70th Highway Geology Symposium

Better highways through applied geology

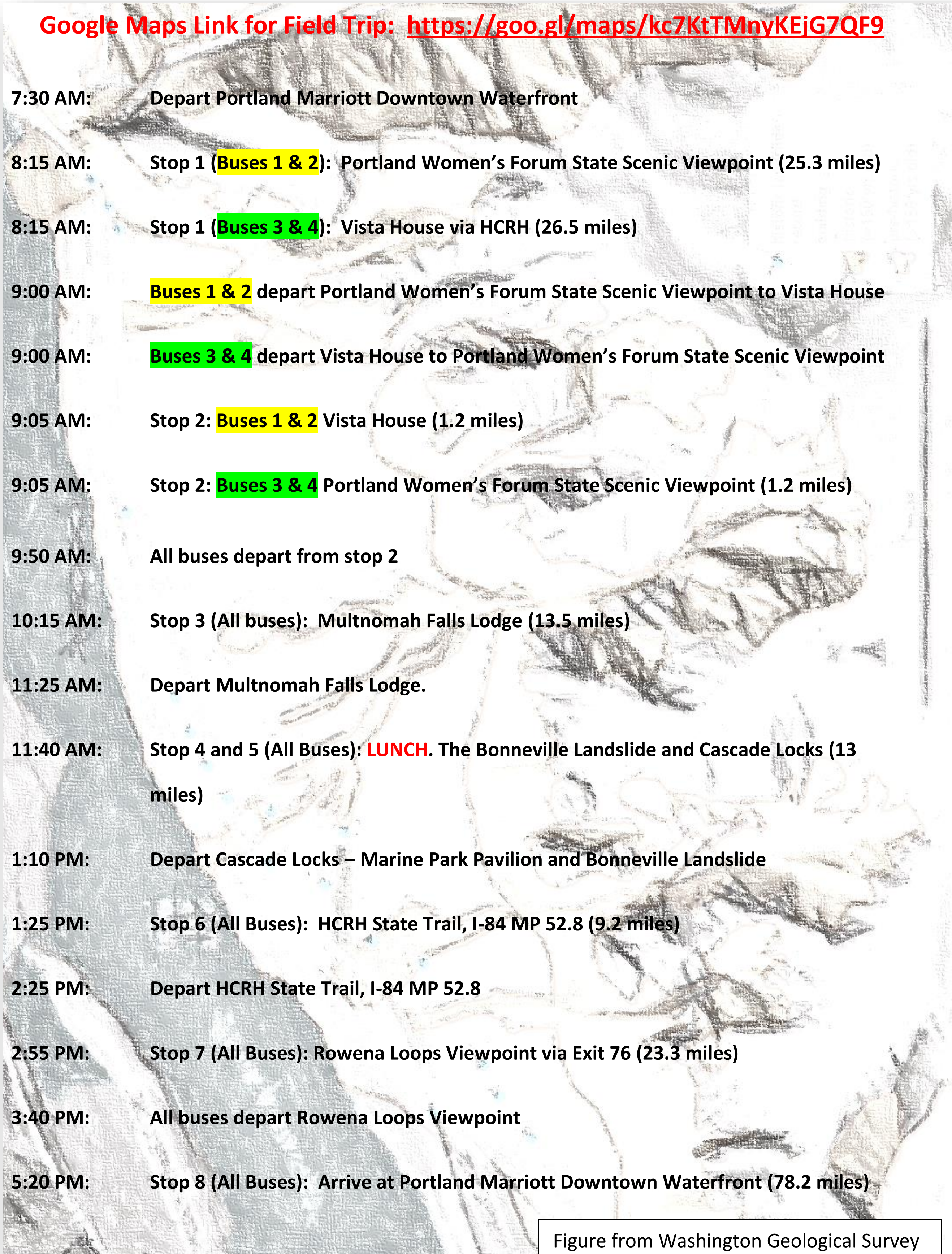
70th HGS Field Trip Guide

“The Magnificent Columbia River Gorge”

Wednesday, October 23, 2019

Figure from Washington Geological Survey.

HGS 2019 – Columbia River Gorge Field Trip Stops



Google Maps Link for Field Trip: https://goo.gl/maps/kc7KtTMnyKEjG7QF9

7:30 AM: **Depart Portland Marriott Downtown Waterfront**

8:15 AM: **Stop 1 (Buses 1 & 2): Portland Women's Forum State Scenic Viewpoint (25.3 miles)**

8:15 AM: **Stop 1 (Buses 3 & 4): Vista House via HCRH (26.5 miles)**

9:00 AM: **Buses 1 & 2 depart Portland Women's Forum State Scenic Viewpoint to Vista House**

9:00 AM: **Buses 3 & 4 depart Vista House to Portland Women's Forum State Scenic Viewpoint**

9:05 AM: **Stop 2: Buses 1 & 2 Vista House (1.2 miles)**

9:05 AM: **Stop 2: Buses 3 & 4 Portland Women's Forum State Scenic Viewpoint (1.2 miles)**

9:50 AM: **All buses depart from stop 2**

10:15 AM: **Stop 3 (All buses): Multnomah Falls Lodge (13.5 miles)**

11:25 AM: **Depart Multnomah Falls Lodge.**

11:40 AM: **Stop 4 and 5 (All Buses): LUNCH. The Bonneville Landslide and Cascade Locks (13 miles)**

1:10 PM: **Depart Cascade Locks – Marine Park Pavilion and Bonneville Landslide**

1:25 PM: **Stop 6 (All Buses): HCRH State Trail, I-84 MP 52.8 (9.2 miles)**

2:25 PM: **Depart HCRH State Trail, I-84 MP 52.8**

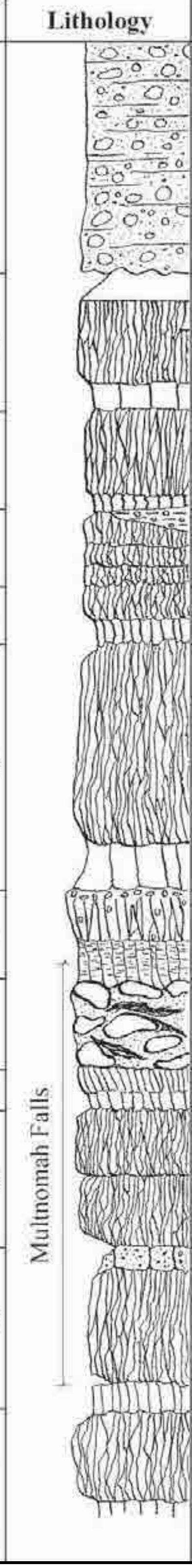
2:55 PM: **Stop 7 (All Buses): Rowena Loops Viewpoint via Exit 76 (23.3 miles)**

3:40 PM: **All buses depart Rowena Loops Viewpoint**

5:20 PM: **Stop 8 (All Buses): Arrive at Portland Marriott Downtown Waterfront (78.2 miles)**

Figure from Washington Geological Survey

Stratigraphic Section Along Multnomah Creek, Multnomah County, Oregon



Fm.	Thick-ness	Description
Troutdale	variable, >200 ft	Troutdale gravels. Cobbles are chiefly Columbia River basalt, but there are a wide variety of other rock types. Sandy to tuffaceous matrix. Unconformity
Grande Ronde Basalt of the Columbia River Basalt Group	120 ft	10-ft covered interval. Hackly entablature, colonnade of 4-ft-diameter columns. Intersertal texture with abundant tachylyte pools. Abundant microphenocrysts of plagioclase and pyroxene.
	85 ft	Entablature: blade-like to edge-like jointing; Colonnade: 1-ft wavy columns. Intersertal, tachylyte-rich flow, non-porphyritic.
	65 ft	Interbed of tuffaceous silty clay, 1 to 2 ft thick. Three-tiered flow; no colonnade. Glassy texture with small vesicles; intersertal and non-porphyritic.
	50 ft	Similar to flow above, but entablature and colonnade present. Intersertal; numerous microphenocrysts of plagioclase and pyroxene.
	225 ft	Entablature: very long, small to bladed columns 3 to 6 in. thick. Colonnade: short, massive columns 5 to 8 ft in diameter. Intersertal and rich in tachylyte in the entablature; colonnade more crystalline, but fine-grained and rich in brown crystallite-filled glass. Both have sparse microphenocrysts of plagioclase.
	80 ft	10-ft vesicular top, and scattered vesicles throughout entablature. Colonnade has platy joints. Abundant microphenocrysts of plagioclase and pyroxene and rare phenocrysts 1 cm long. Intersertal texture.
	75 ft	Pillow lava. Many elongated streaks of lava and hyaloclastic debris between patches of pillows. Abundant microphenocrysts of plagioclase and pyroxene.
	35 ft	Thin glassy flow with well-formed colonnade and entablature.
	120 ft	Two tiers of hackly jointed material. No colonnade. Intersertal; scattered microphenocrysts of plagioclase and a few of pyroxene.
	140 ft	Blocky, vesicular zone at top that forms the marked horizontal crevasse 100 ft above the base of Multnomah Falls. Entablature: hackly, thin columns; Colonnade: 2 to 4 ft columns. Intersertal; sparse microphenocrysts of plagioclase and pyroxene. Abundant interstitial chorophaeite.
	70 ft	Hackly entablature weathering into rounded forms; thin colonnade. Intersertal; abundant microphenocrysts of plagioclase and pyroxene.
	50 ft	Covered interval to level of Columbia River.

