Date: **2-21-2024**, Wednesday
Time: 1015 – 1330
Place: The Dalles Dam, Lyle, WA
Weather: Overcast. About 45 deg F.

Attendees: **Robert Cordie, Biologist,** CENWP-OD-D
Alex Baumann, PE, CENWP-ENC-DG

Subject: The Dalles Dam North Fish Ladder Rockfall Observations

Prepared by: Alex Baumann, PE
Reviewed by: Adam Jones, PG

Background and Summary

A recent rockfall failure occurred in the south-facing rock wall along the northern half of the north fish ladder at The Dalles Dam. A member of the Portland District ENC-DG, Alex Baumann (Geotechnical), visited the site today to evaluate the rockfall and condition of the slope. Alex met with Robert Cordie (Biologist) while onsite. This trip report provides background information on the geologic history at The Dalles Dam, a summary of today's observations at the north fish ladder rockfall location, and recommendations for future work. The attached Figures 1 and 2 show the location of today's observations and Photos 1 through 8 show today's observations.

The failure generally consists of surficial rockfall on the order of 2 cubic yards of rock pieces. The pile of rocks are currently blocking one opening in a ladder weir on the east side and north end of Weir 116 (Figure 1 shows the weir numbering system from the as-built documentation). Each weir in the fish ladder has two openings for fish passage. Based on discussions with project personnel, the openings primarily support lamprey passage, while salmon passage typically occurs over the tops of the weirs. In addition to impacts to fish passage, rockfall potential at the north fish ladder poses a significant safety risk to personnel working in the fish ladder, as rockfall occurrence is typically sudden and can vary in particle size, quantity, and height.

Historically, the north fish ladder was originally constructed by excavating into bedrock consisting of weathered/fractured Columbia River Basalt. In 2015, the USACE completed a Design Documentation Report (DDR) outlining the potential for rockfall along the exposed north fish ladder walls. The 2015 DDR addressed severity of rockfall hazard in specific areas, and included recommended remedial efforts to reduce the risk of rockfall. The efforts to stabilize the rock slopes of the north fish ladder have not been funded or carried out yet. The area observed today is within an area recommended by the 2015 DDR for rockfall mitigation efforts.

Geology and Rock Fracturing at the Dalles Dam

The following information is paraphrased from the 2015 DDR:

The Dalles Dam is located on the western margin of the Columbia Basin where it abuts the Cascade Range. The Columbia basin is filled with up to about a maximum of 5,000 feet of Miocene age Columbia

River Basalt Group (CRBG). The Columbia River Basalt Group consists of flood-basalts which were erupted from fissures in eastern Oregon and Washington and western Idaho from approximately 16.5 to 6 million years ago. The bedrock exposed along the bottom and side walls of the fish ladder is likely the Wanapum Basalt Member of the CRBG, approximately 15 to 14.5 million years old.

The Columbia River Basalt developed a common set of characteristic patterns of fractures and distribution of vesicles (bubbles) in flows as it cools. These cooling fractures tend to form coherent patterns in the large mass or flow.

Fracturing in the basalt rock exposed in the north fish ladder and AWS channel generally consist of widely spaced primary fractures (cooling joints) and close to moderately spaced secondary fracture which bisect the blocks formed by the primary fractures. The fractures are tight to slightly open and often curve away from the vertical toward the bottom of a flows. Based on mapping completed in the AWS channel, fracture surfaces are generally smooth, and are typically stained with iron oxide or coated with an altered secondary mineral. Average fracture spacing ranged from 0.7 feet to 1.6 feet with an overall average spacing of about 1 foot. However, intact blocks or boulders which have weathered from the exposed rock cut faces in the fish ladder are commonly greater than 2 feet diameter, and can be up to 6 feet in diameter.

Mechanical weathering over the last 50+ years has caused areas of the steep rock cuts in the north fish ladder to become unstable creating project life safety and operability concerns. In addition, the open rock joints along the rock faces have allowed brush and trees to establish, which causes additional destabilization of these rock cuts.

