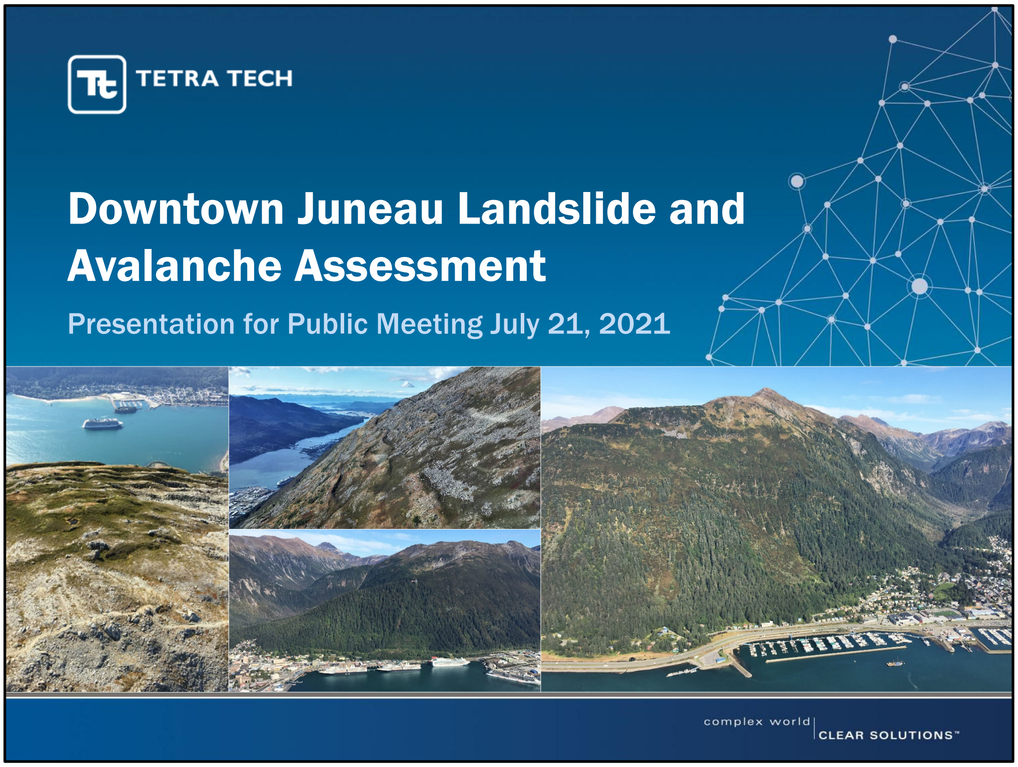
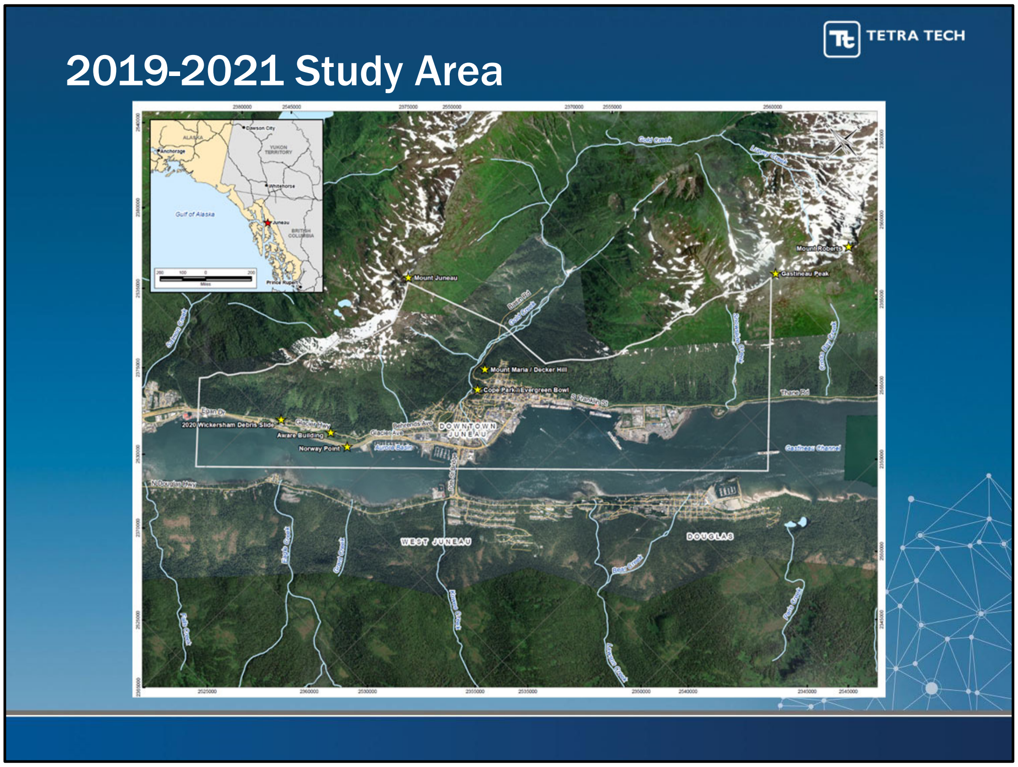
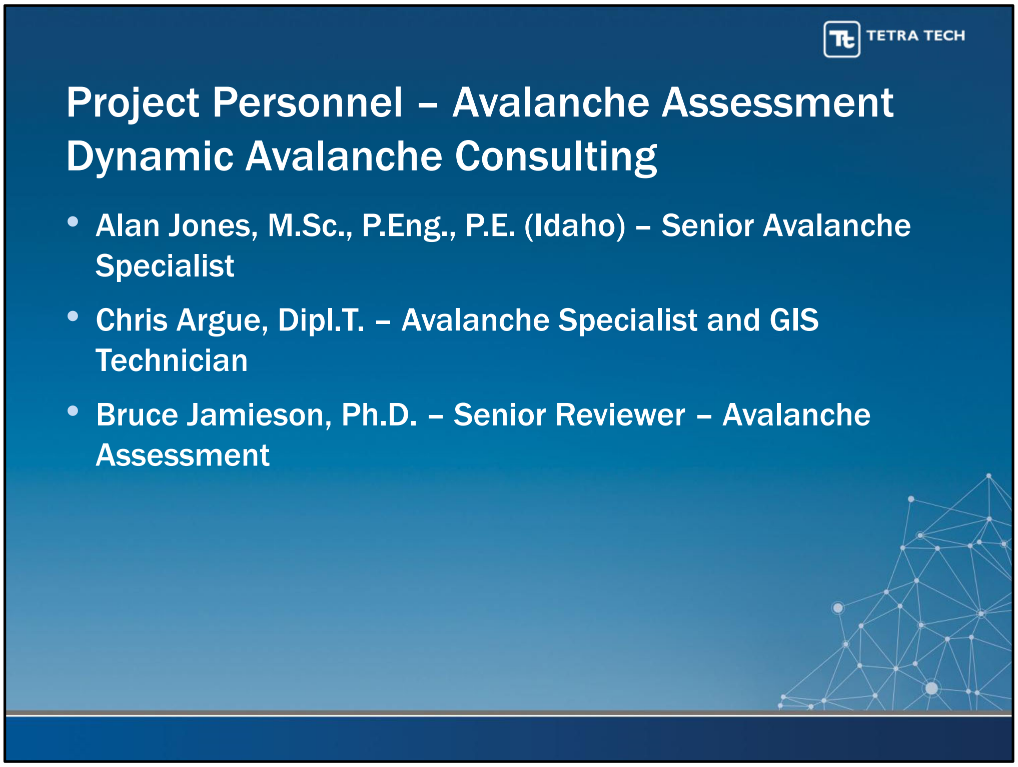


Good evening, everyone. It's a real pleasure for us to join you online tonight. We'll be summarizing the findings from the Landslide and Avalanche Assessment, and we'll have some time for answering your questions at the end of the presentation.

Thanks for your introductions, Teri. I'm Alan Jones from Dynamic Avalanche Consulting and I'll start us off with his summary of the avalanche mapping. Then Rita Kors-Olthof from Tetra Tech will continue with a summary on the landslide mapping and a bit of landslide history in Juneau. Vlad Roujanski can explain more about the mapping procedures if anyone would like more information about that later on.



Here's the project mapping area. You'll notice that we've tipped the image so that northwest is to the left and southeast is to the right along Gastineau Channel. That's so that we can fit more on the page for each of the maps. The mapping extends northwest almost to the Macaulay Salmon Hatchery, and southeast to just past Snowslide Creek.



Here is a list of the personnel from Dynamic Avalanche Consulting who worked on this project. You might have had a chance to meet me, when I was in Juneau in September 2019 for the field investigation.

TETRA TECH

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

TETRA TECH

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/ft² (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/ft² (30 kPa).
Severe	S	▪ Return period less than 30 years; AND/OR ▪ Impact pressure greater than or equal to 600 lbs/ft² (30 kPa).

TETRA TECH

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

TETRA TECH

Methods

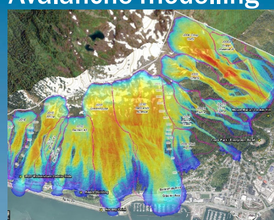
Field Investigation

Historic air photos, imagery, LiDAR

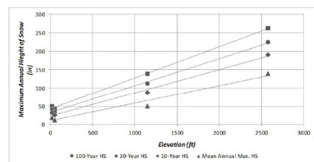
1962

2013

Avalanche modelling



Snow climate



$HS_{100} = 0.0848(Elev) + 42.733 \quad [R^2 = 0.998]$

$HS_{10} = 0.0632(Elev) + 23.817 \quad [R^2 = 0.992]$

$HS_{30} = 0.0736(Elev) + 32.913 \quad [R^2 = 0.997]$

$HS_{Mean} = 0.0478(Elev) + 10.353 \quad [R^2 = 0.970]$

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.

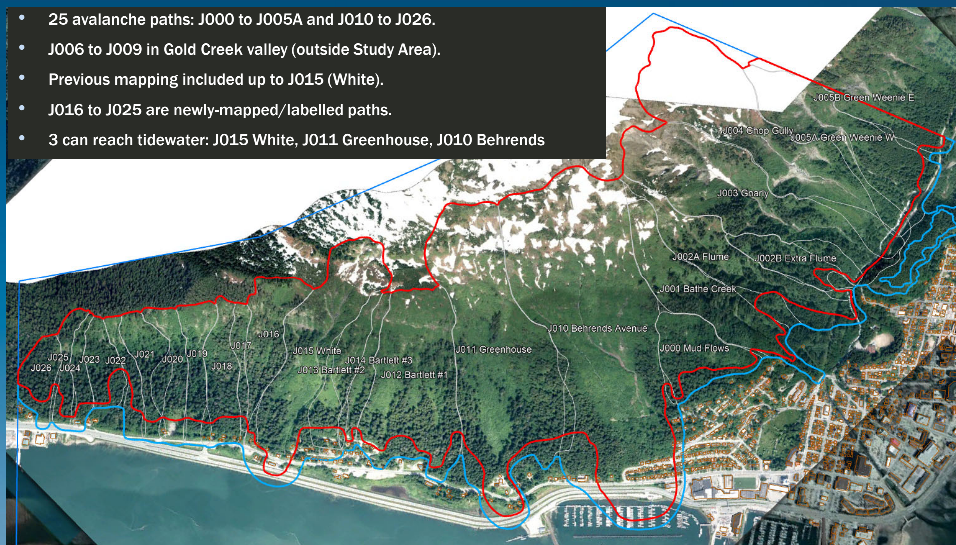
Avalanche Mapping Results

- 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)

TETRA TECH

Avalanche Mapping Results – Mt. Juneau

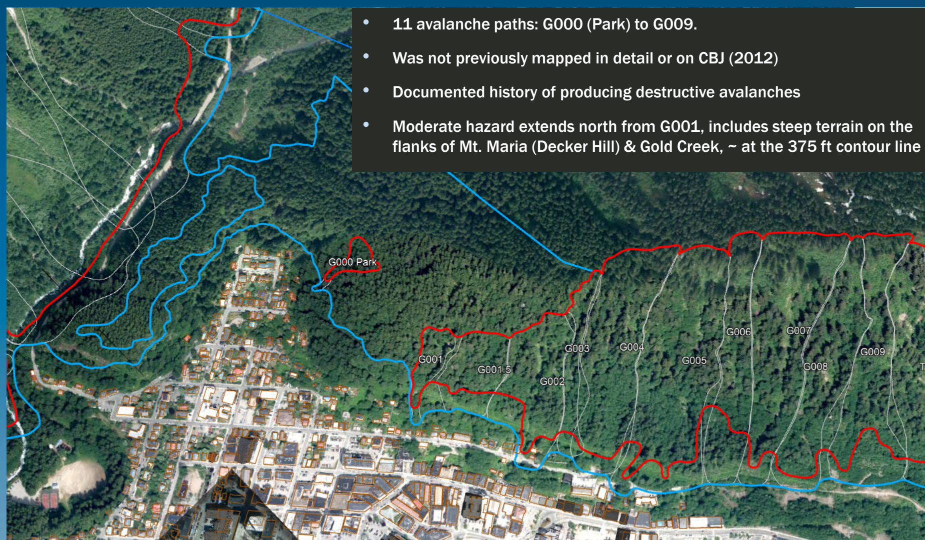
- 25 avalanche paths: J000 to J005A and J010 to J026.
- J006 to J009 in Gold Creek valley (outside Study Area).
- Previous mapping included up to J015 (White).
- J016 to J025 are newly-mapped/labelled paths.
- 3 can reach tidewater: J015 White, J011 Greenhouse, J010 Behrends



TETRA TECH

Avalanche Mapping Results – Gastineau Ave

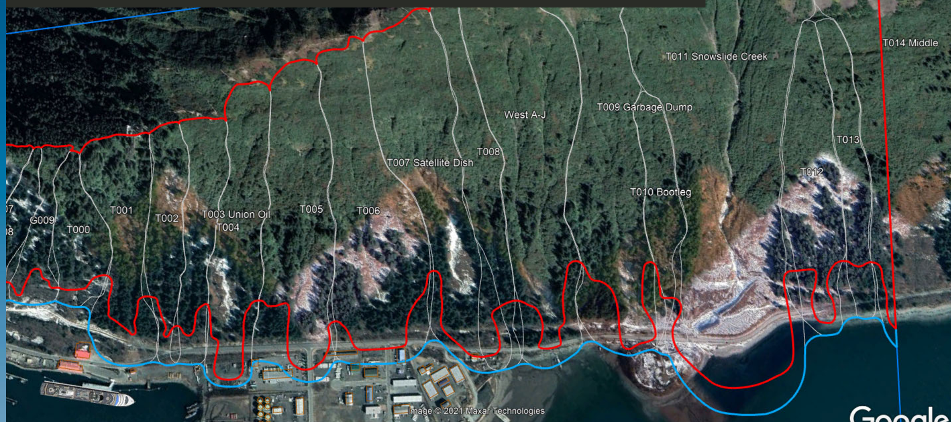
- 11 avalanche paths: G000 (Park) to G009.
- Was not previously mapped in detail or on CBJ (2012)
- Documented history of producing destructive avalanches
- Moderate hazard extends north from G001, includes steep terrain on the flanks of Mt. Maria (Decker Hill) & Gold Creek, ~ at the 375 ft contour line



TETRA TECH

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.

