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Ice Age Floods in the Cheney Area Field Trip Guide

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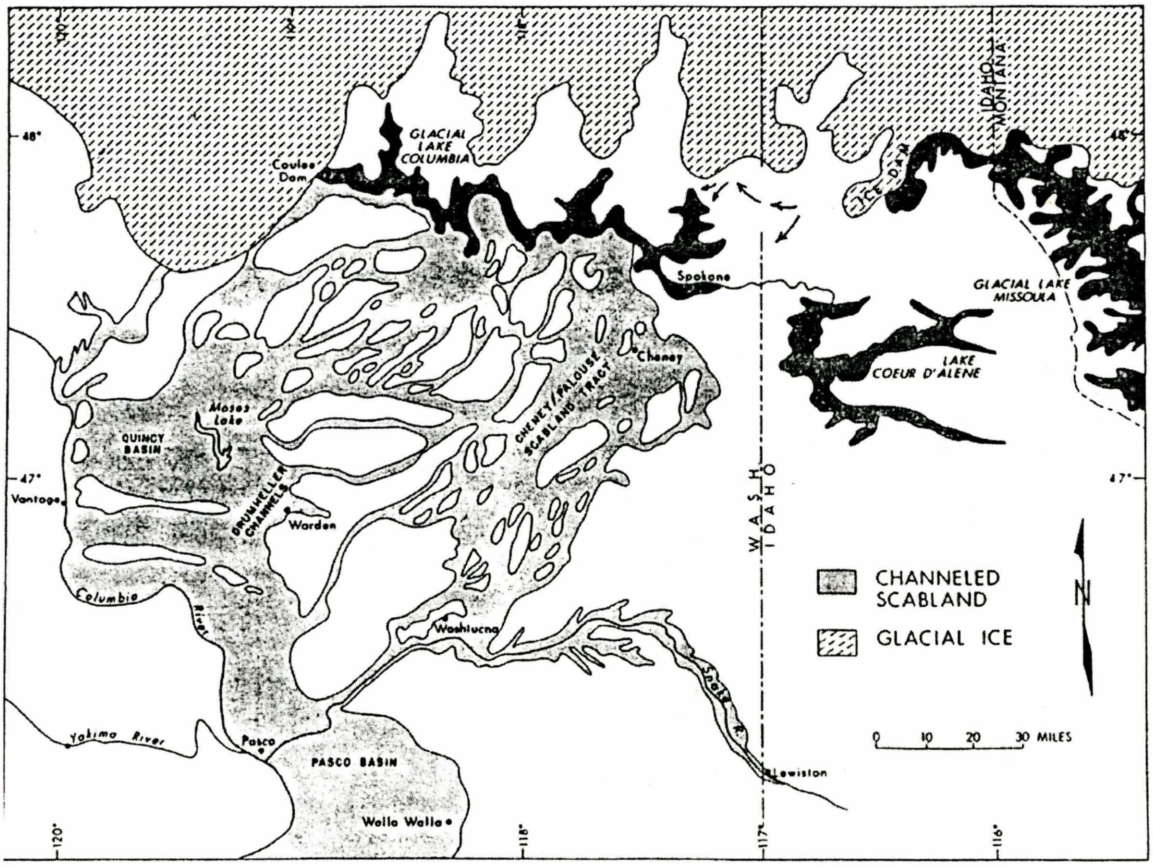
ICE AGE FLOODS IN THE CHENEY AREA

FIELD TRIP GUIDE



May 22, 2004

Eugene Kiver and Dale Stradling, Field Trip Leaders

First Annual Field Trip

Cheney-Palouse Chapter of the Ice Age Floods Institute

INTRODUCTION.

This short guide was developed for the first field trip sponsored by the Cheney-Palouse Chapter of the Ice Age Floods Institute (IAFI). The field trip celebrates the establishment of the first chapter to be established in the Inland Empire. The IAFI and its chapters are dedicated to telling the story of the incredible floods that shaped the topography and lives of humans in the four-state area of the Pacific Northwest. One of the main goals is to make the story more accessible to the general public by encouraging the establishment of a National Geologic Trail administered by the National Park Service. The story of the world's largest well-documented flood is known throughout the scientific world by researchers, academicians, and their students but often remains a "secret" story to most of the general public. Congressional action is needed if this geologic gem is to receive the recognition appropriate for a world-class example of the power of geologic forces.

The field trip begins at the top of the hill with the watertower on the Eastern Washington University (EWU) campus (Parking Lot P 12) in Cheney. The field trip route leads through selected sites in the northern Cheney-Palouse Scabland Tract (Fig. 1) where the erosional and depositonal effects of the catastrophic Missoula Floods can be observed (Fig. 2). An extension of the Cordilleran ice sheet in the Purcell Trench of northern Idaho dammed the mouth of the Clark Fork River in the Lake Pend Oreille area and impounded over 500 cubic miles of water to form Glacial Lake Missoula. The repeated catastrophic release of this lake by ice-dam failure sent enormous flows of water mostly down the Rathdrum Prairie to the Spokane Valley and beyond. The flow of as much as 9.5 CUBIC MILES of water per hour quickly overwhelmed the drainage systems and sent water spilling out of the Spokane Valley and overland through the Cheney-Palouse scabland tract and other areas on the Columbia Plateau (see title page for map of flood path). These were reoccurring events and resulted in dozens of floods about 15,000 to 12,800 radiocarbon years ago during the most recent glaciation.

