

GEOTECHNICAL REVIEW



EXPRESSION OF INTEREST
JULY 2016



Preliminary Geotechnical Report

Proposed Glenpanel SHA
Ladies Mile
Queenstown

Report prepared for:
Maryhill Limited

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1 Introduction

1.1 General

This report presents the results of a preliminary geotechnical assessment undertaken by Geosolve Ltd to provide comment on the geological hazards, subsoil conditions and geotechnical issues potentially affecting the proposed Glenpanel SHA development, Ladies Mile, State Highway 6, Queenstown.

This report has been completed in accordance with the terms and conditions outlined in Geosolve proposal reference 160403, dated 18 March 2016.

The aim of this report is to provide a preliminary geotechnical assessment of the proposed development areas to support a Special Housing Area EOI submission. The comments and recommendations provided should be confirmed by further investigations and engineering assessment during the detailed design stage of a future development.

1.2 Development

Plans provided to Geosolve indicate the proposed development will comprise residential housing. Significant infrastructure (e.g. storm water) hardstand, pavement and landscaped areas will also be required. The cadastral boundary of the proposed development is shown on Figure 1c, Appendix A.

2 Site Description

2.1 General

The proposed development is located on the northern side of SH6, essentially opposite Lake Hayes Estate and Shotover Country subdivisions, and opposite the proposed Sanderson development, see Figure 1a below.

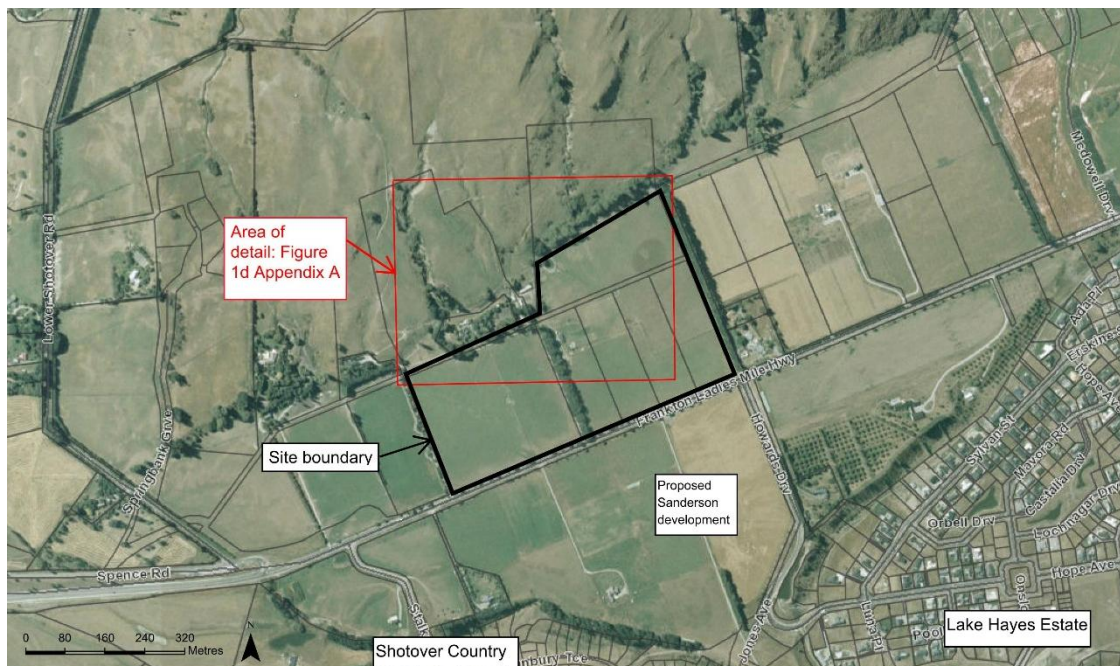


Figure 1a. Aerial view of proposed development site.