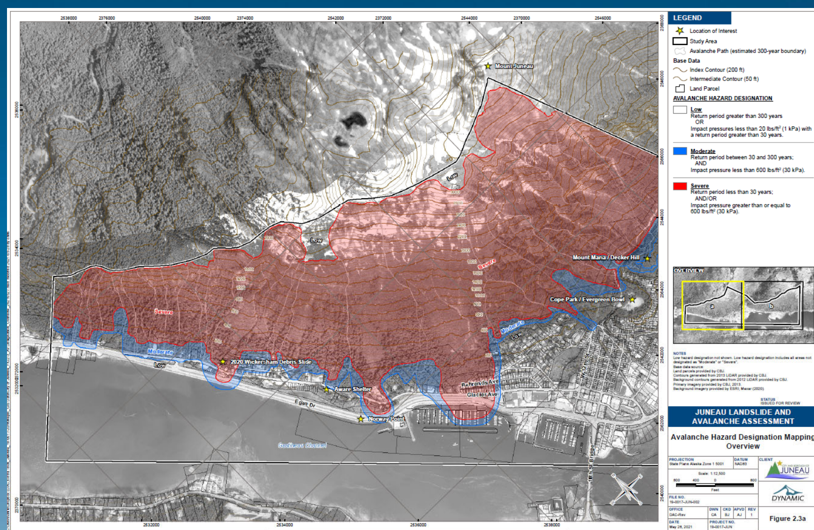


Avalanche Hazard Designation Mapping

- 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)

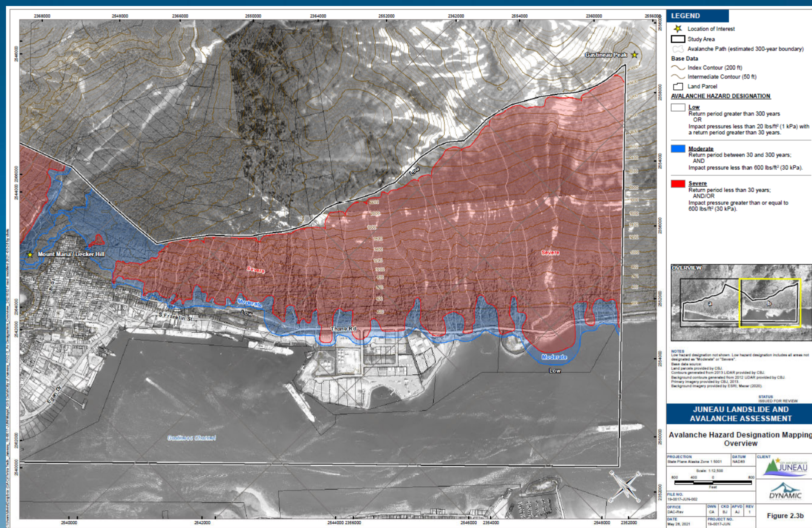
TETRA TECH

Avalanche Hazard Designation Mapping – Mt. Juneau



TETRA TECH

Avalanche Hazard Designation Mapping – Gastineau Ave. and Thane Road



TETRA TECH

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

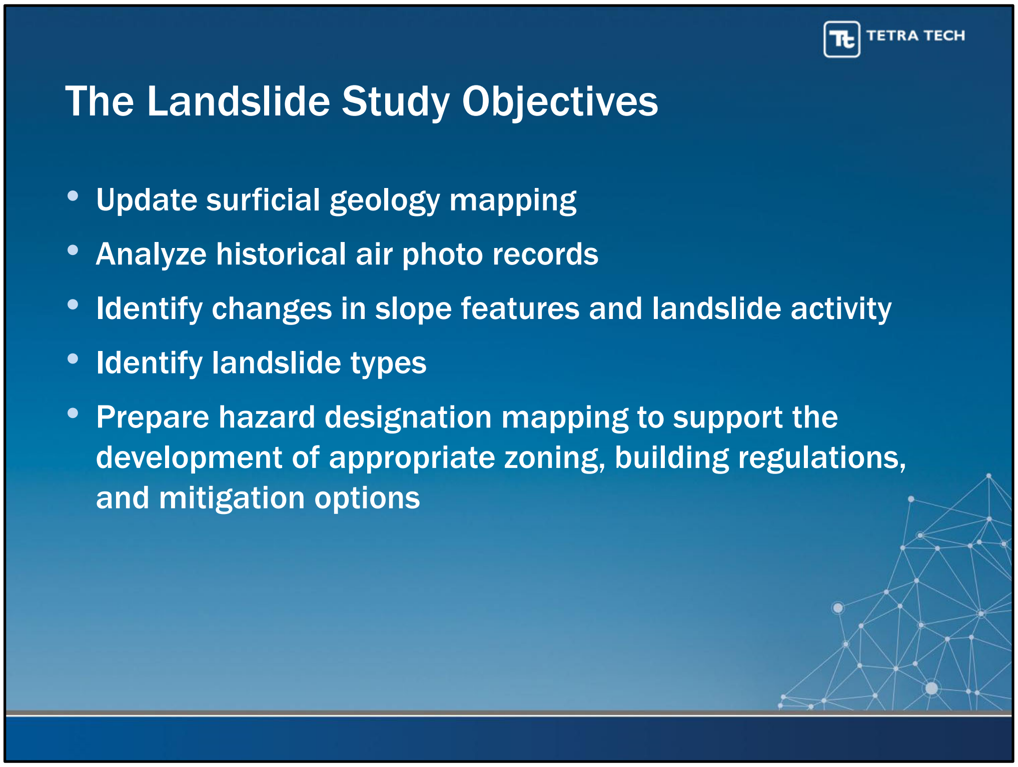
- Avalanches are complex and there is uncertainty in the estimates of frequency and magnitude. Uncertainty reduced by combining and weighting results using various methods.
- Boundaries between *Low*, *Moderate*, *Severe* areas are not hard lines, but rather as transition zones – they do not follow property 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).

TETRA TECH

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

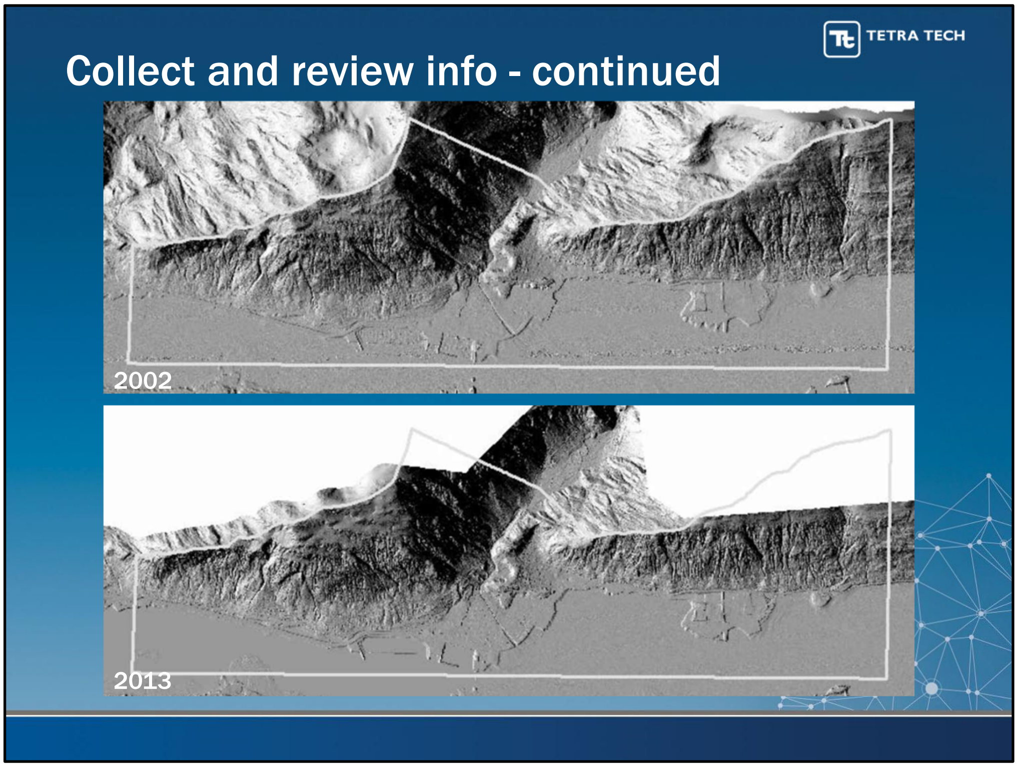
Hi, I'm Rita Kors-Olthof from Tetra Tech. Here are the staff from Tetra Tech who were involved in this project. You've already been introduced to Vlad and me. Shirley McCuaig and Ernest Palczewski worked on the mapping. Some of you might remember Shane Greene, who was in Juneau in September 2019 for the fieldwork. Megan Verburg did the cartography, and Nigel Skermer did the senior review.



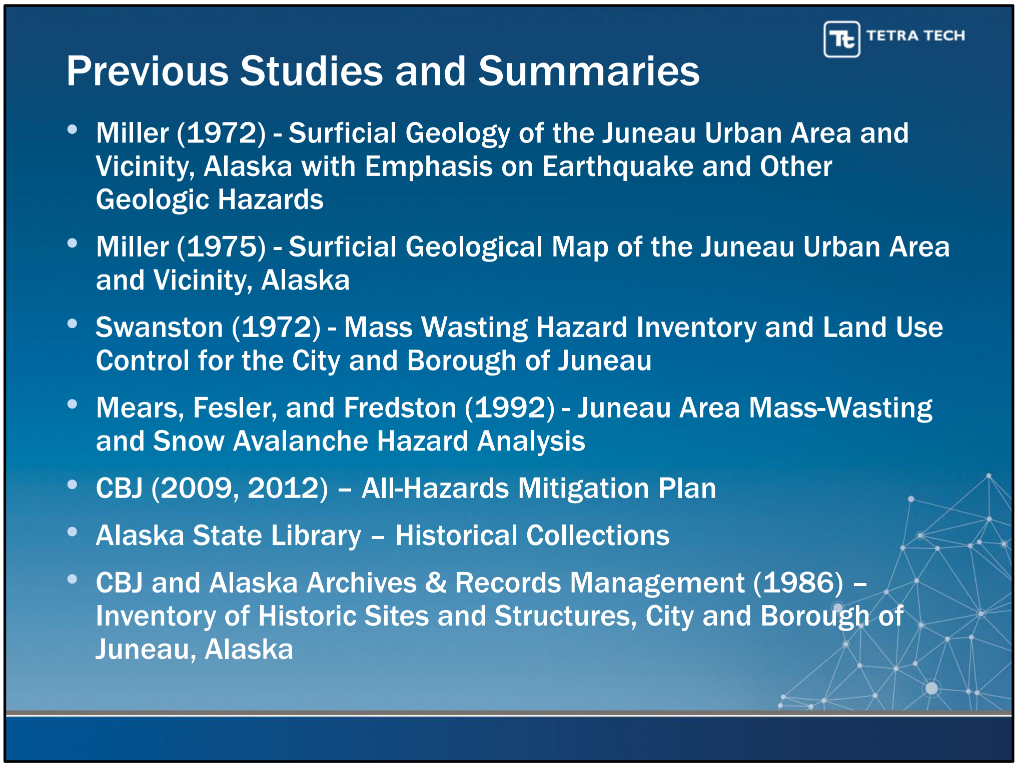
Here is a list of the main goals of the landslide study: update the surficial geology mapping, analyze the historical air photo records, identify changes in slope features and landslide activity, identify landslide types, and prepare the hazard designation mapping to support CBJ's next steps.

The first part of the project was to collect all the information for mapping surficial geology, historical slope movements, and gully erosion features. This information also helps in deciding if a landslide area only slides once in a blue moon, or if it might slide every year or two. We reviewed air photos, satellite images, LiDAR bare earth hillshade models, LiDAR elevation data, geological mapping, previous hazard assessment reports, and incident reports from CBJ.