Observations

The attached Figures 1 and 2 show the plan view of the north fish ladder and the location of the rockfall observed today. Figure 1 shows as-built documentation of the fish ladder construction plans dated March 20, 1957, and Figure 2 shows the remedial rockfall mitigation recommended by the 2015 DDR.

The rockfall observed today occurred approximately between Weirs 116 and 117. In Figure 2 (from the 2015 DDR), the south-facing exposed rock slope between Weirs 115 and 122 is noted as being an area recommended for remedial scaling and vegetation removal. Scaling is a process of removing loose rocks from the slope and is commonly accomplished using pry-bars, picks, or similar hand-held tools by professional rock scaling personnel skilled in scaling techniques and associated equipment/safety. As shown in Figure 2, several locations along the exposed rock walls of the north fish ladder are noted in the 2015 DDR as needing other remediation action, including a combination of rock scaling, localized rock anchors/bolts, or construction of shotcrete walls with mesh, rebar, and rock anchor support.

Photo 2 shows the south-facing exposed rock slope, which contains several areas of potential rockfall hazard. Photos 6 through 8 show the rockfall observed today and overhanging rock mass above the rockfall pocket. The pile of rock below the rockfall pocket is estimated to be on the order of 2 cubic yards and includes rock sizes ranging from about 6 inches to 3 feet in diameter, which are blocking a weir opening. Each weir opening has dimensions of about 2 ft by 2 ft. The largest rock pieces that are piled from the rockfall in this location are estimated to weigh between 1,500 and 2,500 lbs. The height of the piled rock pieces from the rockfall is about 6 to 8 feet. Photo 8 also shows significant vegetation (primarily a tree about 4-in. in diameter with a root system penetrating the rock wall) along the slope in the location of the rockfall.

Discussion and Recommendations

Based on the PDT's observations of the rock slope and rockfall near Weir 116, the recent rockfall was likely caused by the original fracture pattern in the slope and the rapid weathering within the joints from the tree/vegetation roots slowly expanding the joints, allowing moisture to penetrate the rock and accelerate the weathering process. The presence of vegetation on the rock slope will continue to worsen the condition of the rock surface and accelerate weathering. In areas that are not currently vegetated, heavily jointed rock blocks/pieces are also likely to become more loose over time due to the weathering process of the rock structure in these areas.

The large overhanging rock mass immediately overlying the rockfall pocket and tree at Weir 116 is generally heavily vegetated, and thus could not be thoroughly evaluated today, but the slope surface immediately west of this vegetation (approximately between Weirs 115 and 116) appears to consist of several highly fractured/jointed surficial rocks up to 2 feet in diameter. In the area of the rockfall observed today, as well as several other areas noted in the north fish ladder as part of the 2015 DDR, rockfall is a significant risk to the safety of personnel in the in the fish ladder and is a potential impact to fish passage.

Due to the size of the rocks blocking the weir opening (estimated to weigh up to 1,500 to 2,500 lbs each), removal of these rocks by hand may be extremely difficult or impossible. Additionally, due to the height of the rock pile, removal of the large rocks blocking the weir opening may cause further sloughing of rocks and pose as a significant safety risk to personnel, or cause further blockage to the weir opening.

Considering the ongoing rockfall hazard and potential for further sloughing, the Portland District does not recommend the rocks blocking the weir opening be removed by hand. The Portland District also recommends that no personnel enter the fish ladder, especially in areas containing higher risk of rockfall, without adequate slope support or rockfall protection measures until remedial action occurs. The north fish ladder should be further evaluated for weathering and rockfall hazard that has progressed since the 2015 DDR. The 2015 DDR recommendations should be reevaluated for the current condition of rockfall hazards, especially for areas where only scaling and vegetation removal were recommended, as scaling alone can cause further undermining in a raveling slope. Mitigation applicable from the 2015 DDR, as well as any additional or alternative mitigation recommended upon further evaluation of current conditions, should be completed for the north fish ladder to reduce safety hazards to personnel and to reduce potential impacts to fish passage. Figures from the 2015 DDR and photos from today's observations are provided below.