Figure from Washington Geological Survey

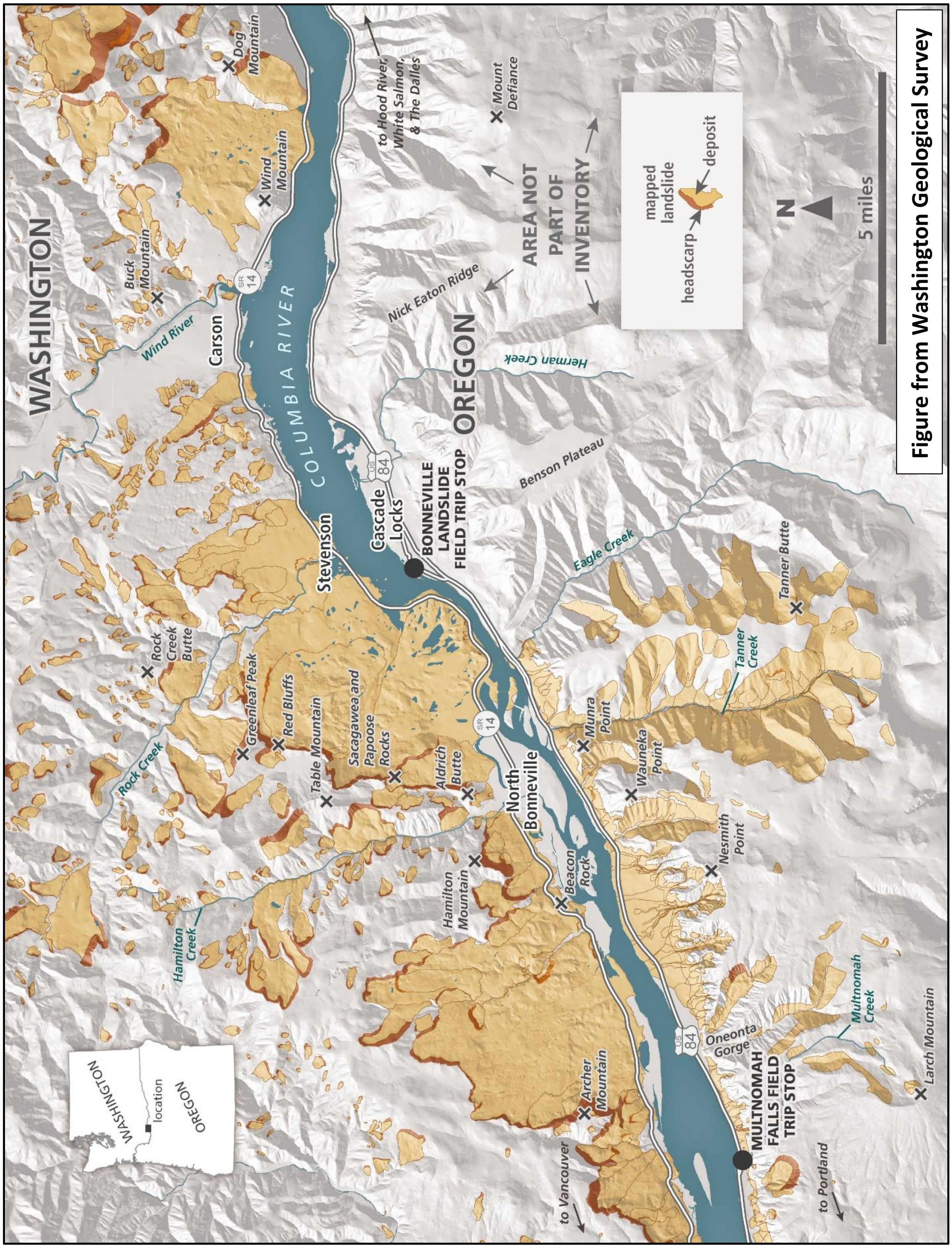


Figure from Washington Geological Survey

Stop 1/2: Portland Women's Forum State Scenic Viewpoint (Chanticleer Point)

8:15 AM: **Stop 1 (Buses 1 and 2): Portland Women's Forum State Scenic Viewpoint (25.3 miles, 35 minutes, no restroom facilities). Total duration at stop 1 is 45 minutes.**

Note *the historic guardrail sections and mile markers and the creeping landslide headscarp that we cross at the top of the large Rooster Rock Landslide complex as we leave the Women's Forum State Scenic Viewpoint and head toward the Crown Point Vista House*

9:05 AM: **Stop 2: (Buses 1 and 2): Crown Point Vista House via HCRH – (1.2 miles, 5 minutes, restroom facilities available – elevator available for ADA if needed). Total duration at Stop 2 is 45 minutes.**

Aerial photograph courtesy of Oregon Department of Transportation (ODOT) of the Portland Women's Forum State Scenic Viewpoint parking area looking northward.

Presenter: Robert Hadlow (ODOT) – *Upper Lot at the placard*

At Portland Women's Forum State Scenic Viewpoint, participants will learn about the Historic Columbia River Highway (HCRH). The talk will focus, in part, on why this location was so important in 1913 for rallying support for the highway's construction. Portland Women's Forum State Scenic Viewpoint was formerly the location of Chanticleer Inn, a rural restaurant that served country dinners to those folks who had automobiles at the time and could venture out of Portland on county roads. Chanticleer Inn was also the location where Sam Hill, the highway's promoter, assembled a group of good roads advocates in August 1913 to persuade the Multnomah County commissioners to provide funding for its initial construction. Hill's strategy paid off. Shortly, the commissioners raised the money through bonds. Surveying for the new highway started in September 1913 and construction began in October 1913. Road advocates celebrated the HCRH's completion in Multnomah County in 1916.

Presenter: Scott Burns (Portland State University (PSU)) – *Lower Lot at the placard*

This site is one of the most spectacular sites in the whole Columbia River Gorge National Scenic Area. It is also one of the five most photographed sites in Oregon. Here we will talk about many things we can see. We compare the Oregon side, which is quite vertical (mainly stacked layers of Columbia River Basalt on top of one another) vs the Washington side, which is low angle (mainly landslides riding on the Ohanapecosh Formation).

We will discuss the story of the two floods that formed the Gorge. The first set of floods were from 15-16.7 million of years ago (Ma), and those were the flood basalts that formed the bedrock, Columbia River Basalt. They came from fissures where Oregon, Washington and Idaho come together, and they flowed to here. The second set of floods were the great Missoula Floods which came through here and deepened and widened the Gorge that was already here. There were 40 floods that reached here between 15,000-18,000 thousand years ago. The floods came as outburst floods from the breaking up of the ice dam that had formed Glacial Lake Missoula in Montana (Flathead Lake Area). The floods covered 16,000 square miles in the Pacific Northwest.

Other features we will talk about are Mt. Zion (cinder cone), Larch Mountain (shield volcano), Crown Point inter-canyon flow, Rooster Rock Landslide, Beacon Rock volcanic plug, sand dunes along the river, and the winds of winter in the Gorge.

Stop 1/2: Crown Point Vista House

8:15 AM: **Stop 1 (Buses 3 and 4): Vista House via HCRH - (26.5 miles, restroom facilities available – elevator available for ADA if needed). Total duration at stop 1 is 45 minutes.**

Note *the historic guardrail sections and mile markers and the creeping landslide headscarp that we cross at the top of the large Rooster Rock Landslide complex as we leave the Women's Forum State Scenic Viewpoint.*

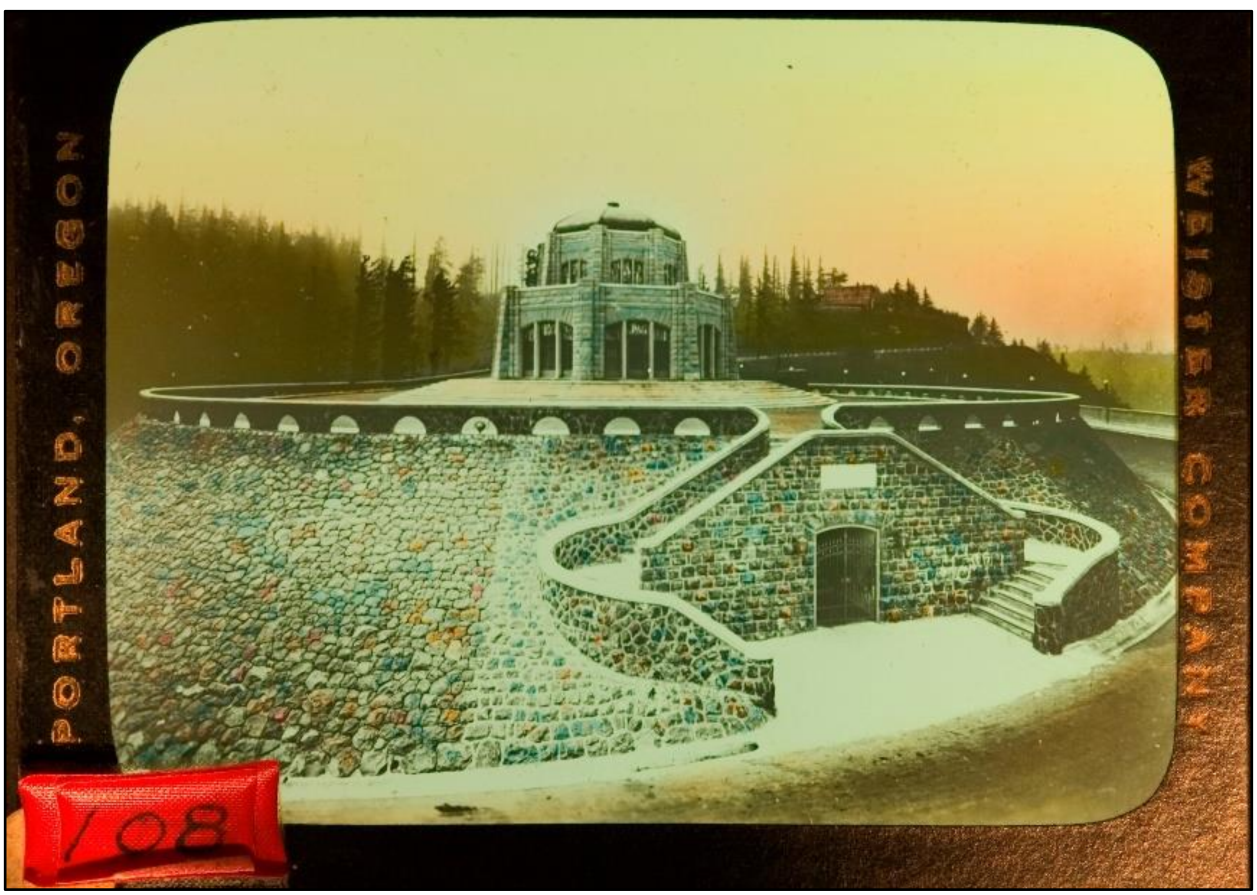
9:05 AM: **Stop 2: (Buses 3 and 4): Crown Point Vista House to Women's Forum – (1.2 miles, 5 minutes, no restrooms available). Total duration at Stop 2 is 45 minutes.**

