Ellensburg Chapter
Ice Age Floods Institute

Leavenworth to Wellington Field Trip

Field Trip Leader:
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Field Trip Overview

Field Trip Description:

This field trip will take us on a transect from the eastern edge of the northeastern Cascades in Leavenworth to just west of the Cascade Crest at the old Great Northern railstop of Wellington. Enroute, we will see evidence for a variety of rock types, geologic structures, climates, glaciations, river and stream processes, vegetation, landslides, wildfires, and snow avalanches. This transect is an area of much historical significance because it has been a main transportation corridor since 1893. It is perhaps because of the intersection of transportation with geology, topography, climate, and vegetation that this area is most famous. While fire and avalanches have impacted this area for centuries, it is only in the last century with the growth of human population and infrastructure in the mountains that that these events have truly become hazards. Our final stop will explore a classic Cascade hazard—snow avalanches--at Wellington, the site of the deadliest snow avalanche disaster in North America.

Tentative Schedule:

10:00 am	**Depart CWU**
11:00	**Stop 1--Leavenworth**
11:45	**Depart**
12:00	**Stop 2—Tumwater Canyon (Swiftwater Picnic Area)**
12:45	**Depart**
1:00	**Stop 3—Lake Wenatchee State Park**
1:45	**Depart**
2:15	**Stop 4—Stevens Pass**
3:00	**Depart**
3:15	**Stop 5--Wellington**
4:30	**Depart**
6:30	**Arrive at CWU**

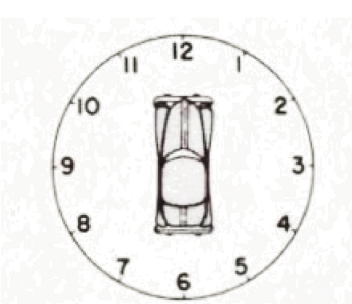

Figure 1. Relative bearings using a clock. Assume that the bus is always pointed to 12 o'clock. Source: Campbell (1975, p. 1).

Ellensburg to Blewett Pass

Route. From Ellensburg, head west and north on US 97 (Figure 2). Follow US 97 to its intersection with WA 970 at Lauderdale Junction. Turn right (east) and continue to follow US 97 through Blewett Pass toward US 2.

Geology. From Ellensburg to Lauderdale Junction, we are in the realm of the Miocene Columbia River Basalts (Figure 3). These basalts originated from fissure eruptions in southeastern Washington, northeastern Oregon, and western Idaho. Tertiary alluvial fans that are now erosional pediment surfaces, and Quaternary alluvial fans that formed from the transport of sediment out of the Wenatchee Range cover the basalts in the Kittitas Basin. From Lauderdale Junction to Blewett Pass, we generally parallel Swauk Creek on the valley floor and the high, western edge of the Columbia River Basalts. This basalt edge is littered with large landslides and rockfalls. US 97 passes through early Eocene Swauk Formation sedimentary rocks, and middle Eocene Teanaway Formation volcanic rocks. The Swauk Formation originated as alluvial fan, braided river, meandering river, lake delta, and lake deposits (Tabor and others, 1984; Taylor and others, 1988). The Teanaway Formation formed as a variety of eruptive features—dikes, shield volcanoes, cinder cones, tuff rings, lava domes, and possibly composite cone volcanoes (Clayton, 1973). So many dikes are present in the vicinity, they are often referred to as a “dike swarm”. Because the Teanaway Formation is harder than the surrounding sedimentary rocks, they form many of the ridges of the drainage. Often, the reddish rocks of these ridges are sparsely vegetated.

Climate. The climate of Ellensburg (~1,500 feet) is semi-arid, with precipitation nearly 9 inches/year. The average annual temperature is about 48^{o}F (Western Regional Climate Center, n.d.). Temperatures decline and precipitation increases as we head toward Blewett Pass. The location of Blewett Pass about 40 miles east of the Cascade Crest and the modest elevation of the Swauk drainage divide (6,360 feet at Lion Rock) ensures that it receives less overall precipitation and less snowfall than similar elevations to the west. Because of these climate realities, there is no evidence of past glaciation in the Swauk Watershed.

Water. Because of the semiarid environment of the Kittitas Basin, most surface water here is exotic—i.e., it falls as precipitation in the surrounding uplands and flows through this basin. While these streams may have robust discharges with late winter/spring snowmelt and with occasional thunderstorms, by late summer their flows are typically quite low.

Vegetation. Non-streamside vegetation in the Kittitas Basin is characterized as shrub-steppe indicating that it is a mix of shrubs such as sagebrush and grassland (i.e., steppe). As we head north, scattered conifers are present in drainages and on north-facing slopes. Further north, as we ascend US 97 to Blewett Pass, we are in true Eastside Forest dominated by Douglas fir and ponderosa pine, reflecting the increase in precipitation.

Land Uses. From the agricultural Kittitas Basin, we pass into the mining- and logging-influenced Swauk Watershed. Mining has occurred in the area since the mid-19th century, and was centered in the Liberty area south of Blewett Pass. You can still see spoils of dredge-based, placer mining of Swauk Creek sediments along the west side of US 97 between Lauderdale Junction and the Liberty Café. Lode and placer mining still occurs in the watershed. The Douglas fir and ponderosa pine forests of the Swauk Watershed have also been logged over time. Our route up Swauk Creek parallels and sometimes even overlies the Cascade Logging Company’s logging railroad route of the early to mid 20th century. Recreation is now the most common land use in the Swauk Watershed in the forms of camping (at developed and undeveloped campsites), hunting, hiking, and winter sports of snowshoeing, cross country skiing, and snowmobiling. A small downhill ski area was present in the upper Swauk Watershed north of Swauk Campground in the 1940’s. The lodge of that ski area is now the Mineral Springs Restaurant.

Ellensburg to Blewett Pass

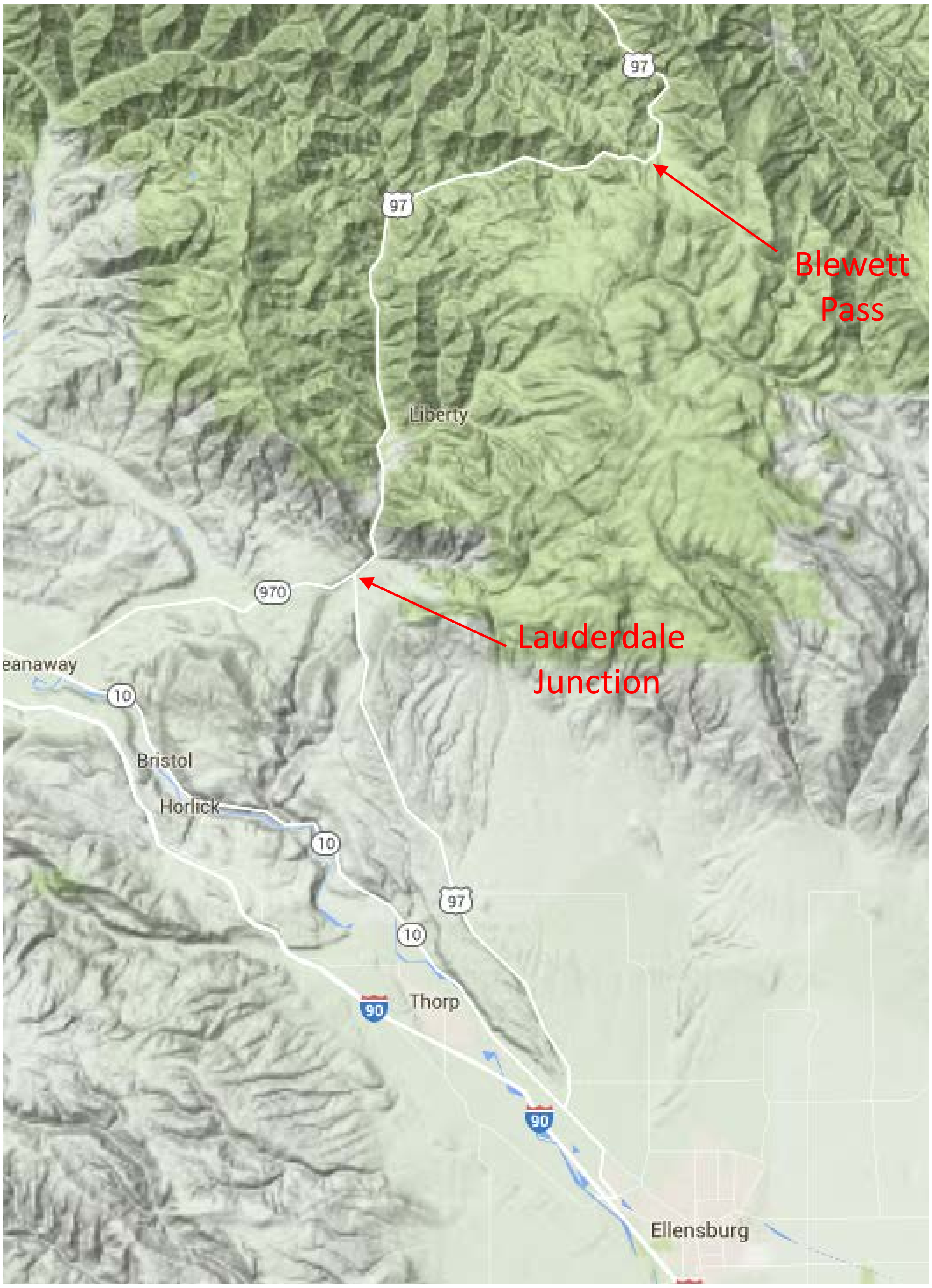

Figure 2. Topography from Ellensburg to Blewett Pass. Source: Google Maps.

Ellensburg to Blewett Pass

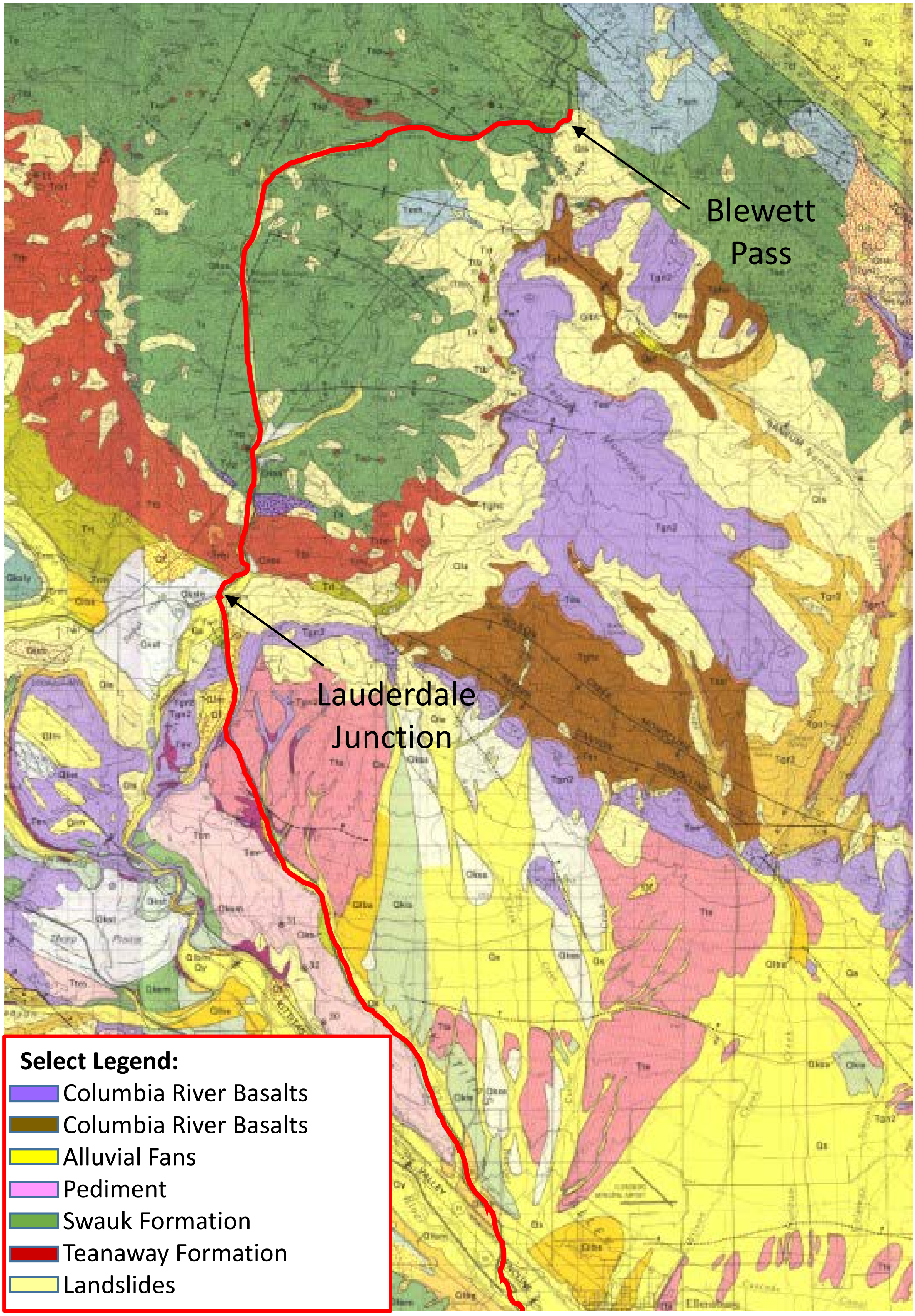

Figure 3. Geologic map from Ellensburg to Blewett Pass. Heavy red line is US 97. Source: Tabor and others (1982).

Blewett Pass To Leavenworth

Route. From Blewett Pass, continue toward US 2 (Figure 4). At US 2, turn left (west) and head toward Leavenworth. In Leavenworth, at the stoplight just after crossing the Wenatchee River, turn right (north) onto WA 209 (the Chumstick Highway). Almost immediately, take the first unmarked left (west) off WA 209, then turn right onto Fir Street. Follow this north for one-half block, then turn left as Fir becomes Pine Street. Follow Pine Street for two blocks to the Pine Street-Titus Road intersection. Turn right (north) onto Titus Road, and drive north approximately two blocks to Icicle River Middle School. Turn right (east) into the school parking lot and park. This is Stop 1.

Geology. From Blewett Pass, we descend the Peshastin Creek drainage (Figure 5). If you look up on this part of the route, you may be able to see part of the Late Cretaceous Mount Stuart Batholith in the distance. We will look at this unit in more detail later. Around milepost 171 (just upvalley from the Old Blewett Pass Highway), we cross from the Swauk Formation onto the Jurassic Ingalls Tectonic Complex (Figure 6). This unit is an ophiolite complex, an accumulation of mafic and ultramafic rocks (i.e., basic to ultrabasic and dark colored), that originated in a large, marginal basin or open ocean, then accreted to the edge of the continent as a terrane (Miller, 1985). A common ultramafic, metamorphic rock in the Ingalls Tectonic Complex is serpentinite. Green serpentinite rocks along the highway indicate that you are now in the Ingalls Tectonic Complex. You can also see "serpentinite barrens" through this area where the vegetation cover is drastically reduced because of the chemistry of the serpentinite. A large active landslide is present near the southern boundary of this unit. Below the junction of Peshastin Creek and Ingalls Creek, US 97 crosses the Leavenworth Fault and we enter the Eocene continental sedimentary rocks of the Chumstick Formation. Because of their similar appearance, some early researchers thought the Chumstick Formation and the Swauk Formation were the same unit (see Evans and Johnson, 1989). It was not until 1981 that the Chumstick was formally defined (Gresens and others, 1981). Early researchers noted that the Chumstick Formation was fault-bounded (Waters, 1930). Reflecting this fault origin, the Chumstick depositional basin was subsequently named the "Chiwaukum Graben" (Willis, 1950). This graben (i.e., a down-faulted block) was the product of extension or was a pull-apart basin formed during transtension (i.e., a combination of extension and lateral stress) (see Cheney and Hayman, 2009). A recent, contrasting model proposed by Cheney and Hayman (2009) is that the Chiwaukum Graben is actually a syncline (i.e., downfold) hence their name the "Chiwaukum Structural Low". In this model, the Leavenworth Fault is a reverse fault (rather than a normal fault that one would expect with a graben), and that the Roslyn Formation (centered on the Roslyn area) is actually the same unit as the Chumstick Formation. Finally, the folds of the Yakima Fold Belt are superimposed on older folds present in the Eocene rocks of the Roslyn, Swauk, and Chumstick Formations. Compression, and related folding and crustal shortening, better fits the regional geologic evidence since the Eocene (Cheney and Hayman, 2009). Stay tuned for more details.

