Aftermath of the Ice-Age Floods: A Bird's Eye View

Bruce Bjornstad

Pacific Northwest National Laboratory

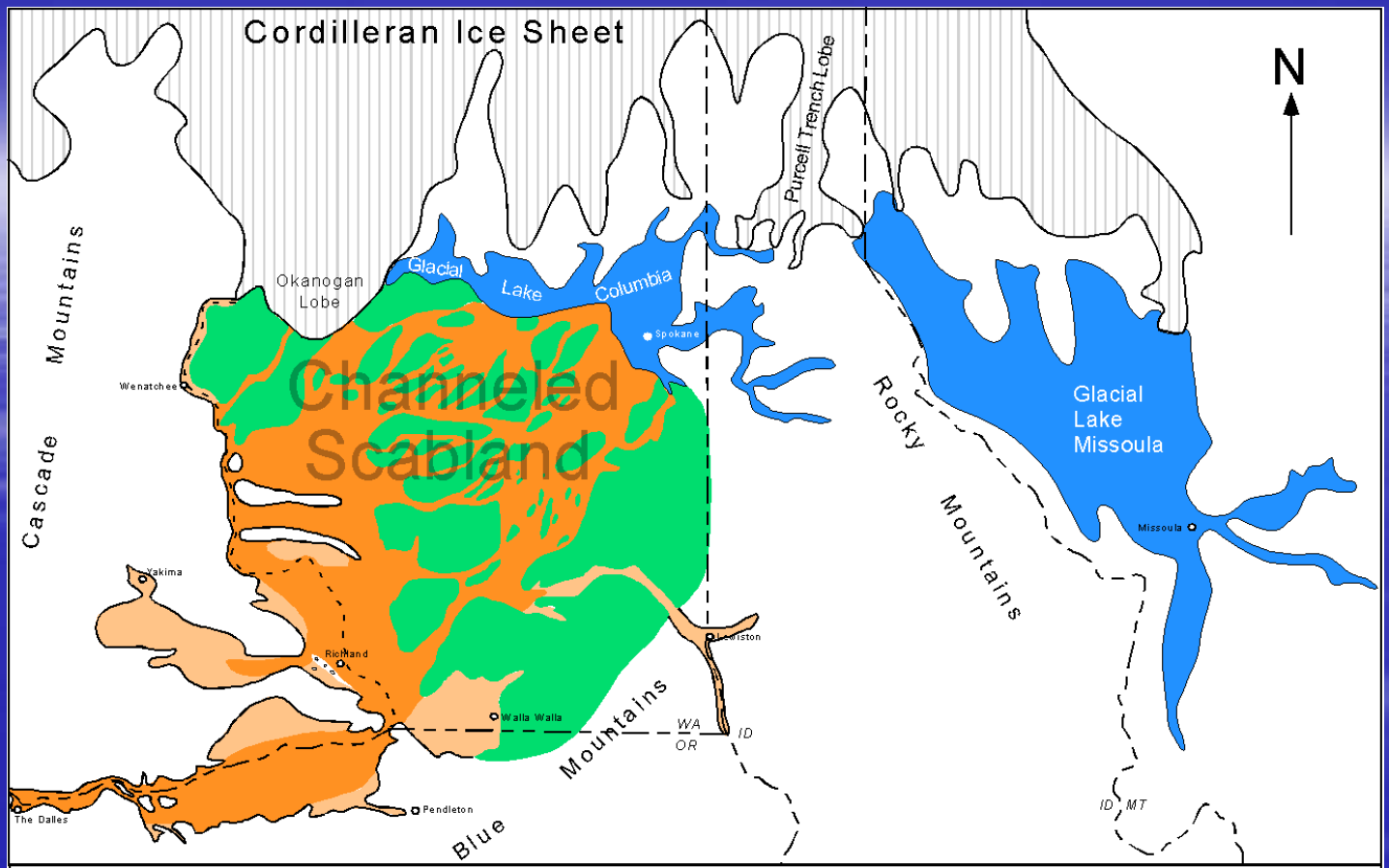
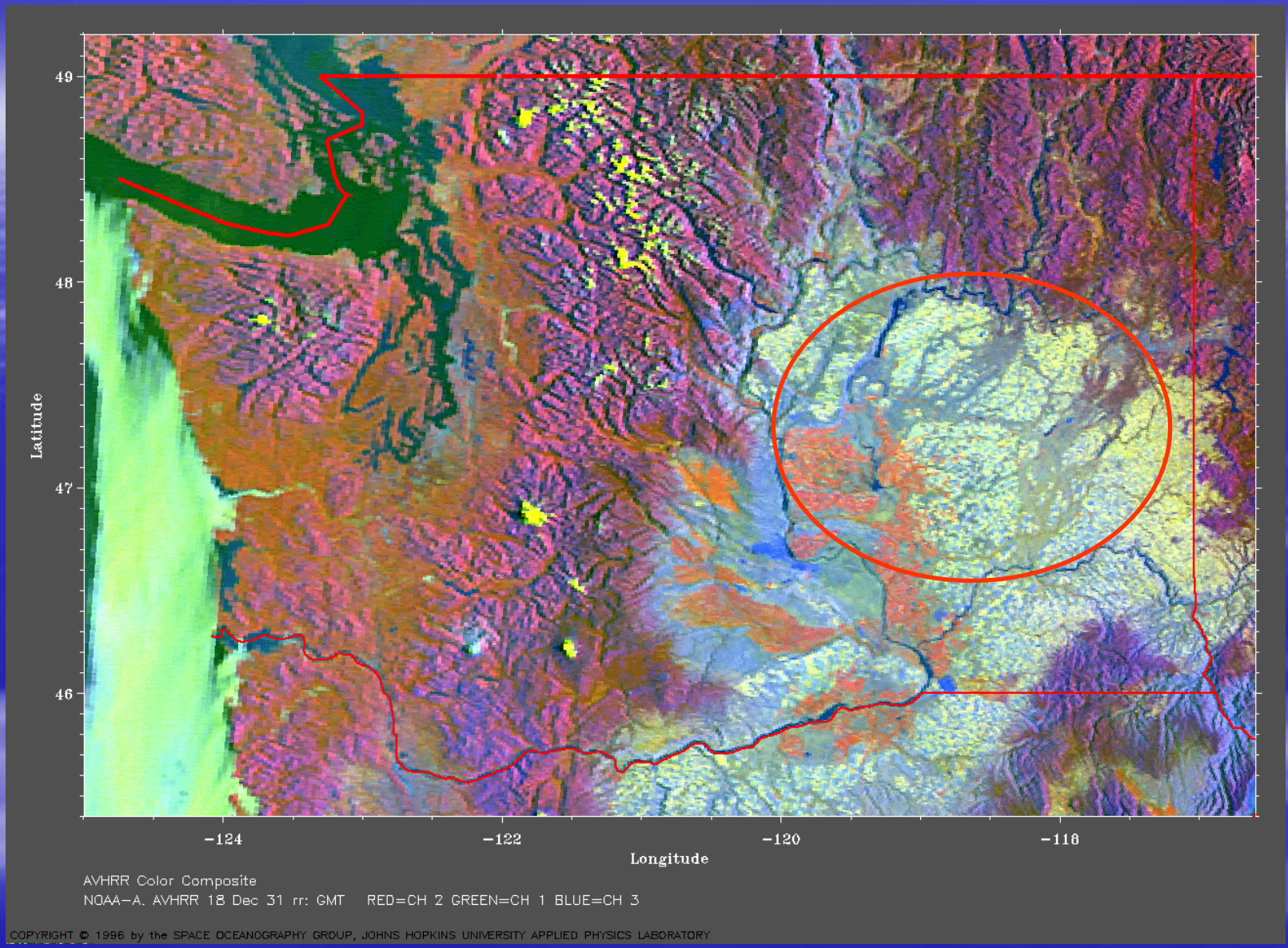


Figure 1. Key geographic elements related to the Ice-Age Floods.

Most Ice-Age floods came from repeated outbursts of glacial Lake Missoula. Downstream, the floods poured out over southeastern Washington, scouring out an interconnected network of channelways (i.e., the Channeled Scabland) over a hundred miles wide.

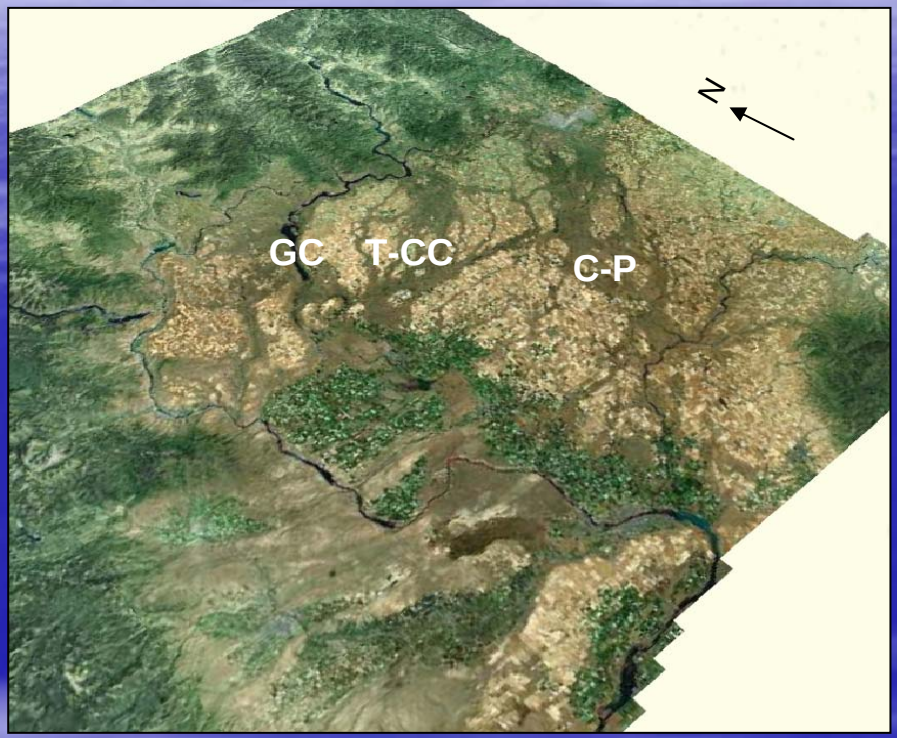
Infrared Satellite Image of Washington State



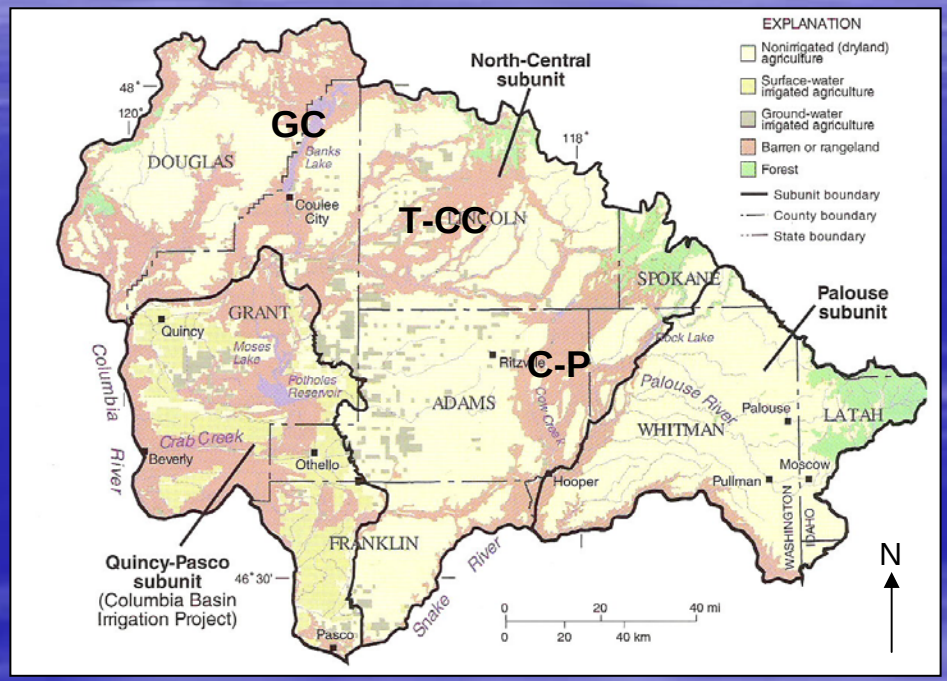
The Channeled Scabland is recognized from outer space where the floods completely removed the loose topsoil, eroding down into the underlying dark basalt bedrock.

