). No obvious geomorphological evidence of activity under static conditions .
D	Areas Susceptible to Shallow Debris Flows	Steep slopes with small catchments and known shallow debris flows, or mudflows in historical times (last 150 years). Inferred from geomorphology or prior knowledge. Principally relating to episodes of heavy rainfall. Includes both failures and areas of potential failure.
E	Areas Susceptible to Major Debris Flows	Areas of rainfall induced rapid debris flows originating from significant catchments i.e. long gullies and streams, carrying significant debris. Includes both failures and areas of potential failure.
F	Areas of Fine Grained Soils Susceptible to Sliding	Slopes with fine lake sediments, glacial till and colluvium with areas of known slides (often rotational). Inferred from geomorphology, literature or prior knowledge. Includes both failures and areas of potential failure.
G	Areas Susceptible to Falls	Slopes susceptible to rockfall and debris fall from steep slopes or subject to rolling or bounding of rock from slopes following a trigger such as earthquake, or weathering, usually associated with rapid failure and large travel distances.
H	Landslides or areas susceptible to sliding in lake sediments	Pre-existing or potential sliding failure in lake sediments or Tertiary sediments.
I	Piping potential in the artesian zone	Areas with piping potential in the artesian zone of the Wanaka aquifer.
J	Areas susceptible to seismic induced spreads or flows	Areas with potential for seismically induced spreads or flows.
K	Potential Hazard - Debris Flood/Debris Flow	Areas on alluvial fans subject to combined debris flow and debris flood hazards.

Table 2 - Register Data Usage Categories (RDUC)

Code	Description
1	Information obtained from detailed maps or survey data for which ground checking has been undertaken, or information that allows accurate definition of location or boundaries from mapped features. It is considered that this information can be used with a high level of confidence but should be independently checked on an individual site basis and that the user should carry out an independent risk assessment.
2	Interpreted data, for which there has been little or no field checking – e.g. boundaries taken from aerial photo interpretation, digitised from small-scale maps, or inferred from contour plans. This information can be used with a reasonable level of confidence but should be verified on an individual site basis and the user should carry out an independent risk assessment.
3	Unchecked data, including anecdotal information, inferences and speculation. This information should be used with considerable caution as well as independent risk assessment.

3.4 Cadastral Information

Cadastral information was provided by QLDC and has been used in the project. Accuracy of hazard boundaries is to be viewed in relation to lot boundaries

3.5 Topology

Topological contours were provided by QLDC at 1m intervals for Wanaka and the immediate surrounding area and at 20 m intervals for more distant locations. Additional 5 m contour data for Albert Town was available from previous investigations and has been included. In the interest of completing as much of the mapping within budget as possible, as agreed, the topology was not merged into a single layer but collated and edited for viewing in relation to the hazard areas. It was noted that substantial errors exist, particularly around Lakeside Rd between Ardmore St and Beacon Point. Considerable time was spent reconciling the data with limited success. It is understood that LiDAR surveys are planned shortly and until then, contour information should be used with caution.

3.6 Site Specific Data

Individual sites which Tonkin and Taylor has previously investigated and for which there may be more detailed surface or subsurface investigations has been included as point data with an associated job number.

3.7 Seismic Hazards

Seismic hazards have now been brought into focus by recent events in Canterbury, and many councils are upgrading their systems as a result. In Wanaka the two main issues will be the intensity of shaking in view of the attenuation that will occur with distance from the Alpine Fault, and consequent effects such as liquefaction and flow slides (lateral spreading). Tsunami hazard is also a consideration, where the topography is sufficiently steep to promote a rock avalanche.

3.7.1 Faulting

Active fault information was used from the GNS QMAP. As the QMAP mapping was done at a large scale of 1:250,000 it is generally only accurate to 100 m. However, the data have been reviewed and are believed to be reasonably accurate where traces are visible at the ground surface and given an RDUC of 2. Where faults are projected (dashed lines) through areas that have no surface expression in areas where the geology is relatively recent, the locations are necessarily speculative. Hence while there is hazard of ground rupture presented, the dashed segments can be viewed as relatively low risk. It would be preferable to ensure the presence of the fault projection is recorded on the LIM or certificate of title to avoid development in close proximity. However development need not be precluded: individual owners should give due consideration on a case by case basis. It is important to appreciate that the seismic risk to Wanaka is greatest from an event on the Alpine Fault, which has 100-300 year recurrence interval (as inferred below) rather than the closer Cardrona Fault which is inferred to have a recurrence interval of some thousands of years. The following figures show the Alpine Fault, inferred historic movements and the intensity of shaking expected in Wanaka (Orchiston, 2010).

