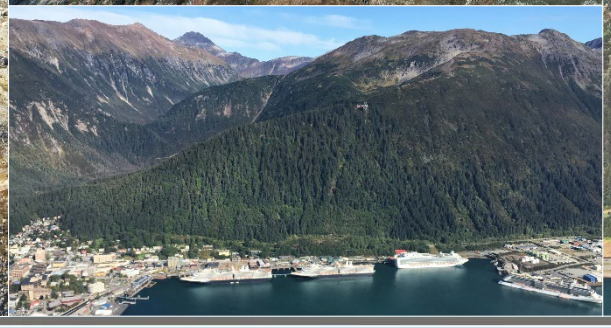
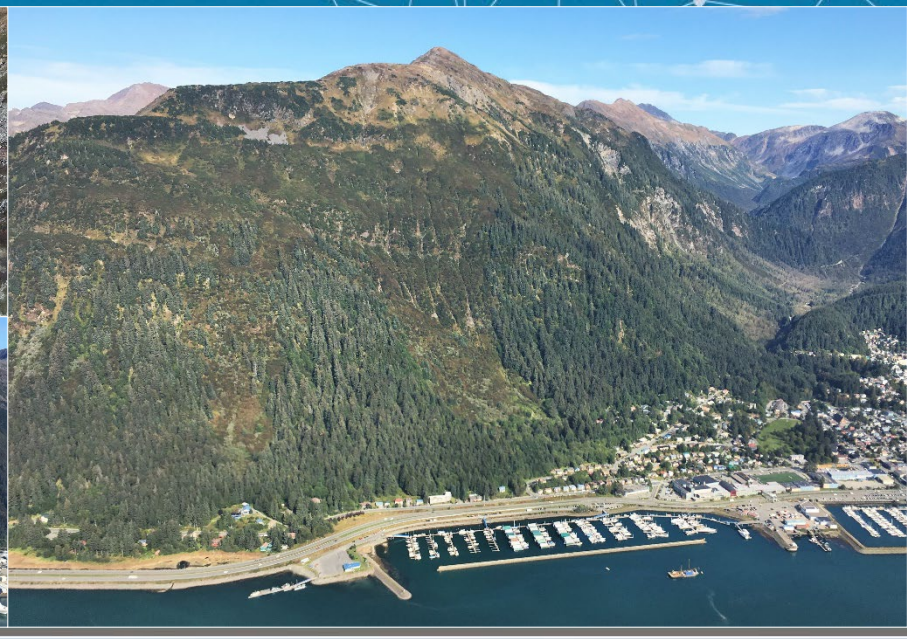
TETRA TECH

Downtown Juneau Landslide and Avalanche Assessment

Presentation for Public Meeting July 21, 2021





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Presented by:

Dynamic Avalanche Consulting - Avalanches:

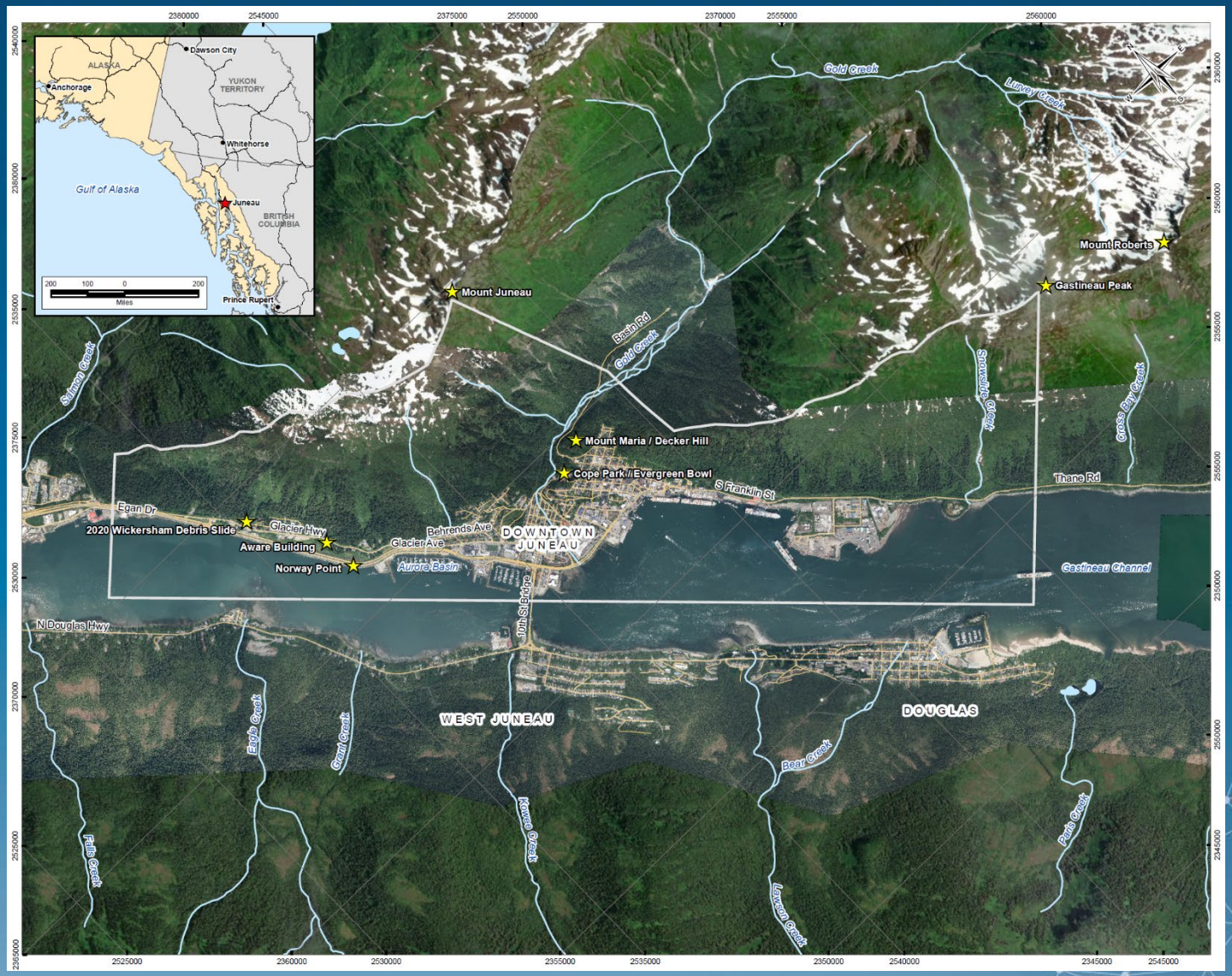
Alan Jones, M.Sc., P.Eng., P.E. (Idaho)
Senior Avalanche Specialist

Tetra Tech - Landslides:

Rita Kors-Olthof, P.E. (Alaska), P.Eng.
Overall Technical Lead and Senior Landslide Specialist

Vladislav Roujanski, Ph.D., P.Geol.
Project Manager and Landslide Hazard Assessment Lead

2019-2021 Study Area



Project Personnel – Avalanche Assessment Dynamic Avalanche Consulting

- Alan Jones, M.Sc., P.Eng., P.E. (Idaho) – Senior Avalanche Specialist
- Chris Argue, Dipl.T. – Avalanche Specialist and GIS Technician
- Bruce Jamieson, Ph.D. – Senior Reviewer – Avalanche Assessment

Snow Avalanche Hazard - Study Objectives

- Identify (map) avalanche paths within the Study Area, including initiation, track and runout zones
- Field investigations
- Technical analyses
- Prepare avalanche hazard designation mapping with *Low*, ***Moderate*** and **Severe** hazard designations

Tasks completed and methods

- Analyzed snow climate data
- Reviewed previous reports and studies
- Reviewed historical avalanche occurrence records, completed magnitude-frequency analyses
- Reviewed air photos, satellite imagery, LiDAR data
- Field investigation to observe terrain, vegetation, evidence
- Meetings with Juneau-based avalanche experts
- Dynamic and statistical avalanche modelling

Avalanche Hazard Designation System

- Reviewed US, Canadian, European systems
- No national guidelines or standards for the US, often determined by town or county
- Most systems based on combination of magnitude (e.g., impact pressure) and frequency, 3 or 4 categories
- CBJ designations equivalent to White/Blue/Red zones (Eur., Can.)

Table 2.3: Avalanche Hazard Designation System

Hazard Designation	Symbol	Hazard Attribute Description
Low	L	▪ Return period greater than 300 years; OR ▪ Impact pressures less than 20 lbs/ft^2 (1 kPa) with a return period greater than 30 years.
Moderate	M	▪ Return period between 30 and 300 years; AND ▪ Impact pressure less than 600 lbs/ft^2 (30 kPa).
Severe	S	▪ Return period less than 30 years; AND/OR ▪ Impact pressure greater than or equal to 600 lbs/ft^2 (30 kPa).

Previous Avalanche Studies

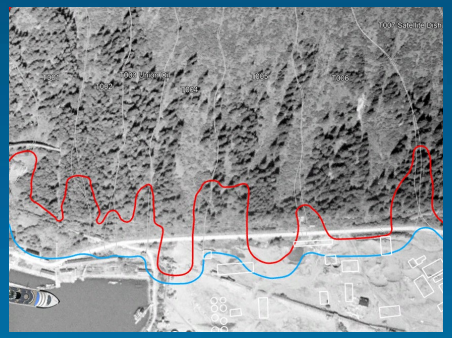
- Historical reports dating back to 1949
- Hart (1967): initial avalanche hazard mitigation options
- LaChapelle (1968): recommendations for Behrends & White Subdivisions
- Frutiger (1972): 1st hazard designation, White/Blue/Red
- Davidson et al. (1979): Mapped High-Mod/Mod to Low potential, limited use due to scale of mapping
- Mears, Fesler, & Fredston (1992) : designated High Severity (Red), Special Engineering (Blue) and Unaffected (White) zones, Behrends & White subdiv.
- CBJ (2009,2012) All Hazards Mitigation Plan: summarized mapping completed to 2012, included Thane Rd., High and Moderate zones
- SLF (2011): Most recent study, mitigation recommendations for Behrends and White Subdivision

Methods

Field Investigation

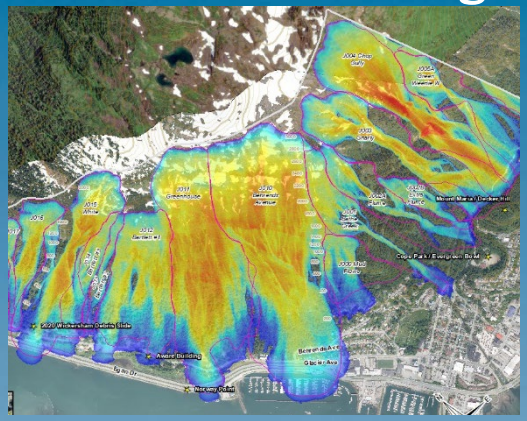
Historic air photos, imagery, LiDAR

1962

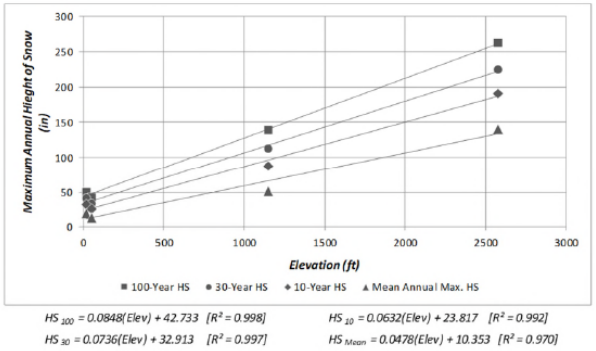


2013

Avalanche modelling



Snow climate



$HS_{100} = 0.0848(Elev) + 42.733$ $[R^2 = 0.998]$ $HS_{10} = 0.0632(Elev) + 23.817$ $[R^2 = 0.992]$

$HS_{30} = 0.0736(Elev) + 32.913$ $[R^2 = 0.997]$ $HS_{Mean} = 0.0478(Elev) + 10.353$ $[R^2 = 0.970]$

