Ellensburg Chapter—Ice Age Floods Institute
Field Trips

Ice Age Lakes in the Grand Coulee

Field Trip Leader:

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Introduction

The Ice Ages resulted in numerous lakes, either from the direct action of ice on landscapes or from the effects of ice sheets on climate patterns. Evidence of Ice Age lakes has been studied around the Western U.S. for more than a century (e.g., Russell, 1885; Gilbert, 1890). Less common is the study of Ice Age lake evidence in Washington state.

Why study Ice Age lakes? They can tell us much about the nature of past landscapes and the climates affecting those landscapes. How does one go about studying an Ice Age lake? We often start by mapping shoreline features. Wave action on lakes, like that on oceans, may result in erosional (e.g., cliffs, platforms) and depositional (e.g., beaches, barriers, and spits) features. Such mapping can help determine the spatial (i.e., length, width, and depth) extent of the lake. The next step is to figure out the timing of the lake—i.e., when it formed, how long it existed, and when it disappeared. Lake sediments, and associated sediments, can often help us with this. We can determine how many years a lake existed by counting annual layers of sediments known as varves. To determine when the lake existed we may examine and date organic materials (including molluscs) (via radiocarbon methods), identify tephra (through electron microprobe analysis), and date mineral beach sediments (through optically stimulated luminescence methods). And because Ice Age lake levels were not static, we may apply some or all of these methods to different shorelines in a particular Ice Age lake basin.

Today, we will explore two Ice Age lakes—one in the Lower Grand Coulee and the other in the Upper Grand Coulee in Central Washington. My goal is to expose you to the evidence and implications of this evidence to Ice Age lake and landscape history in this part of the state. Enjoy!

Tentative Schedule

10:00	Arrive Stop 1—South of Soap Lake
10:45	Depart
11:00	Arrive Stop 2—East of Little Soap Lake
12:30 pm	Depart
12:45	Arrive Stop 3—Between Lake Lenore & Alkali Lake
1:15	Depart
1:45	Arrive Stop 4—Coulee City Park
2:30	Depart
2:45	Arrive Stop 5—Upper Grand Coulee Viewpoint
3:15	Depart
3:30	Arrive Stop 6—Paynes Gulch
4:15	Depart

Stop 1—South of Soap Lake

Route: Our route to Stop 1 takes us from Ellensburg to Soap Lake via I-90, WA 283 and WA 28 (Figure 1). At the intersection of WA 28 and WA 17 south of Soap Lake, head south on WA 17 for about 1.4 miles to a point just north of the railroad trestle over WA 17. If a gate is open into a borrow pit on the west side of WA 17, drive in and park there; otherwise, park alongside WA 17. If you do the latter, make sure your vehicle is completely out of the driving lane of WA 17. GPS Coordinates: 47°21'42.12"N and 119°28'36.99"W. From our parking spot, we will walk through the borrow pit and up onto the abandoned Burlington Northern-Santa Fe Railroad right of way to the south.

Getting our bearings…: We are located at the north end of the Quincy Basin (Figure 2). Soap Lake (town and lake) and Lower Grand Coulee are north, High Hill and Crab Creek Valley are northeast, Rocky Ford is south, and the Beezley Hills are west. The bedrock surrounding us consists of flows of the Columbia River Basalts (Figures 3 & 4) which have been extensively folded and are part of the Yakima Fold and Thrust Belt (Figure 5).

Lower Grand Coulee: Huge Pleistocene floods from Glacial Lake Missoula eroded the Lower Grand Coulee (Bretz, 1932; Bretz and others, 1956; Bretz, 1969) (Figure 6). A large expansion bar formed at the mouth of the Lower Grand Coulee where floodwaters spread out, slowed, and deposited their sediment loads. Ice Age floods from the Crab Creek-Telford scabland tract also deposited their sediment loads here as part of that expansion bar. This giant fan-shaped bar is known as the Ephrata Fan. It fills much of the Quincy Basin. The sands and gravels that were mined from the borrow pit here were deposited by these Pleistocene floods as part of Ephrata Fan. Seven granitic boulders on this bar (but several miles south) have an average age of 15.6 +/- 1.3 ka (i.e., about 15,600 years old) (Balbas & others, 2017) indicating that the Missoula Floods that deposited them occurred about 15,600 years before present.

A Pleistocene Lake in the Lower Grand Coulee: We are just south of an area once inundated by a Pleistocene lake (Figure 7). Lake formation requires a basin and water. The basin was provided by the walls of the Lower Grand Coulee and expansion bar "dam" at the south end of the coulee. Water would have accumulated here from Missoula Floods, the flow of the Columbia River down the Lower Grand Coulee, local runoff, spring flow, and direct precipitation. Bretz and others (1956) were apparently the first to note evidence for the lake. WSU Anthropologist Roald Fryxell's student Jerry Landye (1969) named this Lake Bretz after J Harlen Bretz, the early proponent of

Our Field Stops

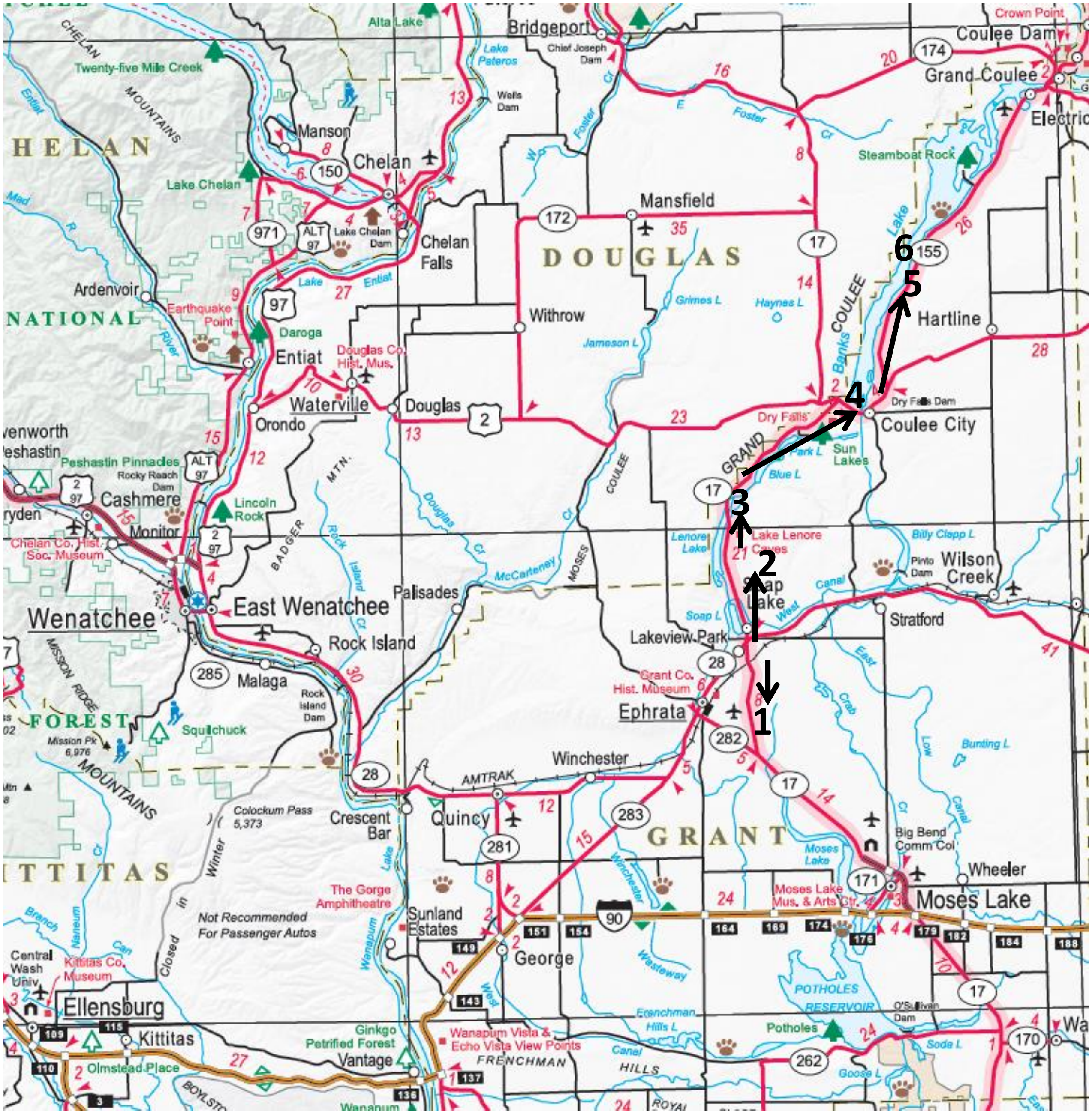

Figure 1. Our route shown with arrows and approximate locations of stops noted with numbers. Source: Washington State Department of Transportation http://www.wsdot.wa.gov/NR/rdonlyres/14A6187A-B266-4340-A351-D668F89AC231/0/TouristMapFront_withHillshade.pdf

Stop 1—South of Soap Lake

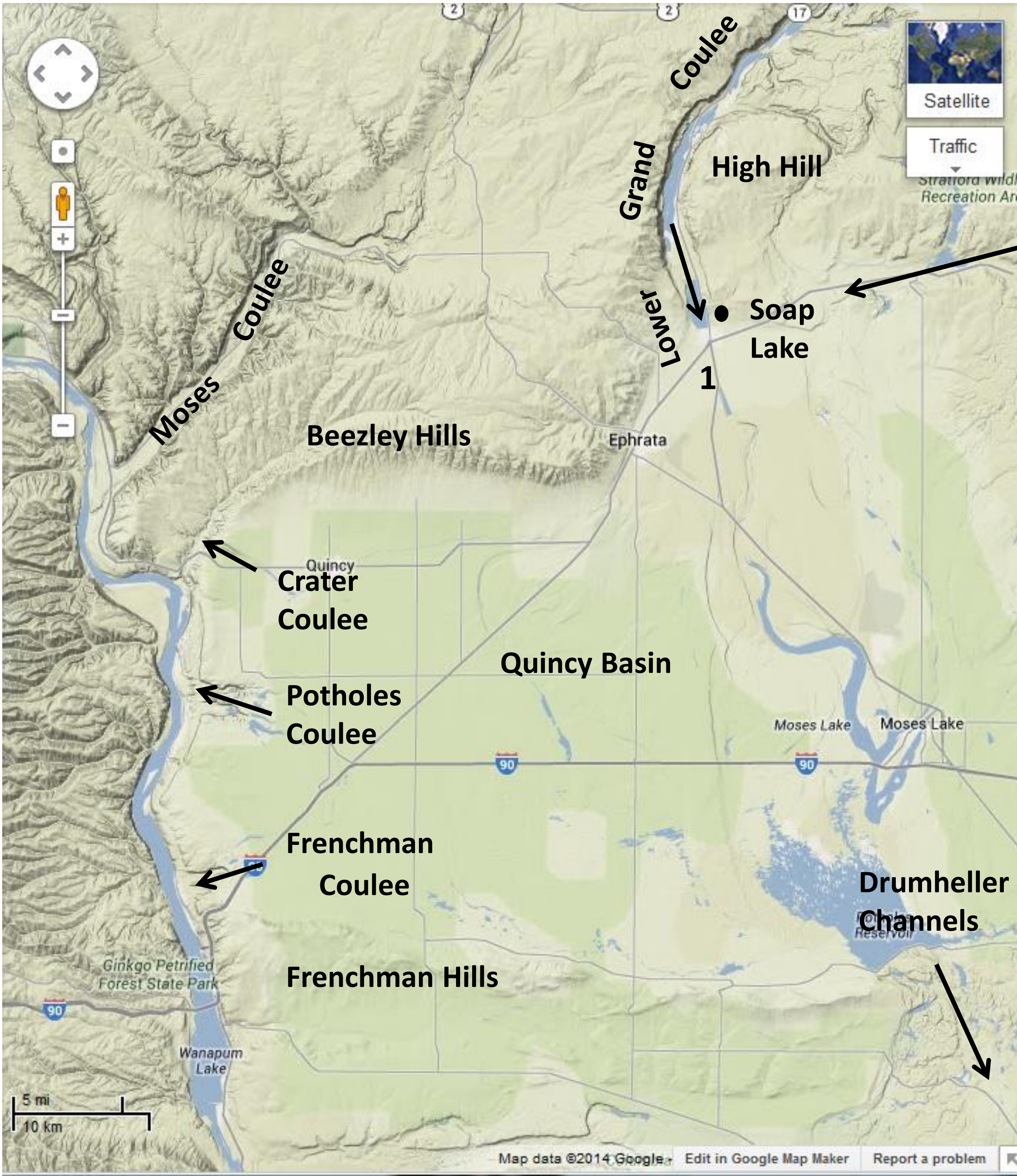

Figure 2. Topography of the Quincy Basin and adjacent areas. Arrows show direction of main flood flows into, and out of, the Quincy Basin. Stop 1 shown near Soap Lake. Source: Google Maps.