The site is undeveloped farmland, however existing dwellings and associated outbuildings are present abutting the northern and eastern boundaries. State Highway 6 (Frankton-Ladies Mile road) forms the southern boundary. Principal site observations are shown on Figure 1c in Appendix A, and general views of the site and main geological/geomorphological features are shown on the photographs provided in Appendix B.

2.2 Topography and Surface Drainage

The proposed development is situated on a sub-horizontal (gently sloping) terrace, with an altitude of approximately 360 m and gradient of 2-3° towards the south. Surface water drainage flows in a general southerly direction. Just beyond the northern boundary the ground rises and steepens, with slopes of 15-25° locally. Two well-incised gullies are formed in the schist bedrock hillslope immediately north of the site, showing low flows from their respective ephemeral creeks. Both creeks terminate in permeable ground prior to entering the site, and although diversion runoff channels or bunds have been formed along the northern boundary, no water was observed in these at the time of site visit. A small seep is present, draining the formed dam near the northern boundary. This also terminates in permeable ground (see detail Figure 1d, Appendix A).

Photographs 1-6, Appendix B show the general view of the proposed development site.

3 Expected Subsurface Conditions

3.1 Geological Setting

The site is located in the Wakatipu Basin, a feature formed predominantly by glacial advances, the last of which occurred approximately 10,000-20,000 years ago. The glaciation scoured the schist bedrock and left extensive deposits of till, outwash gravels and lake sediments. Post-glacial times have been dominated by erosion of both the schist bedrock and overlying sediments and by localised deposition of alluvial deposits by rivers and streams.

The proposed development site is located on the historic Shotover Delta. This feature was formed by the deposition (aggradation) of sediments during a period of high lake levels. Subsequent lowering of the lake, and down cutting by the Shotover and Lake Hayes River, has resulted in a series of elevated historic river terraces across this area of Lower Shotover.

The low, slightly inclined surface that comprises Frankton Flat, Ladies Mile Flat, and the Domain Road-Lower Shotover Flat is inferred to be the aggradation surface of the delta plain (the subaerial part of the fan-delta complex, which is dominated by fluvial processes). The elevation of this surface is 350 to 360 m above sea level and gently inclined towards the south. The IGNS 1:250,000 geological map indicates the proposed development area is located on 'Q1a' deposits described as 'Gravel and Sands in Alluvial Fans.' The hills on the northern margin of the proposed development are shown as Schist bedrock.

No active fault traces are known in the vicinity of the site, however a significant seismic risk exists in the region from potentially strong ground shaking associated with rupture of the Alpine Fault located on the west coast of the South Island. There is a high probability that an earthquake with a magnitude of 7.5 to 8 will occur along the Alpine Fault within the next 50 years.

3.2 Stratigraphy and Geological Conditions

A review of available data, published mapping together with site observations has been completed and the site stratigraphy over the gently sloping river terrace areas is expected to comprise:

- Topsoil, overlying:

- 0.1m to 1.0m thickness of Loess, overlying:
- 0.0-1.0m of localised Alluvial Silt, overlying:
- A significant thickness (10-70m+) of interbedded Deltaic sand and gravel deposits with varying fractions of each constituent material.

In close proximity to the hillslope on the northern boundary of the development, localised areas are expected to be underlain variably by:

- Topsoil, overlying:
- Alluvial fan depositional material, overlying:
- Alluvial Silt, overlying:
- Deltaic sand and gravel.

A review of available Otago Regional Council (ORC) bore data for the southwestern corner of the development indicates the depth of the Deltaic deposits is in excess of 66 m. The location of the ORC boreholes in this area are shown on Figure 1c, Appendix A.

3.3 Groundwater

The regional groundwater is expected to lie well below typical foundation and excavation levels. Groundwater levels are expected to rise gently from the Kawarau and Shotover Rivers towards and beneath the development area. This observation is confirmed by available ORC well data, which indicates groundwater to be 17 m below ground level in well F41/0089, 39 m below ground level in well F410090, and 51 m below ground level in well F41/0134. The location of these wells is shown on Figure 1c, Appendix A.