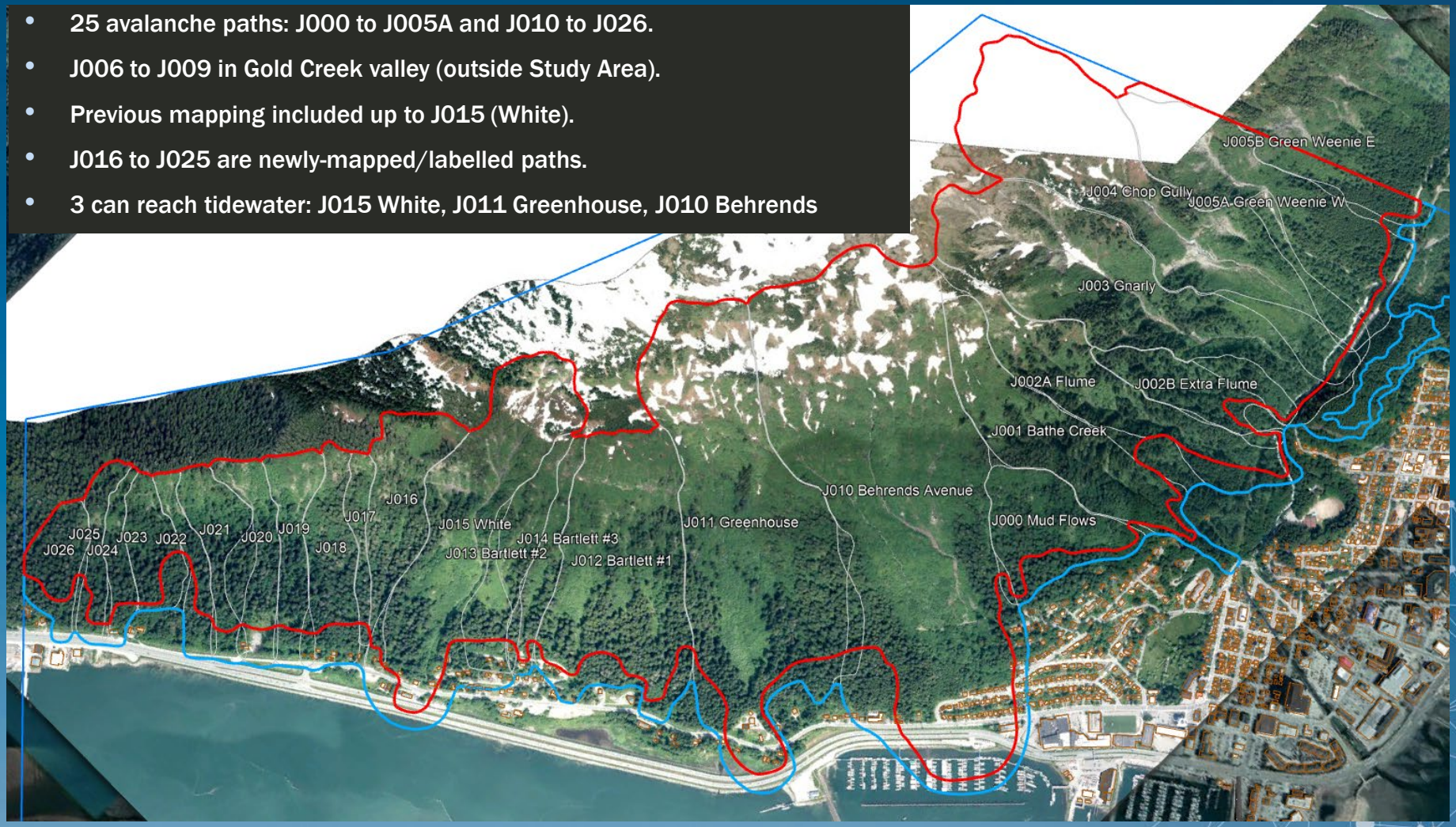
Figure 2.3.4-1: HS vs. Elevation for Annual, 10-year, 30-year, and 100-year Return Periods. Regression equations are provided below that relate the statistical annual maximum HS as a function of elevation for 10-year, 30-year, and 100-year Return Periods.

Avalanche Mapping Results

- Identified 52 unique avalanche paths, each was assigned *Severe*, *Moderate* and *Low* hazard areas.
- Paths identified in 3 areas: Mt. Juneau (25 paths), Gastineau Ave. (11 paths), Thane Road (16 paths).
- Paths mapped to delineate a 300-year hazard boundary for destructive flow (dense and/or powder)

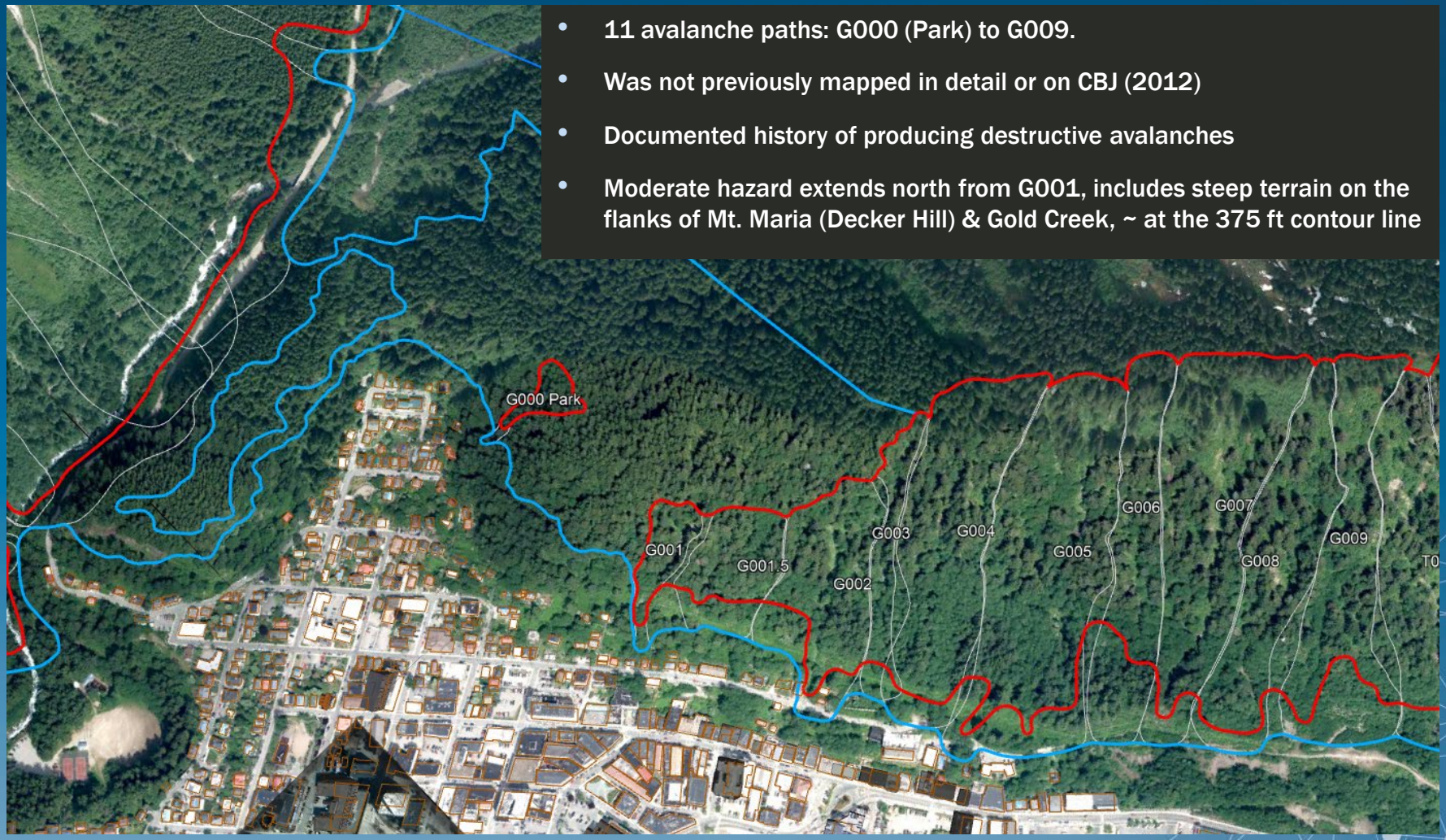
Avalanche Mapping Results – Mt. Juneau

- 25 avalanche paths: J000 to J005A and J010 to J026.
- J006 to J009 in Gold Creek valley (outside Study Area).
- Previous mapping included up to J015 (White).
- J016 to J025 are newly-mapped/labelled paths.
- 3 can reach tidewater: J015 White, J011 Greenhouse, J010 Behrends



Avalanche Mapping Results – Gastineau Ave

- 11 avalanche paths: G000 (Park) to G009.
- Was not previously mapped in detail or on CBJ (2012)
- Documented history of producing destructive avalanches
- Moderate hazard extends north from G001, includes steep terrain on the flanks of Mt. Maria (Decker Hill) & Gold Creek, ~ at the 375 ft contour line



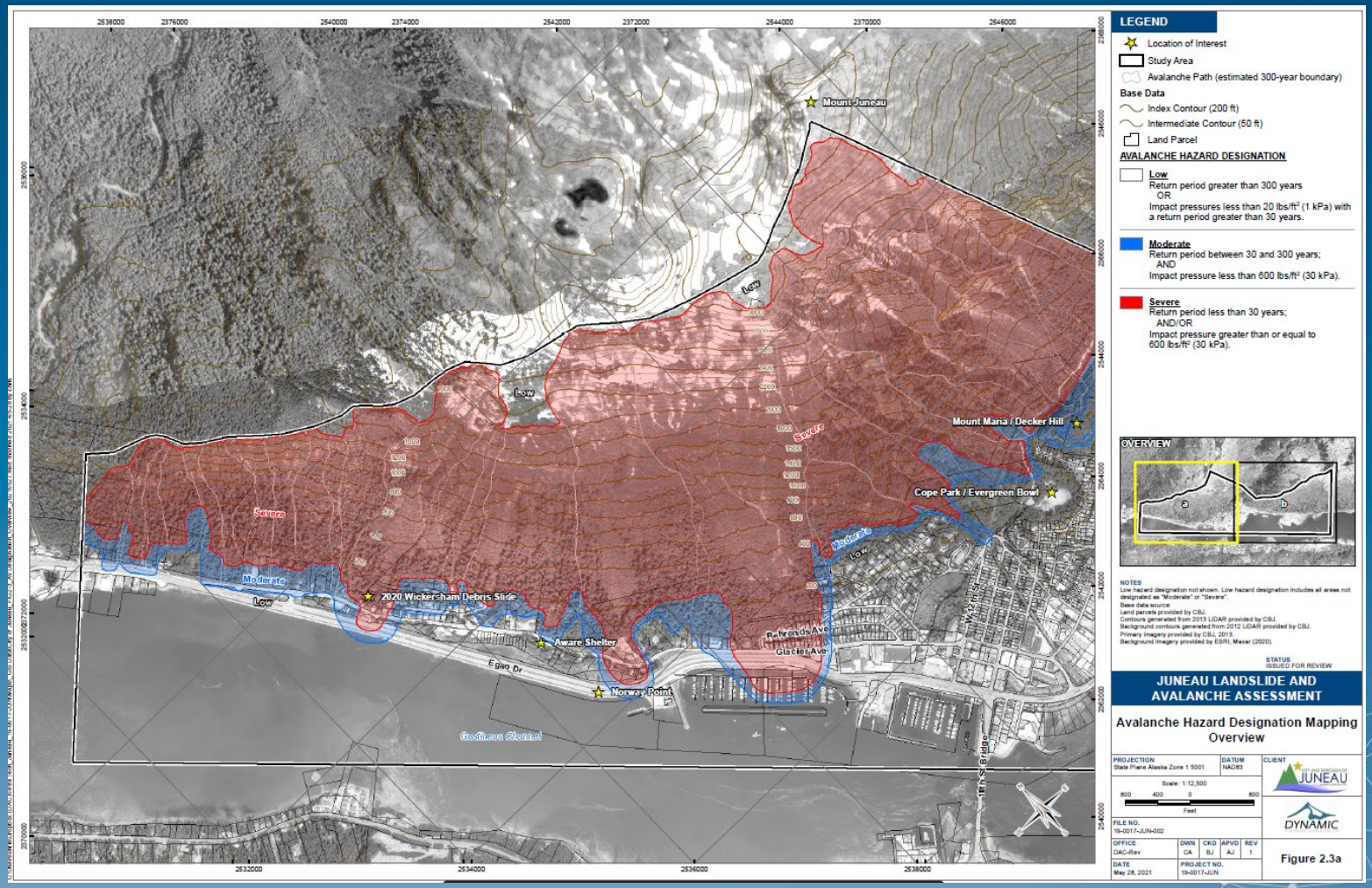
Avalanche Mapping Results – Thane Road

- 16 avalanche paths: T000 to T014 (Middle), all but T000 could affect Thane Road.
- Paths previously mapped (CBJ, 2012) but many were shown to not affect Thane Road or developed areas. Boundaries were extended to reflect field & historical observations.
- T011 Snowslide and T014 Middle have history of reaching tidewater; West A-J, Garbage Dump, T012 were also mapped with potential to reach tidewater.