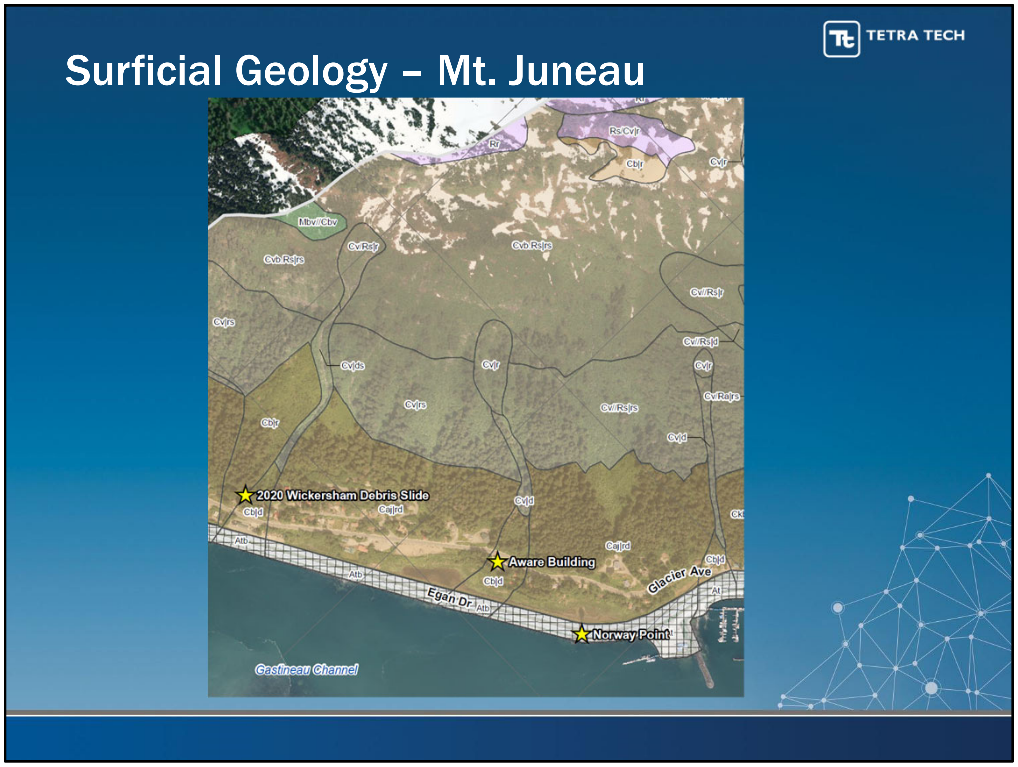
Air photos and LiDAR models are very important parts of the review, because they let us see the slopes and features in 3D. Here are a couple of examples of the coverage that was available for air photos, and how they fit into the project area. We used the 1948 air photos to create the baseline for the maps. The imagery from 1962 that we see here was much better quality than 1948, because cameras were so much better by 1962. So, the baseline mapping was checked as needed using the 1962 air photos. We can see that there were a few gaps in 1977, but the 1997 air photos and the August 2006 colour satellite image were complete.



The 2013 air photos and bare-earth hillshade LiDAR had two areas missing, at the top of Mt. Juneau, and along part of the ridgeline on Mt. Roberts. The 2002 LiDAR coverage included those missing upper slopes, so 2002 was used to fill in the gaps. The main goal was to find enough imagery that showed the slopes in different years for us to be convinced that we understood the slope processes and had a clear idea where the trouble spots are.



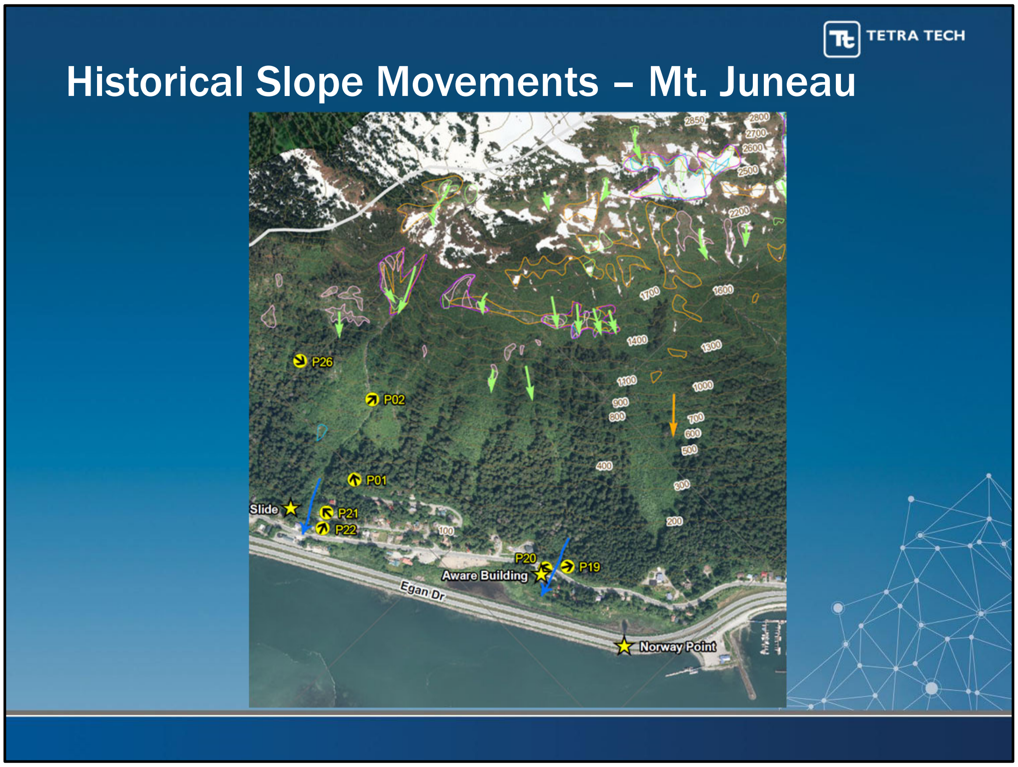
Here's a list of the previous landslide studies and observations in Juneau between 1972 and 2020, including surficial geology work by Miller in 1972 and 1975; a landslide inventory by Swanston in 1972; more landslide study by Mears, Fesler, and Fredston in 1992; and incident reports summarized by CBJ in 2009 and 2012. CBJ also provided a few other incident reports specifically for this project. For more information on slides that happened before 1948, we also looked up historical photos from the online collections at the Alaska State Library, and we reviewed the Inventory of Historic Sites and Structures.



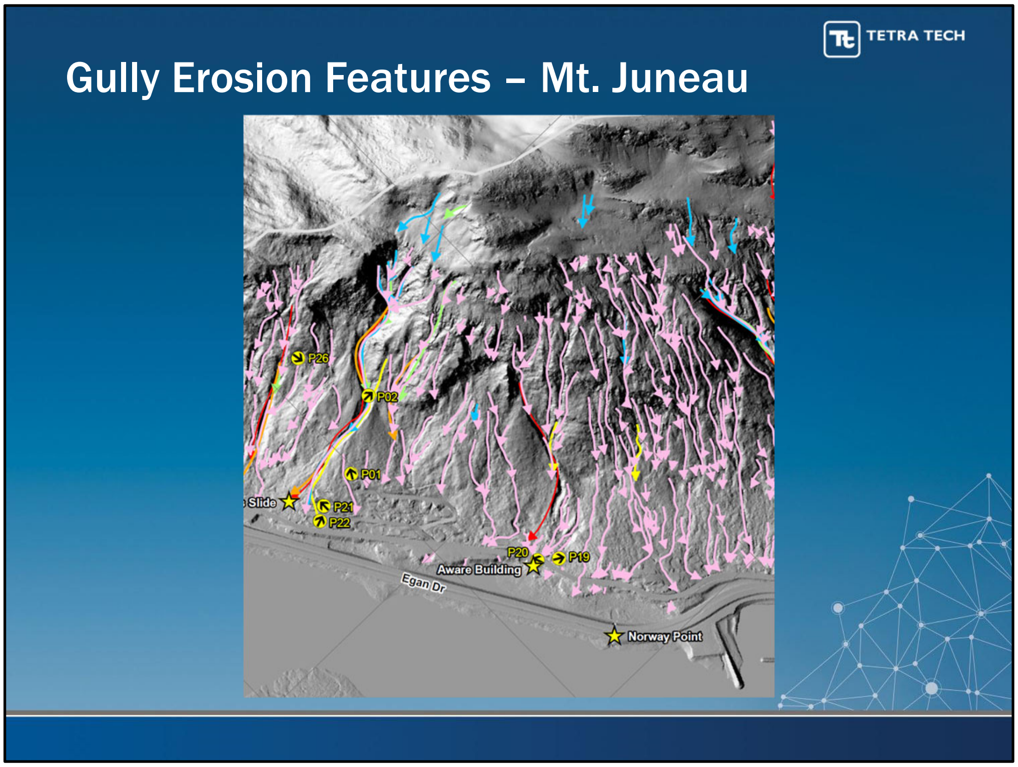
Now, we'll have a quick look at a few points of interest in the mapping, and places that you'll probably be familiar with. Let's start near the northwest end of the project area at Mt. Juneau, with an excerpt from the surficial geology mapping. All the different surficial geology types are identified by their own codes. The purple areas are mostly exposed bedrock (the code for which starts with R for rock), and almost all of the rest is colluvium (the code for which starts with C). Colluvium is material that has fallen, slid, or flowed downslope to end up where it is now, and it could consist of rockfall, rock slides, debris slides, debris flows, creep or slumping. All the brown areas are different areas of colluvium, which might also have some areas of exposed bedrock – like upslope in a bunch of the lighter-coloured areas. Or they might not have exposed bedrock at all – like the lower slopes in the darker-coloured areas. Those long, narrow up-and-down strips show where there are prominent debris flows or slide areas, like the ones at the AWARE shelter and at the northwest end of the White Subdivision on Wickersham. We'll talk about those long narrow strips again later.

The cross-hatching along the shoreline shows where people have made a lot of changes in the terrain, mostly from placing fill to create a larger land area or, in this case, building Egan Drive. That tiny green area at the top of the ridge is almost all moraine or till, from a glacier.

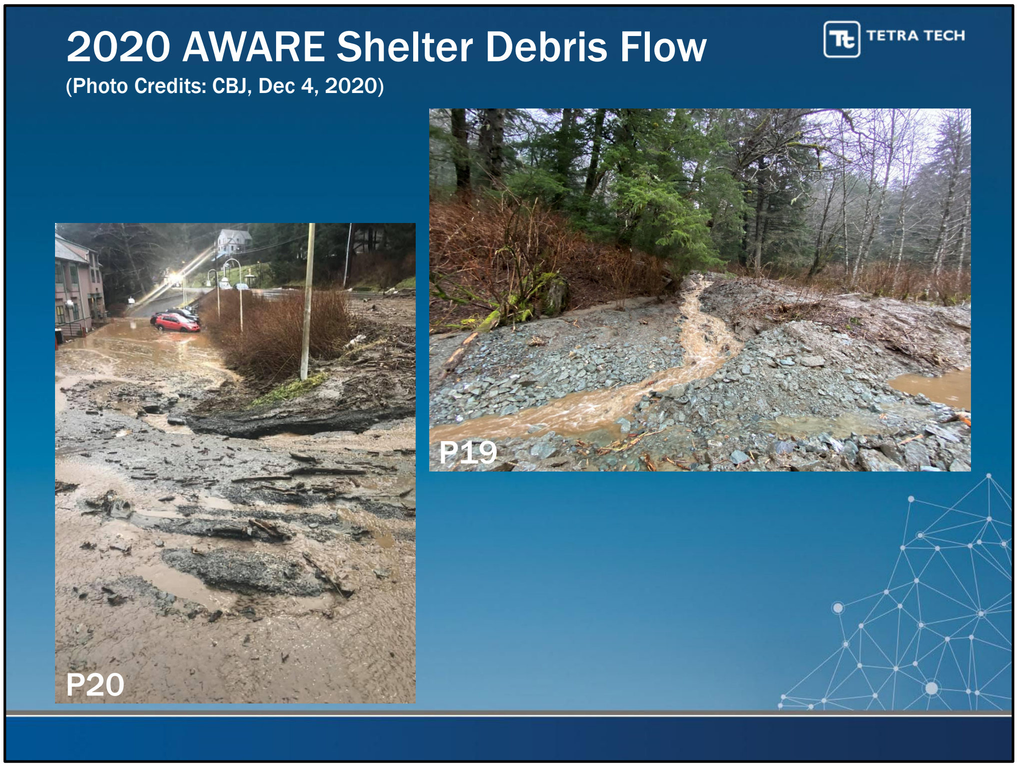
You've probably noticed that these surficial geology codes have lots of sub-codes for more description – is it a thin layer or is it thick, is it steep or flat, is it a ridge, terrace, cone, or fan? Is there a debris flow or slide, or rockfall? Is there a combination of materials, like bedrock and colluvium? In that case you'll see another set of codes after the first. Don't worry too much about the details – even that very first uppercase letter tells you a lot.



Now let's look at the same part of the slope, and see what the historical records can tell us about where the slope has been moving, with evidence from the air photos, satellite imagery, site investigations, and the incident reports. The arrows and outlines are coded by colour to show which air photo year they were identified on. On the lower left, we have the Wickersham Debris Slide area, and the blue arrow at the channel shows that something happened there in 2020. Same thing at the AWARE shelter further southeast. The yellow circles with arrows in them show the location and direction of photos taken at each site that was checked, or that we received info for.