Channeled Scabland

Landsat Image

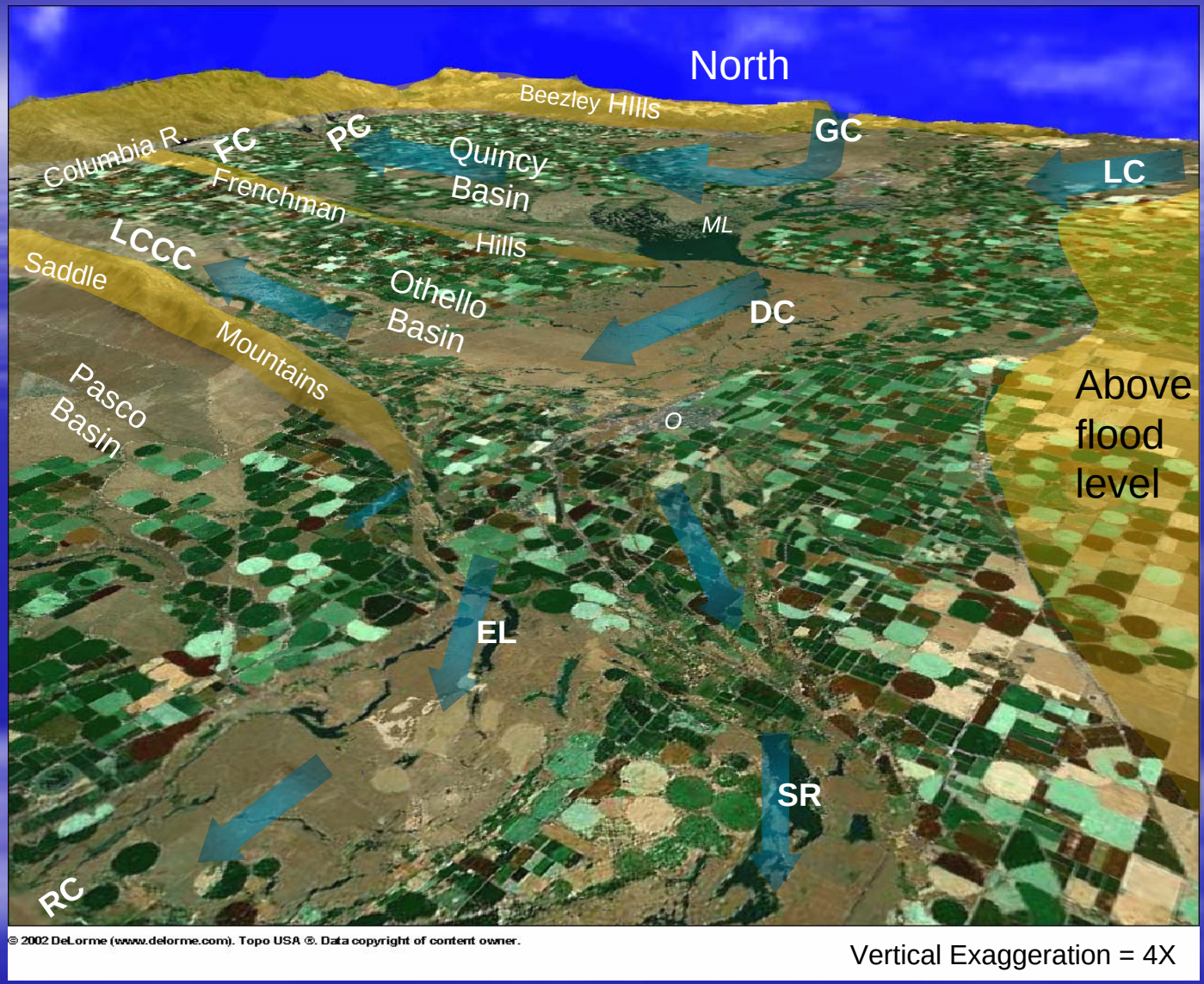


Land-Use Map of the Central Columbia Plateau



Floodwaters descended across the Channeled Scabland via three interconnected routes: 1) the Cheney-Palouse (C-P), and 2) Telford-Crab Cr. (T-CC) scabland tracts, and 3) Grand Coulee (GC). During the largest Ice-Age floods all three routes were simultaneously filled with water from periodic outbursts from glacial Lake Missoula.

Closer View of South-Central Channeled Scabland

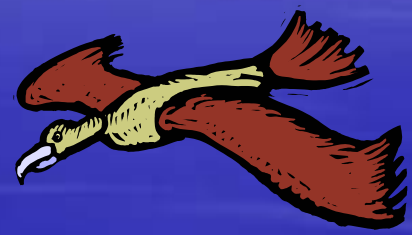


Floodwaters naturally followed the path of least resistance. This included areas of lower elevation or more easily eroded sediment and rock. Higher elevations escaped the floods' wrath.

GC = Grand Coulee, LC = Lind Coulee, DC = Drumheller Channels, PC = Potholes Coulee, FC = Frenchman Coulee, LCCC = Lower Crab Creek Coulee, EL = Eagle Lakes, SR = Scooteney Reservoir, RC = Ringold Coulee, ML = Moses Lake, O = Othello

Telford-Crab Creek
Scabland Tract

Cheney-Palouse
Scabland Tract

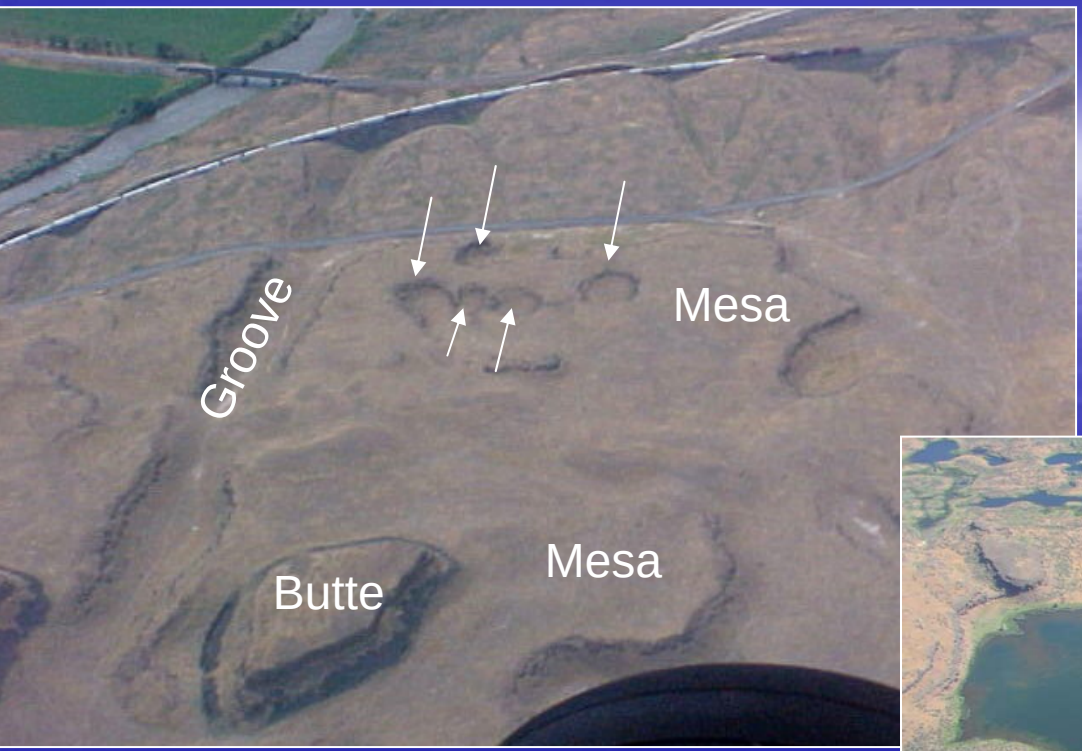


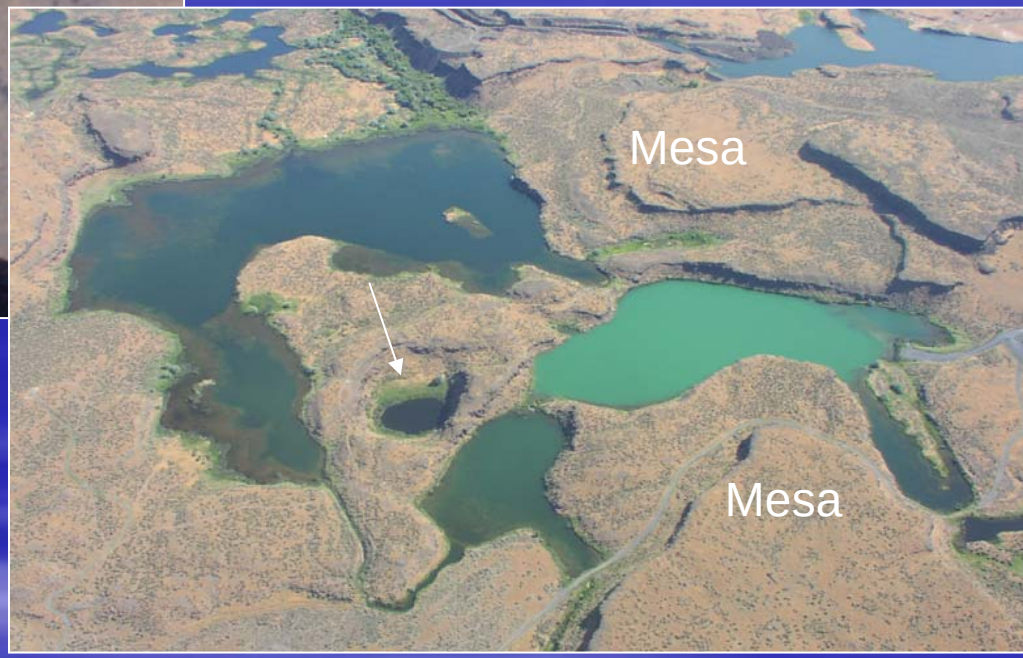
Lower Grand Coulee

Over much of the Channeled Scabland the floods completely stripped away the topsoil, exposing and eroding into the underlying, dark, basalt bedrock.

Between scabland flood channels the gently rolling Palouse hills, composed of windlblown, fine sand and silt, were preserved in areas that lay above flood level.