Stop 1—South of Soap Lake

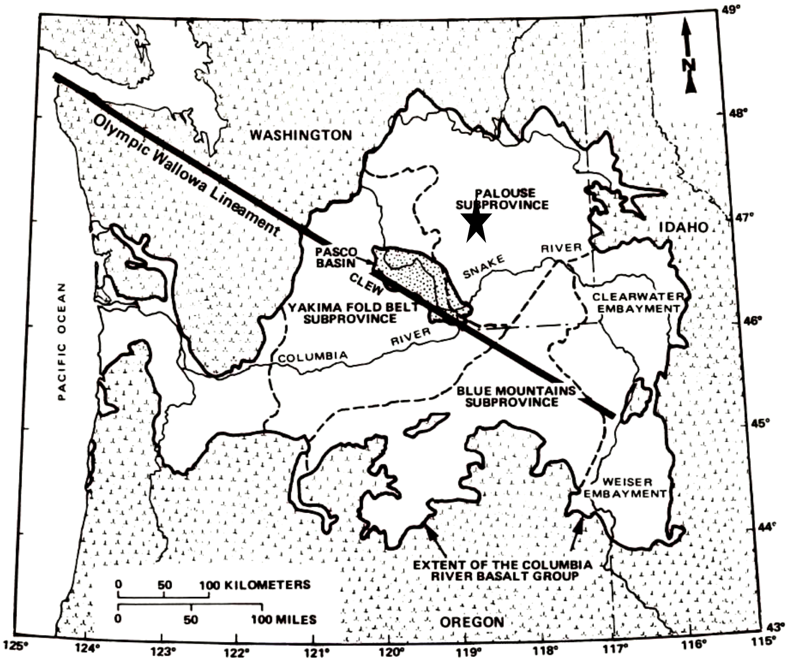

Figure 3. The Columbia Plateau and the areal extent of the Columbia River Basalt Group, the four major structural-tectonic subprovinces (the Yakima Fold Belt, Palouse, Blue Mountains, and Clearwater-Weiser embayments), the Pasco Basin, the Olympic-Wallowa lineament. Star indicates approximate location of the Grand Coulee. Source: (Reidel & Campbell, 1989, p. 281).

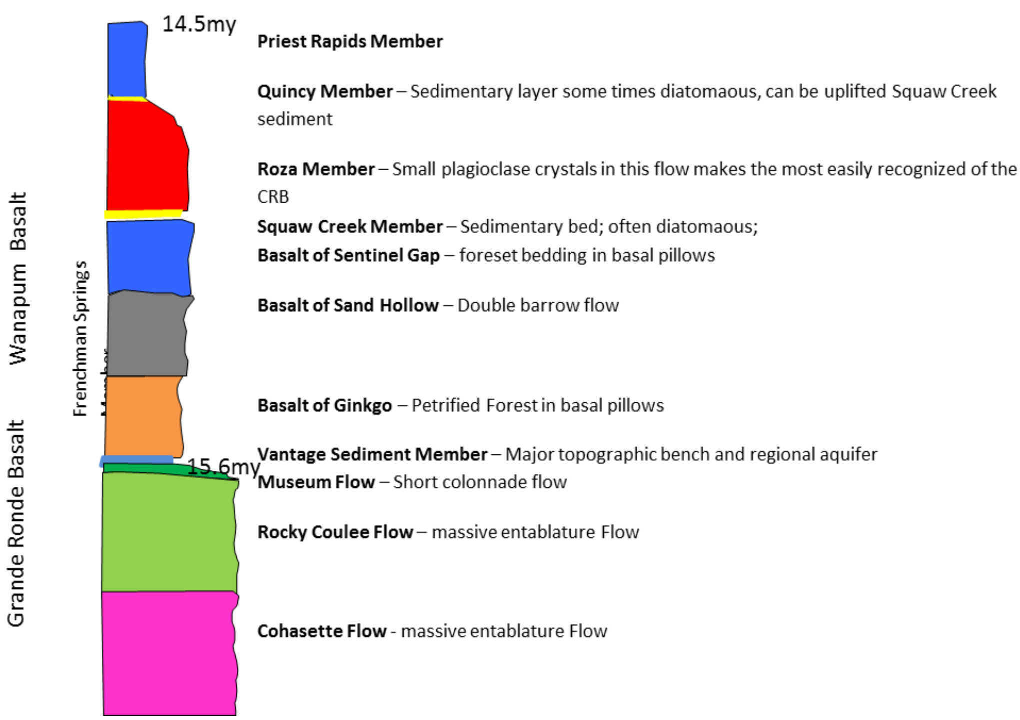

Figure 4. Stratigraphy of the Columbia River Basalt Group. Source: Jack Powell.

Stop 1—South of Soap Lake

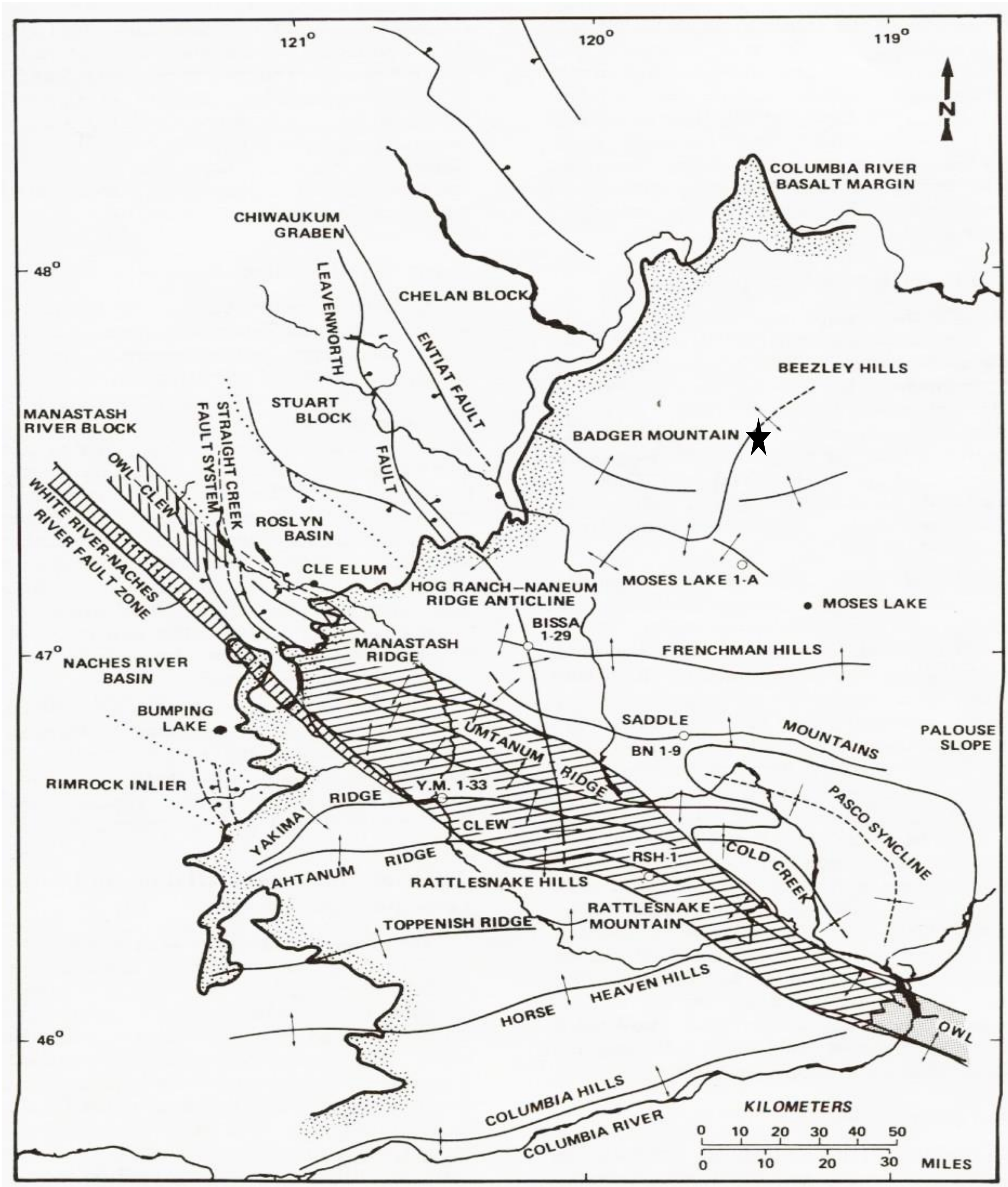

Figure 5. Generalized map of major faults and folds along the western margin of the Columbia Plateau and Yakima Fold Belt. Star indicates approximate location of the Grand Coulee. Source: Reidel & Campbell (1989, p. 281).

Stop 1—South of Soap Lake

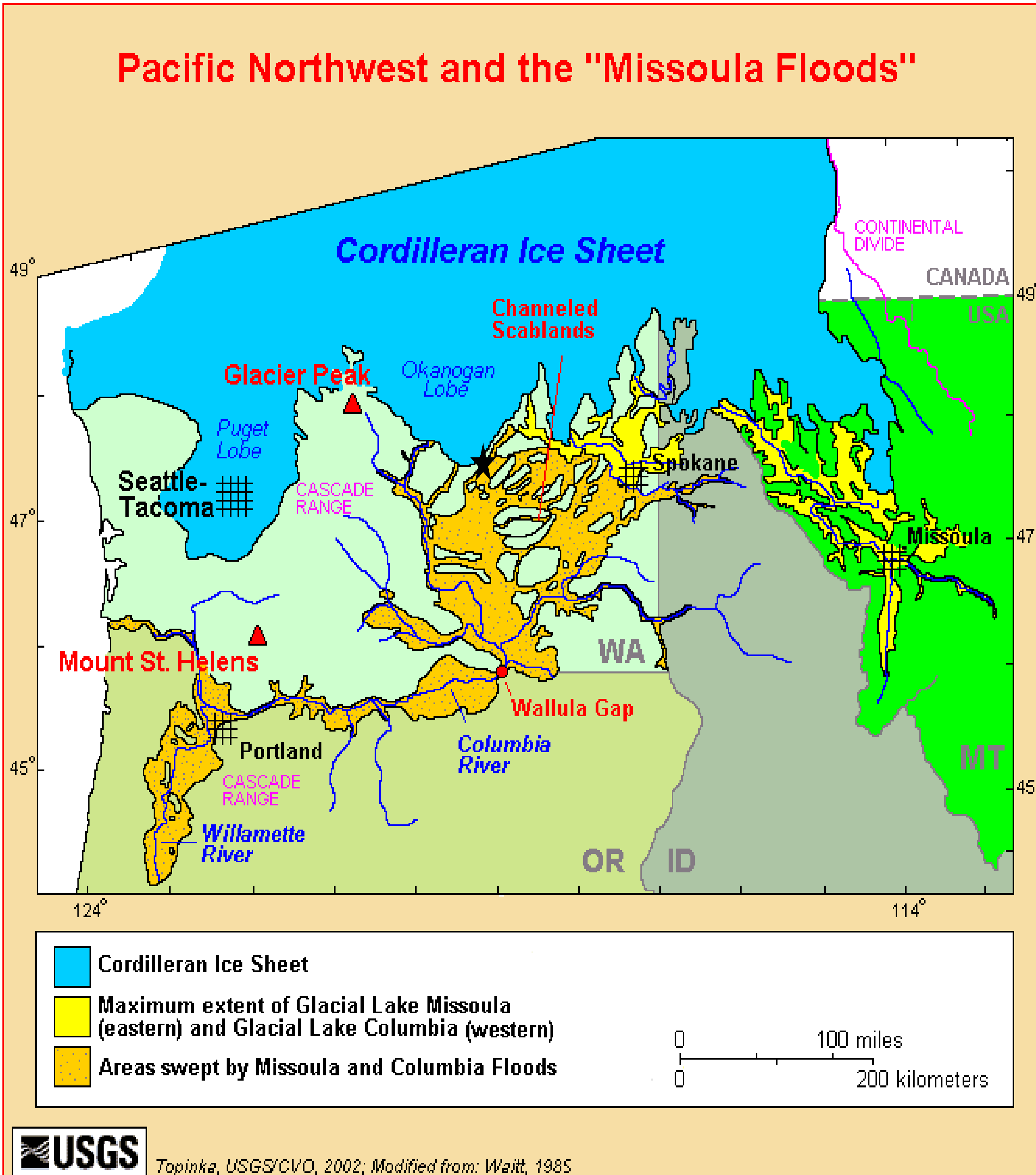

Figure 6. Map of the late Pleistocene Cordilleran Icesheet and Missoula Floods in the Pacific Northwest. Star indicates approximate location of the Grand Coulee. Source: Cascade Volcano Observatory website.