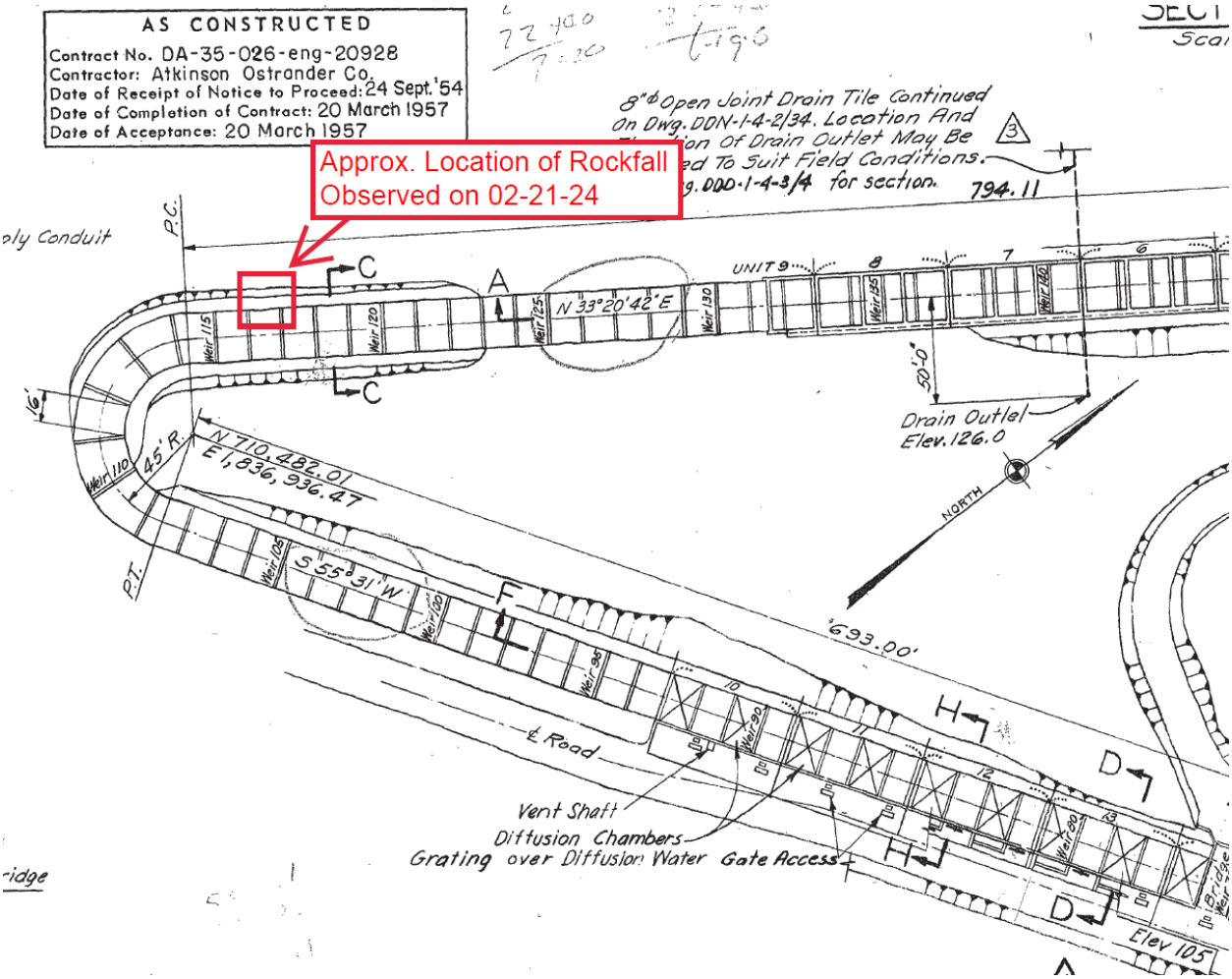

Figure 1: USACE as-built drawing Sheet DDF-1-4-2/1 for North Fish Ladder at The Dalles Dam dated March 1957.