STOP 1. CHENEY-EWU WATER TOWER. Free all-day parking is permitted in Lot P 12 just below the water tower (off Washington Street) on the EWU campus. The view from the top of the hill (2535 feet; 773 m) is superb! Metamorphosed Precambrian and Paleozoic rocks as well as Mesozoic plutonic rocks exposed in the mountain tops of the Rocky Mountains form the higher hills to the north. Voluminous flows of Columbia River Basalt buried mountaintops and lapped onto the edges of some of higher mountains and hills like those to the north (Fig. 3). Some lava flows surrounded individual peaks to form geologic features called Steptoes. On a clear day the type example of such a

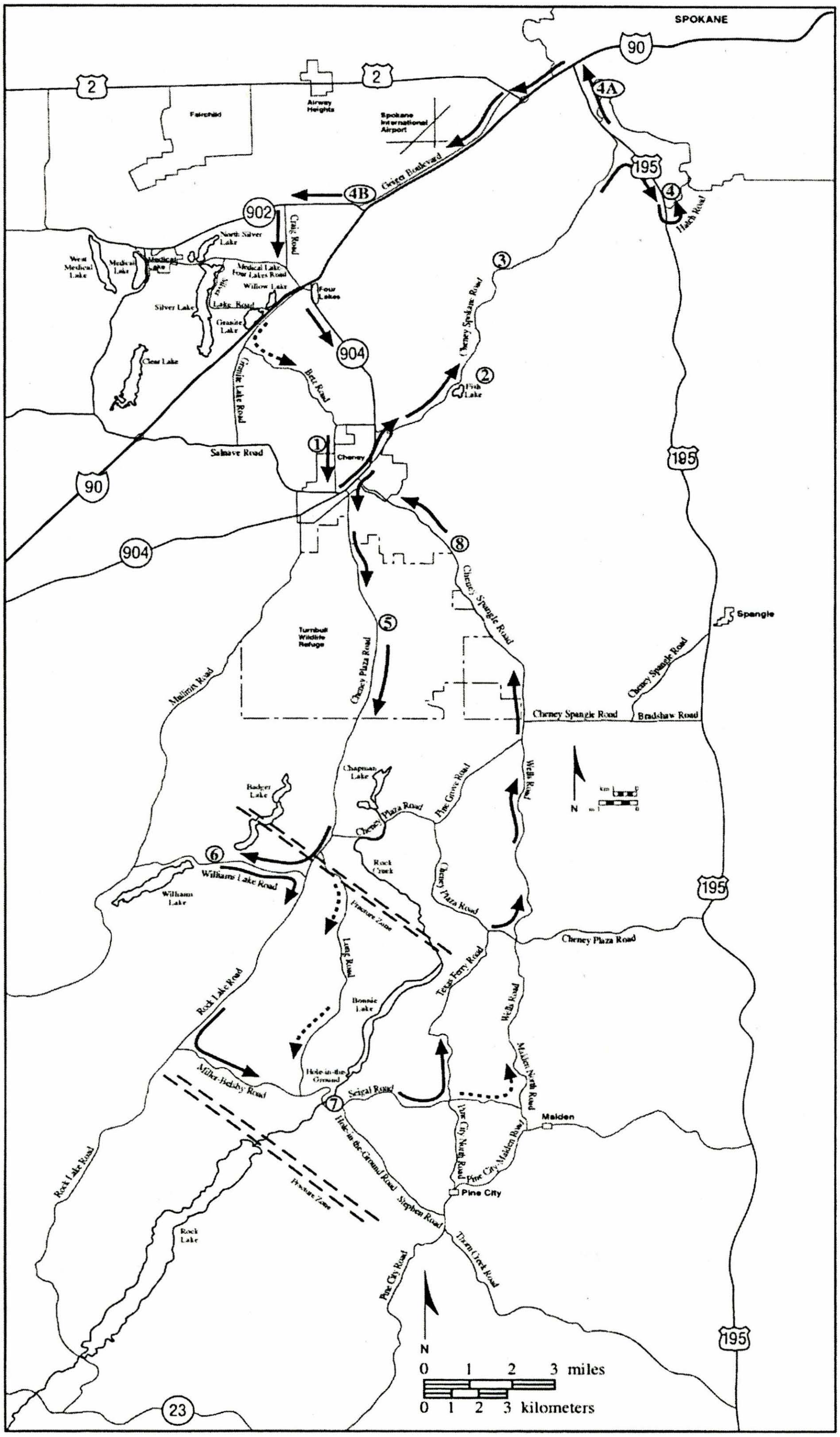


Figure 1. Fieldtrip route and locations of stops. Alternative routes are shown by dashed line.

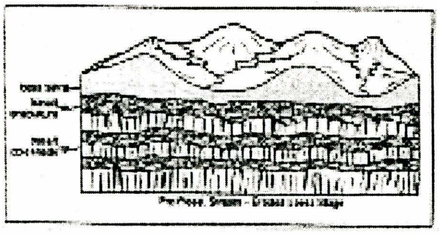


Fig.2B. Loess topography stage

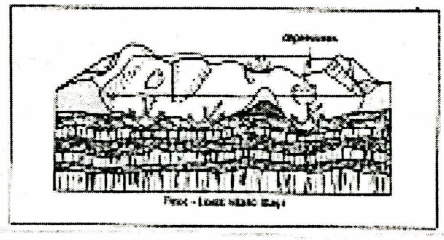


Fig. 2B. Loess island stage

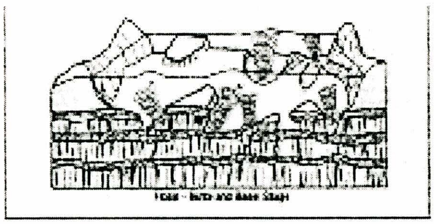


Fig. 2C. Butte and basin stage

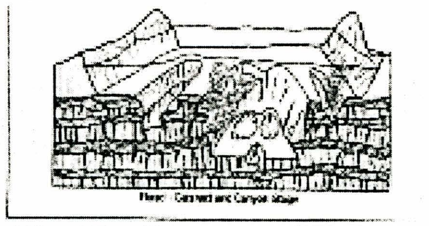


Fig. 2D. Cataract and canyon stage

FIGURE 2. Landscapes in the channeled scabland area. After Baker, 1987.