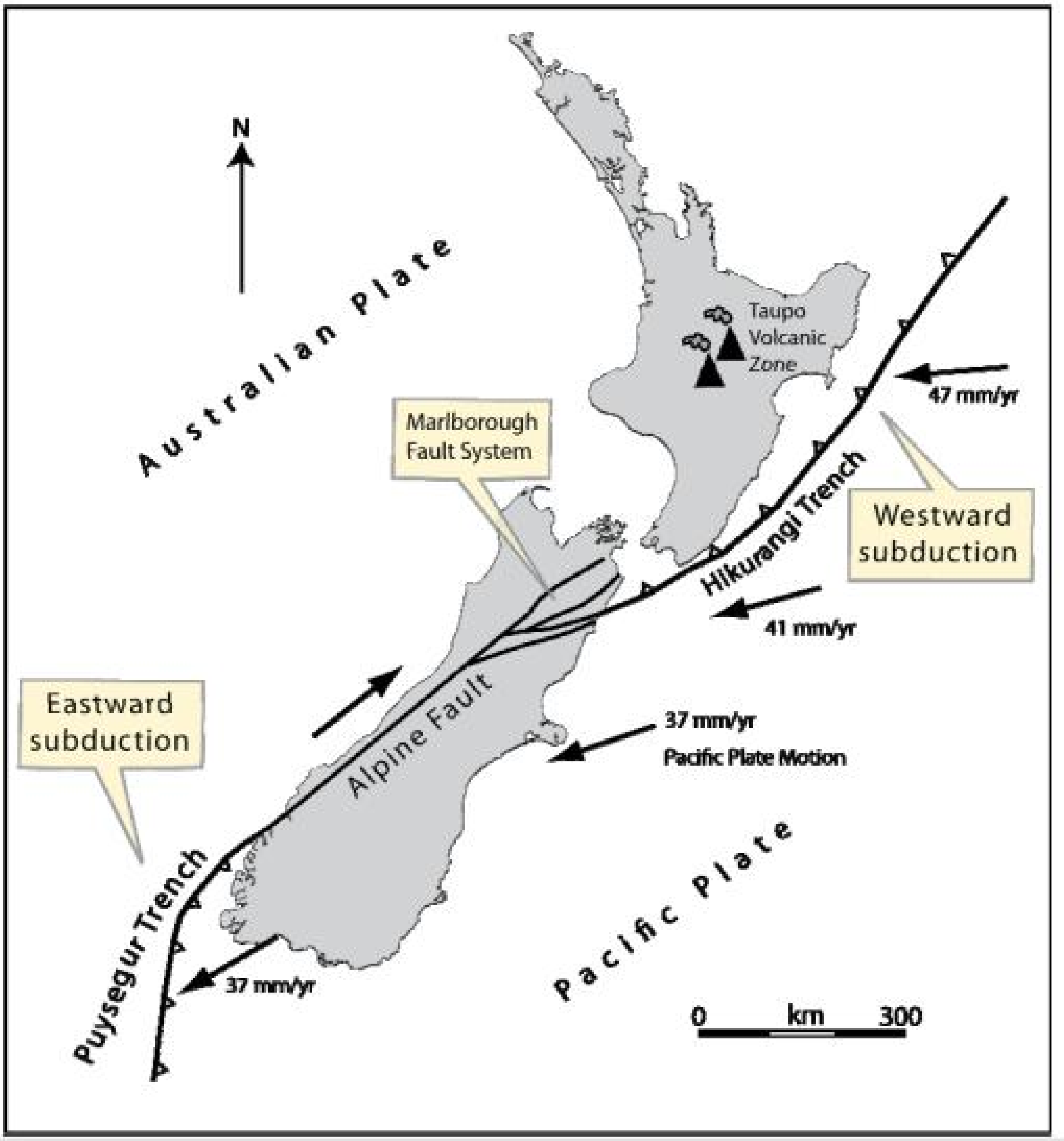

Figure 3.1 Overview of the Alpine Fault

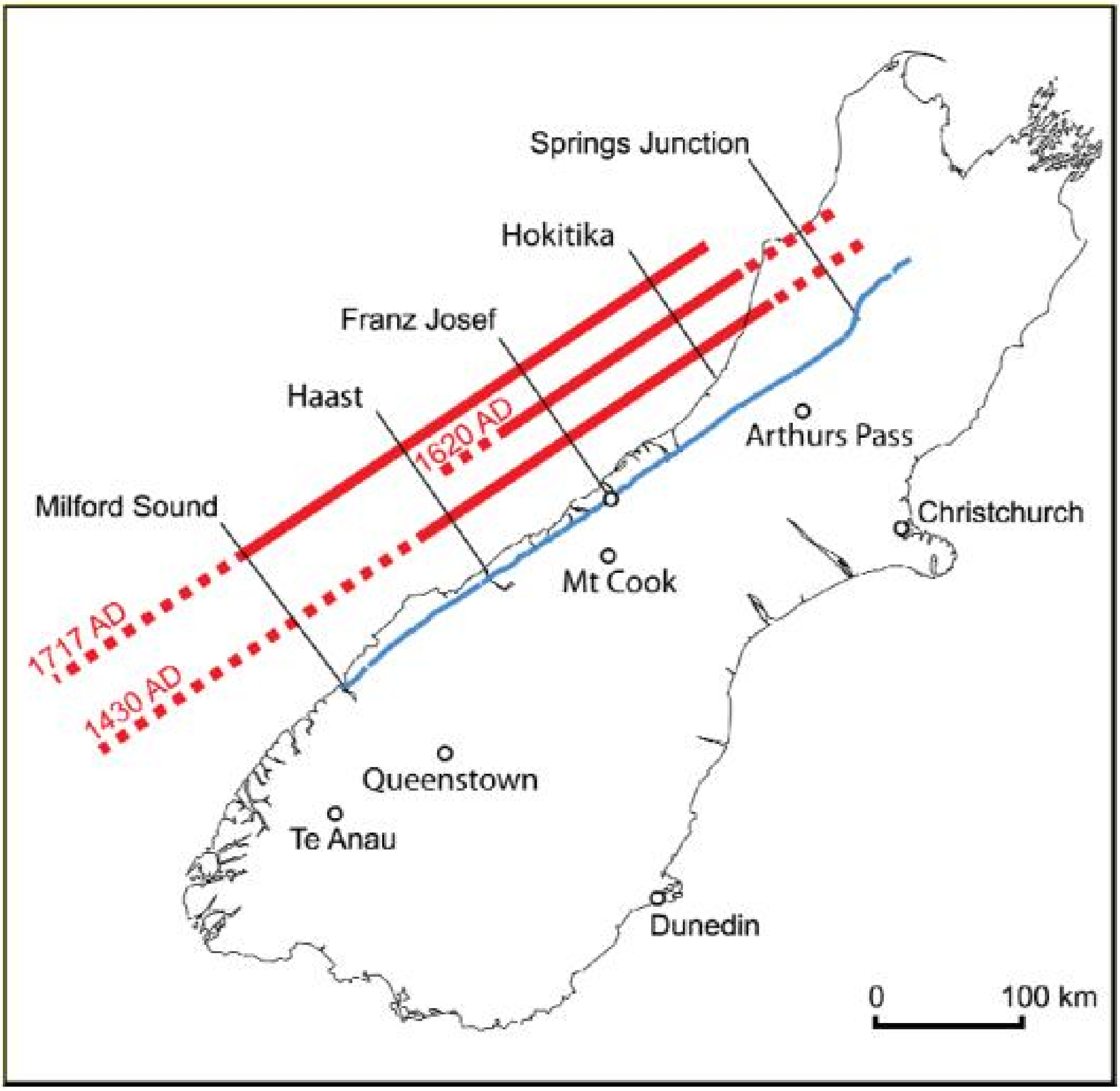

Figure 3.2 Inferred historic movement of the Alpine Fault

The Mercalli Intensity of shaking expected in Wanaka from alternative Alpine Fault events is shown below.