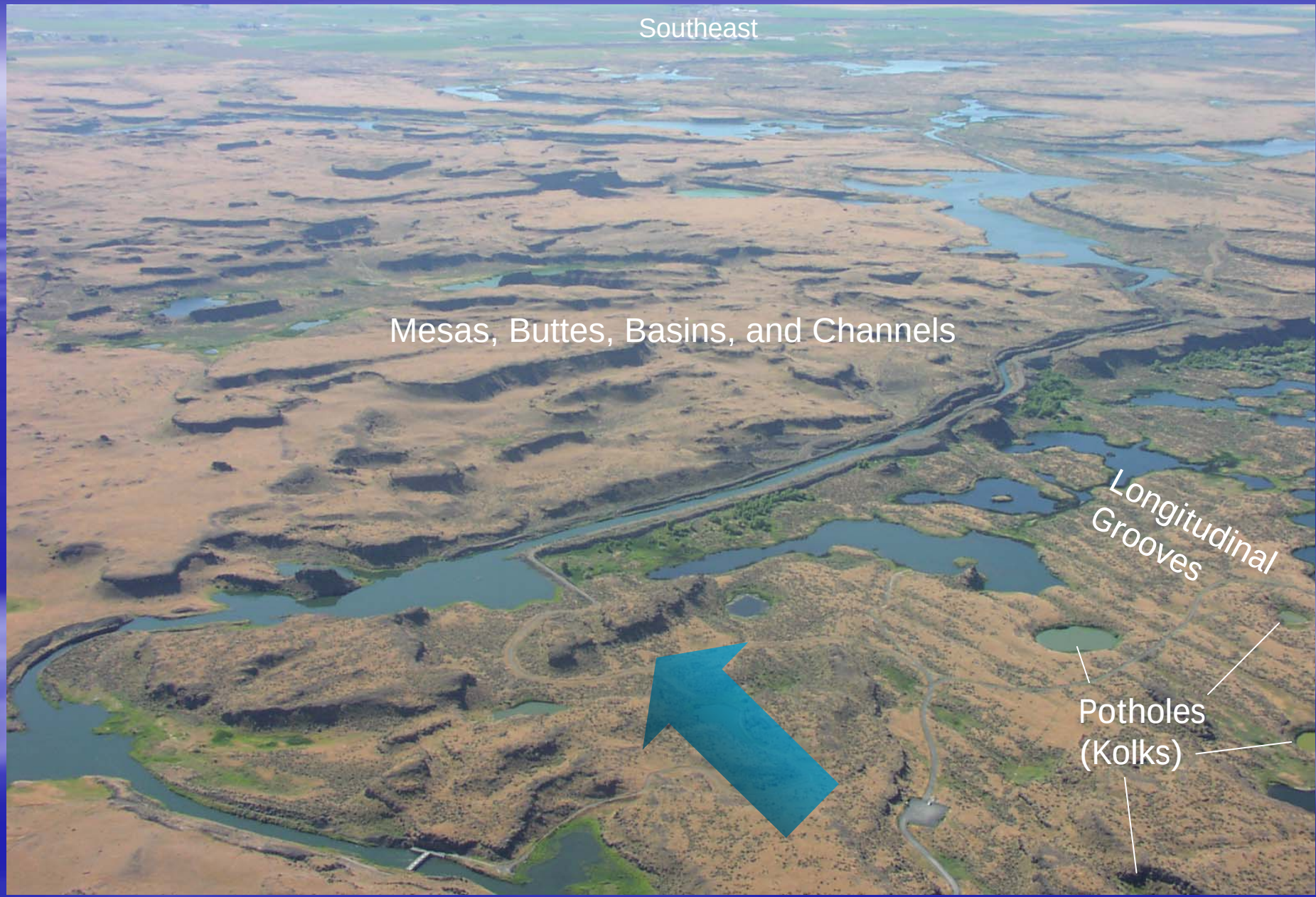
Scabland Features



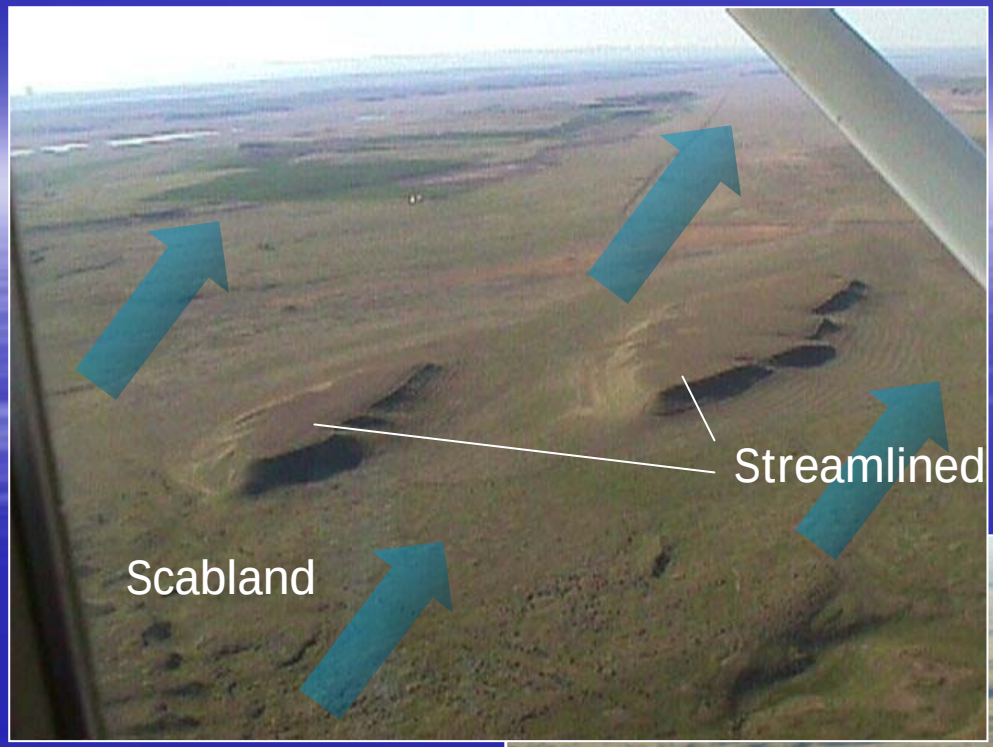


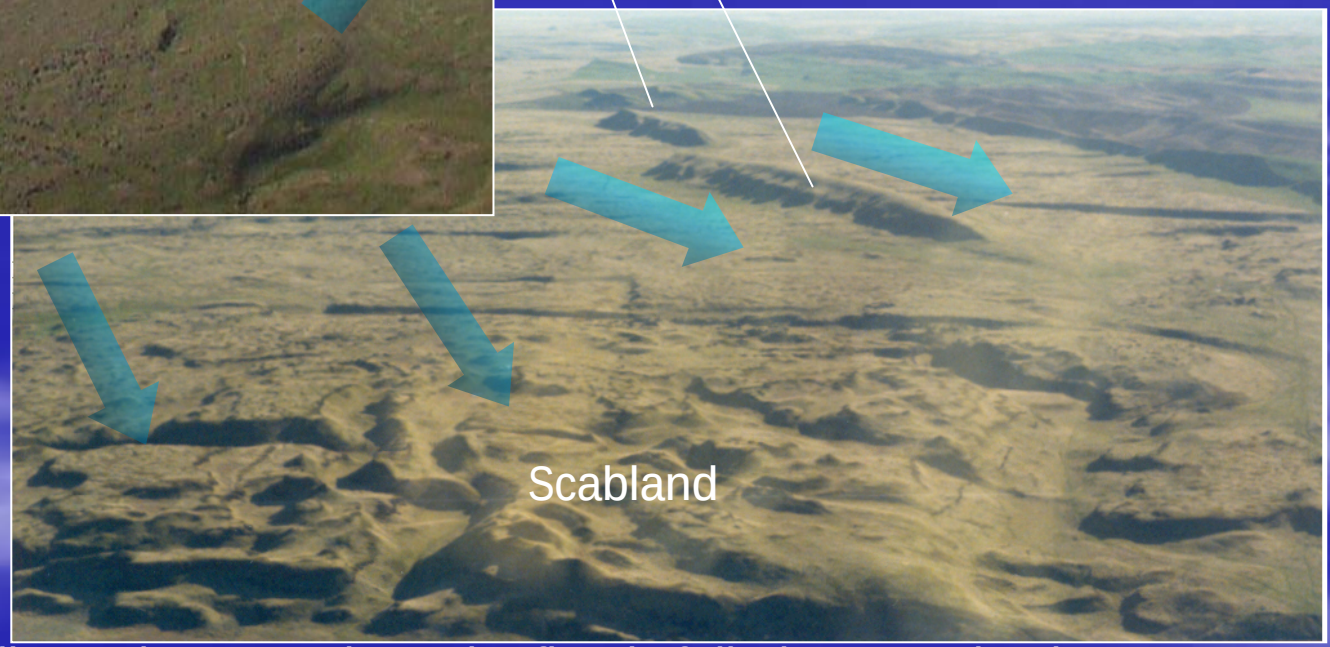
Characteristic of the Channeled Scabland are potholes (arrows), also referred to as kolks, created by violent vortices during flooding. The swirling action created hydraulic lift, which was able to pluck out and transport huge blocks of fractured basalt. Other common scabland features include mesas, buttes, spill-over channels, and grooves.

Scabland Features at Drumheller Channels

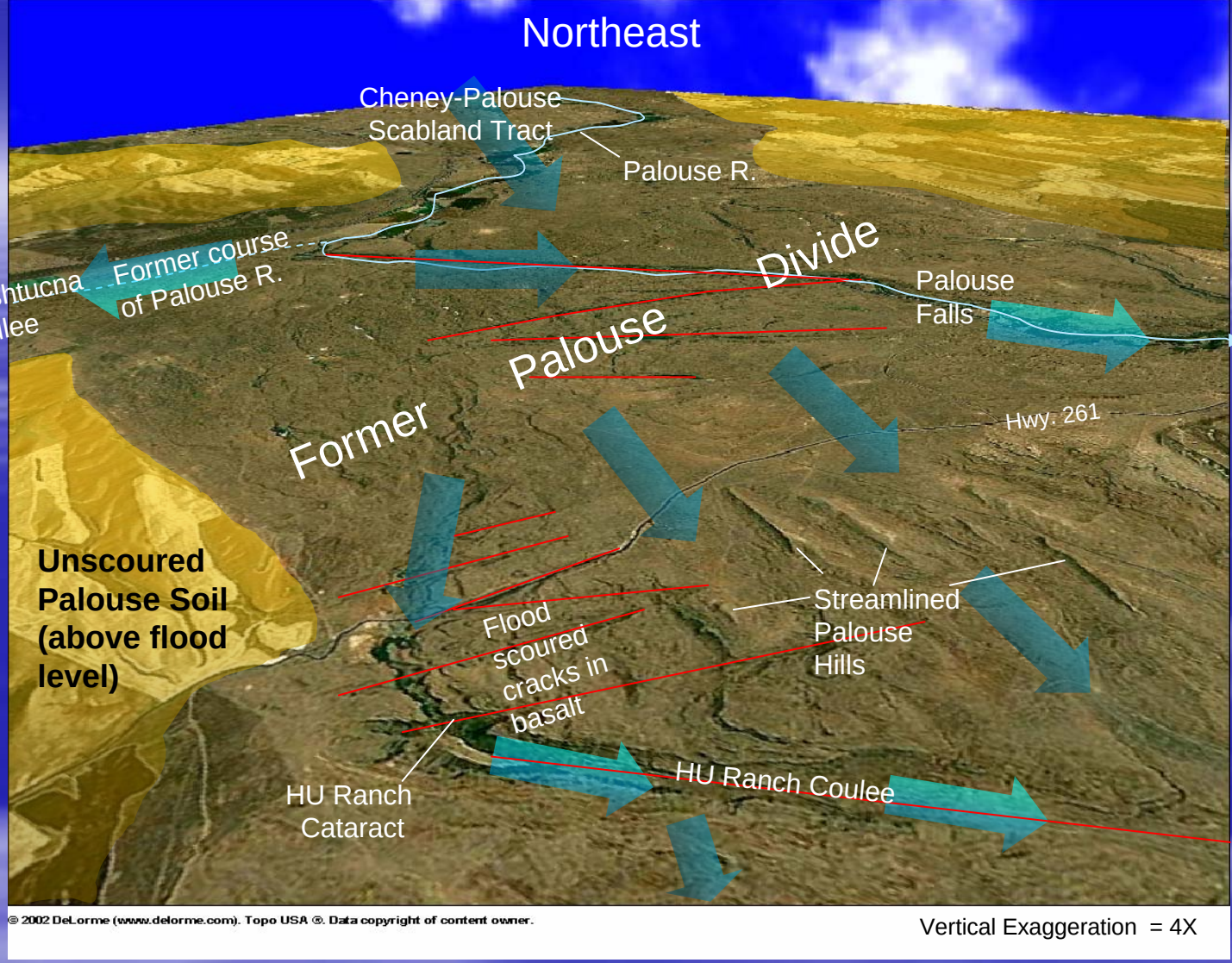


Streamlined Palouse Hills





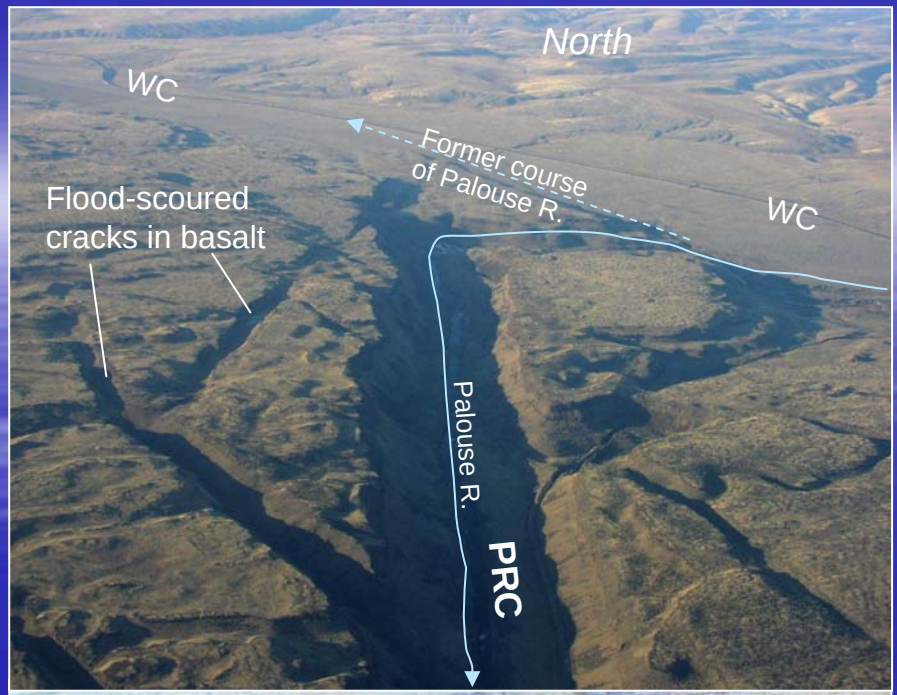
Streamlined Palouse hills mark areas where the floods failed to completely remove all the topsoil within flood channels. These “islands” of loose Palouse soil were eroded and molded into their present shape by the deep, rapidly moving Ice-Age floodwaters.

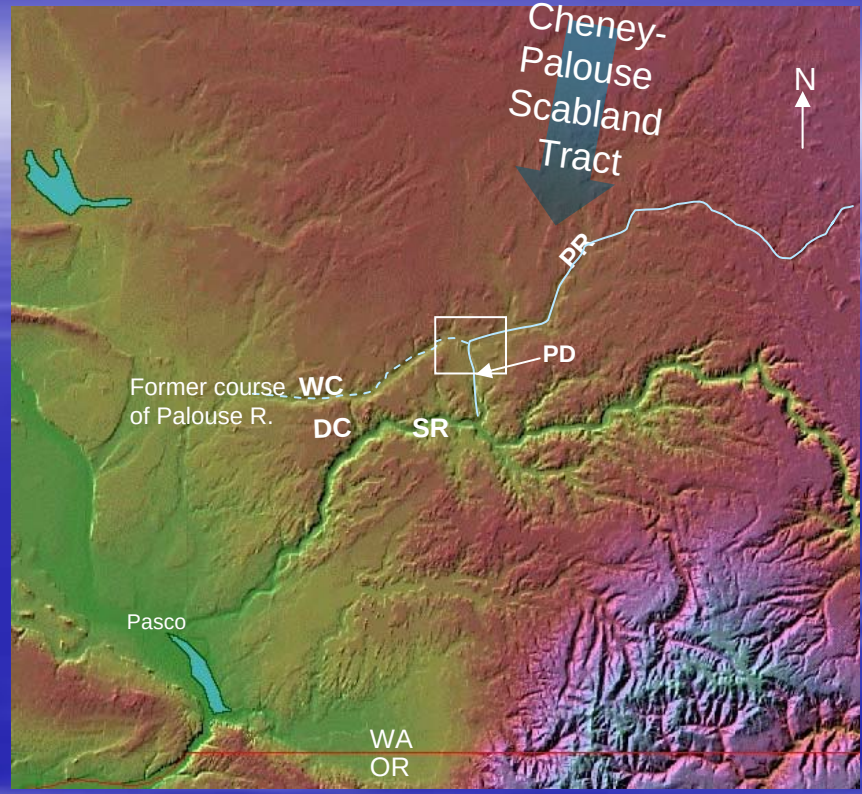


Altered Land-scape

Prior to Ice-Age flooding the Palouse Divide was higher and covered with a thick layer of Palouse soil. Also during this time the Palouse R. ran westward down Washtucna Coulee. With Ice-Age flooding, floodwaters smashed into the Palouse Divide. Because Washtucna Coulee could not handle all the water coming down the Cheney-Palouse tract, floodwaters had nowhere else to go but up and over the Palouse Divide. The floods quickly eroded down into the underlying bedrock where they encountered a number of pre-existing deep cracks (red lines). The floods preferentially eroded the weaker basalt along these cracks. Today the Palouse River and HU Ranch Coulee are entrenched along these subparallel cracks.

Diversion of the Palouse R.