Stop 1—South of Soap Lake

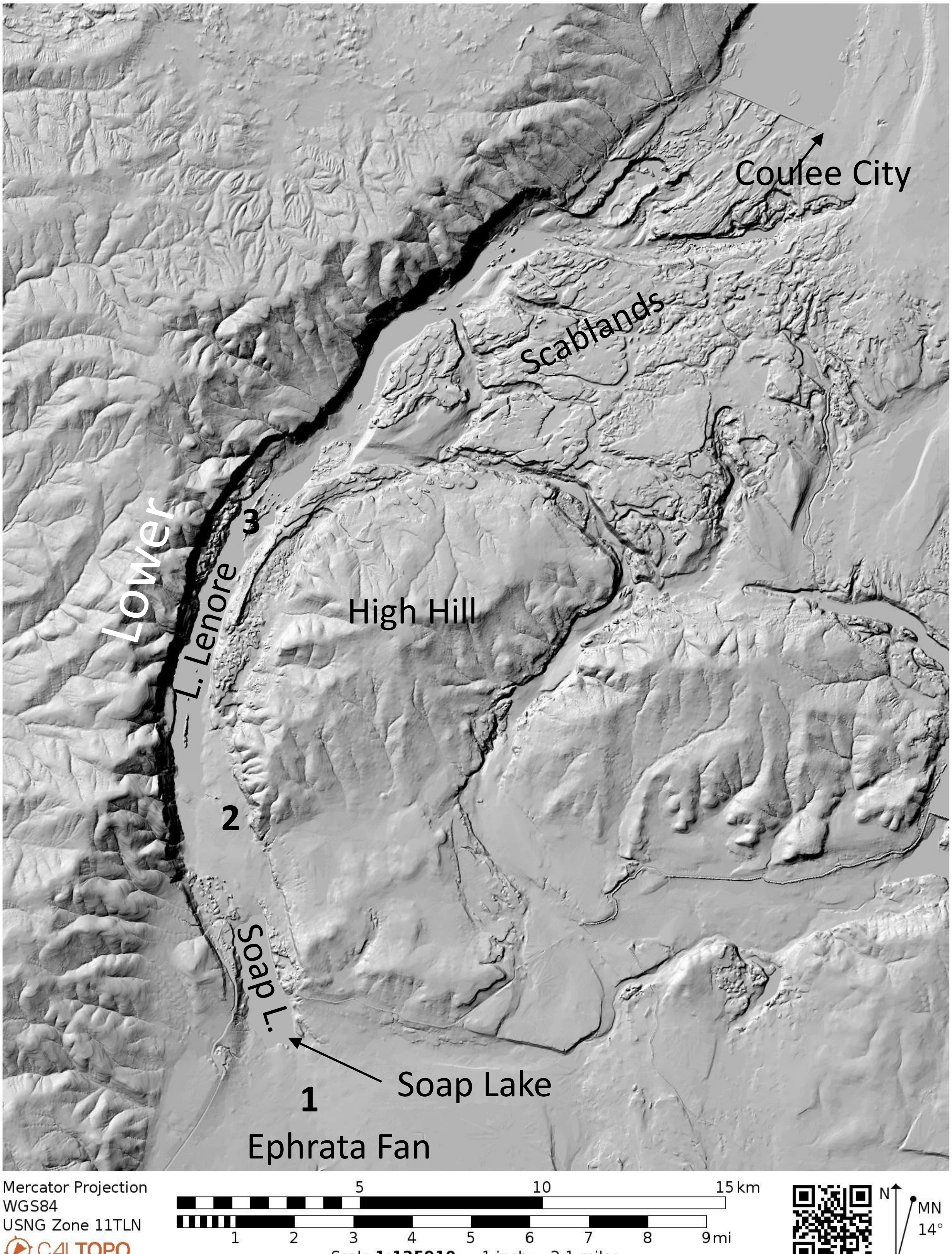

Figure 7. Shaded relief view of Lower Grand Coulee. Approximate locations of field trip stops shown with bold numbers. Source: Caltopo.com.

Stop 1—South of Soap Lake

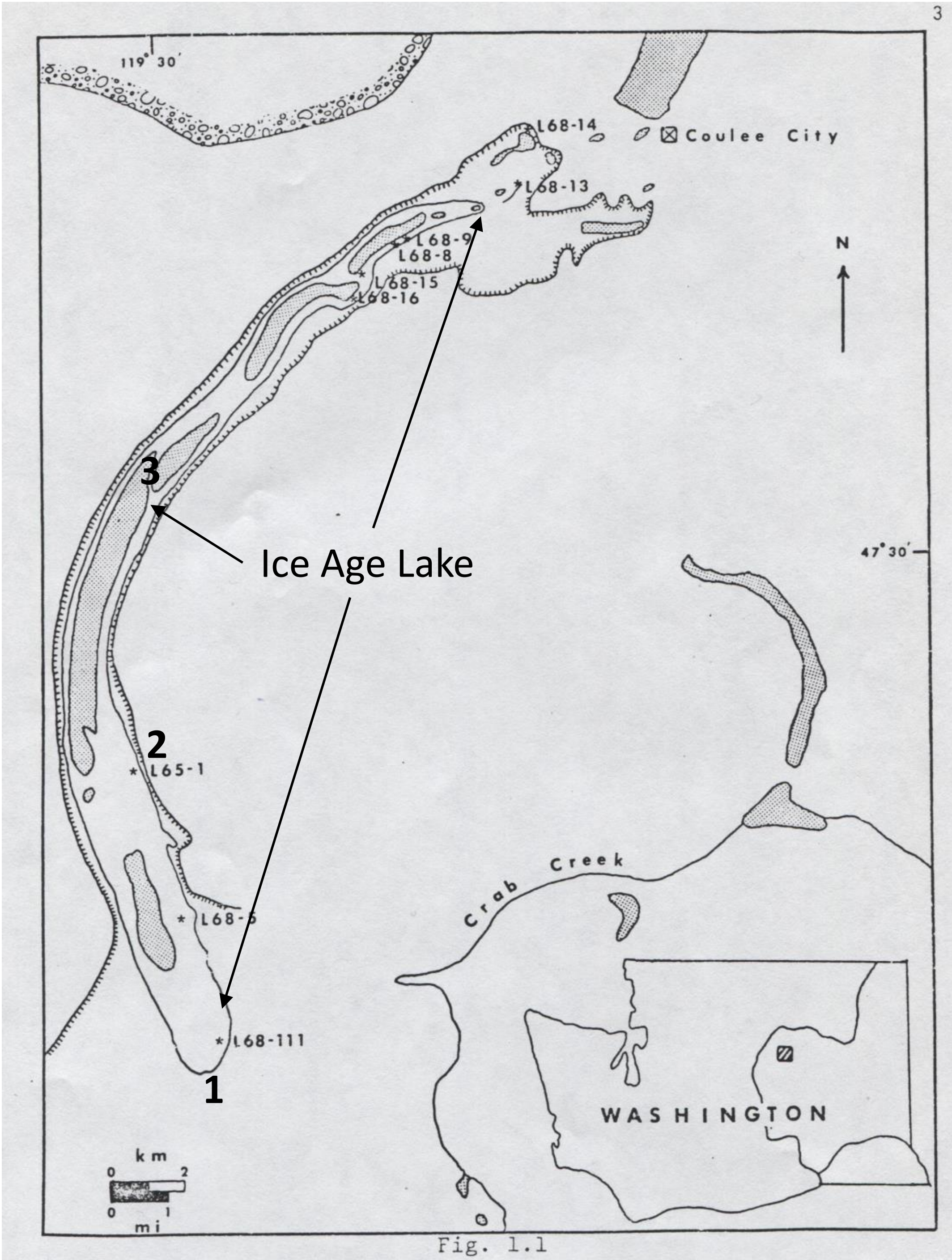

Figure 8. Pleistocene lake in the Lower Grand Coulee outlined with single line. Landuaye's mollusc sample sites shown with letters and numbers. Modern lakes shown as shaded areas. Approximate southern extent of Okanogan Lobe shown in upper left. Approximate locations of Stops 1-3 shown with a bold numbers. Map from Landye (1973, p. 3).

Stop 1—South of Soap Lake

A Pleistocene Lake in the Lower Grand Coulee (continued): …massive ice age floods in the area. Others since have mentioned the lake (e.g., Waitt, 1994; Amara and Neff, 1996; Bjornstad and Kiver, 2012; Waitt and others, 2021). Fryxell (1965) and Landye (1973) studied the lake sediments in more detail. I do not refer to the lake as “Lake Bretz” so to avoid confusion with another, earlier named Glacial Lake Bretz that formed on the south end of the Puget Lobe in the southern Puget Sound region; rather I refer to it as a Pleistocene lake in the Lower Grand Coulee.

Pleistocene Lake Evidence: Unlike long-lasting paleolakes in places like the Great Basin of the Western U.S., this Pleistocene lake did not leave shorelines that we may view today. This may reflect the difficult-to-erode basalts of the Lower Grand Coulee, the relatively short time the lake was present, or both. Instead, the evidence for this lake is primarily its sediment. I assume that a thick sediment fill was deposited throughout the basin by this Pleistocene lake. Subsequent erosion by water and wind has removed all but scattered remnants of these sediments along the steep, unstable walls of the Lower Grand Coulee. The characteristics of these deposits are their bright white colors, fine textures, thin beds, and common inclusion of lake-dwelling molluscs. The beds are often curved or contorted because of soft sediment deformation or the fact that they were deposited over an irregular surface.

Spatial Extent: Pleistocene lake sediments containing molluscs have been found up to 1,159 +/-1 feet elevation (Landye, 1973). That elevation occurs just north of Stop 1 (Figure 9). The lake extended from this elevation here northward in the Lower Grand Coulee nearly to Dry Falls Lake and Deep Lake. Based on a maximum depth of contemporary Soap Lake of 102 feet below a reference elevation of 1076 feet (Wolcott, 1964), this Ice Age lake was, at its deepest, 185 feet deep. Because the Lower Grand Coulee was the pathway for the Columbia River during part of the late Pleistocene it is likely that the lake had a nearly constant overflow at the saddle just north of Stop 1.

From here: We will turn around and head north on WA 17 to the intersection with WA 28. Continue north on WA 17 through Soap Lake toward Coulee City. Total driving distance is about 6 miles to GPS coordinates 47°26'45.65"N & 119°30'29.06"W. Park on the east side of the road, again taking care that your vehicle is completely out of the WA 17 driving lane.

Stop 1—South of Soap Lake

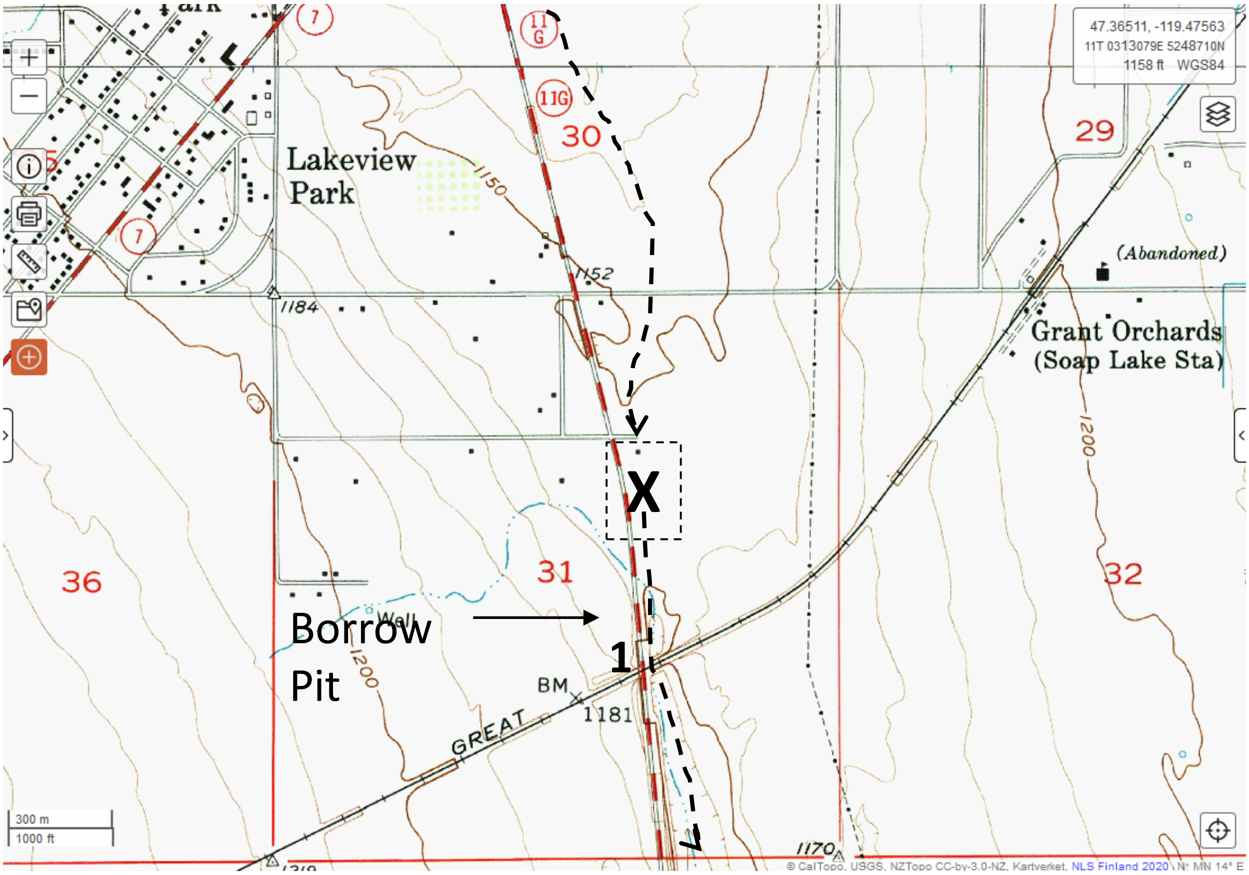

Figure 9. Approximate location (X) of the lowest threshold for the Lower Grand Coulee Pleistocene lake on the expansion bar. Dashed arrow indicates the likely direction of overflow from the lake to the south. Field stop location indicated with 1. Source: Caltopo.