Glaciation. Near the junction of Peshastin Creek and Ingalls Creek, US 97 crosses the moraine remnants of a Pleistocene alpine glacier that descended Ingalls Creek (Hopkins, 1966) (Figure 5). This glacier formed in the cirques in the headwaters of Ingalls Creek (including Ingalls Lake, the north-facing cirques of the Wenatchee Range, and even south-facing cirques in the Stuart Range. High elevation source areas (as high as Mt Stuart at 9416 feet) and locations closer to the Cascade Crest (~17 miles at Ingalls Lake) helps explain why glaciers formed there and not in the Swauk Watershed.

Mining. As in the Swauk Watershed, mining was a prominent activity in the Peshastin drainage, especially in the vicinity of Blewett (Figure 5). Blewett was once the home to more than 250 miners (Washington Writers Project, 1941). Like mining in the Swauk Watershed, Blewett-area mines were placer and lode mines, and were focused on gold. The remains of an arrastre (i.e., a water-powered ore-grinding apparatus) and a more recent stamp mill are still visible at Blewett.

Blewett Pass to Leavenworth

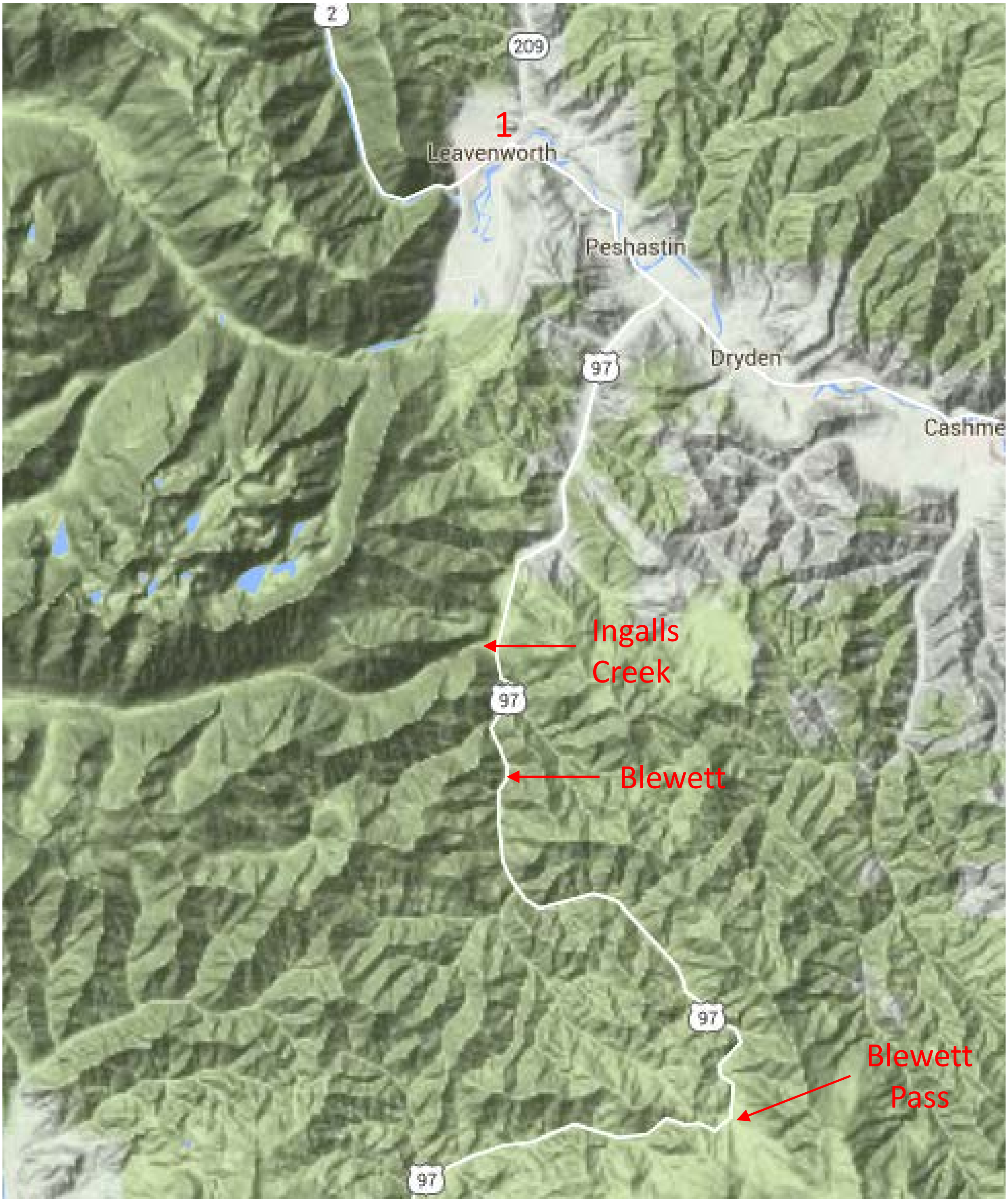

Figure 4. Topography from Blewett Pass to Leavenworth. Number indicates field trip stop. Source: Google Maps.

Blewett Pass to Leavenworth

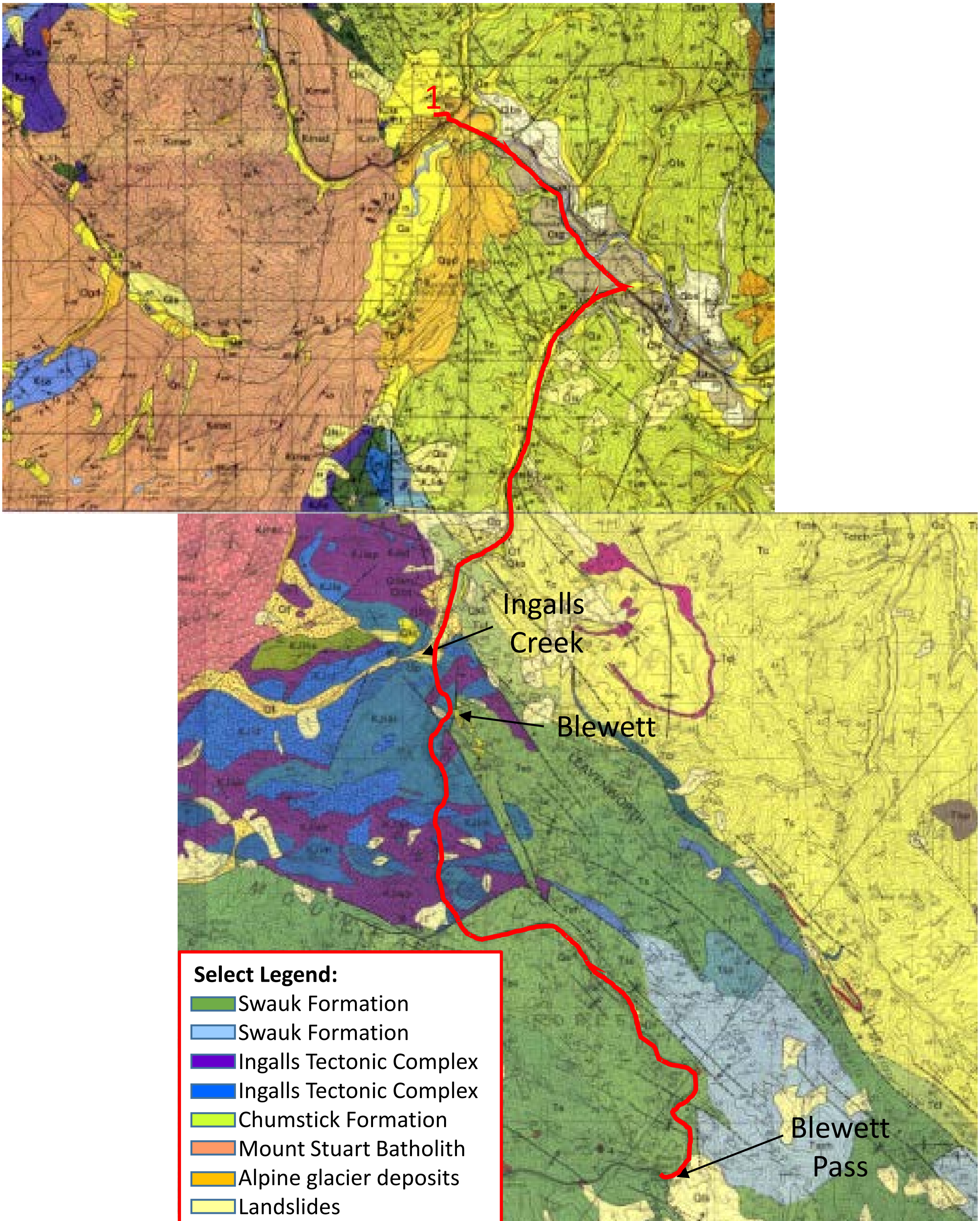

Figure 5. Geology from Blewett Pass to Leavenworth. Heavy red line is US 97 and US 2 route to Stop 1. Number indicates field trip stop. Source: Tabor and others (1982) (bottom) and Tabor and others (1987).

Stop 1--Leavenworth

Location. We are located on a hill just north of the Icicle River Middle School in Leavenworth (Figure 6) amidst deposits of several glaciations (Figure 7).

Geology. The surrounding bedrock is a mix of sedimentary, intrusive igneous, and metamorphic rocks (Figure 8). To the north and east lie sedimentary rocks of the Eocene-aged Chumstick Formation. Intrusive igneous rocks (including granodiorite, diorite, and gabbro) of the late Cretaceous Mt. Stuart Batholith are to the south and west. A sliver of early Cretaceous/late Jurassic Ingalls Tectonic Complex (including schist and amphibolite) lies to the northwest (Tabor and others, 1987).

Glaciation. Glaciation is a big part of the geologic and geographic story of Leavenworth as well as throughout the Eastern Cascades (Figure 9). We are standing amidst glacial erratics deposited by a glacier that originated in the Icicle Creek drainage to our southwest and terminated here (Figure 10). However, this is not a remnant of end moraine; rather, it is till-covered bedrock (Porter, 1969). Glaciation in the vicinity of Leavenworth has been studied since at least 1900 (Russell, 1900; Page, 1939; Long, 1951; Long and Porter, 1968; Porter, 1969; Waitt, 1977; Waitt and others, 1982; Swanson and Porter, 1997; Kaufman and others, 2004; Porter and Swanson, 2008). Russell (1900) developed the first map of the approximate extent of Eastern Cascades glaciers, including those in the Leavenworth area (Figure 9). Page (1939) was the first to map Icicle Creek glacial landforms, recognize multiple glacial advances, and place these glaciations in a chronology. Over the years, this work has been built upon with new and improved methods. The most recent research (Porter and Swanson, 2008) involved more detailed mapping and dating techniques including surface exposure dating of crystalline erratics to determine that the moraine immediately south of us dates to 19,100 +/- 3000 years. It originated from a glacier that descended from the Icicle Creek drainage (Figure 10) and is part of a sequence of five glacial advances that include more extensive glaciers ~105,400 years ago (as far downstream as Peshastin) and less extensive glaciers (in the Icicle Creek Valley) as recently as ~12,500 years ago (Table 1). As Figure 9 shows this was just one of many glacial advances from the Cascades to the lowlands to the east. Nearby glaciated valleys include Ingalls Creek, Nason Creek, White and Little Wenatchee Rivers, Chiwawa River, and the Entiat River.

Existing glaciers. Glaciers today in the Wenatchee River Watershed are much reduced compared to those of the late Pleistocene. Small glaciers are present in the Icicle Creek, Chiwaukum Creek, White River, and Chiwawa River drainages.

Table 1. Average age of boulders sampled on moraines and age of oldest boulder. Source: Porter and Swanson (2008, p. 152).

Mean Age of Boulder Population and Age of Oldest Boulder

Moraine	Population Mean[a]	Oldest Date
Rat Creek II	12,500 ± 500 (n=9)	13,500 ± 600
Rat Creek I	13,300 ± 800 (n=6)	14,500 ± 500
Leavenworth II	16,100 ± 1100 (n=11)	17,000 ± 1000
Leavenworth I	19,100 ± 3000 (n=17)	24,700 ± 1100
Mountain Home	71,900 ± 1500 (n=5)	72,200 ± 1400
pre-Mountain Home	93,100 ± 2600 (n=3)	94,900 ± 3100
Peshastin	105,400 ± 2200 (n=8)	112,800 ± 1700

[a]Excludes outliers

Stop 1--Leavenworth

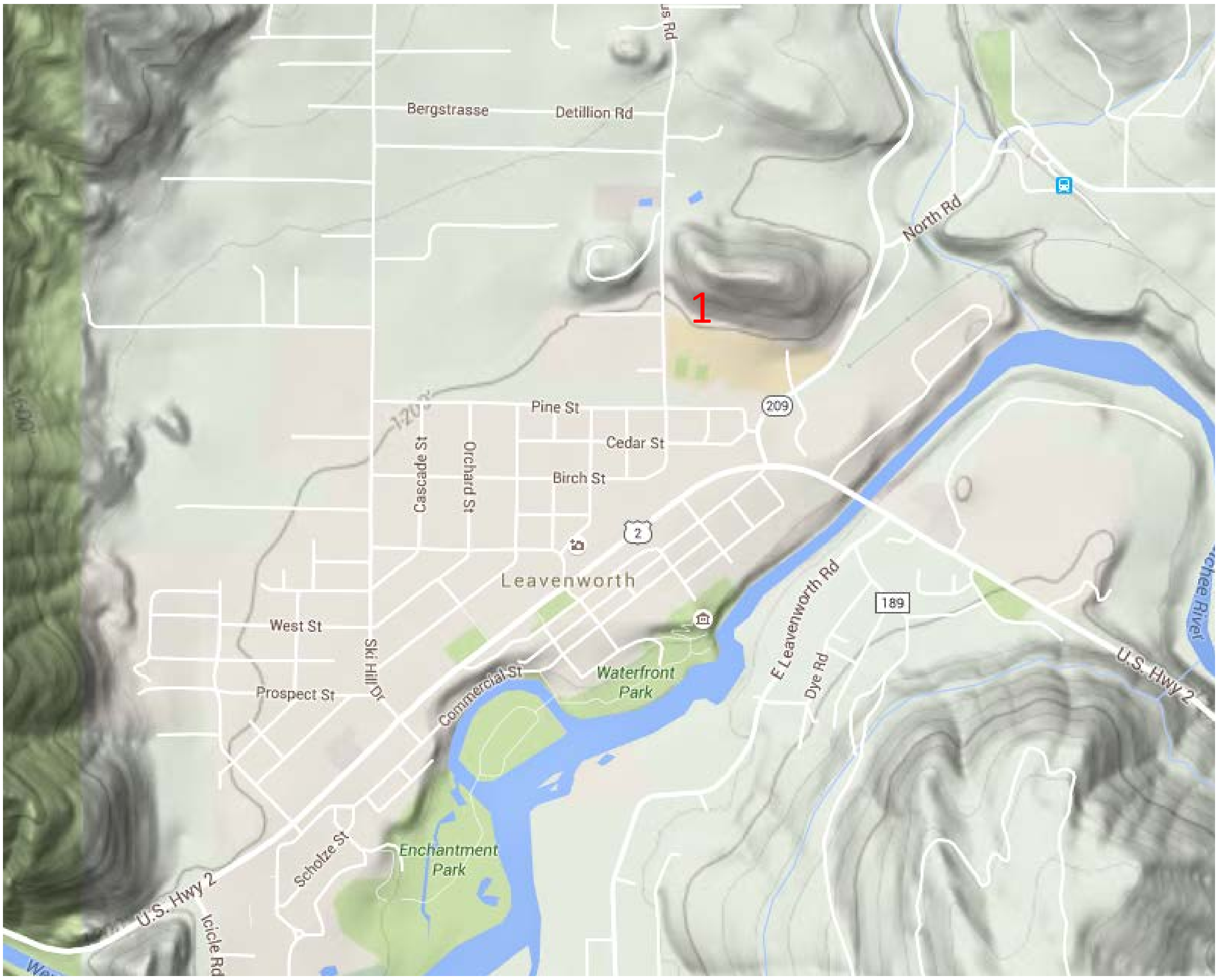

Figure 6. Location of Stop 1 in Leavenworth. Source: Google Maps.

