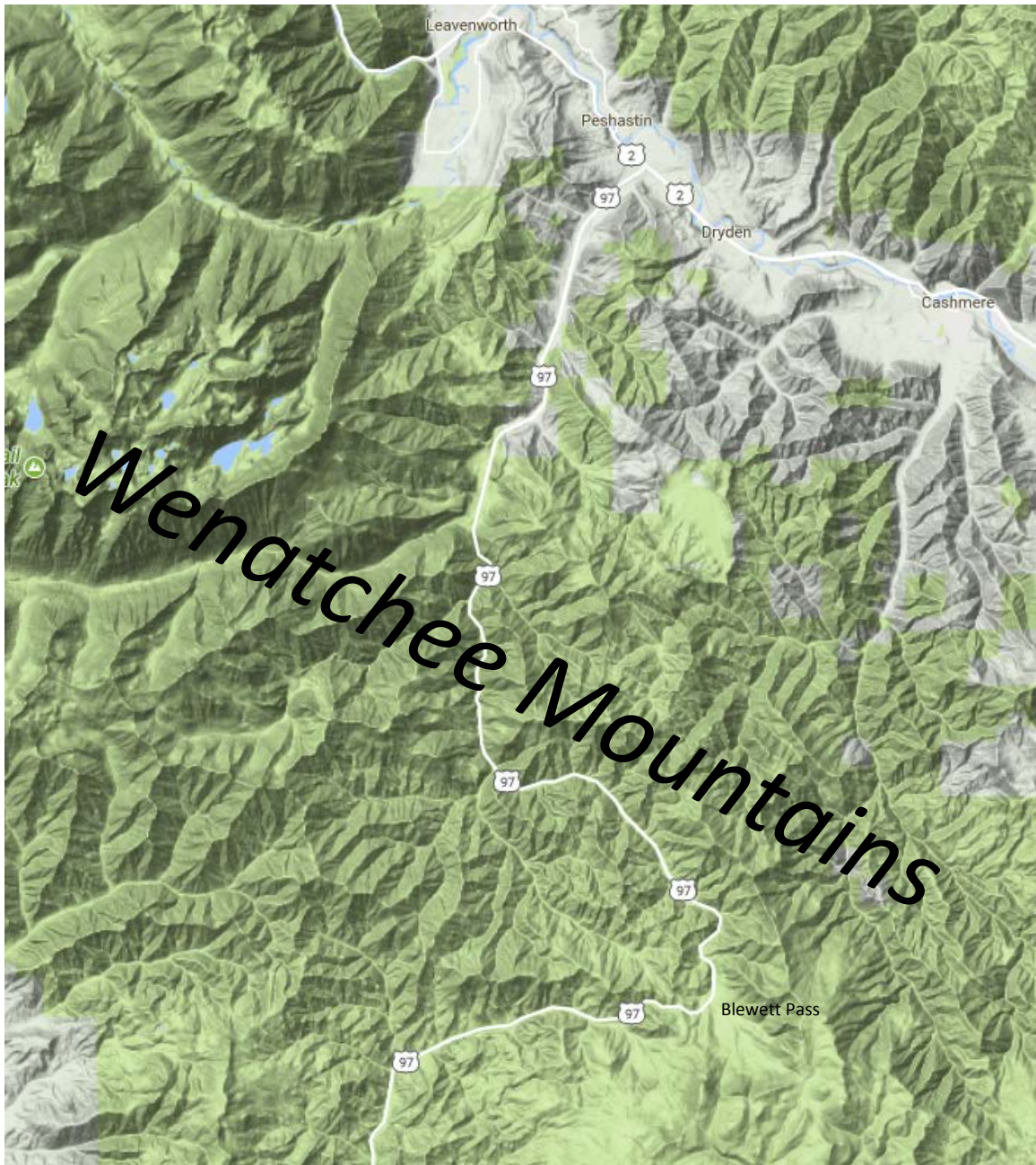# Wenatchee Mountains North: The Peshastin Creek Watershed

Ellensburg Chapter, Ice Age Floods Institute Field Trip

Field Trip Leader:
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24 September 2017

Field Trip Overview

Field Trip Description:

This trip follows a segment of US 97 that we have traveled, but not fully explored, on several previous IAFI field trips. We will focus on the Peshastin Creek Watershed portion of the US 97 corridor in the northern Wenatchee Range. Because of difficulties in crossing US 97 to safe roadside stops, we will do the trip in reverse–i.e., our first stop will be on the Wenatchee River near Peshastin. From there, we will work our way upstream exploring: glaciation and its effects on landforms near the mouth of Ingalls Creek; different rock types that have shaped landforms and vegetation patterns in the area; and history and landscape impacts of mining at the Blewett ghost town. Our final stop will be atop Table Mountain where we will explore the headwaters of Peshastin Creek, the margins of the Columbia River Basalts, huge landslides, and unique rock glaciers.

Tentative Schedule:

10:00	**Depart CWU**
11:00	**Stop 1—Wenatchee River Fishing Access, Peshastin**
	- Pit toilet
11:30	**Depart**
11:45	**Stop 2—Old Blewett Road**
12:15	**Depart**
12:30	**Stop 3--Ingalls Creek Trailhead**
	- Pit toilet
1:15	**Depart**
1:30	**Stop 4—Blewett Site**
2:45	**Depart**
3:00	**Stop 5—Near Milepost 172, US 97**
3:30	**Depart**
4:00	**Stop 6—Windy Gully, Table Mountain**
	- Pit toilet enroute
5:00	**Depart**
6:00	**Arrive at CWU**

Ellensburg to Peshastin

Route. From Ellensburg, head west and north on US 97 (Figure 1). Follow US 97 to its intersection with WA 970 at Lauderdale Junction. Turn right (east) and follow US 97 through Blewett Pass toward US 2 (Figure 2). At US 2, turn left (west) and head toward Peshastin. At Peshastin, turn right (north) onto Main Street and cross the Wenatchee River. Turn right (east) onto School Street and follow this east, then northeast. At its end it becomes a short gravel road that ends at a Washington Department of Fish and Wildlife access site. This is Stop 1.

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, US 97 generally parallels 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 (Figures 3 & 4). From Blewett Pass, we descend the Peshastin Creek drainage, the focus of our trip. 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. Just upvalley from the Old Blewett Pass Highway, US 97 crosses from the Swauk Formation onto the Jurassic Ingalls Complex, a complicated group of marine metamorphic rocks. Below the junction of Peshastin Creek and Ingalls Creek, US 97 crosses the Leavenworth Fault onto Eocene continental sedimentary rocks of the Chumstick Formation.

Climate. The climate of Ellensburg (~1,500 feet) is semi-arid, with precipitation of nearly 9 inches/year (Figure 5). The average annual temperature is about 48°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. Peshastin (represented by Leavenworth in Figure 5) has a similar temperature to, but is much wetter than, Ellensburg.

Water. Because of the semiarid environments of the lowlands, most surface water here is exotic—i.e., it falls as snow in the surrounding mountains, melts, and flows through the basins. 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. Our route traverses part of the Upper Yakima River Watershed and the Lower Wenatchee River Watershed.

Vegetation. Non-streamside vegetation in the basins is shrub-steppe indicating that it is a mix of shrubs such as sagebrush and grassland (i.e., steppe). Most of the mountain vegetation we see along US 97 is Eastside Forest dominated by Douglas fir and ponderosa pine, reflecting the increase in precipitation.

Land Uses. Agriculture dominates the lowlands—hay in the Kittitas Basin and fruit in the lower Wenatchee River Valley. Logging and mining have long been land uses in the mountains. On the south side of the Wenatchee Range, mining was centered in the Liberty area. You can 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 and Peshastin Creek watersheds.
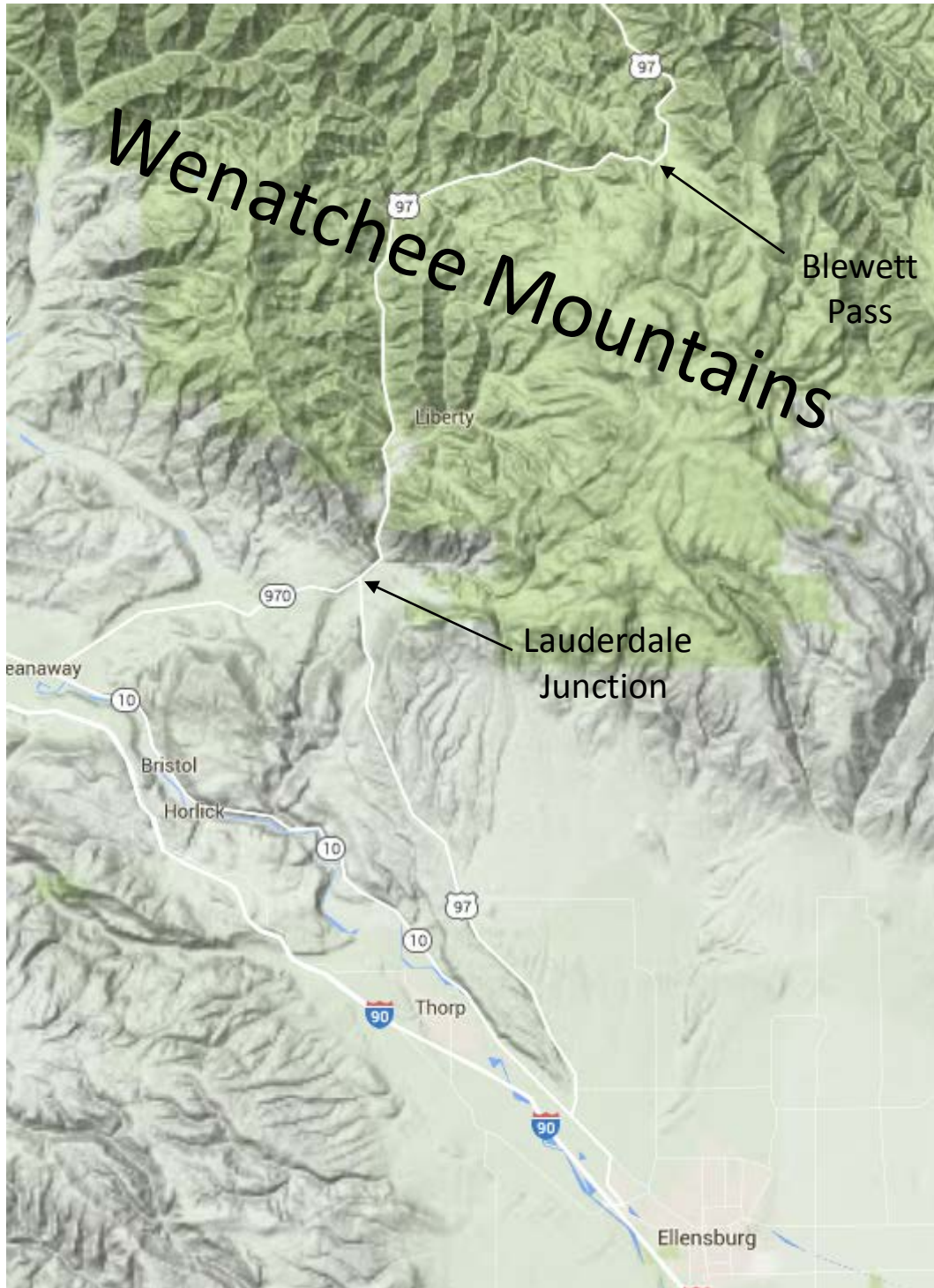
Ellensburg to Blewett Pass

Figure 1. Topography from Ellensburg to Blewett Pass. Source: Google Maps.

