TECHNICAL MEMO

TETRA TECH

ISSUED FOR USE

To:	Teri Camery (CBJ)	**Date:**	April 27, 2022
c:	Scott Ciambor (CBJ)	**Memo No.:**	6
From:	Rita Kors-Olthof, Vladislav Roujanski	**File:**	704-ENG.EARC03168-02A
Subject:	Severe Landslide Hazard Designations at Starr Hill and Gastineau Avenue Downtown Juneau Landslide and Avalanche Hazard Assessment		

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) has prepared an Issued-for-Review (3rd Draft) Report, Downtown Juneau Landslide and Avalanche Assessment for the City and Borough of Juneau (CBJ), dated May 28, 2021 (Tetra Tech 2021); and participated in three Landslide and Avalanche Hazard Public Meetings that took place on July 21, August 10, and September 20, 2021.

Following CBJ's initial email request of July 27, 2021, Tetra Tech responded to comments and questions that arose from the July 21, 2021, Public Meeting with a series of three technical memos. These memos were Issued-for-Review to CBJ, along with an email providing supplemental information, and have since been updated (Tetra Tech 2022a, 2022b, 2022c).

CBJ has now requested a further series of memos to address additional landslide-related questions from the public, as well as a review of historical avalanche data to address further questions that arose following the August 10 and September 20, 2021, Public Meetings; as well as some follow-up questions from CBJ. The scope is as described in Tetra Tech proposal of December 9, 2021, with a few modifications as discussed during the kick-off meeting with CBJ on February 8, 2022. All the completed technical memos will be appended to the Final Draft Report.

This Technical Memo #6 provides some additional explanation of anticipated continued slope instabilities within the landslide hazard designations mapped as *Severe* on the slopes above Starr Hill and Gastineau Avenue.

2.0 SCOPE AND METHODS

The primary objective of this technical memo is to address the question, "The chutes mapped as *Severe* above Gastineau/Starr Hill scour down to bedrock over and over – is a bedrock failure anticipated, or just more flushing from small landslides?" Specific tasks included the following:

- Review completed landslide hazard mapping;
- Locate suitable photographs illustrating landslide hazards in the above-noted map areas, if/as needed;
- Prepare map excerpts, if/as needed;
- Refer to information presented previously in other technical memos, as applicable; and
- Prepare Technical Memo, providing descriptions and/or comparisons, as needed.

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3.0 STARR HILL

3.1 General Considerations

The slope conditions around the Starr Hill subdivision were discussed in detail in Technical Memo #3 (Appendix C of the main report; Tetra Tech 2021d). Rockfalls and rockslides are most prevalent on the slopes above 6th Street, but there are also areas of rockfalls and rockslides above other areas of the subdivision, as described in Technical Memo #3.

3.2 Rockfalls and Rockslides

As noted in Technical Memo #3, Question #1, locations with numerous unstable rock cliffs and bluffs above 6th Street can be expected to continue experiencing rockfalls and rockslides. Swanston (1972) noted that, although the bedrock dips into Last Chance Basin (on the north side of Mt. Maria), cyclical freeze-thaw of water in the fractures and joints of the exposed bedrock, and water acting as a lubricant in the cracks, result in instabilities. The elevated level of slope movement activity on this slope, including several well-established slide paths below prominent bedrock bluffs and cliffs, requires the slopes below the cliffs to be designated as *Severe* hazard. Similar processes can be anticipated anywhere in those locations where bedrock outcrops are present. Depending on the structural orientation of the bedrock (e.g., dipping into the slope or out of the slope), the mass movement process at the outcrop may look more like rockfall (including toppling), or rockslides. Tetra Tech's field records include numerous photos of bedrock outcrops, cliffs, or bluffs, many of which have detached blocks, indicating the likelihood of future rockfall, rockslides, or toppling.

Once in motion, rocks might tend to bounce and roll (for example, where loose rocks can move independently and stop against trees, or structures, or other objects that block them or slow them down (e.g., above much of 6th Street), or they could fall or slide as a larger mass and end up in a large talus cone downslope (e.g., corner of 6th and Nelson Streets). These are the kinds of processes that have been ongoing since long before Swanston's observations and are expected to continue, as shown in the photos from Tetra Tech's recent fieldwork (Tetra Tech 2021a, 2021d).