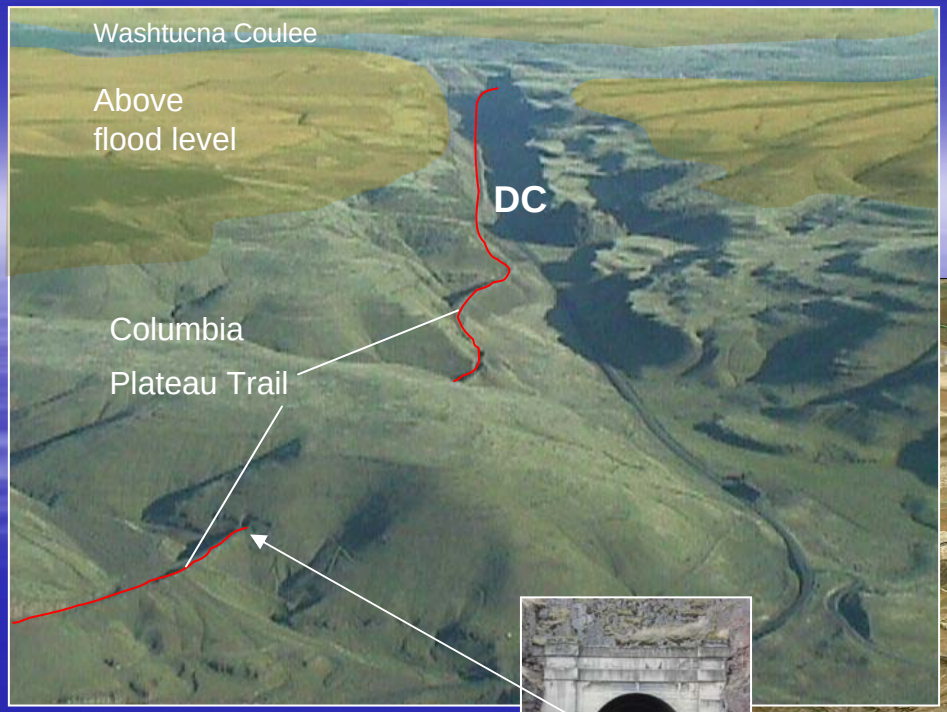




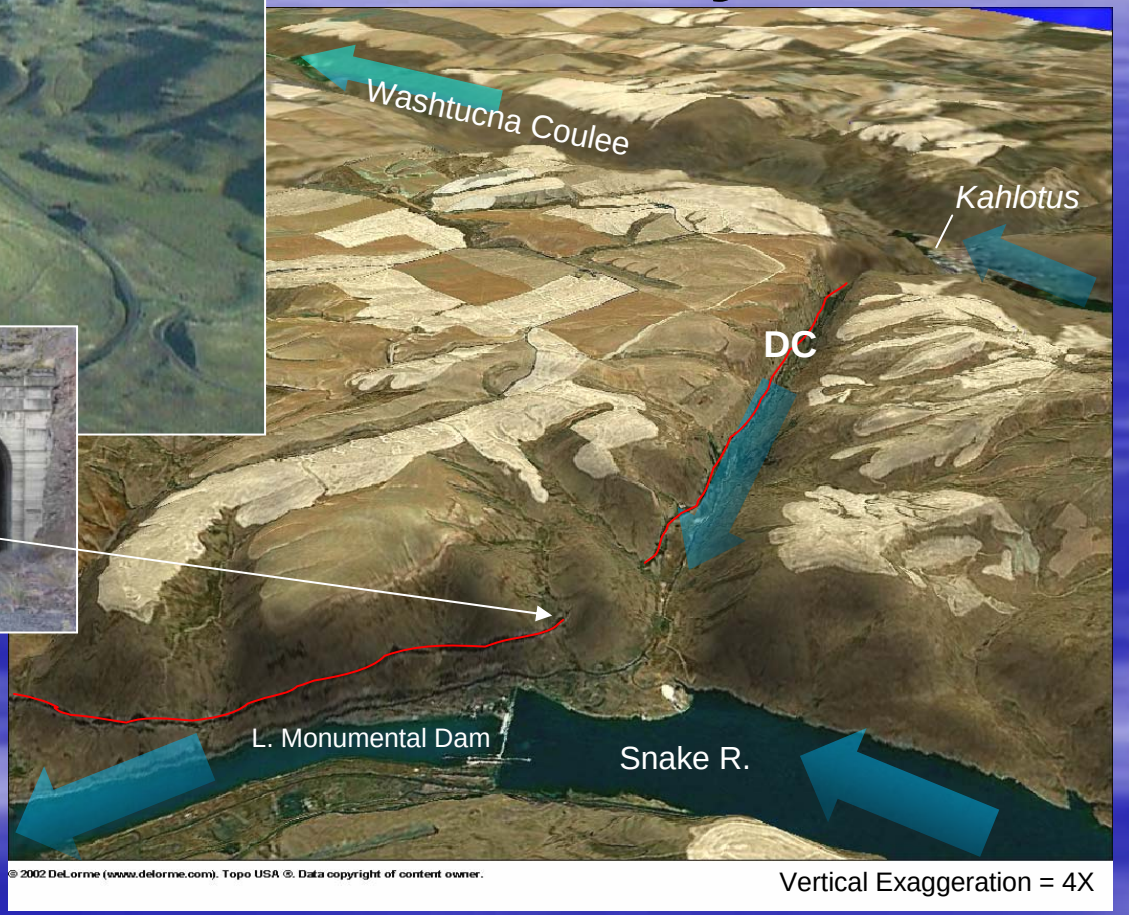
The area shown in the photos at left is represented by the rectangle above. Prior to flooding, the Palouse R. flowed southwestward down Washtucna Coulee. The Palouse R. took an abrupt right turn southward after floodwaters eventually cut a lower channel across the Palouse Divide, creating a shortcut to the Snake R.

PR = Palouse R., PRC = Palouse River Canyon, SR = Snake R., WC = Washtucna Coulee, DC = Devils Canyon, PD = Palouse Divide

Devil's Canyon

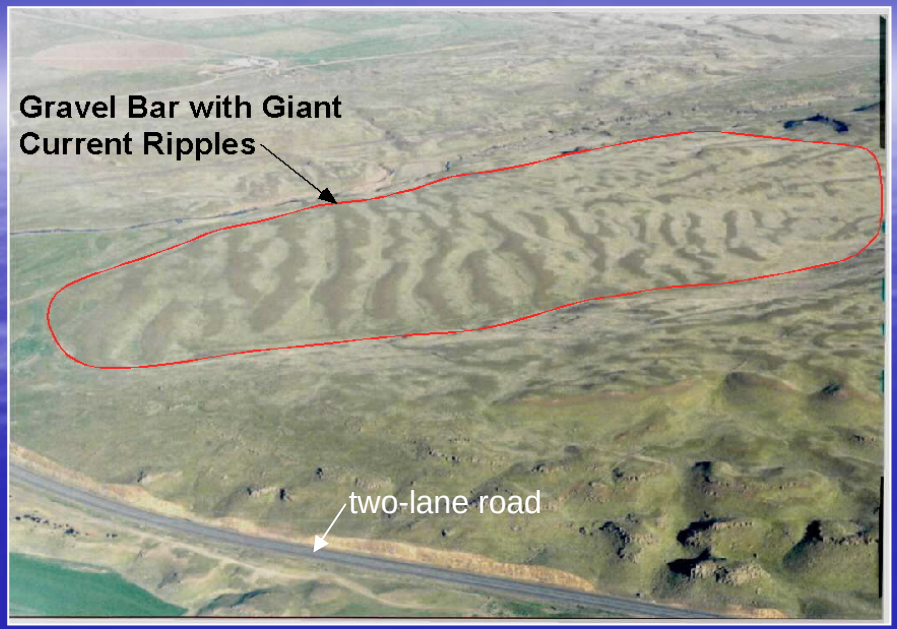


Entrance to RR
Tunnel along
Columbia
Plateau Trail



As with the Palouse R. Canyon (PRC) to the east, floodwaters moving down Washtucna Coulee (WC) overtopped another divide between WC and the Snake R, carving a new channel, called Devil's Canyon (DC). The straightness of DC suggests it too developed in weaker rock along a fracture line in the basalt. Unlike the PRC, DC is dry, since the flow of water in WC and DC was cut off after the last Ice-Age floods.

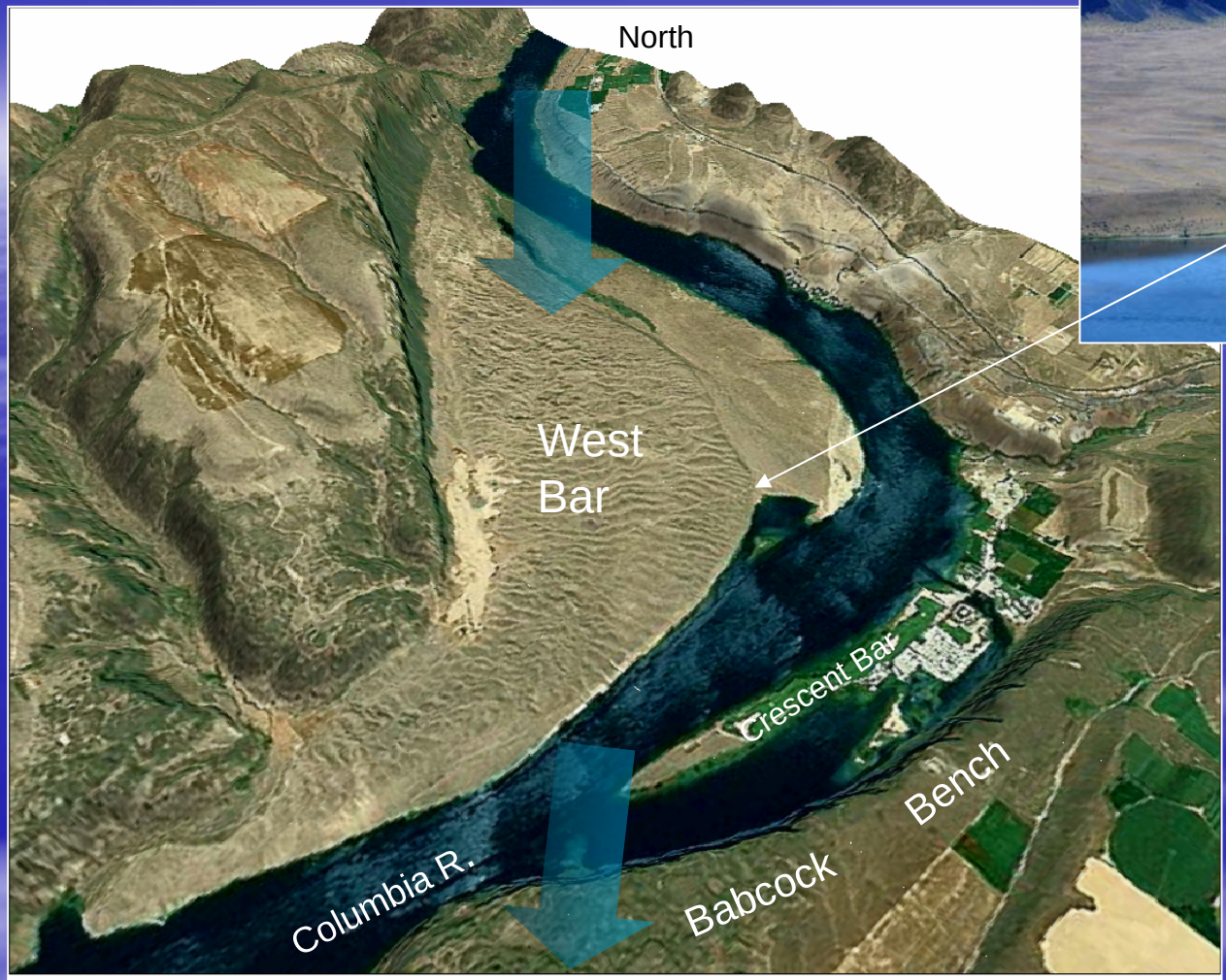
Giant Current Ripples



Channeled Scabland

Snake River

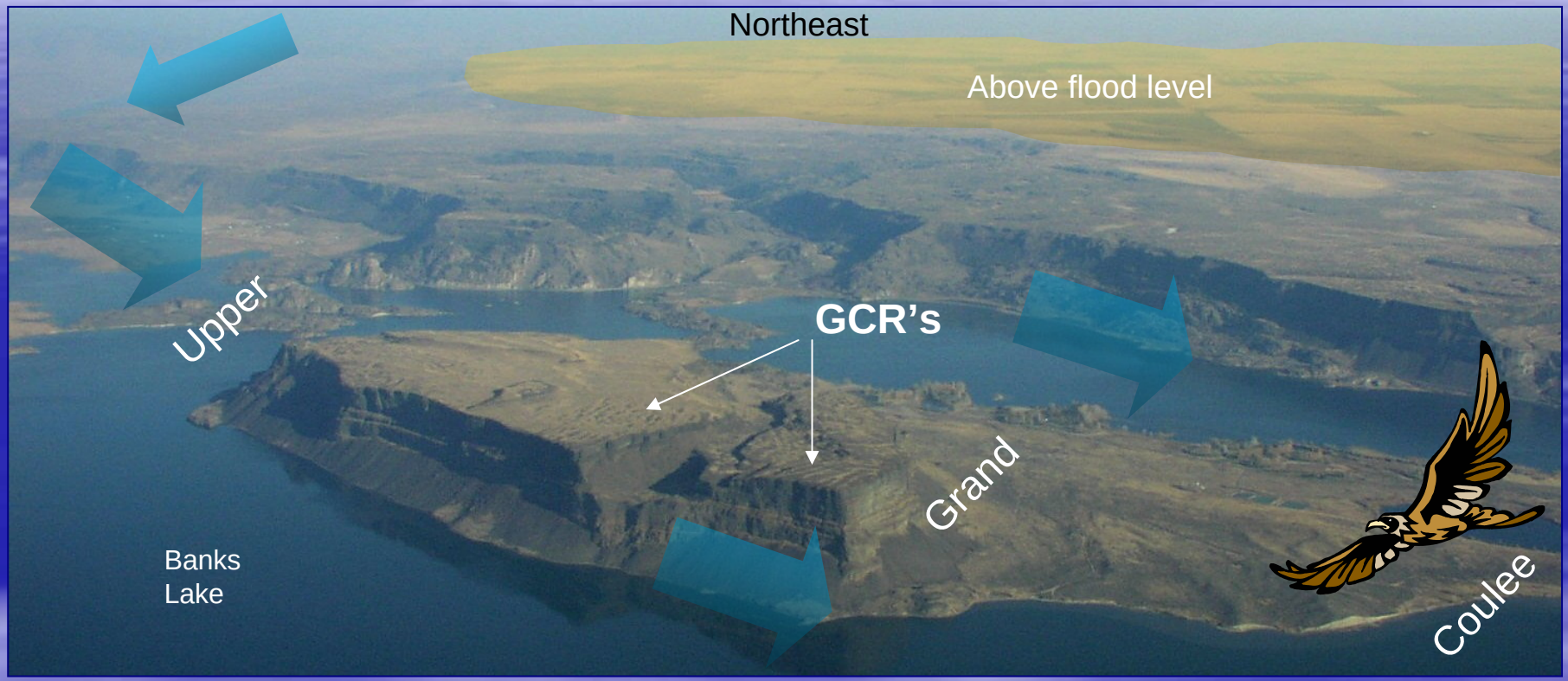
The huge scale of giant current ripples, up to several meters high and tens of meters apart, attests to the magnitude of the Ice-Age floods.