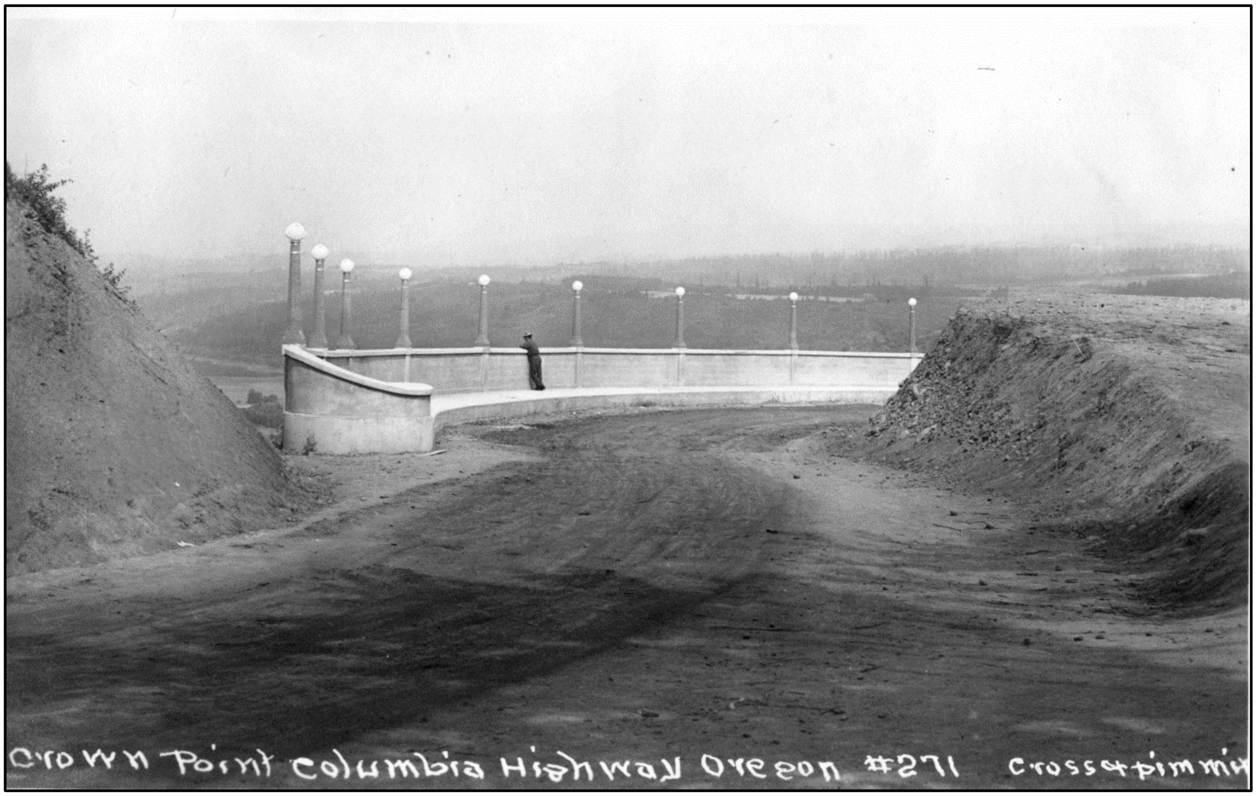
Presenter: Bob Hadlow (ODOT)

Overview of the Columbia River Highway and History of Vista House – *Inside on main level*.

At Vista House, participants will learn about the significance of this wonderful building that opened on Crown Point in 1918. Vista House is a monument to Oregon Pioneers and its rotunda contains artwork dedicated to their memory. The building also has an outdoor observation deck that offers wonderful views up and down the Columbia River. Finally, Vista House was equipped with the most modern of public comfort stations in its day, when traveling outside cities was very primitive.

<u>Above:</u> Aerial photograph courtesy of ODOT of the Crown Point Vista House looking eastward.
<u>Below:</u> Historic photograph of Crown Point Vista House.





Historic photograph of Crown Point Columbia Highway before Crown Point Vista House construction.

<u>Presenter: Nathan Jenks</u> (Bonneville Power Administration (BPA)); *<u>inside on the main level.</u>*

The Crown Point Viaduct Restoration Project was a collaborative effort between ODOT, the FHWA – WFLHD, Oregon State Parks, and a number of other stakeholders and interested parties. The project involved restoring the approximately 600-foot-long, 8-foot-wide, cast-in-place viaduct which was originally constructed in 1914. The viaduct provides an elevated pedestrian walkway with sweeping views of the Columbia River Gorge.

The overall goal of the project was to repair and strengthen the aging viaduct and associated retaining wall while maintaining the appearance and as much of the original structure as possible. The viaduct was in poor condition prior to restoration with cracked and damaged support columns, beams, and deck as well as inadequate foundation support. Portions of the dry-stacked stone retaining wall beneath the viaduct were also in poor condition with failed sections, bulging, settlement areas, and loss of backfill, which in-turn threatened the roadway immediately adjacent to the viaduct.

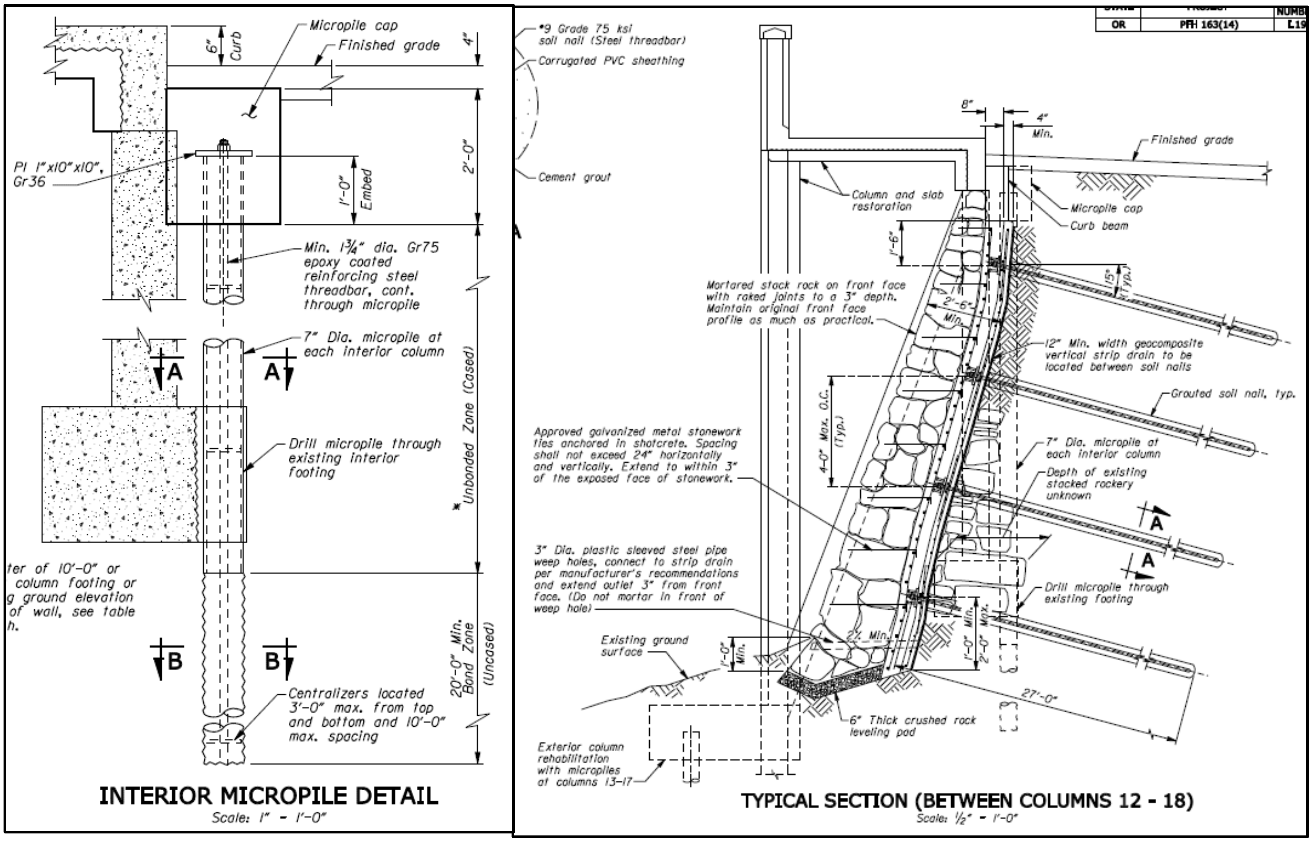
The viaduct is located on a sharp curve, and the ground surface slopes steeply away on the west, north, and east sides. A vertical cliff face dropping to the valley floor is located several tens of feet from the viaduct on the north and east sides. The site is mantled with gravel and cobbles deposited by the Pleistocene-age Missoula floods, underlain by the Miocene-age Grande Ronde Basalt member of the Columbia River Basalt Group. Stratigraphy at the site varies but generally consists of the following as measured from the roadway elevation immediately adjacent to the viaduct: 4 to 8 feet of roadway fill, 20 to 50 feet of Missoula Flood Deposits, 3 to 5 feet of weathered/decomposed basalt, over strong to very strong basalt.