Stop 2: East of Little Soap Lake

Location: From our parking spot along WA 17 east of Little Soap Lake in the Lower Grand Coulee, we will walk about 0.4 mile over very gentle terrain to a borrow pit on Washington state DNR land. This borrow pit is Landye's site L65-1 (Figure 10).

Lake Sediments, Flood Sediments, and Basalts: Stop 2 is located in an old borrow pit in a depression near the east wall of the Lower Grand Coulee. You can see some gravelly sand as well as basalt bedrock, and silty/clayey lake sediments in the walls of the pit (Figure 11). It appears that the basalt did not form a horizontal surface here; rather, there appears to be a depression in the basalts where much of the borrow pit lies. Note how the lake sediments are bedded and drape directly over the basalt bedrock. Perhaps turbid water from Glacial Lake Columbia (in the Upper Grand Coulee) was the source of the fine sediment ultimately deposited as lake sediments here (Waitt and others, 2021).

Also, check out the spherical sand grains that have accumulated in places on the floor of the pit. They are coarse volcanic ash- and *lapilli*-sized ejecta from an eruption of Glacier Peak (see below). Lapilli are various shaped ejecta that are larger than volcanic ash 2-64 mm diameter vs. <2 mm diameter). They formed with the explosion of the molten to semi-molten part of a volcano. The airborne molten and semi-molten rock may develop *vesicles* (i.e., gas bubble holes). This low density material is known as *pumice*. Pick up a handful of the coarse ash/lapilli. Better yet, put a handful into a glass of water and note how some of it floats. The floating nature of the pumice may result in confusing stratigraphic sections! According to Ephrata resident Bill Correll (written communication, September 2021), the pit was created by another Ephrata man, Lee Swartz, who mined the pumice for use in his cement block plant.

Timing of Lower Grand Coulee Ice Age Lake: The presence of easily eroded glacial lake silts and associated molluscs here suggests that a Pleistocene lake occupied the Lower Grand Coulee <u>after</u> the last large Missoula Floods passed through the coulee. Lake sediments sit atop the flood-scoured, vesicular top of a Grande Ronde basalt flow (Gulick, 1990). A radiocarbon date on molluscs from this site yielded a date of 12,000 +/- 310 years (Fryxell, 1965). I used OxCal to convert this to a calendar year age of 13,110 to 13,356. The converted age fits quite well with the presence of Glacier Peak tephra interbedded in the lake sediments with molluscs (Fryxell, 1965; Fryxell and Neff, 1965). Elsewhere, this tephra has been dated at 13,410-13,710 years before present (Kuehn and others, 2009). Therefore, it appears that this Pleistocene lake was present here around 13,100 to 13,400 years ago, approximately 2,000 years after the last major flood passed through the Lower Grand Coulee.

Stop 2: East of Little Soap Lake

Figure 10. Location of Stop 2 in Lower Grand Coulee. This is Landye's (1973) site 765-1. Google Earth Pro image.

Stop 2—East of Little Soap Lake

Figure 11. Wall of pumice borrow pit, Landye (1973) site L65-1. Note scraped exposure just above basalt bedrock. Also note trowel for scale. Source: author.

Figure 12. Close-up of part of wall of borrow pit, Landye (1973) site L65-1. Thicker, light colored units are lake silts and the thinner, darker sediments have more clay. I interpret each of the 11 dark ~horizontal lines as the winter portion of a varve. This suggests that 11 years of deposition are represented in this small exposure. Trowel for scale. Source: author.

Stop 2—East of Little Soap Lake

Timing of Lower Grand Coulee Ice Age Lake (continued): How long did this Ice Age lake exist? Look at the scraped exposure atop the basalt bedrock. Note the alternating thick, light colored beds and thin, dark colored beds (Figure 12). My preliminary interpretation of these couplets is that they are varves with each light and dark pair (or couplet) representing one year of deposition. Traditionally, warm season lake deposits are lighter colored and coarser while the cool season deposits occur beneath an ice cover and are darker (organic-rich) and finer textured. The darker, thin layers here may be richer in organics or they may just hold moisture better than the coarser, lighter sediments. How many varves do you see here? I counted 11 varves representing 11 years here in this very small section. It be good to expose the entire slope here to see if there are more varves.

Estimates based on mollusc sizes and populations suggest that this lake was present for more than 33 years but less than a few hundred years (Landye, 1973). Radiocarbon dates on molluscs at the bottom and top of the lake sediments could help us constrain the lake's time in the Lower Grand Coulee.

Molluscs and the Paleoenvironment: Here and elsewhere throughout the Lower Grand Coulee, Landye (1968, 1969, 1973) identified 27 different freshwater mollusc species in the Lower Grand Coulee Ice Age lake sediments. These organisms, as well as other faunal evidence found at the sites, suggest that the lake was a cool, fresh, and perennial, and fed largely by groundwater. It was lined with sedges and perhaps a few trees. Further, the lake had higher flow through and was better oxygenated in its northern part than in the southern end. It was likely an attractive place for early humans.

World War II Training Site: As you wander around in the pit, keep your eyes open for .50 caliber machine gun bullets. According to Ephrata resident Bill Correll (written communication, September 2021), the trench to the west of us was part of an army target range during World War II. Bill knew someone who had been briefly encamped there who told him that the Army used the area to prepare soldiers for desert fighting in North Africa.

From Here: After returning to our vehicles, we will travel about 5.5 miles north to our next stop between Lake Lenore and Alkali Lake. Parking is available at two places—one pullout north (room for about 5 cars) and one pullout south (room for 20 or so cars if packed in) of the outcrop. The location of the southernmost and larger parking space is 47°31'7.63"N &119°30'2.03"W. En route, look for more Ice Age lake sediment exposures.

Stop 3—Between Lenore & Alkali Lakes

Location. From our parking spot on an eroded remnant of the basaltic Coulee monocline separating Lake Lenore and Alkali Lake, a short,50 yard walk takes us to an overlook of a Pleistocene lake sediment outcrop (Figure 13).

Pleistocene Lake & Glacier Peak Tephra. This site illustrates subtle Pleistocene lake sediment stratigraphy, showing approximately 100 thinly laminated couplets (Figure 14). It is possible that each of these couplets is a varve representing a year of deposition. The site also shows the temporal relationship between the Pleistocene lake and the Glacier Peak eruption (Figures 15 & 16). As noted earlier, Glacier Peak erupted several times between 13,410-13,710 years before present. The plumes from these eruptions reached across Washington and into British Columbia, Alberta, Saskatchewan, Idaho, Montana, and Wyoming (Figure 17). Lakes are ideal places to preserve tephra. One distinct layer of tephra, likely layer G lies near the top of these lake sediments (Figure 15) (Waitt and others, 2021). Lake sediments (mixed with Glacier Peak lapilli-sized pumice and molluscs) indicate that the lake was present during <u>and</u> at least briefly after the late Pleistocene eruption of Glacier Peak. Molluscs are present throughout the lake sediments (Figure 16). Coarse ash and lapilli lie at the top of the lake sediments where their low densities cause them to settle very slowly (Figure 15). The upper lapilli are likely associated with the Glacier Peak layer B (Waitt and others, 2021).

Demise of Ice Age Lake and Formation of Modern Lakes: With the reduction of inflow (retreat of Okanogan Lobe, diversion of the Columbia River back into the Columbia River Valley, draining of Glacial Lake Columbia, and perhaps a hotter, drier climate), the Ice Age lake shrunk to form the current lakes—Park, Blue, Alkali, Lenore, and Soap. Soap Lake is the terminal lake of this chain of Lower Grand Coulee lakes and has no surface outlet (Edmondson, 1992). In arid to semi-arid settings, water loss from such closed basin lakes occurs primarily because of evaporation which concentrates minerals in the remaining water. Closed basin lakes therefore tend to be saline and/or alkaline, and because of its terminal position in the Lower Grand Coulee, Soap Lake is the most saline and alkaline of the Lower Grand Coulee lakes (Bennett, 1962). Lake Lenore and Soap Lake are the second and third largest saline lakes in the state (behind Omak Lake) (Bennett, 1962). Lake Lenore is alkaline and saline, so much so that the it was once considered "useless" by the Washington State Department of Fish and Game (Edmondson, 1991). This designation resulted in Lake Lenore being a 1940's dumping ground for 21,000 lbs of sodium metal by the War Assets Administration. This dumping occurred between Stops 2 and 3. Lake Lenore was considered ideal because the additional sodium was considered harmless to the lake. Google "dumping sodium into Lake Lenore" to see the resulting explosions! Because of Columbia Basin Irrigation Project dilution of the lake, it is now able to support a healthy, introduced population of saline-/alkaline-adapted Lahontan cutthroat trout.

Stop 3—Between Lenore & Alkali Lakes

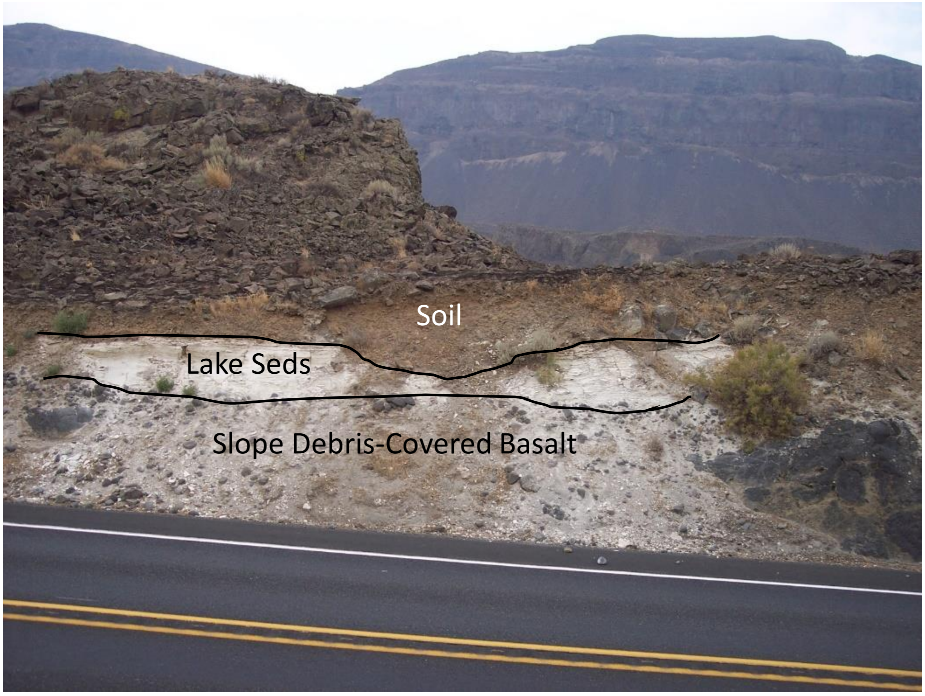

Figure 13. View of Pleistocene lake sediments in WA 17 roadcut between Lenore and Alkali lakes. Lake sediments overlie basalt and underlie the contemporary soil. Author photo.

Figure 14. Close-up of thinly bedded (from ~left to right) paleolake sediments exposed at roadcut shown above. Ruler for scale. Nick Zentner photo.