Vertical Exaggeration = 4X

Giant Current Ripples at West Bar

Steamboat Rock



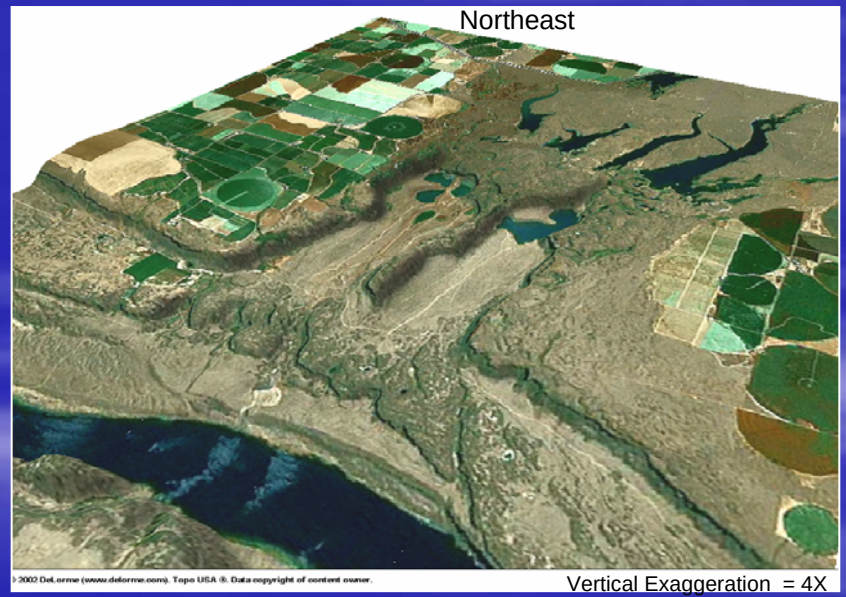
Several sets of giant current ripples (GCR's) are perched atop Steamboat Rock, in the upper Grand Coulee. These ripples lie 750 ft above Banks Lake, a direct indication of the floods depth at this location. Like the prow of a giant ship, the steep vertical face of Steamboat Rock points in the direction of the floods, a most hydro-dynamically stable form for this monolith.

Cataract Canyons

Frenchman Coulee

Dry Falls

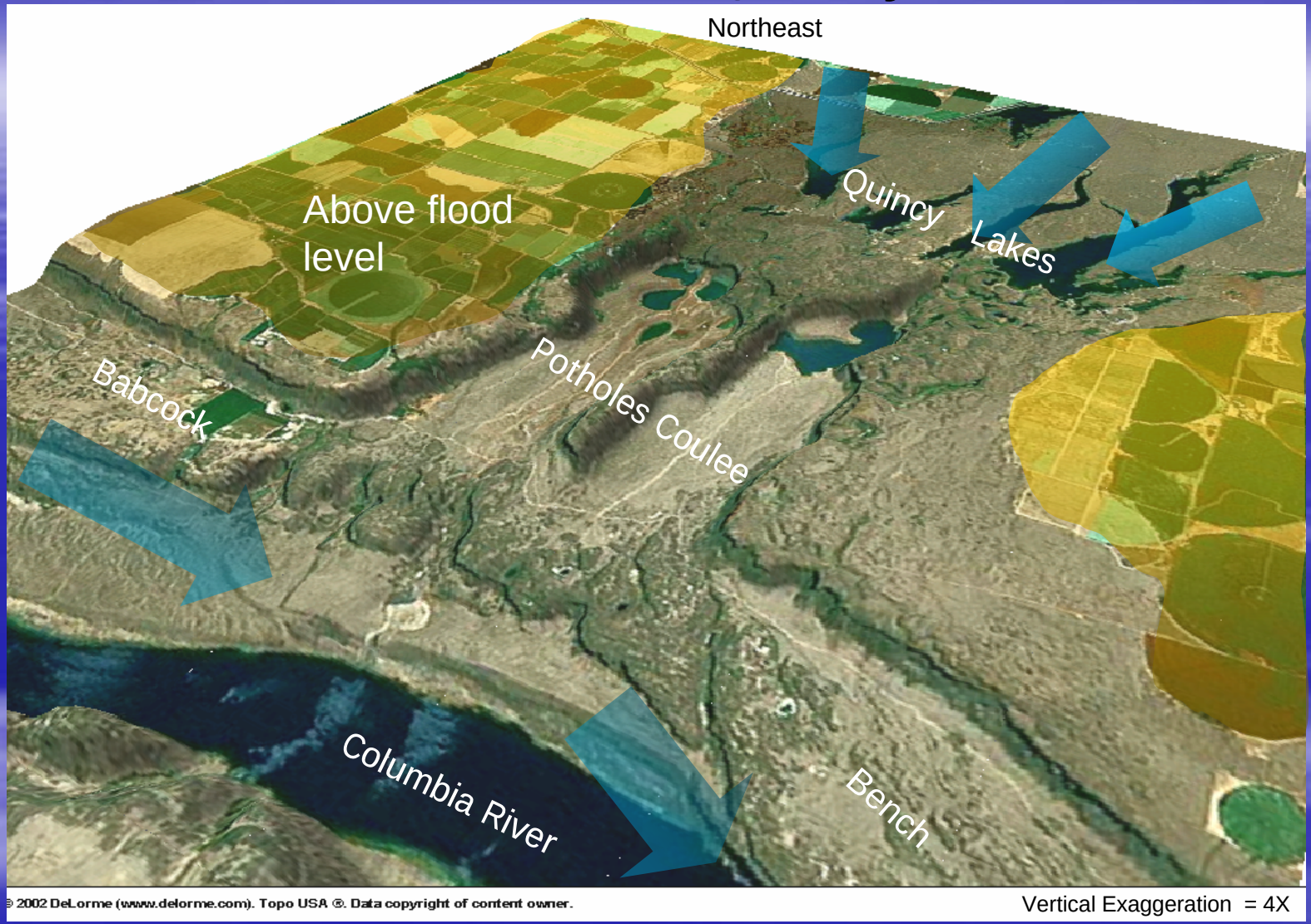
Palouse Falls



Potholes Coulee

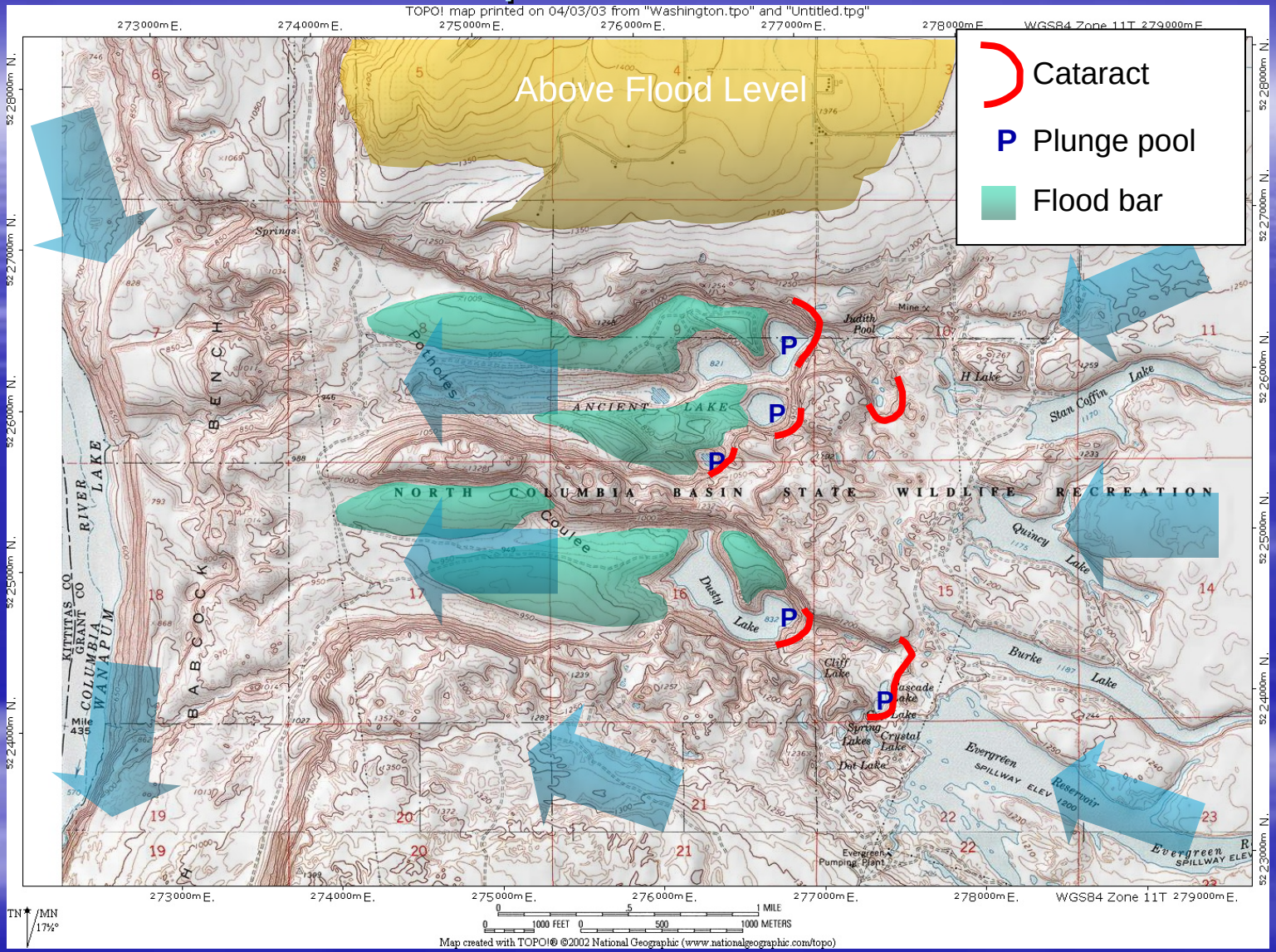
Cataract canyons are another flood feature characteristic of Ice-Age flooding. Shown here are four examples of cataract canyons within the Channeled Scabland. Similar features have been observed on Mars, leading scientists to believe huge floods have occurred on Mars as well.

Potholes Coulee/Quincy Lakes

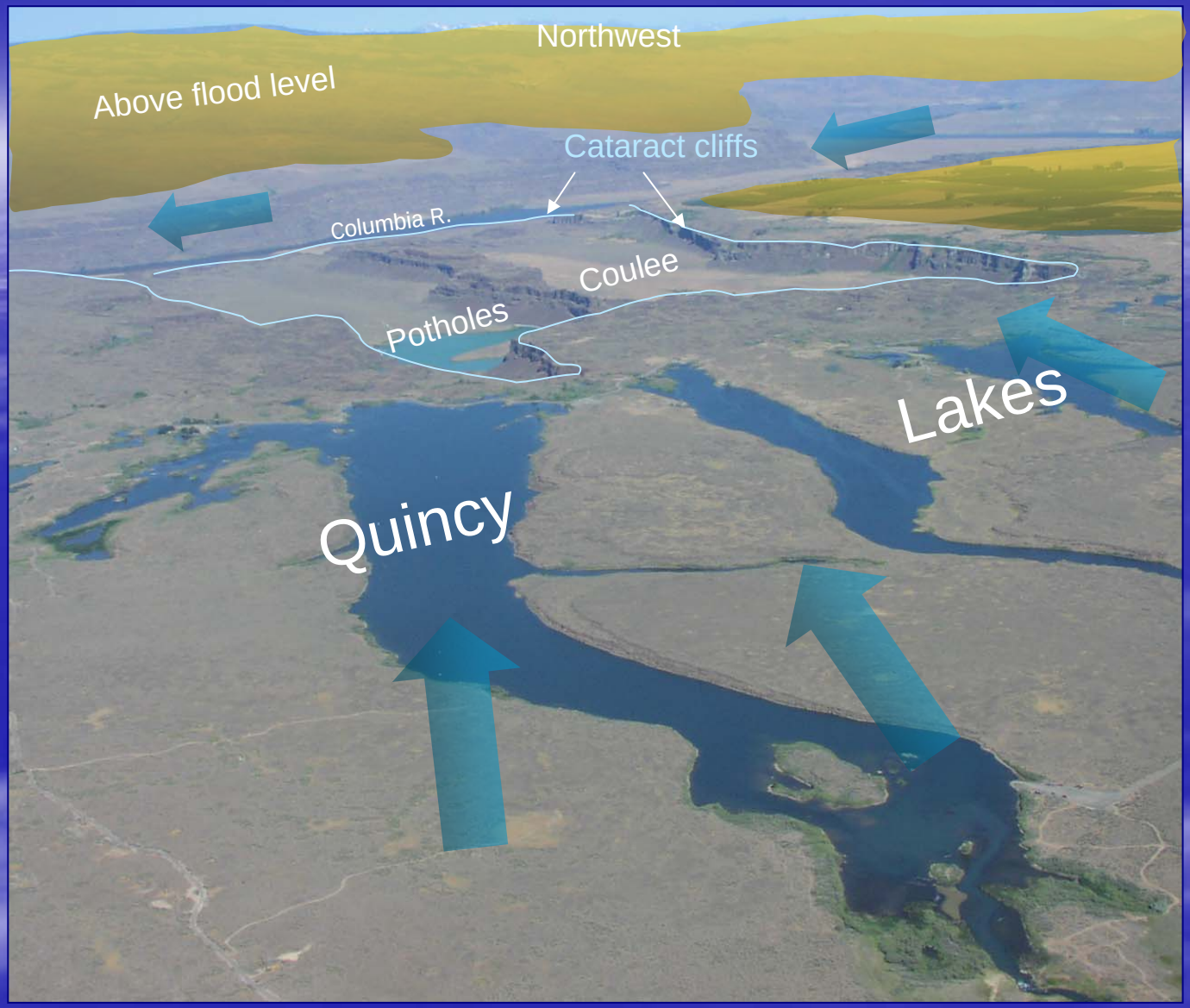


Potholes Coulee is a pair of cataract canyons formed by floodwaters moving west out of the Quincy Basin. Floodwaters also moved down the Columbia River valley from the north, but probably at a lower elevation.

Cataract Complex at Potholes Coulee



During flooding cataracts were like giant waterfalls; the floods eroded down to more-resistant layers of basalt. The force of falling water created huge plunge pools that undercut cataracts at their base. This allowed the vertical walls of cataracts to maintain themselves as they migrated upstream. Huge bars of gravel and sand, hundreds of feet deep and up to a mile long, formed downstream of the cataract complex.



Quincy Lakes is in the foreground with Potholes Coulee and Columbia River beyond and several hundred feet below. In stair-step fashion, floodwaters tumbled over cataract cliffs, first into Potholes Coulee, and then into the Columbia River.