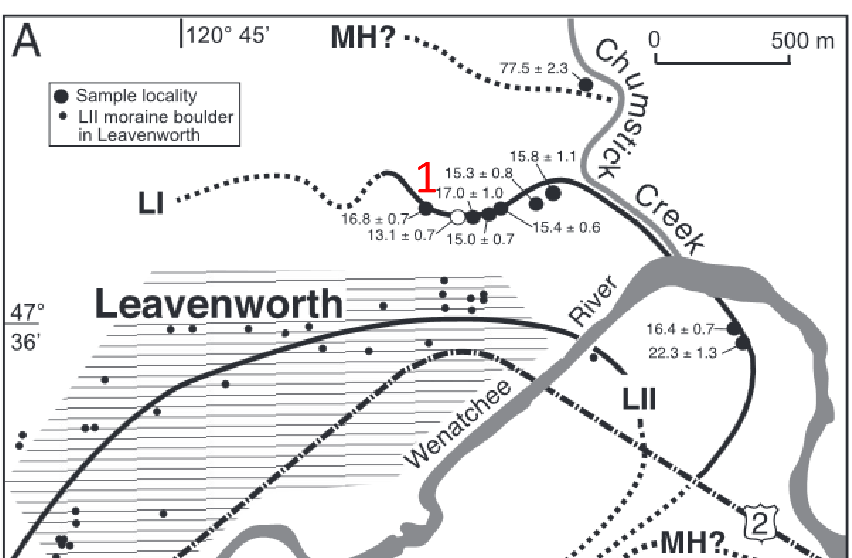

Figure 7. Moraines and their ages in the Leavenworth area. Source: Porter and Swanson (2008).

Stop 1--Leavenworth

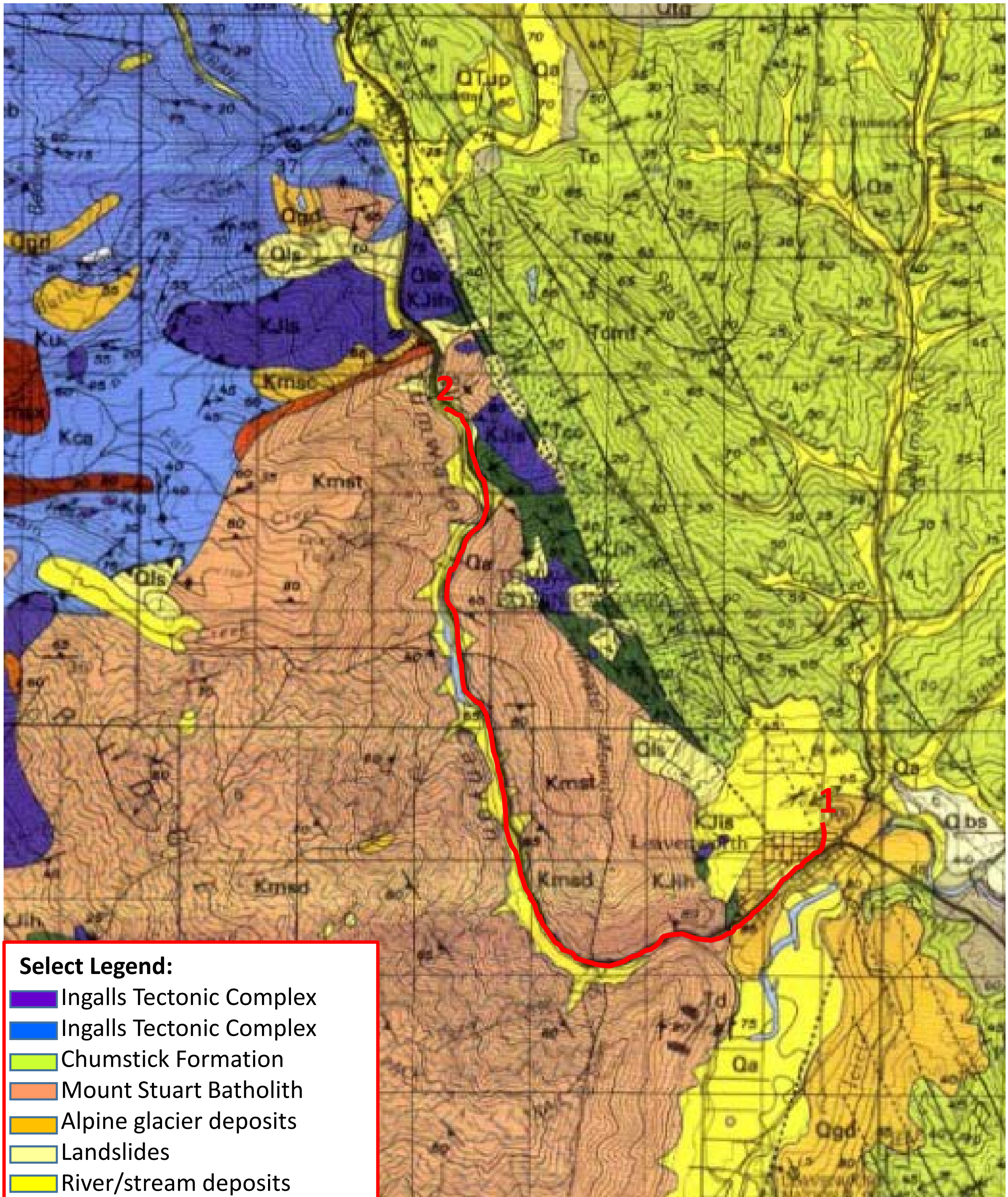

Figure 8. Geologic map of the Leavenworth area. Field trip stops are indicated with red numbers. Heavy red line indicates US 2 route. Source: Tabor and others (1987).

Stop 1--Leavenworth

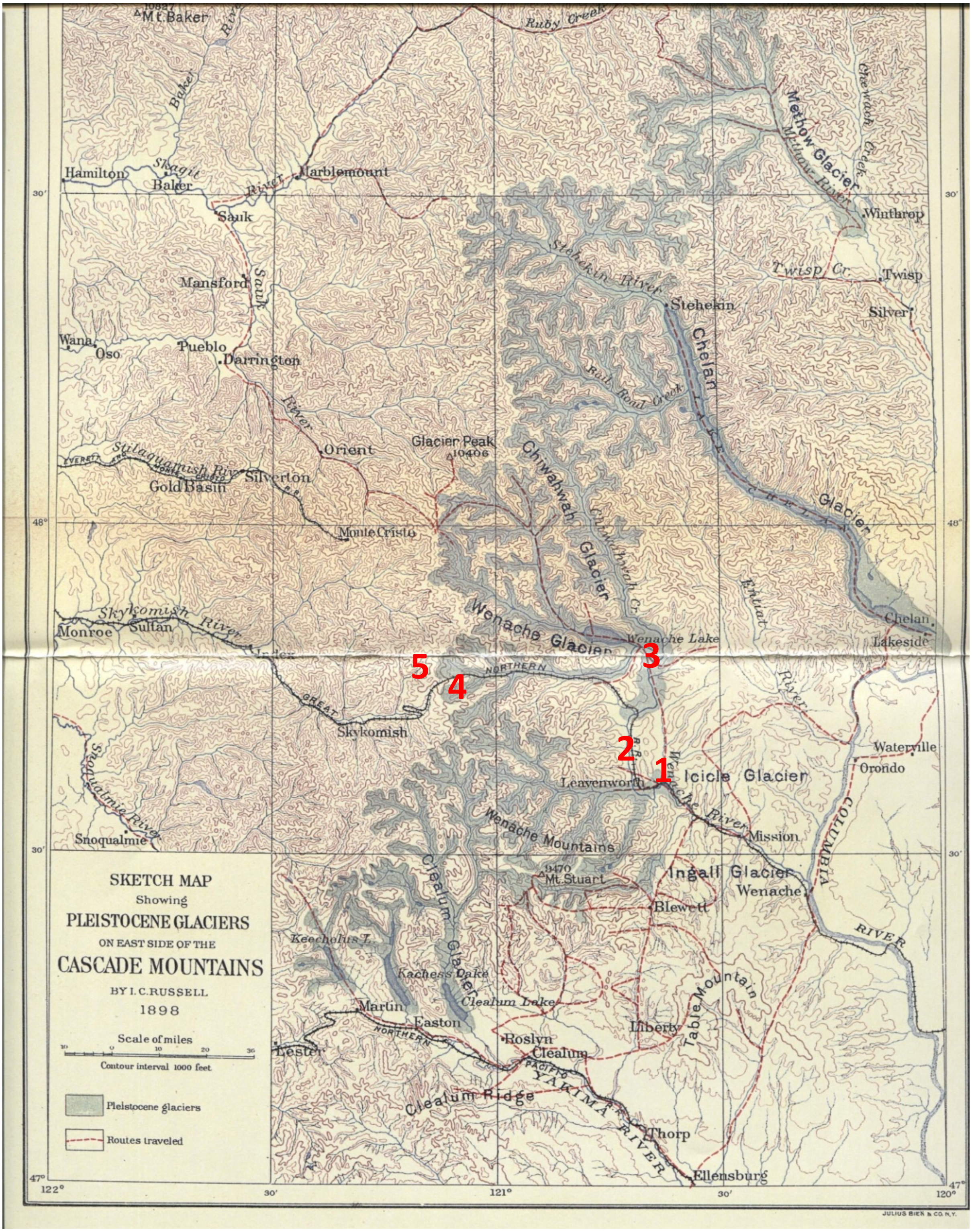

Figure 9. Sketch map showing the extent of Pleistocene glaciers in the northeastern Cascades. Source: Numbers indicate field trip stops. Source: Russell (1900, XVIII).

Stop 1--Leavenworth

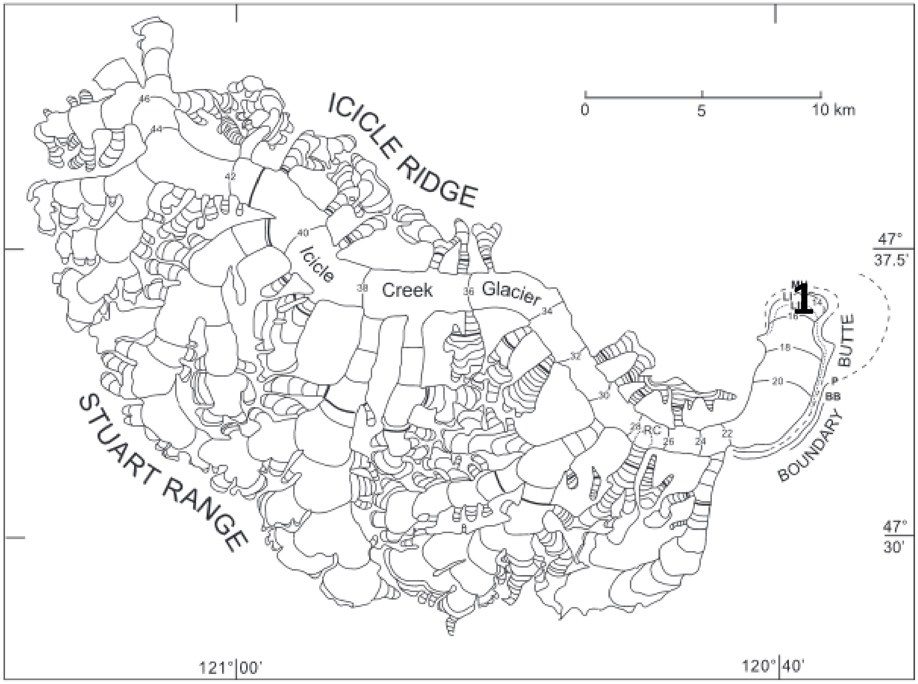

Figure 10. Topographic reconstruction of the Icicle Creek Glacier as of the time of the Leavenworth I (LI) advance. Other glacial moraines shown include Boundary Butte (BB), Peshastin (P), Mountain Home (MH), Leavenworth II (LII), and Rat Creek (RC). Bold number indicates Stop 1. Source: Porter and Swanson (2008).

Climate & Vegetation. Leavenworth's location on the margins of the Northeastern Cascades at ~47^{o}N results in warm, dry summers and cool, wet winters (Figure 11). A result of this climate are the open, Eastside Forests dominated by ponderosa pine and Douglas fir (Figure 12). The wet of winter is often in the form of snow—a driver of the glaciers, past and present, of the area. Snow is also a factor in transportation in the area (see below). The dry of summer, especially when mixed with unstable air masses, leads to fires in the area (also see below).

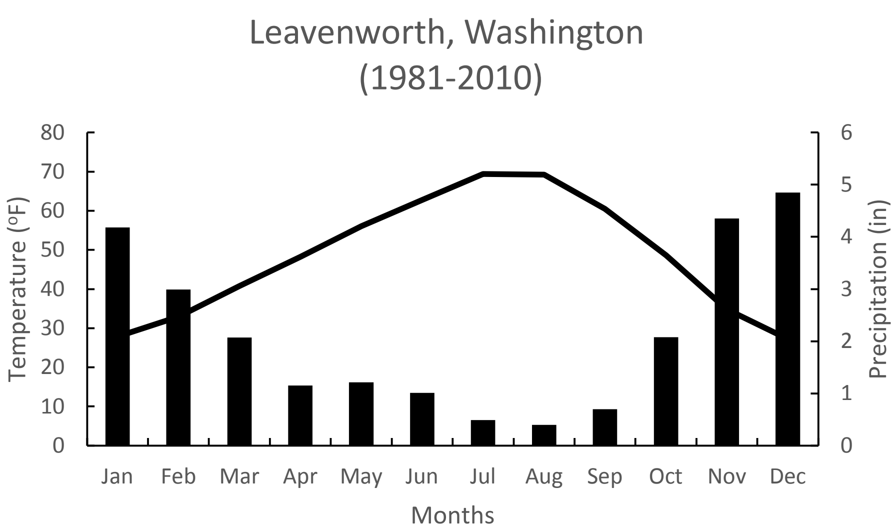

Figure 11. Leavenworth climograph. Temperature shown with line and precipitation represented by vertical bars. Source: Western Regional Climate Center, n.d.

Stop 1--Leavenworth

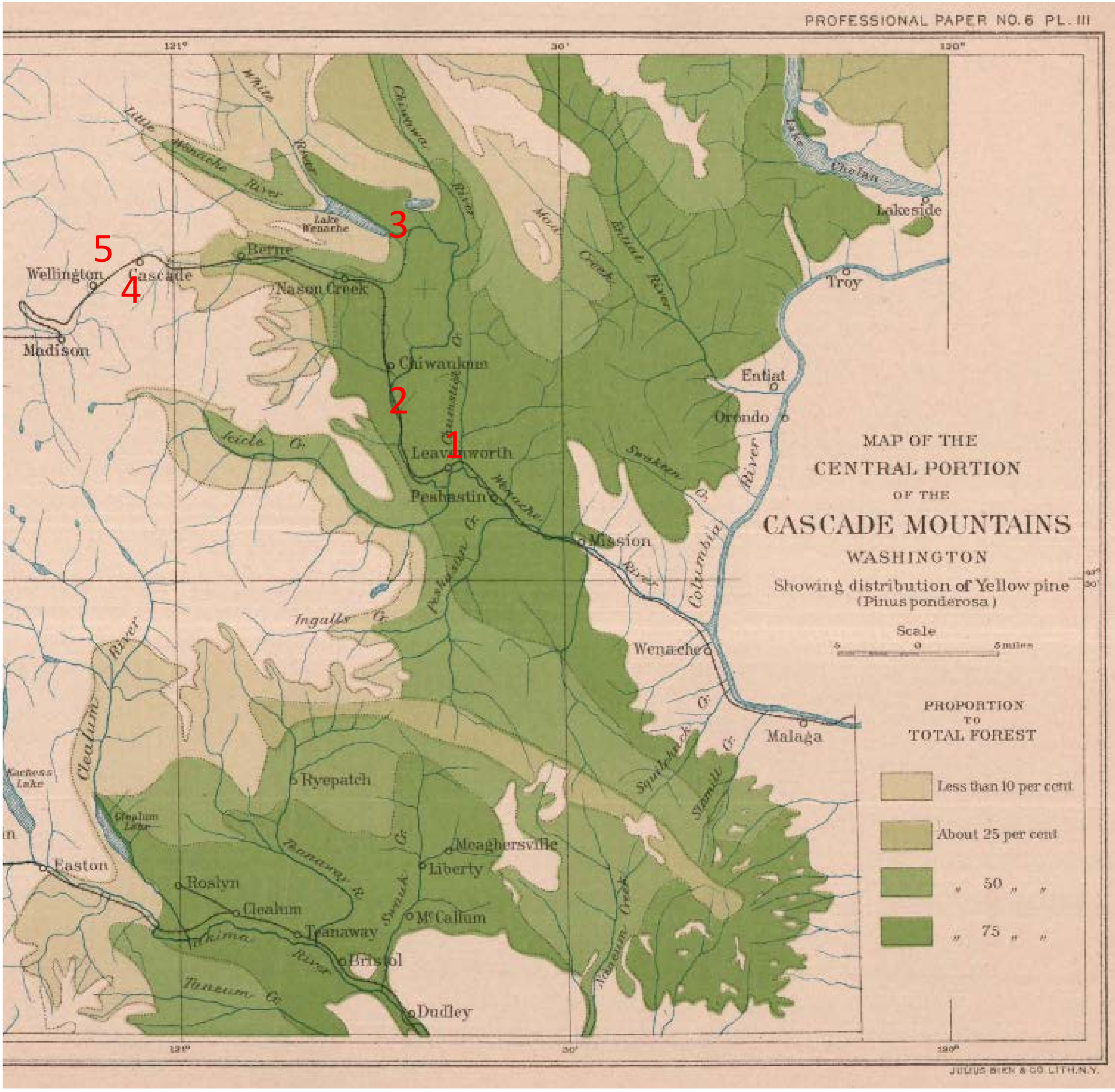

Figure 12. Historical map showing distribution of ponderosa pine and the early route of Great Northern railroad in the northeastern Cascades. Source: Plummer (1902, Plate III)

Great Northern Railroad. The history of the Great Northern Railroad (and its successors Burlington Northern and Burlington Northern-Santa Fe) railroads in the Northeastern Cascades are inextricably intertwined with the geology and physical geography of the area. James J. Hill, the president of the Great Northern, wanted a route to the Puget Sound region that was sufficiently north to serve territory not currently covered by other railroads (Bauhof, 1989). He assigned John Stevens, the engineer who had a found the Marias Pass route through the Northern Rockies, to locate the North Cascades route. Stevens explored each east-flowing

Great Northern Railroad. (continued)… tributary from the Cascades to the Columbia River north of the Yakima River. Nearly all were impractical in terms of topography or water (including a proposed Lake Chelan route). He finally settled on a route following the Wenatchee River through Tumwater Canyon, then up Nason Creek to what is now known as Stevens Pass (Stevens, 1929) (Figure 12). A route through Stevens Pass required extensive engineering because it was so steep. The long-term plan called for maximum grades of 2.2% and a 2.6 mile long tunnel near the summit. Until sufficient funds could be raised and the tunnel constructed, the route that opened in 1893 involved switchbacks with grades as steep as 4% (Bauhof, 1989). Construction of the Cascade Tunnel began in 1897 and was completed in 1900. This tunnel eliminated all eight of the switchbacks (Roe, 1995). Because of problems with noxious fumes from the coal-burning locomotives, the tunnel was electrified in 1909 (Roe, 1995; Bauhof, 1989). Electrification required a power source and that became a hydroelectric plant in Tumwater Canyon west of Leavenworth (see Stop 2).