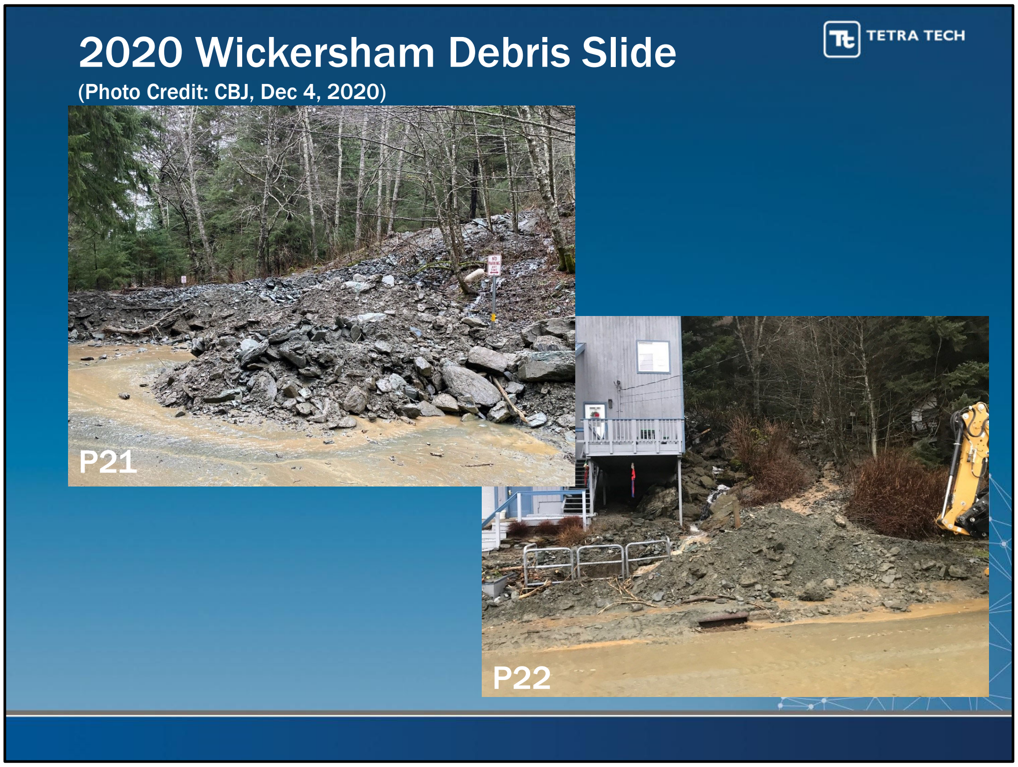


Here are all the gullies that were mapped from the imagery. You might ask, why map the gullies in such detail? That’s because they’re another major way of moving debris downslope, like flushing water, dirt and rocks down half-pipes or conduits, and there are a lot of them! Different colours of arrows mean the gullies were mapped from different years of imagery. All those pink arrows are from the 2013 LiDAR. It looks like there was a lot more activity in 2013, but that’s only because they’re so easy to see on the LiDAR bare-earth image. Looking at the Wickersham Avenue and AWARE shelter areas, notice that there are few different colours of arrows there. The red ones are from 1948, so we know that those gullies have been there for decades and probably longer. We can also see that there is lots of activity in different years at Wickersham.

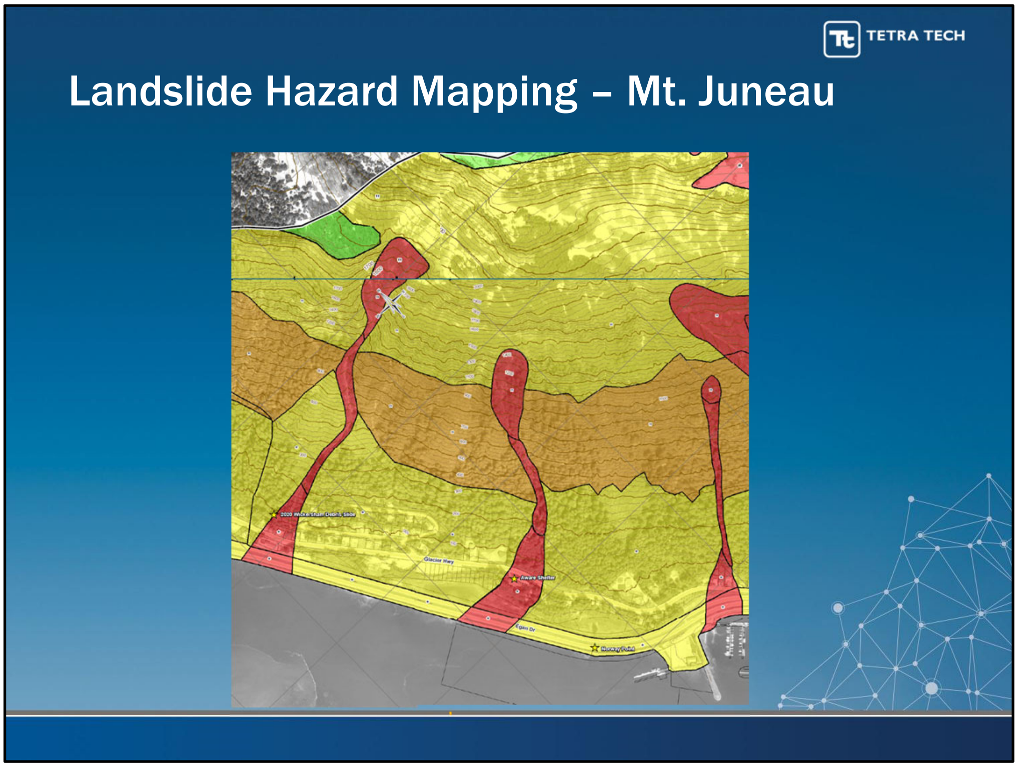


Here are a couple of photos from CBJ, taken on December 4th, 2020, at the debris flow at the AWARE Shelter. They're numbered the same as the photos in the report if you want to look at them again later. Photo P19 is looking southeast and upslope at the debris being deposited on Glacier Highway above the shelter. Photo P20 is looking northwest below Glacier Highway at the parking lot of the shelter, where the debris ended up.

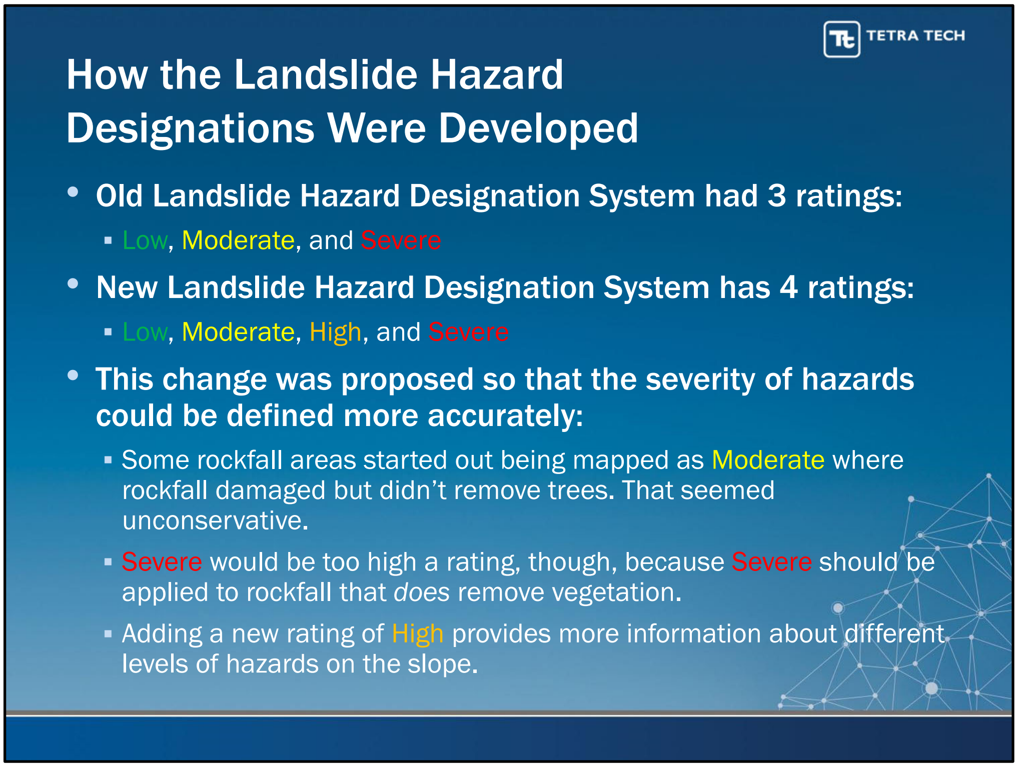
More info: The National Weather Service reported about 6.5" of rain in 48 hours at the Juneau Airport on December 2nd, almost the same amount of rain that would usually fall in the whole month of December. A record-breaking 4.9" of that rain happened in 24 hours on December 1st. By the end of December, Juneau had received more than double its normal amount of precipitation for the month, at about 12.7". (Not a record for December – that was 13.6" in 1997.)



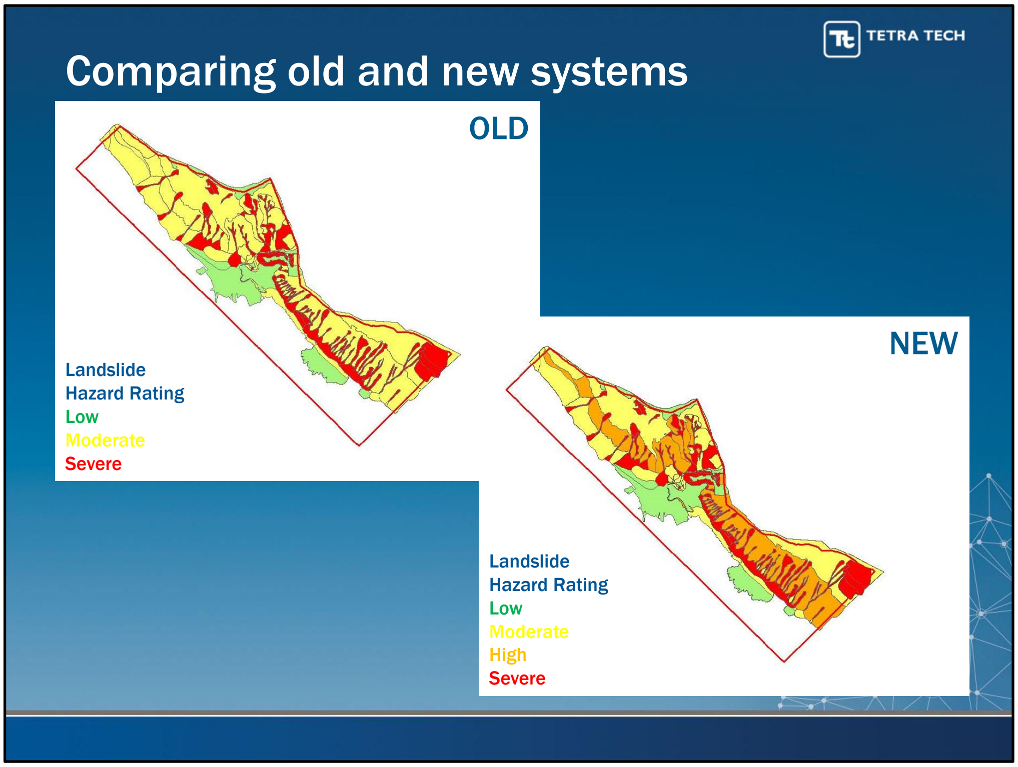
Here are a couple more photos from CBJ, also from December 4th, at the debris slide at the northwest end of the White Subdivision. Photo P21 is looking diagonally upslope at the debris that landed on the northwest end of Wickersham Avenue in the cul-de-sac. Photo P22 is looking upslope at 2020 Glacier Highway where the debris ran out onto the road. The guardrail is located at the concrete sump, which appeared to have been mostly plugged with debris.



All those different kinds of maps that were created, plus the recent observations, lead us to yet another kind of map – the Landslide Hazard Designation Map. All those shapes with different codes on them on the surficial geology map are now classified with different landslide hazard designations. Remember the long up-and-down strips on the geology map? Here, you can see that the long narrow strip at the Wickersham Avenue debris slide is shown in red, which means that the hazard is Severe in this area. Same for the debris flow area at the AWARE Shelter. The slopes beside those red zones that are coloured in yellow are Moderate hazard areas. But further upslope, the areas in orange are designated with a High hazard. The small areas of green at the top are designated as Low hazard.

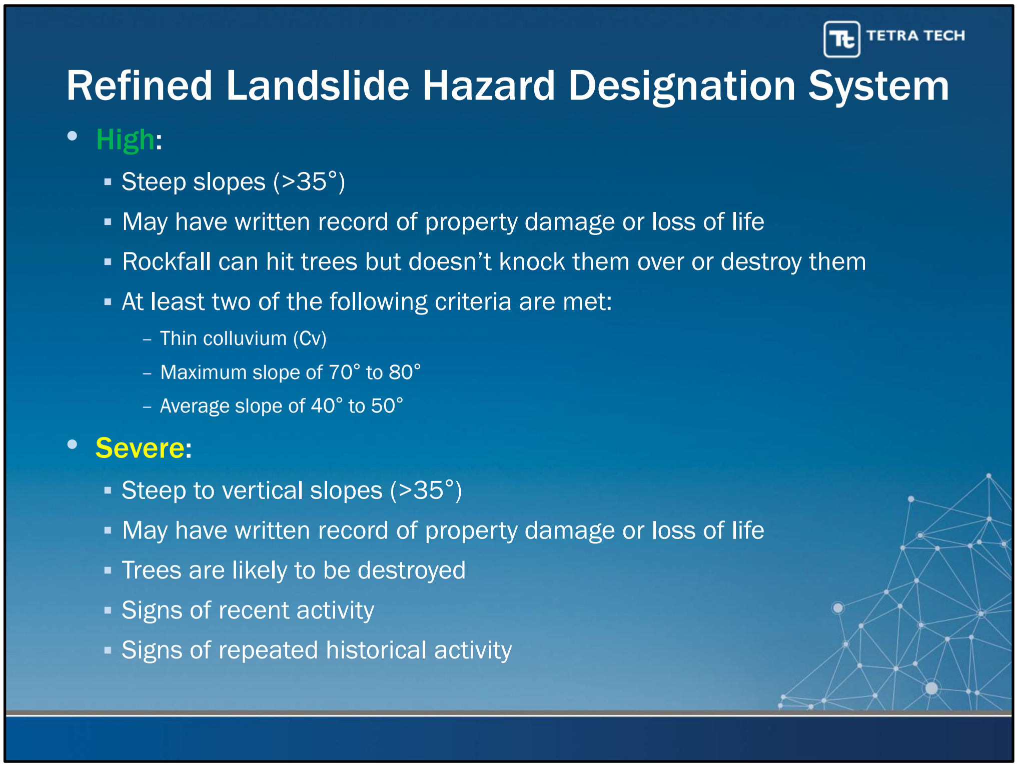


Let’s talk a bit about how the landslide hazard designations were developed (READ SLIDE).