Blewett Pass to Peshastin

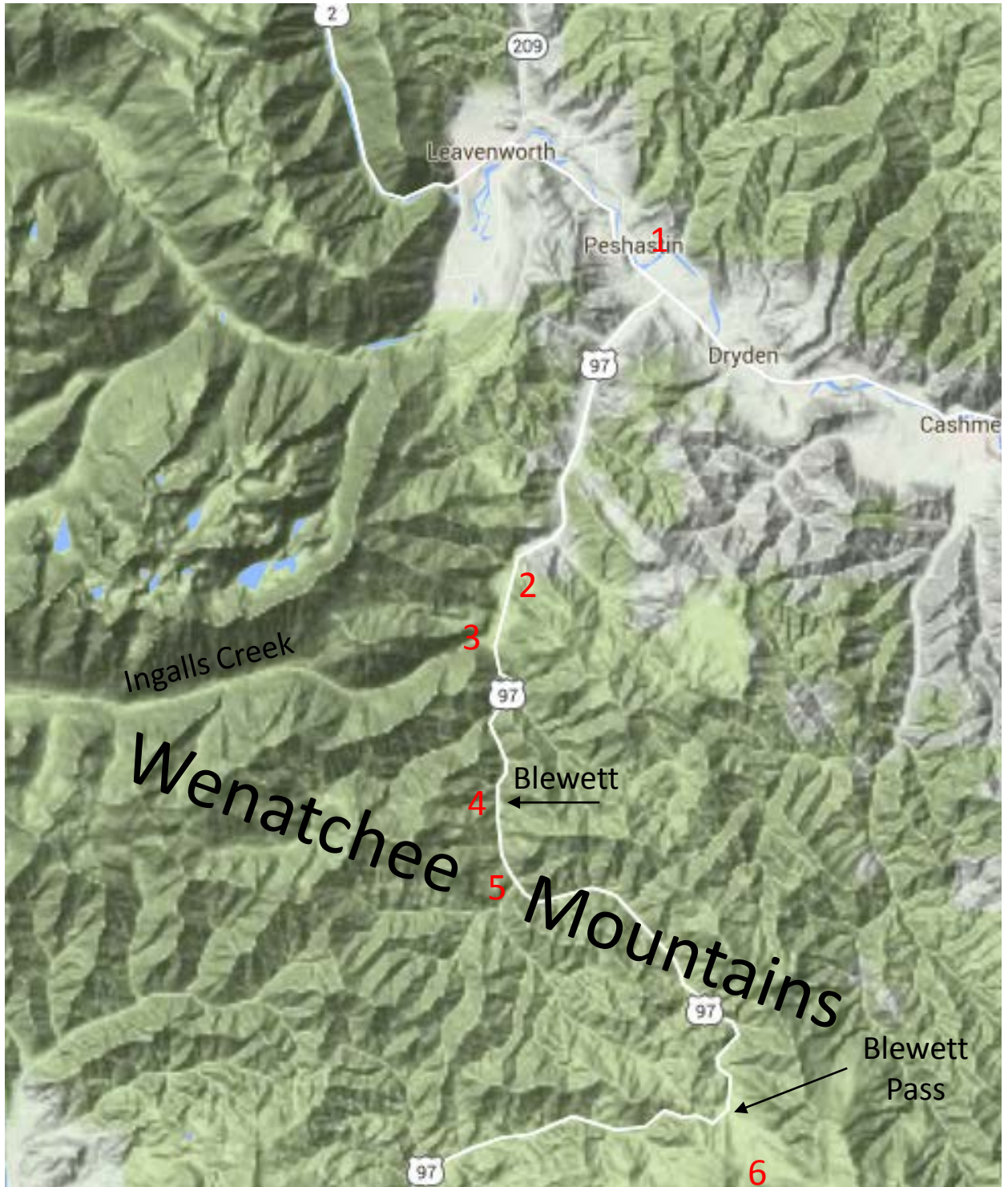**Figure 2. Topography from Blewett Pass to Leavenworth. Red numbers indicates field trip stops. Source: Google Maps.**
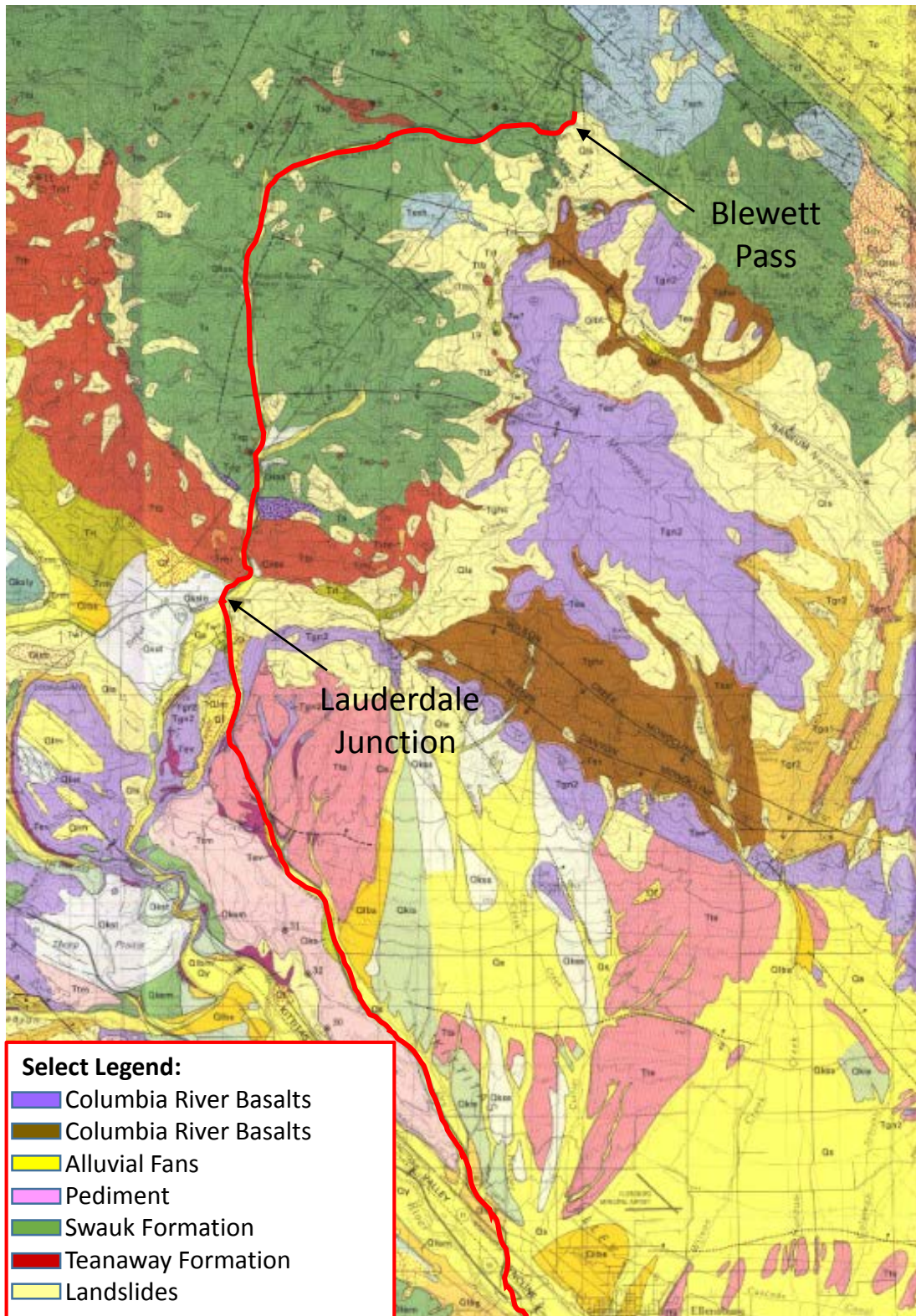
Ellensburg to Blewett Pass

Blewett Pass

Lauderdale Junction

Select Legend:
- Columbia River Basalts
- Columbia River Basalts
- Alluvial Fans
- Pediment
- Swauk Formation
- Teanaway Formation
- Landslides

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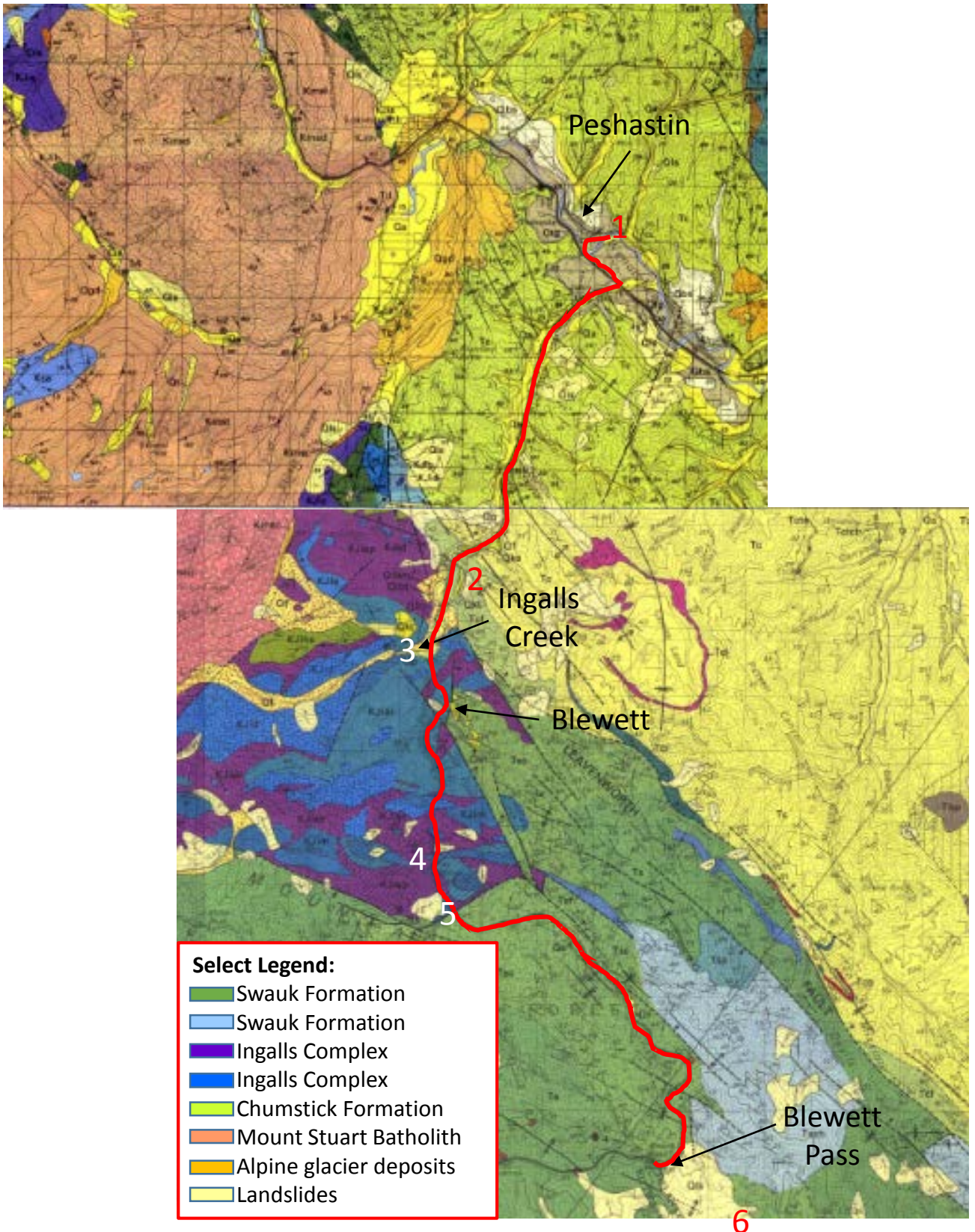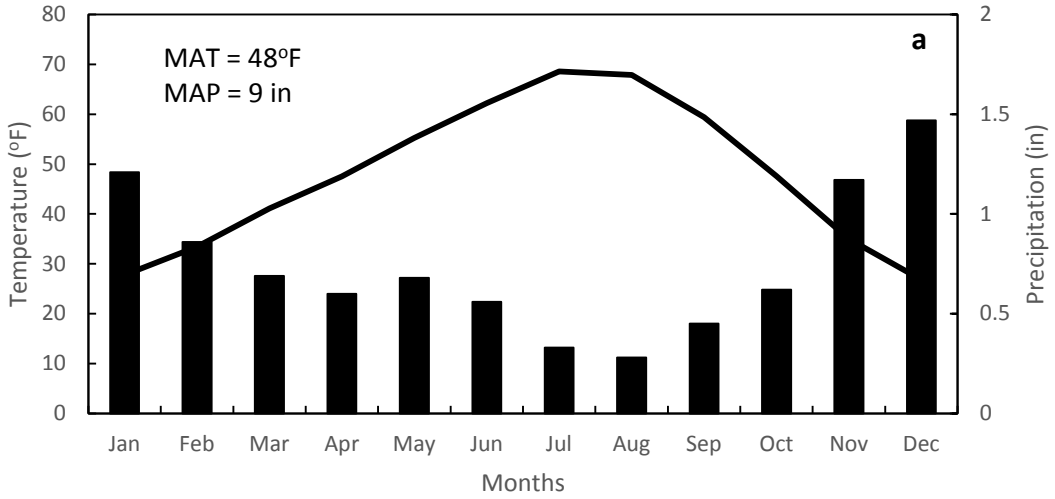
Blewett Pass to Peshastin

Figure 4. Geology from Blewett Pass to Peshastin. Heavy red line is US 97 and US 2 route to Stop 1. Numbers indicate field trip stops. Note location of Leavenworth Fault near Stop 2. Source: Tabor and others (1982) (bottom) and Tabor and others (1987).

Ellensburg to Peshastin

Ellensburg, Washington
(1981-2000)

MAT = 48°F
MAP = 9 in

a

Leavenworth, Washington
(1981-2010)
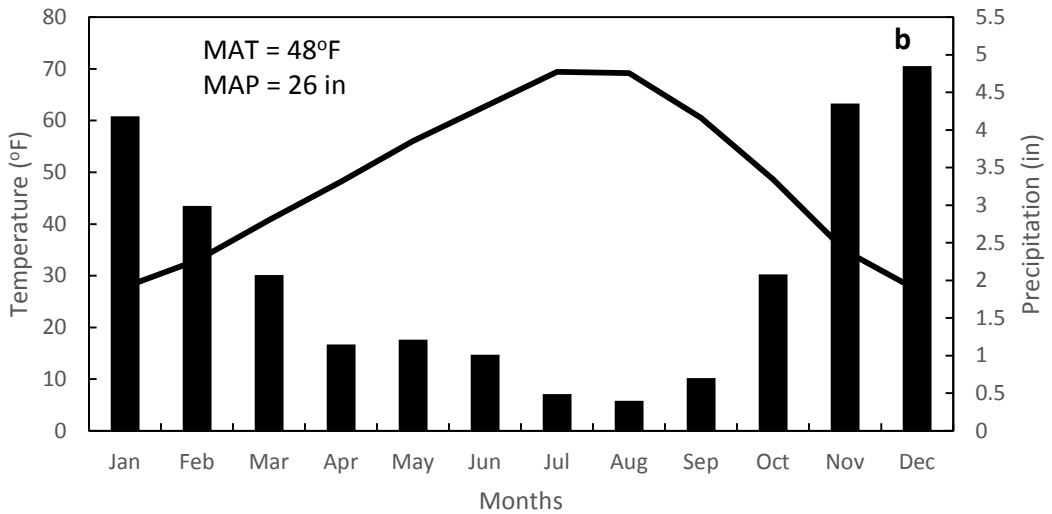
MAT = 48°F
MAP = 26 in

b

Figure 5. Ellensburg (a) vs. Leavenworth (b) climate 1981-2000. Note the different precipitation scales. Source: Western Regional Climate Center (n.d.)

Stop 1—Wenatchee River Fishing Access, Peshastin

Location. We are located at the Washington Department of Fish and Wildlife public fishing access site on the Wenatchee River in Peshastin. You will need a Washington Discover Pass or Washington Division of Fish and Wildlife Access Pass to legally park here.