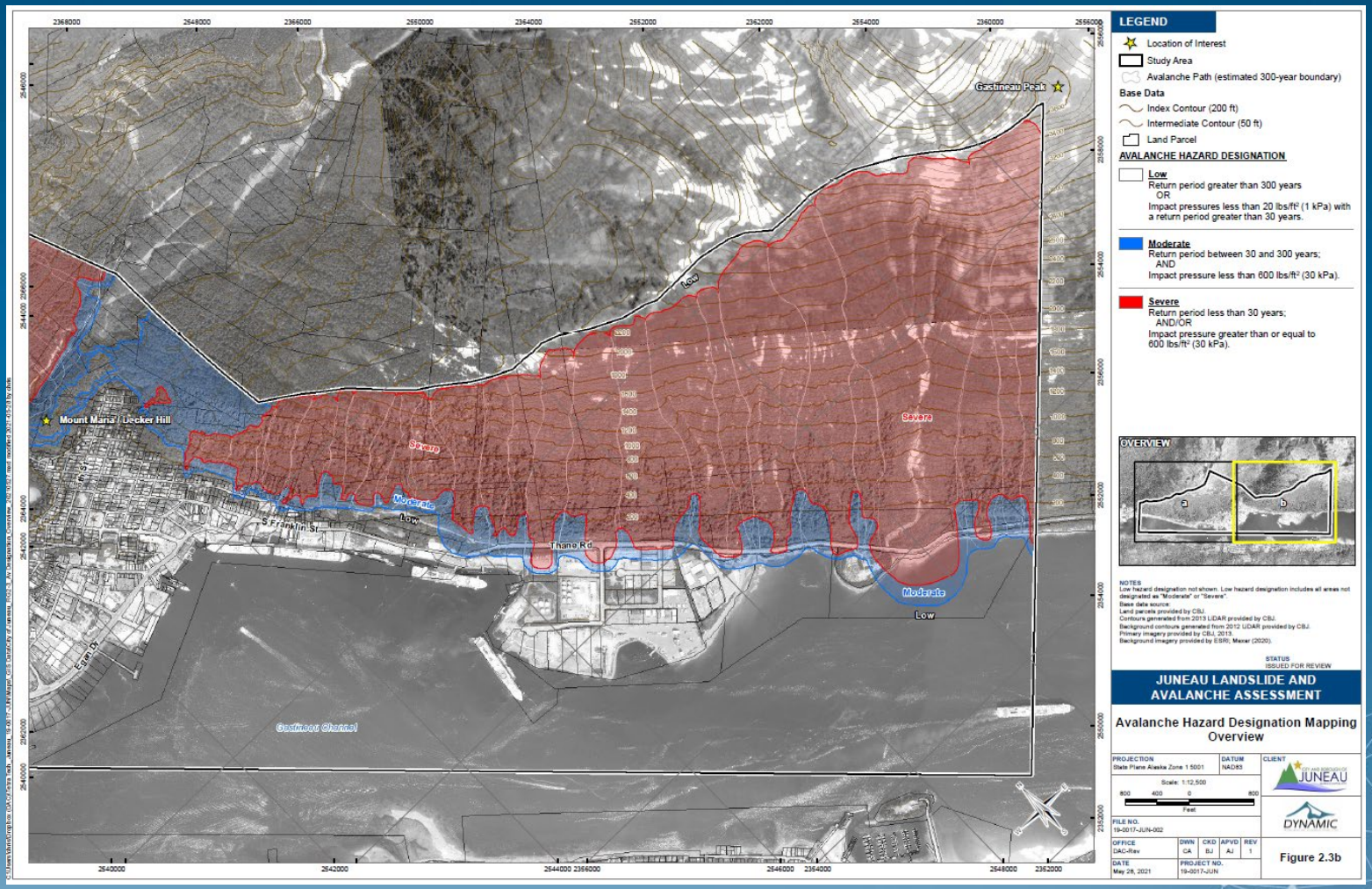
Avalanche Hazard Designation Mapping

- Designates areas in Study area as Low, Moderate or Severe:
  - Figure 2.3a & 2.3b: 2 sheets at 1:12,500 scale
  - Figure 2.4a through 2.4j: 10 sheets at 1:5,000 scale
- ***Severe*** hazard: typically includes initiation zone and track, lower return period (< 30 years) AND/OR higher impact pressure (>= 600 lbs/ft^2)
- ***Moderate*** hazard: longer return period (30-300 years) AND lower impact pressures (< 600 lbs/ft^2)
- ***Low*** hazard: long return period (> 300 years) OR low impact pressure (< 20 lbs/ft^2) (typically powder impacts)

Avalanche Hazard Designation Mapping – Mt. Juneau



Avalanche Hazard Designation Mapping – Gastineau Ave. and Thane Road



Conclusions

- Identified 52 avalanche paths, each with *Severe* and *Moderate* hazard areas. Areas beyond path boundaries are considered *Low* hazard.
- Paths divided into 3 areas: Mt. Juneau (25), Gastineau Ave. (11), and Thane Road (16).
- Level of assessment is suitable for CBJ to determine whether or not land areas could be affected by avalanches
- Continued use of 3-level hazard designation is recommended (Low, Moderate, Severe) with four modifications (see report)
- UAS is completing studies into effects of climate change on the avalanche regime – results will be considered as they become available.

Limitations

- Avalanches are complex and there is uncertainty in the estimates of frequency and magnitude. Uncertainty reduced by combining and weighting results using various methods.
- Boundaries between *Low*, *Moderate*, *Severe* areas are not hard lines, but rather as transition zones – they do not follow property lines or other development lines (e.g. roads)
- Hazard designation maps use data provided by CBJ. Changes in property boundaries and terrain could change boundaries.
- Assessment not completed to a level suitable for determining specific hazard mitigation for properties. Mitigation measures should be determined with additional, site-specific investigation(s).
- Change in forest cover (e.g. fire, disease, pests, landslides, climate change) could change hazard (or create new paths).

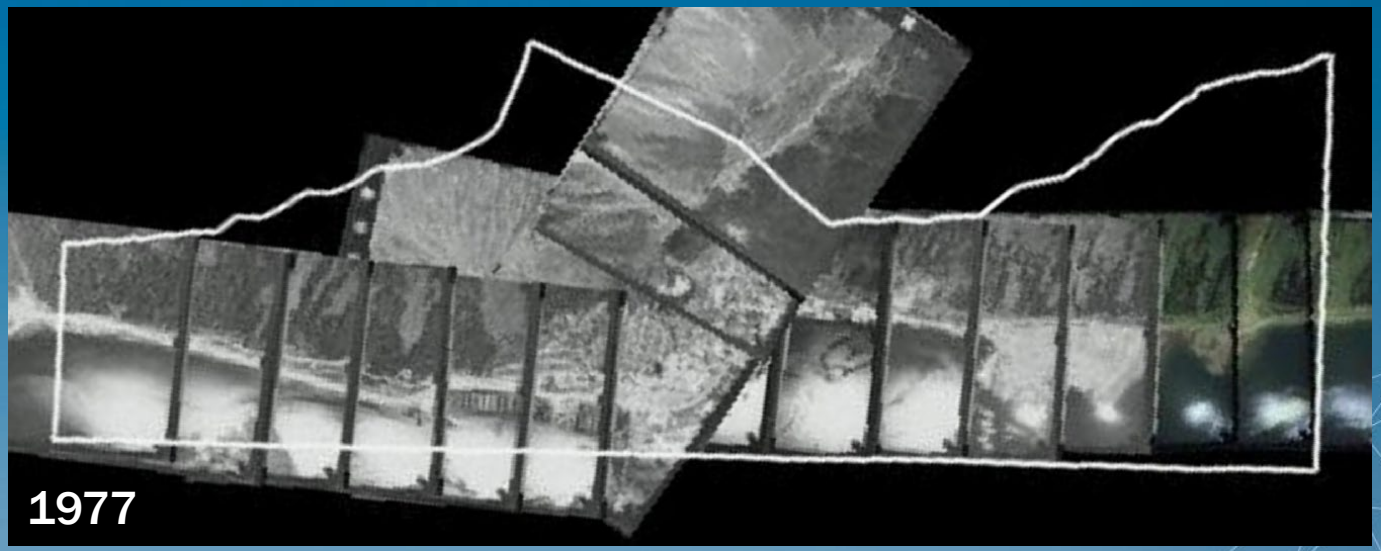
Project Personnel – Landslide Assessment Tetra Tech

- Vladislav E. Roujanski, Ph.D., P.Geol. – Principal Specialist, Senior Geologist – Project Manager and Landslide Hazard Assessment Lead
- Rita I. Kors-Olthof, P.E. (Alaska), P.Eng. – Senior Geotechnical Engineer, Overall Technical Lead and Senior Landslide Specialist
- Shirley J. McCuaig, Ph.D., P.Geol. – Senior Geohazards Specialist – Senior Mapper
- Ernest Palczewski, B.Sc., P.Geo. – Geologist – Mapper
- Shane Greene, M.Sc., P.Eng. – Geotechnical Engineer– Landslide Site Investigator
- Megan Verburg, B.A. Geography / GIS Certificate – GIS/CAD Analyst
- Nigel Skermer, M.Sc., P.Eng. – Principal Engineer – Senior Reviewer – Landslide Assessment