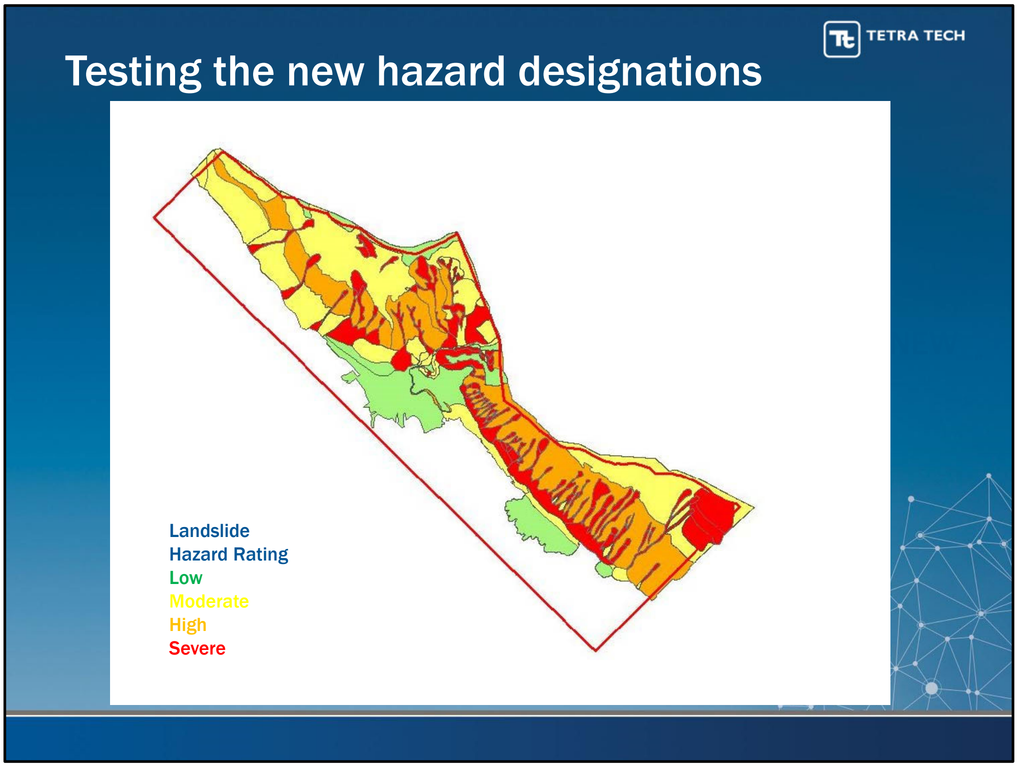
When we compare the landslide hazard maps made with the old system to the maps from the new system, this is what we get. You can see that with the addition of the new High hazard designation, we can pin down a lot more information about the slope. We can clearly see now that the mid-slope on Mt. Juneau has more stability issues than the upper and lower slopes, and we also know that a lot of those issues are due to rockfall. Something similar happens on Mt. Roberts, where we see that most of the upper slope and the very bottom of the slope looks pretty good – only rated Moderate. But most of the lower slope is kind of a mess – rated either High or Severe. Having the High rating really helps us to key in on the differences between those slope areas.

Now, let’s have a closer look at what we mean by Low, Moderate, High, and Severe hazard designations. For Low and Moderate, the slopes are not as steep as for High and Severe. There should be no written record of property damage or loss of life for either Low or Moderate. For Low, there are no signs of historical landslide activity on the air photos. For Moderate, there might be signs like scars on trees, or debris lobes or scarps that are vegetated, and some historical activity seen on the air photos. Moderate can also include low-lying areas that receive debris from slopes above.

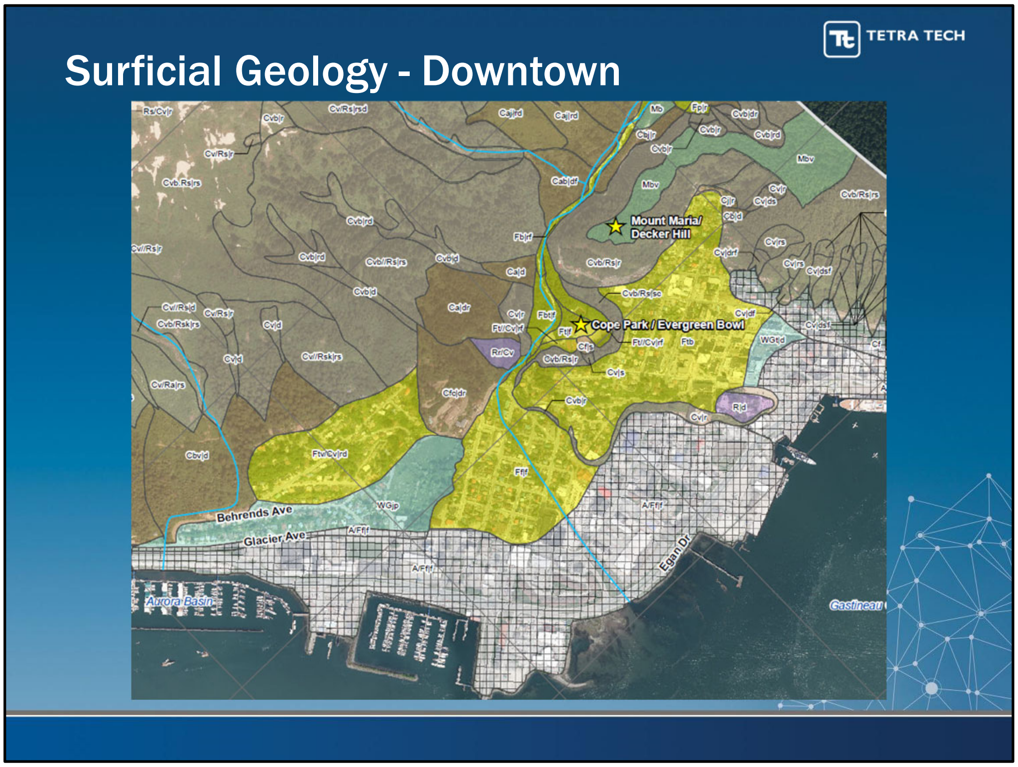


For High and Severe hazard designations, slopes are steeper than 35 degrees, and both can have written reports of property damage or loss of life.

Now we come to the differences between the two. For High, there can be rockfall that hits trees but doesn't knock them over or destroy them. For Severe, trees are likely to be destroyed. For High, you might not be able to see from the air photos that rockfall is happening, but for Severe, there will be signs of recent activity on air photos or from field inspection (like rockfall tracks, debris slide tracks, debris flow paths) and, usually, evidence of repeated historical activity, like when we saw a bunch of different coloured arrows at the same place on the maps for slides and gullies. Slopes that aren't bad enough to be considered Severe, but are iffy for Moderate, can be considered High if they meet at least 2 of these 3 criteria: thin colluvium, maximum slope of 70 to 80 degrees, average slope of 40 to 50 degrees.



Let's look a bit closer at the reasons for designating a High hazard. We tested each category in the surficial geology mapping to see which types of materials typically ended up being more hazardous. That turned out to be colluvium, which makes sense, since it has already *been* moving, and could easily move again. But we discovered something else too. *Thinner* layers of colluvium turned out to be *three* times as likely to be rated Severe instead of Moderate. *Thick* colluvium was *twice* as likely to be rated Severe instead of Moderate. Steeper slopes, up to 70 to 80 degrees, and averaging 40 to 50 degrees, were *5 times* more likely to be rated Severe than Moderate. (That wasn't the case for the near-vertical bedrock cliffs or bluffs, which were equally likely to be rated Severe or Moderate.) Considering those three factors, and checking specific map areas of concern, a High hazard was warranted where at least two of those three factors was present.

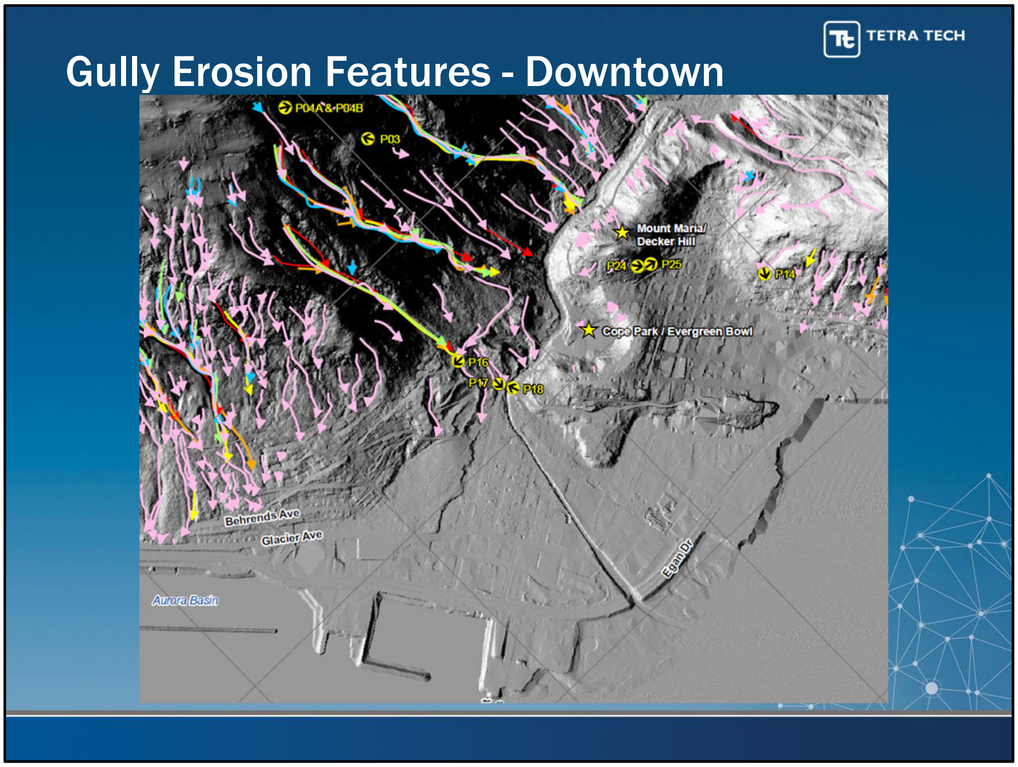


Here's another excerpt from the surficial geology mapping, a little further southeast. Mt. Juneau is on the left, and Mt. Roberts is on the right. You can tell from all the cross-hatching that downtown had a lot of fill material placed to make more room for buildings. In the middle of this image, the side slopes of Cope Park (or Evergreen Bowl) are very clear in the mapping – you can see the colluvium that looks like a backwards C on the map. The colluvium winds its way through downtown to the shoreline, which includes a section along Dixon Street and Calhoun Avenue at the retaining walls. Just to the northeast of Cope Park, there is another stretched-out C shape with colluvium that goes around the sides of Mount Maria at Basin Road and 6th Street. That colluvium continues on, around the Starr Hill subdivision.

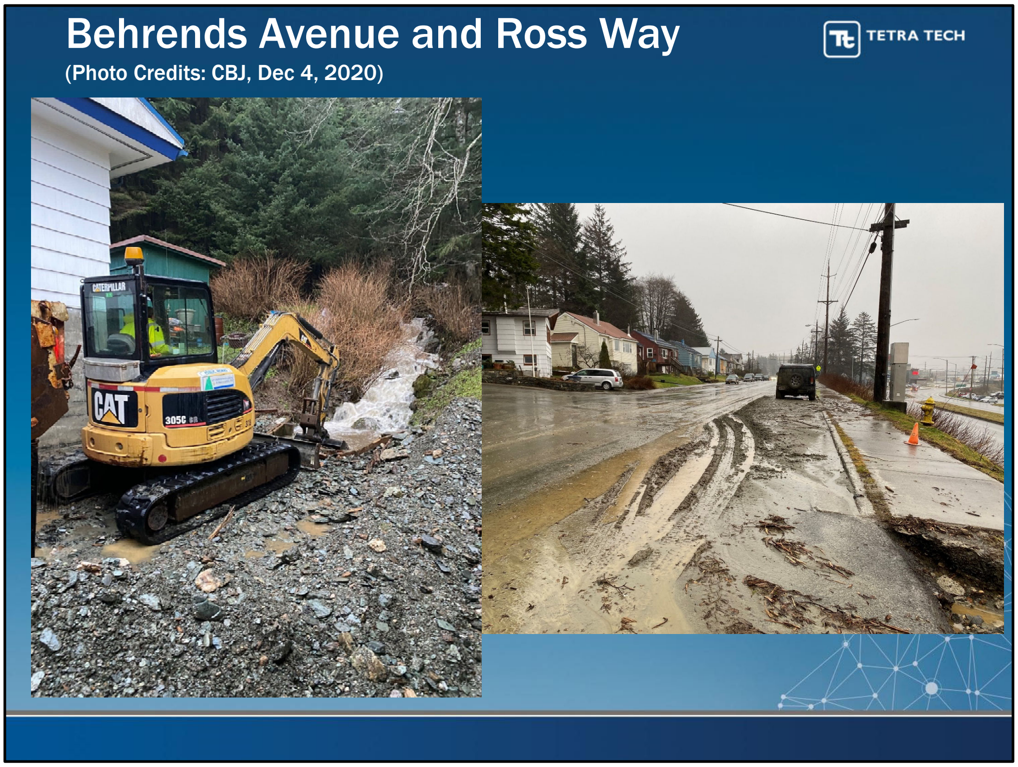
There are also a couple of new types of surficial material in this area that we didn't see on the first geology map. The yellow area is part of the delta of Gold Creek (mapped with a code starting with F for fluvial, meaning deposited by streams). You can see where the creek comes in from the top of the image. Then, after it passes by Cope Park, it runs straight through downtown, where it is contained within the concrete channel. There's an outcrop of exposed bedrock mapped at the south end of Dixon Street, shown in purple. (There's a little more bedrock exposed further northwest, which can be seen from the ground, where Dixon splits from Calhoun.)

Finally, there are two bluish-green areas that consist of glaciomarine deposits, below Behrends Avenue and at the cemetery, and south of 2nd Street. These glaciomarine soils were deposited when sea level was higher than it is now, during and before the last glaciation.