Wenatchee Mountains. Our field day focuses on the north side of the Wenatchee Mountains. The term "Wenatchee Mountains" is poorly understood and often misused. As best I can tell, the origin of the term dates back to Russell (1900, p. 99) who defined these mountains as an offshoot or spur of the Cascade Range lying between the Yakima and Wenatchee rivers. Sylvester (1943) extends the Wenatchee Range west from the Columbia River to the crest of the Cascades. Russell (1900) includes Mt. Stuart within this range making the Stuart Range a subrange of the Wenatchee Mountains. The Chiwaukum Mountains are also a sub range of the Wenatchee Mountains (Beckey, 1973).

Watersheds. We are located near the mouth of Peshastin Creek on the Wenatchee River. Peshastin Creek originates near the crest of the Wenatchee Range where we will be at Stop 6. By the time it reaches the Wenatchee River, Peshastin Creek has grown with the additions of Tronsen, Scotty, Shaser, Negro, Ingalls, and Camas creeks as well as numerous smaller and unnamed streams (Figure 6).

Origins of Wenatchee Mountains & Adjacent Wenatchee River Basin. The Wenatchee Mountains are a result of a variety of rock types that have been folded and faulted. Peshastin Creek joins the Wenatchee River in a structural basin dominated by the Eocene continental sedimentary rocks of the Chumstick Formation (Figure 4). 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. 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).

Peshastin Creek Alluvial Fan. River and stream shapes often give us clues to their past. The shape of the Wenatchee River at Peshastin is odd in that it makes a sharp bend to the northeast in its otherwise northwest to southeast orientation (Figure 7). Hopkins (1966) first noted this odd pattern and attributed it to the large sediment load from Peshastin Creek over time building a large alluvial fan. Such a large sediment load could have come from glacial outwash emitting from the Ingalls Creek glaciers over time. However, it is odd that a relatively small stream—Peshastin Creek—could impact the path of a much larger Wenatchee River. Perhaps Peshastin Creek was able to build the large fan when the Wenatchee River was partially blocked by glacial ice or moraines in the vicinity of present-day Leavenworth. Over time, Peshastin Creek has shifted about on its fan. Today, it traverses the downstream end of the fan (Figure 7). Much of this fan surface is now covered by apple and pear orchards.
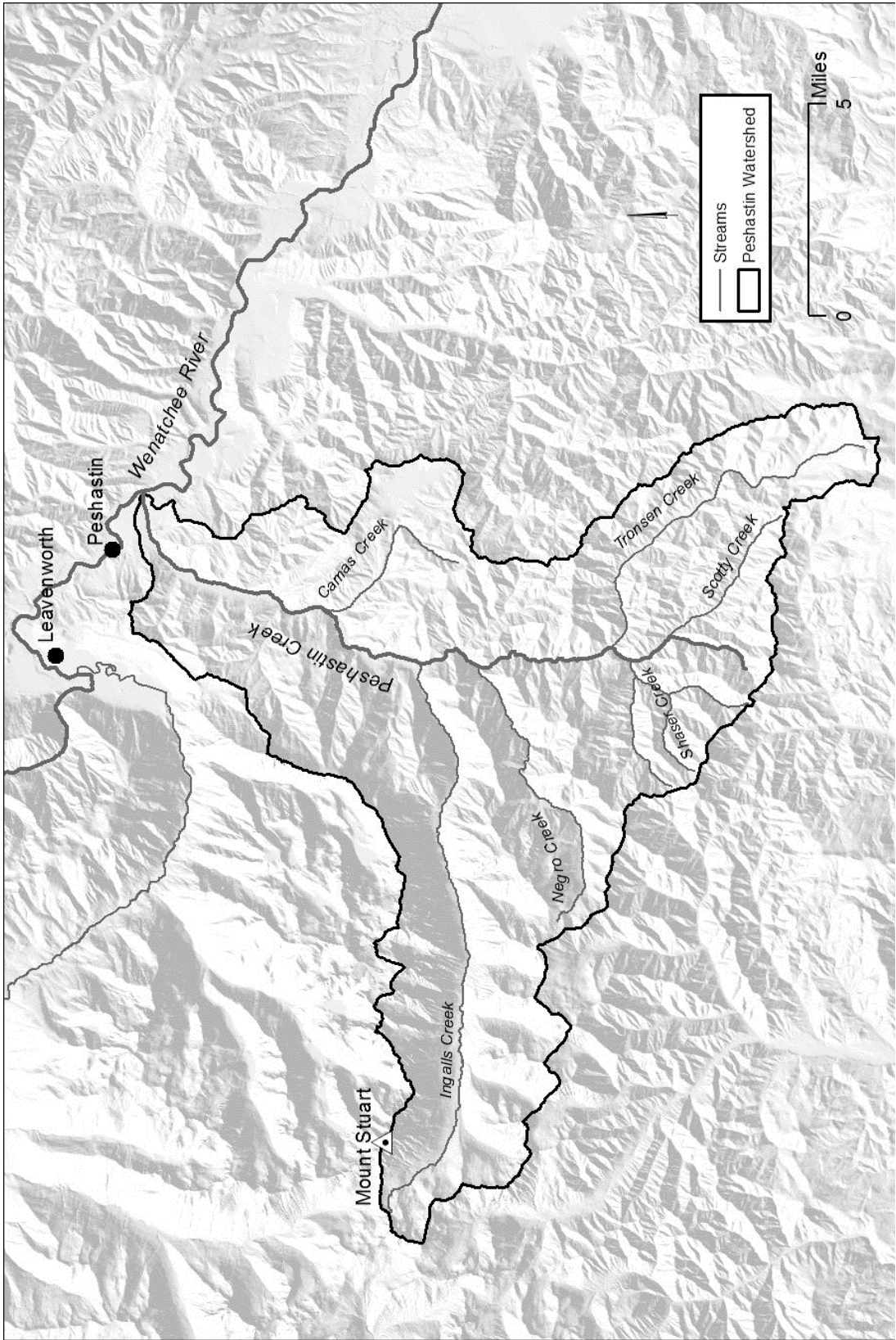
Stop 1--Wenatchee River Fishing Access, Peshastin

Figure 6. Peshastin Creek Watershed map. Source: David Cordner, CWU Geography Department.

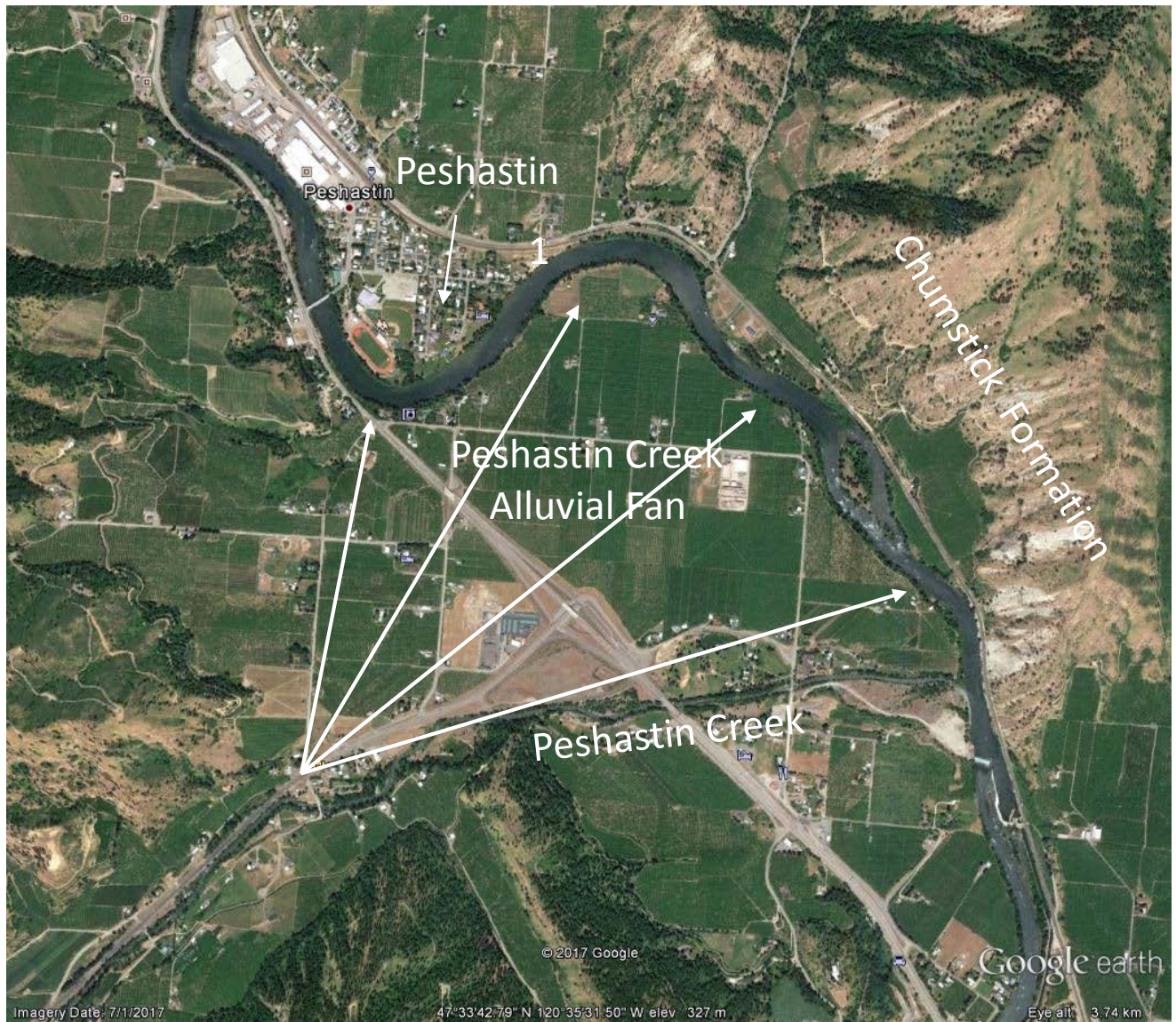# Stop 1—Wenatchee River Fishing Access, Peshastin

Figure 7. Location of Stop 1 on edge of Peshastin Creek alluvial fan. Note how Peshastin Creek and its sediment load appears to have pushed the Wenatchee River northward into the Chumstick Formation. Source: Google Earth.

Peshastin to Old Blewett Road

Route. From Peshastin, return to US 2 and head east. Very soon, exit onto US 97 and head south toward Ellensburg. Drive approximately 5 miles south. Just south of Camas Creek Road, turn left across traffic onto Old Blewett Road. We will follow this for approximately 0.5 mile to Stop 2. Park as far right on the road as you dare. We need to make sure that local traffic can pass us safely.

Stop 2—Old Blewett Road

Location. We are located on a short segment of the Old Blewett Road approximately 1 mile downstream of Ingalls Creek Road.

Past Glaciers & Their Landforms. We are parked on the inside of the "Intermediate" aged right lateral/end moraine of the Ingalls Creek Glacier identified by Hopkins (1966) (Figure 8). How do we know? We crossed several subtle ridges on Old Blewett Road. These ridges are composed of a mix of debris sizes ranging from silt to boulders. The boulders tend to be subangular. The main ridge of the lateral/end moraine is also very visible on Google Earth (Figure 9). Finally, note the presence of erratics along the road.

Moraines form from the deposition of till from the edge of glacial ice. Lateral moraines form on the sides and end moraines form on the downstream ends of glaciers. Their size is time-dependent—i.e., they are larger when a glacier occupies an area for a longer time. They initially take a ridge-like form that over time may be smoothed by weathering and erosion. Erosional removal is especially true of end moraines that often initially block valleys. The glacier that deposited this moraine was an alpine glacier originating high in the Ingalls Creek drainage (see Stop 3). This Ingalls Creek Intermediate glacier advanced nearly 16 miles from Ingalls Peak at the head of Ingalls Creek Valley to this location! Subsequent erosion has removed much of the end moraine and the left lateral moraine (i.e., the lateral moraine formed on the left hand side of the valley when viewed looking downstream). Based on the elevations of erratics where the glacial ice moved across Hansel Creek Valley, ice near here was ~750 feet thick!