The primary geotechnical elements of the project included reestablishing adequate foundation support for the 29 column pairs, as well as reconstruction of approximately 110 feet of retaining wall with wall heights up to about 18 feet. Structural repairs and rehabilitation to the columns, beams, and deck/sidewalk were also included. Numerous alternatives were considered and generally fell within three overall concepts, 1) remove and replace existing roadway, fill, and retaining wall and reconstruct or repair various elements, 2) provide supplemental foundation support as needed and construct a soil-nail wall to stabilize the failed wall areas, and 3) construct a reticulated micropile wall.

Approach #2 was the selected alternative based primarily on cost and constructability considerations, but also for its benefits in retaining the historic character of the structure. Both options 2 and 3 allowed for continued, one-lane traffic, during construction which was an important requirement for ODOT and other stakeholders.

The final design for the geotechnical elements included providing supplemental foundation support through the use of micropiles at all 29 of the interior column foundations and 15 of the 29 exterior column foundations as shown on the attached figure. The existing dry-stacked stone retaining wall was partially removed using a top down approach and a soil-nail wall was constructed for the full height to provide a durable retaining wall system. The dry-stacked stone that was removed for construction of the soil-nail wall was then replaced as facing to retain the historic appearance and materials as used in the original construction. While the construction was not without challenges, the overall project was considered a great success with positive feedback from the stakeholders and the public.

Photos of the viaduct prior to restoration project. Note the additional support at exterior columns in the left photograph on the left and the failed wall section in the photograph on right.



Plan details. <u>Left detail</u> shows interior column micropile support. <u>Right detail</u> shows soil-nail wall stabilization and exterior micropile support.

Construction photo showing completed micropiles and micropile cap on the interior side.

Construction photo showing soil-nail wall construction beneath viaduct on the exterior side.

9:50 AM: **__ALL BUSES__ Depart Vista House and Women's Forum Scenic Viewpoint.**

__Note__ *the beginning of cascades section on Interstate 84 at Latourell Falls and the first signs of Eagle Creek Wildfire begins at Shepperd's Dell.*

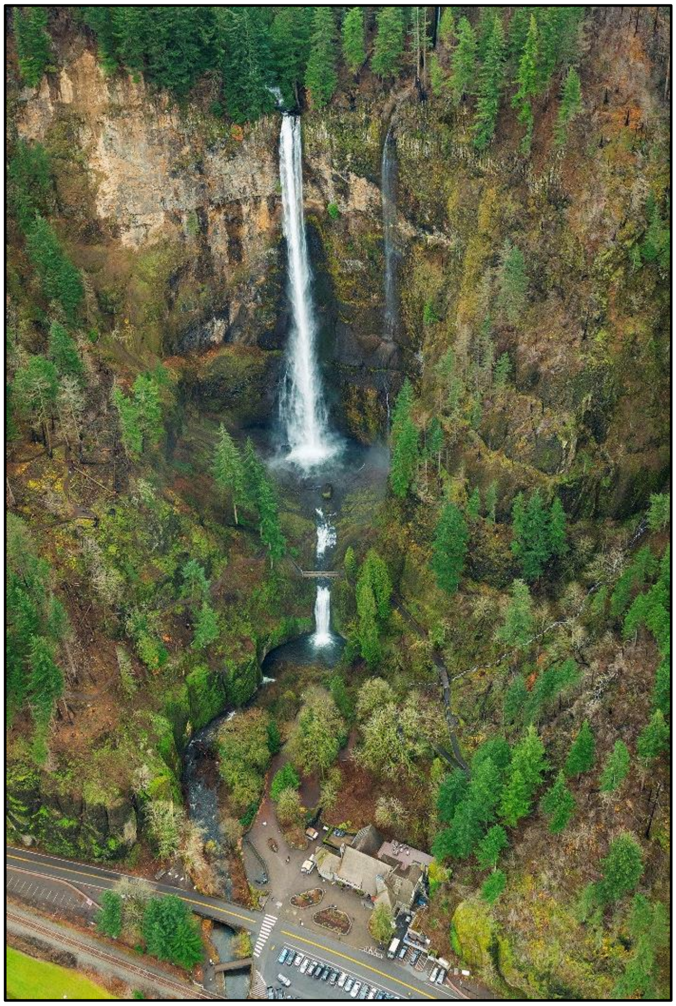
10:15 AM: **Stop 3 (All Buses): Multnomah Falls Lodge via Corbett on-ramp to I-84 – 13.6 miles, 21 minutes, restroom facilities available. Total duration at stop 3 is 60 minutes.**

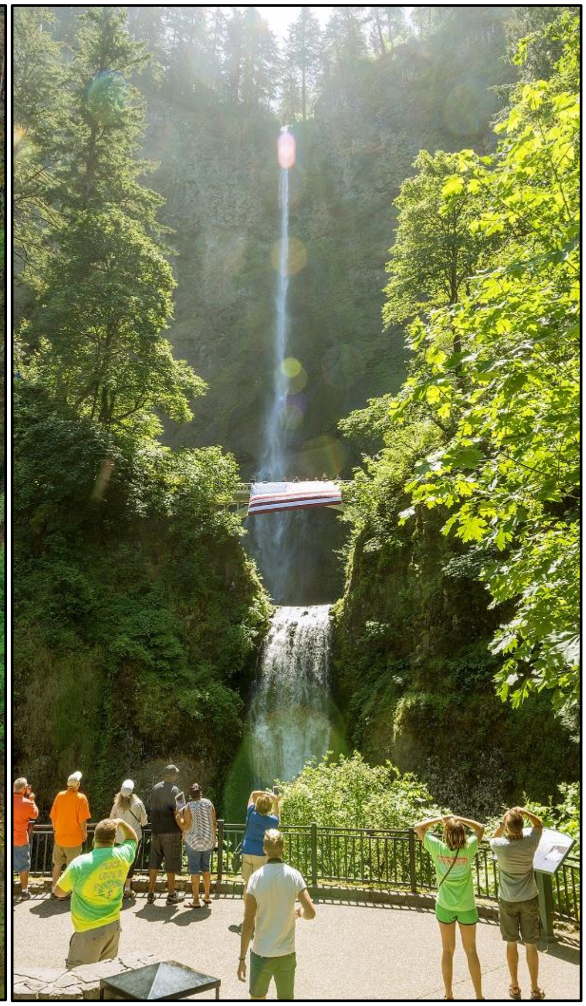
Stop 3: Multnomah Falls Lodge

__Presenters: Ryan Cole__ (United States Forest Service (USFS)) and **__Stephen Hay__** (ODOT) - *__Base of Falls discussion followed by a short hike to Benson Bridge to look at the different flexible rockfall fences and take pictures of the Falls from Benson Bridge if time allows.__*

Multnomah Falls is over 600 feet high and is fifth highest waterfall in the US. We will discuss the site geology, provide an overview of the Eagle Creek Fire - Response and Repairs and Future Preparedness.

The Eagle Creek Fire began September 2, 2017 near the town of Cascade Locks, and burned 48,861 acres of federal, state, county and private lands within the Columbia River Gorge National Scenic Area. Multiple federal, state, and local agencies responded to the fire which impacted Interstate 84 (I-84), the primary east-west transportation corridor from Portland, local communities, and significant cultural landmarks such as the Multnomah Falls Lodge. Mandatory evacuations were ordered throughout the affected area and I-84 was closed for weeks due to fire related damage. A United States Forest Service (USFS) Burned Area Emergency Response (BAER) team, with cooperation from the (ODOT), was established in September





<u>Left:</u> Aerial photograph courtesy of ODOT of Multnomah Falls. <u>Right:</u> Photograph looking up at the Falls and Benson Bridge.

2017 to assess the risk of post-fire threats to Critical Values at Risk. Significant geohazards, including debris flows, debris dam outburst flooding, and rockfall were identified throughout the burn area. Post-fire emergency treatments initiated by the USFS and ODOT included hazard tree falling and rockfall mitigation.