Leavenworth, the Great Northern, and the Timber and Fruit Industries. Leavenworth had its origins as a town in 1892 with the coming of the Great Northern railroad. By early 1893, over 700 residents and 40-50 businesses occupied the town (Roe, 1995). Originally, the Great Northern passed through Leavenworth in a northeast to southwest direction. The layout of the town and US 2 reflects its railroad history (Figure 6). Leavenworth was soon after designated as a division point and the Cascade Division headquarters for the Great Northern complete with depot, roundhouse, repair facilities, and coal bunkers (Washington Writers Project, 1941; Roe, 1995). The original Great Northern depot was located where present-day US 2 passes the Leavenworth swimming pool (Lindsay Korst, personal communication, 14 July 2016).

In addition, Leavenworth's location in the forested Eastern Cascades also meant it was also the home to the large sawmills over time including Lamb-Davis Lumber Company (Roe, 1995). As a reflection of the times, much of the resulting lumber became lath (for lath and plaster walls in homes) and fruit boxes. One orchardist alone needed 100,000 boxes for his fruit (Roe, 1995)! Over time, the influence of railroads and logging diminished. In 1922, Great northern moved its Cascade Division headquarters from Leavenworth to Wenatchee. And in June 1929, the Great Northern changed its route from Tumwater Canyon to the Chumstick Valley therefore bypassing Leavenworth (Roe, 1995). The closing of the saw mill in the late 1920's was another huge economic blow to the town.

Leavenworth and Tourism. As far back as the early 1900's, merchants began to think of tourism as another part of economic survival here (Roe, 1995). Ideas began to circulate in 1911 for a scenic highway that would link eastern and western Washington through Stevens Pass. The Stevens Pass Scenic Highway officially opened in July 1925 to much fanfare. Eventually, it would follow pieces of abandoned railroad right of way (e.g., Tumwater Canyon and switchbacks near Stevens Pass). By 1937, it was designated primary State Highway 15 and in 1948, it became US 2. In 1963, it also became known as state route 2 (Roe, 1995).

Despite tourists brought by the Stevens Pass Scenic Highway, Leavenworth continued in economic decline into the 1960's. Local business people, with the assistance of the University of Washington's Bureau of Community Development, settled on rebranding the town as a Bavarian village. What you see today represents nearly 50 years of work to change the image and economic status of the town.

Leavenworth to Tumwater Canyon

Route. From Icicle River Middle School, return to US 2 and head west. In ~2 miles, enter Tumwater Canyon and continue following US 2 another ~4 miles to the eastern part of the Swiftwater Picnic Area. Be careful turning across traffic to park on the left side of the road. A pit toilet is available here. Stop 2 is a short walk west on a trail along the Wenatchee River.

To Note. On this short drive, note the bridge over the Wenatchee River, the dam on the river, the steep walls of Tumwater Canyon, fire scarred trees, and the rapids of the river. These will all be topics of discussion at Stop 2.

Stop 2—Tumwater Canyon

Location. We are located at the Swiftwater Picnic Area in Tumwater Canyon (Figure 13).
Geology. The bedrock here mostly consists of intrusive igneous rocks (e.g., diorite and tonalite) of the Mt. Stuart Batholith (Figure 8). This batholith was emplaced about 93-96 million years ago in an island arc setting (i.e., a chain of volcanic islands located at a plate boundary) (Paterson and others, 1994). Nearby, there are also slivers of middle to late Jurassic Ingalls Tectonic Complex including diabase, gabbro, argillite, and glassy green serpentinite that originated on the ocean floor (Paterson and others, 1994).
The Canyon and Fluvial Processes. The Wenatchee River in Tumwater Canyon occupies a bedrock channel. As you can see, much alluvium (i.e., river deposits) and colluvium (i.e., rockfall, debris flow, and landslide sediments) covers some of this bedrock. Tumwater Canyon is likely the result of the Wenatchee River exploiting the ample joints of the underlying bedrock. The narrowness of the canyon can be attributed to its fluvial (i.e., flowing water) origins and the hard, underlying bedrock (much of which is granitic). Upstream, where the bedrock becomes softer Ingalls Tectonic Complex, the canyon walls are lower (especially on the east side and less steep, and the valley floor broadens. Because much of the canyon is in hard rock, the energy of the river has been focused vertically rather than laterally. The overall gradient of Tumwater Canyon is about 1.3% (about 69 feet/mile). Step-pool sequences characterize the longitudinal profile of the Wenatchee River through Tumwater Canyon even though the overall gradient is a slightly low for such features. These sequences appear to stabilize steep gradient channels and prevent them from vertically eroding (Ritter and others, 2011).
Glaciation. The V-shape of Tumwater Canyon suggests that it was not glaciated. However, Cabin Creek Valley, a tributary to Tumwater Canyon about 2 miles south of Swiftwater Picnic Area may have been glaciated to its mouth (Merrill, 1966). Glacial outwash from several valleys upstream was also likely deposited in the canyon helping form the channel bars that are so common here.
Great Northern Route. Tumwater Canyon was the original route of the Great Northern Railroad beginning in 1893. However, because of recurring snow avalanches and rockfall from the steep slopes (Figure 14), the line was moved to the Chumstick Valley north of Leavenworth in 1929 (Roe, 1995). Later, US 2 followed the railbed through the canyon. Heavy snows still close transportation through Tumwater Canyon as happened in Winter 1996-97.
Hydropower. The bridge near the mouth of Tumwater Canyon, and the dam a few miles upstream were major components of the Tumwater Hydroelectric Project which was constructed to serve the electric locomotives required to pull trains through the Old Cascade Tunnel. Construction of the dam, a ~2 mile long penstock, and generators occurred in 1908-09. The three 2000 kilowatt generators were located near the mouth of Tumwater Canyon (Figure 15). The lower bridge carried the penstock from river right to the generators on river left.

Leavenworth to Tumwater Canyon

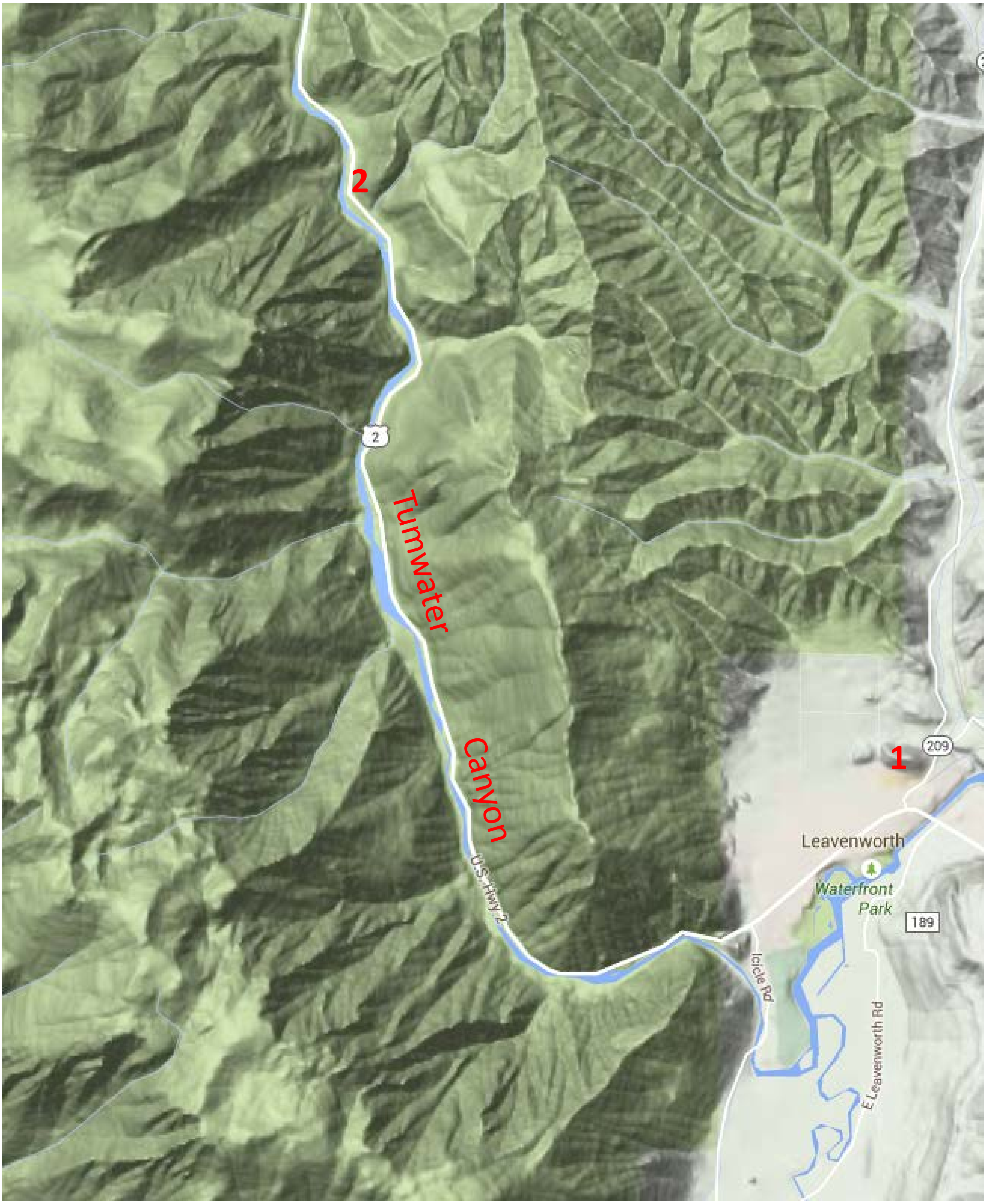

Figure 13. Tumwater Canyon. Red numbers indicate field trip stops. Source: Google Maps.

Stop 2—Tumwater Canyon

Figure 14. Rotary plow clearing snow from Great Northern tracks in Tumwater Canyon, ca. 1917. Powerlines visible are from generating plant on river side of railbed. View downriver. Source: Ray Wheeler photo, Washington State Historical Society.

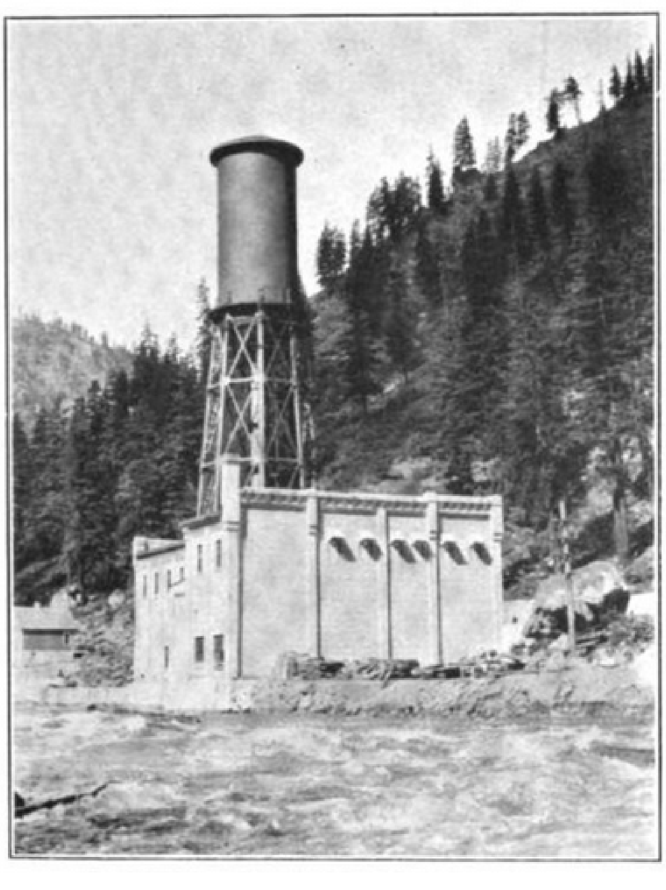

Figure 15. Great Northern power generating plant, Tumwater Canyon. View upriver. Source: Parker and Lee (1922)

Stop 2—Tumwater Canyon

Hydropower.(continued)…Power generated at the plant was transmitted 30 miles to the east portal of the Old Cascade Tunnel. The power plant operated from 1909 to 1956 (Parker and Lee, 1922; http://www.gngoat.org/tumwater_dam.htm). By then, the railroad had converted to less smoke-emitting diesel locomotives therefore there was no more need for electric locomotives.

Fire. Throughout Tumwater Canyon, you have seen evidence of fire in the burned forest. This evidence dates at least to the 1994 Hatchery Creek fire. Fire is a naturally common phenomenon in eastside forests. In the nearby Teanaway River Valley, Wright and Agee (2004) found that small, prehistoric wildfires burned somewhere in their study area every 3 years. Fire suppression beginning in the early 20th century changed this regime leading to the build-up of fuels and increasing the potential for high intensity, catastrophic fires. Here, and elsewhere in the Eastern Cascades, the dilemma is how to allow natural, low intensity fires to burn at frequent intervals to prevent the build up of fuels and resulting conflaggerations. Some of the concerns of high intensity burn areas such as those in the Hatchery Creek Fire area are increased debris flows, snow avalanches, and rockfall (Badger and Galster, 2003). Rockfall and debris flows are already a concern in the canyon based on the presence of rockfall on the road, rock nets on the steep rock faces, and debris fans at canyon mouths.

Tumwater Canyon to Lake Wenatchee

Route. From Swiftwater Picnic Area, continue north on US 2 approximately 7 miles to Coles Corner (Figure 16). There, turn right (northeast) onto WA 207 and travel approximately 3.5 miles to Nason Creek Campground and the south entrance to Lake Wenatchee State Park. Turn left (west) onto Cedar Brae Road and follow this road to State Park Road that will lead into Lake Wenatchee State Park. We will park in one of the parking lots near the swimming area. To legally park here, you will need a Washington State Discover Pass.

Glaciation. Approximately 1.5 miles north of Stop 2, Hatchery Creek enters Tumwater Canyon. An alpine glacier may have descended this valley to the canyon floor (Merrill, 1966). Near milepost 90 about 0.5 miles north of the Wenatchee River crossing, note the two small, wooded hills to the left (west) bracketing the mouth of Chiwaukum Creek. These hills are the right and left lateral remnants of an arcuate end moraine deposited by a glacier that descended the Chiwaukum Creek valley (Merrill, 1966). A moraine remnant is also present just south of Cole's Corner. This moraine formed from coalescing alpine glaciers from the north (Waitt, 1982).