So when was glacial ice here? First, we know that this moraine is old but sufficiently young to still be recognized as a moraine.   Second, Hopkins (1966) used a variety of relative measures to differentiate the Intermediate glaciation from the Younger glaciation (upvalley) and Older glaciation (downvalley) (Figure 7; Table 1). These included granite weathering ratios, boulder frequencies, depths of oxidation, soil B horizon development, and degree of moraine modification (Table 1). These methods are as appropriate today as they were in 1966 to sort out relative moraine ages.   Using similar relative age data from the nearby Icicle Creek Valley, Swanson and Porter (1997) suggests that the Ingalls Creek Intermediate moraine is "Peshastin" in age. We now have several options to determine absolute ages of moraines. One such method, surface exposure dating, allows us to date granitic boulders on moraines. Such dating reveals an average age of 105,400 +/- 2200 years for similar moraines in the Icicle Creek drainage (Swanson and Porter, 2008). So...it makes sense that this Intermediate- or Peshastin-age moraine is around 105,000 years old.
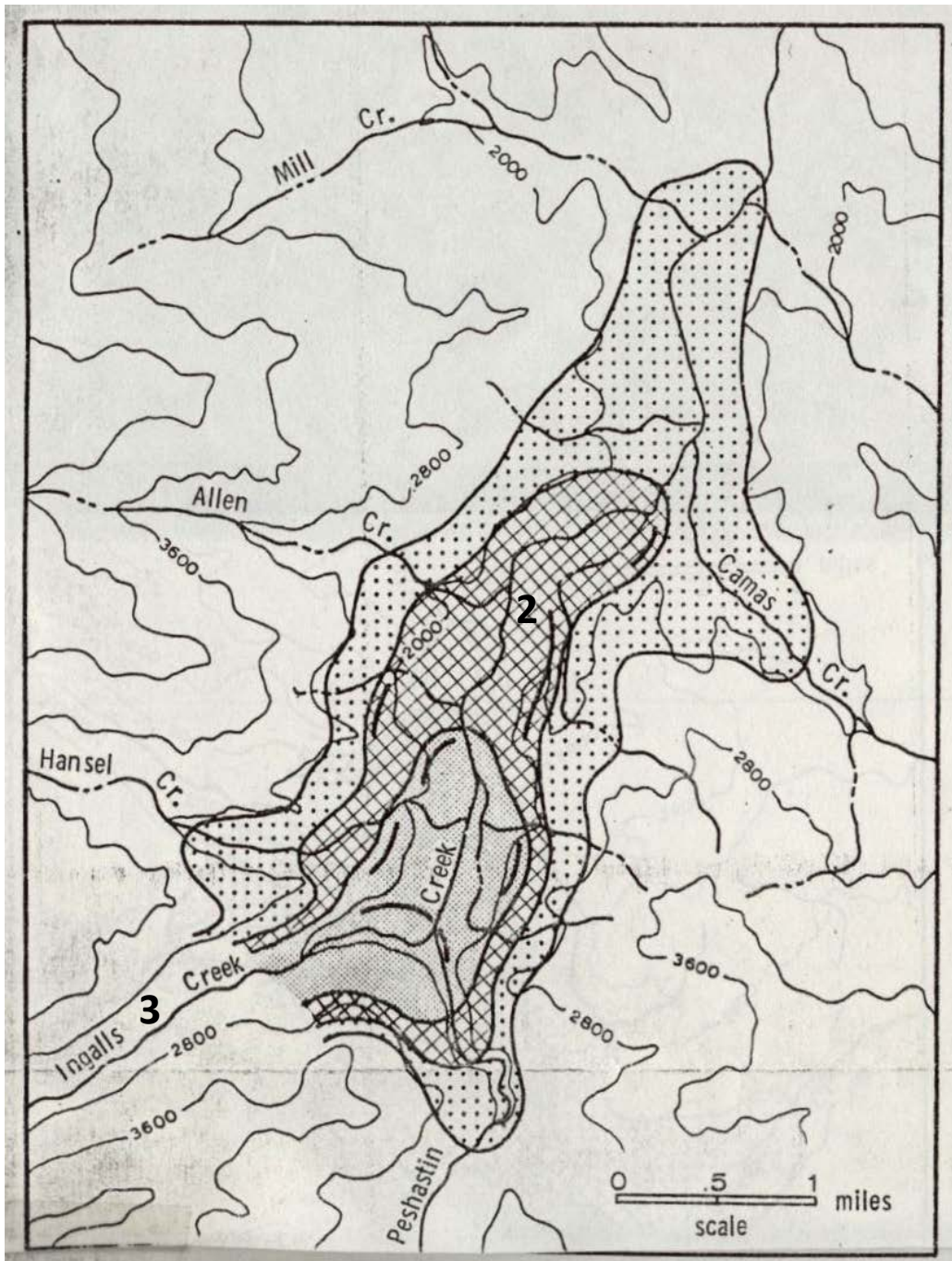
Stop 2—Old Blewett Road

Figure 8. Extent of three Ingalls Creek glaciations that spilled into lower Peshastin Creek Valley—Older drift (stipled), Intermediate (cross-hatched), and Younger (grey shade) (Hopkins, 1966). Numbers indicate approximate locations of stops 2 and 3. Source: Hopkins (1966, p. 27).
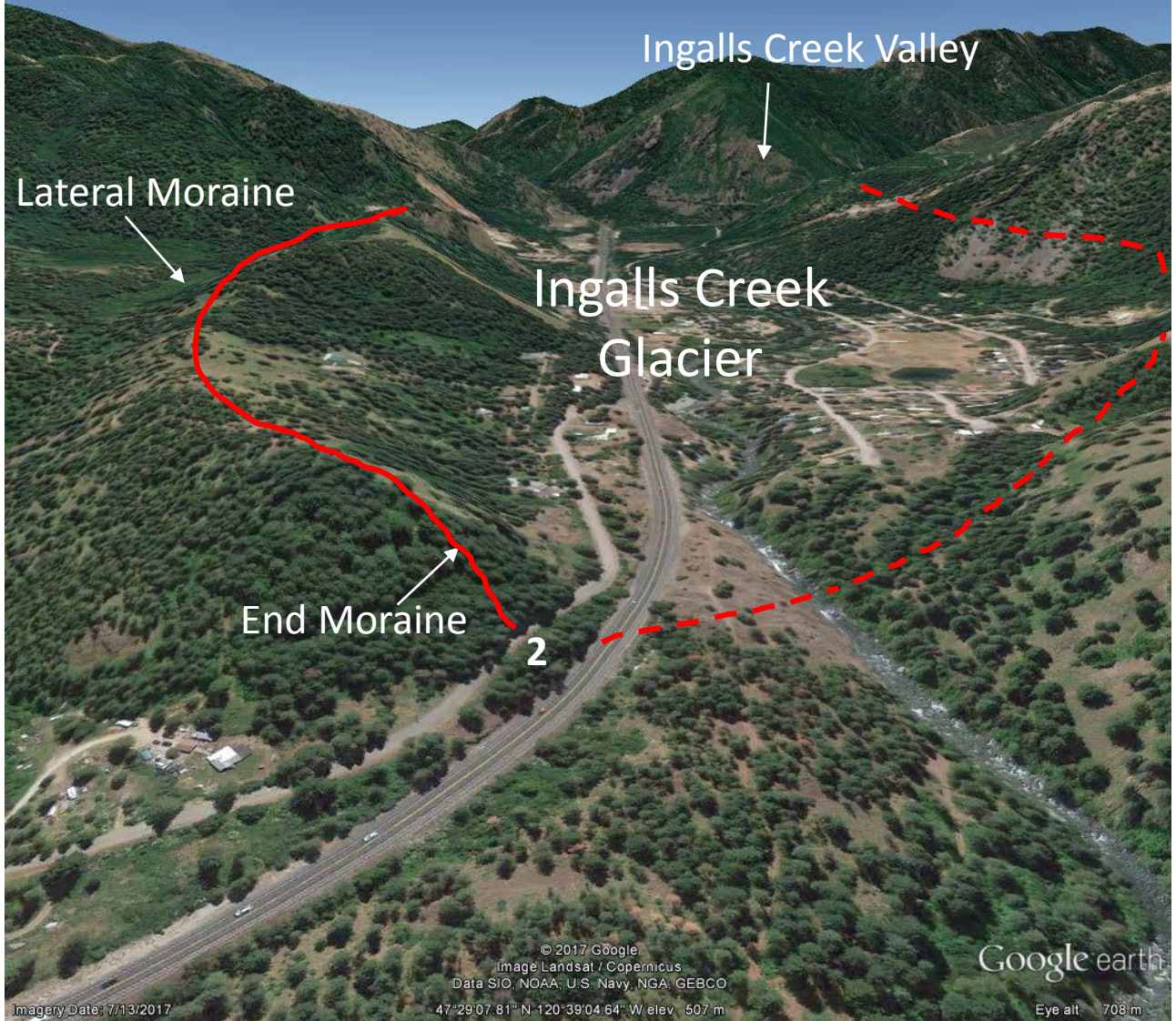
Stop 2—Old Blewett Road

Figure 9. View up Peshastin Creek Valley toward mouth of Ingalls Creek. Solid red line indicates the location of lateral and end moraines associated with the Peshastin-age glaciation. Dashed red line indicates approximate location of left lateral and end moraines if they were present. Maximum extent of Peshastin-age glaciation went just beyond bottom of image. Number indicates approximate location of Stop 2. Source: Hopkins (1966); Google Earth.

Stop 2—Old Blewett Road

		GRANITE-WEATHERING RATIO (f:w)	BOULDER FREQUENCY	DEPTH OF OXIDATION (inches)	B HORIZON (inches)	DEGREE OF MODIFICATION OF MORAINES
YOUNGER DRIFT	III			24		Sharp and easily discernible
	II	87:13	101.0	36		
	I	81:19	88:6	45	~18	
INTERMEDIATE DRIFT		47:53	24.3	72	24	Subdued, but discernible
OLDER DRIFT		4.96	11.3	>120	40	Essentially no topographic expression

Table 1. Mean values of time-dependent relative age parameters associated with the Ingalls Creek glacier. Younger Drift = Leavenworth; Intermediate Drift = Peshastin; Older Drift. Source: Hopkins (1966, p. 61).

Old Blewett Road to Ingalls Creek Trailhead

Route. Continue south on Old Blewett Road to its junction with US 97. Re-join US 97 and continue south for less than 1 mile. Turn right (west) onto Ingalls Creek Road and follow it less than 2 miles to the U.S. Forest Service Ingalls Creek Trailhead.

Glacial Evidence. While not immediately apparent from the road (or on Google Earth), Ingalls Creek skirts the end moraine of the Leavenworth 1 glaciation (Figure 10). This moraine is not nearly as distinct as that at Stop 2 but it is distinguished by its till composition (seen south of the junction of US 97 and Ingalls Creek Road) and its slightly higher elevation compared to the surroundings. Also, note the ample large erratics present along the road to Stop 3.

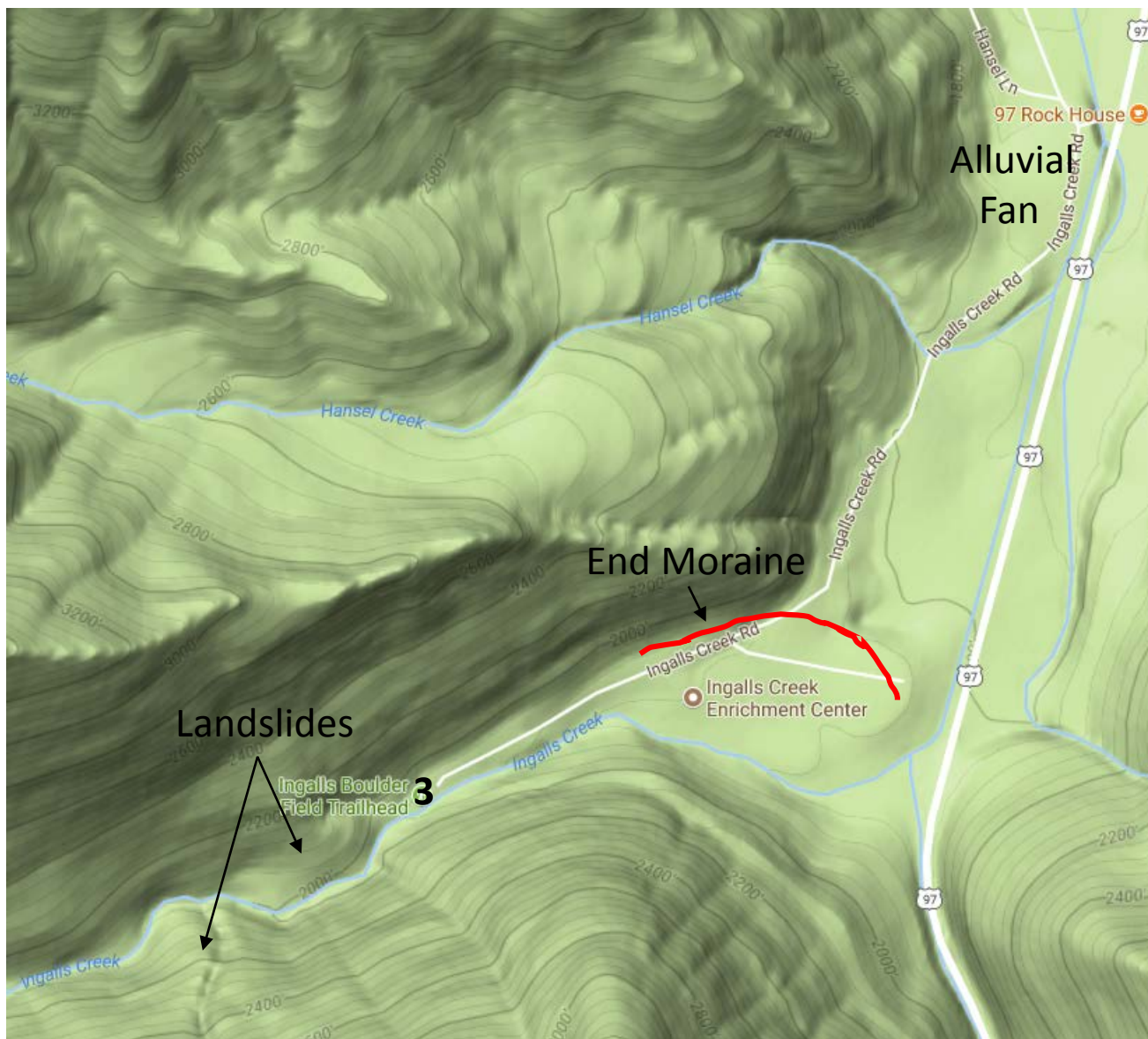# Stop 3—Ingalls Creek Trailhead

Figure 10. Topography in vicinity of Ingalls Creek Trailhead. Note Younger (i.e., Leavenworth-aged) end moraine at mouth of Ingalls Creek). Also, note two landslides near mouth of Ingalls Creek Valley. Number indicates approximate location of Stop 3. Source: Google Maps.

Stop 3—Ingalls Creek Trailhead

Location: We are located at the USFS Ingalls Creek Trailhead. You will need a Northwest Forest Pass to legally park here. We will walk a short way up Ingalls Creek Valley from the parking lot.

The setting. Ingalls Creek Valley has its origins at ~6500 feet elevation at Ingalls Lake, at the eastern foot of 7,662 feet elevation Ingalls Peak (Figure 11). The highest points in the drainage include many peaks in the Stuart Range including Mt. Stuart (9,415 feet) and Sherpa Peak (8,605 feet). The highest peaks in the Wenatchee Range proper (to the south) are generally lower –e.g., Three Brothers at 7,303 feet and Navaho Peak at 7,223 feet).