Fire impacts at the historic Multnomah Falls Lodge only consisted of smoke damage due to the courageous efforts by fire strike teams to save the historic structure. The Lodge was closed for three months and the HCRH at this location remained closed until November 2018. Geotechnical specialists from the USFS and the ODOT assessed impacted infrastructure throughout the burn area. Hazards identified at Multnomah Falls included hazard trees and rockfall. Hazard trees have been removed and rockfall fences placed along the south side of the HCRH and upslope of the Lodge. Approximately 3,000 lineal feet of 10 foot-high flexible rockfall fences have been installed and more frequent rockfall is estimated to continue for 5 to10 years post-fire. Significant progress has been made to reduce the risk of hazard trees and rockfall falling within the fire perimeter, but much work remains.

Looking down the rockfall chute where a 10 foot-high flexible rockfall fence was constructed above the historic Multnomah Falls Lodge.

Approximately 3000 linear feet of 10 foot-high flexible rockfall fence along the Historic Columbia River Highway near Multnomah Falls Lodge.

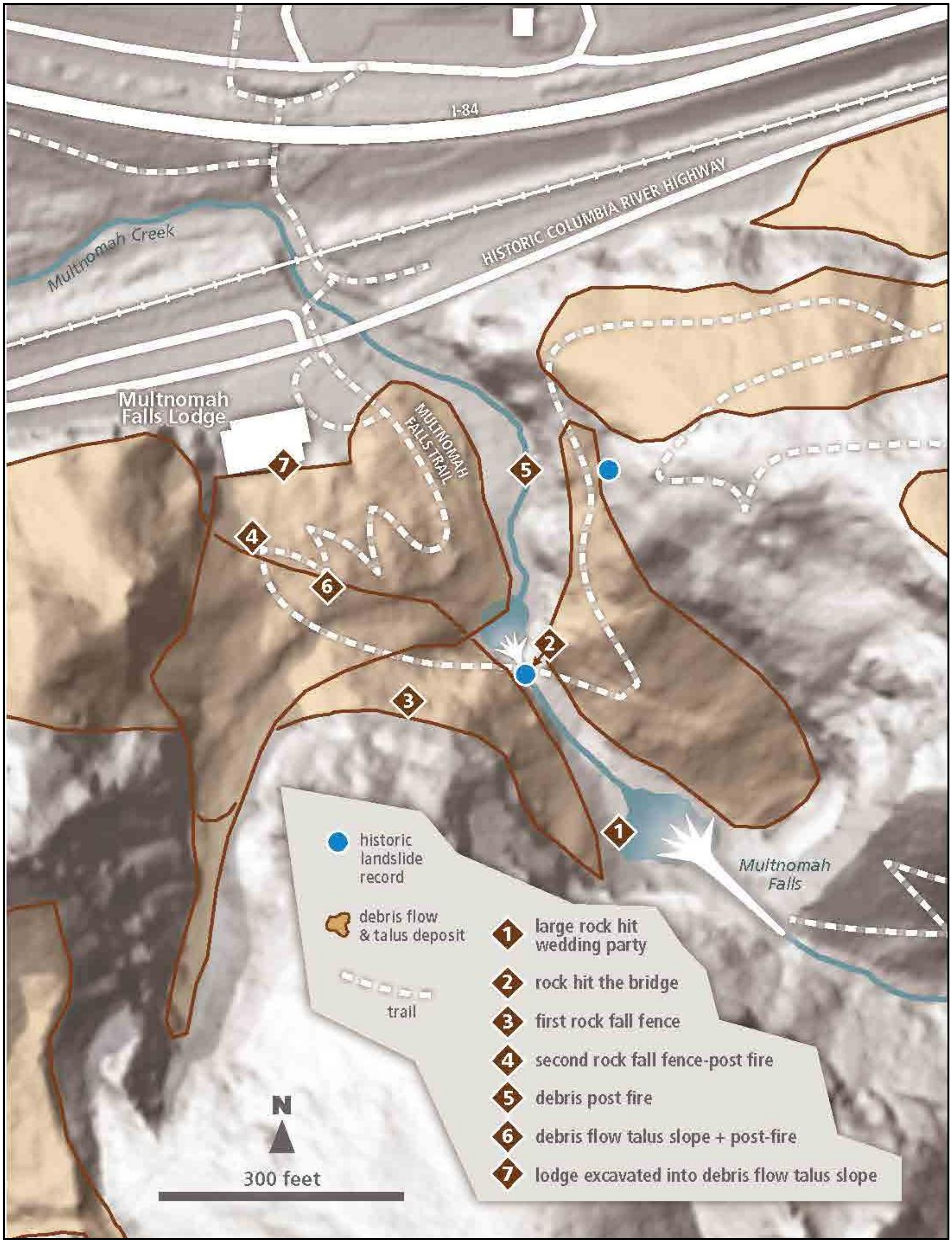


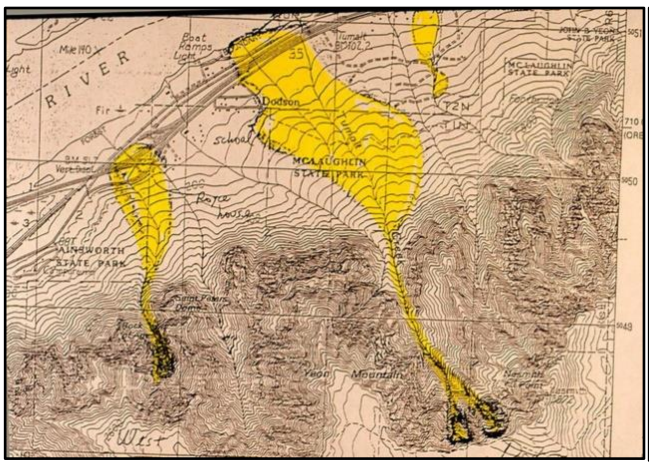
Figure from Washington Geological Survey.

11:25 AM: Depart Multnomah Falls Lodge

Note *the long sections of flexible rockfall fences and recent hazard tree removal as we head east of Multnomah Falls; the Oneonta Tunnel closure and rehab that is ongoing following the fire, the Dodson Debris Flow Fan and events from 1996 to present; and that we are approaching the nexus of the wildfire initiation as we look east as we pass John B. Yeon Trailhead on our way to Cascade Locks. Also note that people will begin to see a parallel trail that weaves in and out of the forest as we head east on I-84. This is referred to as the Historic Columbia River Highway State Trail and we will be hearing more about this in the afternoon.*

THE DODSON DEBRIS FLOWS – "A Story Along the Way…"

In the middle of the Gorge is a large debris flow/alluvial fan with the hamlet of Dodson on it. This large debris flow and alluvial fan most likely has formed from repeated debris flows over the past 15,000 years building it after the last Missoula Flood flowed through the Gorge. In February 1996, Northwest Oregon and Southwest Washington State received a huge amount of precipitation from a large "Pineapple Express," or Atmospheric River, from the central Pacific in four days. In the Gorge, we got over 35 inches of precipitation. It caused seven major debris flows on this fan.



Left: Topographic map with alluvial fan and debris flow channels highlighted in yellow. Right: Oblique photograph taken from Washington looking southwest at Dodson alluvial fan complex.

The first one was the Royce Debris Flow which occurred just after noon on the second day of the storm. A house was inundated by at least 4 pulses over the next three days. The debris flow moved about 6.5 miles per hour (mph). This blocked I-84 and the train tracks. Later that same day at 10 PM, another debris flow came from a landslide dammed lake upstream that breached and sent a huge debris flow down the drainage at over 35 mph down Tumult Creek. This debris flow impacted several trucks on I-84 and six cars of a train into the Columbia River. Thankfully, no one was killed. In the intersection near the Royce Debris Flow, where the old highway intersects I-84, another debris flow occurred in 2001 and filled up the whole on-ramp intersection with debris, but did not impact I-84. With the great relief, the presence of colluvium hollows that collect debris during periods of acquiescence between large storm events in the headwaters of several creeks and streams in the Gorge, and the propensity for large tropical storms to impact the NW each year, debris flows continue to be a major geohazard that shapes and impacts the Gorge.

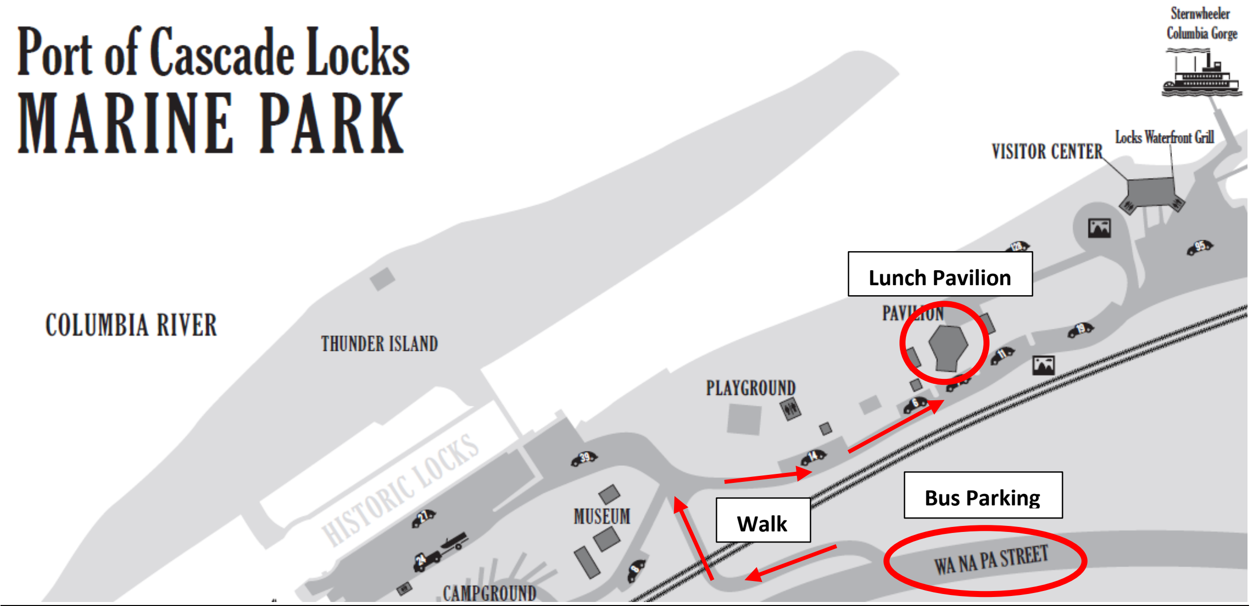
 

<u>Left:</u> Tumult Creek Debris Flow across I-84 and railroad. <u>Right:</u> Royce Debris Flow (west end of fan).