Stop 3—Between Lenore & Alkali Lakes

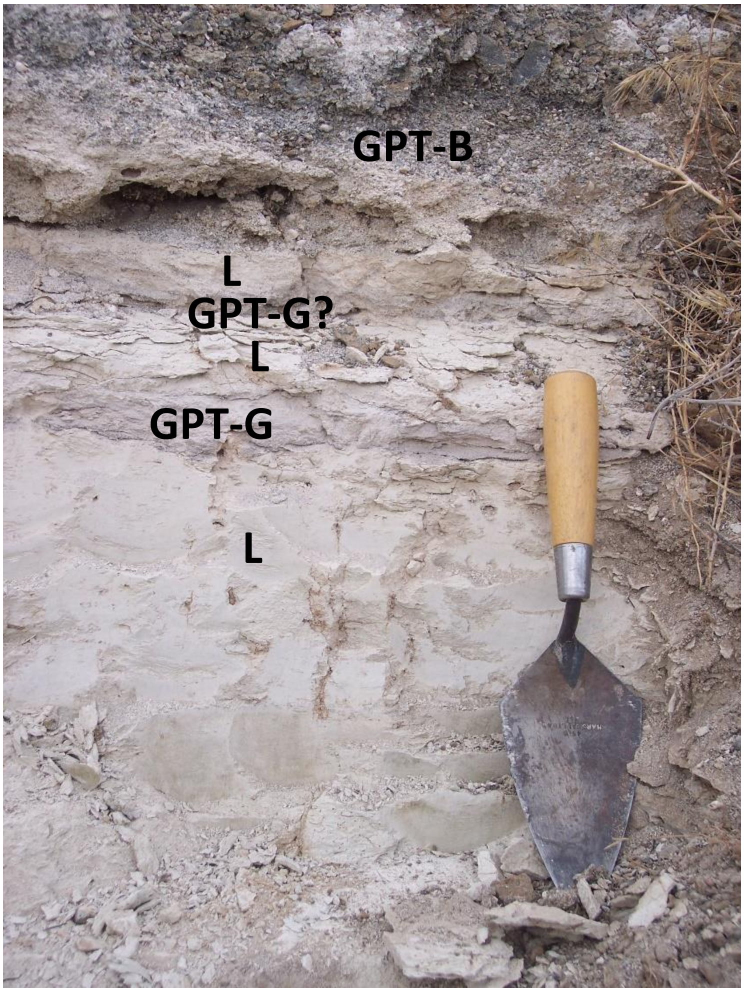

Figure 15. Close-up view of Pleistocene lake sediments (L) and Glacier Peak tephra layer G (GPT-G) at Stop 3. Note lake sediments and Glacier Peak tephra lapilli layer B (GPT-B) near the top of the section. Molluscs are present in the lake sediments. Author photo.

Figure 16. Close-up view of molluscs in Pleistocene lake sediments at Stop 3 outcrop.

Stop 3—Between Lenore & Alkali Lakes

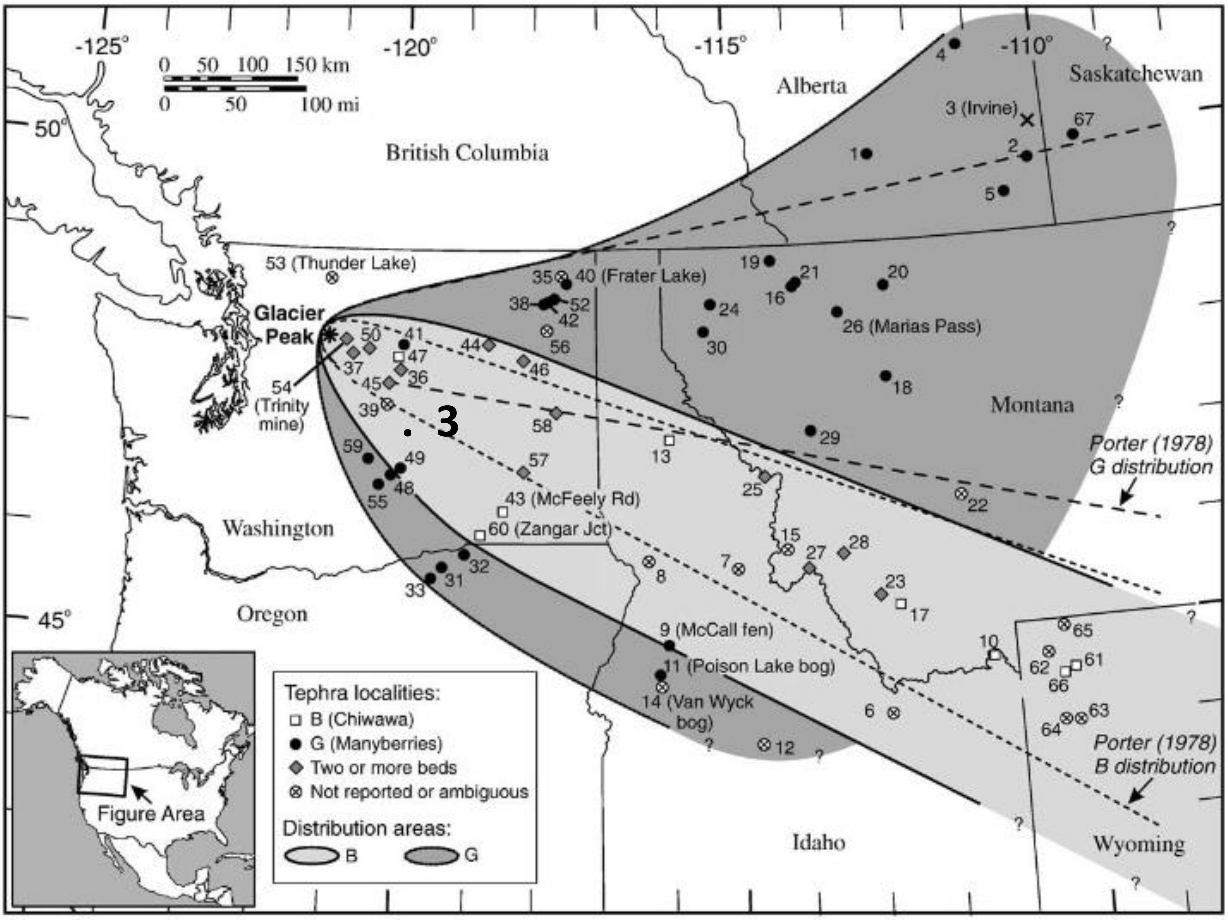

Figure 17. Distribution of the B and G layers of Glacier Peak tephra in western North America. Numbers represent different sites throughout region. Bold 3 indicates approximate location of Stop 3. From Kuehn and others (2009).

From Here: Continue upcoulee on WA 17 past Dry Falls to the junction of WA 17 and US 2. Turn east (right) onto US 2 and follow this to Coulee City. Turn north (left) into the City Park. Total driving distance is about 13.5 miles. Restrooms are available here. We will meet on the northernmost part of the park where camping and picnicking is permitted at 47°37'9.75"N and 119°17'35.48"W.

Stop 4—Coulee City Park

Location: From our parking spot at the north end of Coulee City Park, we have a great view of the Upper Grand Coulee and Banks Lake.

Upper Grand Coulee: The Upper Grand Coulee formed from the headward recession of a giant waterfall that formed over the Coulee Monocline just north of present-day Coulee City (Bretz, 1932; Bretz and others, 1956; Bretz, 1969). The source of the water in the waterfall was an Okanogan Lobe-diverted Columbia River as well as floodwater from numerous outbreaks of Glacial Lake Missoula in northwestern Montana/northern Idaho. This cataract receded about 25 miles, ultimately breaching the Columbia River Valley.

Banks Lake: Banks Lake is a reservoir in the Upper Grand Coulee impounded here by the South Dam as well as the North Dam on its north end. Water filling the lake is pumped up from the Columbia River (impounded as Lake Roosevelt). Banks Lake water is then released via the Main Canal (just west of here in the South Dam) to flow south providing the irrigation water for the 670,000 acre Columbia Basin Irrigation Project focused on the Quincy Basin, Royal Slope, and Pasco Basin.

Coulee City: Coulee City is a town that owes its origins and continued existence to water, agriculture, the U.S. government, and transportation. The town formed here because of the presence of McEntee Springs. Since 1952, Banks Lake has been a source of recreation, hence tourism dollars for the town. The town has long served as an agricultural center and is the nearest railhead for area farmers. Coulee City was initially located at the junction of a trail that travelled the length of the Upper Grand Coulee and one leg of the Caribou Trail that ascended the Coulee Monocline onto the Waterville Plateau to the west (Anglin, 1995). During construction of Grand Coulee Dam, it was a rail junction for a line that ran north to the town of Grand Coulee. More recently, it lies near the junctions of US 2, WA 17, and WA 155.

Coulee City Expansion Bar: An abrupt escarpment parallels US 2 and then WA 155 before the highway enters the Upper Grand Coulee. This escarpment is not in basalt; rather, it is the eroded edge of a large expansion bar that occupies the Hartline Basin (Figure 18). The escarpment indicates that larger floods created the bar and subsequent smaller floods eroded the edge of the bar. The expansion bar formed as large floods exited the confines of the Upper Grand Coulee, lost velocity, and deposited their coarse textured load. This 300 foot tall (extending to 1850 feet elevation) expansion bar once may have spread from the Hartline Basin west to the west wall of the Upper Grand Coulee, helping impound the south arm of Glacial Lake Columbia (Bjornstad and Kiver, 2012; Waitt and others, 2021). The remnants of this bar are primarily confined to the Hartline Basin. Because of the coarse nature of the bar sediments, much of the bar land is not suitable for dryland farming; rather, crops require irrigation on these coarse textured parent materials.

Stop 4—Coulee City Park

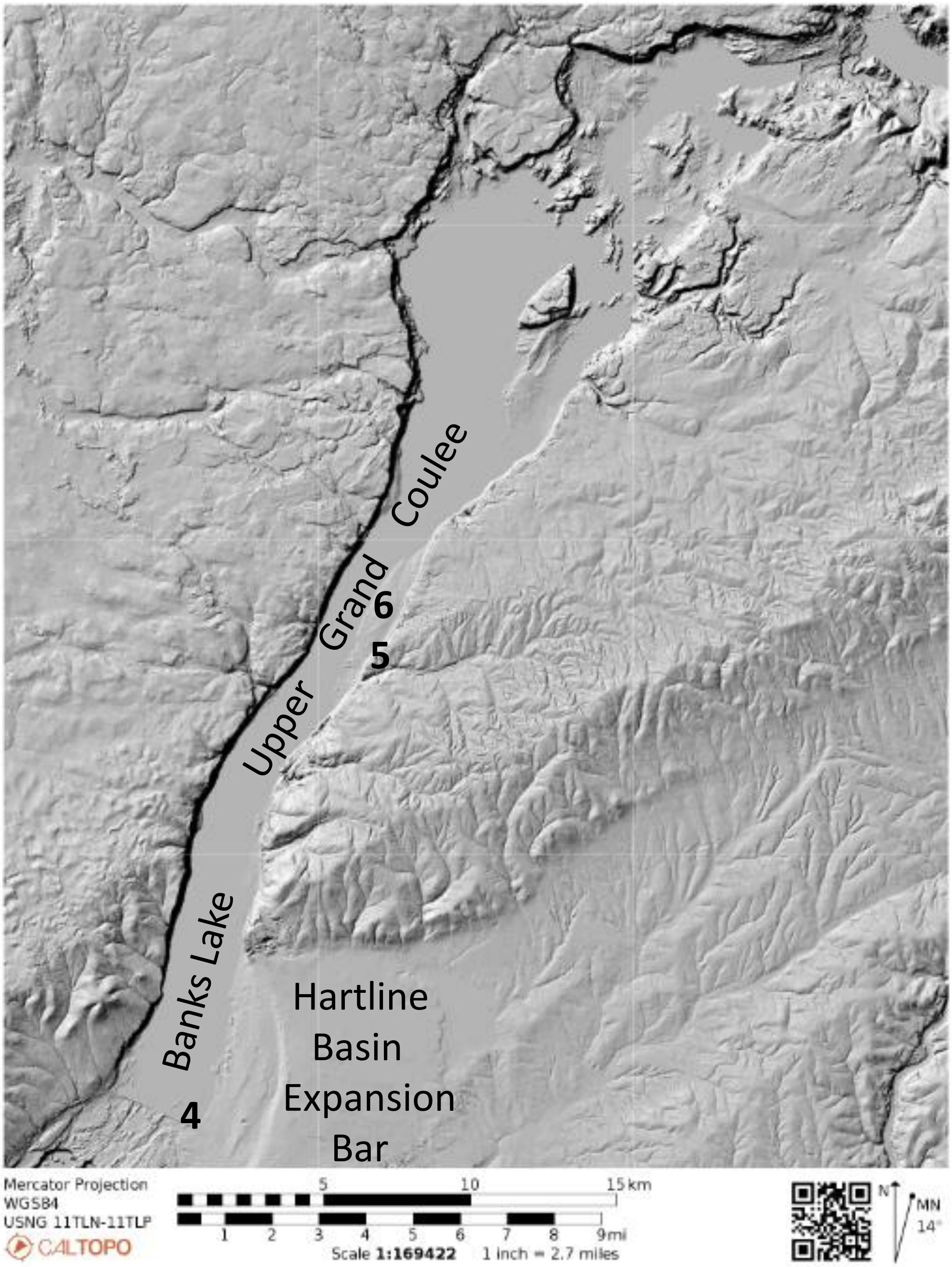

Figure 18. Shaded-relief image of Upper Grand Coulee. Bold numbers indicate field trip stops. Source: Caltopo.com.

