



## Puget Lobe Chapter Seattle, Washington

The Puget Lobe Chapter is named for the lobe of the Cordilleran Ice Sheet that overrode the Puget Sound area during the latest ice-age advance, the Fraser Glaciation. The ice sheet formed in Canada between the Rocky Mountains and the Pacific Coast. Contributions from the area between Kamloops, BC, and Vancouver Island flowed south but couldn't overtop the Cascade Range and the Olympic Mountains. The sheet split into two lobes near the eastern margin of the Olympic Mountains. The Puget Lobe flowed south into the Puget Lowland trough, and the Juan de Fuca Lobe flowed west into the Strait of Juan de Fuca to the Pacific Ocean.

To help the public see and understand this story, the Puget Lobe Chapter sponsors guest speakers at bi-monthly meetings and hosts field trips throughout the year. These presentations benefit from our large contingent of professional geologists, scientists, and engineers that share technical presentations, field guides, and public displays. To learn more about the chapter and attending a presentation, contact us at <https://IAFI.org/puget-lobe-chapter/>



Learn MORE at [IAFI.org](http://IAFI.org) or [facebook.com/IceAgeFloods/](https://facebook.com/IceAgeFloods/)

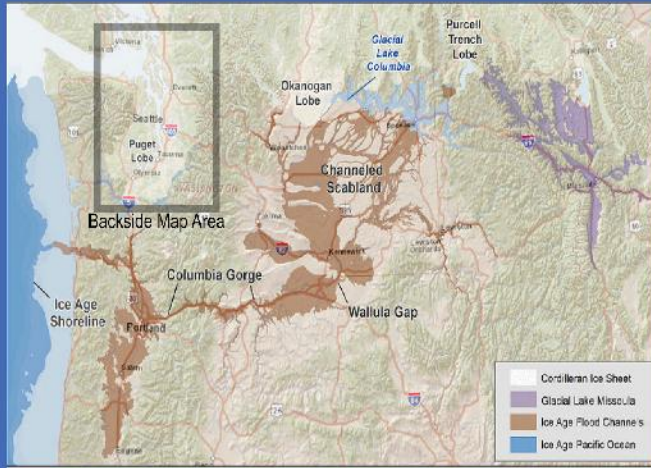


## Ice Age Floods National Geologic Trail

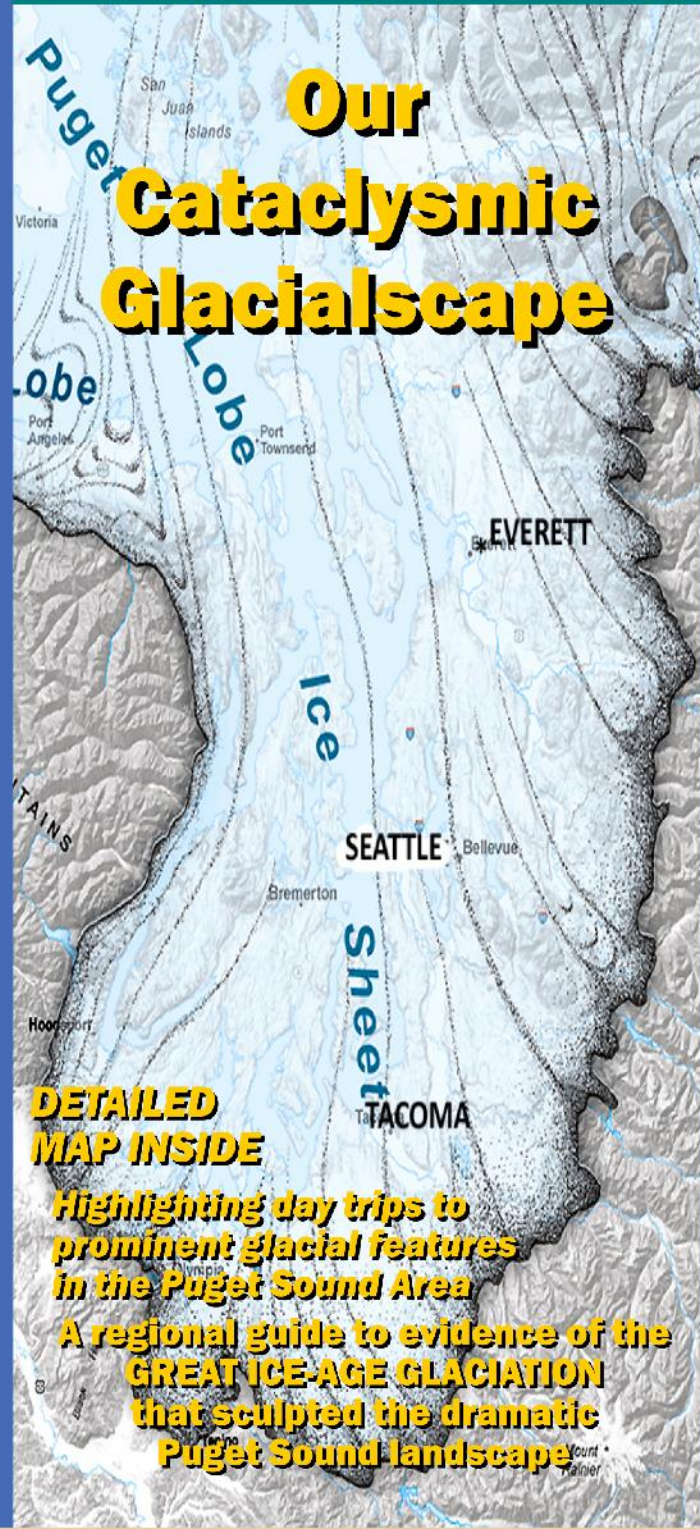
Since the 1990s the Ice Age Floods Institute (IAFI) has worked to create and to build support for the Ice Age Floods National Geologic Trail.

The Ice Age Floods National Geologic Trail is essentially a network of marked touring routes extending across parts of Montana, Idaho, Washington, and Oregon, with several special interpretive centers located across the region. Many interested parties are being brought together in an effective and collaborative interpretive program at a remarkably low cost, despite the extraordinary size of the region.