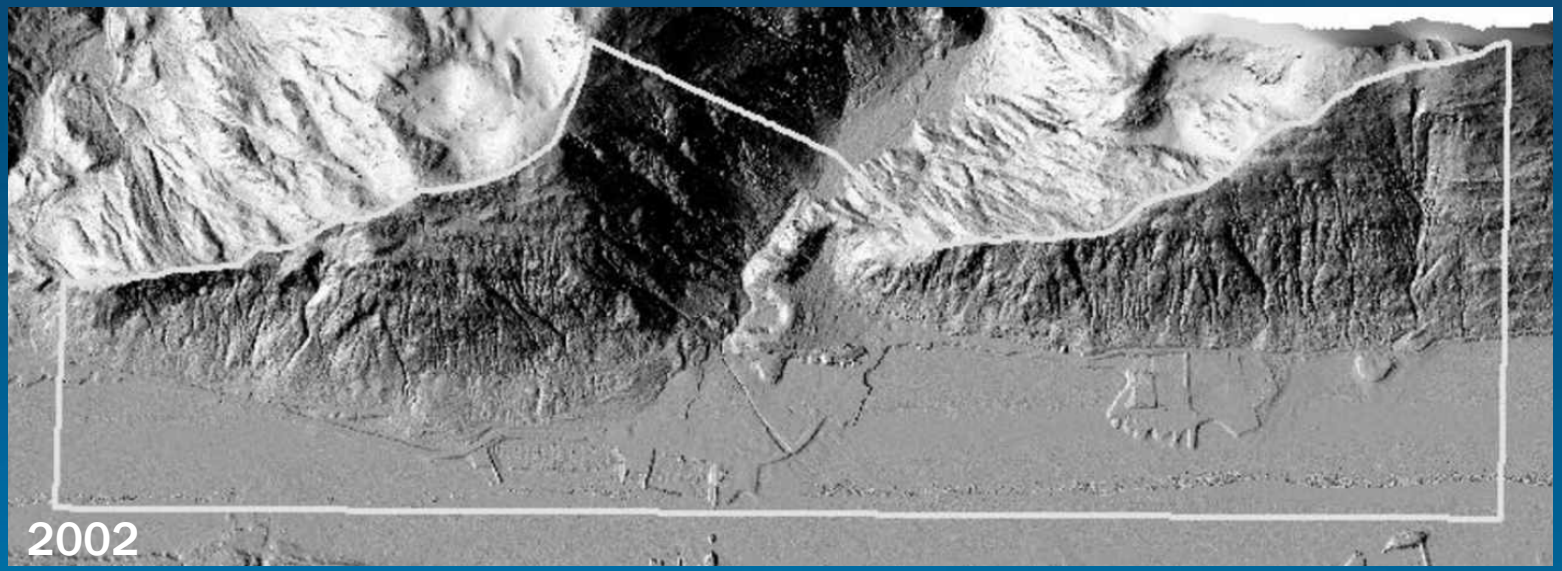
The Landslide Study Objectives

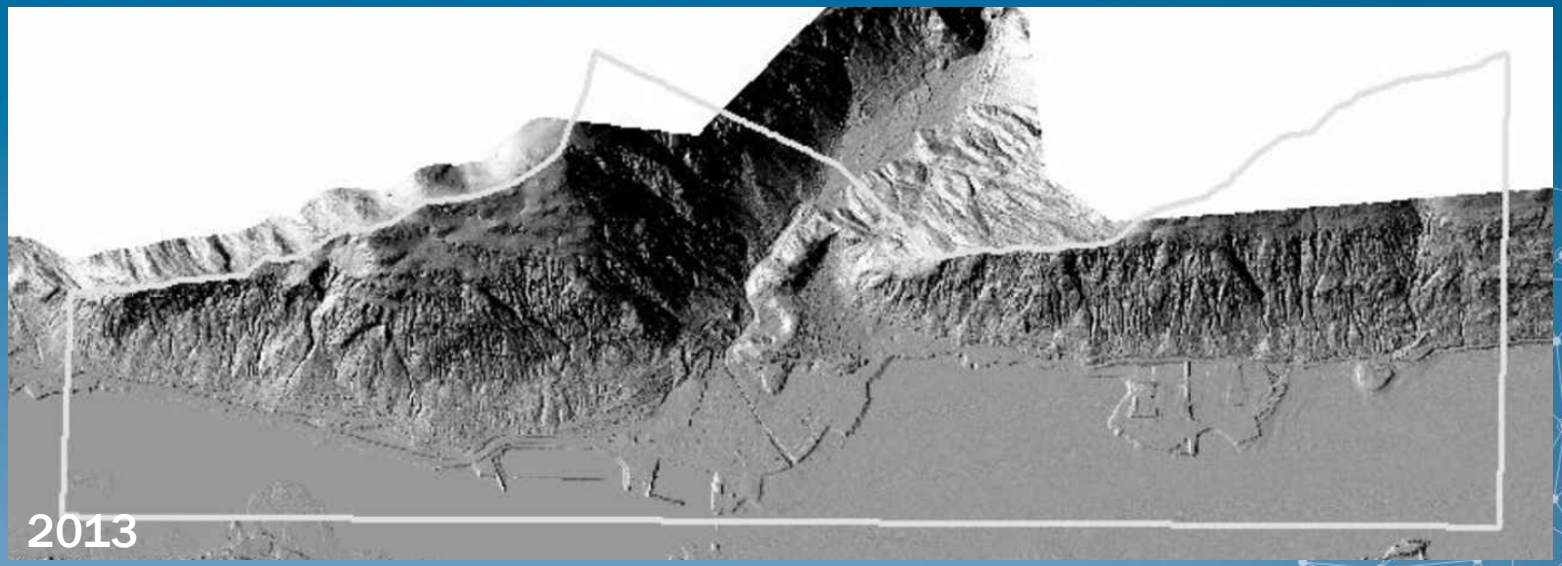
- Update surficial geology mapping
- Analyze historical air photo records
- Identify changes in slope features and landslide activity
- Identify landslide types
- Prepare hazard designation mapping to support the development of appropriate zoning, building regulations, and mitigation options

Collect and review available info



Collect and review info - continued





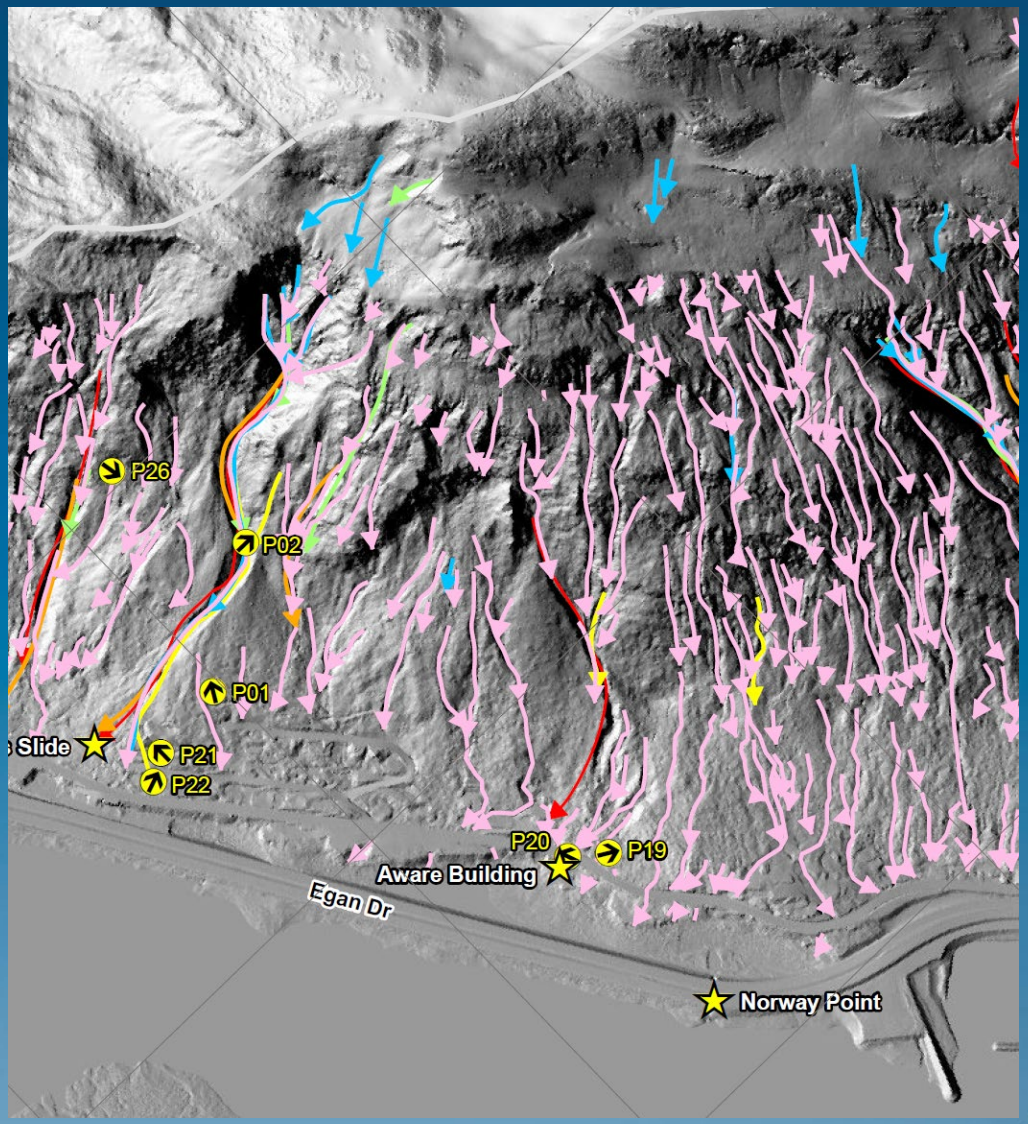
Previous Studies and Summaries

- Miller (1972) - Surficial Geology of the Juneau Urban Area and Vicinity, Alaska with Emphasis on Earthquake and Other Geologic Hazards
- Miller (1975) - Surficial Geological Map of the Juneau Urban Area and Vicinity, Alaska
- Swanston (1972) - Mass Wasting Hazard Inventory and Land Use Control for the City and Borough of Juneau
- Mears, Fesler, and Fredston (1992) - Juneau Area Mass-Wasting and Snow Avalanche Hazard Analysis
- CBJ (2009, 2012) – All-Hazards Mitigation Plan
- Alaska State Library – Historical Collections
- CBJ and Alaska Archives & Records Management (1986) – Inventory of Historic Sites and Structures, City and Borough of Juneau, Alaska

Surficial Geology – Mt. Juneau

Historical Slope Movements – Mt. Juneau

Gully Erosion Features – Mt. Juneau



2020 AWARE Shelter Debris Flow

(Photo Credits: CBJ, Dec 4, 2020)

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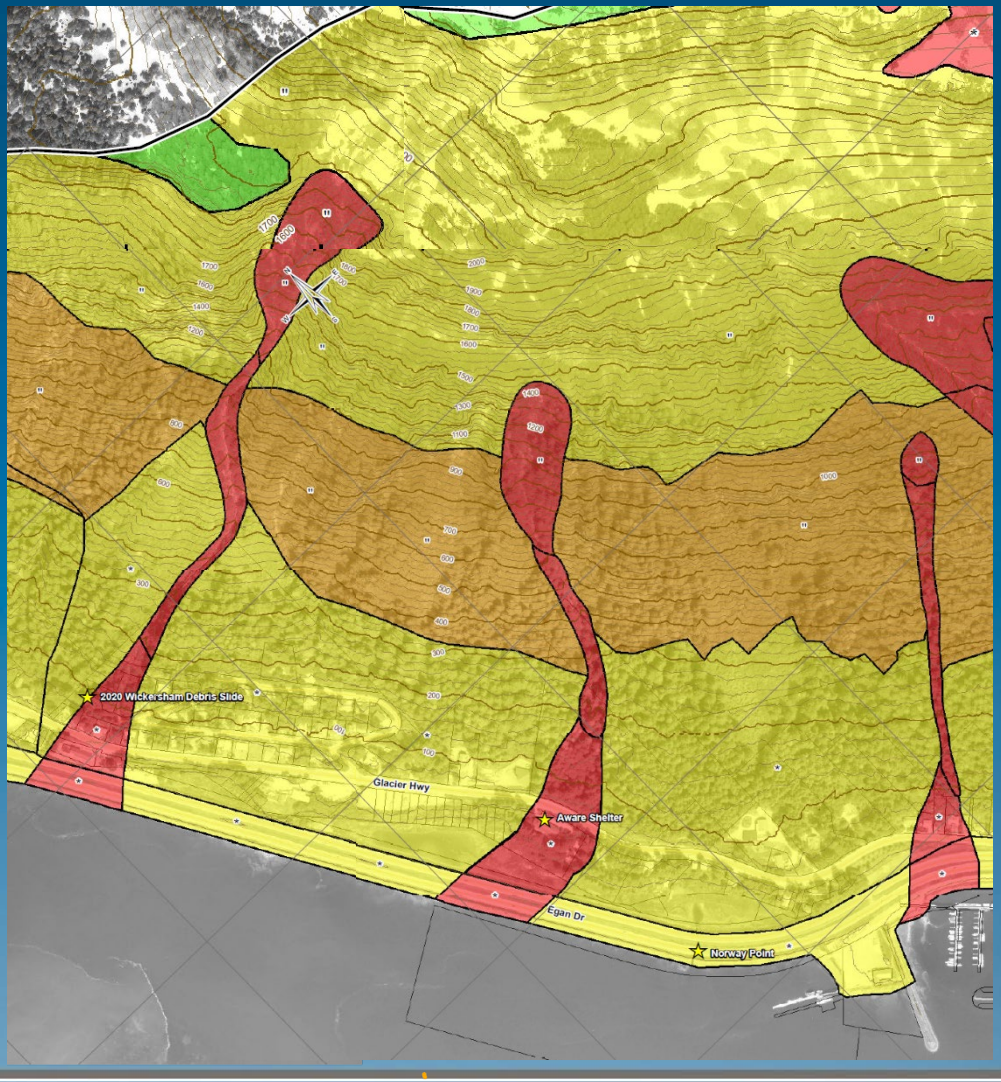
2020 Wickersham Debris Slide