Stop 4—Coulee City Park

Glacial Lake Columbia: This “river/lake” formed because the Okanogan Lobe of the Cordilleran Icesheet blocked the Columbia River Valley resulting in a large lake that, at times, extended upstream to near the mouth of the Spokane River. As the water rose behind the ice dam, it eventually overtopped low saddles to flow to the south. Prior to the incision and opening of the Upper Grand Coulee into the Columbia River Valley, outlets for Glacial Lake Columbia included Foster Creek and Moses Coulee to the west, and the Cheney and Crab Creek/Telford scabland tracts to the east (Waitt, 2021). Much of the erosion that occurred in these various scabland tracts occurred with the passage of large floods from Glacial Lake Missoula. Once the Upper Grand Coulee was “open” to the Columbia River Valley by early in the last glaciation, the Columbia River (as Glacial Lake Columbia) extended into the coulee. This has been termed a “lake or very sluggish river” (Bretz, 1932; Atwater, 1987) that was flowing slowly through the Upper Grand Coulee, over Dry Falls and down the Lower Grand Coulee to the Quincy Basin. The “open” Upper Grand Coulee also became the lowest pathway for Missoula Floods.

Spatial Extent: The Upper Grand Coulee version of Glacial Lake Columbia could extend up to at least 1540-1545 ft elevation. This is the elevation of the bedrock threshold at Coulee City (Figure 19). This threshold may have been higher if the Hartline Basin expansion bar extended across the coulee (Bjornstad and Kiver, 2012) and/or because of the bulge in Earth’s crust near Coulee City caused by isostatic depression associated with the Okanogan Lobe in the Upper Grand Coulee.

From here: Return to US 2. Drive east, then briefly north on US to its junction with WA 155. Continue north on WA 155 paralleling Banks Lake into the Upper Grand Coulee. Total mileage from the Coulee City Park entrance to the north end of the Million Dollar Mile is about 10 miles. Park in the large wide spot on the west (left) side of the highway at 47°44'32.58"N and119°13'54.85"W.

Stop 4—Coulee City Park

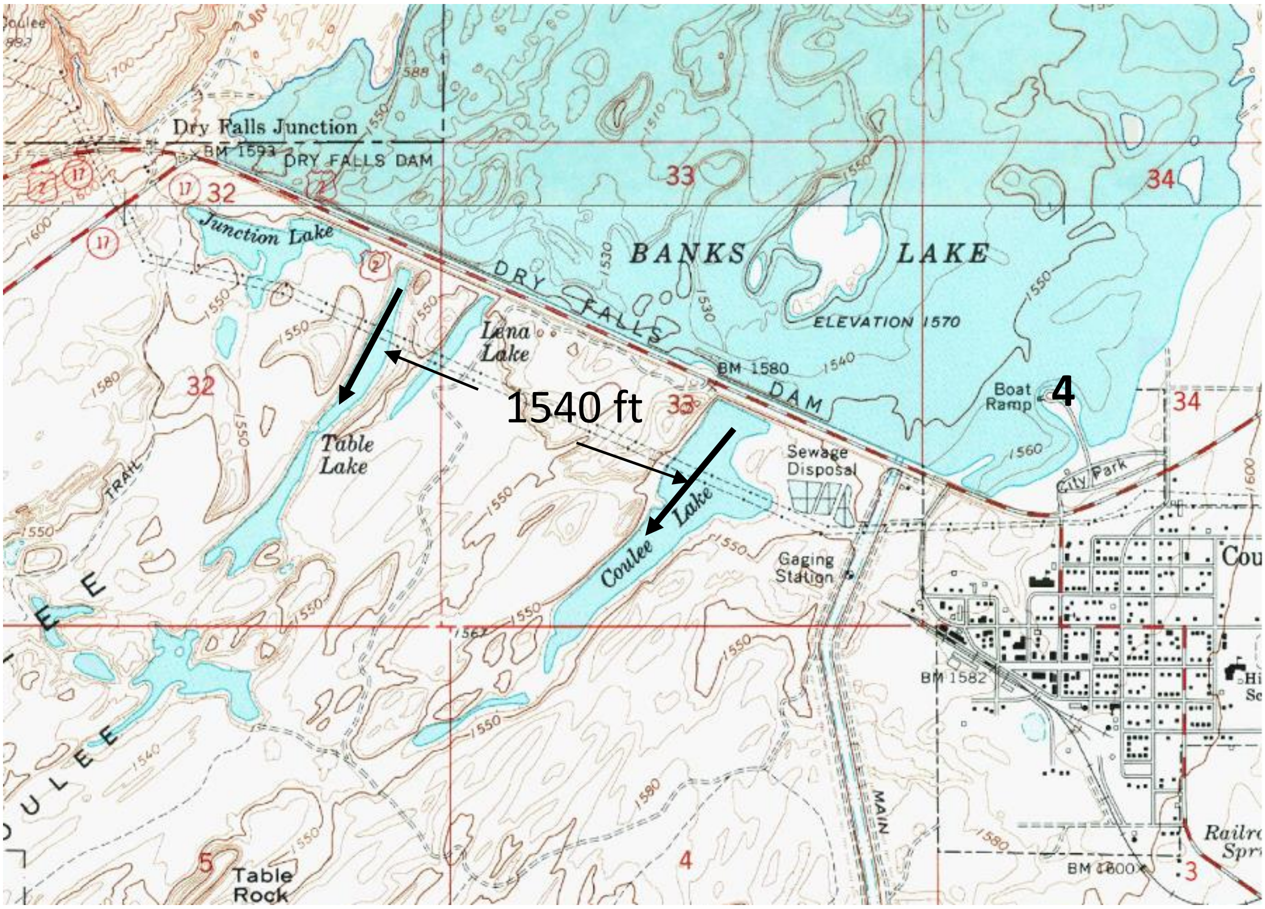

Figure 19. The ~1545' elevation threshold of Glacial Lake Columbia near present-day Coulee City. Above that elevation, water from that river/lake would have flowed southwest (see arrows) into the Lower Grand Coulee, just off map. Source: Caltopo.com.

Stop 5—Upper Grand Coulee Viewpoint

Location: We are parked on the north end of the Million Dollar Mile, a roadcut through the basalts that reportedly cost a million dollars to excavate in the late 1940's/early 1950's. This is one of the most spectacular highway viewpoints in the Upper Grand Coulee (Figure 20).

Glacial Lake Columbia Evidence: Sediment and landform evidence of Glacial Lake Columbia is present in the Upper Grand Coulee. Sediment evidence consists of rhythmites, either in the form of varves or as quiet water lake beds alternating with high energy flood beds. Sedimentary evidence of Glacial Lake Columbia will be our focus at our final stop. Evidence of floods intermingled with Glacial Lake Columbia deposits can be found in the lee of Steamboat Rock.

Landform evidence of Glacial Lake Columbia includes: 1) multiple, parallel channels eroded in soft glacial lake sediments; and 2) fan deltas that formed at the mouths of streams that once were tributary to Glacial Lake Columbia. We can see these multiple parallel channels on the contemporary Google Earth image (Figure 21) but even better on the pre-Banks Lake image (Figure 22). Glacial lake sediments are easily eroded often resulting in multiple, parallel channels, especially on uniform slopes. Pardee (1918) named the thinly bedded, fine-textured, pale-colored sediments in north central Washington the Nespelum Silt. Bretz (1932) and Flint (1935) first identified these and others in the Upper Grand Coulee as paleolake sediments.

We assume that the fan deltas upcoulee of us (Figure 23A) were constructed at the highest level of Glacial Lake Columbia. The top of the Horse Coulee fan delta surface (Figure 23B) is at about 1660 ft while top of the Foster Coulee fan delta surface (Figure 23C) lies at about 1670 ft. Recall that the highest level of Glacial Lake Columbia at Coulee City was about 1540 ft. How can such a discrepancy exist? The answer likely lies in isostatic deformation in which the removal of the Okanogan Lobe from the Upper Grand Coulee has resulted in rebound of Earth's Crust approximately 130 ft in 19 miles (about 7 feet of rebound/mile). This value is less than, but in the ballpark with, that reported for the Puget Lobe (Thorsen, 1989).

From Here: Continue north for about 1 mile on WA 155 to a gravel road that leads to a Washington Department of Fish and Wildlife boat launch. Take this road and park in the parking lot. You will need a Discover Pass or a WDFW Vehicle Access Pass (free of charge to those who purchase WA fishing or hunting licenses) to park here. GPS coordinates: 47°45'20.47"N & 119°13'26.96"W.

Stop 5—Upper Grand Coulee Viewpoint

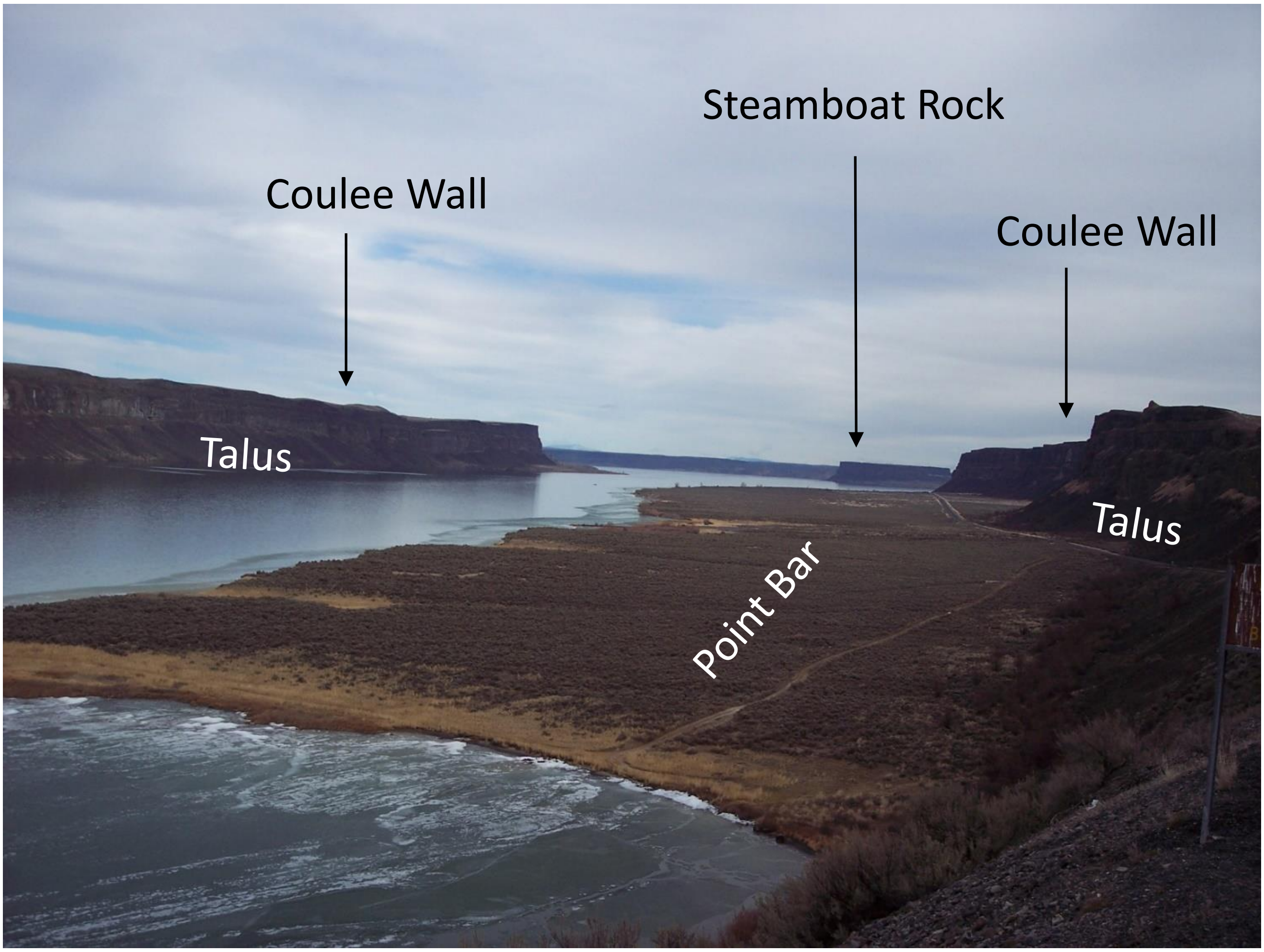

Figure 20. View from the northern end of the Million Dollar Mile northward in the Upper Grand Coulee. Note the abrupt coulee walls, extensive talus deposits, and arge point bar on which Payne's Gulch is situated. Note Steamboat Rock in the distance. Source: author photo.

