**The Story of the Great Floods**

During the latter stages of the last ice ages, 18,000 to 12,000 years ago, a large mass of glacial ice blocked the path of the Clark Fork River at the Montana/Idaho border. As the water rose behind this 2,000 foot high, 35 mile wide ice dam, it flooded the valleys of Western Montana. At its greatest extent the resulting lake—Glacial Lake Missoula—stretched east to Drummond, as far south as Darby, and north into the Flathead and Blackfoot river valleys.

Periodically, the dam would fail. The failure was often catastrophic, resulting in a large flood of ice-filled water that would rush down the Columbia River drainage across northern Idaho, eastern Washington, through the Columbia River Gorge, into Oregon’s Willamette Valley, and finally draining into the Pacific Ocean near Astoria, Oregon. The lake at its maximum height and extent contributed more than 500 cubic miles of water to the largest of these floods, more than Lake Erie and Lake Ontario combined, which would drain in just a few days.

**Glacial Lake Missoula High Water Markers**

Since 2010, The Glacial Lake Missoula Chapter of the Ice Age Floods Institute has installed several engraved stone monuments near popular hiking trails and attractions. These monuments are placed at 4200 ft elevation, approximately the high water mark of Glacial Lake Missoula at capacity. To date, you can discover these markers at:

- **Mt. Sentinel** - on Ridge Line Trail above the “M”, (46.8858255, -113.9730790) and on the Pengelly Ridge Trail from the gravel pit trailhead in Pattee Canyon (46.8368780, 113.9771260)
- **Mt. Jumbo** — on the Backbone Trail from the Lincoln Hills Trailhead (46.8885060, -113.9496910) and on the “L” trail above the “L” (46.8740240, -113.9656790)
- **Lake Como** — just east of the swimming area parking (46.0682520, -114.2395420)

**Directions for this tour**

The entire route is about 225 miles following either return option and takes at least 4 hours. From Exit 96 to Stop 3 is about an hour, and from St. Regis to back to Exit 96 is about an hour.

**To use this map on your phone** even where there is no cell phone coverage:

- Download the free app Avenza Maps from the app store
- Download a slightly larger version of this map from http://iafi.org/Missoula-Glacial-Lake-Route/ or find it by using the QR code below, then store it on your phone in Avenza Maps. The blue dot on the map will show at your location.
Stop 1. Glacial Erratic
Location: University of Montana Campus. Main Oval.

As glaciers moved through the landscape they picked up large boulders which became embedded in the ice. Chunks of ice will raft these boulders into glacial lakes or deposit them as the ice melts and flood waters recede. Erratics such as the one the UM campus can be found throughout Missoula neighborhoods and the entire region.

Stop 2. Strandlines
Location: Can be seen on the slopes of both Mt. Jumbo and Mt. Sentinel looking east from many locations in the Missoula valley.

Ancient shorelines or strandlines are evident by the multiple benches ground into the slopes of hillsides, visible as perfectly parallel lines. Glacial Lake Missoula had no outlet, and the lake level rose until the ice dam failed and the water emptied. Each successive ice dam existed for fewer years than the one before, resulting in a lower ancient horizontal shoreline. Snow and low evening light emphasize the lines.

Stop 3. Little Money Creek Gulch Fill
Location: From Missoula take Exit 96 from I-90, travel north on US 93 to Ravalli, turn west on MT 200 to pullout at Mile Marker 91 for best view.

Geologists Joseph T. Pardee and David Alt described these gulch fills as the result of currents eddying into tributary gulches and filling them with debris scoured from valley walls. J.T. Pardee estimated the flow of water through this narrow valley at between 8 and 10 cubic miles per hour – more than the combined flow of all modern rivers in the world. Gulch fill can be seen in many locations along this river.

Stop 4. Rainbow “Dog” Lake
Location: Continue on MT 200, turn N on Hwy 28E at Plains, travel 9.2 miles to the end of the lake for an open view from the highway.

Rainbow Lake is now thought to be a cataract retreat lake formed by the retreating upstream erosion of a 100 ft waterfall. The sudden change in elevation as the water level along the Clark Fork near the present town of Plains dropped over 1700 ft created flows of up to 60-70 mph through the Boyer Creek spillway. Any weak spots in this resistant rock were torn apart, and the plunge pool of the waterfall created a current that continued to undermine the brink, which then collapsed. This process repeated, forming a deep lake along the entire migration distance.