Figure from Washington Geological

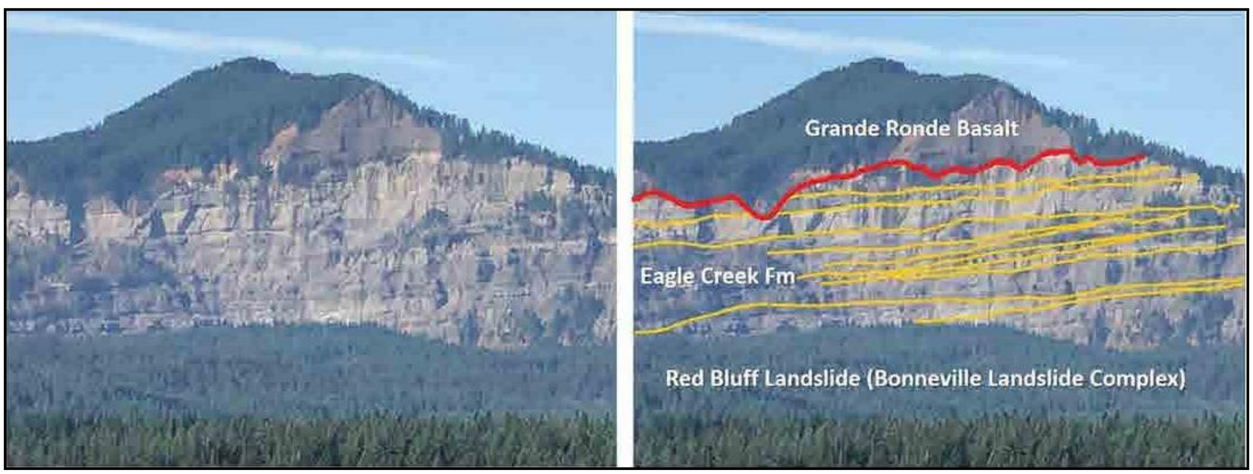
11:40 AM: **Stop 4 and 5 (All Buses): LUNCH. The Bonneville Landslide and Cascade Locks – Marine Park Pavilion (Lunch) via HRCH, get on I-84 at Exit 35 East and get off at Exit 44, Cascade Locks 13.3 miles, 14 minutes, restroom facilities available, total duration at Stops 4 & 5 is 90 minutes.**

STOP 4/5: LUNCH AND BONNEVILLE LANDSLIDE



Map of Bus Parking and Pavilion Locations for Stop 4 (Lunch) and Stop 5.

<u>Presenter: Scott Burns</u> (PSU) – <u>*Meet at the Pavilion after lunch.*</u>



The Bonneville Landslide headscarp with geologic stratigraphy mapped on the right.

The Bonneville Landslide is the most studied landslide in the Pacific Northwest because we built our first dam on the Columbia River buttressed up against it in 1937 – Bonneville Dam. One did not want to have a landslide that might reactivate and cause the dam to fail. This landslide came down from the Washington side and crossed the Columbia River and totally stopped flow for a number of years. It killed the forests upstream (noted by Lewis and Clark when they came through here in 1805). It created a lake all the way to The Dalles, Oregon, over 55 miles upstream. Eventually, the dam broke and a wall of water 50 feet-high flowed down into what is now Portland. It created the Cascades of the Columbia, the most treacherous reach of the river to cross. Dating of logs from the landslide and tree trunks of dead trees in back of the dam give an approximate date of the landslide to be 1450 AD. It most likely was initiated by an earthquake that happened then up near Toppenish, Washington. **In**terferometric **S**ynthetic **A**perture **R**adar (**InSAR**) shows that parts of the landslide are still moving today.

Aerial photograph courtesy of ODOT looking to the northwest from Oregon at the Bonneville Landslide in the left half of the photograph.

Year of Observation	Observations and Interpretations	Geochronological Age (years BP)
1805	Lewis and Clark estimate the landslide occurred 20–30 years before their arrival, based on communication with local residents and observations of the exhumed sunken forest. Their interpretations were cited in Charles Lyell's seminal 1830–1833 Principles of Geology (Schuster and Pringle, 2002; Pringle, 2009)	175
1958	First radiocarbon date from sunken forest from wood salvaged before the flooding of the Columbia River by the 1930s construction of Bonneville Dam (Lawrence and Lawrence, 1958)	700
1984	Second radiocarbon dates published from sunken forest wood salvaged from the 1978 construction of the second powerhouse of the Bonneville Dam (Minor, 1984)	800
1998	Third radiocarbon dates published (Pringle and Schuster, 1998)	300-500
2001	Lichenometry dates interpreted to correlate the Bonneville landslide event with the 1700 Cascadia subduction earthquake (Reynolds, 2001)	287
2003	Minimum age based on interpretation of downstream deposits from Bonneville landslide dam breach that underlie dated pumice deposits from Mount St. Helens (Pierson and others, 2003).	370
2004	Re-dating of original Lawrence samples to mid-1400s (O'Connor, 2004).	495-535
2015	Dendrochronology and wiggle-matching radiocarbon dates (Reynolds and others, 2015)	513-529

Bonneville Landslide figure from Washington Geological Survey.

Figure from Washington Geological Survey

1:10 PM: **Depart Bonneville Landslide and Cascade Locks - Marine Park Pavilion**

Note *existing rockfall fences, bin retaining walls on the cut side and the trail weaving toward and away from the highway, mostly on the original HCRH alignment.*

1:25 PM: **Stop 6: HCRH State Trail, I-84 MP 52.8, 9.2 miles, 12 minutes, no restroom facilities. The total duration at Stop 6 is 60 minutes.**

STOP 6: HISTORIC COLUMBIA RIVER HIGHWAY STATE TRAIL

Presenters: Eric Lim (WFLHD) and **Brent Black** (Cornforth Consultants) – *Meet on the Trail.*

Eric Lim: Discussion on the upcoming sections in design and construction and the type of work being undertaken to capture the historic features of the original Historic Columbia River Highway (HCRH) design and construction for this regional trail system.

The HCRH State Trail Project is a collaborative effort between the FHWA –WFLHD, ODOT, Oregon State Parks and Recreation Department, U.S. Forest Service, Hood River County, The Historic Columbia River Highway Advisory Committee, and a number of other stakeholders and interested parties. The project involves restoring the alignment of the Historic Columbia River Highway, the nation's first scenic highway, into a pedestrian and bike trail connecting the cities of Troutdale and The Dalles.

The remaining segments of the trail in design between Wyeth and Hood River, include Segments E, F, G, and H. Numerous challenges faced include rockfall areas adjacent to the trail, bridges over Perham Creek and Mitchell Creek, numerous cut and fill retaining structures adjacent to I-84, and a tunnel through Mitchell Point. The Historic Columbia River Highway formerly was tunneled through the 900-

foot tall basalt promontory, but the tunnel was later blasted away during construction of I-84. The tunnel was famous for its adits or windows cut out of the rock to allow light to the driver and provide views of the gorge. We will discuss current design efforts are focusing on a new tunnel with adits similar to the historic tunnel, as well as balancing rockfall mitigation, and scenic area visual, environmental, and cultural concerns throughout these segments.

Historic photograph of the Mitchell Point Tunnel with adits. Sources for figures can be found at https://www.oregon.gov/ODOT/Regions/Documents/HCRH/Trail-Plan-Part-1-Wyeth-Hood-River-HCRH.pdf

Presenter: Brent Black - HCRH State Trail - Wyeth Section Design and Construction

The HCRH State Trail Plan centers on 11 miles of the trail between Exit 51 on I-84 (Wyeth, OR) and Ruthton County Park (Hood River, OR). This trail alignment is divided into eight segments (A through H) to facilitate a phased project approach and support civil, geotechnical, and structural design efforts and construction. These segments were further subdivided into reaches with similar geologic conditions, topographic features, and/or proposed improvements. Segments A through D consists of a 4-mile section of the trail that starts at Exit 51 on I-84 and ends at Starvation Creek State Park. This segment was subdivided into 14 reaches where rockfall from the adjacent slopes were a major concern. The longest reach is 1,350 feet long and the maximum slope height extends 1,150 feet above the trail alignment. A segment of the trail was constructed on an 850-foot long bench that was excavated within a near-vertical cliff using controlled blasting techniques.