Stop 5—Upper Grand Coulee Viewpoint

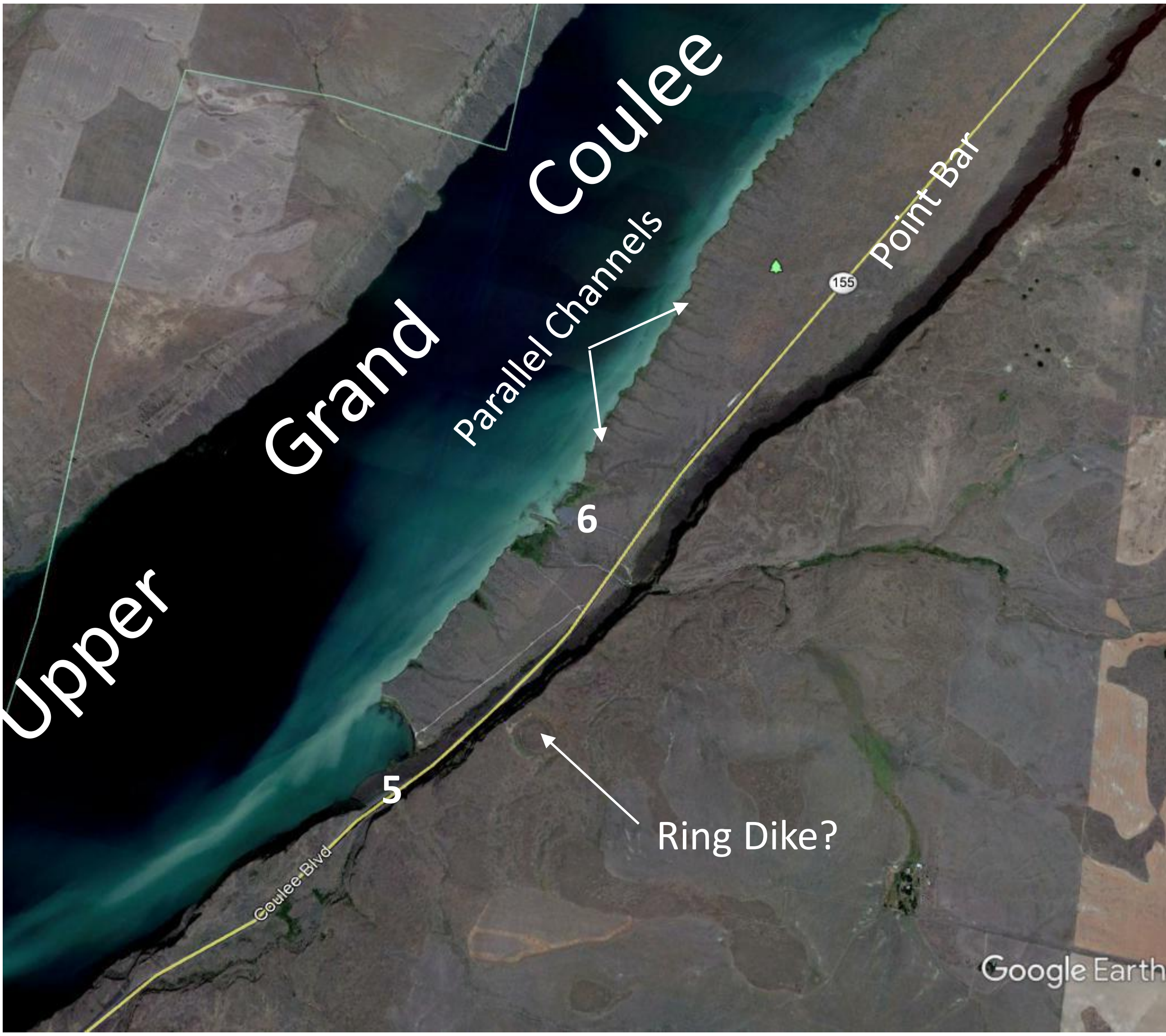

Figure 21. 2021 overhead view of central portion of the Upper Grand Coulee including the north end of the Million Dollar Mile and Payne Gulch. Note the large point (or crescent) bar on which the Payne Gulch (6) sits. Also, note the numerous parallel channels eroded in the Banks Lake edge of the point bar. Source: Google Earth Pro.

Stop 5—Upper Grand Coulee Viewpoint

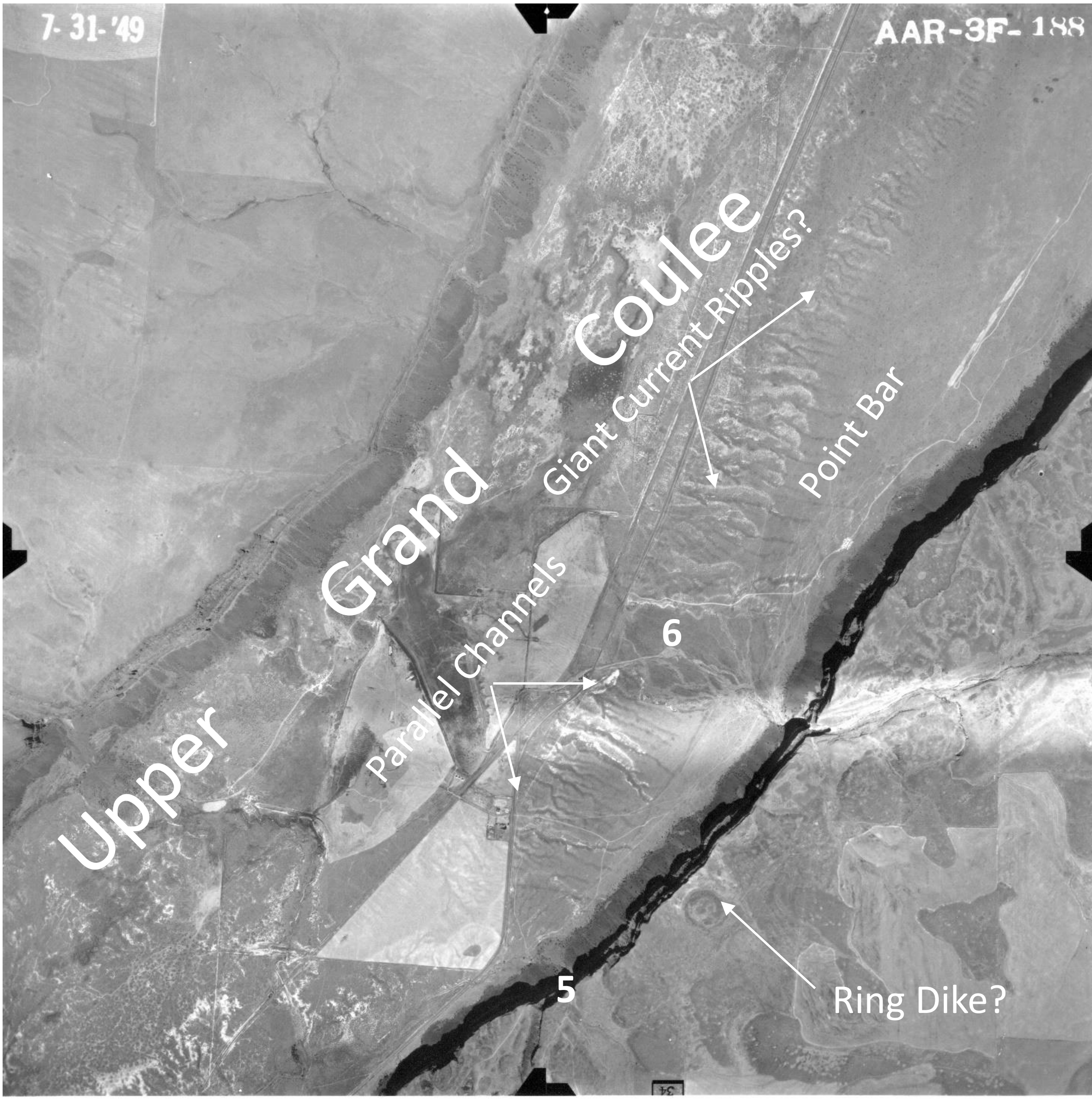

Figure 22. 1949 overhead view of central portion of the Upper Grand Coulee including the north end of the Million Dollar Mile (5) and Payne Gulch (6). Note the large point (or crescent) bar on which the Payne Gulch sits. Also, note the numerous parallel channels eroded in the Banks Lake edge of the pointl bar. These channels indicate the presence of easily eroded glacial lake sediments on the coulee floor. Also note the possible giant current ripples present on the point bar indicating flood flow. Source: Photo number AAR-3F-188, Grant County, 1949, Central Washington Historical Aerial Photograph Project.

Stop 5—Upper Grand Coulee Viewpoint

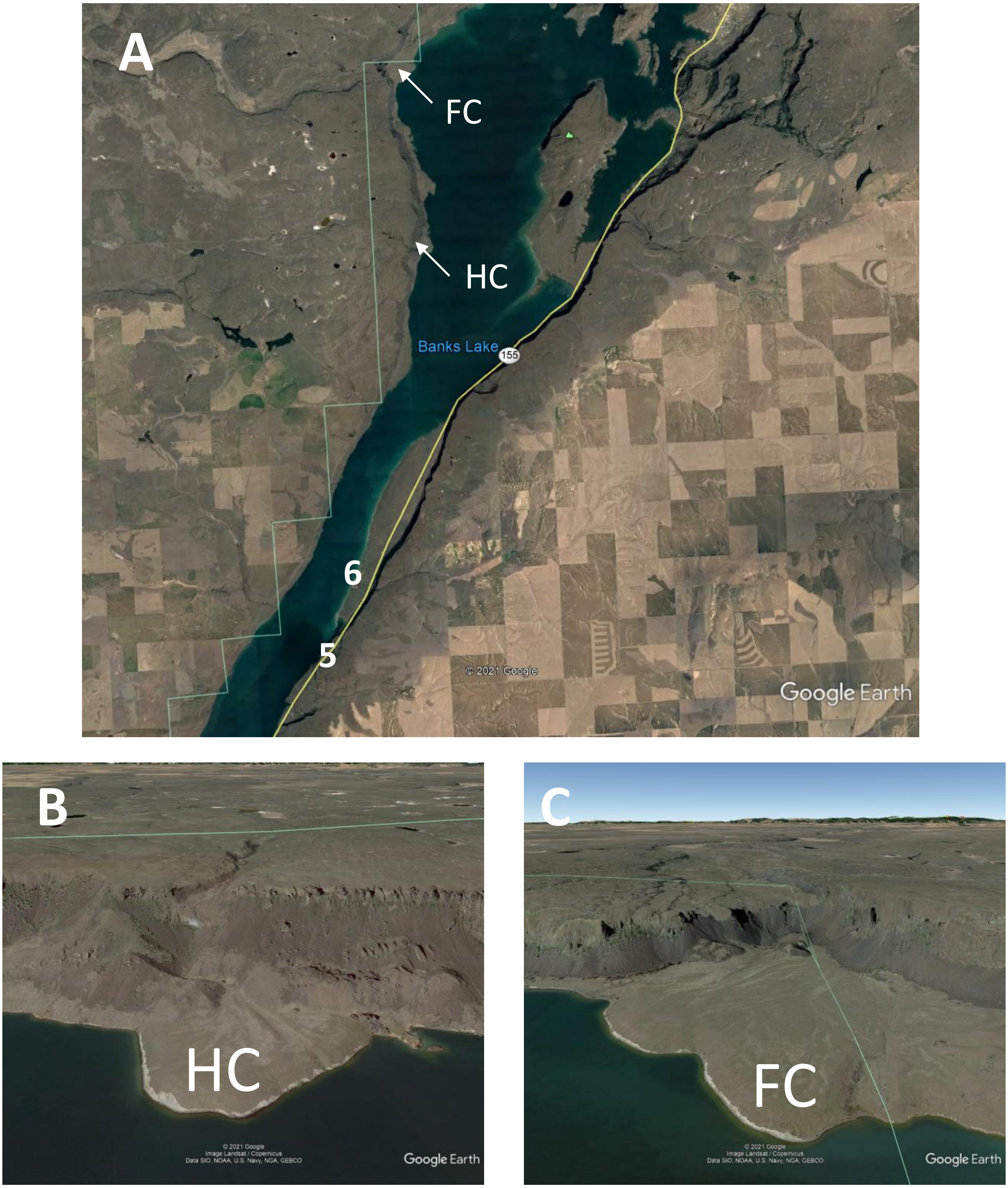

Figure 23. Landform evidence of Glacial Lake Columbia in Upper Grand Coulee. Fan deltas built into Glacial Lake Columbia at the mouths of Horse Coulee (A & B) (top elevation 1160 ft) and Foster Coulee (A & C) (top elevation 1670 ft). Source: Google Earth Pro.

Stop 6—Paynes Gulch

Location: From the large parking lot, we will walk a short distance north on the edge of a wetland, then cut down to lake's edge to the sediment exposure. This is Brian Atwater's Paynes Gulch field site (1986, 1987).

Paynes Gulch Exposure: Approximately 18 feet of sediment is exposed here (Figure 24). This exposure is actively retreating because of undercutting caused by wave action, especially at high levels of Banks Lake. The lowermost sediments are boulders and cobbles associated with the underlying point bar deposited by earlier Missoula floods (Figure 24) These coarse sediments are only exposed at low lake levels like those encountered in late summer and fall.