Geology. Ingalls Creek follows a geologic boundary for much of its length—the Ingalls Complex lies to the south and the Mount Stuart Batholith to the north forming the Stuart Range (Figure 4). The Ingalls Complex will the topic of Stop 5. The Mount Stuart Batholith consists of intrusive igneous rocks (e.g., diorite and granodiorite) that were emplaced about ~91-96.5 million years ago (Ma) in an island arc setting (i.e., a chain of volcanic islands located at a plate boundary) (Paterson and others, 1994).

Glaciers and Glaciation. At present, no glaciers exist in the Ingalls Creek Basin. As we saw at Stop 2, glaciers were here, however, several times in the past. This glacial history was first recognized by Russell (1900) and Smith (1904). University of Washington Quaternary geologist extraordinaire Steve Porter and his students explored the glacial evidence of the Eastern Cascades beginning in the mid-1960's. One of Porter's students, Kenneth Hopkins, did his Master's thesis on Ingalls Creek Valley glaciation (Hopkins, 1966).

The glacier that occupied Ingalls Creek Valley was a valley glacier fed by cirque glaciers and an ice field. Cirques are evident in Figures 11 & 12 at higher elevations on both sides of the valley. They are especially well-developed on the north-facing slopes south of the valley floor. Additionally, the icefield in the Snow Lakes area of the Stuart Range spilled ice into Ingalls Creek Valley via several large troughs (Russell, 1900; Porter and Swanson, 2008). The largest cirque glaciers were found in the vicinity of Ingalls Lake where elevations are higher (so temperatures are lower) and precipitation is greater because of its relative proximity to the Cascade Crest which lies about 17 miles west of Ingalls Peak. In addition to the cirques and troughs above, how do we know that Ingalls Creek Valley was glaciated? Probably the best indicator is the ~straight, U-shaped valley of Ingalls Creek (Figure 13). You can also find erratics (i.e., exotic boulders), and striations and grooves (created by glacial erosion) in this valley. See if the erratics reflect the varied geology of the Ingalls Creek Valley.

It appears that part of the Ingalls Creek glacier spilled over a divide to the north of the valley proper into the Hansel Creek drainage (Figure 13). Perhaps this loss of ice prevented the Ingalls Creek glacier from straightening its valley as is the norm in glacial valleys.

Landslides and Streams. The U-shapes of glaciated valleys characterized by their steep sides are prone to post-glacial landslides. Two such landslides are present just upvalley of the Ingalls Creek Trailhead (Figures 10 & 13). Each is a deposit that looks out of place in relation to the valley walls, and each has pushed Ingalls Creek toward the opposite side of the valley. Landslides, then, are important to shaping glaciated valleys and their streams by affecting their horizontal (i.e., planimetric) and vertical (i.e., longitudinal) forms. Landslides also affect the composition of the floodplain delivering a variety of rocky sediment and large woody debris (Figure 14).
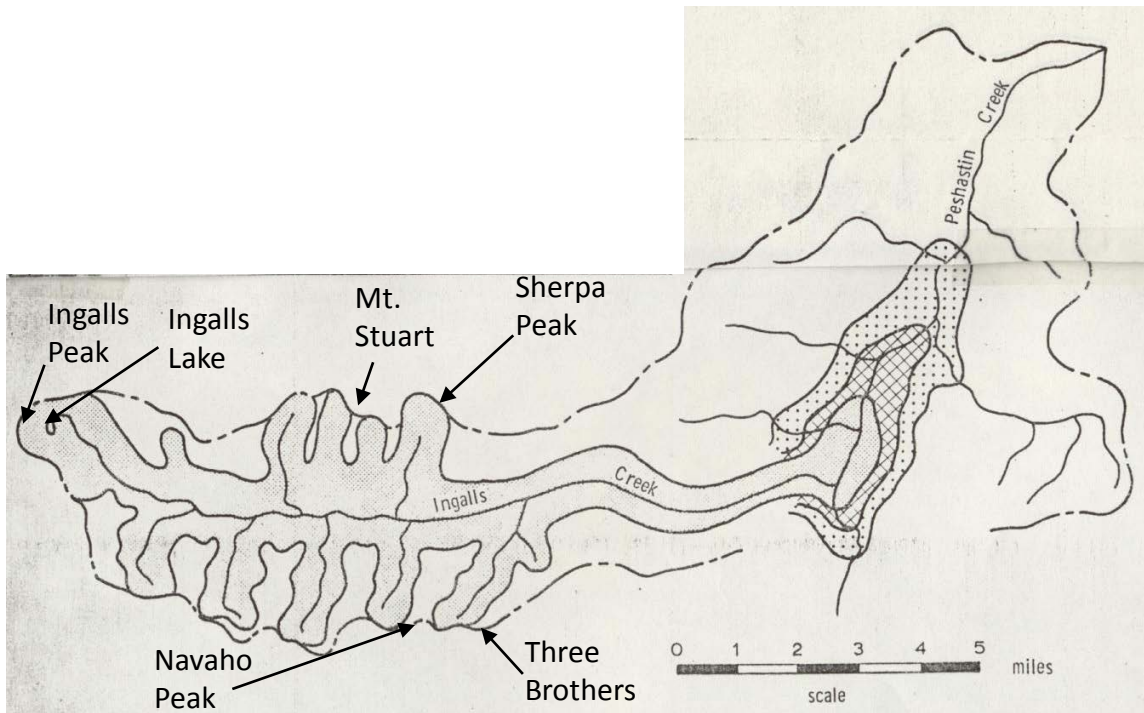
Stop 3—Ingalls Creek Trailhead

Figure 11. Extent of Ingalls Creek Valley glaciers. Younger (shaded), Intermediate (cross hatched), and Older (stipled) glaciations in the Ingalls Creek and Peshastin Creek valleys. Recognize that, while only the Younger deposits are shown in upper Ingalls Creek, all three glaciations originated at high elevations in the basin. Source: Hopkins (1966, p. 27)

Figure 14. Ingalls Creek at Ingalls Creek Trailhead. Source: Karl Lillquist photo.
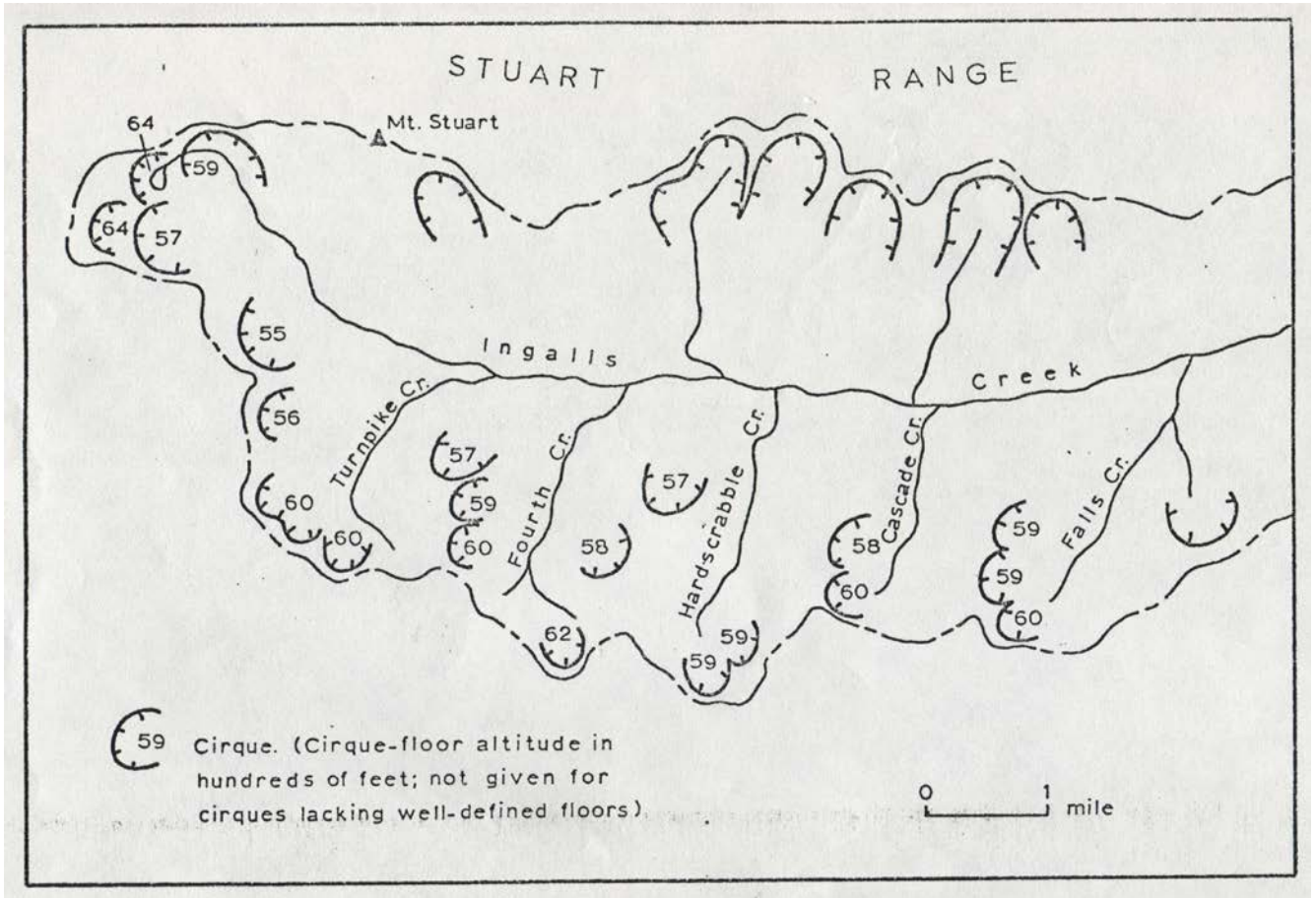
Stop 3—Ingalls Creek Trailhead

Figure 12. Cirques and cirque floor altitudes in the upper Ingalls Creek Watershed. Note how more cirques exist on the north-facing slopes of the valley than the south-facing slopes. Source: Hopkins (1966, p. 11).

Ingalls Creek Trailhead to Blewett

Route. From the Ingalls Creek Trailhead, return to US 97, then head south approximately 4 miles to the site of Blewett. At Blewett, we will turn right onto an indistinct road that runs in front of the old stamp mill. We will make this turn immediately after the end of the guard rail. Park on this road. This is Stop 4.

Mazama Ash & Alluvial Fans. A distinct layer of ~7,600 year old Mazama ash is present approximately midway up in the alluvial fan of Hansel Creek (Figure 10) (Hopkins, 1966; Porter, 1969). Its position within this fan, as well as others in the area, suggests that the early Holocene was a time of widespread alluviation. Look for it in the streamcut on the right (west) soon after we join US 97 and head south.

Non-glacial Valley. Note the generally narrow, winding nature of the Peshastin Creek valleys in which US 97 follows. This characterizes a valley that was not glaciated.

Geology. Note the shiny, green (on fresh surfaces) rock as we ascend. These are ultramafic metamorphics of the Ingalls Complex.

More Landslides. Note the fresh scars of at least four recent landslides in the Ingalls Complex along this segment of US 97. The largest of these originated/reactivated in the very wet Winter of 1996 and resulted in Blewett Pass being closed for weeks.
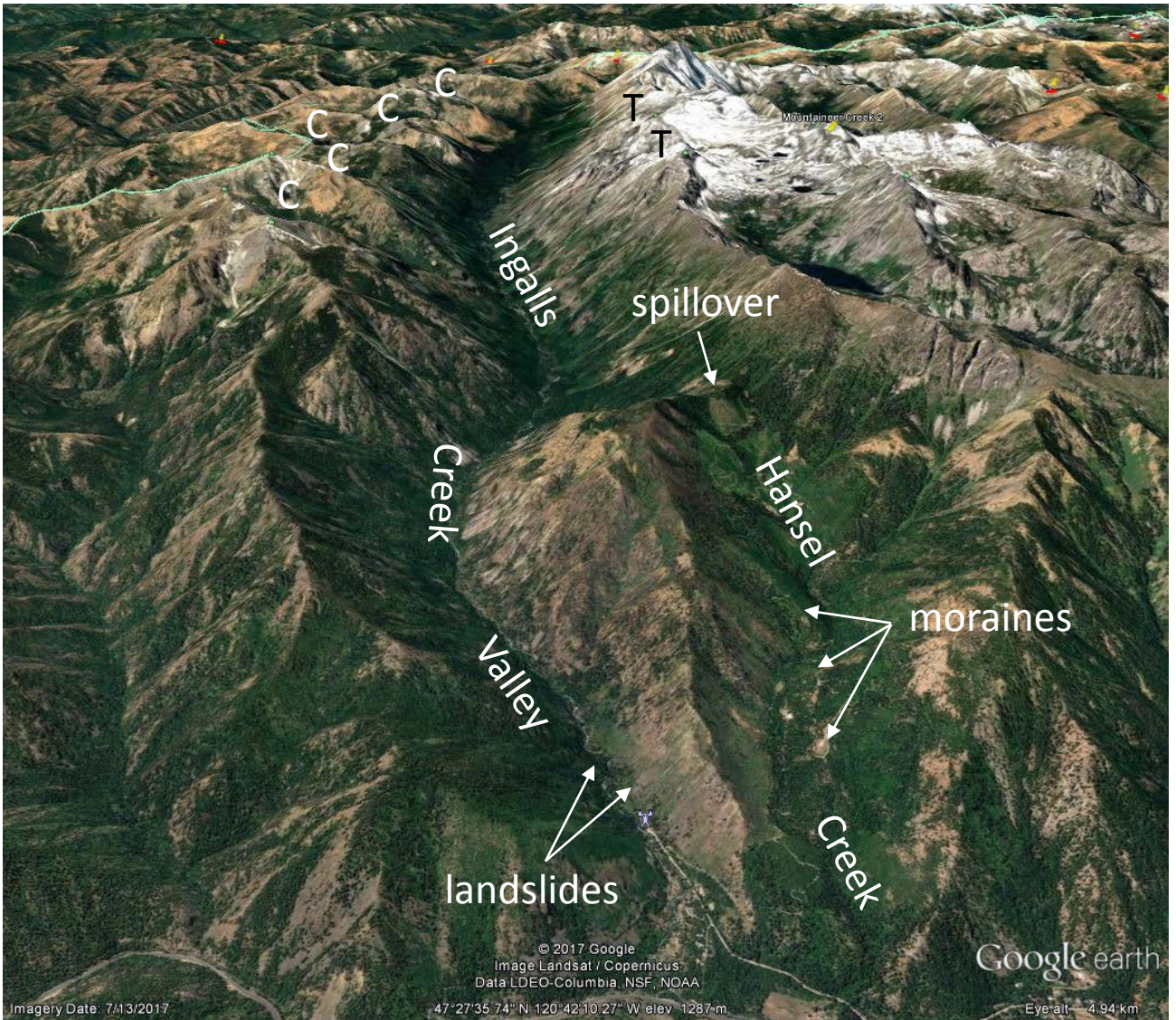
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Stop 3—Ingalls Creek Trailhead

Figure 13. Oblique aerial view up Ingalls Creek Valley with cirques (C) of north-facing slopes of valley and troughs (T) of south-facing slopes of Stuart Range. Cirques formed best on north-facing slopes where cirque glaciers could grow because snowpack was mostly shaded from sunlight. Troughs formed from spillover of an icefield in the Snow Lakes Basin. Both sources of glacial ice fed the large Ingalls Creek valley glaciers over time. Source: Google Earth; Hopkins (1966).