Valley Origins. Just upstream of Hatchery Creek, we cross the Wenatchee River and leave the Wenatchee River valley. The river drains from Lake Wenatchee, our next stop. What is the origin of the ~dry valley we follow from the Wenatchee River crossing to Coles Corner? Is it the former route of the Wenatchee River? Does it represent a former path of Nason Creek into the Wenatchee River? It is likely that glaciation, in terms of actual alpine glaciers, their meltwater, or their deposits, played a role in the formation of this now mostly dry valley.

Railroad. Just upstream of the Wenatchee River crossing, we go under the Burlington Northern-Santa Fe railroad. From the Chumstick Valley north of Leavenworth, the railroad tunnels through a ridge of Chumstick Formation, then follows the Wenatchee River downstream before tunneling through two ridges just south of Winton. Winton, as well as Chiwaukum (near where the Wenatchee River entered Tumwater Canyon), were rail stops on the early Great Northern line (Roe, 1995).

Tumwater Canyon to Lake Wenatchee

Figure 16. Topography from Tumwater Canyon to the Lake Wenatchee/Nason Creek areas. Red numbers indicate field trip stops. Source: Google Maps.

Stop 3—Lake Wenatchee

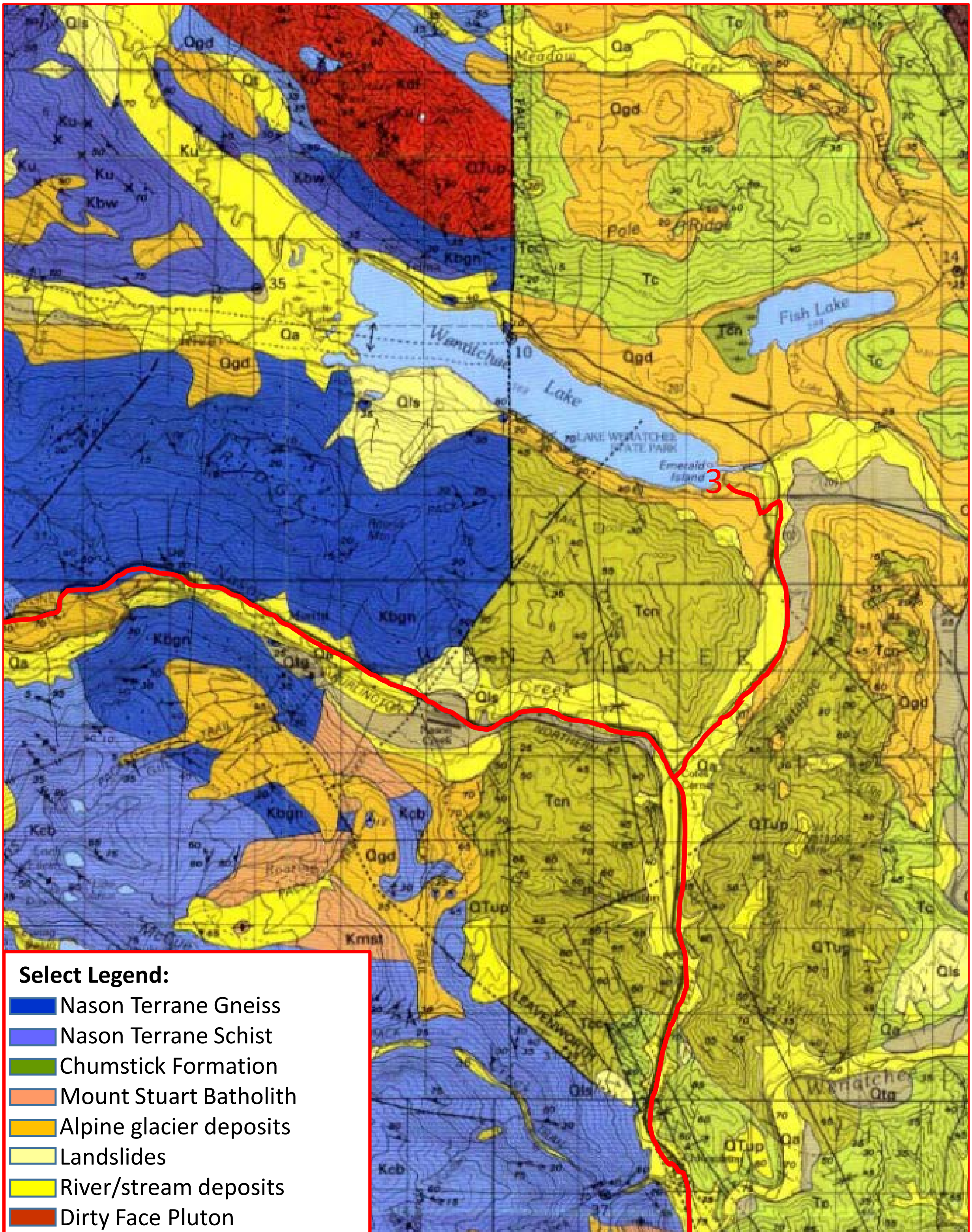

Figure 17. Geology in the vicinity of Lake Wenatchee. Numbers indicates location of field trip stop. Heavy red line indicates route. Source: Tabor and others (1987).

Stop 3—Lake Wenatchee

Location. We are located on the southeast end of Lake Wenatchee in Lake Wenatchee State Park (Figure 16).

Geology. The southeast end of Lake Wenatchee lies within the Chumstick Formation (Figure 17). This is the same bedrock found just north of Leavenworth. Midway uplake, the geology changes abruptly across the north-trending Leavenworth Fault. To the east of the fault, Chumstick Formation is present. To the west and south of the lake lies Late Cretaceous banded gneiss of the Nason Terrane (Figure 16). Terranes such as the Nason Terrane are pieces of plate that travel atop other plates away from their places of origins. North of the lake, and west of the fault lie Late Cretaceous granitics of the Dirty Face Pluton (Tabor and others, 1987).

Glaciation and Lake Wenatchee's Origins. At several times in the Late Pleistocene, glaciers formed in the mountains to the north and west of Lake Wenatchee, and advanced into the area (Figure 18). These originated in amphitheater-shaped cirques at high elevations where cool temperatures allowed snowpack to remain over time, changing to firn and ultimately glacial ice. The mass of additional snowpack and firn on the glacial ice caused the ice to flow downslope. Nimick (1977) identified two distinct glaciations—Pole Ridge and Plain--in the area based on weathering differences. He further subdivided the more recent Plain glaciation into four members based on differences in the stratigraphy of the glacial sediments. Each member of the Plain glaciation represents a time when glaciers paused, typically during retreat. Each of these pauses is indicated by unsorted glacial till, often in the form of a moraine. Plain IV end moraines impound Lake Wenatchee on its southeastern end (Figure 19). Slightly older Plain III moraines impound Fish Lake. The Plain moraines appear to correlate in age with the Leavenworth moraines (Porter, 1978). Therefore, Lake Wenatchee originated from glaciers eroding a trough and the Plain IV glacier depositing end moraine that blocked the valley outlet.

Figure 18. View up Lake Wenatchee from beach at Lake Wenatchee State Park. Note U-shaped trough occupied by Lake Wenatchee. Also note the modification to the trough on the left (west) side by mass wasting. Source: Author photo.

Stop 3—Lake Wenatchee

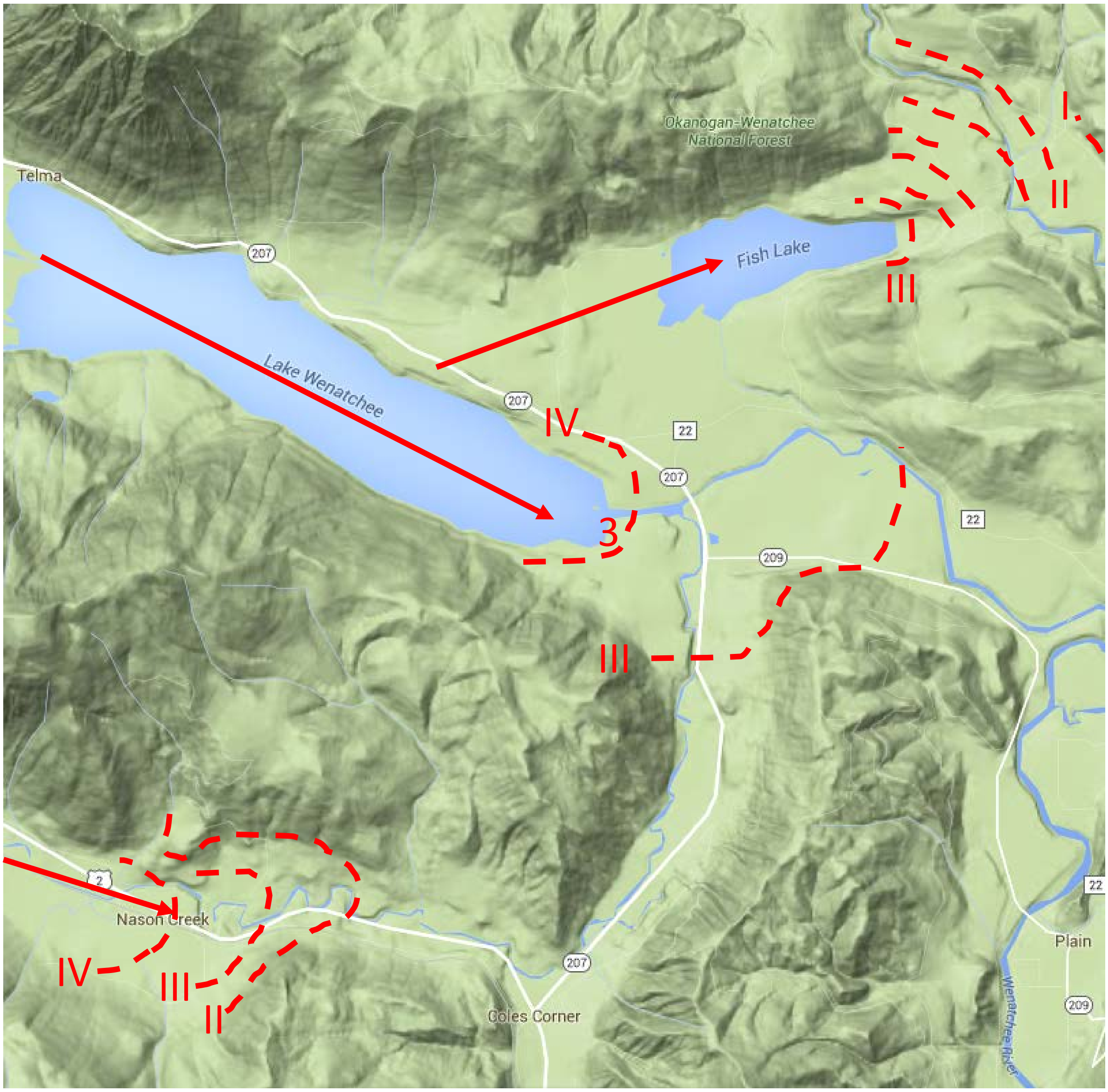

Figure 19. Topography in the vicinity of Lake Wenatchee and the Nason Creek Rest Area. Arrows indicate the approximate glacier movement directions. Dashed lines are moraines of Plain I-IV glaciations. Red Arabic number indicate field trip stop. Source: Google Maps, Nimick (1977).

Mass Wasting. A large (>2 mi^2) landslide is present on the west side of the Lake Wenatchee trough (left side when viewed from the State Park). It originated high on Nason Ridge and modified the topography of the west wall of the trough (Figures 17 & 18) (Tabor and others, 1987). Waitt (in Tabor and others, 1987) identified a large, potentially very dangerous *incipient blockslide* (i.e, "deeply crevassed and fractured bedrock area") above Lake Wenatchee. The risk is that these weakened areas will eventually descend into Lake Wenatchee. The displaced water will inundate shoreline areas many meters above lake level damaging property and potentially leading to loss of lives.

Lake Wenatchee to Stevens Pass

Route. From Lake Wenatchee State Park, return to WA 207. Turn right (south) onto WA 207 and return to US 2. Follow US 2 approximately 20 miles to Stevens Pass (Figures 20-22). Park in the large parking area on the north (right) side of US 2. We will then walk on the overpass over US 2 and gather on the slope above the Pacific Crest Lodge.

Geology. Geologically, we are located just west of the Leavenworth Fault having crossed it between Coles Corner and the Nason Creek Rest Area (Figure 17). According to Waitt (1982), you can see the fault as an abrupt topographic break to the south of the rest area. Westward are the Late Cretaceous gneisses and schists of the Nason Terrane, and the Late Cretaceous Mount Stuart Batholith tonalite and granodiorites.

Glaciation. Nason Creek and Stevens Creek (near Stevens Pass) are U-shaped glacial valleys covered in places with Quaternary alluvium and glacial deposits (Figures 17, 20 & 21). The sources of the glacial ice were numerous cirques to the west and south. Most of this ice came from shaded ~north-facing cirques to the south of Nason Creek in the Chiwaukum Mountains (Figures 20 & 21). You can see these cirques on the ridges above US 2. These various ice sources merged to form a valley glacier that descended Nason Creek to the vicinity of the rest area. Based on landforms and stratigraphy exposed here long ago, Nimick (1977) mapped Plain II, III, and IV moraines here. These moraines are difficult to now see from US 2 (or on Google Earth). However, associated glacial outwash terraces are visible from the highway as evidenced by their bench-like forms, and the rounded, sorted, and bedded sediments within. A large Washington State Department of Transportation quarry operation here also indicates the present of sands and gravels derived from glacial outwash. These "clean" sediments are ideal for road building and maintenance. Further upvalley, in a ~3 mile stretch between Merritt and Gaynor, glaciation was unable to smooth the valley floor leaving schist and amphibolite bedrock "humps" akin to those seen along I-90 in the Upper Yakima River Valley between Lake Easton and Lake Keechelus.

Great Northern Railroad. As we ascend Nason Creek toward Stevens Pass we parallel the original rail line of the Great Northern Railway and pass the remains of former rail stops Merritt, Gaynor, Berne, and Cascade Tunnel (Figures 20 & 22) (Roe, 1995). This rail line over the Cascades was built and maintained with largely immigrant labor. James J. Hill famously said "Give me enough Swedes and whiskey, and I will build a railroad to hell" (Krist, 2007). At Berne, the east portal of the "Eight-Mile Tunnel" (also known as the "New Cascade Tunnel") is partially visible. When completed in 1929, this tunnel was the solution to most of the snow avalanche hazards that had plagued the line since its inception (see **Stop 5**). My paternal grandfather, Edwin Lillquist, was a laborer on tunnel crews that bored through Mt. Stuart Batholith and Nason Terrane rocks here (Figure 22). Next upvalley (but not visible from US 2) is the east portal of the "Old Cascade Tunnel" at what was once known as "Cascade Tunnel" or "Tunnel City". When completed in December 1900, the 2.6 mile long Cascade Tunnel through Mt. Stuart batholith removed 678 feet of elevation from the route (4061 feet to 3383 feet) (Bauhof, 1989) and eliminated 8.5 miles of switchbacks. For seven years prior to the construction of the Cascade Tunnel, three prominent switchbacks created an acceptable grade for the Great Northern just east of Stevens Pass (Figure 22). You can still see remnants of these switchbacks on USGS topographic maps, Google Earth, and on the ground. The Pacific Crest Trail just north of Stevens Pass follows one of these switchbacks. Five more switchbacks were on the steeper west side of the range (Roe, 1995).