Bottleneck at Wallula Gap

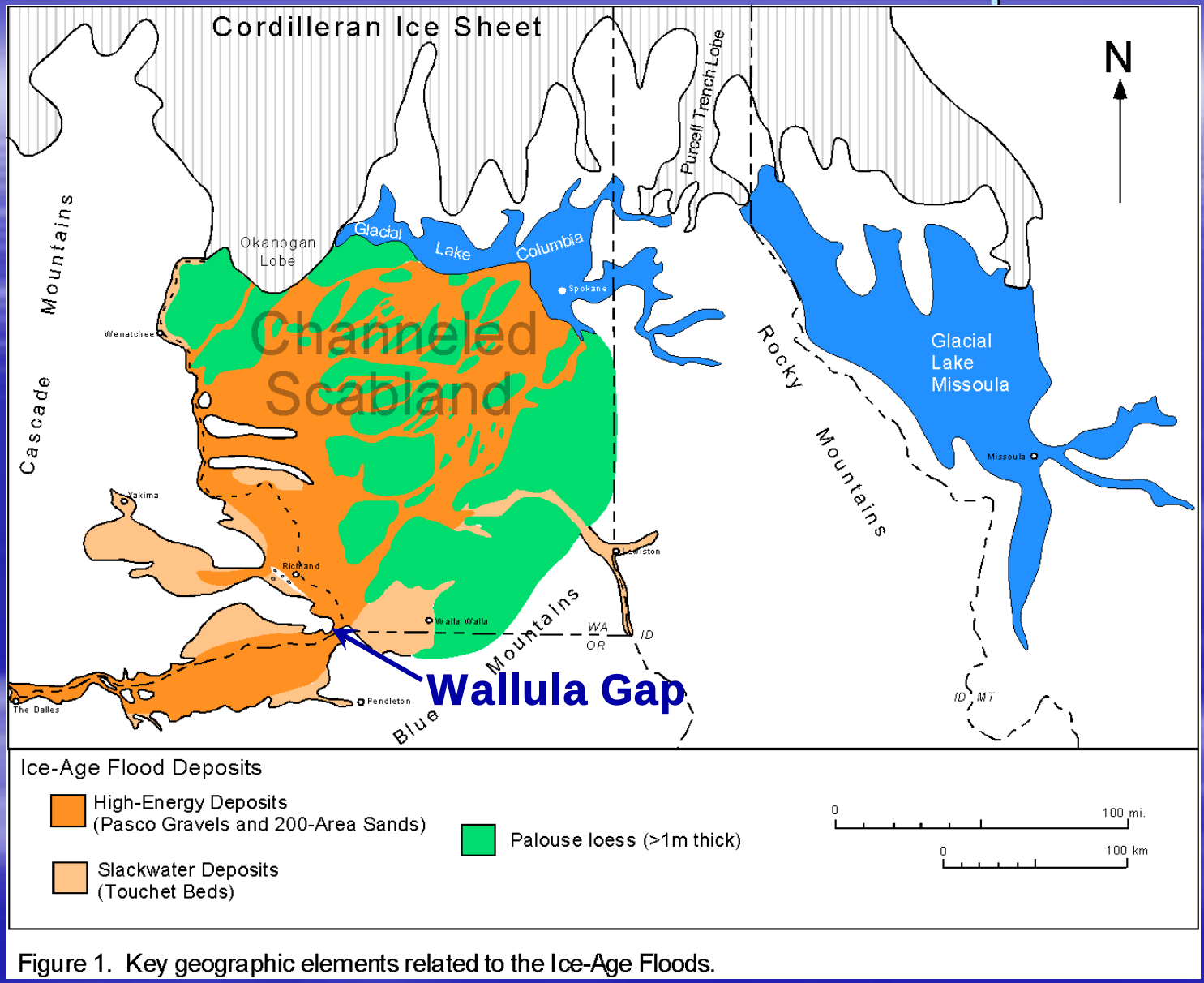
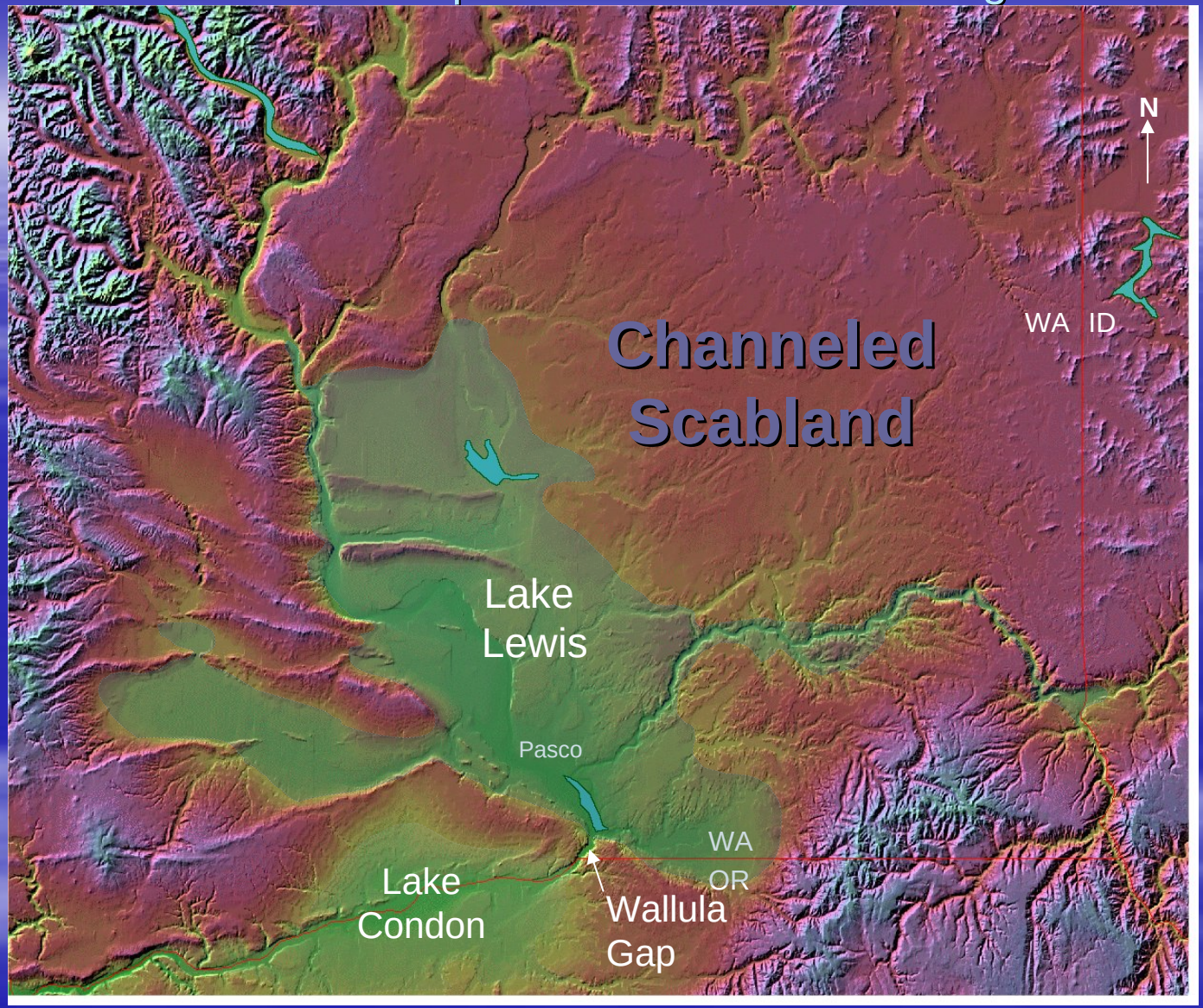


Figure 1. Key geographic elements related to the Ice-Age Floods.

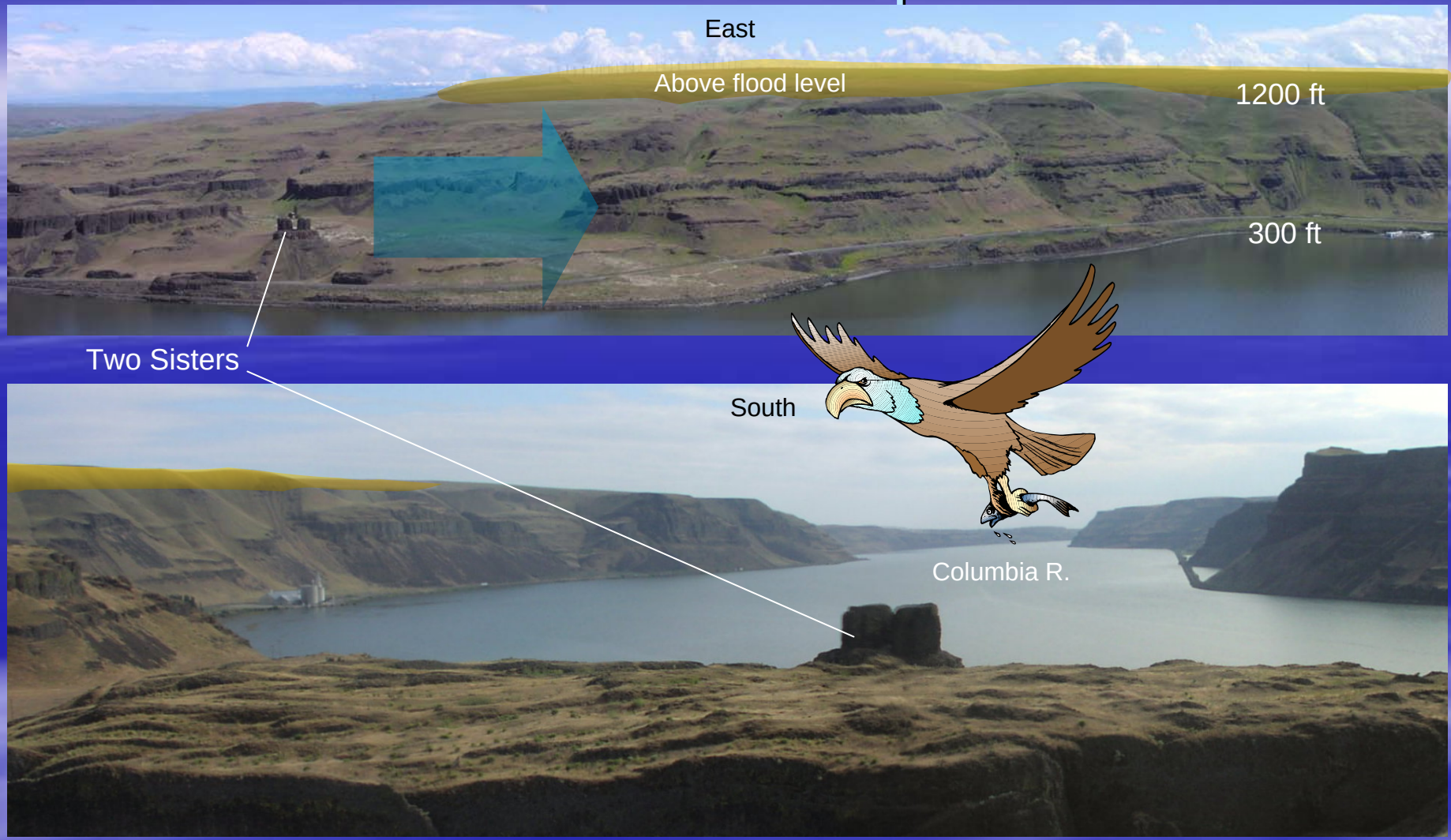
All floodwaters were forced to pass through a single, narrow constriction at Wallula Gap.

Elevation Map of Southeastern Washington



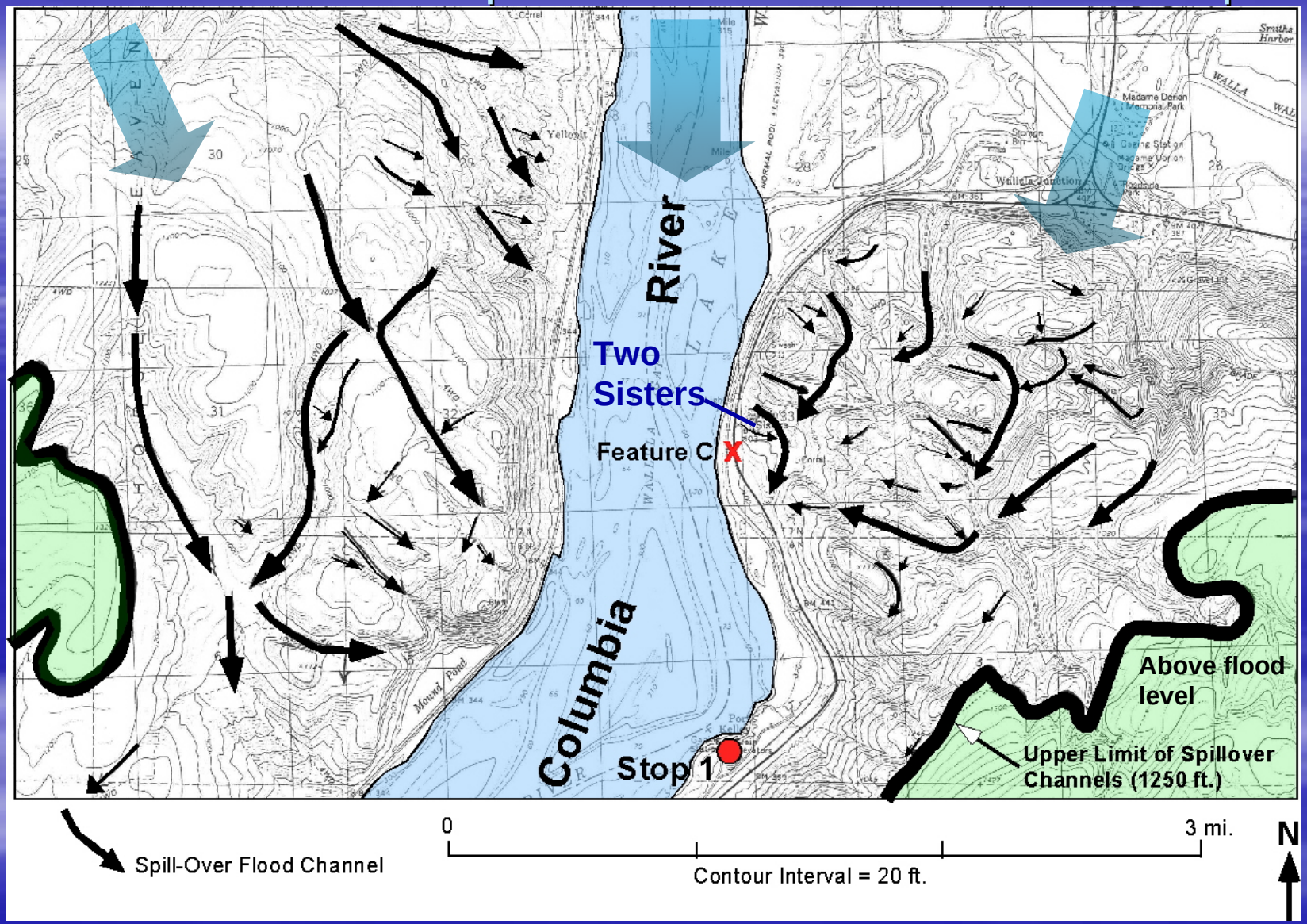
During larger floods the volume of water entering the Pasco Basin was greater than could pass through the narrow opening at Wallula Gap, so the water backed up to an elevation of 1200 ft, forming temporary Lake Lewis. Downstream, Lake Condon rose to a 1000-ft elevation behind another hydraulic constriction in the Columbia. R. Gorge. Lakes Lewis and Condon only lasted a few days, or as much time required for all the water to drain out to the Pacific Ocean.