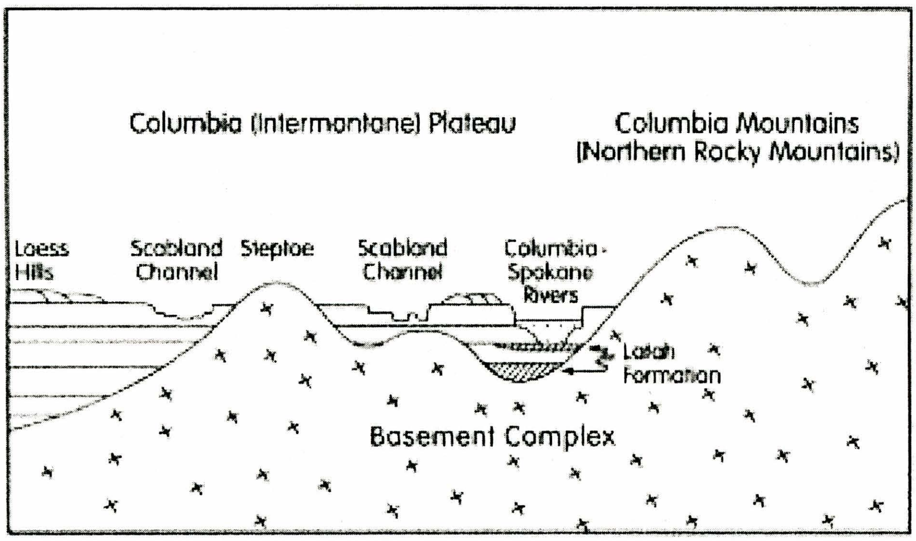


FIGURE 3. Generalized cross section showing stratigraphic relations of geologic units in the Cheney-Spokane area.

On a clear day the type example of such a feature, Steptoe Butte, can be seen 35 miles (56 km) to the southeast. Topping the bedrock are the wind-deposited silts (Palouse Formation) called loess.

The thick loess cover is mostly gone in the Cheney townsite area due to its removal by floods of almost unbelievable magnitude. What remains is one to four feet (0.3 to 1.1 m) of post-flood loess except where even that has been eroded away. The water tower site is on the east edge of a 3- by 7-mile (4.8-11.3-km) long loess island that was partly protected from erosion by Wrights Hill, a steptoe near the town of Four Lakes. The Cheney loess island is one of the largest in the Channeled Scabland.

Flood waters exiting the Spokane Valley and flowing southward on the West Spokane Plains spilled through a series of low areas in the long steptoe-like ridge that extends from Mica Peak in the Spokane Valley to Fancher Butte and Booth Hill west of Medical Lake (Fig. 4). Flood waters roaring through the spillover locations reunited to form this segment of the Cheney-Palouse Scabland Tract. The Tract here is 23 miles (37 km) wide. South of the spillover locations and south of the Cheney Palouse island floodwaters reunited forming a monstrous deluge roaring towards the Tri-Cities area. The water tower site is located near the head of the Cheney-Palouse Scabland Tract, the major spillway route for Missoula floods through eastern Washington. The 130-mile (km-long) massive scabland system begins where Missoula floodwater spilled around the southwest wall of the Spokane Valley and extends southwestward through Cheney and into the Tri-Cities area in southern Washington.

Missoula floodwaters roared through the water gap near Four Lakes and joined waters pouring southward from the Fish Lake channel. Local deposits of coarse sand and gravel were left in semi-protected sites where the transporting power of the cataclysmic floods was reduced. Some of these deposits have distinct morphologies and are referred to as flood bars (Fig. 5). For example, the downtown area of Cheney is located on a shoulder bar.

The forested area to the south of Cheney contains Turnbull National Wildlife Refuge and other areas inundated by over 220 feet (67 m) of Missoula floodwater. The scabland to the west of the Cheney loess island in the Medical Lake area flood channels is barely visible over the loess topography.

DIRECTIONS TO STOP #2. Turn left on Washington Street and follow the road past the SR 904 traffic light to the Cheney-Spokane road. Turn left on the Cheney-Spokane road and proceed north to the Fish Lake Trailhead of Columbia Plateau State Park. Park at the trailhead (a daily parking fee or an annual state park permit is required).

The field trip route from the water tower leads across the eastern edge of the Cheney loess island, crosses the Four Lakes-Cheney flood channel, and then continues on to the Fish Lake channel. We are heading up stream here against the approaching wall of floodwater! Erosion is partly controlled by topographic features and topography is often controlled by bedrock weaknesses including faults, joints, and other rock features. Such

FIGURE 4. DEM image showing part of the West Spokane plains and the spillways through the steptoes.

features are more easily eroded and often are expressed as straight or curvilinear valley segments and other topographic alignments called lineaments. The Minnie Creek drainage leading from Cheney to Fish Lake (azimuth 37^{0}) and eventually to the pre-flood channel of Latah Creek follows such a lineament and may reflect an underlying bedrock fracture or fractures. A similar lineament and flood channel extends from Four Lakes to Cheney (azimuth 330^{0}) with the two lineaments intersecting on the northeast side of Cheney. Distance to next stop: 5 miles, 8 km.