Lake Wenatchee to Stevens Pass

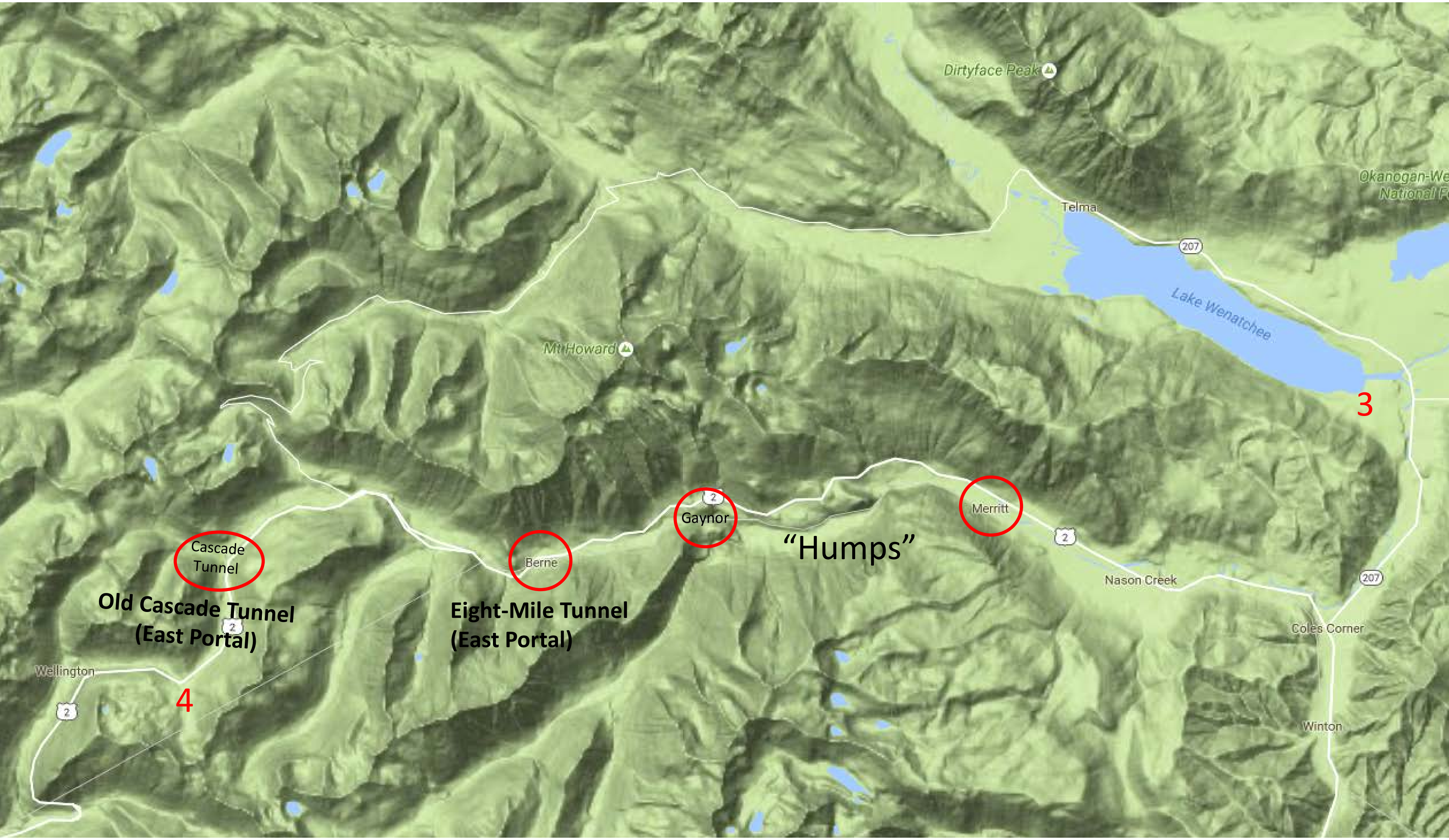

Figure 20. Topographic map of US 2 corridor from Lake Wenatchee to Stevens Pass. Note the red circled former railsteops. Red numbers indicate locations of field trip stops. Source: Google Maps.

Lake Wenatchee to Stevens Pass

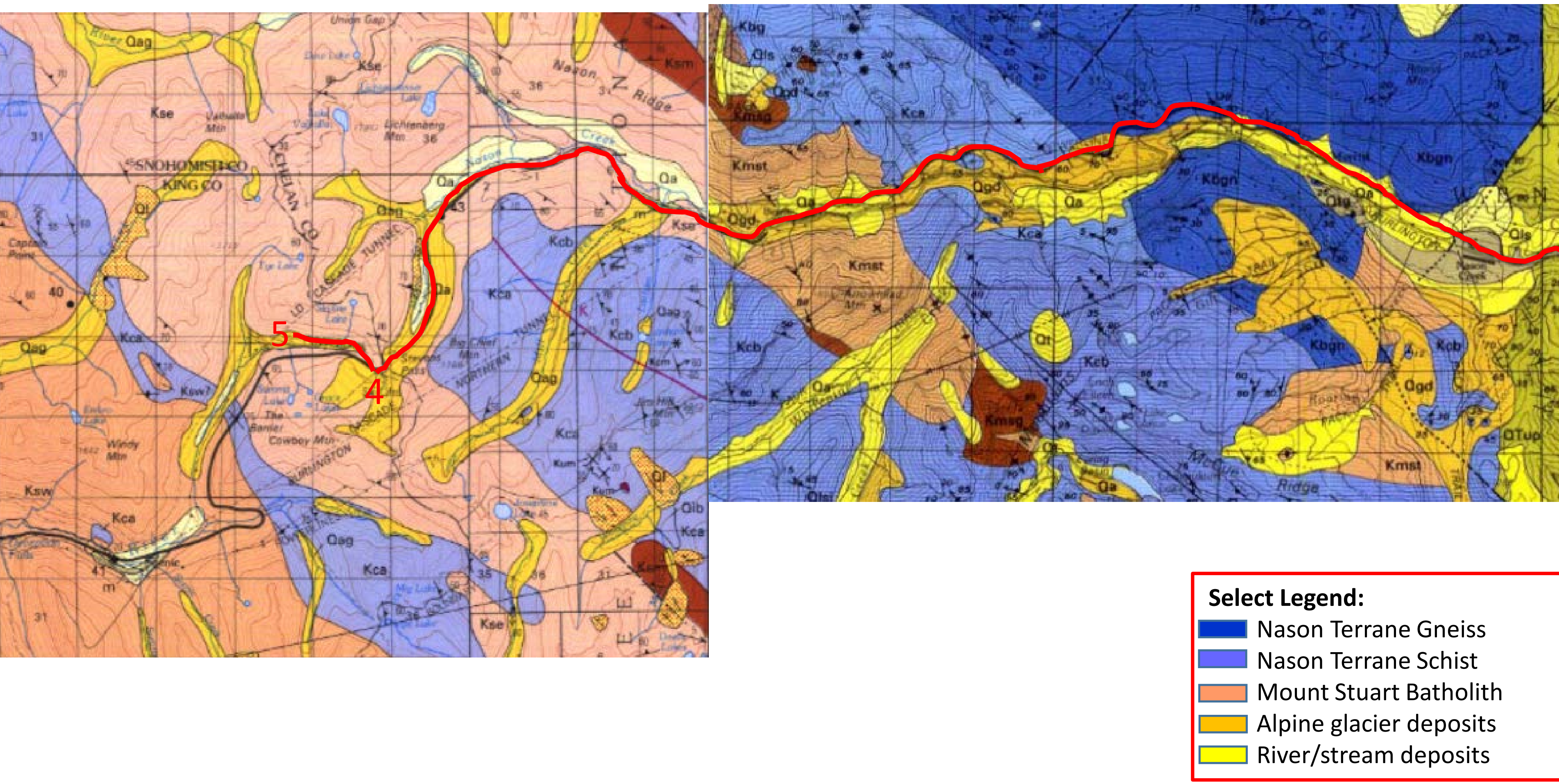

Figure 21. Geologic map for the Nason Creek to Stevens Pass area along the US 2 corridor. Red numbers indicated field trip stops. Red line indicates route. Sources: Tabor and others (1987); Tabor and others (1993).

Lake Wenatchee to Stevens Pass

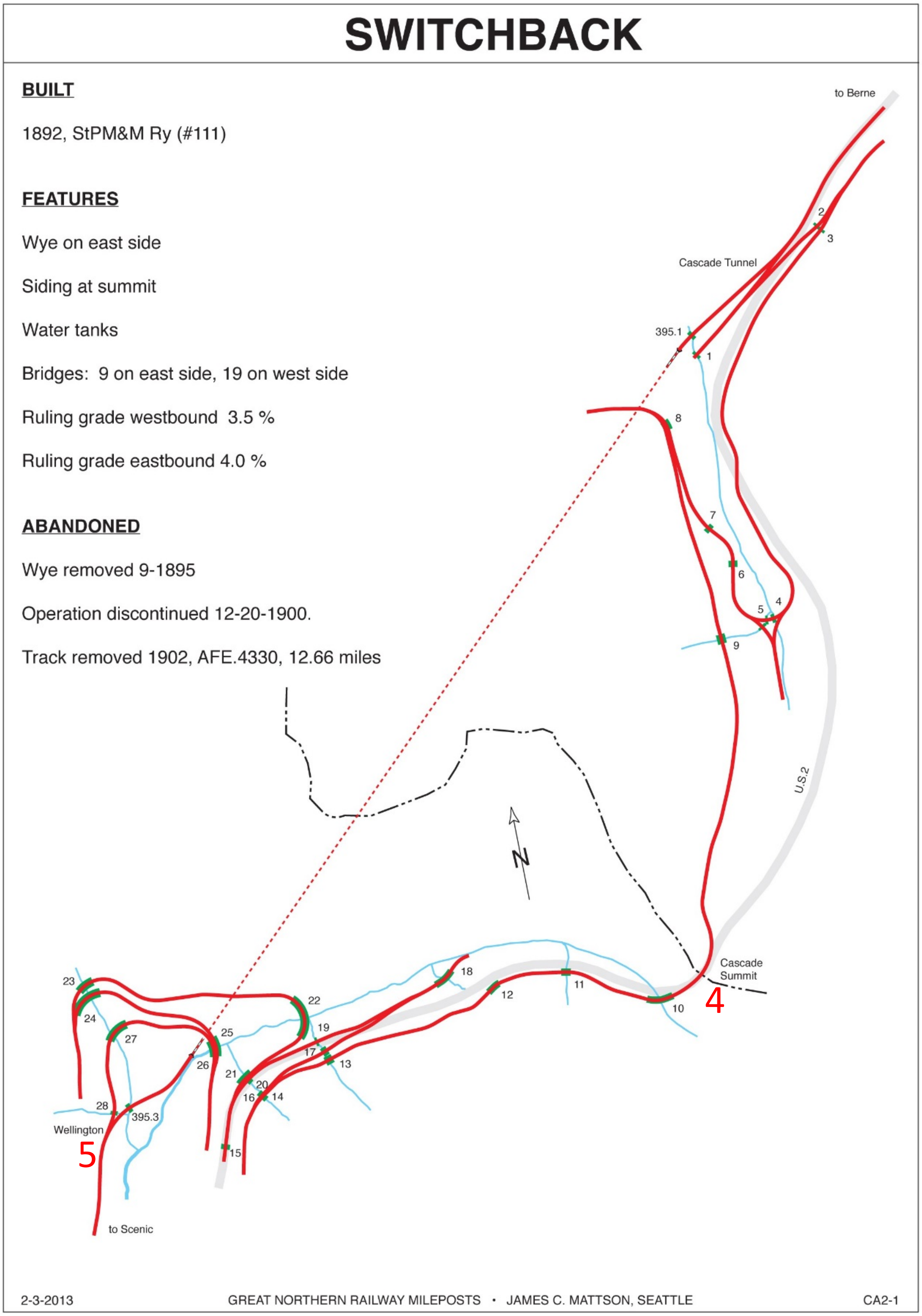

Figure 22. Great Northern Railway alignments near Stevens Pass, 1893 to present. Red numbers indicate approximate locations of field trip stops. Source: James C. Mattson, 3 February 2013.

Stop 4—Stevens Pass

Location. We are located at the Stevens Pass Ski Area above the Pacific Crest Lodge on the south side of US 2 (Figure 23).

Geology. The bedrock geology here is tonalite and granodiorite of the Mt. Stuart Batholith (Figure 21).

Climate. The climate of Stevens Pass is subalpine with a strong maritime influence. The Cascade Crest location helps explain the subalpine conditions where the average annual temperature is only 39°F (Figure 24). The maritime influence is seen in the average total annual precipitation of nearly 83 inches/year (Western Regional Climate Center, n.d.). This is more than three times the precipitation of that of Leavenworth, all in a span of 23 miles straight line distance! Given that most storms in the Pacific Northwest occur in the winter, much of the precipitation that falls here is snow. Average total annual snowfall for the 1939-1994 period here was 472 inches/year (or ~39 feet/year)! We can attribute much of the precipitation here to orographic uplift of maritime air masses by the Cascade Range. However some of this precipitation is the result of Stevens Pass being in the Puget Sound Convergence Zone formed by maritime air masses splitting around the Olympic Range then converging in the area between Everett and Seattle. With convergence comes uplift and precipitation. The effects of the convergence zone often extend into the Cascades with Stevens Pass feeling more of the brunt than does Snoqualmie Pass (Renner, 1992; Mass, 2008).

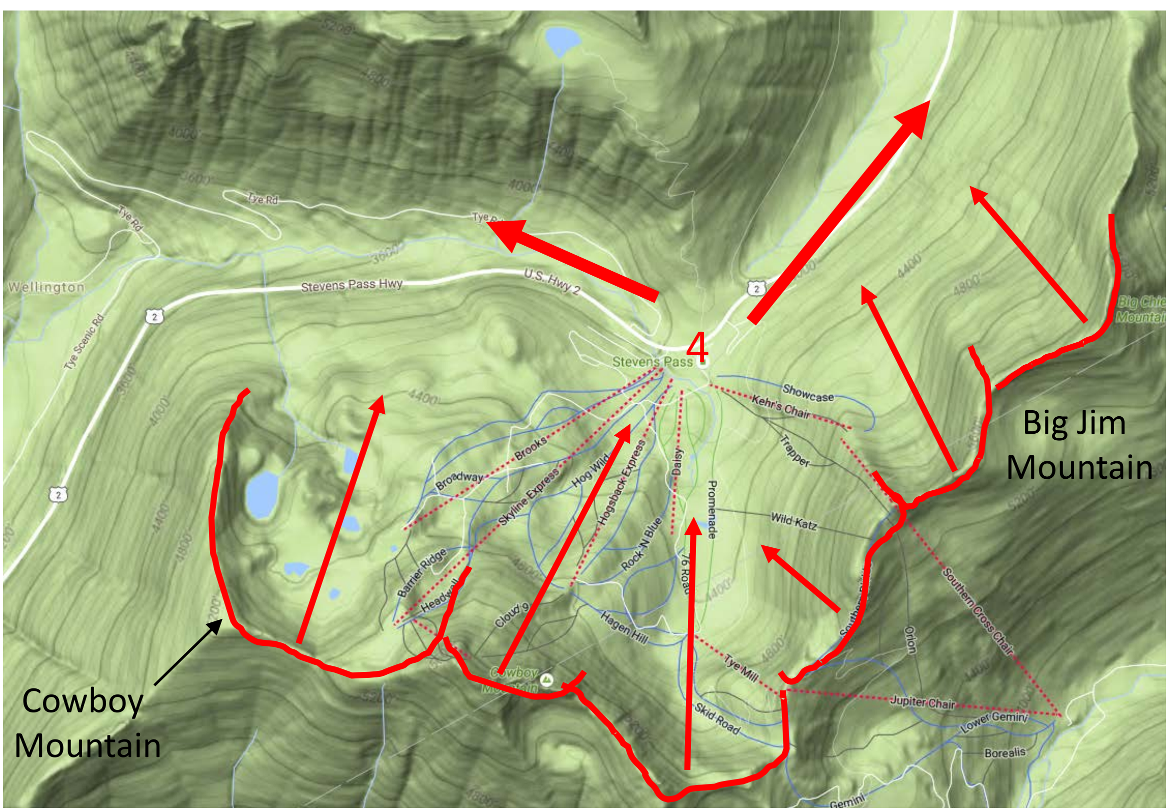

Figure 23. Stevens Pass Area. Number indicates approximate location of field trip stop. Glacial cirques indicated with red curved lines. Approximate direction of glacier movement indicated with red arrows. Ski lifts are shown with dotted red lines while ski runs are shown in light blue. Source: Google Maps.

Stop 4—Stevens Pass

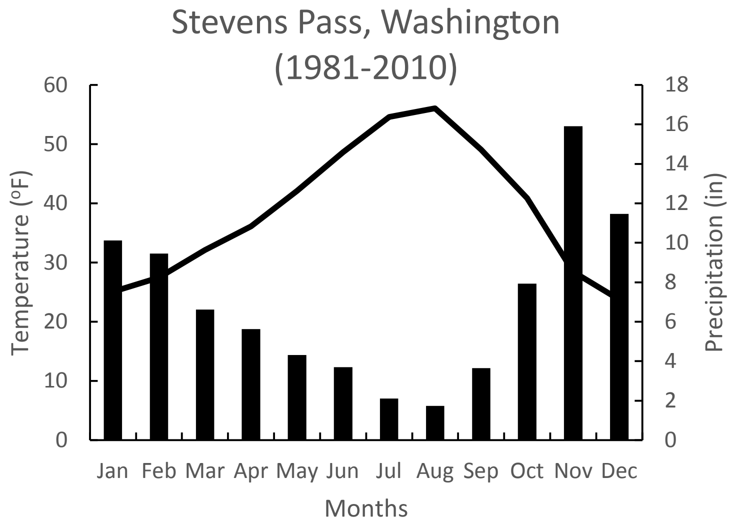

Figure 24. Stevens Pass climograph. Temperature shown with line. Precipitation represented by vertical bars. Source: Western Regional Climate Center.