The trail is being developed under the National Park Service on existing public lands, with no changes in jurisdiction and no threats to private property rights. The role of the National Park Service is to coordinate and manage the planning of the project and the telling of the story, without taking custodianship of public and private lands.



## A GUIDE TO ICE AGE GLACIATION AND FLOODS IN THE PUGET SOUND AREA



### DETAILED MAP INSIDE

Highlighting day trips to prominent glacial features in the Puget Sound Area

A regional guide to evidence of the GREAT ICE-AGE GLACIATION that sculpted the dramatic Puget Sound landscape

## Interesting Puget Lobe Facts!



Ice-age sea level was 300 to 400 feet lower world-wide because so much water was stored in northern ice sheets.

Ice moved south of the Canadian border 19,000 years ago, blocked the Strait of Juan de Fuca 18,300 years ago, passed Seattle 17,900 years ago, and reached its maximum extent south at Olympia 16,900 years ago.

The Puget lobe was 150 miles long and 60 miles wide south of the Canadian border, and advanced southward at 450 feet/year.

As the ice advanced southward, its weight depressed Earth's crust 275 feet at Seattle and 130 feet at Olympia.

The thickness of the ice lobe was 5000 feet at the Canadian border, 3000 feet at Seattle, and 700 feet at Olympia.

By 16,000 years ago, ice had retreated (melted) sufficiently for Puget Sound to again drain to the Strait of Juan de Fuca.

By 11,000 years ago, rise of the depressed crust (isostatic rebound) to pre-ice levels in the Puget Lowland was nearly complete.

Humans were in the area by at least 13,800 years ago, as shown by the butchered remains of the Manis mastodon.