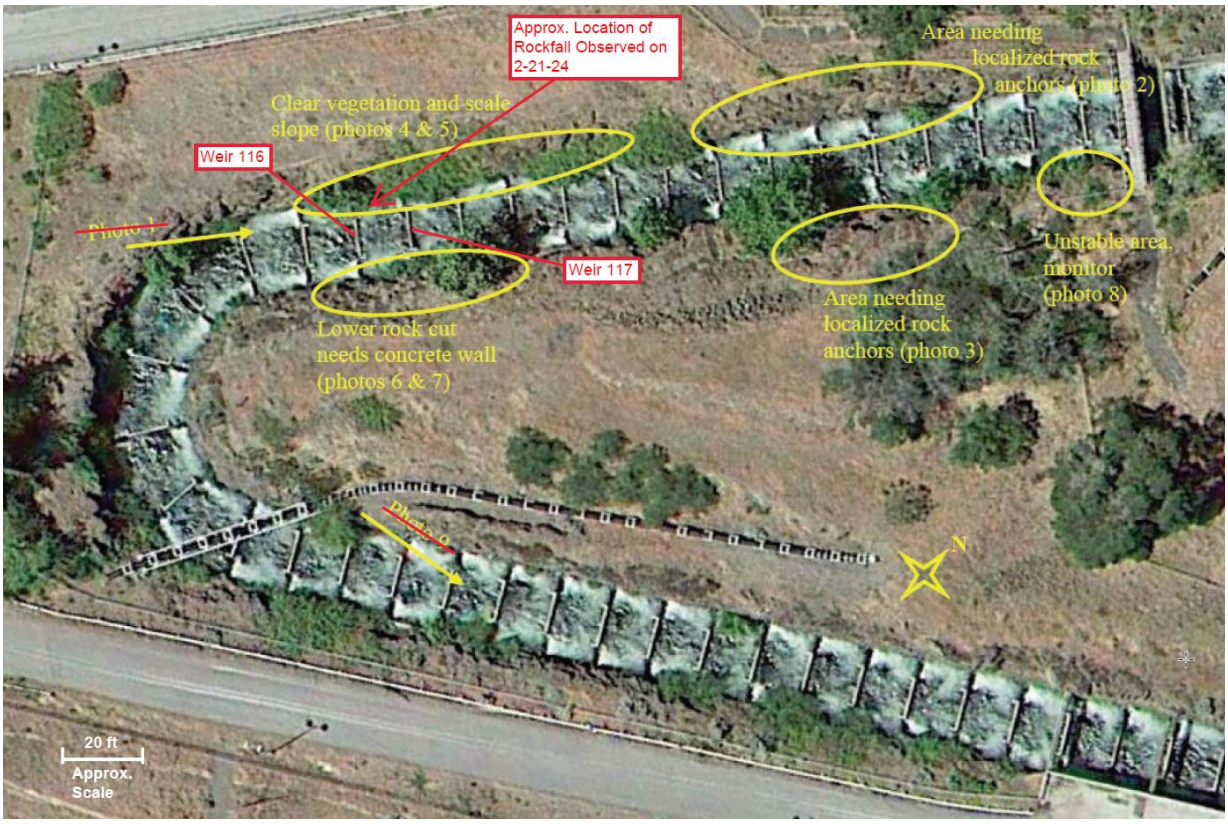

Figure 2: Figure from 2015 DDR showing DDR recommendations for rockfall mitigation, and the February 21, 2024 field observation location.

Photo 1: Looking northeast from west bend of north fish ladder, looking at north half of the ladder.