Some of the slide paths above 6th Street appear to be smooth and open, suggesting that rockfall and/or rockslides are relatively frequent, scouring the area with each event, and vegetation cannot readily become re-established. In some cases, the very steep slopes could also reduce the rate of revegetation. In other locations, deciduous vegetation has become re-established, but rockfall continues.

Where debris accumulates in gullies, for example, from bedrock cliffs or bluffs upslope, and/or from debris slides within the gullies, the potential exists for that debris to eventually become part of a debris flow. Small debris flows tend to accumulate in wedges in gullies, until a combination of debris and extreme precipitation or rapid snowmelt results in much larger debris flow event that can scour out the gully. Also, the addition of more debris from ongoing failures upslope could potentially result in slope failures resulting from overloading of debris on the slope, especially if combined with heavy rainfall or a rapid snowmelt. See also the discussions about debris flows in Technical Memo #2, Question #9, and Technical Memo #3, Question #4 (Appendix C of the main report; Tetra Tech 2022b, 2022c).

See Technical Memo #3 for excerpts from the mapping and photos from the slopes around Starr Hill.

4.0 GASTINEAU AVENUE (SLOPES OF MT. ROBERTS)

4.1 General Considerations

Two general areas are considered along Mt. Roberts with respect to rockfall or rockslides:

- Past and probable future natural slope instabilities originating on natural terrain, and becoming incorporated into debris lobes on open slopes or in gullies (most of the length of the current Mt. Roberts Study Area); and
- The potential very large deep-seated bedrock slide southeast of Snowslide Creek.

In the context of the question to be answered from Section 2.0, only the first of these items can be addressed with the information currently available. The evaluation of natural slope instabilities is based on the slope observations made during the mapping project and is applicable to the entire slope of Mt. Roberts within the Study Area (Tetra Tech 2021a).

4.2 Rockfalls and Rockslides

In general, the same considerations as noted in Section 3.0 for Starr Hill also apply to Mt. Roberts. For example, the bedding planes of the bedrock on Mt. Roberts also dip into the slope, in this case, towards the northeast. However, the findings in Tetra Tech (2021a) suggested that although rockfall and rockslides (along with debris slides) could initiate in the upper portions of the slide paths on Mt. Roberts, landslide events that reach the lower slopes tend to consist of debris flows or debris slides. Those debris flows or debris slides could incorporate rock fragments originating from areas of bedrock outcrops within the colluvium on the mid to lower slopes or, in the case of Snowslide Creek, also from further upslope where the surficial materials consist mostly of bedrock. This does not mean that such events are less severe than rockfall or rockslide events, only that the length of the slope means that there could be a few different types of landslide events between the top and bottom of the slope. Just as for Starr Hill, wherever rockfall and rockslide processes are occurring now, these are the kinds of processes that have been ongoing for decades and centuries, and they are expected to continue.

The processes described for Starr Hill are the same as on Mt. Roberts, though the slope length is greater on Mt. Roberts, and although debris slides on open slopes are often similar in size to those above Starr Hill, larger events are possible, particularly for debris flows or debris slides within gullies (see Figures 1.4b, 1.4c, 1.5b, and 1.5c in Tetra Tech 2021a). In general, however, along the upper slopes of Mt. Roberts, where bedrock is more common at ground surface than colluvium (60% to 75% bedrock), or *much* more common than colluvium (80% to 95% bedrock), the slopes are considered more stable (rated *Moderate*) than the lower slopes that have more colluvium than bedrock (rated *High* or *Severe*). The only places where that rule-of thumb does not apply on Mt. Roberts is the potential very large deep-seated bedrock slide southeast of Snowslide Creek, and the three very large debris-flow initiation zones leading into Snowslide Creek itself (all rated *Severe*).

A summary of Tetra Tech's mapping near the northwest end of Mt. Roberts is shown in Figure 1, and the southeast end of the Study Area along Mt. Roberts is shown below in Figure 2, both with surficial geology on the left and landslide hazard designation mapping on the right. There is a clear correlation between the type and shapes of the surficial geology units and the landslide hazard designations.