Perched seepages may be encountered at shallow depths near the hillside area, and within the alluvial fan material, near the northern part of the site.

3.4 Natural Hazards

3.4.1 Seismic

A significant seismic risk is present across the region, as discussed in Section 3.1 above.

3.4.2 Slope Stability

The hillside upslope of the site is identified on the QLDC Webmaps hazards register as a landslide area 'susceptible to shallow debris flows or mudflows' (Halliday 2002, Opus Consultants report). This area does not extend onto the site, and apart from localised gully erosion upstream of the historic alluvial fans, no deep seated, recent or active instability of the soil slopes was observed during the site walkover.

Small scale rock fall associated with localised weathering and gradual fretting of the rock within the incised gullies beyond the northern boundary was observed.

3.4.3 Liquefaction

The QLDC GIS mapping system indicates the proposed development area is within an area designated as 'possibly susceptible' to liquefaction. This assessment is based on a regional study completed by Opus, see Hazard Map Figure 1b, Appendix A.

The depth to groundwater (17-50m+), existing borehole summary logs, and subsequent studies completed in adjacent areas, indicate liquefaction risk is nil to low in the development area. This area

is considered, by Geosolve, to be the equivalent of LIC1 with respect to liquefaction investigation category.

3.4.4 Alluvial Fan

A small portion of the upper (northern) extent of the site lies within an area mapped by the ORC Alluvial Fans Project Stage 1 (regional scale), as lying at the toe of an active debris-dominated alluvial fan (Figure 1b, Appendix A). However, subsequent more detailed alluvial fan assessment, undertaken in the ORC Stage 2 (selected areas) mapping, did not identify alluvial fan activity at this location. A second, historic alluvial fan feature which does not appear on the QLDC database, was also identified some 300 m further east (Figure 1d, Appendix A). Again, no recent fan activity was noted, with an established topsoil horizon overlying the fan deposits. Small ephemeral streams in both gullies associated with the fans drain to permeable ground prior to reaching the site boundary (at the time of site visit), and both have northeastward-draining formed diversion channels at the outlets, should surface flows increase. These channels, just beyond the northern site boundary, will need to be maintained to preserve potential flood mitigation to the site.

From the available information and our site inspection and interpretations, we conclude that the risk from alluvial fan activity is low. If subsequent detailed investigations reveal any significant hazard, this is expected to be minor and affecting small areas only, and if necessary could be readily avoided or mitigated by standard planning or engineering measures.

4 Preliminary Engineering Considerations

4.1 General

The proposed development is expected to be achievable from a geotechnical perspective. Ground conditions will largely be similar to the adjacent Frankton Flats, Lake Hayes Estate and Shotover Country Developments, however, further investigation and assessment will be required during the detailed design phase and recommendations are provided in the sections below.

The preliminary recommendations and opinions contained in this report are based upon ground investigation data obtained at discrete locations and historical information held on the GeoSolve database. The nature and continuity of subsoil conditions away from the investigation locations is inferred and cannot be guaranteed.

Site specific intrusive investigations should be completed at the detailed design phase of the project to confirm all recommendations provided in this report.

4.2 Excavations

Excavations can be readily achieved across the site area. If deep excavations are required, geotechnical investigation should be completed to confirm the near surface soil profile and appropriate temporary and permanent batter angles and any retaining issues.

4.3 Construction near Slope Crests

Development plans, and site topography, indicate buildings are unlikely to be located close to slope crests.

4.4 Foundations

Shallow foundations can be constructed across the site, however reduced foundation bearing capacities are likely if bearing on surface silt deposits. Increased foundation bearing is expected to be available at depth on sand and gravel materials.

Specific investigation and assessment should be completed to determine a cost effective foundation solution for the proposed buildings, at the detailed design stage.