Stop 5. Markle Pass Kolks
Location: Continue on Hwy 28, then turn south on Hwy 382 and drive about 8 miles to the top of the pass.

In areas adjacent to the road are deep rocky holes and circular ponds carved out of the bedrock by underwater “tornadoes” which pluck out rocks due to surface friction and a sucking action of gas bubbles. The “tornadoes” are caused by water churning in tight circular eddies as the flow is restricted. Numerous kolks are found in the passes near Camas Prairie including Burgess Lake.

Stop 6. Camas Prairie Ripples
Location: Continue on Hwy 382 to a pullout with an informational marker at mile marker 13.

In Camas Prairie there are numerous visible long ridges of sediment that are as much as 35 ft. high and 100 ft. apart. In 1942, Geologist Joseph T. Pardee identified these unique parallel ridges found in the Camas Prairie as “giant” ripple marks. With an average height between 13-30 feet, these current ripple marks would dwarf any ordinary ripple mark you might find on a beach or in a river today. The Camas Prairie ripple marks were formed as the deep and swift flowing water from Glacial Lake Missoula raced through the failed ice dam at speeds up to 65 miles per hour.
Stop 7. Ninemile Rhythmites
Location: Take exit 82 from I-90, travel N on Ninemile Rd uphill for 1.2 miles to a vehicle pullout on the left across from the northside roadcut.

The light pink sand and silt sized materials at this location were deposited on the bottom of Glacial Lake Missoula. These silt deposits are mostly found in areas where the basin was wide and not touched by the high-energy draining. These deposits are called ‘rhythmites’ due to the cyclic pattern of layers. Some of these could represent a sequence of draining and filling, demonstrating seasonal variation such as in modern day glacial lakes. These paired layers are like ‘varves’. Darker layers may represent winter deposits, and the lighter layers represent summer deposits. By counting varves geologists have estimated the lake collected at least 1000 years worth of sedimentation at this location.

Sloan Bridge Bluffs
Located where a partially unpaved road between Hwy 382 and US 93 crosses the Flathead River; take 211/Round Butte Rd at the Dairy Queen north of Ronan.

The white bluffs to the north record the sedimentation at the bottom of Lake Missoula. The continental ice sheet is only 18 miles away, and this is the rock flour washing off the ice, making the lake near the ice this color. There are no gaps or old soil horizons to indicate much time passing between each filling of the lake in the waning stages of the ice dam sequence.

Eddy Narrows
Follow St Hwy 200 past where Munson Creek intersects the Highway, 11 mi west of Plains. A Forest Service trailhead marks a good viewing spot.

In this narrow canyon about 10 miles long, the walls were bare of talus and soils up to the level estimated to be the highest level of the lake (1000 ft), and there are polished grooves in the bedrock on a bench 340-400 feet above the Clark Fork River that run parallel to it. Since there is no evidence of glaciation in this area, the only explanation is the rapid draining of Lake Missoula. In 1942, J.T. Pardee was able to calculate the speed and volume of water which could flow through this restricted area.

St. Regis Notch
Located at Exit 33 from Interstate 90

A prominent notch cut in the bedrock north of St. Regis marks a channel cut where the flood waters rushing down the Clark Fork River failed to make the sharp right turn to the north where it meets the St. Regis River and were forced back over the adjacent hills.

Other Points of Interest

Ninepipes Pingo Scars
Located on Hwy 212 west of the intersection with US 93

Pingos are places where permafrost type ice formed beneath exposed lake bottom sediments and freeze/thaw cycles resulted in the formation of small round depressions enclosed within a rampart-like rim or edge. Other circular depressions may be kettles, formed when a chunk of ice melts, leaving coarse materials behind. A national wildlife refuge and a local museum are also located nearby.

Paradise Center
Turn right off MT 200 in Paradise, onto 1st Street. Go 4 blocks and turn right onto North Avenue and continue uphill to the school. Call 406-826-0500 for hours

This exhibit includes an interactive topographic relief map of the entire Glacial Lake Missoula area. A model railroad and other historic items are also displayed.