Now let’s look at the same area of Juneau, and see what the historical air photo records can tell us. In the upper left part of this image, especially higher up on the slopes of Mt. Juneau, we can see lots of debris slide activity that shows up in several years of imagery, as you can see from the different colors. More debris slides are seen on the side slopes of Cope Park, and rockslides are seen above Nelson Street. Now let’s look at the gullies.



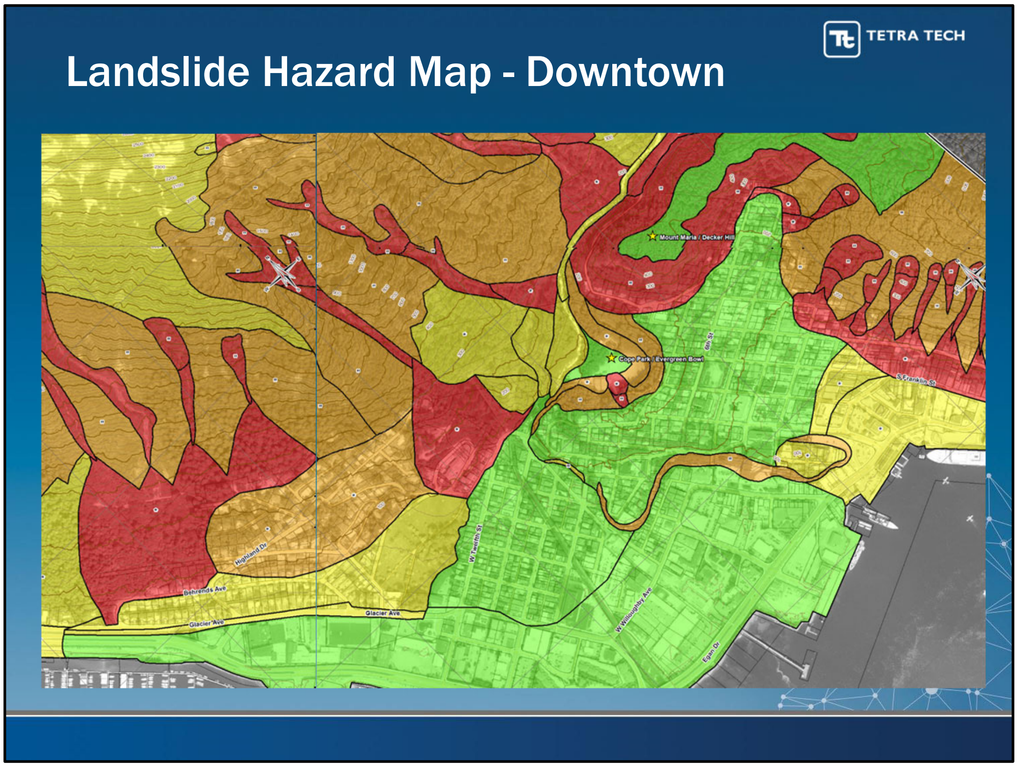
In this map area, numerous gullies are visible on the air photos and the LiDAR, that are shown here on an excerpt of the 2013 LiDAR image. Again, the red arrows show gullies that were already clearly visible in 1948. Gullies with several colours tend to be more active than the ones that only have one or two colours. But remember that the pink arrows are from the 2013 LiDAR, which makes the gullies easier to see than they are on the air photos. Many of the gullies lead down to the Behrends Subdivision, to Gold Creek at the top of the photo and in the area of the Irwin Street bridge (at the P17 and P18 markers). Plenty of short gullies are also present on Mt. Maria and in Evergreen Bowl, and numerous gullies are seen at the northwest end of Mt. Roberts. The LiDAR is useful for another reason – remember that winding strip of colluvium through downtown? On the LiDAR, that steep slope section is clearly seen, just like the outcrop of bedrock at the end of Dixon Street. Let’s have a look at a few photos.



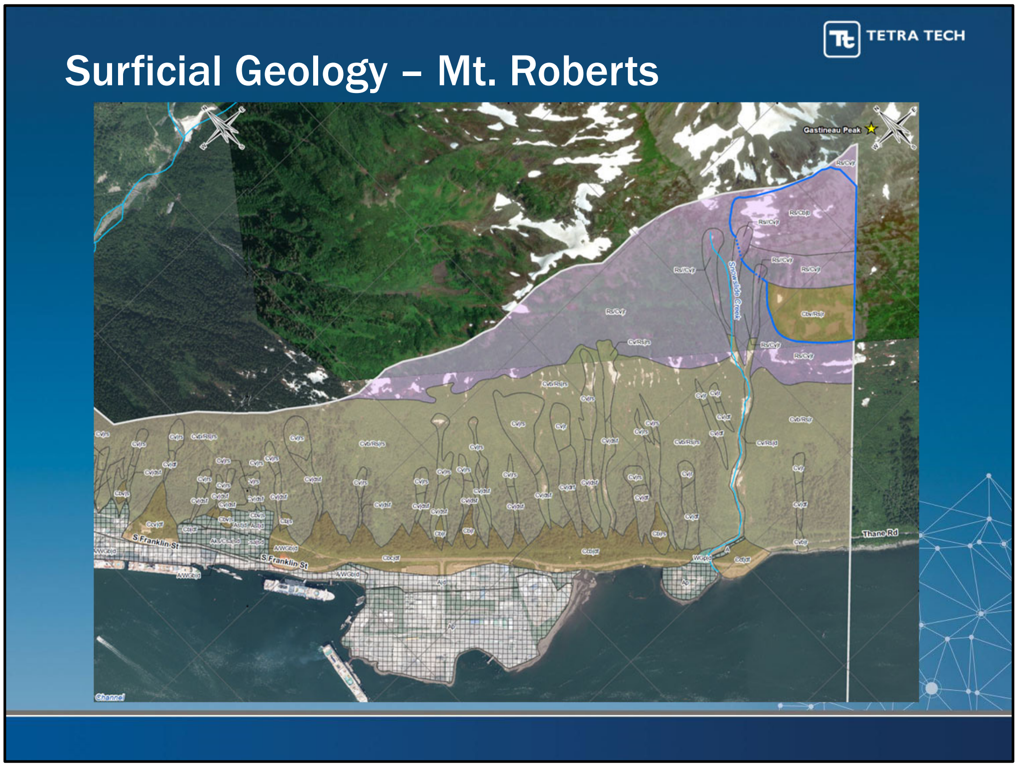
These photos are from CBJ, taken on December 4th, 2020. On the left is the cleanup of debris near the northwest end of Behrends Avenue, on the uphill side of the road. The debris must've been carried by one of those gullies we saw on the LiDAR image. It looks like the gullies can carry a lot of water too. The photo on the right is looking southeast along Glacier Avenue, where Ross Way enters. Ross Way carried some debris and water from Behrends to Glacier. Debris can also run southeast on Behrends Avenue.

Debris flow deposits are seen at the Irwin Street bridge over Gold Creek. Photo P17 is from the north bank of the creek, looking south at the debris deposited near the bridge. Photo P18 is looking north at the debris deposited under the bridge. These photos are from Tetra Tech's landslide fieldwork in September 2019.

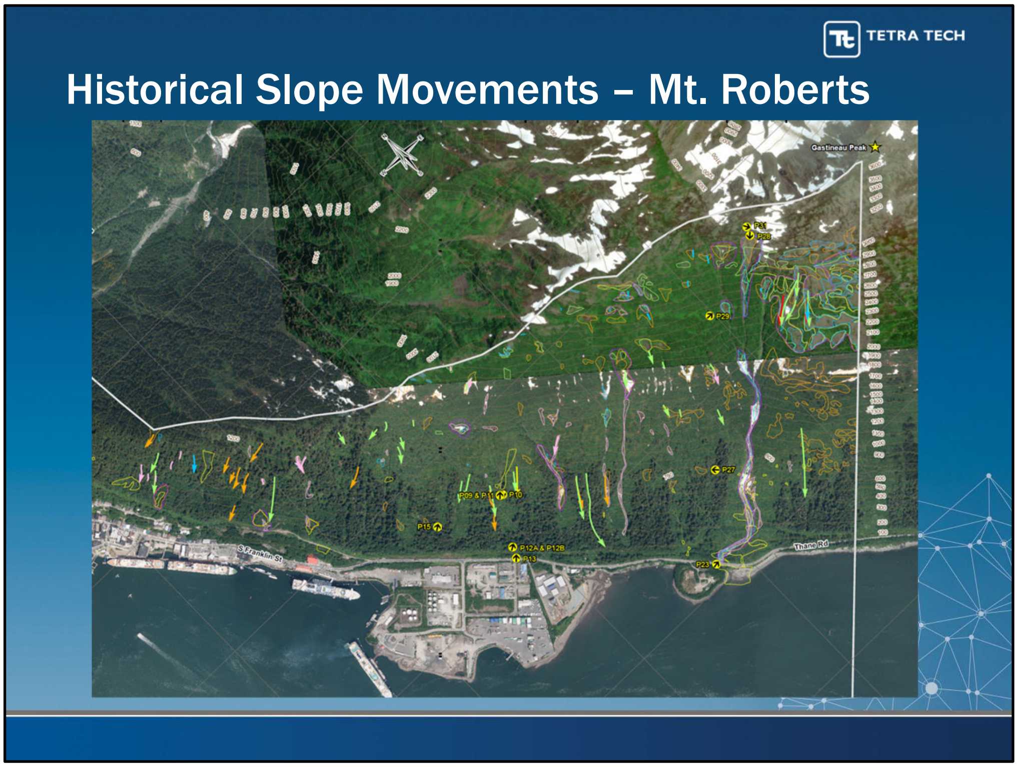
Rockfall is also common in Juneau. These recent examples (probably within the past 5 years) are from the slopes above Basin Road on the south side of Mt. Maria. Remember that stretched-out C-shape that we saw on the geology map? This rockfall area is in it. On Photo P24, we can see that a tree was damaged from rockfall. P25 gives an idea of the size of some of those pieces.



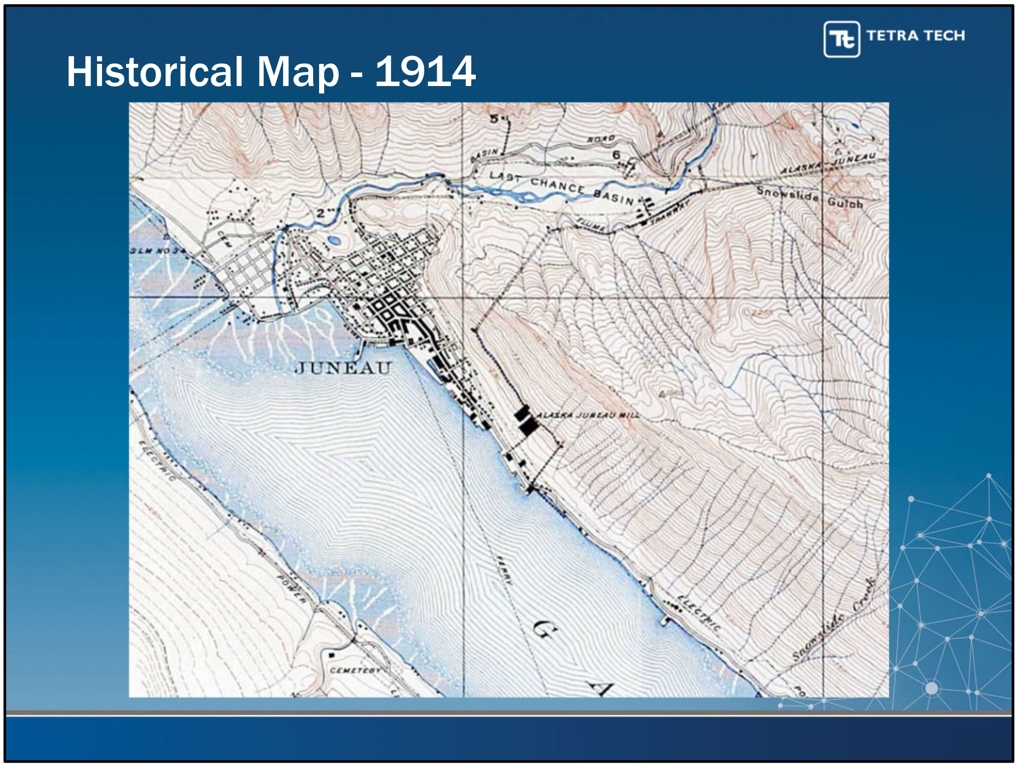
Zooming in a little bit from the previous maps, here are the landslide hazard designations for the downtown and surroundings. Red areas mark Severe hazard, for example, the area along Behrends Avenue and upslope, the far ends of Gruening Avenue, Coleman Street and Judy Lane, uphill portions of the lots above Willow Street, the east end of Evergreen Avenue and the Gold Creek Flume Trailhead down to Hermit and Rheinhardt Streets, above and below Basin Road, a section of the slope in Evergreen Bowl, and a lot of property along the toe of Mt. Roberts.