Glaciations. Low temperatures and ample precipitation are a recipe for glacier formation and associated cirque development. We are standing on the floor of a north-facing, compound cirque formed in Cowboy Mountain and Big Jim Mountain (Figure 23). In the mid-latitudes of the northern hemisphere, the sun's rays always come from a southerly direction; therefore, most cirques are north-facing (or facing away from the sun) which enhances the accumulation of snow, the conversion of snow to firn, and the conversion of firn to glacial ice. Compound means there are actually six cirque headwalls above us here, two of which fed into a glacier that descended the Stevens and Nason creek valleys to the east, and four that fed a glacier that descended the Tye River Valley to the west. This pattern is similar to that seen at Snoqualmie Pass where the cirque at Alpental fed glaciers that descended the west and east sides of the Cascade Crest. Within this cirque, we are standing on an end moraine which was formed as a glacier paused and remained in one place before retreating.

Timing of Glaciations. Based on the positions of moraines at Stevens Pass (Figure 25), Porter (1978) correlated the Stevens Pass moraines with the late Pleistocene Rat Creek moraines of the Icicle Creek drainage and the Hyak moraines of the upper Yakima River drainage. The presence of multiple *tephras* (including ash and small gravel size fallout known as lapilli) allowed Porter to estimate a likely late Pleistocene age for the moraines. The absence of Glacier Peak tephra layer M atop the moraine suggests that it formed after the ~13,710-13,410 calendar years before present (cal yr BP) eruption (Porter, 1978; Kuehn and others, 2009). However, the moraine is overlain by 6,600 year old Mt. Mazama "O" layer tephra indicating that it was deposited more than ~7,627 cal yr BP (Porter, 1978; Zdanowicz and others, 1999). An alternative hypothesis is that the absence of Glacier Peak tephra on these moraines is more a function of their location on the margin of the tephra plume (Figure 26) than their age (Waitt, 1982). Supporting this hypothesis are the observations of R.B. Waitt, P.T. Davis, and J.E. Beget who found Glacier Peak tephra mantling late Pleistocene moraines in similar positions to those at Stevens Pass in several dozen cirques southeast and east of Glacier Peak. These contradicting hypotheses demand more research. In yet higher cirques in the North Cascades, there is evidence for early Holocene and late Holocene ("Neoglacial") glacial advances (Waitt, 1982).

Stop 4—Stevens Pass

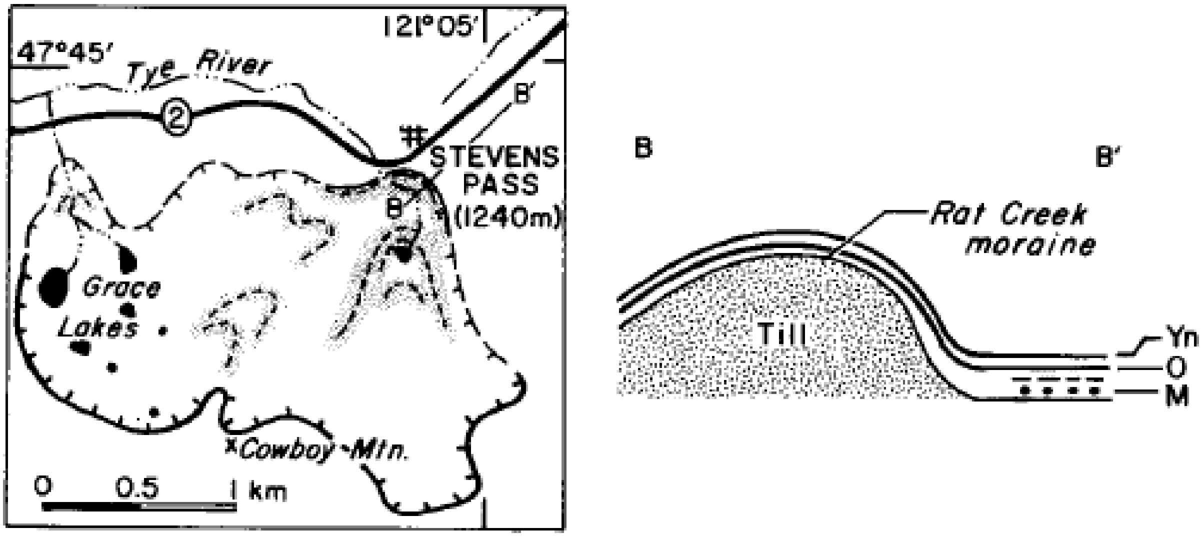

Figure 25. Relationship of Glacier Peak tephra layer M, Mt. Mazama layer O, and Mt. St. Helens layer Yn to late-glacial moraines at Stevens Pass. Field trip stop is atop the moraine near (1240m). Source: Porter (1978, p. 39).

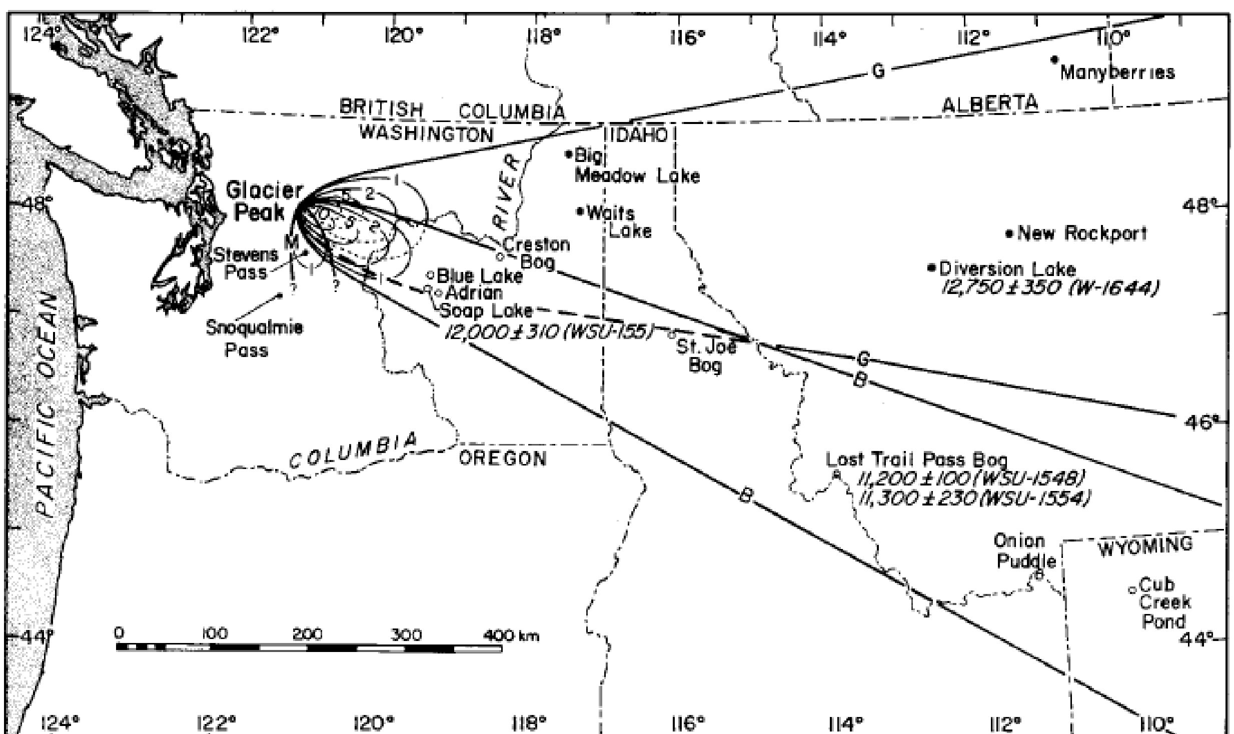

Figure 26. Inferred distribution of Glacier Peak tephra layers G, M, and B in the northwestern United States and adjacent southwestern Canada. Note the location of Stevens Pass in relation to layer M. Source: Porter (1978, p. 31).

Stop 4—Stevens Pass

Ski Areas, Glaciation and Snowfall. Because of direct sunlight and its impacts on snowpack, most of Washington's ski areas are located on north-facing slopes. And in areas that were once glaciated, most of these north-facing slopes are cirques. Such is the case at Stevens Pass where the ski lifts and runs exploit the slopes of the north-facing cirques (Figure 23). Skiing at present is, and glaciation of the past was, enhanced by the mixing of warm, moist air from the west with cold, dry air from the east at relatively low Steven Pass.

Railroads. The original Great Northern switchback route crossed Stevens Pass about where US 2 does. Eastbound, it followed the south facing slope of the ridge north of present-day US 2. As noted earlier, the railbed is now the Pacific Crest Trail. Westbound, it appears to have descended the Tye River Valley on or near the current road bed that we will follow to Wellington (**Stop 5**).

Stevens Pass to Wellington

Route. Return to US 2. Immediately after passing under the pedestrian overpass, take the first right onto an unmarked gravel road. Follow this road for approximately 2.5 miles as it descends the west side of the Cascade Range. When you reach a prominent intersection, take a right and in a short distance you will arrive at the site of Wellington. This site may also show up as "Tye" on your maps.

To note on this short drive. Part of this road generally follows the 1893-1900 switchback alignment of the Great Northern route over the Cascades. Our road switchbacks three times before we reach our turn into Wellington. The railroad had five switchbacks along this same general route (Figure 22). Later, this became the route of the original Stevens Pass highway. In places (especially below the turn into Wellington) the asphalt of this highway remains. The U-shaped valley we follow was created by the west-flowing glaciers that originated in the Stevens Pass cirque (Figure 27). The steep walls of this glacial valley are prone to snow avalanches. Avalanche hazards increased along this highway over time with the removal of forests by fire (University of Washington Geology Department Staff, 1963). You can see these as vertical stripes of deciduous forest through the more prominent coniferous forest.

Stop 5--Wellington

Location. We are located at the site of Wellington, once a key rail stop located at the west portal of the Old Cascade Tunnel along the Great Northern Railway (Figure 28) You will need a Northwest Forest Pass to legally park here.

Geology. As at Stevens Pass, the bedrock geology is dominated by two Late Cretaceous units--tonalities and granodiorites of the Mt. Stuart Batholith, and schists and amphibolites of the Nason Terrane (Figure 22). Superimposed on this are Pleistocene glacial till and outwash.

Topography. Wellington is located at the junction of two arms of the Tye River Valley (Figure 28). Both of these arms were glaciated as indicated by their U-shaped profiles. Glaciers from the Stevens Pass cirques shaped the eastern arm while glaciers from the vicinity of Tye Lake eroded the western arm. The topography suggests that the glaciers coalesced in the vicinity of Wellington and descended nearly to present-day Scenic before being joined by glaciers from the Tunnel Creek drainage.

Stevens Pass to Wellington

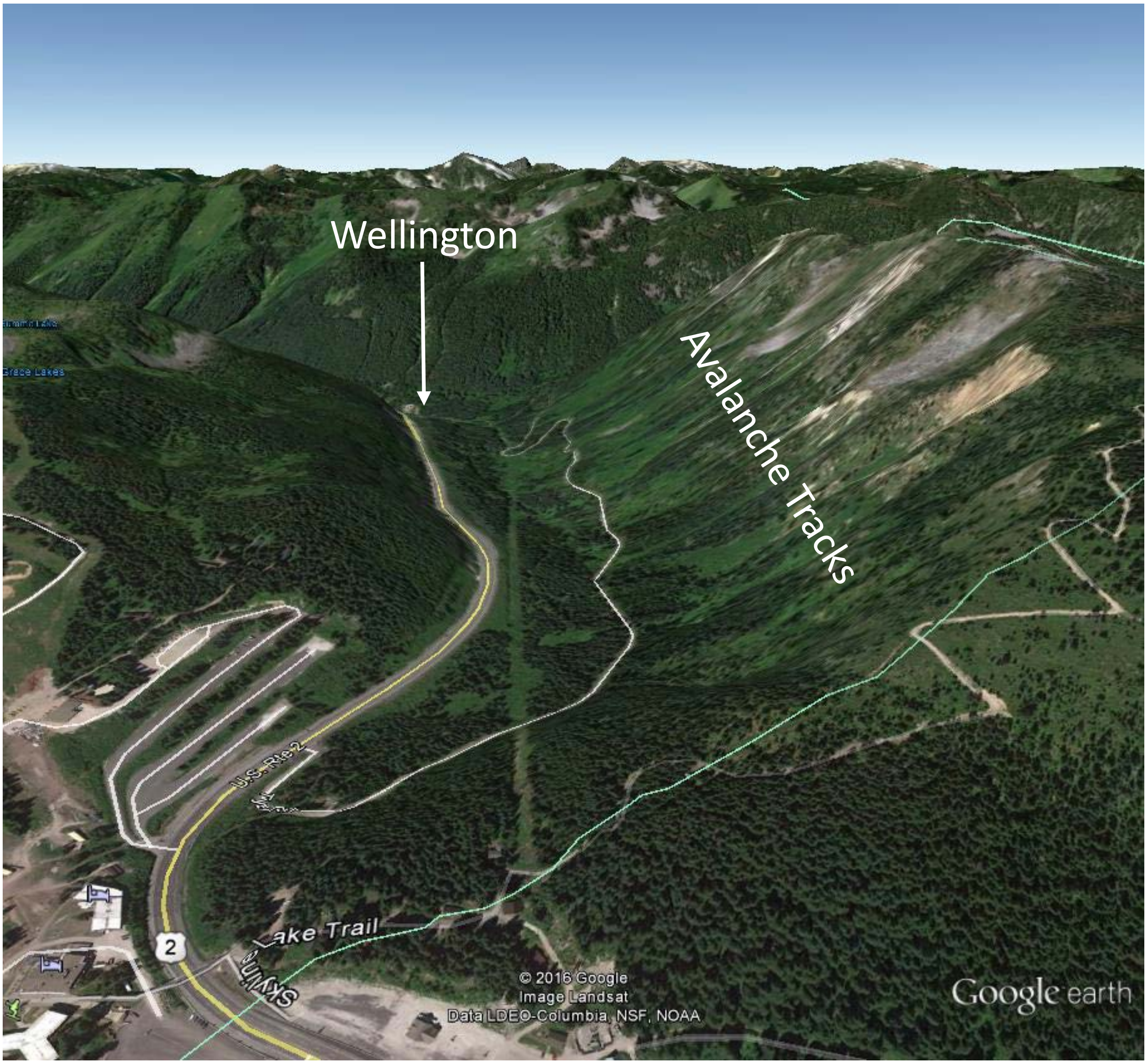

Figure 27. Glaciated upper Tye River Valley viewed from Stevens Pass toward the west. Note: 1) the U-shape of the valley indicating past glaciation; and 2) the numerous avalanche tracks on the mountain to the north indicated by lighter colored vegetation. Source: Google Earth.

Stop 5—Wellington

Early History of Wellington. Wellington originated in 1893 as a rail stop on the original switchback route and persisted until the completion of the Eight-Mile Tunnel in 1929 (Roe, 1995; Wandell, 1999). During the construction of the initial Cascade Tunnel, it was a construction camp at the tunnel's west portal. Upon completion of the tunnel, it became a key stop for tunnel maintenance, and for adding and removing the electric locomotives that were used to move trains through the tunnel from 1909 to 1929. It was also home to several rotary snowplow crews, and to snow shovelers hired to keep the tracks clear in the long winter months. As of Winter 1910, Wellington consisted of a three spur lines near the tunnel mouth (Figures 29 & 30). West of the tunnel portal and the spurs sat a crew bunkhouse and cookhouse, a small depot, a roadmaster's office, section house, and an electric engine house. Still further west, there were two sidetracks, passing tracks, and a runaway track. Just upslope of the depot was the Bailets Hotel and various houses and shacks where railroad employees lived (Roe, 1995; Hult, 1960; Krist, 2007).

Avalanches in the Cascades. Avalanches were (and are) a way of winter life here. Avalanches are a function of snowfall, slope, vegetation cover, and triggering events. To deal with avalanches early on the Great Northern built wooden "snowsheds" over the tracks in particularly avalanche-prone areas. Rotary snowplows were used to clear avalanches from railroad tracks. However, deep or tree-laden avalanches had to be cleared manually therefore the need for crews of snow shovelers.