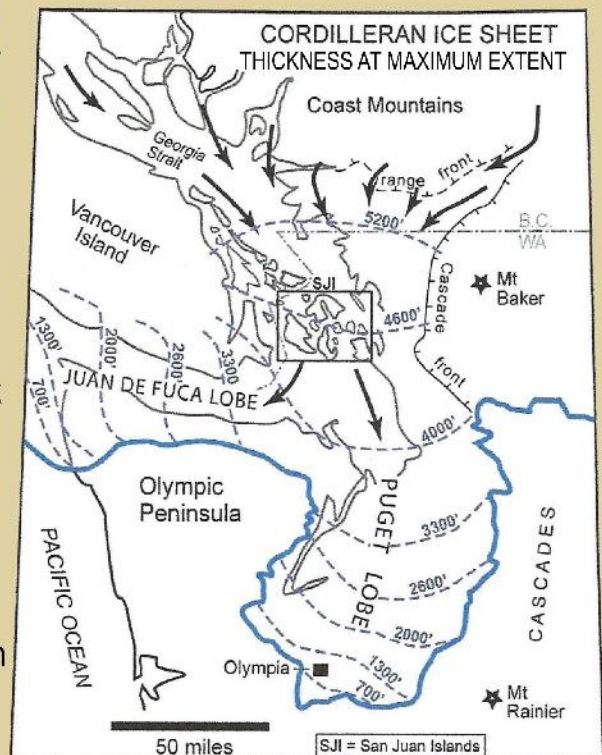
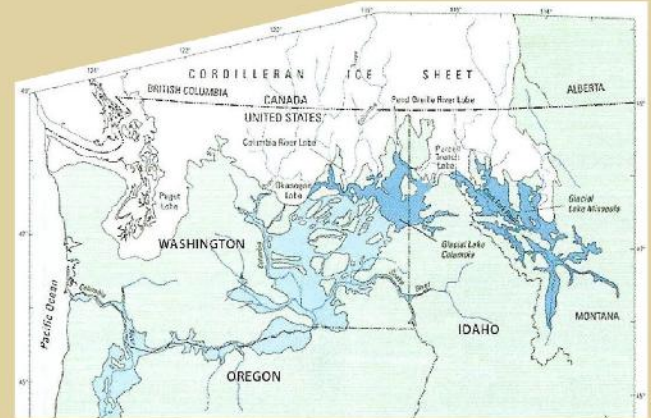
Scan this QR code for an animated advance and retreat of the Puget lobe critical to understanding this story.

## The Puget Lobe Story of Ice and Water

During the peak of the most recent ice age, the vast Cordilleran continental ice sheet covered southwestern Canada and northern parts of Washington, Idaho, and Montana. An eastern "Purcell" lobe of the ice sheet descended into the Idaho panhandle, damming the Clark Fork River with ice and impounding Glacial Lake Missoula. The ice dam failed and rebuilt repeatedly, resulting in cataclysmic floods that roared across northern Idaho, eastern and central Washington, through the Columbia River Gorge, and into Oregon's Willamette Valley before emptying into the Pacific Ocean.

Western Washington was isolated from the Missoula Floods, but it experienced similar significant sculpting by ice and water. Ice from mountain ranges in western Canada expanded south into Washington. One lobe occupied the Strait of Juan de Fuca, and another lobe covered the Puget Lowland. Water that pooled south of the ice sheet in the Puget Lowland escaped to the Pacific Ocean via the Chehalis River valley. Rivers from the western Cascade Range and eastern Olympic Mountains added to the huge volumes of meltwater from the ice sheet. Finally, the ice melted back sufficiently to reconnect Puget Sound with the Strait of Juan de Fuca, and drainage to the Pacific Ocean was restored.