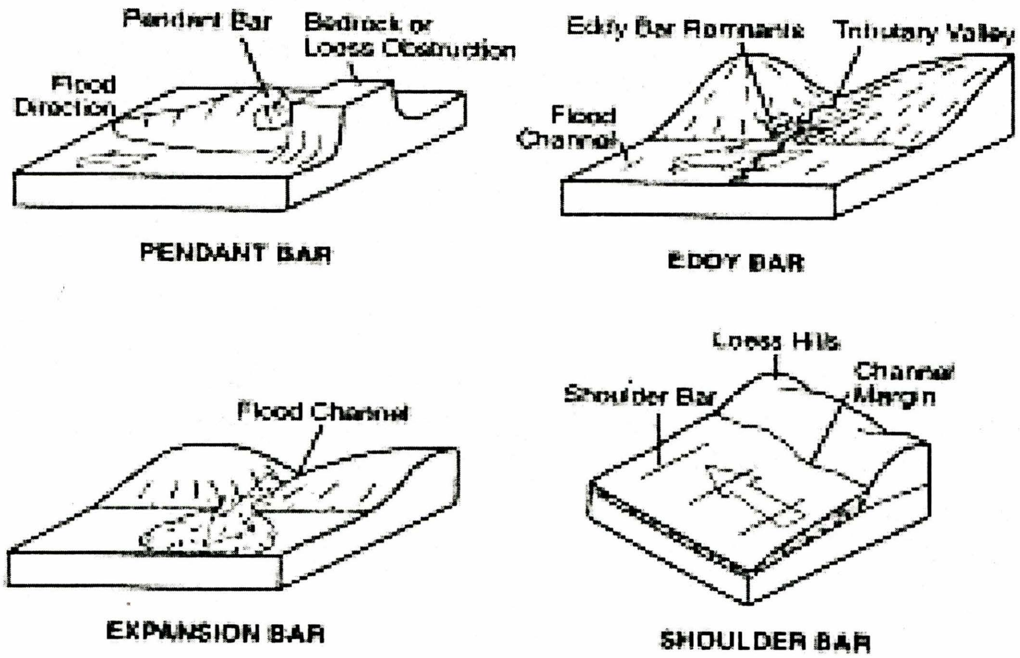


FIGURE 5. COMMON TYPES OF FLOOD BARS. After Kiver and Stradling, 2001

STOP 2. FISH LAKE COUNTY PARK AND COLUMBIA PLATEAU TRAIL STATE PARK TRAILHEAD. The rails-to-trails project here has enabled Washington State Parks (as of 2004) to develop a 23.6-mile (km) section of trail from Fish Lake to Martin Road near the town of Sprague. With proper funding, the remainder of the 130-mile-long (km-long) trail will be developed for public recreation in the future (Fig. 5). The Trail will terminate at Ice Harbor Dam on the Snake River but will likely be extended to the Tri-Cities area.

Construction of the Spokane Portland and Seattle (SP&S) railroad was begun in 1912 under the direction of the railroad magnate, James J. Hill ("The Empire Builder"). The SP&S connected to the Northern Pacific tracks along the Snake River and thence continued through the Columbia Gorge. The southern route provided a quicker, more reliable, and safer route through the Cascade Mountains. The route from Spokane to the Tri-Cities follows closely in places the historic Mullan Military Road that was completed in 1862 by Lieutenant John Mullan. The Mullan Road opened up a large part of the eastern Columbia Plateau to settlement. The SP&S route was technically superior to the Cascade Mountain route. However it was closed in 1987 by the Burlington Northern directors back east who only saw duplication in multiple routes and a lack of commerce along the southern route. The right-of-way was rail banked and placed under the

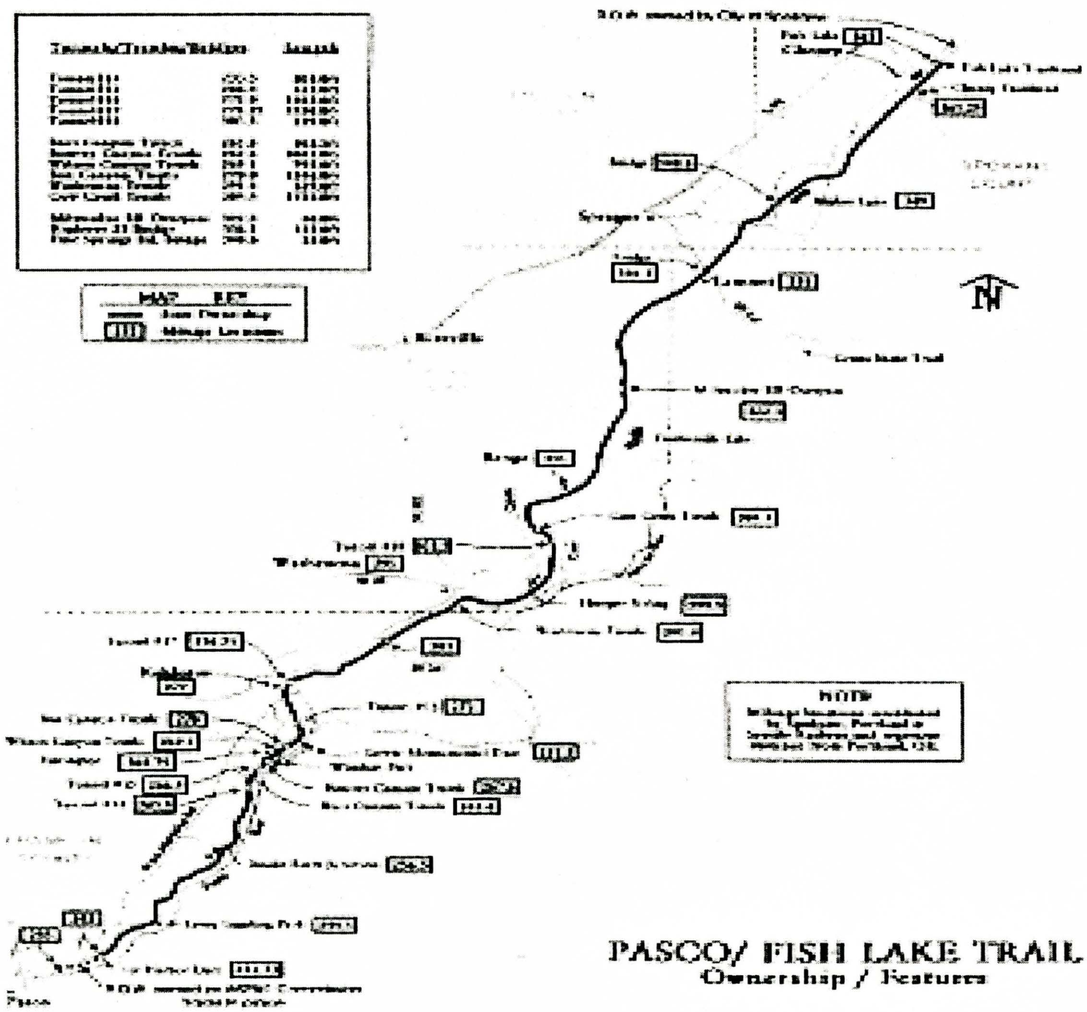


FIGURE 6. MAP OF THE COLUMBIA PLATEAU TRAIL STATE PARK.

jurisdiction of Washington State Parks. When funding becomes available, the entire 130-mile (km) route will be easily accessible to hikers, bikers, and equestrians. Connection to the nearby Centennial Trail in Spokane and with the planned cross-state trail system will make this region a Mecca for bicycle enthusiasts.