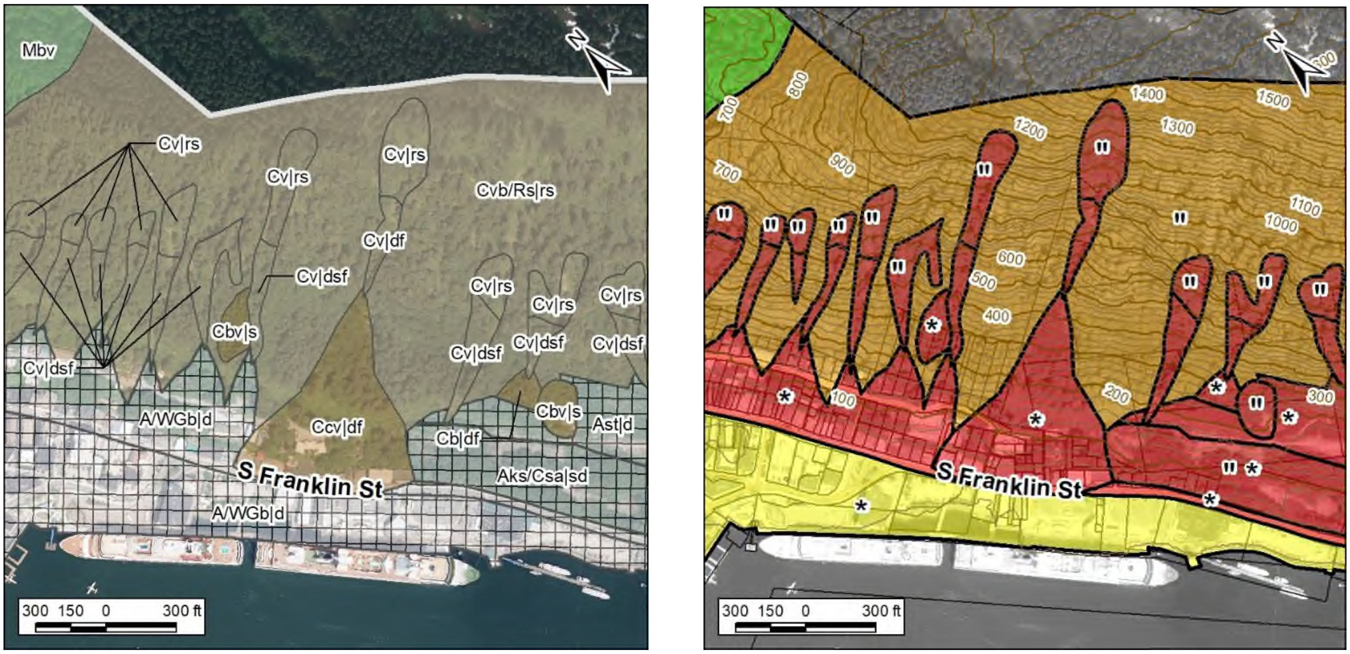

Figure 1: Excerpts from Figure 1.3b Surficial Geology (left) and Figures 1.6c and 1.6h Landslide Hazard Designation Mapping (right).