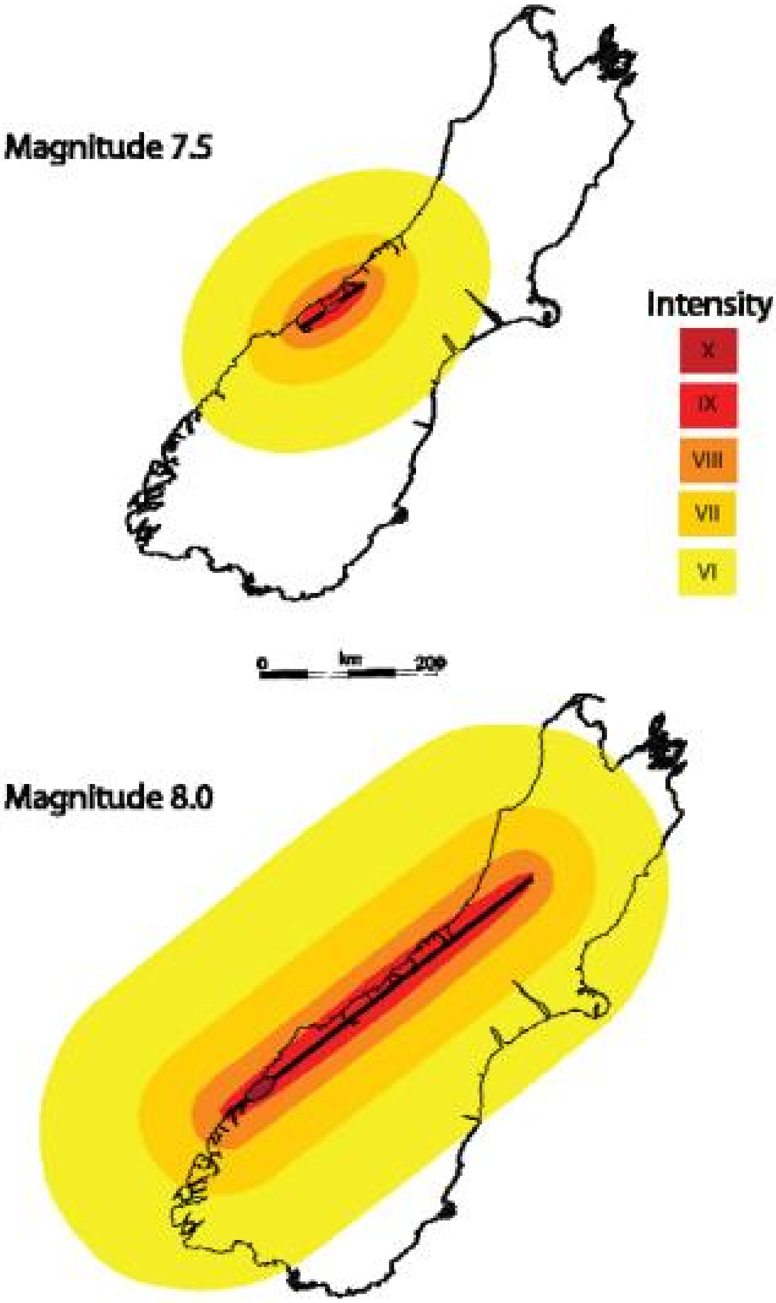

Figure 3.3 Predicted Mercalli Intensity from Alpine Fault movements.

Table 3.1 Mercalli Scale of felt earthquake intensity.

MM 1: Imperceptible
Barely sensed only by a very few people.

MM 2: Scarcely felt
Felt only by a few people at rest in houses or on upper floors.

MM 3: Weak
Felt indoors as a light vibration. Hanging objects may swing slightly.

MM 4: Largely observed
Generally noticed indoors, but not outside, as a moderate vibration or jolt. Light sleepers may be awakened. Walls may creak, and glassware, crockery, doors or windows rattle.

MM 5: Strong
Generally felt outside and by almost everyone indoors. Most sleepers are awakened and a few people alarmed. Small objects are shifted or overturned, and pictures knock against the wall. Some glassware and crockery may break, and loosely secured doors may swing open and shut.

MM 6: Slightly damaging
Felt by all. People and animals are alarmed, and many run outside. Walking steadily is difficult. Furniture and appliances may move on smooth surfaces, and objects fall from walls and shelves. Glassware and crockery break. Slight non-structural damage to buildings may occur.