The Columbia Plateau Trail follows directly through the northwest end of Turnbull National Wildlife Refuge and into the heart of the Cheney-Palouse Scabland. The Trail provides exciting opportunities for those wishing to "follow the floods" through a poorly known and inadequately studied area of eastern Washington. The route is virtually an "outdoor museum" of flood and other geologic features. In addition, the gradation from forest to steppe to desert vegetation as well as abundant wildlife throughout the Trail's length are also major attractions. The route passes through one of the most sparsely settled parts of Washington State.

The relationship of older bedrock to the overlying Columbia River Basalt and flood erosion is well displayed at this site. The ridge of older rock that extends from Mica Peak in the Spokane Valley to Fancher Butte and Booth Hill west of Medical Lake is part of the Northern Rocky Mountains. These late Precambrian (Belt Rock) and early Paleozoic metamorphic rocks are exposed near the trailhead and across the lake in the tall Steptoe hills. This ridge and its continuation to the west form the southern end of the "West Spokane Plains". Converging of Missoula floodwaters through lower parts of the ridge excavated the spillways. Initially, a number of spectacular waterfalls were generated. Cataract retreat and downcutting created elongate plunge pool lakes that are called "spillover lakes" (Kiver and Stradling, 2001). Cataract recession produces some of the most spectacular topographic features in the Channeled Scabland (Fig. 2d). In the early stages of development a dryfalls probably existed at these spillover locations. However, later floods destroyed these landforms leaving only elongated lake basins like that at Fish Lake. Plunge pool remnants exist today in the depths of Fish, Silver, and Clear Lakes. The Fish Lake double plunge pool is best described a few hundred yards down the trail. The lake consists of two pools separated by a shallow ridge that forms an island when water levels are low. Lake elevation is 2171 feet (662 m) and the pools are each 48 feet (15 m) deep.

The high steptoe peak (Prosser Hill) across the lake has a small plunge-pool lake in a gap between its double peak. This lake and its associated flood-eroded topography indicate an upper flood level of about 2600 feet (793 m), 330 feet (100 m) above the level of Fish Lake! Thus flood waters here were almost 400 feet (m) deep. Distance to next stop is 4 miles (6.4 km).

DIRECTIONS TO STOP 3. Return to Cheney-Spokane Road, turn right (north) and proceed northeast along the Cheney-Latah Creek lineament (azimuth 37^0) to the large Key Rock gravel pit near the present site of the town of Marshall. The route follows along lower Minnie Creek, an underfit stream that occupies the upper Cheney-Latah Creek lineament to Marshall along the Fish Lake flood channel. Missoula floodwater near today's location of the town of Marshall poured over the west wall of the Fish Lake valley from the West Spokane Plains. Angular bends in the Fish Lake channel near Marshall produced conditions conducive to the deposition of very coarse sand and gravel. This huge shoulder bar complex was formerly used as a landfill further south and currently has two operating sand and gravel pits.

STOP 3. KEY ROCK SAND AND GRAVEL PIT. The exposures here are continually changing as the pit is enlarged. However, the east-edge exposures usually show the typical tall, dipping beds deposited on the edge of a bar that builds out into a deeper channel. The edge beds of the bar here are mostly sand that dips in long foreset beds as steeply as 22^0 to the southeast (azimuth 165^0). The layers flatten out and become horizontal towards the valley side as exposed in the central part of the gravel pit.

Sediment size increases to cobble size in the center of the bar where currents were extremely strong. However, rare foreset beds dipping upcurrent (north) suggest that there were local eddy currents during deposition. Flood energy varied greatly with time and location during a single flood producing sediment layers ranging from coarse gravel in the initial phase to sand and silt during the waning phase. At least three high-energy flood gravel layers separated locally by prominent thin-bedded, fine-grained sand layers record at least three separate floods here. A cut-and-fill structure exposed on top of the high pit walls contains flood gravels and planar layers of sand and perhaps silt.

High-energy gravel layers often show high-angle crossbedding and are matrix-poor indicating rapid deposition. Lower energy planar-stratified sands with occasional pebble and cobble clasts occur along the flanks in the steeply dipping foresets. A layer of Mount St. Helens "S" ash was discovered in the late 1970s by Kiver and Stradling in similar deposits where the Castle Materials pit is currently operating. Two or three flood layers above the ash indicate that at least that number of floods occurred after 13,000 radiocarbon years ago. Distance to Stop 4 is 6 miles (10 km).

DIRECTIONS TO STOP 4. Proceed north on the Cheney-Spokane Road and turn right on Qualchan Road. Turn south (right) on SR 195 and make a U-turn by Hatch Road. Move quickly to the right-hand lane and turn right into Campion Park by the big boulders at the entrance.

At the town of Marshall by the Key Rock Pit the northeast trending Cheney-Latah Creek lineament (azimuth is 37^0) is intersected by the east and then northwest-trending upper Marshall Creek lineament (azimuth 330^0). The upper Marshall Creek lineament terminates at the junction of the two valleys. The bending and widening of the valley here at the lineament intersection influenced the location of the Key Rock flood bar. The Marshall Creek lineament parallels the prominent Latah Creek lineament five miles to the east. Movement probably associated with the Latah Creek lineament on June 25, 2001 is believed to account for a series of shallow temblors with magnitudes as great as 4.0, The Spokane Earthquake was strongly felt in the downtown Spokane area. Likely, a mosaic of mostly inactive basement faults underlies the Spokane-Cheney area.