Wallula Gap

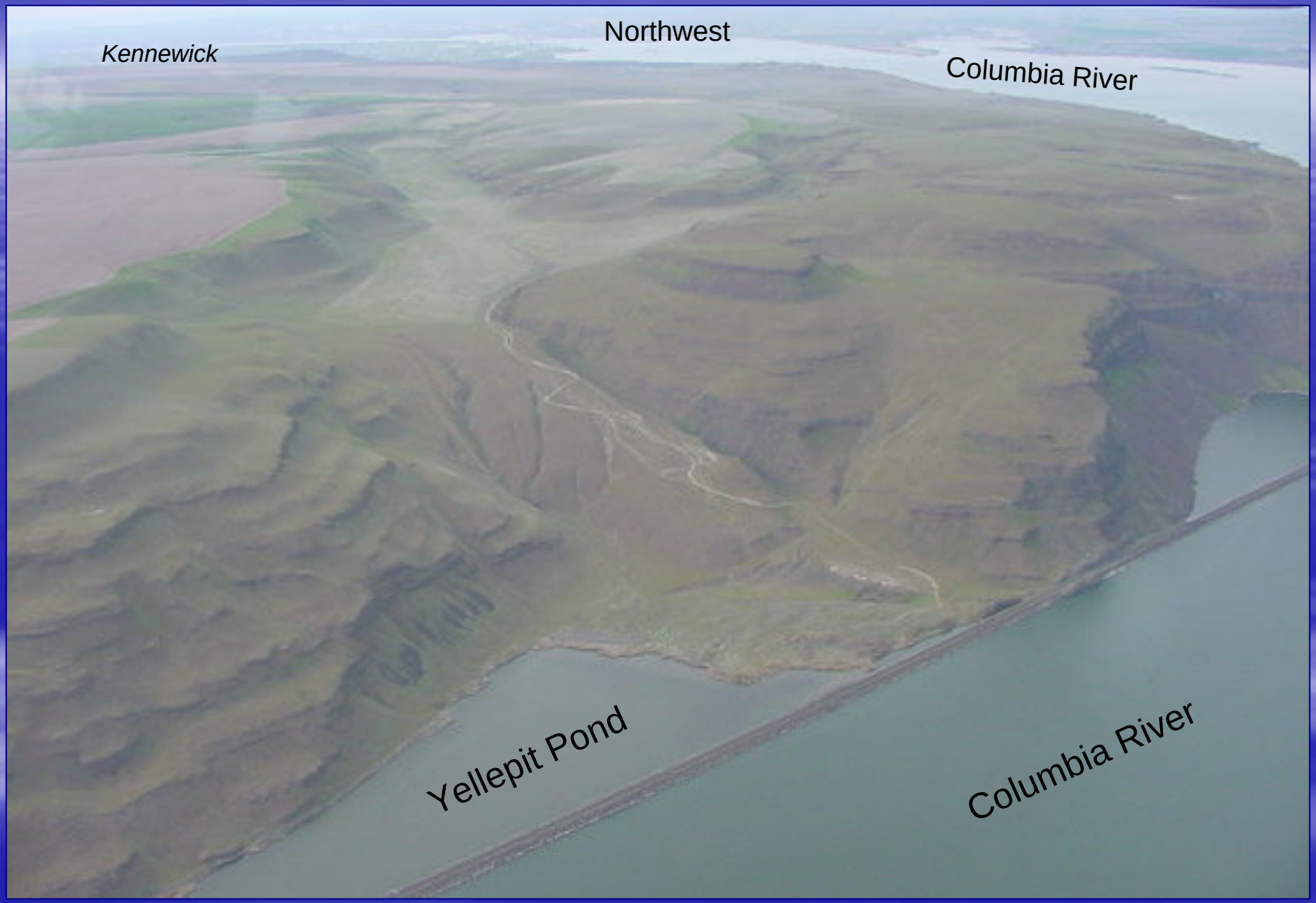


During the largest floods, water levels in Wallula Gap were up to 900 ft higher than today. Below the high water mark (1200 ft) slopes were stripped clean of soil and scabland-like features, such as mesas, buttes, spill-over channels, and pinnacles (e.g., Two Sisters) are the predominant landforms.

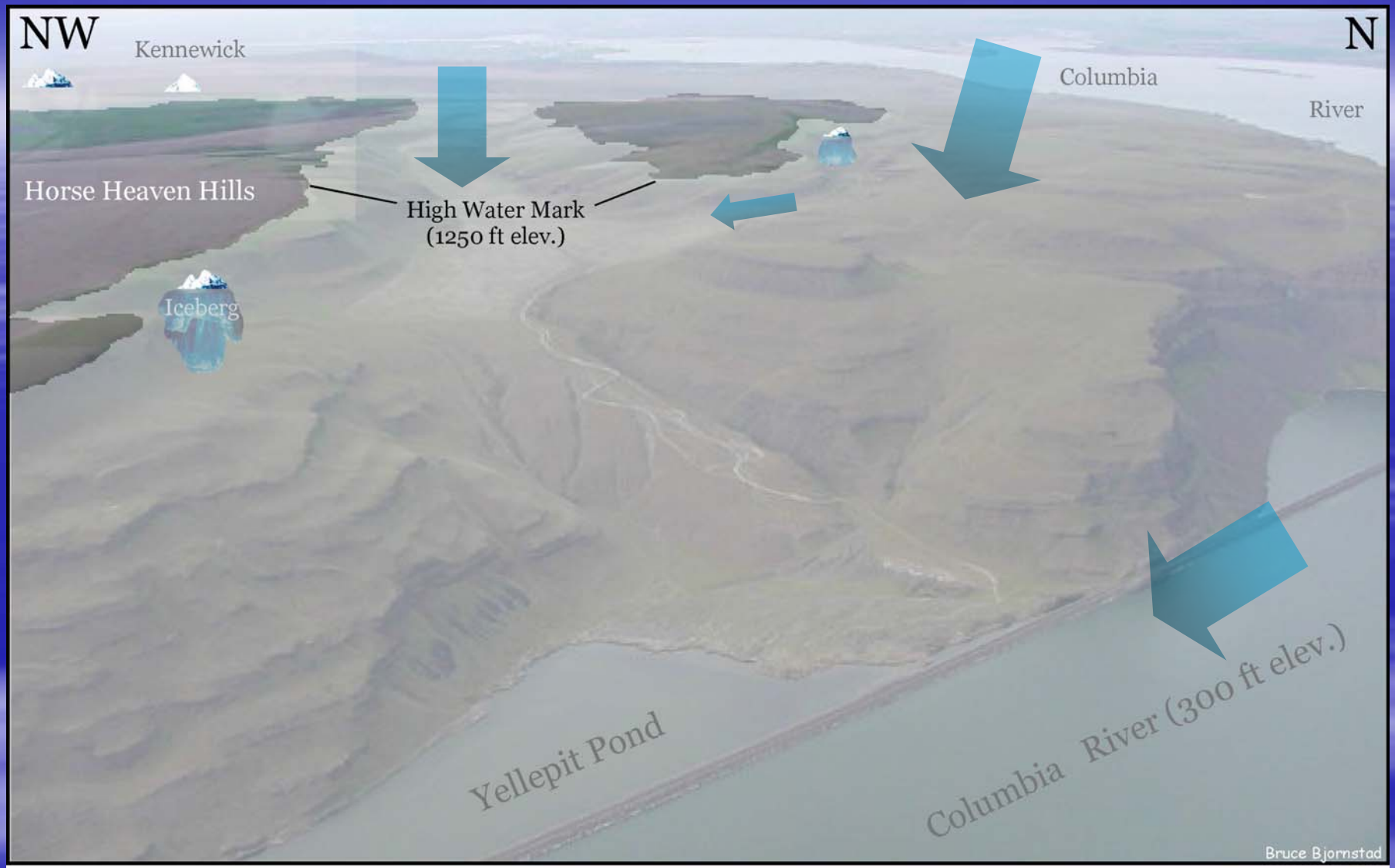
Chaotic Network of Spill-Over Channels at Wallula Gap



Water levels rose to ~1200 ft during the largest floods, the height to where we see flood-scoured spill-over channels. Above 1200 ft lie only smooth, soil-covered slopes, unaffected by the raging torrent below. All floodwaters were forced to pass through this single opening, which at its narrowest, was ≤3 mi. wide.



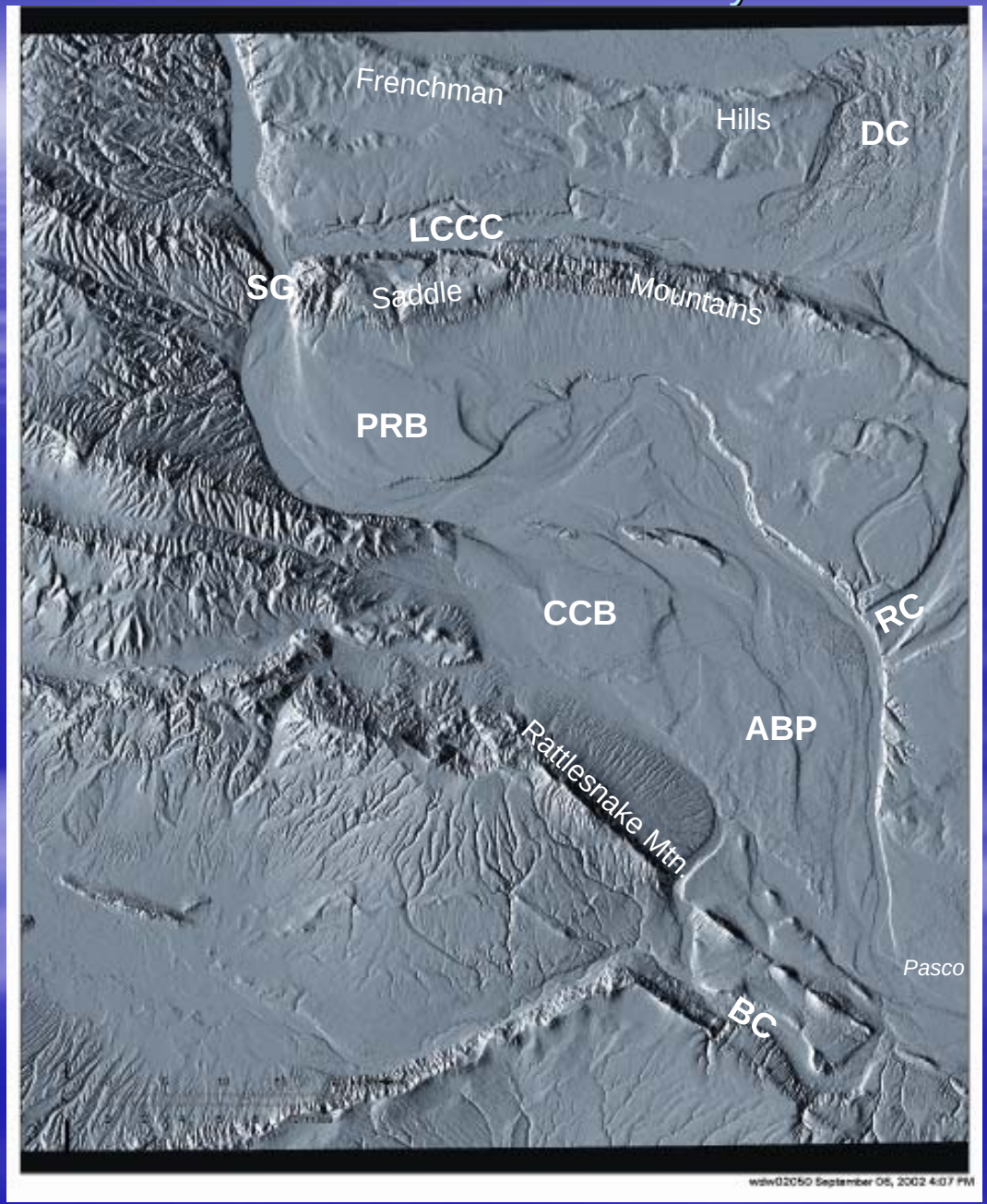
Northwest end of Wallula Gap as it appears today.



Maximum Flood at Wallula Gap

Northwest end of Wallula Gap as it might have appeared during maximum flood stage.