As in the Lower Grand Coulee, paleolake sediments here are generally fine textured and thinly bedded (Figures 25 & 26). Rhythmic changes in color and texture indicate that most of the beds are varves. Ripple-laminated, basal very fine sands are overlain by silts and clays. The sands indicate downcoulee currents, perhaps associated with outflow from Glacial Lake Columbia (Atwater, 1987) to the Lower Grand Coulee. Approximately 180 varves are present here (Atwater, 1987) which, when combined with the lack of evidence of catastrophic flooding, indicates that the Okanogan Lobe remained in place and Glacial Lake Columbia existed for at least 180 years after the last Glacial Lake Missoula flood came through the Grand Coulee.

Hard, irregularly shaped pieces of fine-textured sediment are common on this beach (Figure 28) and on other Glacial Lake Columbia beaches. While I have not seen them in the Lower Grand Coulee Pleistocene lake deposits, they are present with the Glacial Lake Foster sediments on the Waterville Plateau. How do they form? Precipitation of carbonate minerals? Compaction? No molluscs have been identified in Glacial Lake Columbia sediments here. This may be a result of water that is too turbid to support life. No Glacier Peak tephra has been found in Upper Grand Coulee's Glacial Lake Columbia sediments.

A soil has formed atop the Glacial Lake Columbia sediments and loess of the exposure (Figure 29). This moderately developed soil (A-Bw-Bk horizons) supports a late Pleistocene age for the lake sediments.

Demise of Glacial Lake Columbia: As noted above, Glacial Lake Columbia existed at least 180 years after the last Missoula Flood passed through the Upper Grand Coulee. The lake existed until the Okanogan Lobe retreated northward, once again opening the Columbia River Valley for flow. When??? Age of large flood down Columbia?

Stop 6—Paynes Gulch

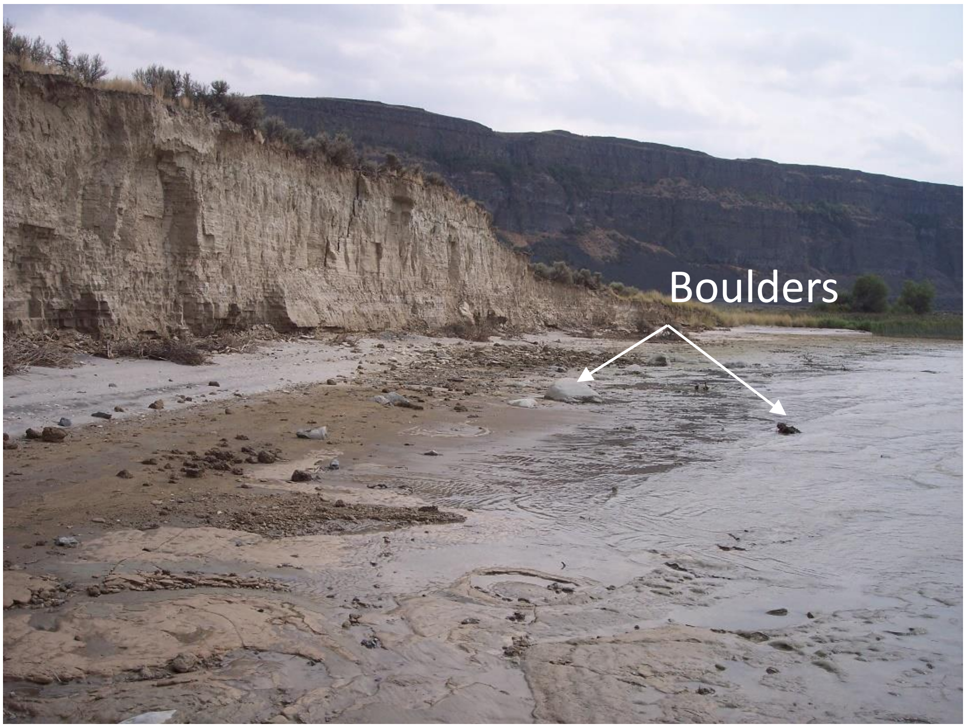

Figure 24. Paynes Gulch exposure. Note the boulders of the underlying point bar. Source: author, August 2021.

Figure 25. Varves exposed at Paynes Gulch. Source: author, April 2014.

Stop 6—Paynes Gulch

Figure 26. Close-up of individual varves exposed at Paynes Gulch, each of which indicates one year of deposition. Source: author photo, April 2014.

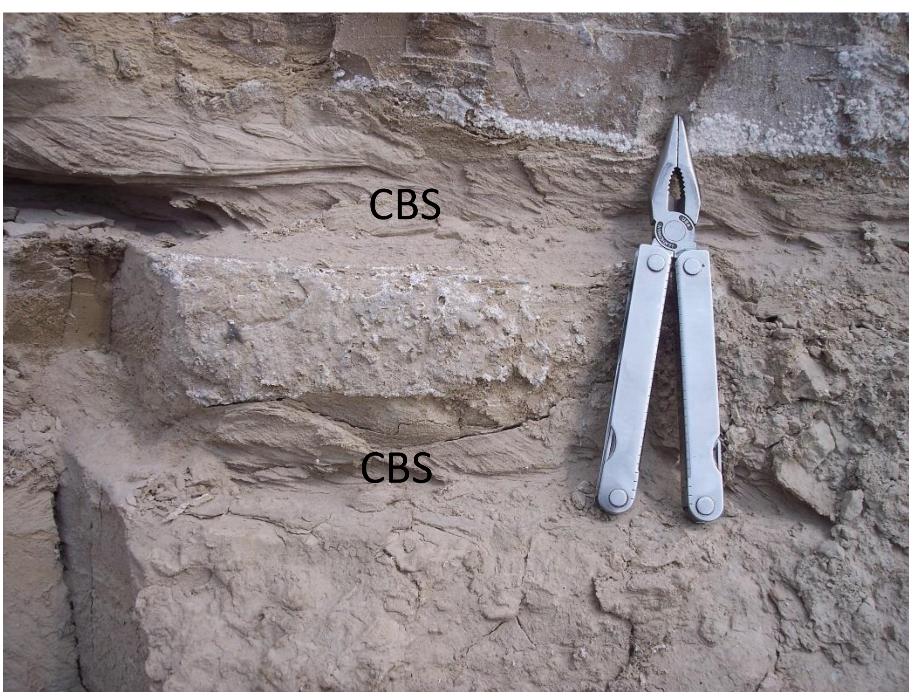

Figure 27. Closeup of individual varves, Paynes Gulch. Note the cross-bedded sands (CBS) representing flow in the river lake during summer months. Source: Author photo, August 2021.

Stop 6—Paynes Gulch

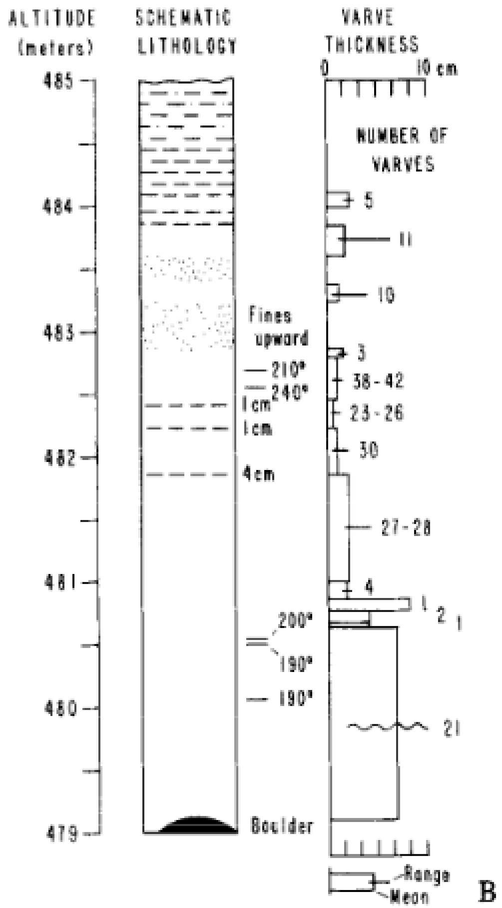

Figure 28. Numbers, thickness, and texture of varves. From Atwater (1987).

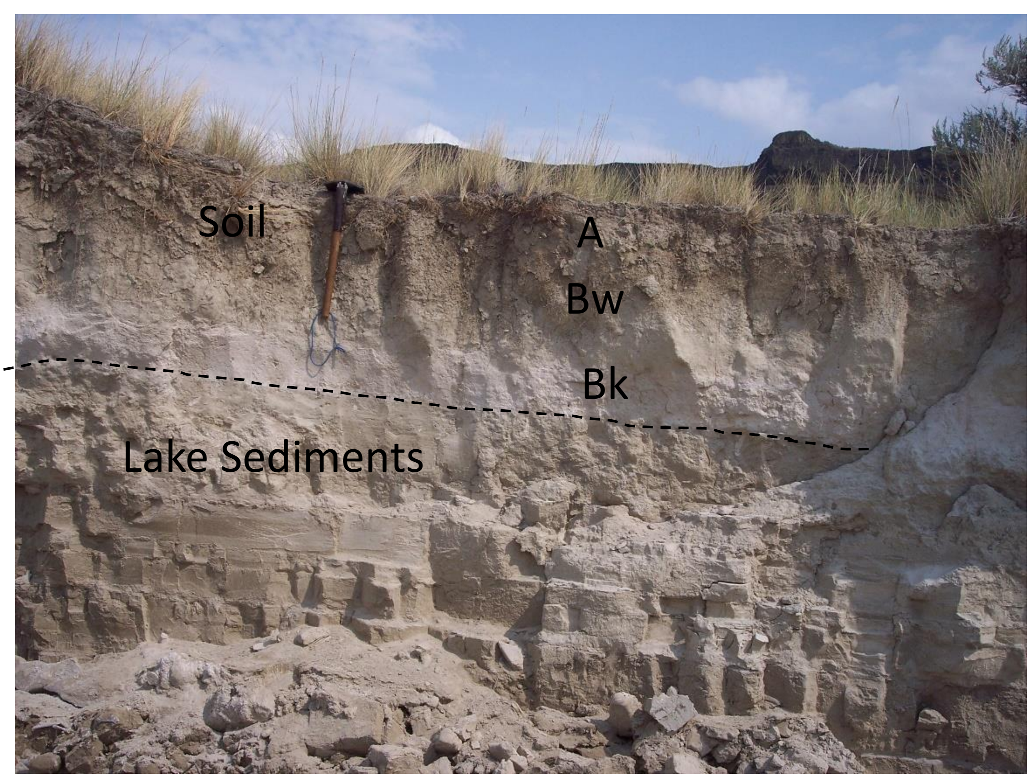

Figure 29. Soil formed in loess? and Glacial Lake Columbia sediments. Source: author photo, August 2021.

Wrap-up
A Grand Coulee Chronology
(summarized from various sources)

- Advance Of Okanogan Lobe to north of present-day Brewster
  - 1st Missoula Floods pass through Columbia River Valley
- Advance of Okanogan Lobe to vicinity of present-day Brewster
  - Formation of Glacial Lake Columbia
  - Diversion of Columbia River & Missoula Floods through Foster Creek and down Moses Coulee
- Advance of Okanogan Lobe to vicinity of Grand Coulee Dam
  - Diversion of Columbia River & Missoula Floods through Foster Creek & Horse Coulee, and down Moses Coulee
  - Diversion of Columbia River and Missoula Floods down "Coulee Creek"
  - Headward recession of "Coulee Falls" to north of Steamboat Rock & formation of Upper Grand Coulee
  - Diversion of Columbia River & Missoula Floods down Northrup Canyon and into Upper Grand Coulee
  - Further recession of Upper Grand Coulee to Columbia River Valley
  - Diversion of Columbia River & Missoula Floods down entire Upper Grand Coulee
- Advance of Okanogan Lobe into much of Upper Grand Coulee
  - Advance of Okanogan Lobe into much of Upper Grand Coulee
- Retreat of Okanogan Lobe to near head of Upper Grand Coulee
  - Recession of Okanogan Lobe to near head of Upper Grand Coulee
  - Occupation of Upper Grand Coulee by Glacial Lake Columbia
  - Passage of several Missoula Floods through Glacial Lake Columbia in Upper Grand Coulee
- Retreat of Okanogan Lobe from Columbia River Valley
  - Passage of 1 large flood down Columbia River Valley
  - Desiccation of Glacial Lake Columbia
  - Formation of numerous small saline lakes in upper & lower Grand Coulee
- Creation of Banks Lake with diverted Columbia River water in 1952

Wrap-up

The physical geography and geology of the lower and Upper Grand Coulees have been studied for more than a century. We know that the coulees have been shaped by normal Columbia River flows, huge Missoula Floods, ice age lakes, wind, and now human activity. As you have seen today, we continue to learn and have questions about this landscape. This is true of the glacial lakes that occupied the lower and upper Grand Coulees.

Thanks for supporting the activities of the Ellensburg Chapter of the Ice Age Floods Institute. I hope you have enjoyed your time with us today. If you have questions or comments about his field trip feel free to contact me at lillquis@cwu.edu or (509) 963-1184. Hope to see you on our next trip!

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