The route from Marshall then follows the lower end of the Cheney-Latah Creek (azimuth is 37^0) lineament to the northeast where it ends at the larger Latah Creek lineament. Latah (Hangman) Creek valley was both a main conduit for a significant volume of south-flowing Missoula floodwater towards the town of Spangle and also provided a slackwater environment for deposition of finer sediments during smaller floods or the waning phases of a larger flood. Glacial Lake Columbia and perhaps Glacial Lake Spokane sediments also occur in the Latah Creek valley.

STOP 4. CAMPION PARK, HEYER POINT DEVELOPMENT LANDSLIDE. The Department of Natural Resources established Campion Park in 1966 as an aquatic land enhancement. Major stream modifications during establishment of the present location of SR 195 pushed Latah Creek against the right wall of Latah Creek forming an undercut bank and setting up conditions that would contribute to the subsequent slope failures.

Exposed here and elsewhere along Latah Creek is a complex stratigraphy of Ice Age flood sand and gravel and lake beds. Prior to the two 50-year floods of 1996 and 1997 the bare bluffs across the stream were forested similar to the slope immediately downstream. Latah Creek (Hangman Creek on U.S. Geological Survey maps) rapidly undercut the far bank and triggered significant downslope movements. In a later year, perched irrigation water derived from the development behind accumulated slightly above the mid-slope causing even more movements to occur. There has been an attempt to stabilize the lower slope by placing large boulders (riprap) along the stream edge. Large logs were placed in front of the riprap during the fall of 2003 to further attempt to stabilize the steep slope behind. Upslope irrigation causing slope retreat is still a major problem as two smaller movements occurred during the winter of 2003-2004.

The sediments exposed in the large trough to the north (left) side are considered to be a slump feature based on analysis of the sediment units according to Meyer and others (1999). An unpublished study of the secular magnetic variation in the sediments supports the slump hypothesis (Roy Breckenridge, written communication April 2004). An alternate explanation would be that trough filling by fine lacustrine sediments and sandy flood deposits accounts for the feature. Both explanations require that an interval of erosion occurred following the deposition of the lower beds, a conclusion that is supported by other evidence in the Latah Creek valley.

The sediments below the trough were radiocarbon dated as 32,450+/-830 to greater than 40,000 years and are considered to be pre late Wisconsin (Wisconsin refers to the last glaciation in North America) by Meyers and others (1999). The 32,000 year date seems anomalous in consideration of what is known about the glacial chronology elsewhere. The upper sediments are considered to be late Wisconsin shallow-lacustrine (lake) and outburst-flood deposits capped by graded slackwater sediments that resemble the Touchet Beds of southeastern Washington (Meyer and others, 1999, p. 24). Evidence described a little more than two miles to the north along Latah Creek and Qualchan Golf Course (Kiver and Stradling, 1980; Rigby 1982; and Waitt, 1984) also records two episodes of deposition separated by an erosional interval but both units there are likely to be late Wisconsin. The lower units at Stop 4a are sublacustrine flood and lake rhythmites and the upper subaerially deposits are flood gravels. This latter site will be looked at as a "rolling stop" (Stop 4A) after leaving Campion Park.

As glaciers retreated at the end of the Wisconsin, the level of glacial Lake Columbia lowered. Lower base levels initiated down cutting by the Columbia River and its tributaries including the Spokane River. Latah Creek in turn partially excavated its thick sedimentary fill exposing the valley wall sediments. Downcutting along the upper Spokane River was arrested by the resistant ridge of basalt that forms the lip of Spokane Falls. Distance from Stop 3 to Stop 4A is 2 miles (3.2 km), rolling stop 4B is 13 miles (21 km), and Stop 5 is 30 miles (48 km).

DIRECTIONS TO ROLLING STOPS 4A AND 4B. Follow SR 195 north past Rolling Stop 4A to 16th Avenue, the next road past the well-marked Thorpe Road intersection. Turn left and follow the road over the I-90 overpass to the traffic light on Sunset Boulevard. Turn left towards the top of Sunset Hill and veer left onto Geiger Boulevard towards Rolling Stop 4B.

ROLLING STOP 4A. The undercut cliff by Qualchan Golf Course contains evidence for two episodes of flooding and 15 or more separate floods separated by tens of years of non-flooding. A Mazama ash layer (6700 radiocarbon years old) is evident in the partially filled stream channel that is cut into the Ice Age (Pleistocene) sediments on the north end of the undercut bank. The channel and the ash are of course younger than the surrounding sediments and post-date the last flood. This important locality is where conclusive evidence that over a dozen floods separated by a few decades of non-flooding was first established (Stradling and others, 1980; Rigby 1982; Waitt, 1984, 1985). Based on the thickness of the rhythmites, here and elsewhere later floods tended to be smaller (Atwater,1986; Waitt, 1984).

After leaving Rolling Stop 4A the route climbs Sunset Hill out of the Spokane Valley and onto the Columbia Plateau. Missoula floodwaters spilled violently out of the Spokane Valley here and created a butte and basin topography (Fig. 2). The intense scouring at the spillover was lessened as spreading water quickly lost momentum and some tens of feet of flood gravels and sands were dumped onto the scoured bedrock (mostly basalt) surface of the West Plains. Where energy levels and other conditions were appropriate giant current dunes (giant ripple marks, megaripples) were formed in abundance on the West Plains. The giant current dunes along Geiger Boulevard begin south of the Waste-to-Energy Plant. Rolling stop 4B will be made in the giant current dune field.

ROLLING STOP 4B. GIANT CURRENT DUNE FIELD ON "AIRPORT SURFACE". The bus will slow down here to observe a road cut in the megaripples formed by late Ice

Age floods. The flood gravels here are reversely graded with a large cobble concentration in the upper 18 inches (59 cm), which in turn is underlain by smaller size gravel with a matrix of sand and granules. A thin cover of less than12 inches (40 cm) of loess occurs here. Giant current dunes are common on the West Spokane Plains where flood velocity and water depth as well as the availability of sand and gravel were conducive to their development. Kiver and Stradling (2001) estimate that the giant current dune complex covers over 10,000 acres on the West Spokane Plains and is the largest dune field along the Missoula Flood path. Many giant current dune areas on the Columbia Plateau and in the Markle Pass area of Montana contain taller ripples with longer wavelengths but do not cover such an extensive area. The ripples strike perpendicular to the direction of water flow. Immediately to the southwest the water again becomes more erosive where it converges between the buttes in the spillover locations. Distance to Stop 5 from Stop 4 is 30 miles, (48 km).