MM 7: Damaging
General alarm. People experience difficulty standing. Furniture and appliances are shifted. Substantial damage to fragile or unsecured objects. A few weak buildings are damaged.

MM 8: Heavily damaging
Alarm may approach panic. A few buildings are damaged and some weak buildings are destroyed.

MM 9: Destructive
Some buildings are damaged and many weak buildings are destroyed.

MM 10: Very destructive
Many buildings are damaged and most weak buildings are destroyed.

MM 11: Devastating
Most buildings are damaged and many buildings are destroyed.

MM 12: Completely devastating
All buildings are damaged and most buildings are destroyed.

3.7.2 Liquefaction and Flow Slides

Ground damage during earthquake shaking is likely to be in the form of liquefaction and flow slides in the Wanaka region, but will be minor unless the shaking is of Intensity MM7 or greater.
In general, Wanaka is less susceptible than Christchurch to liquefaction, under a given intensity of shaking.

Flow slides within the inter-glacial lake sediments are likely to be more damaging than liquefaction under an Alpine Fault event. The lake sediments underlie much of the Albert Town area. In the last decade 2 large landslides have developed in lake sediments near Albert Town: one on the right back just upstream of the bridge and the other on the left bank about a kilometre upstream of the bridge. These developed in static conditions, possibly as a result of lateral erosion and/or downcutting by the Clutha River, although there are claims that one of them was triggered by vibrations from machinery. Some flow slides in lake sediments can therefore be expected under moderate or strong earthquake shaking. For this reason, (and also because of recent issues with a lake sediment landslide during residential development) all the areas where lake sediments is exposed or inferred to be present, have been shown on the hazard map.

In Wanaka, there is a large existing flow slide (Category F) located with its axis on Ardmore St. Its head scarp surrounds the DOC Centre and the toe intrudes into the lake. The slide was first identified from aerial photographs in the 1980s, by which time most of the affected land had been developed to form one of the main commercial streets of Wanaka. The immediate post-glacial lake level of Lake Wanaka was about 30 metres higher than at present hence it was originally considered likely that the Ardmore St flow slide was triggered (probably by an earthquake) when groundwater conditions were much more adverse for stability. (The most critical condition usually develops when lake level is at about one third to one half of the way up the slope.) If so the slide may now have a substantial margin of stability with the lower lake level. However, a detailed study of the slide has never been carried out and its safety factor under an Alpine Fault earthquake is unknown. The lake has probably been close to its present level for several thousand years in which interval it has probably experienced at least 20 Alpine Fault movements. The slide has so far undergone at least 30 metres of displacement hence if the displacement is an ongoing incremental process with each Alpine Fault event then in any individual earthquake it is unlikely to average much more than about a metre of displacement. In the last decade, a number of excavations have been carried out either side of Ardmore St and a lot more has been understood about the aquifer that governs stability in this part of Wanaka. Substantial artesian pressures have been identified on either side of Ardmore St. Any artesian pressures are extremely adverse for slope stability. Limited investigations that have been carried out suggest that inter-glacial lake silts (the likely source of flow slide potential) are likely to underlie much of Ardmore St. The status of the slide, particularly under seismic shaking might now be regarded as uncertain. However the positive aspect of a slide subject to artesian pressures is that relatively minor drainage invariably causes widespread depressurisation with consequent cost effective stabilisation. However resource consent would be an issue in this instance. To adequately evaluate the seismic stability of the landslide, about 2-3 drillholes would be required with sampling for shear testing and installation of piezometers. In view of the current likelihood of Wanaka experiencing an Alpine Fault event in the medium term, and the flow slide hazard presented to a significant number of premises, it appears timely to review the potential for damage from the Ardmore St Slide and consequently the need for subsurface investigations and quantitative seismic stability analysis of this feature.

4 Application

All files for the study are contained on a CD accompanying the hardcopy of this report. Appendix B lists the electronic files that accompany this report available for viewing and interrogation of the study area. Software for viewing the DWGs is also contained on the CD, or can be downloaded from:

http://usa.autodesk.com/adsk/servlet/pc/index?id=6703438&siteID=123112

If development is proposed in the vicinity of any area where a hazard or potential hazard has been identified, the site should be examined by an inspector or engineer competent to confirm the status of the site and the need for further investigations, preferably at the feasibility stage or at the subdivision stage (for private developments) as well as at the building consent stage. The latter would also be necessary if substantial modifications to the land profile (especially excavations) are proposed.