Stop 4--Blewett

Location. We are located on the west side of US 97 at the old Blewett townsite just downvalley from Milepost 174.

History of Mining in the Area. Gold was likely first discovered here by prospectors returning from the Cariboo and Fraser River mining areas in British Columbia, and the Similkameen area in northern Washington (Dow, 1963). Early efforts at mining here were hampered by poor transportation routes that limited the amount of supplies that could make it to the area. While gold was the primary interest, it was not present in great quantities. Silver, copper, lead, and zinc were also here in minor quantities. Interactions with Native Americans also limited early gold mining here (Tozer, 1965). Blewett (referred to early on as Culver Camp) was the main townsite serving the Blewett Mining District over more than 50 years. It was active as a placer mining center focused on Peshastin Creek gravels from ~1860-1874, and on hard rock (or lode) mining from 1874 until ~1910. Figure 15 shows placer and lode mining claims in the area as of 1911. Both forms of mining have continued intermittently since then.

Placer Mining. Placer deposits originate from the weathering and erosion of bedrock ore bodies, and the concentration of these ores in stream sediments. Mining at Blewett, like that in many places, began with placer deposits. Legend has it that a Captain Ingalls discovered gold in Peshastin Creek gravels in the Wenatchee Mountains in 1855-56 but died before he could begin mining (Dow, 1963). Certainly by 1860, placer mining was occurring near here (Glover, 1954). While the narrow nature of the valley limited the extent of gold-bearing gravels, gold was well-distributed throughout the gravels. Peshastin Creek gold is also relatively pure containing less silver than does gold from the Swauk area (Livingstone, 1963). The best placer deposits were found downstream of Blewett near the mouth of Negro Creek (Figure 15) (Weaver, 1911). Peshastin Creek gold nuggets weighed less than 1 ounce and were often found at the gravel-bedrock interface.

Lode Mining. Lode mining began in 1874 with the discovery of gold-bearing quartz veins at the head of Culver Gulch (Livingstone, 1963), the mouth of which is just north of the old stamp mill site here. Mineralization occurred along west-northwest striking, silica-carbonate-sulphide veins that occur within the serpentinized peridotite of the Ingalls Complex. These veins may be as wide as 16 feet (Weaver, 1911; Reynolds, 1923; Margolis, 1994). The distribution and orientation of mining climbs partially reflects these veins (Figure 14).

Gold Processing. Gold was processed to remove impurities in two ways at Blewett—arrastras and mills (Figures 16 & 17). Both are representative of processing at other sites in the Pacific Northwest over time.

At least two arrastras were present in the vicinity of Blewett. Weaver (1911, p. 68-69) describes one of the arrastras as follows:

The pit is twelve feet in diameter, three feet deep, and built of granite brought from outcrops not far away. The power is obtained by a large overshot water wheel, twenty-six feet in diameter, and run by a stream of water brought from the gulch by a flume and carried directly over the upper portion of the wheel. This operates a horizontal wheel to which granite boulders weighing over one-half ton are attached by chains. These are known as drag blocks and crush the ore to a fine powder. The arrastra is said to have crushed from one to two tons of ore per day.

Figure 15. Map of mining claims, Blewett Mining District as of ~1911. Note the general East-West orientations of the mining claims reflecting the orientation of the mineralized zone. Source: Weaver, 1911.

Stop 4--Blewett

Figure 16. Arrastra at Blewett. Located just south of old stamp mill site on west side of US 97. Source: http://www.exploringhistoryinyourhikingboots.com/blewett-wa-usa/
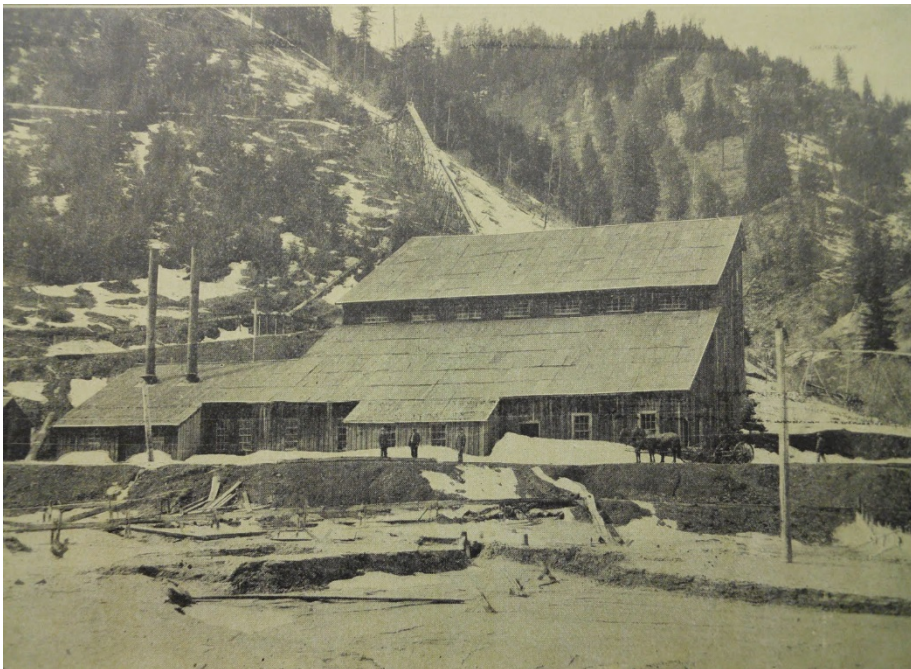

Figure 17. Stamp mill at Blewett as of ???. Looking west. Note the ore tram on the hillslope above the mill. Source: http://oldblewett.blogspot.com/

Stop 4--Blewett

Gold Processing (continued). Mercury was then added to the powder to amalgamate with gold. The mercury-gold amalgamation was heated to remove the mercury leaving behind pure gold. Unfortunately, the gold combined with sulphides was not amalgamated with mercury, therefore was lost in the process (Hodges, 1897). The Blewett arrastra present on the west side of US 97 and just south of the stamp mill site was used from 1861 to 1880 (Livingstone, 1963) (Figure 16).

The second mode of processing was via stamp mills. The foundation of a large, 20 stamp mill remains on the west side of US 97 here (Figure 17). The first stamp mill in the area was a six stamp mill powered by water. It likely came to the area via the wagon road from Ellensburg (see below) in 1879. It had the advantage over arrastras in that it could better deal with fine gold and gold combined with sulphides. Other mills followed including a two stamp mill in 1880, a ten stamp mill in 1891, and the twenty-stamp mill in 1892 (Tozer, 1965) that was first powered by water then wood (Woodhouse and others, 2002). The twenty stamp mill was described in Tozer (1965, p. 50) as:

On the ground floor is the engine room with two large boilers and the machinery for washing concentrates, four in number, through which all the sand is passed and the refuse matter washed out of it. On the second floor is found the copper plates over which all of the gold passes after coming from the stamps and the free gold is saved on these plates by means of quick silver; on the third floor is found what is called the stamps and are twenty in number, weighing one thousand pounds each, which are raised and dropped by means of a shaft with cross pieces which raise them a short distance and drop them, the weight of the stamps crushed the ore. These stamps make a terrible noise in working. On the fourth and last floor is found the ore dump. Here starts the rock which to the naked eye shows no worth…

A cable tramway delivered ore to the top of the mill (Tozer, 1965). The 20 stamp mill constructed at the mouth of Culver Gulch was the largest mill at its time in Washington state (Dow, 1963).

A cyanide plant was added to the Blewett stamp mill in 1895 to process the tailings heaps because the mercury process was not recovering as much gold as it should have. In this process, tailings were dumped into large vats containing a weak solution of potassium cynanide. The potassium cyanide dissolved the gold which was later precipitated out by running the solution over a bed of zinc shavings.

Cyanide and mercury are very toxic to humans and other living things. One of my current CWU masters students, Scott Kugel, is focusing his thesis research on water and sediments around old Upper Yakima River Watershed stamp mill sites to determine whether cyanide and mercury are present in measureable quantities.

Total Production. It is estimated that gold production from the Blewett Mining District totaled $1,500,000 over the period 1870 to 1901. From 1901 to 1910, another $200,000 in gold was produced (Weaver, 1911).

Blewett. Over time, Blewett townsite (Figure 18) and its population waxed and waned with the productivity of mines and the regional economy. The town formed in the late 1870's. In its early years, it could best be described as a company town complete with stamp mill, two arrastras, boarding house, blacksmith shop, and sawmill. Following the period of decline, the revival of mining in the 1890's led to several stores, a barber shop, a blacksmith shop, saloon, several restaurants, two boarding houses, town hall, and houses. A minister, doctor, and lawyer made regular visits (Tozer, 1965). Most of the residents of Blewett and the surroundings were white and male. However, several notable exceptions exist. Negro Creek, a part of the Blewett Mining District, was named after at least one African-American miner around 1860 (Tozer, 1965). Chinese immigrants likely worked the lower Peshastin Creek stream gravels (Tozer, 1965). At its peak, Blewett once housed over 250 miners; by 1941, the population was just 54 (Washington Writers Project, 1941).
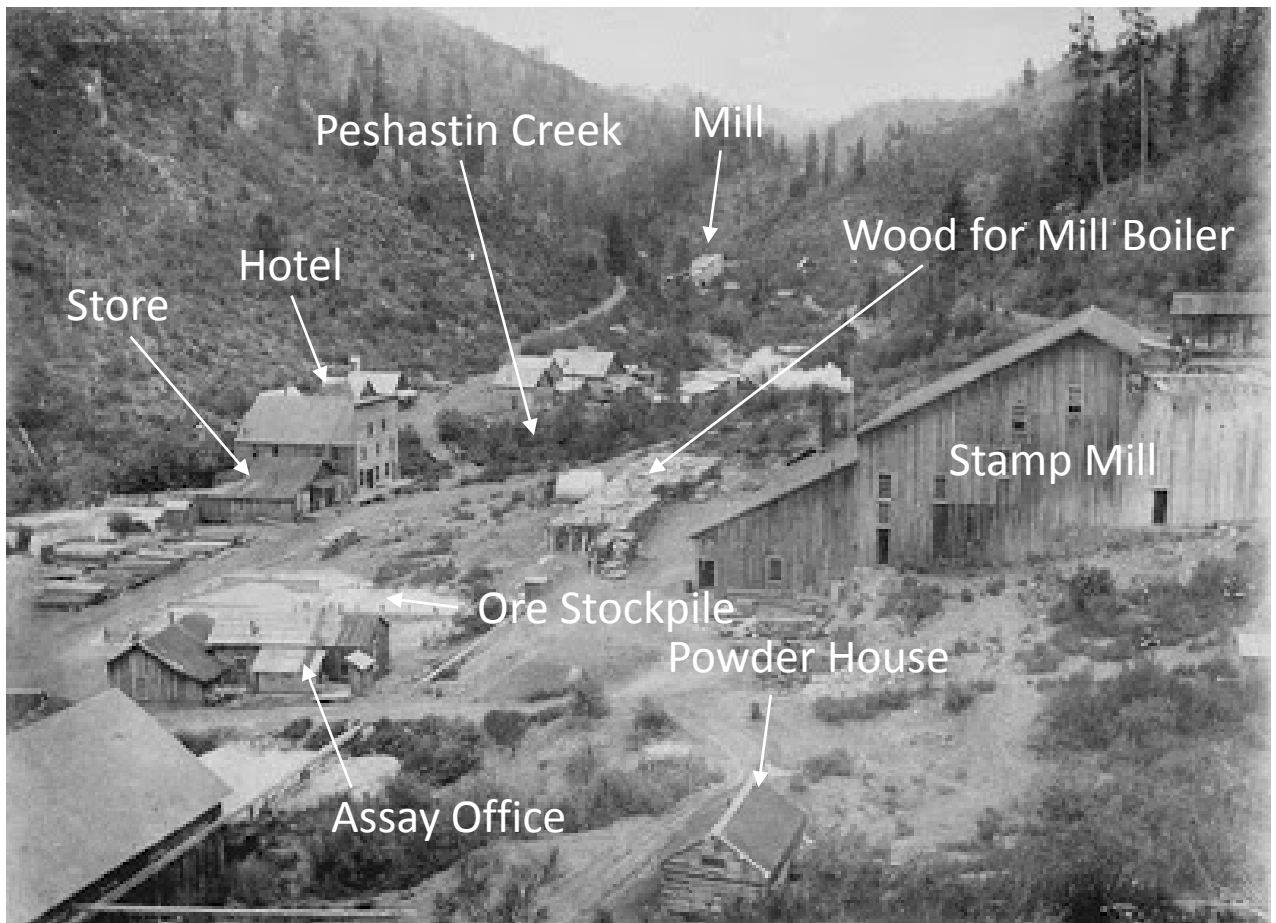
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Stop 4--Blewett

Figure 18. Blewett townsite in 1900 looking south toward Blewett Pass. Identifications of features from Kate Bailey in Livingstone (1963). US 97 would now pass along the bottom of the valley. Notice the largely denuded forest area mentioned in Plummer (1902). Source: Livingstone (1963).