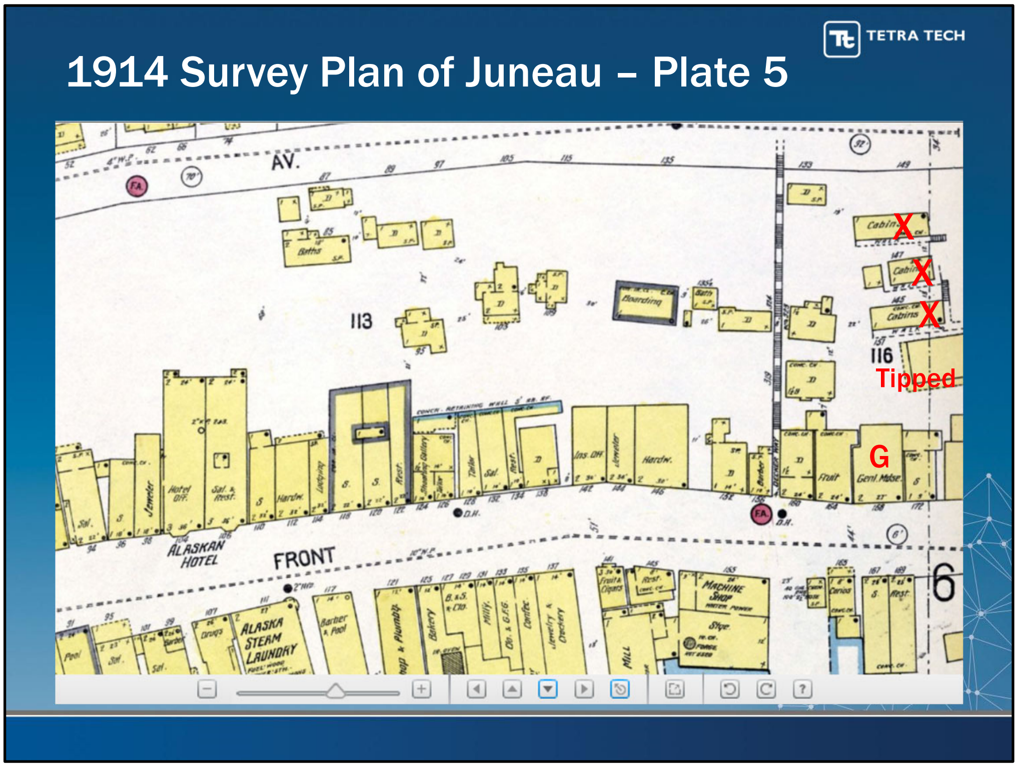
Here's our last excerpt from the surficial geology mapping, along Mt. Roberts. Again, there are some fill features built out from the toe of the slope, partly below South Franklin Street, and including some mine waste rock built out into Gastineau Channel. Notice the colluvial cones all along this slope, some of which have been regraded and/or had roads or trails built across them. Some of that work was related to the old Alaska-Juneau flume and mill. The stream running downslope near the southeast end of the map is Snowslide Creek, which can also produce debris flows. Just southeast of Snowslide Creek at the top of slope is an area of bedrock shown in purple that might be unstable.



Here are the debris slide areas that were mapped for Mt. Roberts based on the air photos and satellite images. As before, different colours mean different years of imagery. It looks like there is a lot going on here, but that's not all. There are several landslides that happened before the first air photos were flown, that were reported in some of the previous studies. To add to those observations, we looked up several old maps of Juneau, a historical inventory of buildings in Downtown Juneau, old news reports with descriptions of the landslides, and some photos from the Alaska State Library so that we could see how those old slides fit in to our mapping, and then decide if the mapping needed to be adjusted. Let's have a look.

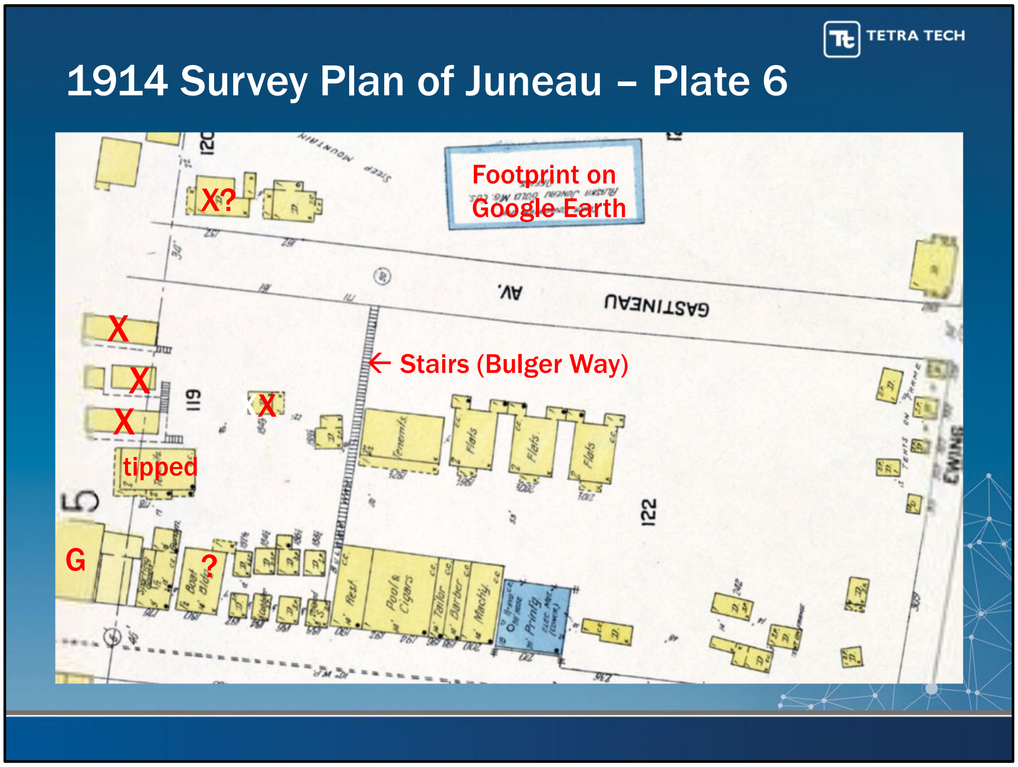


This is a 1914 map of Juneau that shows the old Alaska-Juneau flume and mill. These structures, and how they relate to some of the old landslides, can still be seen on some of the historical photos and more-detailed maps of the community.

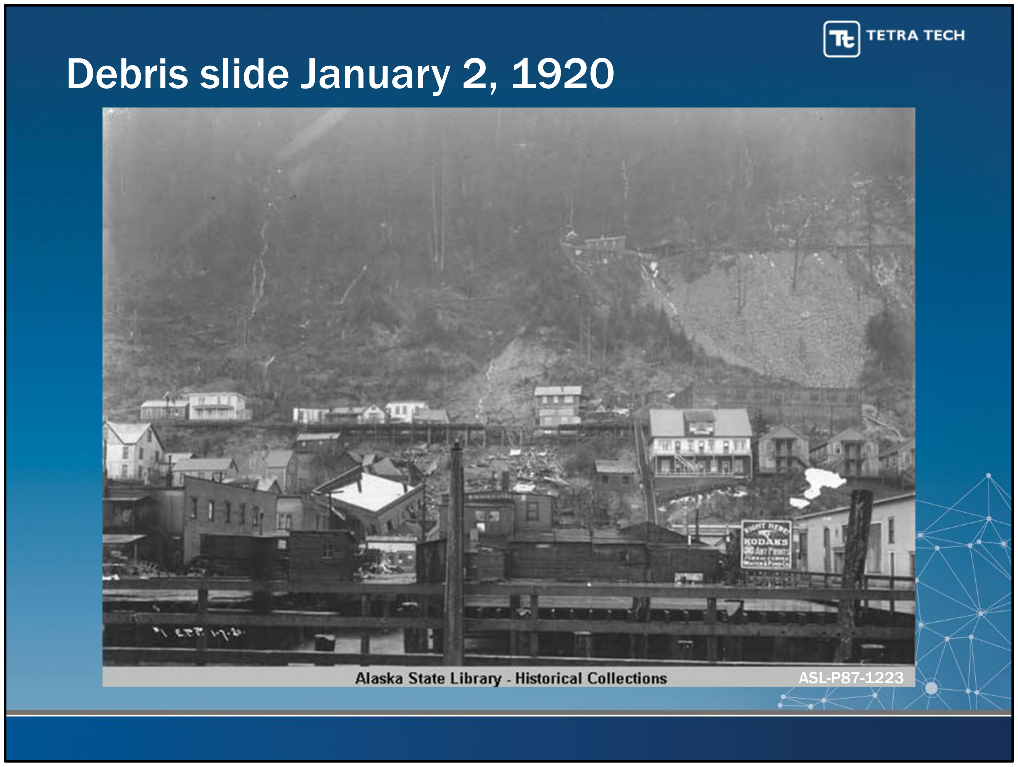


Here's an excerpt from the 1914 survey plan for Juneau from the Sanborn Map Company. Notice the main street was called Front St. in 1914. There still is a Front St. in Juneau, further to the northwest. But this part of the old Front Street is now called South Franklin Street. Here's the Alaskan Hotel, which still exists. And marked with a red G, was Goldstein's Store, which is now the Filipino Community and Bingo Hall. These are important locations, because both buildings were landmark structures that were hit by debris slides and that news reports of the time specifically reported on.

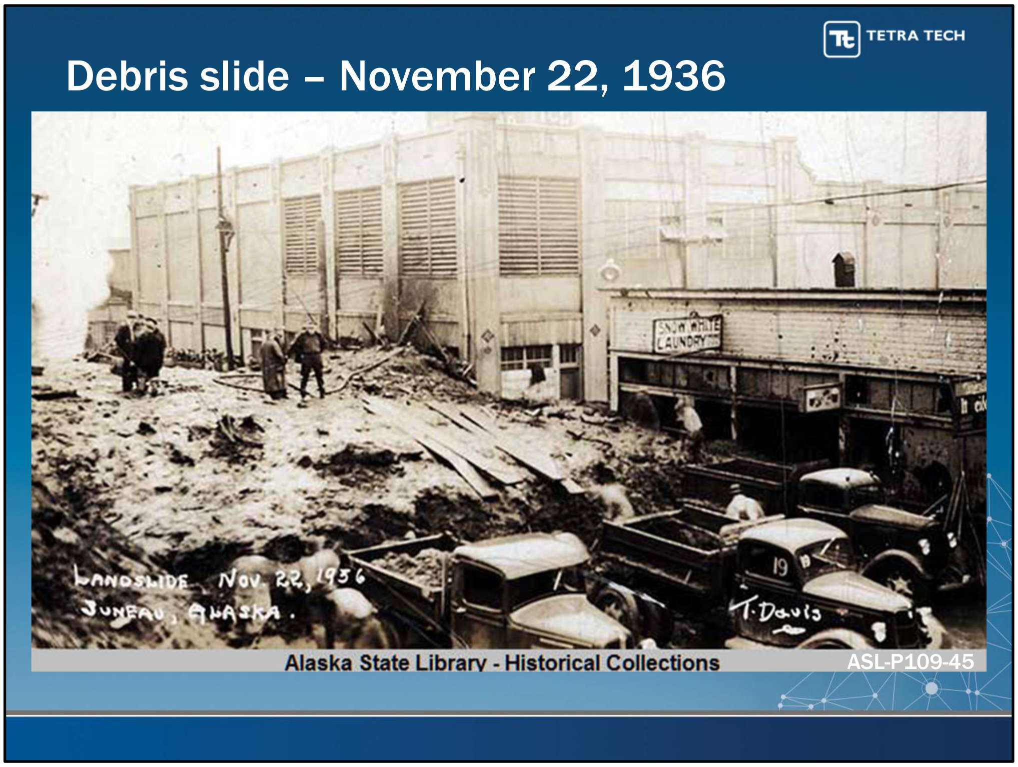
Debris slides on January 2nd, 1920, killed 4 people, injured eight, and destroyed 16 buildings. Some buildings were destroyed by the debris directly, and others from buildings being pushed into them. Debris broke through into the back of Goldstein's Store. The 3 buildings marked with red X's seem to have been destroyed, and the next one downslope was apparently tipped over.



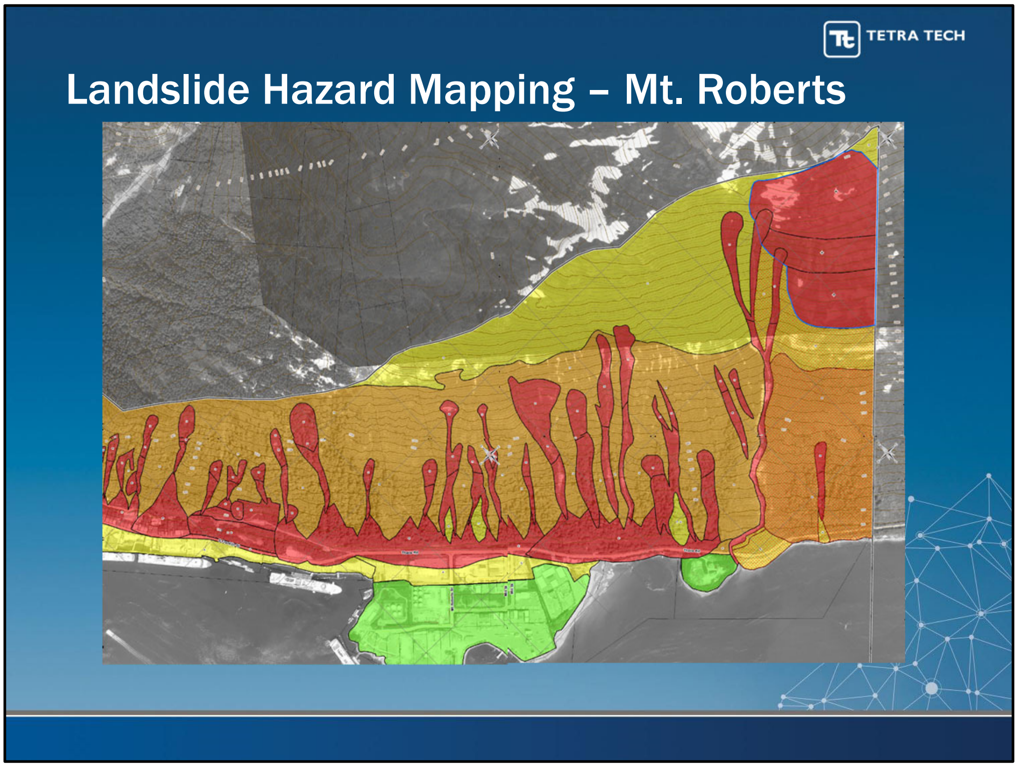
Continuing onto the adjoining survey plan, we can see a few more structures that were damaged or destroyed in 1920, including a couple of "maybe's". We can also see the outline where the old mine office used to be. You'll see what I mean about "maybe's" when we go to look at the photos. It can be challenging to decide exactly which buildings were destroyed when some of them are partly covered by debris from other buildings. But we can see the approximate boundaries of the disaster, since the stairs survived and so did the buildings to the southeast.