4.5 Rock Fall

Bluffs and relatively steep slopes are present immediately beyond the northern boundary of the site. Preliminary assessment indicates the risk of rock fall is low. There is some natural weathering and minor fretting of the rock faces observed in some areas in the incised gullies, but these are unlikely to impact on the site.

4.6 Groundwater issues

No significant groundwater issues are expected, however minor seepages may be encountered in excavations close to the hillslopes, and within the alluvial fan materials, in the northern areas of the site.

5 Neighbouring Structures/Hazards

Distances to adjoining structures: The site is situated in a rural setting, but with existing residential buildings at one location along the northern and one along the eastern boundaries. The existing buildings are not expected to be adversely effected provided geotechnical input to the project is provided at the detailed design and construction phase.

Aquifers: No aquifer resource will be adversely affected by the development. If ground source heating, water abstraction, or other deep drilling activity is undertaken, consenting may be required with respect to groundwater and confirmation should be sought from the local and regional councils.

Hazards: A regional seismic hazard is present in the Wakatipu area. No specific investigation and assessment is considered necessary with respect to alluvial fan and liquefaction hazards. Slope stability and rock fall hazards are discussed above in Sections 4.3 and 4.5.

6 Conclusions and Recommendations

- From a geotechnical perspective, construction of the development is considered technically feasible. Developments have been readily achieved in similar ground conditions across the Shotover, Lake Hayes and Frankton Areas.
- Preliminary assessment indicates that standard engineering or planning solutions will be available to address any likely geotechnical issues or hazards that may arise.
- There is a region-wide seismic risk at the site, which should be addressed in all future engineering design.
- Further assessment with respect to liquefaction and alluvial fan hazards is not considered necessary. Existing drainage diversion channels from the alluvial fans should be maintained and engineered sumps/discharge areas constructed as required.
- The northern-most (upslope) lots may have some degree of exposure to locally sourced storm runoff, which is common to hillside developments and unrelated to alluvial fan activity. This risk is typically addressed with minor site drainage as appropriate depending on the individual platform configurations.
- Further investigation and assessment will be required at the detailed design phase of the project. The assessment should confirm the preliminary recommendations in this report, and provide detailed engineering recommendations as appropriate. The principle geotechnical issues to be addressed include:
 - Confirmation of the near surface soil stratigraphy and foundation bearing capacities;
 - A further confirmation of rock fall/bluff instability/surficial slope erosion hazard mitigation requirements in the northern area of the site;
 - Other geotechnical inputs as required for detailed design e.g. Pavement CBR values for roadway construction, safe temporary and permanent batter angles.

7 Applicability

This report has been prepared for the benefit of Maryhill Limited 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.

It is important that we be contacted if there is any variation in subsoil conditions from those described in this report.

Report prepared by:

A handwritten signature in black ink, appearing to read "Peter Nicolson".