Linkages to the Region. Early on, the mines of Peshastin Creek were more linked to the communities in the upper Yakima River Valley rather than those in the Wentachee River Valley. A trail, then by 1879, a wagon road led from Blewett to Ellensburg. The wagon road enabled the transport of all sorts of mining equipment and supplies. The route to Ellensburg travelled up Peshastin Creek, then Scotty Creek (sometimes called Little Peshastin Creek on old documents) to old Blewett Pass, then down Swauk Creek. By the early 1890;'s regularly scheduled stages served the Peshastin from the Yakima River Valley. By 1898, a wagon road was finally constructed to the town of Peshastin, 18 miles north. This provided closer access to supplies and a transcontinental railroad (Great Northern). Nearer access to the railroad was especially important for the transport of heavy mining equipment to Blewett. Construction of the Blewett Pass Highway began in 1915 (Dow, 1963). By Fall 1916, one could drive from near the mouth of Ingalls Creek to Blewett pass in a long morning (Dow, 1963). The old Blewett Pass highway was so steep near the summit that automobiles had to back up the final stretch or the carburetor's couldn't get fuel (Dow, 1963). By 1918, a motor stage line was operating from Wenatchee to Ellensburg via Blewett Pass with the one-way trip taking from 7am until noon (Dow, 1963, p. 103).

Blewett to Near Milepost 172

Route. Carefully re-enter US 97 and drive x miles south to near Milepost 172. We will park in a large pullout. This is Stop 5.

Stop 5—Near Milepost 172

Location. We are located at a large pullout on the west side of US 97 near milepost 172. This site is just south of the Old Blewett Pass Highway turnoff.

Ultramafic Rocks, Accreted Terranes, and Ophiolite Complexes. Ultramafic rocks are those rocks that contain mostly mafic (i.e., dark colored, iron- and magnesium-rich) minerals. Many ultramafics form as magma rises to the ocean floor surface at spreading centers. Cooling leads to differentiation of the magma into a variety of ultramafic rocks including basalt, diabase, gabbro, peridotite, and serpentinite. These ultramafics then may be subducted beneath less dense continents. During subduction, not all of the rock may be subducted; instead, some slabs may be thrust onto the continent (Figure 19). These slabs of ultramafic rock are ophiolite complexes.

Ingalls Complex. The ultramafics here are part of the Ingalls Complex (Figure 4). This unit is an ophiolite complex that originated in a large, marginal basin or open ocean, then accreted to the edge of the continent as a terrane (Miller, 1985) (Figure 19). A common ultramafic, metamorphic rock in the Ingalls Complex is serpentinite which is distinctive because of its green color and often bright sheen. The Ingalls Complex is just one of several ophiolite complexes that formed in the Middle to Late Jurassic in Western North America (Figure 20). These include the California Coast Range ophiolite, Smartville Complex of California's Western Sierra Nevada Range, Josephine opiolite of the Klamath Mountains of southern Oregon, and the Bridge River and Hozameen Groups of southern British Columbia. The Ingalls Complex has been correlated to the ~162 million year old Josephine ophiolite of southern Oregon and northern California. In turn, it has been intruded by the 91-96.5 Ma Mount Stuart Batholith. It is overlaid by Eocene sedimentary rocks to the south (MacDonald & others, 2008).

Serpentinite Barrens. Most rocks at Earth's surface have a composition similar to that of Earth's mantle including aluminum, calcium, sodium, potassium, and phosphorus. Ultramafic rocks often occur in the form of ferromagnesian silicates that include the elements magnesium, iron, silicon, and oxygen. Such composition is similar to that of Earth's mantle therefore is out of equilibrium with Earth's surface. As a result, few plants are adapted to growing on ultramafics. Further, two of the three main plant macronutrients--potassium (K) and phosphorus (P)-- are typically lacking in ultramafics. This results in "serpentinite barrens" in which the vegetation cover is drastically reduced (Figure 21). Reduction in vegetation often leads to high levels of erosion, especially on the steep slopes that characterize much of the middle and upper Peshastin Creek Watershed. Serpentinite barrens and associated erosion are present (but not always easy to get to) in the US 97 corridor through the Peshastin Creek Watershed. Check them out on Google Earth. Look for barren areas that appear slightly olive green.
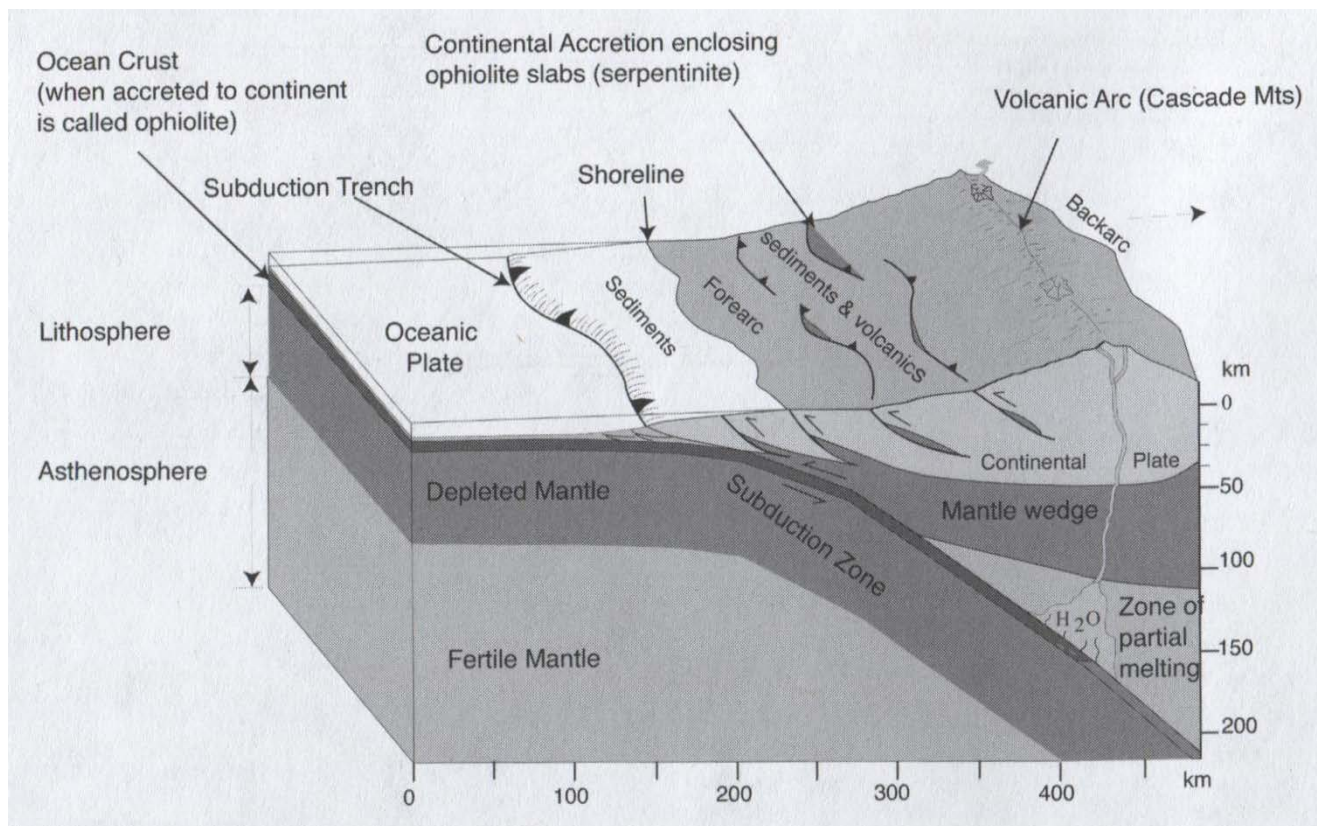
Figure 19. Pacific-type active plate margin characteristic of western North America illustrating subduction and accretion of ocean crust and mantle. As subduction continues over time, labs of accreted crust and mantle are lifted to the land surface as subduction continues. Source: Alexander and others (2007).

Swauk Sandstone and Teanaway Basalts. In addition to the Jurassic Ingalls Complex, US 97 passes through early Eocene Swauk Formation continental sedimentary rocks, and middle Eocene Teanaway Formation volcanic rocks (Cashman, 1974). 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 (like the areas of serpentinite). The big difference is that the serpentinite areas are typically light green while the basalt areas are rusty red. In this roadcut, you can see highly deformed ultramafic rocks that have been intruded by Teanaway Basalt dikes (Figure 22). This highly complex geology represents emplacement of the Ingalls Complex ophiolites—this is really complicated on its own. Next, these rocks were uplifted and eroded. Sandstones and conglomerates of the Swauk Formation were unconformably deposited atop these rocks. Folding, faulting, and intrusions of Teanaway Basalt followed (Tabor and others, 1982; Tepper and Dawes, 2014).
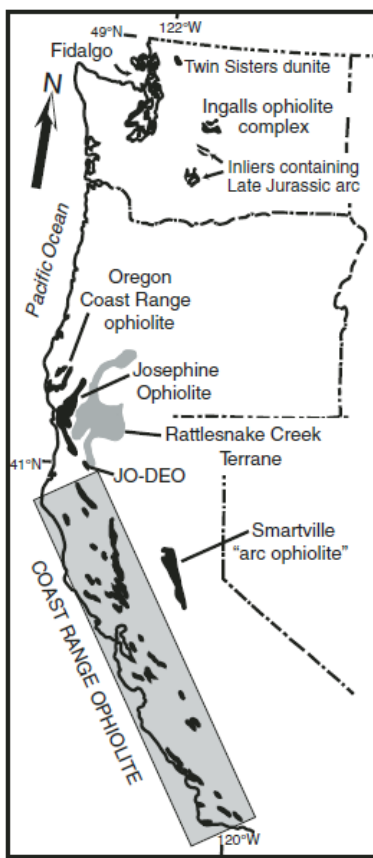
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Figure 20. Middle to Late Jurassic ophiolites of the western U.S. Source: MacDonald & others (2008).

Figure 21. Serpentinite barrens near the head of Negro Creek, Upper Peshastin Creek Watershed. Source: Karl Lillquist photo.
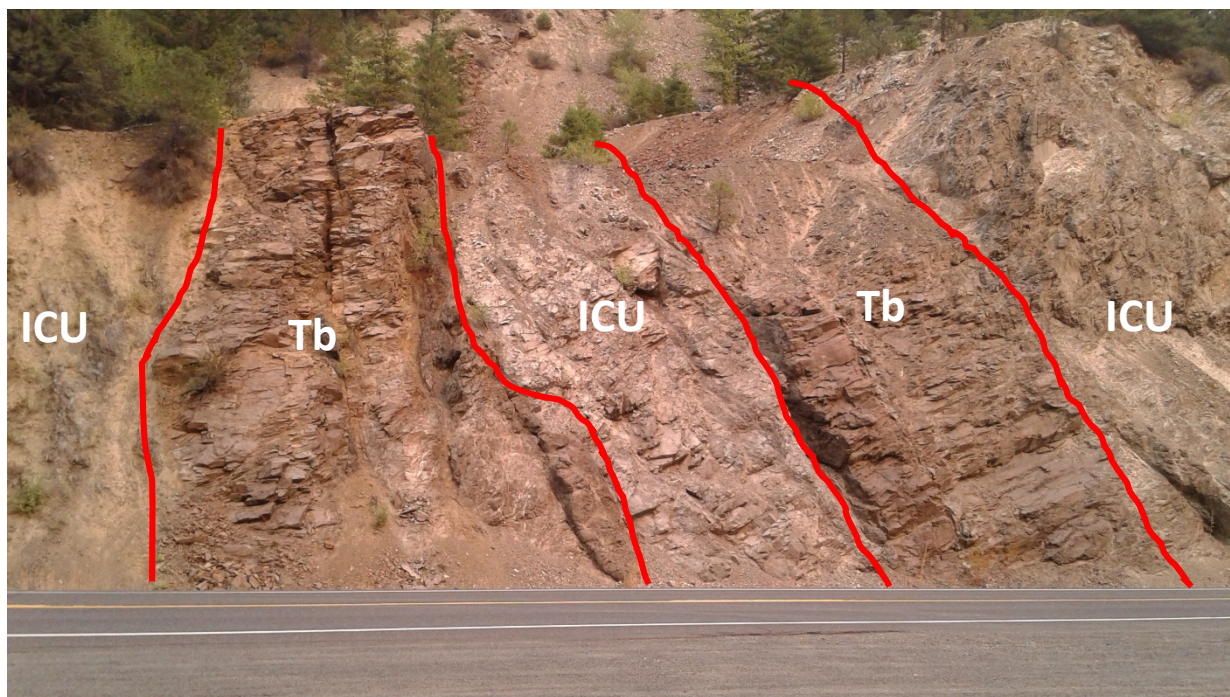
Stop 5—Near Milepost 172

Figure 22. View east across US 97 at Ingalls Complex ultamafics (ICU) and Teanaway Basalts (Tb). Note how the Ingalls Complex is deformed by folding and faulting, and how it is intruded by Teanaway Basalt dikes. Further south in the same roadcut, sandstone and conglomerate of the Swauk Formation are present. Source: Karl Lillquist photo.

Near Milepost 172 to Windy Gully

Route. Continue south on US 97 to Blewett Pass. At Blewett Pass, turn left (south) onto gravel USFS road 9716. Follow this up to its junction with USFS road 9712. Turn left (east) onto USFS road 9712 and follow it up to its junction with USFS road 35. Stay left on USFS road 9712 as it directs you to Haney Meadow. We will park at an undeveloped campsite near a sharp bend in the USFS 9712 less than 1 mile from that junction. From this parking spot, we will hike approximately 0.25 mile to our viewpoint over Windy Gully.