This photo is from a ship in the channel. Remembering the survey plans, you can tell that there are few buildings missing, and there's the tipped building. You can also see where the slide debris ran down through a trestle at Gastineau Avenue. Uphill from the tenements and the flats on the right, you can see the office, and higher still, there's the flume. It's not clear whether the overflow of the flume contributed to the debris slide, since there was also nearly 2" of rain in 24 hours. But we can see at least 2 places where concentrated water was running downslope.



On October 16, 1936, a debris slide destroyed several buildings and buried one resident after nearly 1.5” of rain. Debris ran into the back of the Alaskan Hotel. We don’t have a photo of that slide, but just over a month later, on November 22nd, nearly 4 inches of rain in 48 hours triggered another slide that caused 15 deaths. Debris covered South Franklin Street to a depth of 10 feet. The first slide was reported to be followed by a second that was up to 100 feet wide and 10 to 40 feet deep. This is the Juneau Cold Storage building on the south side of the road and about 200 yards southeast of Goldstein’s, where the debris ran up another 3 feet onto the wall of the building and splashed muddy water 5 or 6 feet higher still. If the building hadn’t been there, the slide debris probably would’ve gone further, so that’s an adjustment that was made on the mapping.



Based on the mapping of slide features from the aerial imagery and the locations of the debris slides that happened before there were air photos, we can map the landslide hazard designations for the Mt. Roberts slope. The first cone on the left is where the debris slide at Goldstein's happened in 1920, and the second big cone is where the slide at Juneau Cold Storage happened in 1936, so we can see that the mapping from the air photos captured this area quite well.

The main adjustment in the mapping was that the lower boundary was moved out slightly towards the channel in a few places, so that it at least covers South Franklin Street, and further in some areas. That's a logical change, since we know that streets will be cleaned up after debris slides or flows, and typically the air photos won't reveal the runout unless the slide goes past the road. One more important thing to notice on this image – at the top right, the bedrock feature (purple on the geology map) looks like it might become a deep-seated failure. It hasn't happened yet, but if it does, it has the potential to go all the way into Gastineau Channel, taking a lot of slope material with it. Let's look at a few photos.

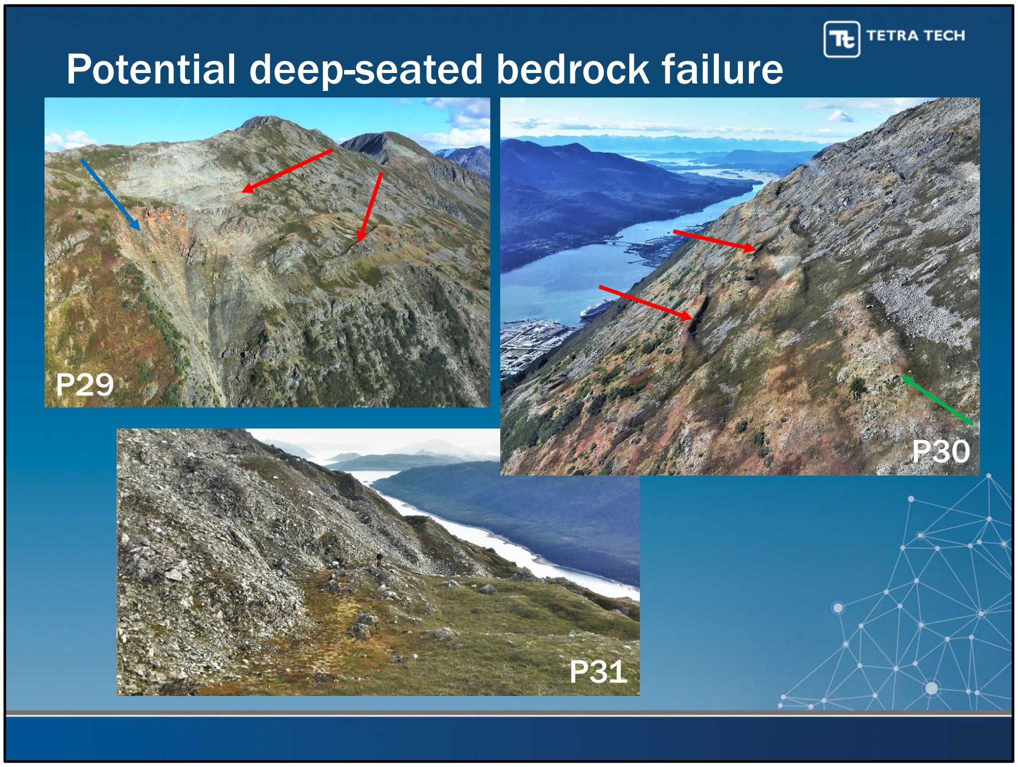
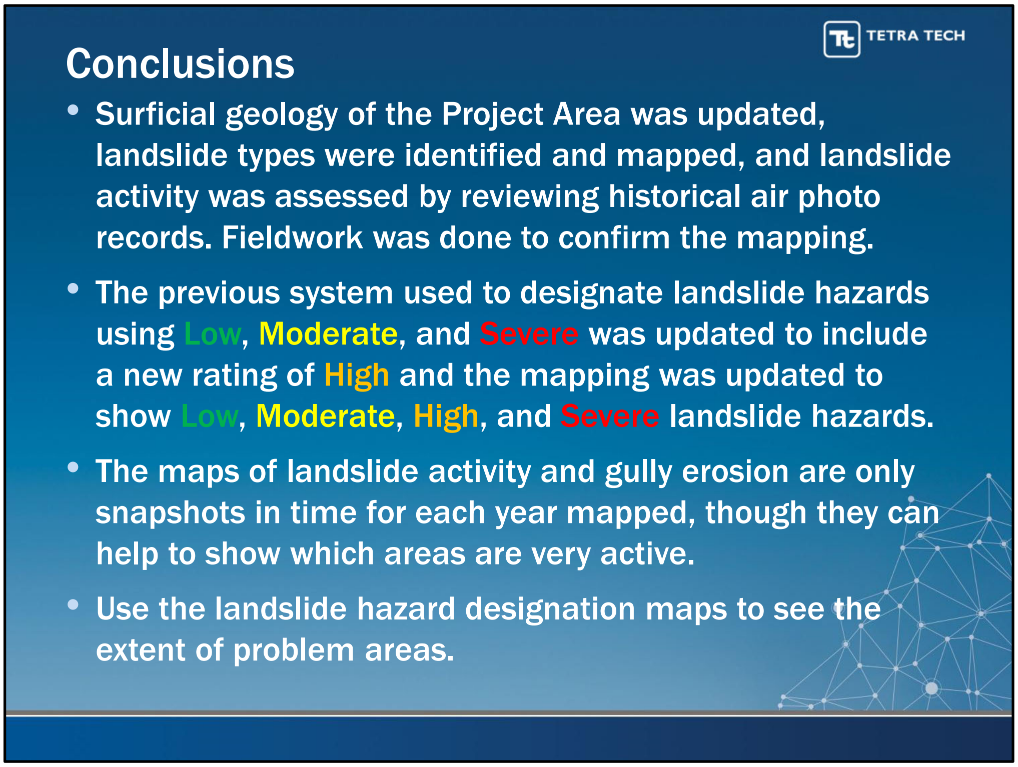


Photo P29 is looking east at the top of Snowslide Creek (at the blue arrow), and the bedrock slope to the southeast, where the Severe landslide hazard has been mapped. The red arrows are pointing at deformed, wavy and discontinuous bedrock features. These and multiple ridge-and-valley-like features suggest deep-seated creep in the bedrock.

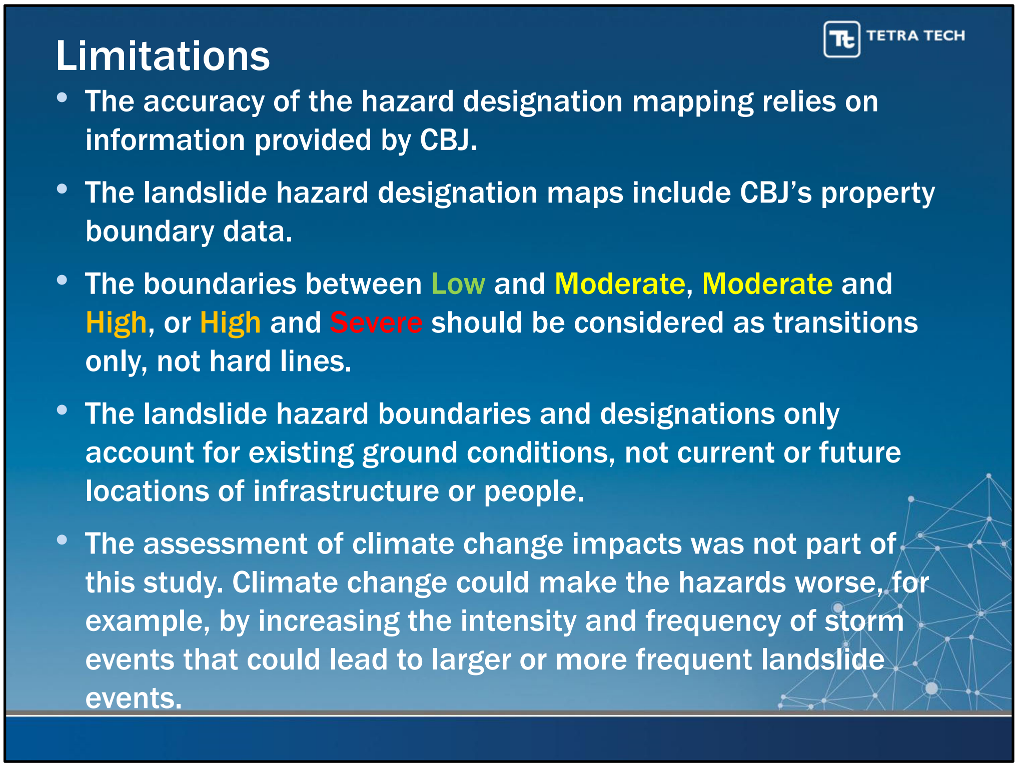
Photo P30 is looking north at the same slope. Wavy lines at the red arrows suggest unstable bedrock, straight lines at the green arrow further southeast suggest stable bedrock.

Photo P31 is looking southeast at the area of bedrock creep. Potentially ploughed bedrock is on the left, and the ridge-and-valley structures can be seen along the skyline in the middle.

The upshot here is that this feature needs more investigation.



Here are a few conclusions from the mapping: (READ)



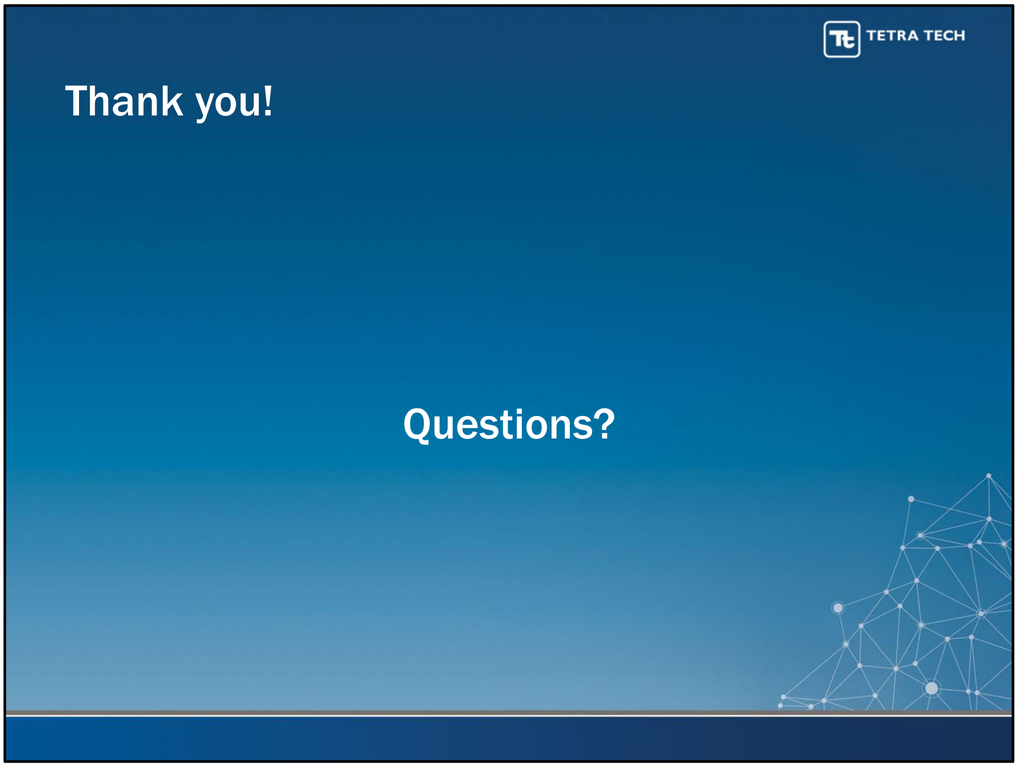
Here are the limitations of the mapping work:

- The accuracy of the hazard designation mapping relies on information provided by CBJ, such as the LiDAR, and the landslide hazard incident reports. If more incident reports become available, from either CBJ or any of you through CBJ, such reports would help improve the accuracy of the mapping.

- The landslide hazard designation maps include CBJ's property boundary data, which has not been verified by Tetra Tech. If that data changes, the mapping may need to be updated.

- The boundaries between Low and Moderate, Moderate and High, or High and Severe should be considered as transitions only, not hard lines. One property could have more than one hazard designation, and geologic conditions can be different from than those anticipated from mapping and field-checking.

- The landslide hazard boundaries and designations only account for ground conditions, not current or future locations of infrastructure or people.
- The assessment of climate change impacts was not part of the landslide study scope. 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.



That brings us to the end of our presentations. Thank you so much for coming. We have a few minutes now for questions.