(Photo Credit: CBJ, Dec 4, 2020)

Landslide Hazard Mapping – Mt. Juneau

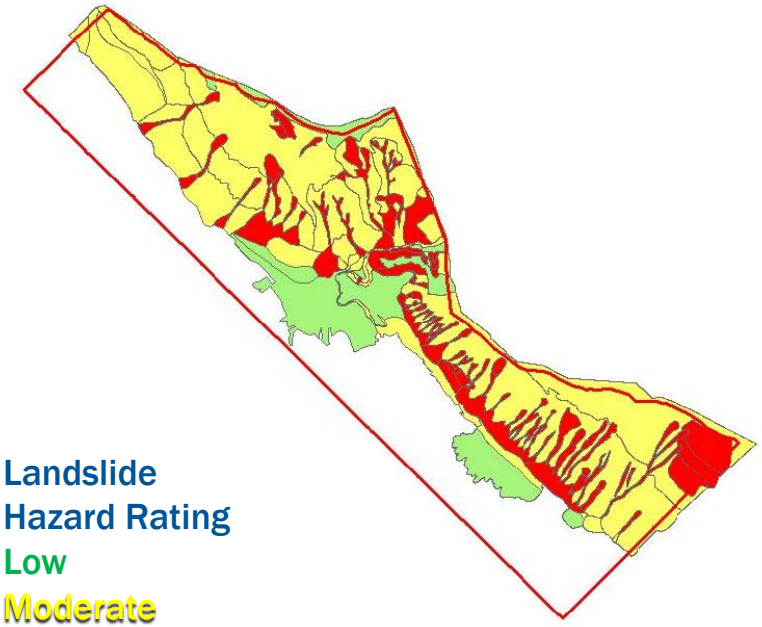


How the Landslide Hazard Designations Were Developed

- **Old Landslide Hazard Designation System had 3 ratings:**
  - Low, Moderate, and Severe
- **New Landslide Hazard Designation System has 4 ratings:**
  - Low, Moderate, High, and Severe
- **This change was proposed so that the severity of hazards could be defined more accurately:**
  - Some rockfall areas started out being mapped as Moderate where rockfall damaged but didn't remove trees. That seemed unconservative.
  - Severe would be too high a rating, though, because Severe should be applied to rockfall that *does* remove vegetation.
  - Adding a new rating of High provides more information about different levels of hazards on the slope.

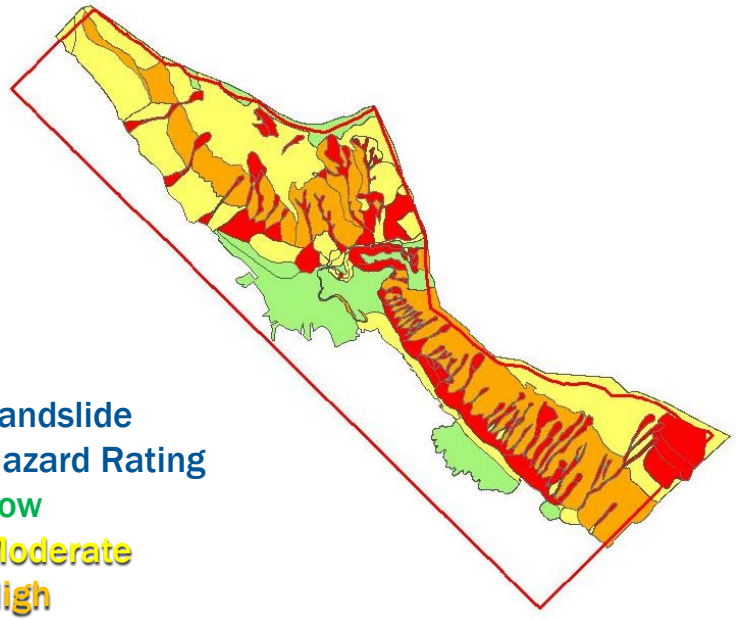
Comparing old and new systems

OLD



Landslide
Hazard Rating
Low
Moderate
Severe

NEW



Landslide
Hazard Rating
Low
Moderate
High
Severe

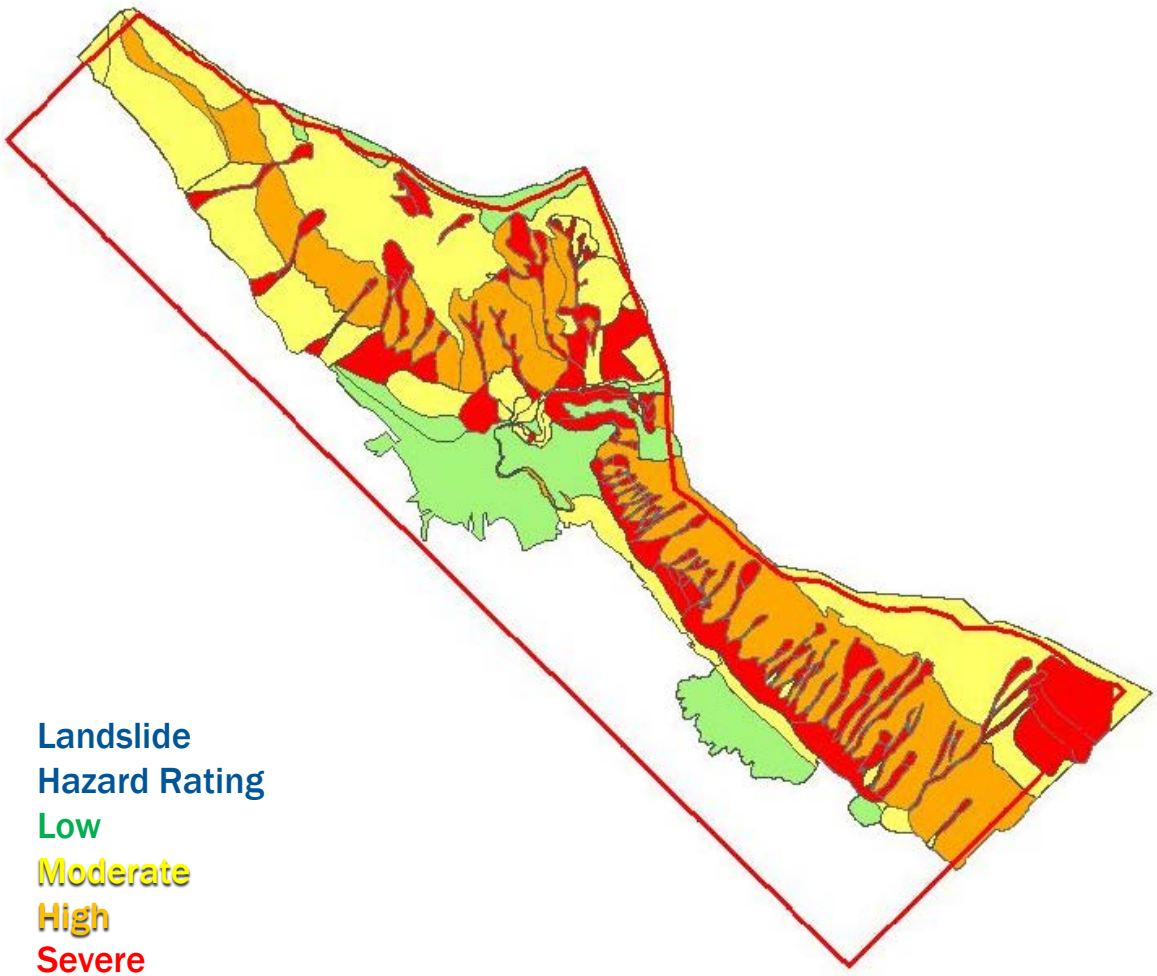
Refined Landslide Hazard Designation System

- **Low**:
  - Gentle to moderate slopes (0° to 26°)
  - No written record of property damage or loss of life
  - No signs of historical landslide activity on the air photos
- **Moderate**:
  - Moderate to Moderately steep slopes (27° to 35°)
  - No apparent written record of property damage or loss of life
  - May be signs of historical activity (scars on trees, vegetated debris lobes or scarps; some historical activity visible on air photos)
  - Can include low-lying areas within the runout zones of slides from nearby slopes above

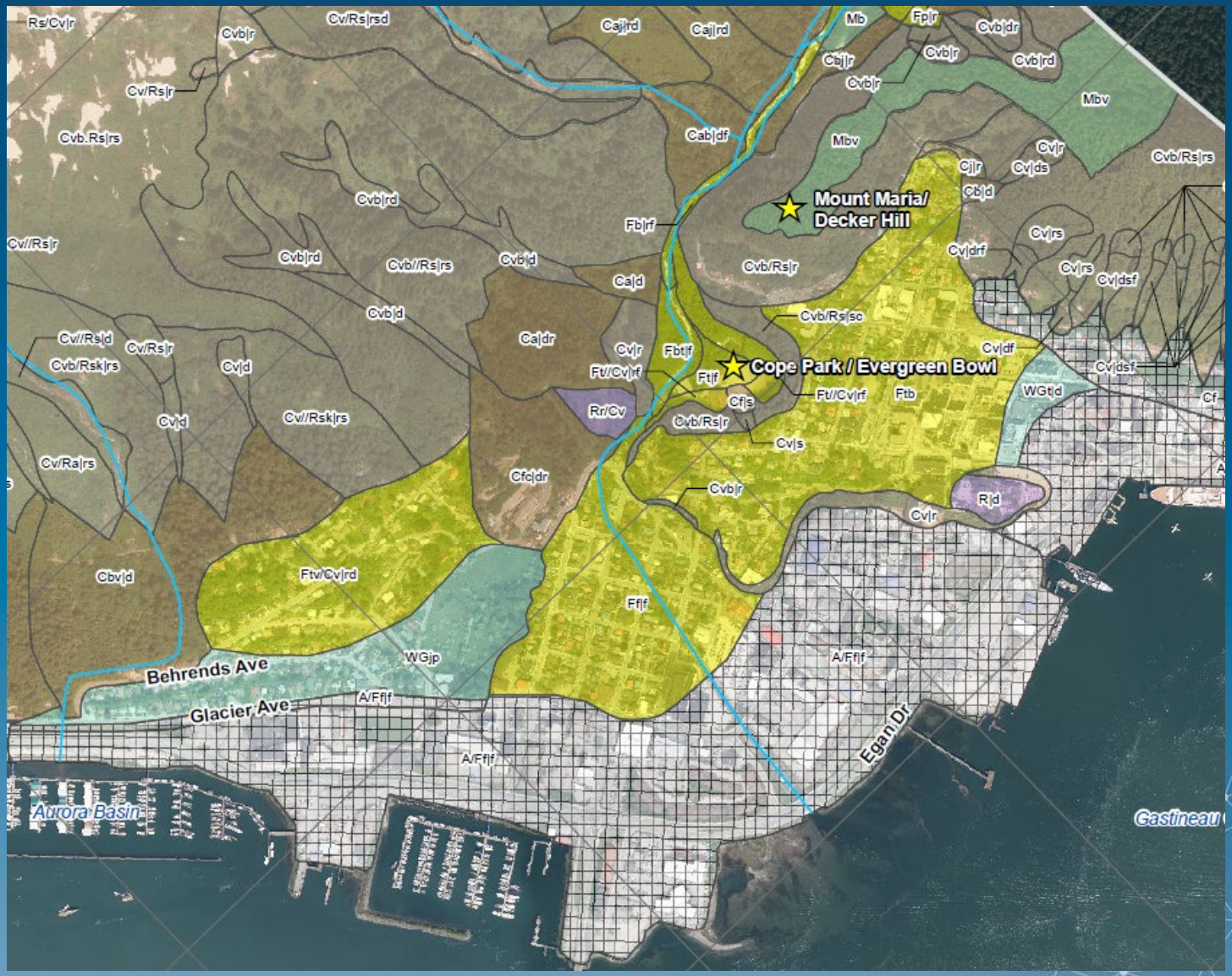
Refined Landslide Hazard Designation System