Rockfall risk reduction designs capable of precluding 99% of impacting rockfalls and 90% of rolling rockfalls from reaching the trail and I-84 were desired (i.e. 90% retention of rolling rocks). This was accomplished using a combination of scaling, rock bolting, gabion basket walls, draped high-tensile strength mesh, mid-slope attenuator fences, and flexible rockfall barriers along the uphill side of the trail depending on site conditions. Context sensitive measures were incorporated into the design to reduce the visual impacts of the rockfall risk reduction elements. They included the staining of all metal components, rock-faced gabion baskets, and contouring draped mesh sections so it conforms to the slope shape. Over 3,000 linear feet of low-deflection, flexible rockfall fence barrier without upslope tiebacks was constructed. Other challenging geotechnical elements included: over 2,000 linear feet of MSE walls and reinforced soil slopes, a tied-back gravity wall, a 750-foot long viaduct supported on spread footings with micropile and tie-downs, a 400-foot long soldier pile tie-back wall, one micropile supported bridge, and one bridge on conventional spread footings.

Before and after construction photos from left to right along Wyeth Section from top to bottom.

Construction started in the summer of 2017 and is scheduled for completion in Fall 2019. The Eagle Creek Fire that occurred in September 2017 hampered construction efforts and increased the concerns associated with rockfall and hazard trees. An approximately 200-foot wide section of the extensive talus slope along Shellrock Mountain mobilized during the fire and travelled up to 15 feet beyond the original toe of the talus slope, which required the trail grade to be raised approximately five feet through this area.

2:25 PM: Depart HCRH State Trail, I-84 MP 52.8 for Rowena Loops viewpoint.

Note *that we will pass through Hood River, famous for its wind surfing and access to Mt. Hood and the Columbia Gorge for recreation. Notice the change in vegetation and climate as we head east toward Mosier and The Dalles. Between Hood River and Mosier, an early segment of the HCRH trail section, about 5.5 miles long, reopened the portion through the historic Mosier Twin Tunnels that can be accessed from Hood River and Mosier to the east. The twin tunnels can be seen up in the basaltic cliffs as we drive toward Mosier on I-84.*

Note *that as we drive up the Rowena Loops you will see a risk reduction rockfall mitigation that will be discussed at Stop 7.*

Stop 7: Rowena Crest Overlook

2:55 PM **Stop 7: Rowena Loops Viewpoint via Exit 76 - Rowena Interchange to WB HCRH to Rowena Crest Overlook (23.3 miles, 30 minutes, portable restrooms are available). Total duration of stop 7 is 30 minutes.**


Left: Aerial photograph of Rowena Loops courtesy of ODOT. Red polygon is the location of a risk reduction rockfall project by ODOT. Right: Photograph of the lower Rowena Loops taken from the upper viewpoint.

Presenters: Robert Hadlow (ODOT), **Jamie Schick** (McMillen Jacobs Associates), and **Scott Burns** (PSU)

Robert Hadlow: At Rowena Crest, participants will learn about how the Rowena Loops that take the highway from the crest to river level, maintain engineer Samuel Lancaster's design standards of maximum 5 percent grades and minimum 200-foot turning radiuses on the HCRH. Lancaster established grade and curvature standards years before the American Association of State Highway Officials (AASHO) adopted road design standards for application across the country.

Jamie Schick: The Historic Columbia River Highway (US 30) traverses the Columbia River Gorge along the south side of the Columbia River. Towards the eastern end of the Gorge it passes over the crest of Rowena Bluffs, a broad plateau punctuated with a near vertical 500-foot cliff adjacent to the river. This cliff consists of a series of Miocene-aged Columbia River basalt flows. East of this cliff the highway drops steeply back to the river, passing beneath several steep cliff faces that represent the headscarp of an ancient landslide. This includes a nearly 300-foot-high cliff near mile point 64.7 (red polygon in the picture above).

On May 7, 2017, the lower 75 feet of the cliff failed and fell onto the roadway, burying both lanes for nearly 200 feet with almost 20 feet of debris (figure below). This section of the cliff is dominated by columnar jointing that have developed columns exceeding eight feet in diameter. These columns terminate into a flow contact at approximately 75 feet above road grade. The flow contact includes a five to 15-foot-thick zone of highly weathered, closely fractured vesicular basalt. The failure undermined this flow contact, creating a nearly 10-foot overhang and was at risk of undermining the remainder of the cliff above.

Pre and post rock failure views looking north along the highway.

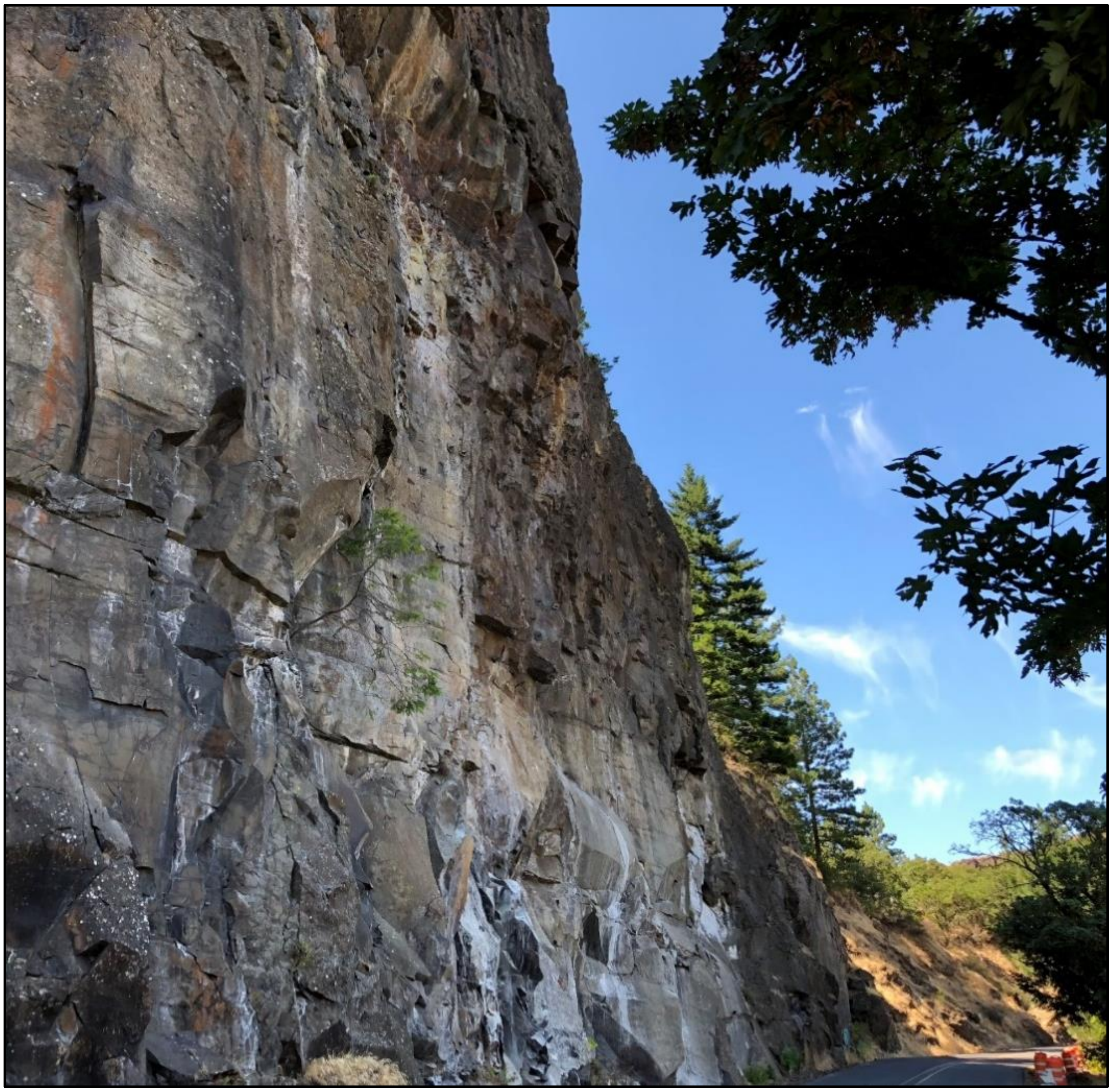
Initial response consisted of a site reconnaissance on May 8th to evaluate the site conditions and develop an approach to stabilizing the slope and reopening the road. The contractor, Triptych, mobilized on May 11 from southwest Oregon to begin safety scaling both above and within the failure area. Most of this work focused on the lower 150 feet of the cliff, accessed using a 145-foot boom lift. Scaling of the overhang was limited because of the safety risk to workers and the risk of exacerbating this condition by overscaling and destabilizing more of the cliff face. This scaling effort enabled an earthwork contractor to safely enter the failure area and remove the rockfall debris.

Initial mitigation response efforts focused on stabilizing the remaining lower columns as well as the columns above the interflow. Approximately 600 linear feet of rock bolts were designed to support this approach and were installed by Rock Supremacy from Bend, Oregon, between approximately May 17th and May 23rd (figure on next page). Rock bolt lengths varied between 10 and 25 feet and were tensioned to 30 kips. Rock bolt heads, nuts and plates were coated with Natina over the galvanization to reduce visual impacts. Final testing and tensioning were completed by May 26th, allowing the highway to reopen in time for the Memorial Day holiday.

Ongoing installation of rock bolts using 145-ft man-lift.

A second phase of investigation and design was completed to address the overhanging highly weathered interflow. This included additional site mapping and scanning of the project area using a drone-mounted light detection and ranging (Lidar) system operated by ODOT's Geometronics Group based in Salem, Oregon. The resultant surface created by the imaging was used to develop sections for design as well as to obtain accurate quantities for estimating purposes.