Locally on the West Spokane Plains the Mount St. Helens "S" ash (13,000 radiocarbon years old) occurs about one meter below the surface. The ash was deposited between floods and is sometimes found as a discrete layer and also as ash clasts. The clasts of ash were likely scoured from a frozen layer by the succeeding flood or floods. Ash clasts and similar but larger clasts of loess were often deposited in a frozen condition and are associated with pebble and cobble-size sediments (Stradling and Kiver, 1982).

DIRECTIONS TO STOP 5. After leaving Rolling Stop 4B turn right on Medical Lake Road, left on Craig Road by the large gravel pit, and left on the Medical Lake-Four Lakes Road. Continue to SR 904 and turn right towards Cheney. Go through downtown Cheney and turn left on the Cheney-Plaza road. Watch for signs and turn left towards Turnbull National Wildlife Refuge. Stop at parking area with restrooms for LUNCH!

The route from Rolling Stop 4B continues to follow the flood across the West Spokane Plains with its thin gravel and giant current dune landforms towards the steptoe ridge with the flood-eroded water gaps containing spillover lakes. Near Four Lakes SR 904 leads through the Meadow Lake spillover and follows the Four Lakes-Cheney flood channel. The channel follows the Cheney-Four Lakes lineament (azimuth is 330^0) between the Wrights Hill steptoe to the southwest and the Needham Hill steptoe to the northeast. The fieldtrip route leaves the Cheney shoulder bar after making a left turn onto the Cheney-Plaza Road towards the Refuge. Many gravel pits, roadcuts in flood gravels, and surfaces of flood areas in the northern part of the Cheney-Palouse Tract have cobbles and huge boulders derived from Idaho and/or Montana. How are these heavy objects lifted out of the Spokane Valley and brought up here? This field problem can be examined more thoroughly at Stop 8 this afternoon. Scabland features and basalt outcrops will dominate the scenery for the entire afternoon!

STOP 5. TURNBULL NATIONAL WILDLIFE REFUGE AND LUNCH STOP. The Cheney area is extremely fortunate to have this important area in their "backyard". About 15,600 acres are set aside to protect migratory and resident birds and to help maintain a healthy population of wildlife in the surrounding area. Such areas are increasingly valuable as the human population of Spokane County and other areas continues to increase dramatically. A 5.5 mile-long (8.9 km-long) public access road provides access to a small part of the Refuge to visitors. The Refuge's environmental education program is outstanding and touches thousands of students and others each year. The Refuge is also a key component in maintaining a migration corridor for transient herds of elk and most recently moose.

The Refuge is unique in that it has an unusual abundance of wetlands compared to other scabland areas. Missoula floodwaters exiting the spillover lake channels to the north inundated a 23-mile (37 km) wide surface with over 200 feet (660 m) of water. Flow direction and both erosional and depositional landforms are primarily elongated to the southwest, a consequence of regional slope and perhaps a regional fracture system. Whereas deposition is common north of the spillover lakes and the bedrock ridge of older rock, erosion dominates through this section of the Cheney-Palouse scabland.

Deposition of sediment in the West Plains allowed water flow to become more energetic, turbulent, and consequently erosive where it was forced through the spillways between the buttes that make up the steptoe ridge (Fig. 4). Sufficient erosion has occurred to eliminate higher relief landforms leaving a much reduced butte and basin topography (Fig. 2). Future floods will cause the high cliffs to the south (Stop 6) to migrate northward forming another generation of higher relief landforms. The sequence would likely follow the generation of cataract-canyon forms followed by removal of remaining loess islands and a lowering of forms to a butte and basin stage. Those forms would eventually be further subdued in relief similar to those found in the Turnbull area.

DIRECTIONS TO STOP 6. Leave Refuge and turn left (south) on the Cheney-Plaza road to the Rock Lake road. Continue straight and turn right onto the Williams Lake road and then right on the Badger Lake Road. Park by the first highway bridge. Distance to Stop 6 is 9 miles (14 km).

The route from Turnbull follows through butte and basin features and is often very close to the location of the 1862 Mullan Military Road, the first road through this part of the Washington Territory. Near the intersection of Rock Lake Road and Chapman Lake Road the road crosses the mile-wide (1.6 kilometer-wide) Damage Creek-Buckeye Creek fracture zone (azimuth is 300^0, an impressive northwest-southeast trending lineament in basalt that deflected a substantial part of the floodwater southeastward towards the

Bonnie Lake-Rock Lake lineament (azimuth is 40^0). Note the groups of low mounds of silt (Mima mounds) that have formed on the basalt and the occasional patch of gray ash deposited during the May 18, 1980 Mount St. Helens eruption. A large loess island west of Williams Lake road marks the local division of floodwater between the Williams Lake channel and the Amber Lake channel.

STOP 6. WILLIAMS LAKE PLUNGE POOL AND DRY FALLS; CAUTION! There is a major vertical drop-off here, please stay a comfortable distance back from the edge. Also, depending on weather conditions, rattlesnakes could be up and about.

The evidence here is one of the "smoking guns" that giant floods must have swept through the Cheney-Palouse landscape. The large dryfalls here is analogous to the famous Dry Falls of the Grand Coulee and formed in a similar manner. Floodwater poured over a pre-existing cliff or ridge near the south end of Williams Lake and formed one or more waterfalls. As the water undercut the bedrock at its head, the falls (nickpoint) migrated upstream leaving high vertical side walls and a closed depression that holds Williams Lake. Another falls migrated upstream to form the Badger Lake basin that begins about 1.5 miles (1.0 km) to the northeast. The plunge pool located at the head of Williams Lake is 115 feet (35 m) deep and the plunge pool at the head of Badger Lake is 105 feet (32 m).