- **High**:
  - Steep slopes (>35°)
  - May have written record of property damage or loss of life
  - Rockfall can hit trees but doesn't knock them over or destroy them
  - At least two of the following criteria are met:
    - Thin colluvium (Cv)
    - Maximum slope of 70° to 80°
    - Average slope of 40° to 50°
- **Severe**:
  - Steep to vertical slopes (>35°)
  - May have written record of property damage or loss of life
  - Trees are likely to be destroyed
  - Signs of recent activity
  - Signs of repeated historical activity

Testing the new hazard designations

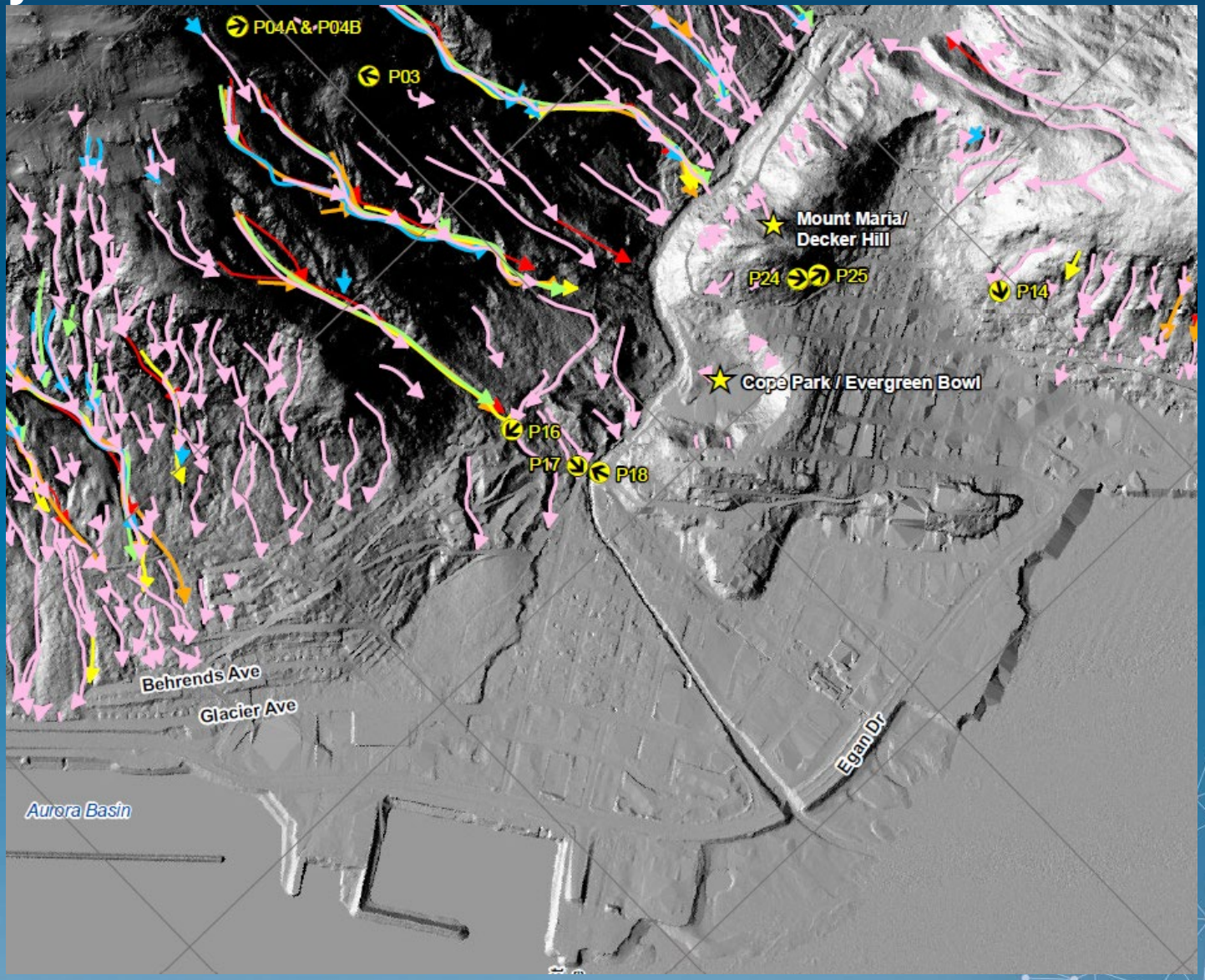


Surficial Geology - Downtown



Historical Slope Movements - Downtown

Gully Erosion Features - Downtown



Behrends Avenue and Ross Way

(Photo Credits: CBJ, Dec 4, 2020)

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Irwin Street Bridge

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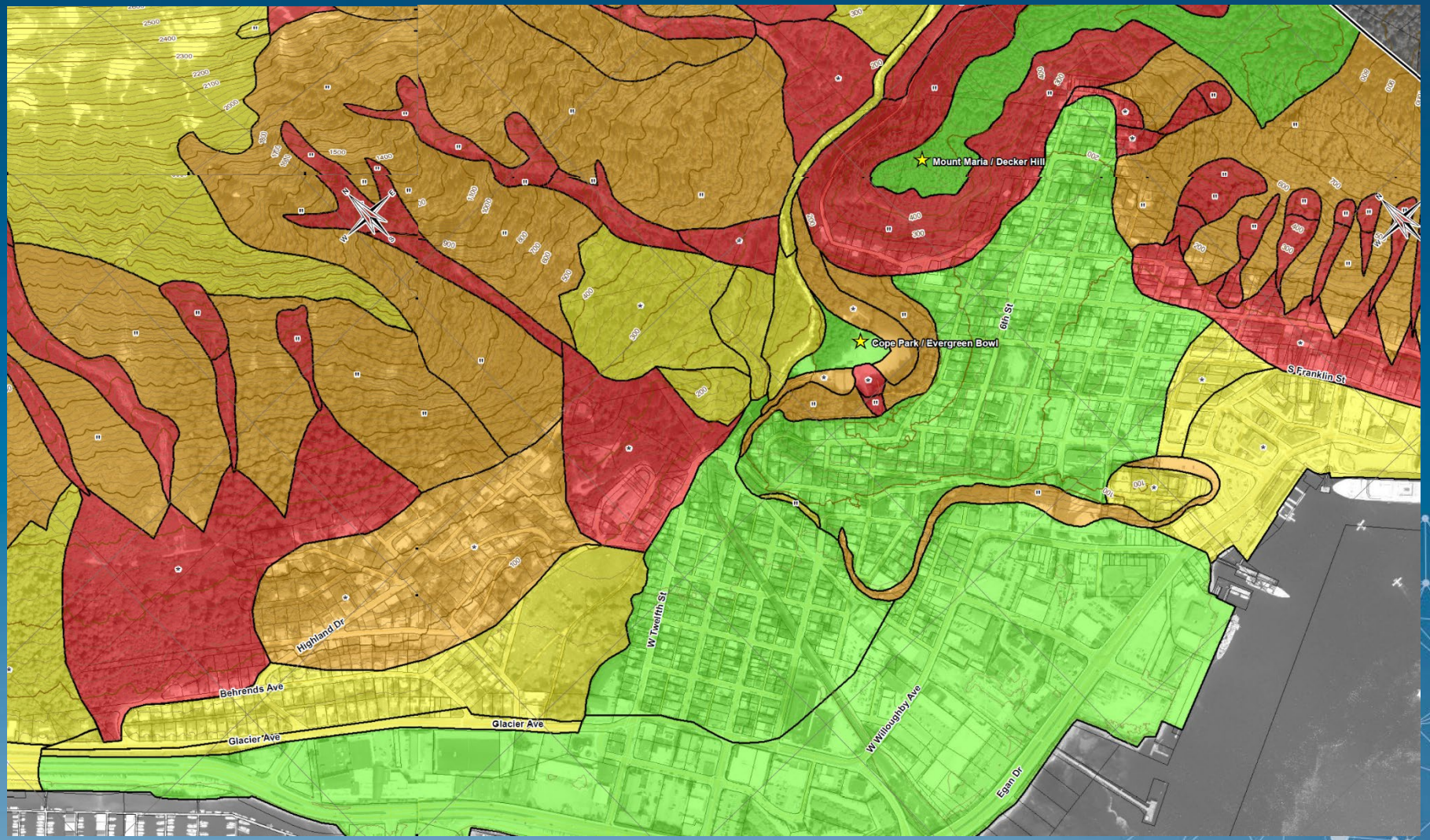
P18