5 Conclusions and Recommendations

1. Hazard mapping with focus on flow slides has been upgraded for priority areas around Wanaka and Albert Town. Extension to areas likely to be subject to development is recommended as funding allows.
2. An upgrade of earthquake liquefaction hazards was not included in the brief for the current study. The current QLDC hazards register shows areas considered "Susceptible" and "Possibly Susceptible" to liquefaction under earthquake shaking. This work was carried out in the 1990s and is in need of updating. The current liquefaction maps are geologically outdated and too generalised, and need to be replaced by maps which convey a ranking of the liquefaction hazard, showing "high", "moderate", "low" in the same manner as those produced for the Christchurch urban area by ECAN. This can be done using the existing Tonkin & Taylor Ltd site investigation data base, and relatively minor additional field work.
3. Updating of the liquefaction mapping is especially important in the light of the recent Christchurch liquefaction experience, and the high probability of a future Alpine Fault earthquake subjecting the QLDC region to strong seismic shaking in the next 50 years. The segment of the Alpine Fault closest to Wanaka has historically moved every 100-300 years and the last movement was in 1717. An Alpine Fault earthquake could therefore be considered imminent. The shaking in Wanaka is predicted to be about MM VII to VIII (moderate to heavy damage expected). Consequent liquefaction would be expected where saturated loose sands and non-plastic silts are present. Remedial solutions such as piling or compaction should be adopted for new structures on these materials.
4. Priority for liquefaction hazard mapping should be given to the Queenstown and Wanaka town areas. In particular low lying regions adjacent to Lake Wakatipu and Lake Wanaka, and those areas likely to be developed in the medium term. The map upgrade should be carried out in the short to medium term rather than longer.
5. Potential hazards in the form of seismically induced spreads or flows (Category J) have been identified qualitatively. Site specific subsurface investigations may be required for appropriate quantification.
6. A limitation with the current earthquake code that has been evident from the Canterbury earthquakes is the issue of topographic amplification of seismic waves at elevated locations (cliff tops or steep terrain). Higher than normal code accelerations need to be used in the design of structures in these locations. Using the data collected in Christchurch, it would now be a straightforward exercise to delineate areas which would be subject to seismic amplification using the topographic contour model now established for Wanaka. This could be done as an additional layer for the hazard map, and used at the time of issuing a building consent to ensure the necessary additional bracing and slope stability implications are addressed in the design.
7. There have been a number of cases in recent years where land which has been formally recorded on the QLDC Hazard Map as a dormant or slowly creeping slide, has still been developed. In some cases as the result of the developer approaching successive consultants until a favourable report has been provided, (sometimes without due consideration of earthquake effects) that is then submitted to QLDC. It is suggested that in the unlikely event that development is proposed for a recognised hazard area (as defined on the updated QLDC Hazard Register), then prior to granting

an unrestricted consent, QLDC may wish to carry out their own objective peer review of the developers proposal, to minimise not only the risk to the immediate owner but also that to future unsuspecting purchasers.

8. The current status of the Ardmore St Slide and its potential for re-activation as a result of movement on the Alpine Fault is uncertain. Improving seismic stability is usually costly. However, information from recent studies of the aquifer affecting the Ardmore St Slide indicates that the slide could probably be provided with greatly enhanced resistance to earthquake at relatively minor cost. In view of the substantial number of structures located on it, consideration should be given to the consequences of seismically induced displacement. To address the issue pro-actively, 2 to 3 drillholes would be required for sampling and testing, accompanied by installation of piezometers.

6 Applicability

This report has been prepared for the benefit of Queenstown Lakes District Council 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.

This opinion is not intended to be advice that is covered by the Financial Advisers Act 2010.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

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7 References

[1]. Australian Geomechanics Society. Landslide Risk Management Concepts and Guidelines. Sub-committee on Landslide Risk Management. Link:

http://www.australiangeomechanics.org/LRM.pdf

1. Orchiston C.H.R. 2010. Tourism and Seismic Risk: Perceptions, preparedness and resilience on the zone of the Alpine Fault, Southern Alps, New Zealand.

Appendix A: Hazard Maps

- Will be available at http://files.tonkin.co.nz/

Appendix B: Electronic Files

- Will be available at http://files.tonkin.co.nz/