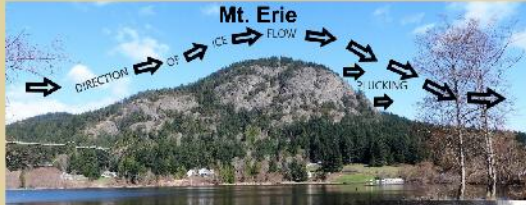
Although largely hidden by extensive vegetation, roads, housing, and commercial development, the Puget Lowland exhibits a rich variety of ice-age geologic features. Five selected sites illustrate (1) Scouring and plucking of bedrock as ice moved south from Canada; (2) Erosion by ice and meltwater as ice moved farther south; (3) Southwestern release of meltwater to the Pacific Ocean via the Chehalis River; (4) Outburst floods from impounded streams in the Cascade Range foothills; and (5) Large lakes and valleys excavated by ice and water with many glacial erratics strewn over the landscape. The IAFI.org website provides more details and lists additional Ice Age geologic sites of interest.



# Explore Prominent Ice Age Features in the Puget Sound Basin

Jump into the Continental Glacial history with a DRIVE/HIKE/LEARN day tour. Discover why our region is like nowhere else.

## 1 Mt. Erie & Washington Pk Ice Plucking and Bedrock Scouring



**MODERATE DRIVE / EASY ACCESS - ROUNDTRIP 5 hours** from Seattle, plus drive/hike Mt. Erie and Washington Park



The Canadian ice sheet encountered numerous bedrock hills and mountains in its first 40 miles south of the border, both in the San Juan Islands and on the mainland to the east (Bellingham area).

**Mt. Erie**, in a City of Anacortes park on Fidalgo Island, is an excellent example of ice-plucked bedrock. Mt. Erie's stoss (up-lobe, north) side has a gradual slope (where the automobile road is located), whereas the lee (down-lobe) side is steep, the result of ice-plucking as the ice passed over the mountain. From the top of Mt. Erie are fine views of Puget Sound to the south and vistas to the west and east, including Mt. Baker, Glacier Peak and other hills, such as Mt. Constitution in the San Juan Islands, that were similarly ice-sculpted.

**Washington Park**, also a City of Anacortes park, contains a large ice-carved groove cut in a bedrock sidewall. The moving ice carried rocks of all sizes that were the abrasive that scoured the bedrock.

## 4 Ice-Marginal Meltwater Channel and Jökulhlaups



**MODERATE DRIVE / HIKE ROUNDTRIP 2 hours** from Seattle, plus 3-hour hike

A meltwater channel at the eastern margin of the ice, formed by meltwater and runoff of western Cascade rivers, ran south along the Cascade foothills. The 90-mile-long channel from the Skykomish River south to the Nisqually River is clearly visible on lidar mapping or Google Earth. Thirty miles of the channel lie north of **Rattlesnake Lake** at North Bend. The lake occupies the spillway, a U-shaped gap gouged by the ice lobe as it rounded Mt. Si. Unable to overtop Rattlesnake Ridge, the ice found a route south past Rattlesnake Ledge. In the process, the Cedar River was rerouted, as were other rivers in the western Cascades, such as the lower Sauk and Skagit Rivers, which were diverted by Vashon ice at Rockport to flow south through the lower Sauk valley to the Stillaguamish River. In post-Vashon time these two rivers again flowed north from Darrington to the modern Skagit valley.

**Jökulhlaups** (glacial outburst floods) occurred along this 90-mile-long channel when impounded waters (temporary lakes) from Cascade rivers periodically broke through ice or moraine dams at the margin of the Puget lobe. The Skykomish River, largest of these rivers and impoundments, may have triggered sequential failures in impoundments to the south with its outburst floods. Jökulhlaups also occurred in other places as the Puget lobe retreated, such as at Penn Cove on Whidbey Island and near Tacoma.

## Lake Sammamish, Glacial Erratics and the end of the Vashon Stade Glacial Lakes



**SHORT DRIVE/EASY ACCESS ROUNDTRIP 1 hour** from Seattle, plus drive/hike at Lake Sammamish

**Lake Sammamish** is a classic ice-age remnant. Its depression, like that of Lake Washington, was excavated by moving ice and water, possibly in a pre-existing trough. Cougar Mountain offers sweeping views of the lake. Seven miles long, more than a mile wide, and 100 feet deep, Lake Sammamish is surrounded by hills 300' to 500' high.