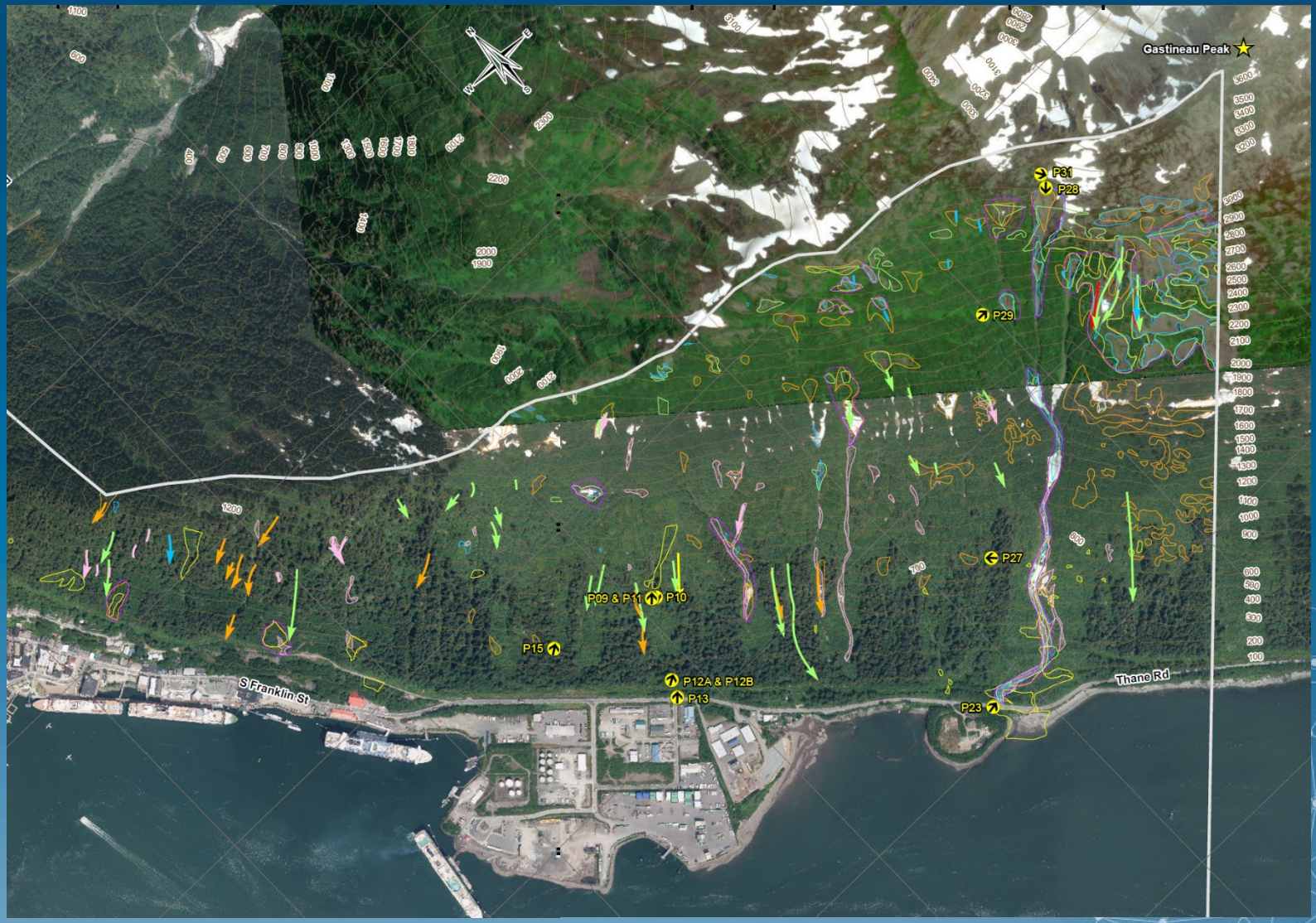
Basin Road

Landslide Hazard Map - Downtown

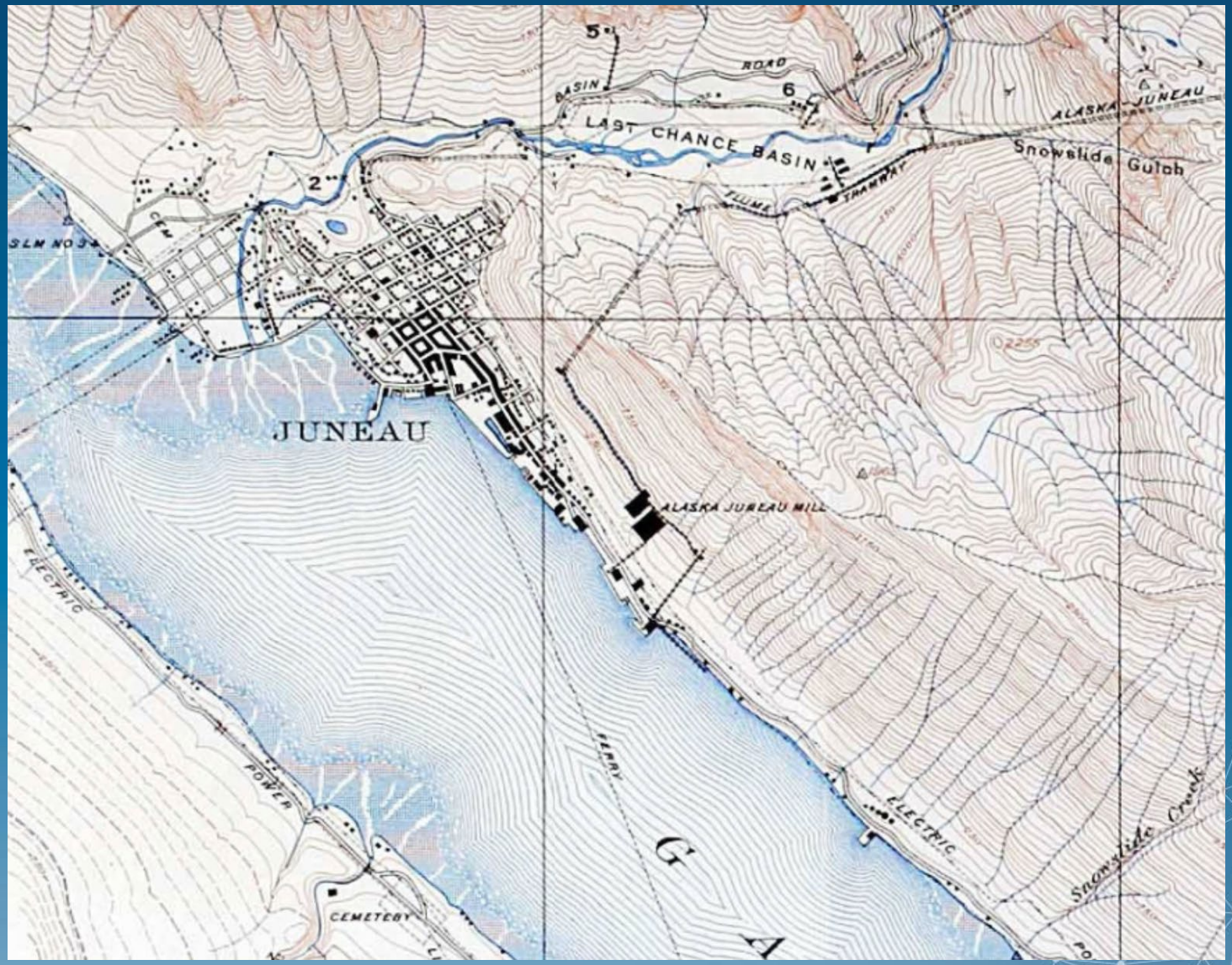


Surficial Geology – Mt. Roberts

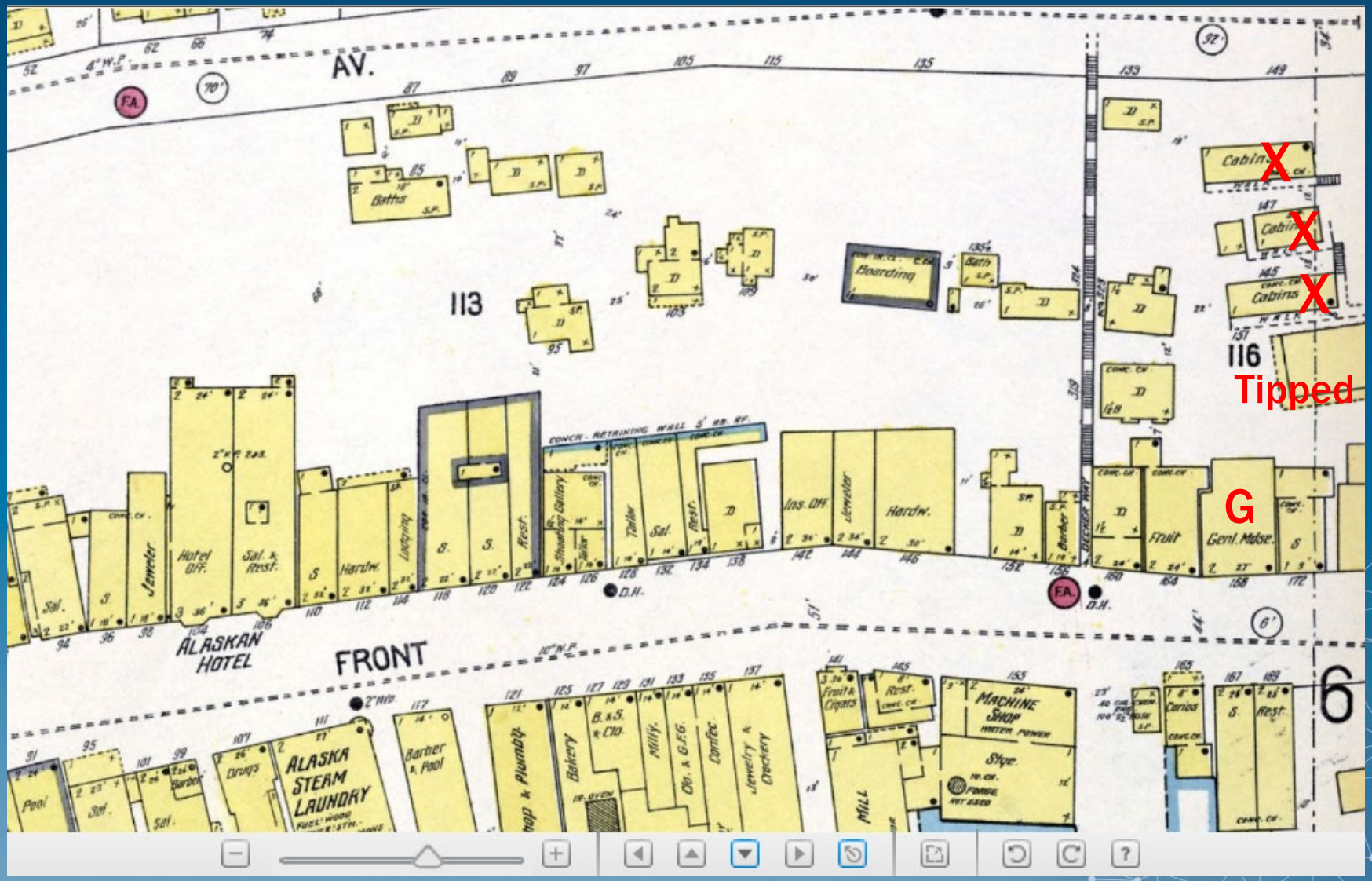
Historical Slope Movements – Mt. Roberts