Below the dry falls and just above the Williams Lake road is a marshy area where another plunge-pool remnant is mostly filled in with windblown and organic sediment. The sediment was deposited following the last major flood and contains pollen-rich sediment and volcanic ashes whose time of eruption is known. Nickmann (1979) studied the pollen to help describe the change of vegetation and therefore the changing post-glacial climate. Tephra (airborne volcanic sediment) derived from the eruption of the Glacier Peak Volcano in the North Cascade Mountains fell into a shallow pond here 11,200 radiocarbon years ago. The Glacier Peak ash forms the lowermost deposit in the plunge pool. Thus, based on the ash evidence here and near Stop 3 (Key Rock quarry) the last flood occurred sometime between these two ash falls. The age of the last flood is estimated to be about 12,800 radiocarbon years ago. Distance to Stop 7 is 13 miles (21 km).

DIRECTIONS TO STOP 7. Two ways to Stop 7 are described. The fastest route is to return to Rock Lake Road and turn right (south). Proceed to Miller Road and turn left (east) to Belsby Road. Follow Belsby Road to the bottom of Hole-in-the-Ground and park off the road near the bridge. Another route would turn left on Rock Lake Road and right on Long Road to Belsby Road.

Both routes follow the flood direction through scabland channels flanked by some well-developed loess islands. Miller and Belsby Roads lead across loess islands to the most spectacular canyon system area in the northern Cheney-Palouse Scabland Tract. A number of divide crossings across loess islands (especially along Long road) helps to determine the maximum depth of floodwater here. Water depth was at least 150 feet (46 m) above the Long Lake Road and the top of the high cliffs along Bonnie Lake located about a mile or two to the east of the road.

STOP 7. HOLE-IN-THE-GROUND. The spectacular effects of the wayward floodwater diverted by the Damage Creek-Buckeye Creek lineament discussed earlier are apparent. After that diversion floodwater was again diverted, this time into the southwest-northeast-trending Bonnie Lake-Rock Lake lineament (azimuth is 40^0). Again a series of waterfalls were generated near the south end of Rock Lake and migrated up the fracture zone leaving 300-foot-high (m) side walls. The lower end of Bonnie Lake lies a half-mile to the north and the dry falls at the head of Rock Lake lies 2.6 miles (km) to the southwest. Rock Lake's plunge pool is 320 feet deep (m) making it the deepest natural lake on the Columbia Plateau. Thus flood depth over Hole-in-the-Ground approached 600 feet (183 m) deep and close to 900 feet (274 m) over the bottom of Rock Lake! Water velocities in the main channel likely exceeded 60 mph!

This rugged area is a semi-wilderness area managed by the Belsby family and other ranchers and farmers. The best public access is by boat from the south end of Rock Lake. If so inclined, one can hunt (with the necessary permit from the landowners) the bison and other big game on the Canyon Crest Hunting Ranch. A good view of the 100-head bison herd is often seen along Belsby Road.

An interesting cave-like opening in the southwest wall along an old wagon road is either a steam explosion opening or more likely a lava tree (a tree engulfed by lava and whose shape is preserved as a cavity). One of only four natural arches known in eastern Washington occurs in the canyon to the north. Distance to Stop 8 is about 21 miles (34 km).

DIRECTIONS TO STOP 8. A number of routes to Stop 8 are also possible. The best roads are to follow the Hole-in-the-Ground road eastward to Pine City and/or Malden and take Pine City North or Wells road north to the Cheney-Spangle road.

A more interesting route is possible by taking the left fork at the intersection 1.5 miles (1 km) east of Hole-in-the-Ground. This unmarked dirt road is a continuation of the Belsby Road but should be avoided during wet conditions. Turn right at the intersection with Seigal Road and turn left onto Texas Ferry. Turn right on Cheney Plaza and left on Wells road to Depot Springs road at Stop 8.

The Pine City-Malden route follows the Pine Creek flood channel towards Malden. Floodwaters occupied the Spangle floodway to the northeast when the volume of the

Latah Creek valley was exceeded. Water poured southward towards Spangle and Rosalia near present day SR 195 and westward along Pine Creek into the Hole-in-the-Ground channel. Scabland features including flood bars are locally present in the Pine Creek flood channel.

The Belsby Road route passes near the edge of a spectacular 80-foot-deep (24-meter) elongated kolk depression that is partly obscured by a Ponderosa forest. The route north parallels Bonnie Lake. Excess water spilled out of the Bonnie Lake canyon creating loess islands, divide crossings, and scabland surfaces, especially near the precipitous edge of the Bonnie Lake canyon. Both routes described here climb onto a loess upland along Wells Road and eventually descend into the Cheney-Palouse Scabland Tract. The tall EWU dormitories and other buildings in Cheney are visible to the northwest. Flood water along this southeast edge of the main Cheney-Palouse Scabland Tract flowed south out of Latah Creek to Spangle and then southwesterly. The field trip route traverses across the linear butte and basin topography to Depot Springs and continues towards Cheney.

STOP 8. DEPOT SPRINGS FLOOD BAR. Coarse, poorly-sorted gravel with some large boulders is similar to that ascribed by early workers (including Bretz, 1928 and Flint 1938) to the Cheney-Spangle glacial moraine. Indeed, some near-glacial deposits reworked by meltwater do resemble these sediments. However, the location of these deposits in a definite scabland channel and their location downstream from a small butte with a cataract alcove and small plunge pool indicate that catastrophic flooding was the last event to occur here. However, the possibility does exist that older glacial deposits were present but were subsequently reworked and redeposited by floods. Such a hypothesis would easily explain the erratic boulders up to 9 feet (2.7 m) long that are commonly found in this area, an explanation that does explain similar boulder accumulations along Lake Roosevelt (Kiver and Stradling, 1986, 1995). However, flood mechanisms including rafting by icebergs and powerful currents could also explain the boulders.

END OF FIELD TRIP. Continue north along the Cheney-Spangle Road to Cheney and the P 12 parking lot by the water tower.

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