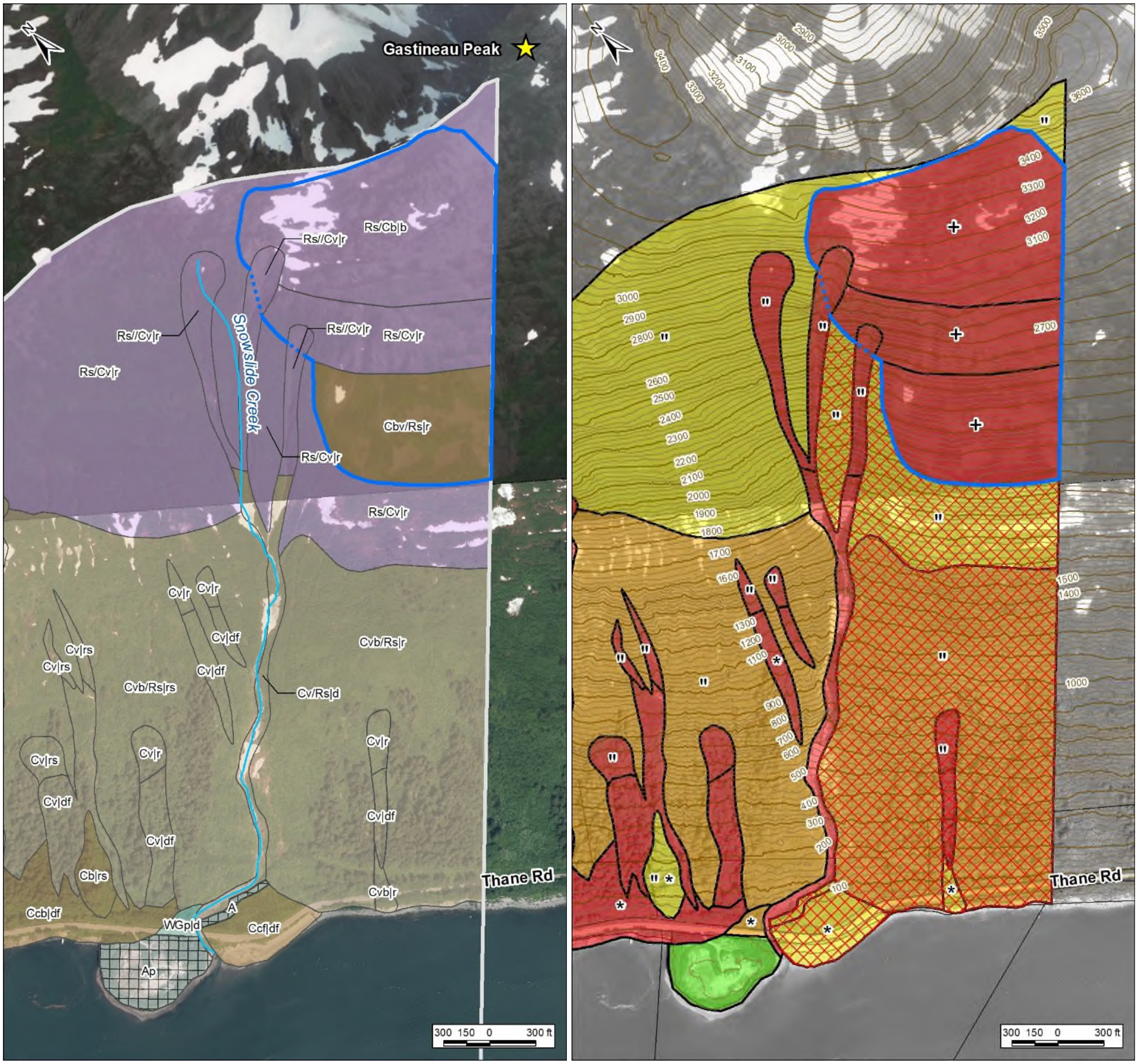

Figure 2: Excerpts from Figure 1.3c Surficial Geology (left) and Figures 1.6e and 1.6f Landslide Hazard Designation Mapping (right).

5.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of the City and Borough of Juneau and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than the City and Borough of Juneau and its agents, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

6.0 CLOSURE

We trust this technical memo meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

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April 27/22
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REGISTERED PROFESSIONAL ENGINEER

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REFERENCES

Swanston, D. (1972). Mass Wasting Hazard Inventory and Land Use Control for the City and Borough of Juneau. Appendix II. Report to the City and Borough of Juneau, Alaska.

Tetra Tech Canada Inc. (Tetra Tech), 2021. Downtown Juneau Landslide and Avalanche Assessment. Prepared for the City and Borough of Juneau (CBJ), Issued for Review (3rd Draft). Dated May 28, 2021. File Number: 704-ENG.EARC03168-01.

Tetra Tech. (2022a). Technical Memo #1. Landslide Mapping Accuracy and Modelling, Downtown Juneau Landslide and Avalanche Hazard Assessment. Prepared for CBJ. Tetra Tech File: 704-ENG.EARC03168-02A. April 27, 2022.

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Tetra Tech. (2022c). Technical Memo #3, Rev.1. Mapping Overview at Starr Hill Subdivision and Additional Information, Downtown Juneau Landslide and Avalanche Hazard Assessment. Prepared for CBJ. Tetra Tech File: 704-ENG.EARC03168-02A. April 27, 2022.

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GEOTECHNICAL

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The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary investigation and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.8 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.9 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.10 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

1.11 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.12 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.13 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

1.14 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.15 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

1.16 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

1.17 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client’s expense upon written request, otherwise samples will be discarded.