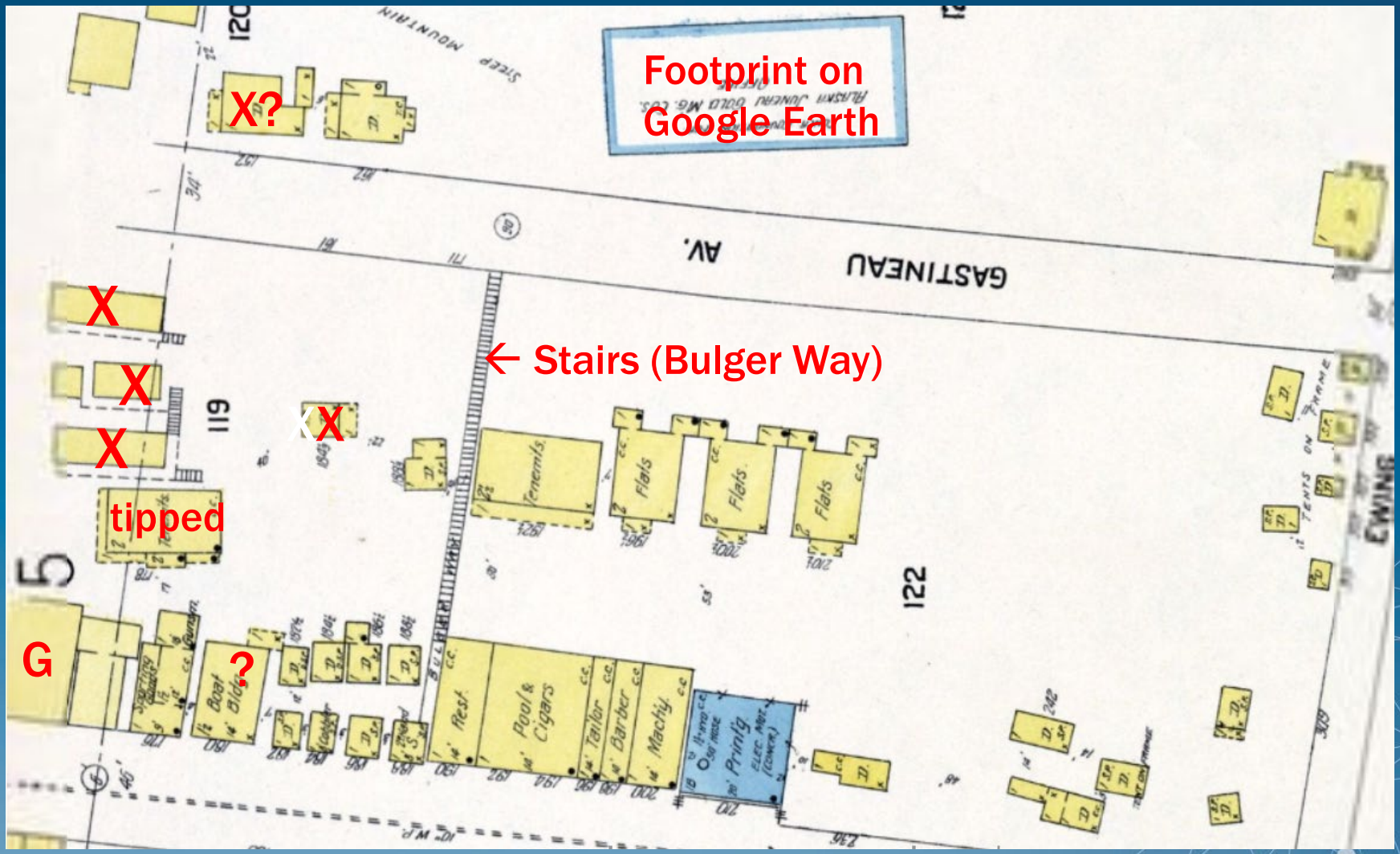
Historical Map - 1914



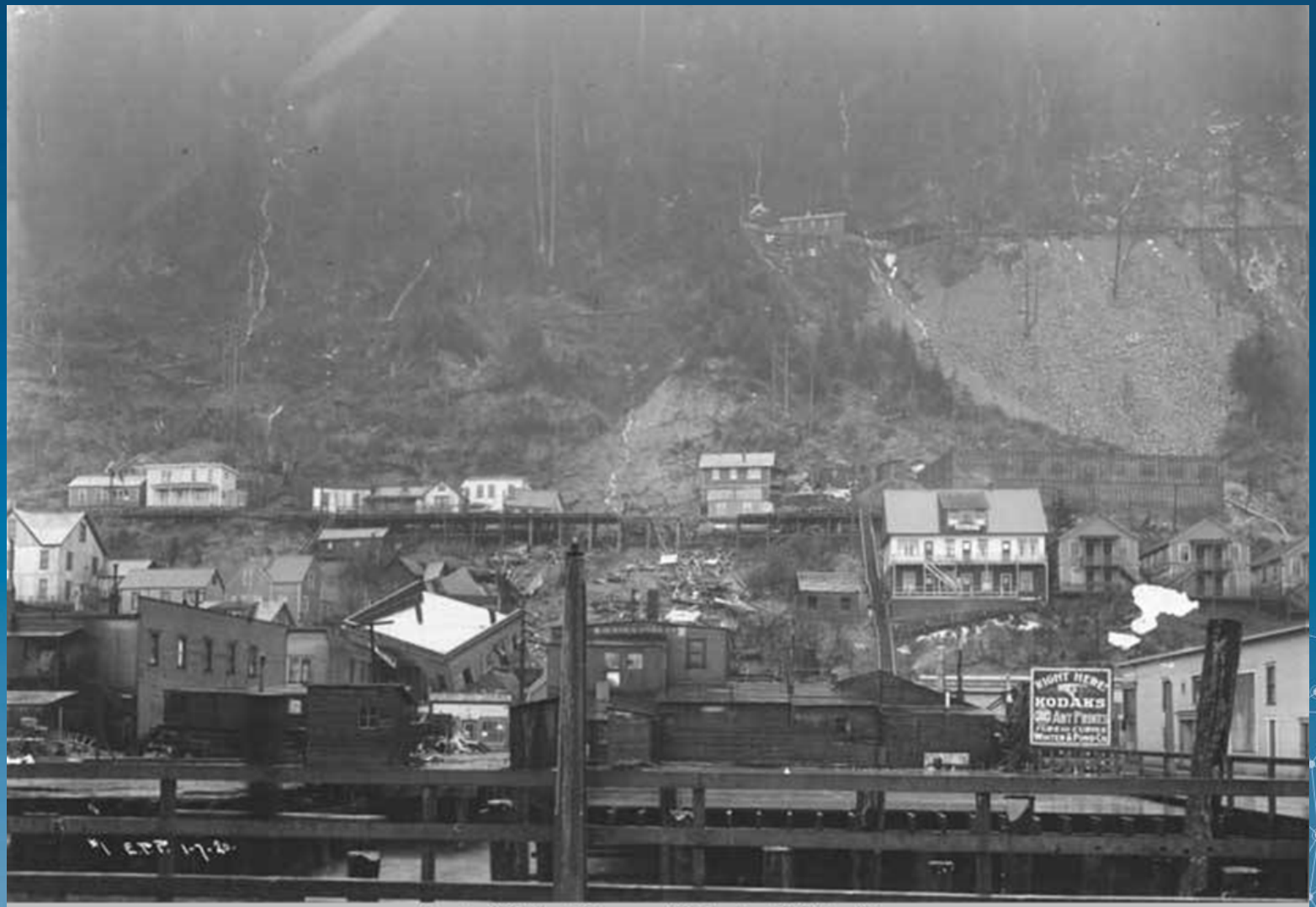
1914 Survey Plan of Juneau – Plate 5



1914 Survey Plan of Juneau – Plate 6



Debris slide January 2, 1920



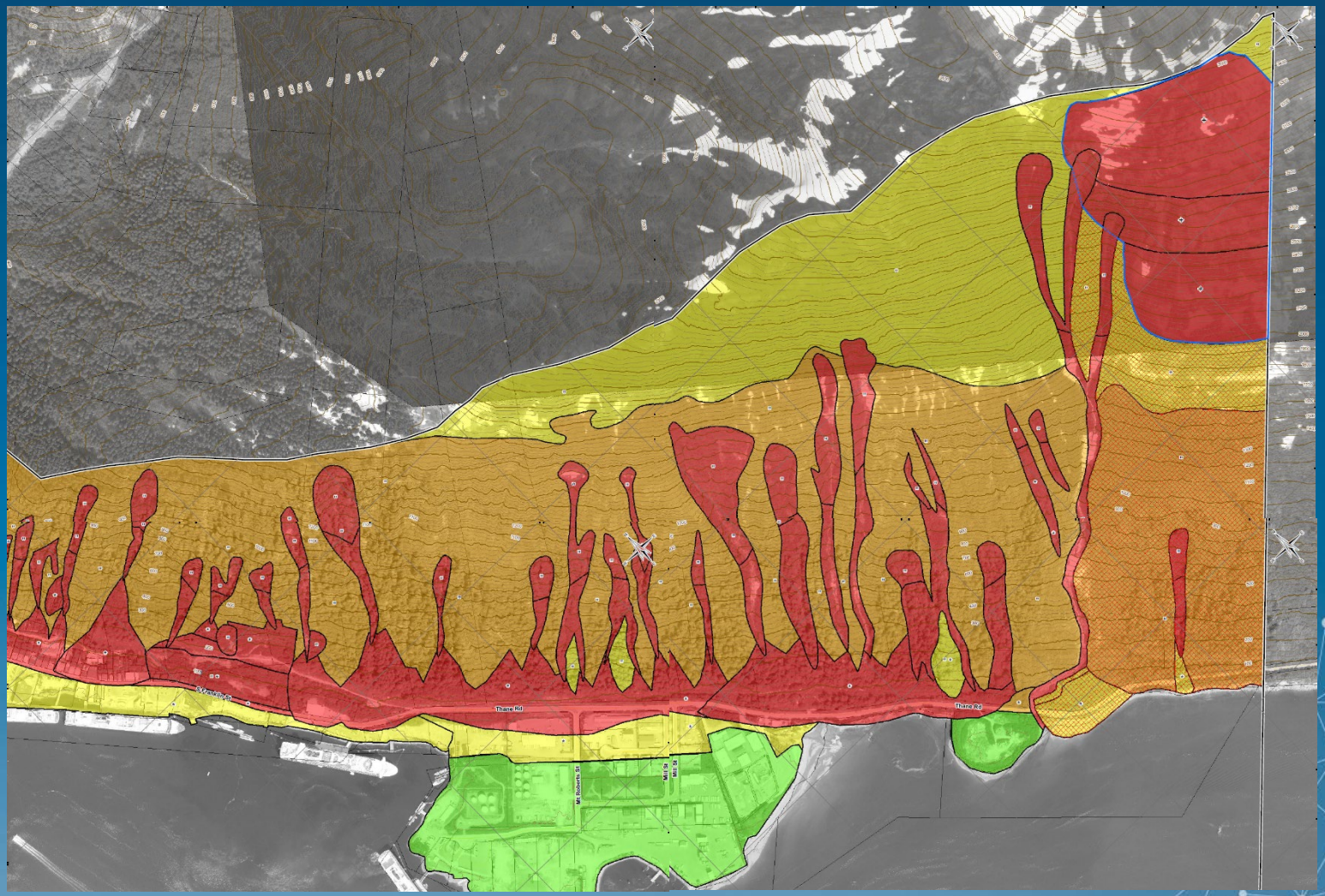
Alaska State Library - Historical Collections ASL-P87-1223

Debris slide – November 22, 1936

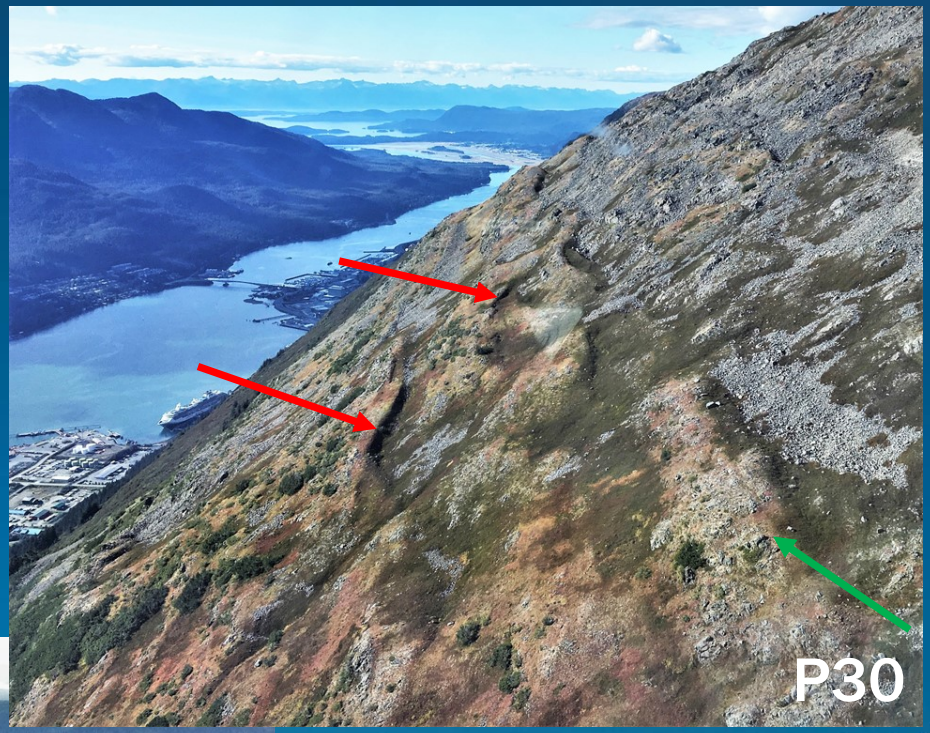
Alaska State Library - Historical Collections

ASL-P109-45

Landslide Hazard Mapping – Mt. Roberts



Potential deep-seated bedrock failure



Conclusions

- Surficial geology of the Project Area was updated, landslide types were identified and mapped, and landslide activity was assessed by reviewing historical air photo records. Fieldwork was done to confirm the mapping.
- The previous system used to designate landslide hazards using Low, Moderate, and Severe was updated to include a new rating of High and the mapping was updated to show Low, Moderate, High, and Severe landslide hazards.
- The maps of landslide activity and gully erosion are only snapshots in time for each year mapped, though they can help to show which areas are very active.
- Use the landslide hazard designation maps to see the extent of problem areas.

Limitations

- The accuracy of the hazard designation mapping relies on information provided by CBJ.
- The landslide hazard designation maps include CBJ's property boundary data.
- The boundaries between Low and Moderate, Moderate and High, or High and Severe should be considered as transitions only, not hard lines.
- The landslide hazard boundaries and designations only account for existing ground conditions, not current or future locations of infrastructure or people.
- The assessment of climate change impacts was not part of this study. Climate change could make the hazards worse, for example, by increasing the intensity and frequency of storm events that could lead to larger or more frequent landslide events.

Thank you!

Questions?