Final design included an anchored high-tensile strength wire mesh system across the weathered flow top, as well as additional scaling and spot rock bolting. The system was coated with Natina staining over the galvanization to minimize its visual impacts (figure on the next page). Wire mesh anchor nails were designed for a 6.5 foot spacing and extended to 15 feet from the slope face to anchor the system to competent rock. This phase of construction was initiated on January 8, 2018, proceeded without delays, and was completed by Rock Supremacy by early February 2018.



The completed installation of anchored, high tensile strength wire mesh with Natina stain over the galvanization, minimizing its visual impacts.

Scott Burns: At the eastern end of the Gorge is Rowena Loops overlooking the Columbia River and Lyle, Washington, where the Klickitat River (which drains Mt. Adams) flows into the Gorge. At this site we will see a major fault (Chenoweth Fault) that turns the basalt flows on end, a major landslide created by the last Missoula Flood and has the old highway winding down through it, and mima mounds on the plateau. Formation of mima mounds is one of the incredible mysteries of geology. Note the vegetation we have been traveling through in the last 20 miles. We have decreased annual precipitation from 40 to 20 inches/year.

3:40 PM: **All buses depart Rowena Crest Viewpoint WB via HCRH to Mosier and get on I-84 at Exit 69 to head to Portland Marriott Downtown Waterfront (78.2 miles, 81 minutes with no traffic).**

STOP 8: MARRIOTT DOWNTOWN WATERFRONT

5:20 PM **Stop 8: Arrive at Portland Marriott Downtown Waterfront**

Speaker Bios

Scott Burns, RG, LG, CEG, PhD: Scott just completed his 49th year of teaching at the university level, with past positions in Switzerland, New Zealand, Washington, Colorado and Louisiana before coming to Portland State University 29 years ago. He has a BS and MS from Stanford University and his PhD from the University of Colorado. He is an engineering geologist and environmental geologist who also studies soils. His areas of expertise are landslides, radon gas, heavy metals in soils, Missoula Floods, and terroir of wine. He has over 100 publications including two books and has had 48 MS and PhD students complete degrees under him. He has been chair of three different geology departments and also has been an Associate Dean. He has been president of AEG, chair of the engineering geology division of GSA, and also president of IAEG (first American president in its 54 year history). He was chair of the HGS the last time there was a meeting in Portland in the early 1990's. burnss@pdx.edu

Robert W. Hadlow, PhD: ODOT – Historian**:** For nearly 30 years, Robert W. Hadlow has researched and written on historic road resources throughout the United States. In 2001, Oregon State University Press published his Ph.D. dissertation from Washington State University as *Elegant Arches, Soaring Spans: C. B. McCullough, Oregon's Master Bridge Builder.* Hadlow is the senior historian with the Oregon Department of Transportation, where he completes Section 106 and Section 4(f) compliance work. In 2000, he prepared a National Historic Landmark nomination for the Columbia River Highway Historic District. Hadlow is a member of the Transportation Research Board's Standing Committee on Historic and Archaeological Preservation in Transportation. When he is not pursuing transportation history, you might see him out on the backroads around Portland driving his 1939 Buick Roadmaster. Robert.W.Hadlow@ODOT.state.or.us

Nathan Jenks, LG, PE: Currently a Geotechnical Engineer for the Bonneville Power Administration in Vancouver, Washington since September 2019. Previously he was the Geotechnical Group Manager at the Western Federal Lands Highway Division of the FHWA. He has been with Western Federal Lands for about 13 years. Nathan holds undergraduate and graduate degrees in Geological Engineering from the Colorado School of Mines and his experience in geotechnical engineering has been focused on roadway and bridge projects in the Northwest US and Alaska. Nathan is a registered professional engineer and licensed geologist in the state of Washington. nkjenks@bpa.gov

Ryan Cole, CEG: USFS Engineering Geologist: Ryan Cole began his career in geology in 2008 with the US Geological Survey's Oregon Water Science Center, while working towards obtaining a BS in geology from Portland State University, which he completed in 2009. Ryan began working for the US Forest Service in 2011, and earned his MS in geology in 2013, also from Portland State University. Ryan has held a variety of geology-related positions within the agency, which includes work in the mining, energy, abandoned mine reclamation, CERCLA, and engineering fields. He is currently an engineering geologist on the Mount Hood National Forest and Columbia River Gorge National Scenic Area. racole@fs.fed.us

Stephen Hay, CEG: ODOT – Region 1 Geo/Hydro/Hazmat Unit Manager. Stephen Hay graduated from Portland State University in 1995 with a BS in Geology and BS in Geography. He spent three years as a geotechnical consultant working throughout the northwest before joining the Oregon Department of Transportation as an Engineering Geologist in Portland (Region 1). For the past 20 years Stephen has worked on ODOT transportation projects throughout the state and specializes in geotechnical hazard mitigation with an emphasis on rock slopes and landslides. Additionally, he is responsible for short and long-term aggregate resource identification and development. Stephen is a Certified Engineering Geologist (Oregon) and Licensed Engineering Geologist (Washington). Stephen.Hay@odot.state.or.us.

Eric Lim, PE: Senior Geotechnical Engineer at the Western Federal Lands Highway Division of the FHWA. Eric has been with Western Federal Lands for about 4 years after spending 15 years as a consulting geotechnical engineer in the Pacific Northwest. Eric graduated from Humboldt State University in 1999 and is a registered Professional Engineer in Washington and Oregon, and a registered Geotechnical Engineer in Oregon. Eric.Lim@dot.gov

Brent Black, CEG: Brent is a Senior Engineering Geologist for Cornforth Consultants, Inc. and its division Landslide Technology where he has worked for nearly 27 years. His areas of expertise include rockfall and rock slope evaluation and mitigation, landslide stabilization, site investigation and instrumentation, geologic hazards, and construction quality assurance. Brent serves on the board of the Engineering Geology committee for the TRB and is the chair for the subcommittee on Landslides. He is also serving on TRB subcommittees for Rockfall Management and GAM and was recently a panel member on the NCHRP committee for developing guidelines for certification and management of flexible rockfall protection systems. bblack@CornforthConsultants.com

Jamie Schick, CEG: James Schick is an engineering geologist for McMillen Jacobs Associates with over twenty years' experience in the practical application of the geological sciences to both large and small-scale engineering, permitting, and environmental projects for both the public and private sector. He has expertise in detailed site characterizations as well as broad general surveys for projects involving transportation, tunnels, dams, trenchless crossings, pipelines, industrial facilities, and power generation sites. Jamie has extensive experience with unstable rock and soil slope investigations and remediation and previously worked for the Oregon Department of Transportation as part of their unstable slopes GAM team and as the state rock slope geologist. Schick@mcmjac.com

Field Trip Planning Committee Bios

Douglas A. Anderson, LEG: FHWA – Western Federal Lands Highway Division – Engineering Geologist. Doug has been the engineering geologist for the Western Federal Lands Highway Division of the Federal Highway Administration since 2013, with 25 years of engineering geology and geotechnical experience with an emphasis in rock slope stability, rockfall hazards, blasting, landslide mitigation, geotechnical investigation and instrumentation technics, material source development and rehabilitation, large earthwork projects, and geotechnical asset and performance management. For 14 years, prior to joining Western Federal Lands, Doug worked his way up to the assistant chief engineering geologist for the Washington State Department of Transportation in Olympia, Washington after spending nearly four years as a geologist with the US Forest Service on the Mt. Hood National Forest on the heels of completing his bachelor's degree in geology at Portland State University in 1995. Mr. Anderson is a licensed geologist and engineering geologist in Washington State and has passed the Cold Region's Engineering Course required for licensing in the State of Alaska.

Stephen Hay, CEG: ODOT – Region 1 Geo/Hydro/Hazmat Unit Manager. *See speaker bio above.*

Evan Garich, PE: FHWA – Western Federal Lands Highway Division – Geotechnical Engineer. Evan Garich is a geotechnical engineer that has worked with Western Federal Lands Highway Division of the Federal Highway Administration since 2016. His areas of expertise include seismic hazard analysis and deep foundation design. He is responsible for the design and construction of transportation related assets in the northwest U.S and Alaska as a key member of the Western Federal Lands Geology and Geotechnical Team. He came to Western Federal Lands after working for WSP, formerly Parsons Brinkerhoff, for nine years working up to a lead geotechnical engineer after completing his degrees from Texas A&M and Portland State University in 2007. Mr. Garich is a professional engineer in Oregon and Washington and has passed the Cold Region's Engineering Course required for licensing in the State of Alaska. Furthermore, his favorite color is green!

Marc Fish, LEG: Washington State Department of Transportation – Assistant Chief Engineering Geologist. Marc works as an Engineering Geologist for the Washington State Department of Transportation and manages their unstable slopes program. He is a licensed Engineering Geologist in Washington State and has over 22 years of experience managing risk relating to unstable slopes and developing cost effective remediation designs for rock slopes, landslides, and debris flows along Washington State highways.

References

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Acknowledgements

Special thanks to the Washington State Geologic Survey and Oregon Department of Geology and Mineral Industries for sharing their knowledge and previous Geologic Society of America Field Trip Guide and illustrations, as cited above. We would be remiss if we didn't also thank Thomas G. DeRoo, Retired Geologist from the Mt. Hood National Forest, for sharing his wealth of knowledge and previous field trip guide information that he developed for the Columbia River Gorge and Mt. Hood Volcano, as also cited above. We appreciate them letting us stand on their shoulders to ***hopefully*** make a more interesting and educational field trip for **YOU**, the HGS Participants!

Above all, the 2019 HGS Field Trip Planning Committee hopes you have a great field trip experience this year!