It was one of the last glacial lakes to empty as the Puget lobe melted back. Imagine Glacial Lake Sammamish still full of 500-foot-thick ice as melting from the maximum ice thickness of 2400 feet continued. Stagnant ice trapped in the lake's depression may have taken hundreds of years to melt away. To the east, the top of Tiger Mountain (elev. 3000') was exposed above the ice as a 'nunatak'. Lower ice-covered hills, like Cougar Mountain (elev. 1600'), reappeared as the ice melted.

**Glacial Erratics** are among the most commonly noticed Ice-Age remnants. They are pieces of rock that differ from the type of rock native to the area in which they rest. They are carried by glacial ice or ice rafting, often over distances of hundreds of miles. They can be seen in many places on Cougar Mountain.

## 2 Major Troughs & Drumlins in the Seattle Area



**LOCAL FEATURES / EASY ACCESS - Walking & biking tours, plus the Space Needle**



**Major troughs** in the Puget Lowland may have been excavated by previous glaciations before the latest Vashon Glacial Stade, then partially refilled with river sediments. But in Vashon time, as the Puget lobe advanced from the north, proglacial rivers carried huge quantities of sand and gravel south (over 200 cubic miles of advance outwash), infilling the entire Puget Lowland to form a plain sloping toward the Black Lake spillway.

When the Puget lobe advanced over the Lowland, deep troughs were scoured by meltwater running subglacially (beneath the ice sheet). Our saltwater troughs are the largest ice-age features in the area. For example, the trough from Whidbey Island to Tacoma is 50 miles long, up to 8 miles wide, and 800 feet deep. Lakes Washington and Sammamish were excavated in the same way. Filled with water, these troughs add much to the Puget Sound area's scenic beauty.

**Drumlins** typically are small hills shaped by the moving ice sheet, tending towards an egg shape with steepest slopes and summit at the up-ice end. **Seattle's drumlins** are long north-south hills that complicate east-west travel through the city. The city's troughs and drumlins can be seen from ferries, bridges, or the higher hills around Seattle, and a fine aerial view of these features can be had from the Space Needle. An easy way to experience a drumlin is to walk through the **I-90 pedestrian tunnel** or walk over it through the residential neighborhood above. Lidar maps reveal drumlins elsewhere in western Washington as well.