Mass Wasting & Cirque-like Features. Initially, the road ascending from Blewett Pass goes through in-place Swauk sandstone and Teanaway basalt. Higher up, much of the terrain shows evidence of massive landslides and rockfall (i.e., mass wasting). As USFS road 9712 ascends to the northern end of Table Mountain, it passes through a large, basalt-covered amphitheater-shaped landform. This feature looks like a cirque but it lacks clear moraine evidence at its base. Instead, late Geographer Martin Kaatz and I attribute this and other similar features on Table Mountain to large rotational landslides (Lillquist, 2001). This illustrates the geomorphic concept of "equilfinality"—i.e., different processes result in similar features. As an aside, the road through here can be quite a ski run! It is informally known by cross country skiers as the "Hungarian Express", named after longtime CWU History faculty member (and cross country skier) Zoltan Kramar.

Stop 6—Windy Gully Viewpoint

Location: We are above a popular backcountry skiing and snowshoeing location informally known as Windy Gully on the northern edge of Table Mountain.

Watersheds. We are in the headwaters of the Tronsen Creek, a high tributary to Peshastin Creek, which is a tributary to the Wenatchee River (Figure 23). However, our automobiles are parked in the headwaters of the Naneum Creek which is a tributary to the Yakima River. Our short hike from the automobiles to this view point crossed the subtle drainage divide separating these two watersheds. In addition to making good hydrographic boundaries, drainage divides are also used for political and management boundaries. This drainage divide is the Kittitas-Chelan county boundary, and the Cle Elum-Wenatchee River ranger district boundary for the Okanogan-Wenatchee National Forest.

Columbia River Basalts. In addition to being located on a hydrographic boundary we are also on a geologic boundary (Figures 3 & 4). Our viewpoint is very near the northern extent of the Columbia River Basalts. In particular, we are located atop the Grande Ronde Basalt of the Columbia River Basalts. From our stop, you can see these basalts underfoot, in the rock glacier below, and composing Windy Knob across the way (Figure 24). The basalts were deposited atop sedimentary rocks of the Swauk Formation.

Landslides. It is likely that the Columbia River Basalts, when deposited ~15.5-17 million years ago in this area, extended further north of this point. Over time, the incompetent sedimentary beds of the Swauk Formation have failed resulting in huge landslides along the west and north faces of Table Mountain. In addition to causing the retreat of Table Mountain to the south and east, landslides here have created large slide blocks and much hummocky terrain at the base of Table Mountain. Windy Knob (Figures 22 & 23) is possibly one such slide block that moved from south to north from the edge of Table Mountain. My primary evidence for this is the shape of Windy Knob, and stream patterns. The shape of Windy Knob suggests that it is backtilted (like a student slumping in a chair during one of Nick's or my lectures). An intermittent stream forms at the head of Windy Gully and flows west before turning sharply north at the base of the Gully. Sharp stream bends are uncommon in nature. Landslides may cause such abrupt drainage changes. Problems with my theory include the lack of a large, cirque-like source area upslope of Windy Knob. Further, I have not looked in detail at the weathered basalts to determine if they are tilted.

Talus. Post-landslide physical weathering and rockfall has resulted in ample talus on the Columbia River Basalt slopes. Talus is ubiquitous on the margins of Table Mountain because of the often well-defined colonnade and entabulature jointing. Further, Columbia River Basalt jointing often results in large, blocky talus.
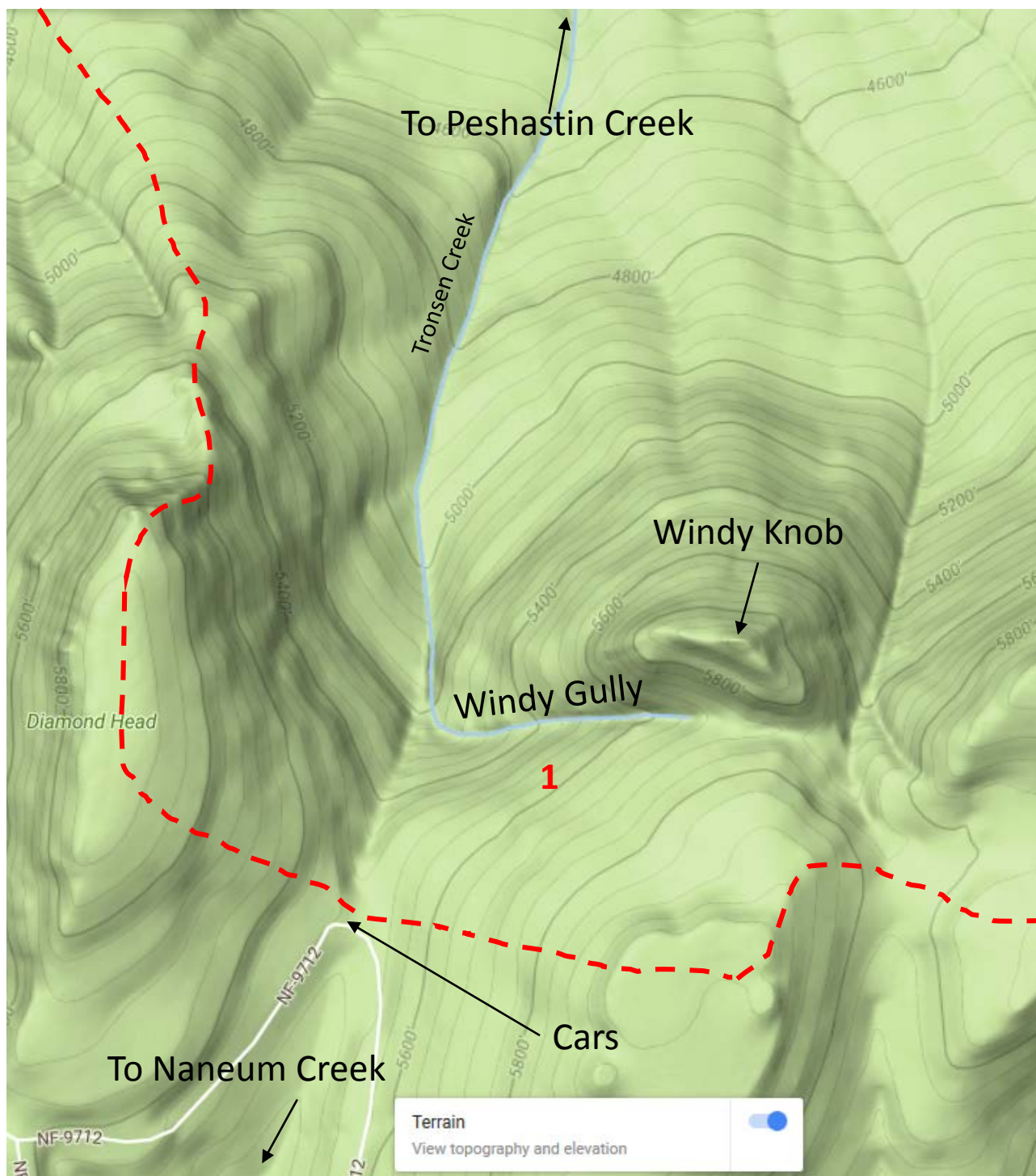
Stop 6—Windy Gully Viewpoint

Figure 23. Windy Gully and vicinity. Red dashed line represents the approximate position of the divide separating the Peshastin and Naneum creek drainages. Note Windy Knob and the sharp bend in upper Tronsen Creek. Source: Google Maps.

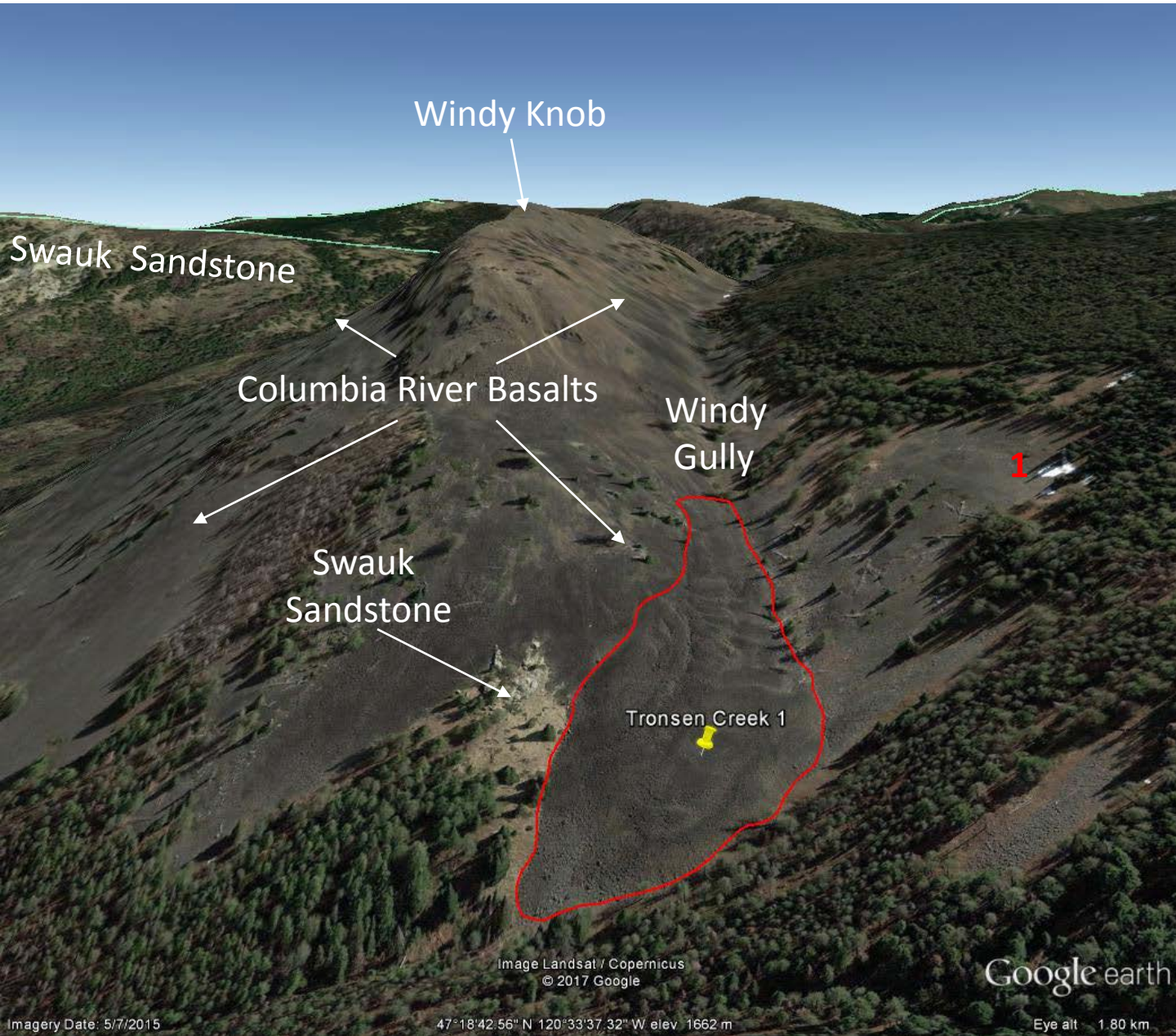# Stop 6—Windy Gully Viewpoint

Figure 24. View east up Windy Gully. Note: 1) the Grande Ronde member? Of the Columbia River Basalts overlying the Swauk Sandstone; 2) tilted appearance of the Grande Ronde basalts of Windy Knob; and 3) Tronsen Creek 1 rock glacier in Windy Gully. Source: Google Earth.

Stop 6—Windy Gully Viewpoint

Glaciers & Rock Glaciers. Upper Tronsen Creek does not appear to have been glaciated in the Pleistocene ice ages. Porter's (1977) research suggests that temperatures may not have been sufficiently cold and precipitation was likely too low for glaciers to have developed here. However, rock glaciers and related talus features did form on the margins of Table Mountain and elsewhere in Washington's Eastern Cascades where precipitation was insufficient for glaciers but where average annual temperatures were near 32°F. Microclimates associated with shading likely played a role in their formation as did basalts that weather into blocky debris. We are looking down on Tronsen Creek 1 rock glacier. After several passes through the area on skiis and snowshoes, I recognized this tongue-shaped mass of blocky talus with steep margins as a rock glacier (I'm a slow learner). Google Earth imagery confirmed this (Figure 24). In addition to the overall shape, its surface has pressure ridges that indicate that this mass of blocky talus and permafrost has slowly moved en masse in the past. The lichen covered rocks of its surface and its relatively low elevation indicate that it is no longer active. Former CWU Geography student Mark Weidenaar and I mapped this (Weidenaar, 2013) as an inactive feature meaning it is no longer moving but likely still contains permafrost. Current graduate student Adam Riffle will soon use ground penetrating radar to determine if this rock glacier contains permafrost. This is part of his thesis research in which he hopes to examine the interiors of ~12 Eastern Cascades rock glaciers. It is this permafrost that is of much significance in our warming world. The permafrost of the interiors of rock glaciers melts slowly because of the insulating nature of the overlying rock debris. The meltwater from rock glaciers helps form the base flow of streams so important for migrating fish. In a warmer world where glaciers are greatly diminished, the ice of rock glaciers and related talus features will play an increasingly important role in stream flow, especially during our typically dry summers. This is but one of 124 identified rock glaciers in the Eastern Cascades. Additionally, we are in the process of mapping related talus features which may also contain permafrost. Stay tuned!

Wrap-up

Thanks for joining us today! You have had an opportunity to see a geologically, climatologically, and topographically diverse mountain setting shaped by a variety of rock types, folding, faulting, glaciation, streams, weathering, mass wasting, and humans. I hope the features and processes I have tried to convey to you make sense. If you have any questions, comments, or corrections for the field guide, please feel free to contact me at karl.lillquist@cwu.edu or 509 963-1184.

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