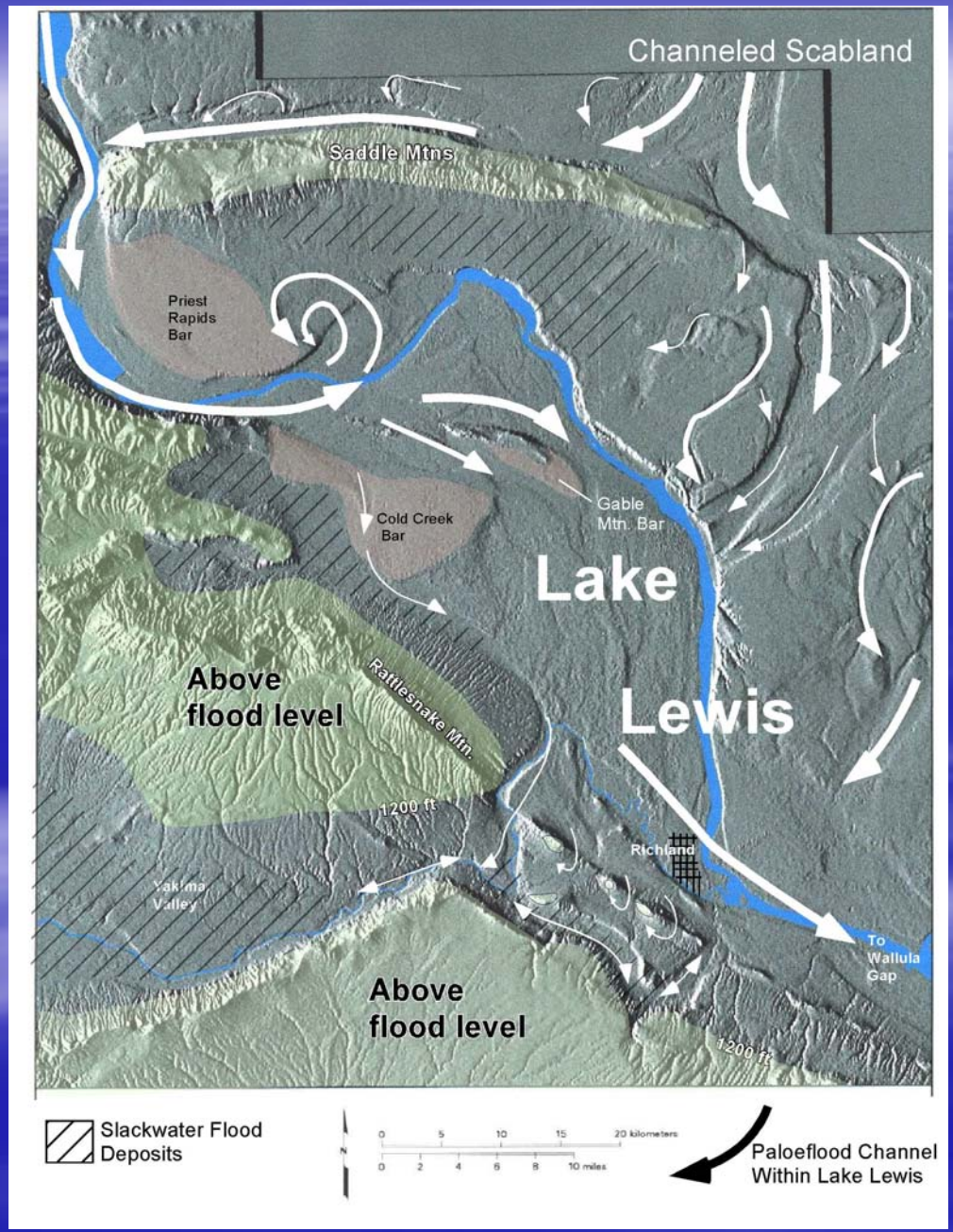
Large-Scale Flood Features of the Pasco Basin and Vicinity



Flood features stand out in this computer-generated, DEM (digital elevation model) image. Low-angle, false illumination helps to bring out small, subtle differences in topography on the Earth's surface. Areas channelized by the floods are especially striking.

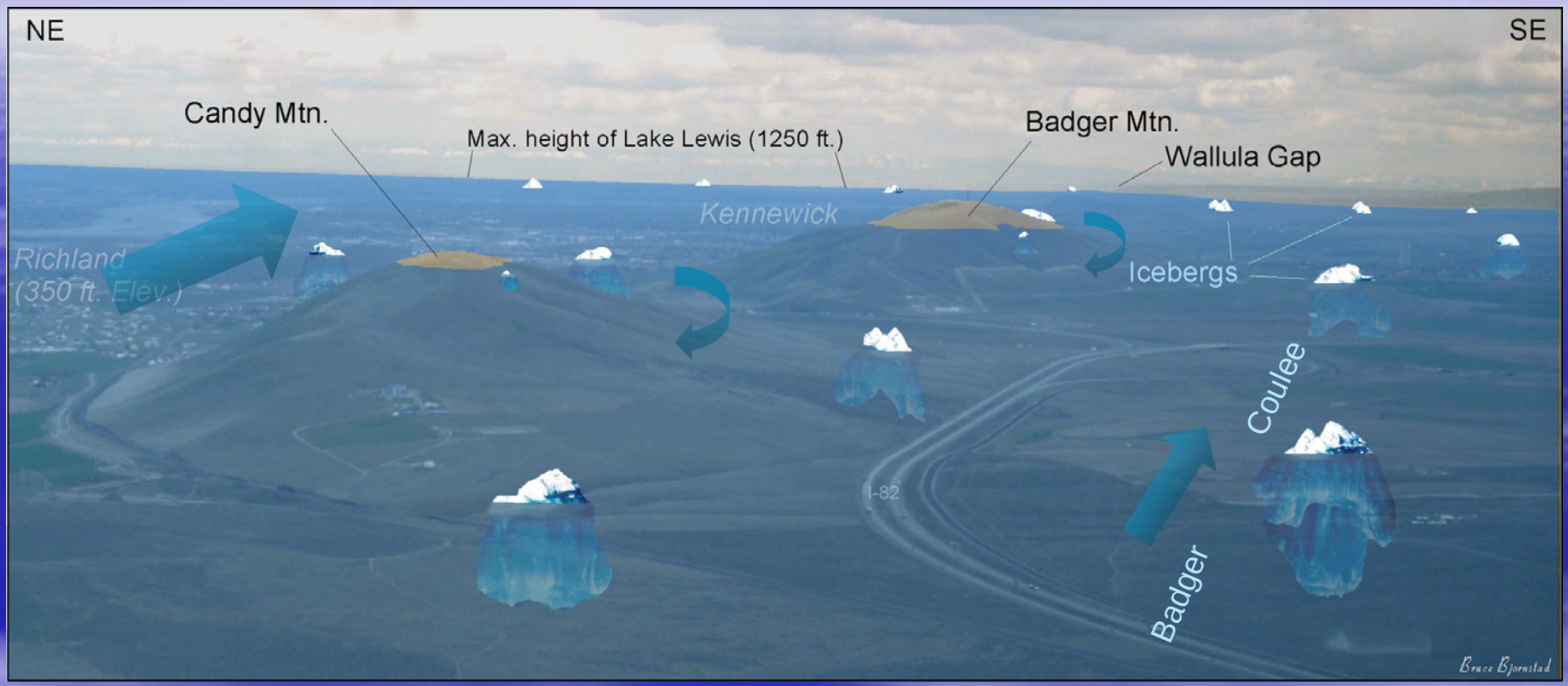
DC = Drumheller Channels
LCCC = Lower Crab Creek Coulee
SG = Sentinel Gap
PRB = Priest Rapids flood bar
CCB = Cold Creek flood bar
ABP = Anastamosing braidplain
RC = Ringold Coulee
BC = Badger Coulee

Movement of Floods Through the Pasco Basin



Illustrated with arrows are the locations of high-energy flood channels, which developed in the Pasco Basin. Notice that no channels formed around the margins of the basin, or in the back-flooded Yakima valley. At these locations, the current energy slowed down and was not powerful enough to form channels. In these areas primarily slackwater sediment was deposited.

Tri-Cities During Maximum Flood

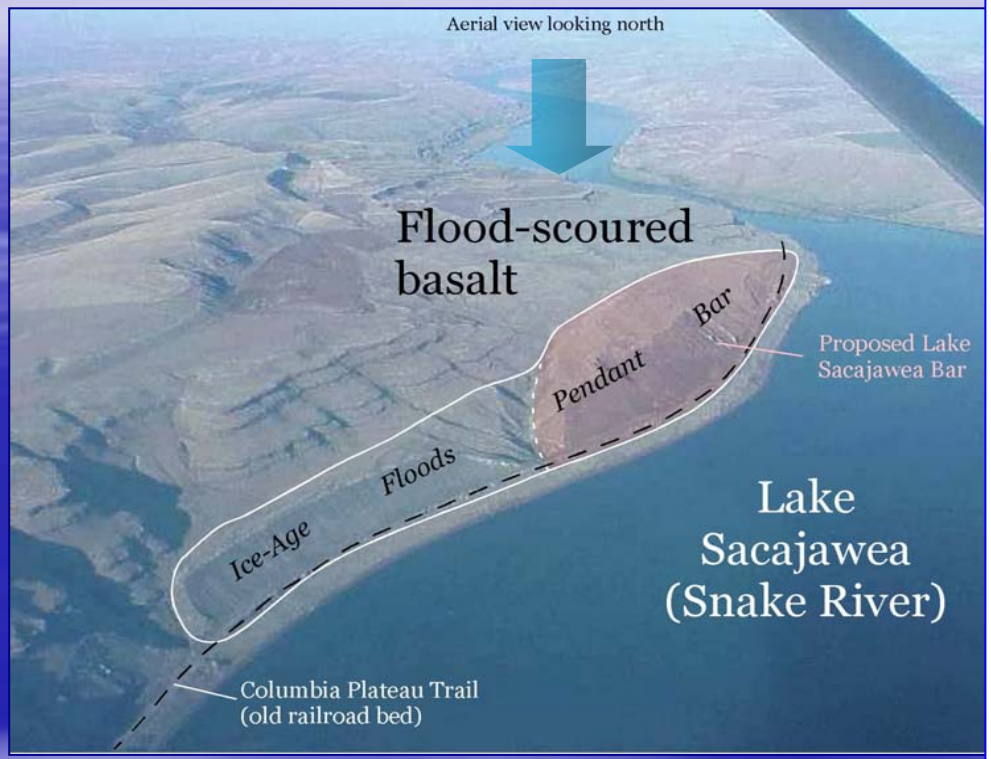


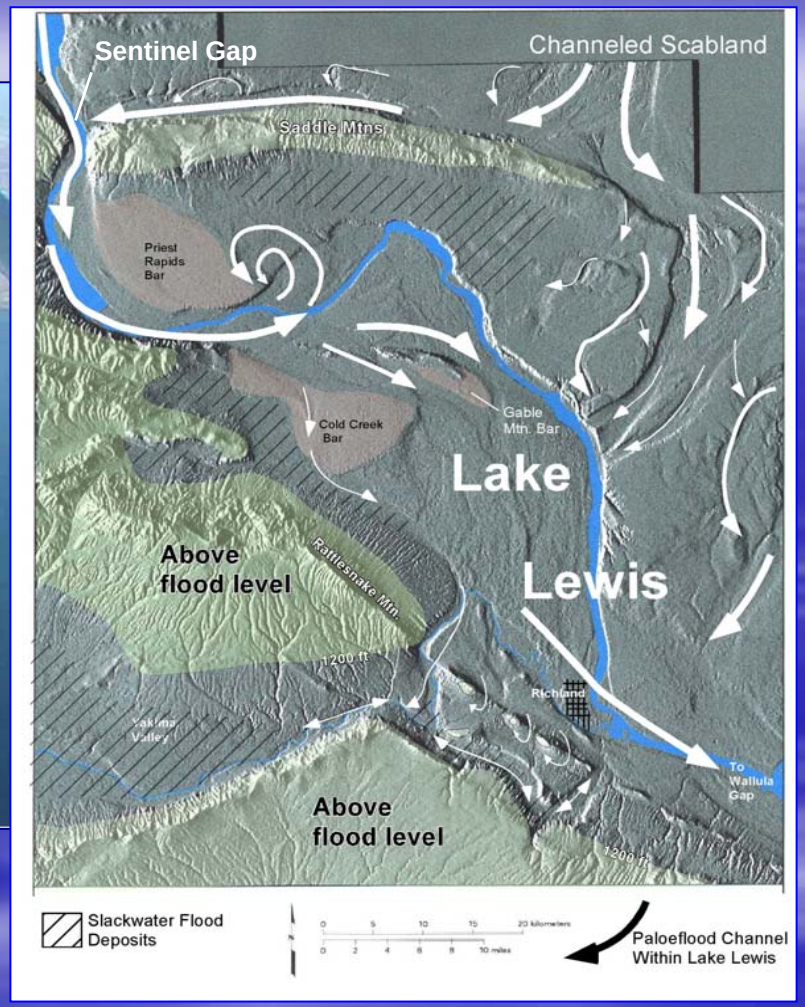
During the largest floods the Tri-Cities lay under 900 ft of floodwater (i.e., Lake Lewis) that backed up behind the hydraulic constriction at Wallula Gap. During this time the tops of the local hills (e.g., Badger and Candy Mtns.) were “islands” poking out above Lake Lewis. Icebergs naturally migrated toward the quieter waters of Badger Coulee, which was out of the main path of the floods to the north. Backeddies may have also developed as the floodwaters passed by the “islands”. The high water mark for the floods in the Pasco Basin (1200 ft elev.) is based on the maximum observed height of erratics, which is coincident with channeling at Wallula Gap.

Ice-Rafted Erratics in Badger Coulee

This pair of light-colored granodiorite boulders stands out in stark contrast with the surrounding terrain, which consists of a thick layer of windblown soil over dark basalt bedrock. The only logical explanation for these exotic boulders is that they floated in on a large iceberg. The erratics apparently became grounded against the steep hillside, 200 ft above the valley below, as Lake Lewis drained. The larger erratic is 42 ft around at the base, 11 ft high and estimated to weigh 100 tons. Applying Archimedes Principle, the size of the iceberg carrying these erratics must have been at least 25 times greater than the erratics themselves.

Giant Flood Bars





The massive scale of Ice-Age flood bars is illustrated in the two images above. Lake Sacajawea bar (left) at 400 ft high, is the tallest of the flood bars, while Cold Creek bar (right), is perhaps the longest (over 10 miles). Giant bars of gravel and sand formed along the floods path either: 1) downstream of obstructions (pendant bar), or 2) beyond flow constrictions (expansion bar). Lake Sacajawea and Gable Mountain bars are two examples of pendant bars, while Priest Rapids and Cold Creek bars, located within the Pasco Basin, are expansion bars that formed after floodwaters exited Sentinel Gap and entered Lake Lewis.

Mid-Summer Sunset Over Dusty Lake, Potholes Coulee

This ends our slide show of a bird's eye view of the many unusual and unique landforms left behind by the great Ice-Age Floods. I hoped you enjoyed this tour and invite you to learn more about these unique, earth-changing events by going to: www.iceagefloodsinstitute.org.