## 3 Southwest Meltwater Escape Black Lake & Chehalis River



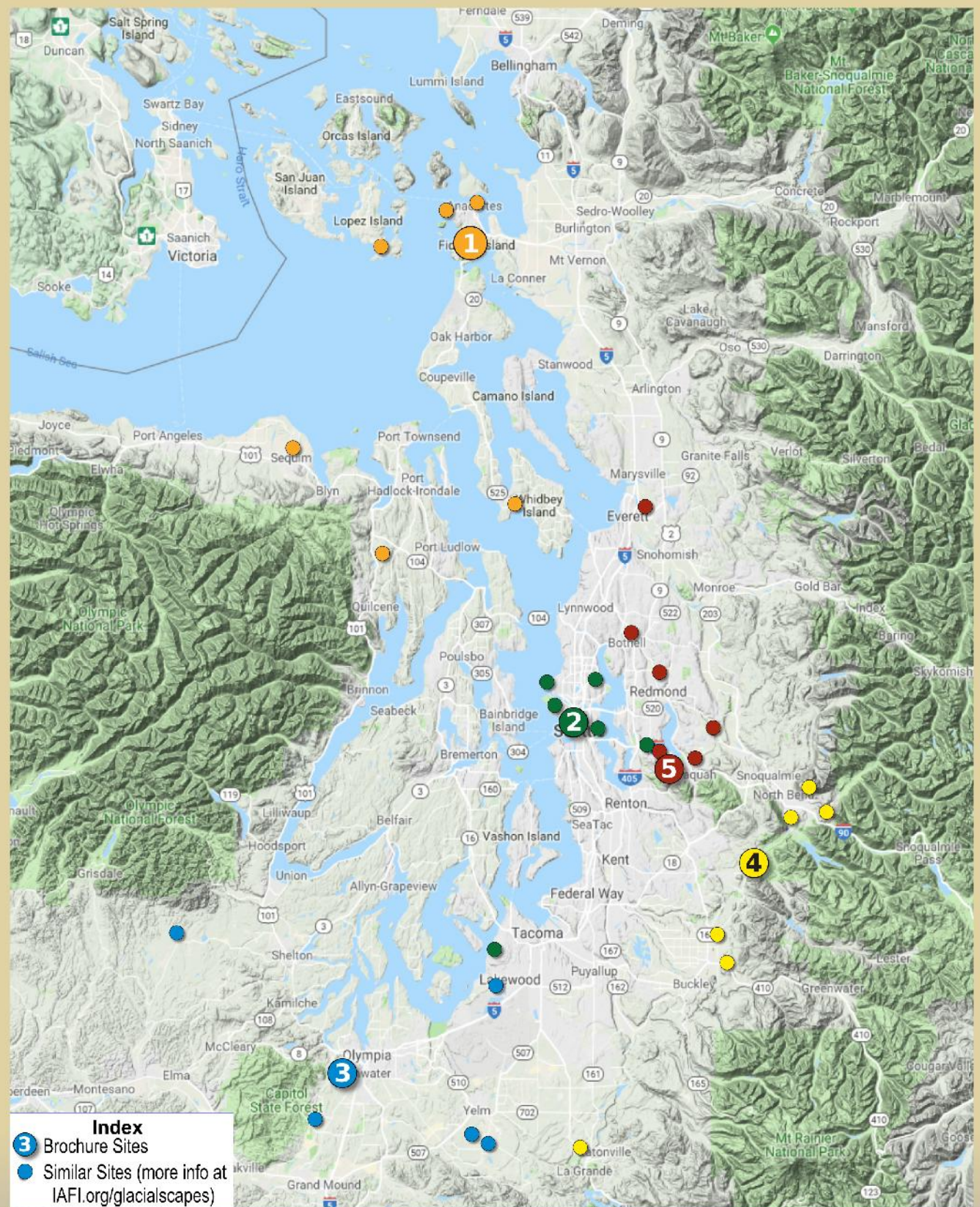
**LONG DRIVE / EASY WALKS ROUNDTRIP from Seattle, 3-7 hours** plus walking/hiking time.



The **Black Lake spillway** southwest of Olympia was the main outlet for meltwater that pooled ahead of the advancing ice lobe in proglacial Lake Russell. Black Lake, elevation 110 feet and 20 feet deep, is surrounded by glacial outwash and till, and it lies in a low part of the Puget lobe's terminal moraine area. From Black Lake, the Black River runs south and joins other meltwater paths west from Tenino to converge with the Chehalis River near Oakville. The meltwater path via Matlock joins the Chehalis River at Satsop, 27 miles downstream.

Today's slow, meandering **Chehalis River** in the valley from Oakville to Aberdeen is nothing like the raging torrent it was in ice-age times. Proglacial Lake Russell continued to drain through the Chehalis River valley until the outlet to the Strait of Juan de Fuca reopened near the end of the Vashon glacial retreat. Some estimates equate seasonal ice-age Chehalis River flow rates of meltwater, precipitation, and periodic jökulhlaups from the eastern ice margin with present-day Columbia River flow rates. The Chehalis River valley was deeper when sea level was 300 to 400 feet lower, and it connected across the continental shelf to the submarine Grays Harbor Canyon 30 miles west of Grays Harbor. Post-glacial sediment has since filled both the river's valley and its continental shelf route.

Visit <https://iafi.org/glacialscaapes/> or scan this QR code for an online interactive map and additional details about these features, associated road tours, trails, and other ice-age features in the Puget Sound area.



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