Events Leading up to the Wellington Disaster. The late winter of 1910 was harsh throughout the West (Beals, 1910). On the evening of 22 February 1910, two Great Northern trains were heading west toward Seattle. Train 25, the Seattle Express, made the regular trip from Spokane to Seattle. Several hours behind was Train 27, the Fast Mail, transporting U.S. Mail from St. Paul, Minnesota. A late winter storm slowed and eventually halted the trains at the east portal of the Cascade Tunnel in the early morning of the 23rd. The trains remained at Cascade Tunnel until the evening of the 24th when they were moved to Wellington in anticipation that the tracks westward would soon be clear. In Wellington, the trains were parked on the passing tracks below a slope that had not experienced an avalanche during the lifetime of the railroad. Continued snowfall and avalanches kept the tracks closed westbound and eastbound for the next five days effectively trapping the trains at Wellington. By the early morning hours of 1 March, rain was falling during a tremendous thunderstorm. Approximately 125 people were aboard the Seattle Express and the Fast Mail (Krist, 2007).

Wellington Avalanche. The heavy rain atop the deep snows concerned Engineer Charles Andrews so much he could not sleep. He was outside at 1:42 am, when he heard, then saw, the avalanche. Author Ruby El Hult (1960, p. 66-67) summarized his observations as he "*saw White Death moving down the mountainside above the trains. Relentlessly it advanced, exploding, roaring, rumbling, grinding, snapping—a crescendo of sound that might have been the crashing of ten thousand freight trains. Colossal it was—in the manner the world might end. Onward it rolled in a majestic wave, crumbling the whole canyon wall before it. It descended to the ledge where the side tracks lay, picked up cars and equipment as though they were so many snow-draped toys, and swallowing them up, disappeared like a white, broad monster into the ravine below.*" The deep snows on the slope above the trains had fractured, releasing a slab avalanche. The avalanche was likely several hundred feet wide at its crown. By the time it had travelled approximately 1600-2000 feet to the trains, it was 1000-1400 feet wide (Munger, 1911; Gallagher, 1967). Both trains—the Seattle Express (seven cars plus one locomotive) and the Fast Mail (four cars plus one locomotive) plus Cascade Division Superintendent James O'Neill's private car, one steam locomotive, four electric locomotives, a rotary snowplow, several boxcars, the electric enginehouse,

Stop 5--Wellington

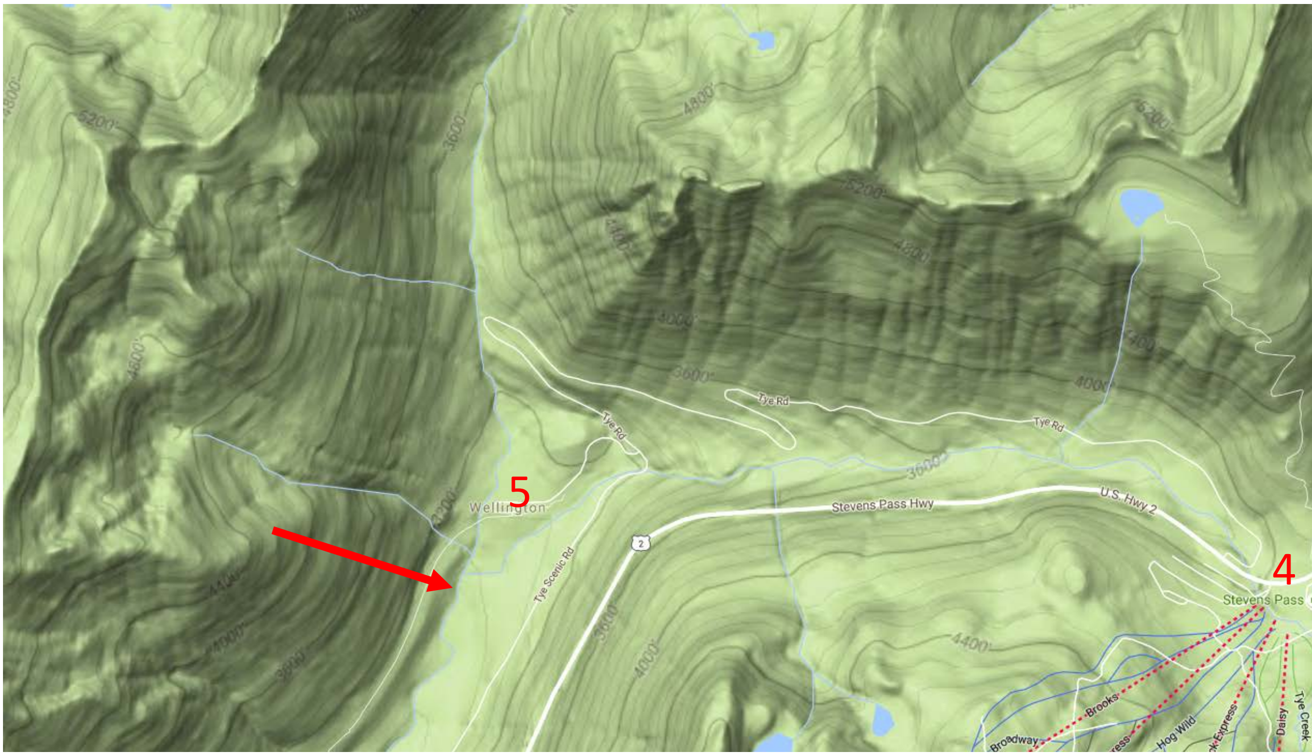

Figure 28. Wellington area including topography and the area of the fatal 1910 avalanche. Red arrow is the approximate path of the Wellington Avalanche. Numbers indicate field trip stops. Source: Google Maps.

Wellington Avalanche. (continued). …a water tower, telegraph lines, and several shacks were swept 150 feet to the Tye River Valley floor below (Hult, 1960; Gallagher, 1967; Anderson, 1989; Moody, 1998; Krist, 2007; Burwash, 2009). The force of the snow and associated trees and rocks of the avalanche crushed and mangled passenger and mail cars. Despite the efforts of surviving Wellington residents, 96 passengers, U.S. mail personnel, and railroad employees died.

Causes of the Wellington Avalanche. So why did an avalanche occur here in March 1910? It really comes down to the variables mentioned above. First, a huge amount of snow fell during the previous week. Lots of snow (at least 11 feet) fell in the three storms that hit the area over the eight days that the trains were snowbound. The latter two storms brought heavy snows as well as sleet and rain. The precipitation of the three storms fell on old, hard snow that offered little resistance to sliding. Further, strong winds loaded slopes creating drifts as deep as 20 feet in places (Beals, 1910; Gallagher, 1967). The snow fell on a slope was estimated to be 75% (~37^{o}) (Munger, 1911), a value that falls within the zone of highest avalanche danger (Figures 30 & 31). In addition, the slope was smooth, lacking in bedrock ledges and gulleys therefore offering little in terms of resistance. Third, the forest cover that is so prevalent now was not there in 1910. Fires burned the slope three times between 1893 and 1910 so all that remained on the slope prior to the avalanche were snags, downed logs, stumps, and very little brush (Figures 30 & 32) (Munger, 1911). Like the topography, the vegetation offered little resistance to an avalanche. What ultimately triggered the avalanche--a loose snow avalanche from above (Munger, 1911)? Thunder and lightning (Krist, 2007). We may never know the answer.

Stop 5--Wellington

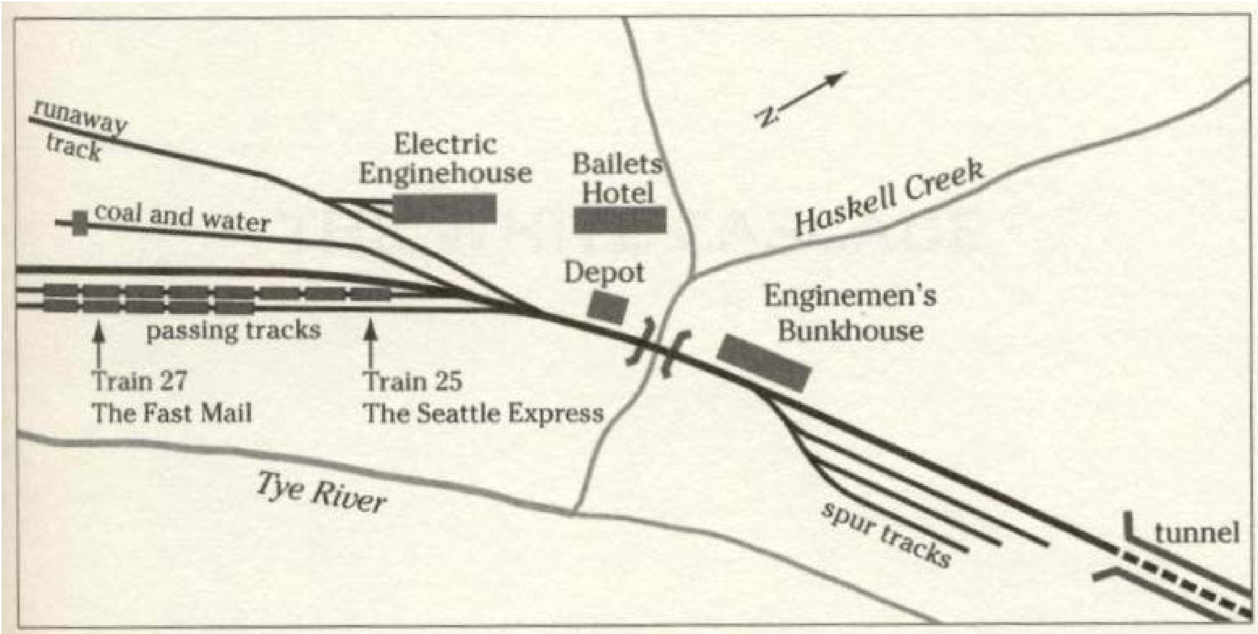

Figure 29. Map of Wellington as of 1910. Source: Krist (2007).

Property of Museum of History & Industry, Seattle

Figure 30. Wellington and the Great Northern Railway, ca. 1910 (post-avalanche). View west from spur tracks toward slope that failed in March 1910 (see arrow). Source: Webster and Evans photograph, Museum of History and Industry, photograph number 1983.10.8959.

Stop 5--Wellington

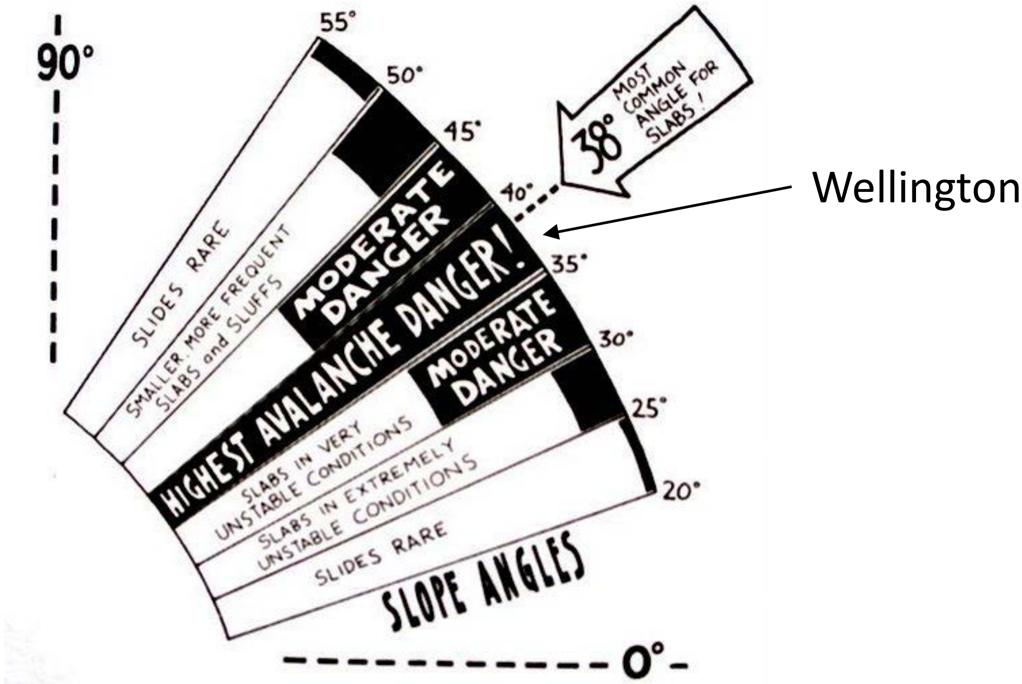

Figure 31. Most common slope angles for avalanches. Note the 37^{o} slope angle at Wellington. Source: O'Bannon and Cleland (2012).

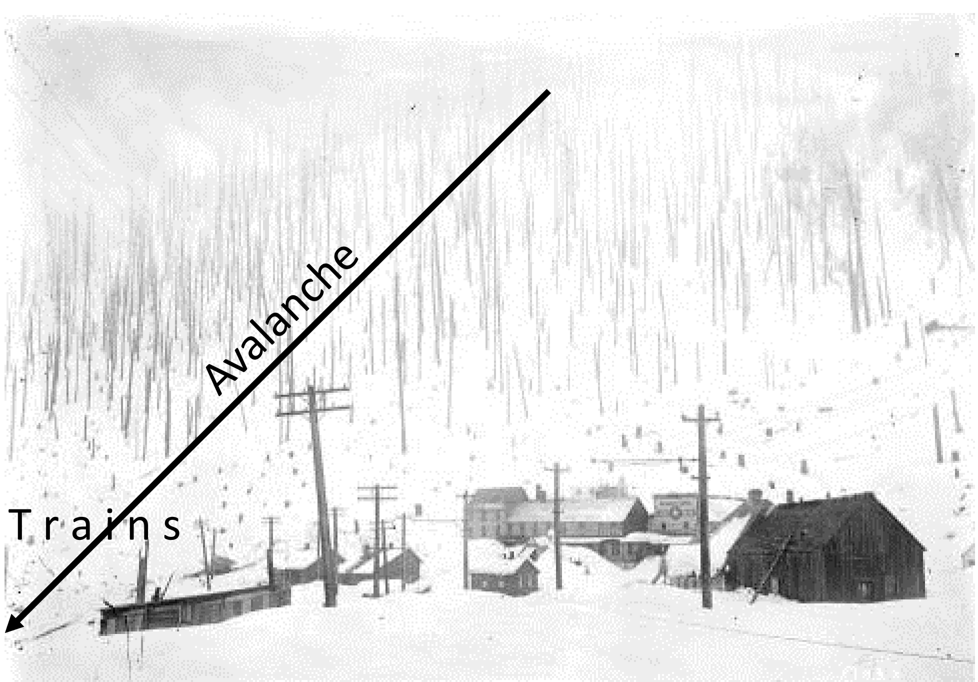

Figure 32. Post-avalanche view from near the mouth of the old Cascade Tunnel toward the west to Wellington and the burned- over forest of the avalanche slope. Arrow indicates avalanche path. Trains were situated near the word "Trains". Source: Ashahel Curtis photograph, 10 March 1910, Washington State Historical Society, identification number 1943.42.17456.

Stop 5--Wellington

The Aftermath. In the following days, months, and years, many changes came to Wellington. It was not until 10 March that the Great Northern line east opened, and 12 March that the line to the west was cleared (Krist, 2007). The last body was not recovered from the wreckage until June of 1910. The jury for a formal inquest by the King County Coroner's Office found that the cause of the avalanche was beyond human control. However, they also found fault with Great Northern's placement of the trains, their lack of coal at Wellington, and the low wages paid to laborers stating that all played a role in the disaster. In October 1910, the Great Northern quietly changed the name of Wellington to Tye in a public relations move *(*Krist, 2007*).* A subsequent lawsuit by the son of one of the victims was found in favor of the plaintiff but was subsequently overturned by the Washington State Supreme Court who stated: *It is plain, from the evidence in the case and from undisputed facts that this avalanche was what is known in law as vis major, or an Act of God, which, unless some intervening negligence of the railway company is shown to have cooperated in it, was the sole cause of the accident, and for which the railway company is not liable* (Krist, 2007). Because of the Wellington disaster and subsequent avalanches, additional snowsheds were constructed between Wellington and Scenic. Prior to 1910, nearly 7,600 feet of snowsheds were in place. All of these were primarily constructed of wood. In 1910-11, a 2,462 foot long all concrete snowshed approximately 0.1 mile west of the Wellington parking lot was constructed where the trains were swept away in March 1910 (Wandell, 1999). By 1914, eight of the 12 miles between Wellington and Scenic were in tunnels or covered with snowsheds (Anonymous, 1914). Despite these snowsheds and tunnels, avalanches still wreaked havoc on the Great Northern line around Stevens Pass, and snowsheds were expensive to build and maintain. As a result, plans were drawn up for the Eight-Mile Tunnel that would bypass the most avalanche-prone part of the route. The tunnel was initiated in December 1925 and completed in January 1929. With its completion came the end of Tye (i.e., Wellington).

Wrap-up

This stop concludes our field trip. Thanks for joining us today! If you have any questions, comments, or corrections for the field guide, please feel free to contact me at lillquis@cwu.edu or 509 963-1184.

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