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Peter Nicolson

Senior Geologist

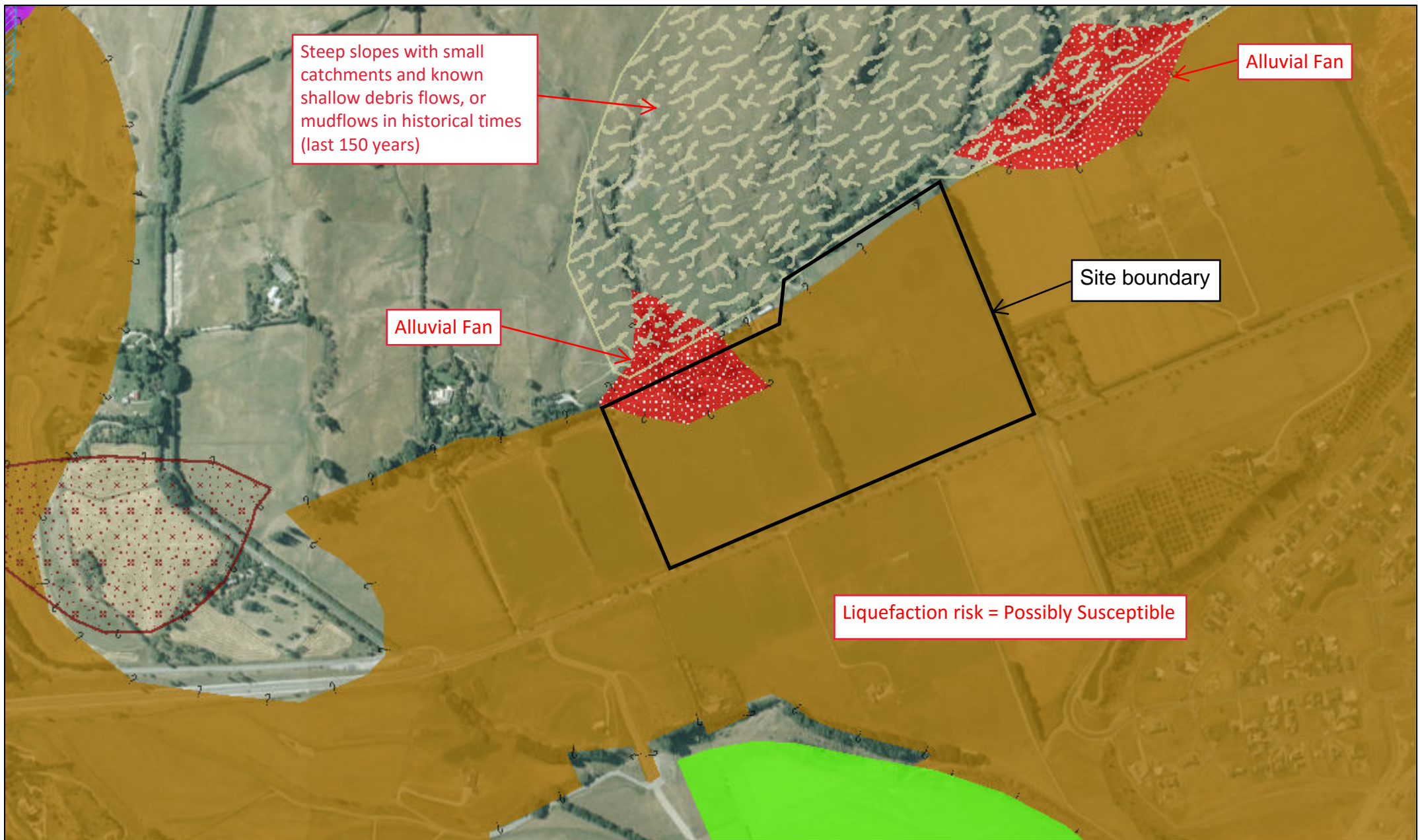
Reviewed for GeoSolve Ltd by:

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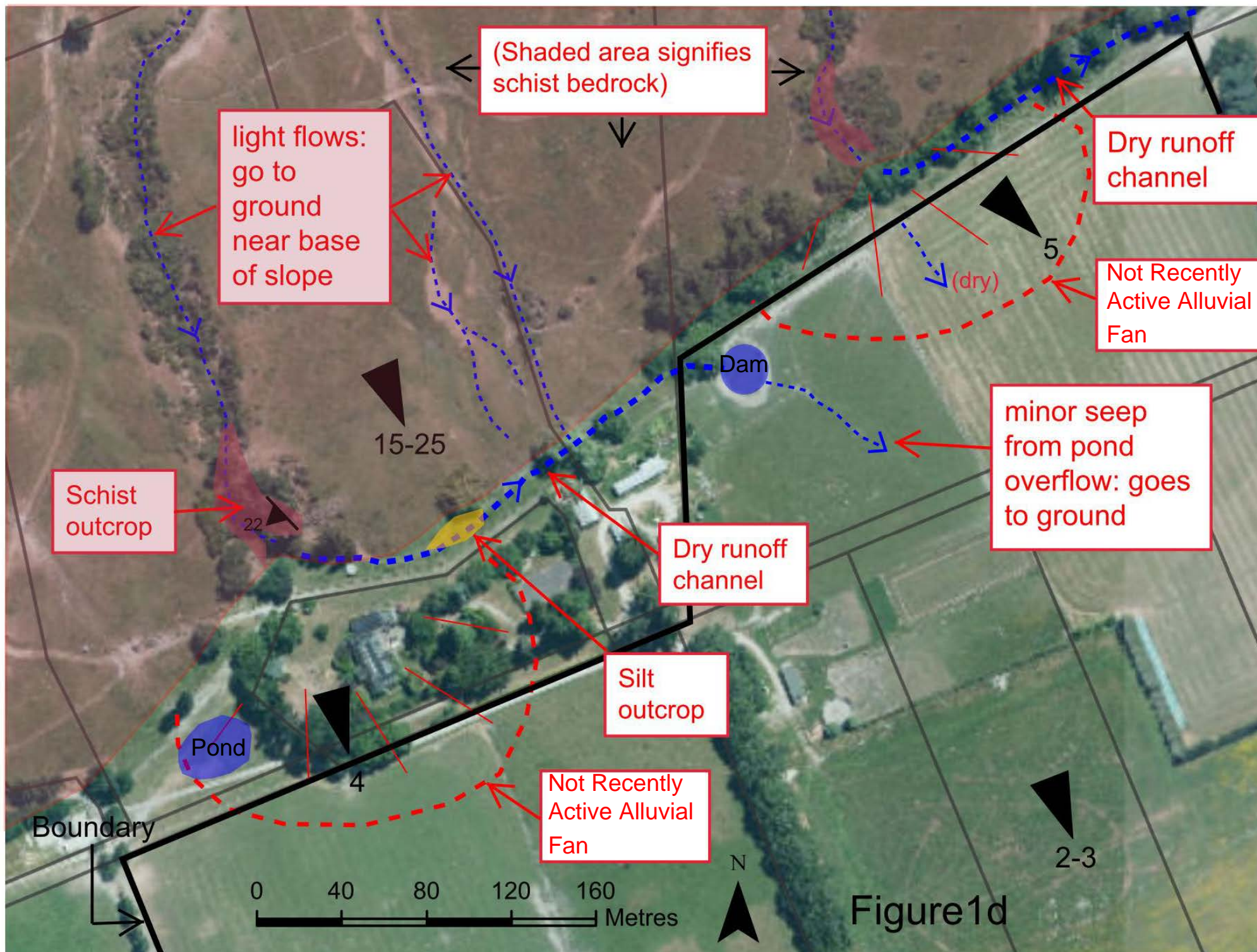
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Fraser Wilson

Senior Engineering Geologist

Appendix A



The map is an approximate representation only and must not be used to determine the location or size of items shown, or to identify legal boundaries. To the extent permitted by law, the Queenstown Lakes District Council, their employees, agents and contractors will not be liable for any costs, damages or loss suffered as a result of the data or plan, and no warranty of any kind is given as to the accuracy or completeness of the information represented by the GIS data. While reasonable use is permitted and encouraged, all data is copyright reserved by Queenstown Lakes District Council. Cadastral information derived from Land Information New Zealand. CROWN COPYRIGHT RESERVED



Appendix B



Photo 1: View west across western part of subdivision area.



Photo 2: View southeast across eastern part of subdivision area. SH6 just beyond the low treeline.



Photo 3: View south down onto eastern part of subdivision area.



Photo 4: View northeast towards eastern-most alluvial fan feature, northern boundary area. Gully indicated by vegetation extending upslope.



Photo 5: View downstream from mouth of main alluvial fan gully. Weak stream flow evident on left. Glenpanel homestead on downstream part of fan.



Photo 6: Schist exposure, main alluvial fan gully.