Photo 2: Looking north from west bend of north fish ladder, looking at weirs 113 through 118 (from closest to farthest)

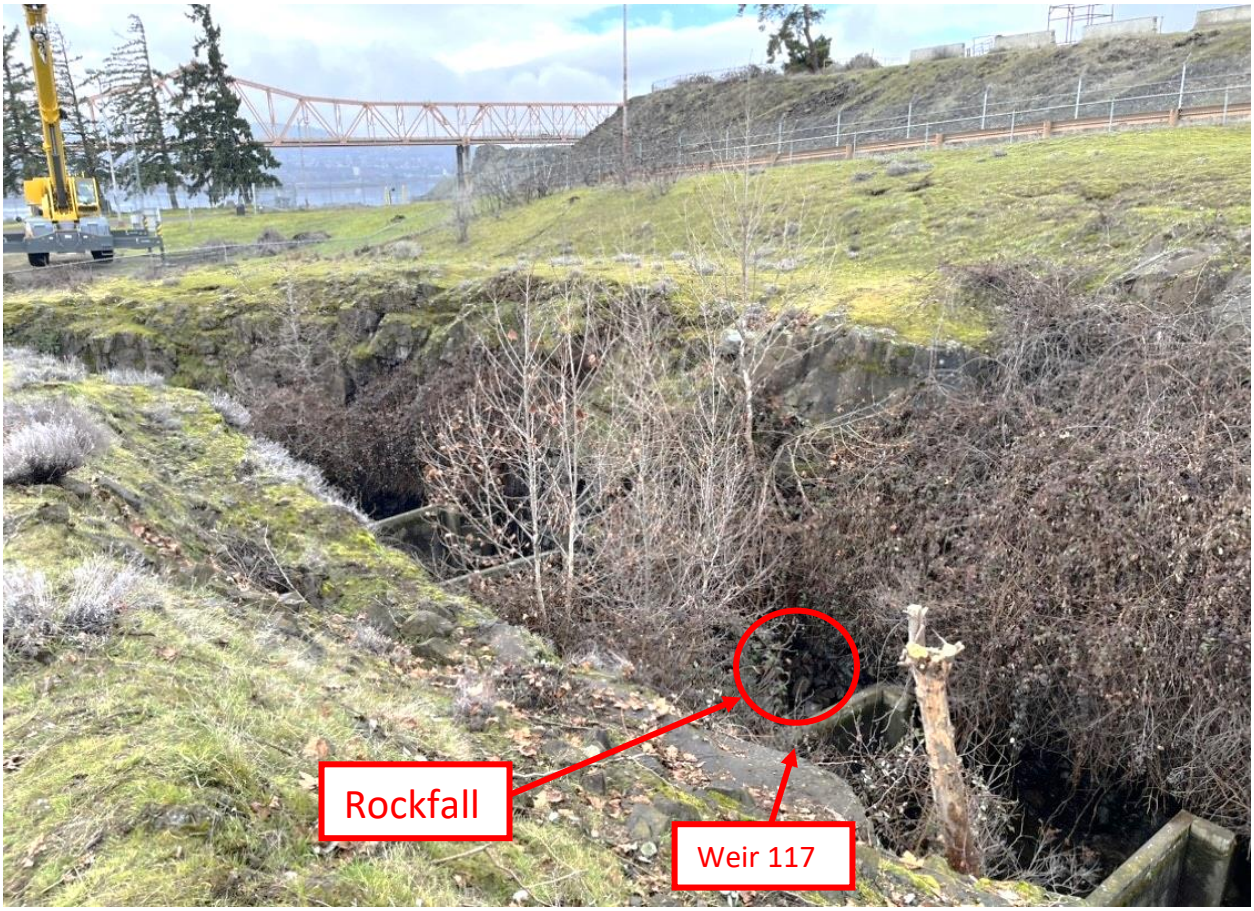

Photo 3: Looing west from top of rock cut (looking toward south-facing wall) at north fish ladder, looking toward weirs 114 through 118 (from left to right, weir 116 is not visible in this photo).

Photo 4: North half of north fish ladder, looking north and down into fish ladder at Weir 116 and adjacent rockfall

Photo 5: Interior of north fish ladder, looking at north end and west side of Weir 116, south-facing wall. Weir opening shown is opposite side of rockfall blockage. Rockfall boulder visible through opening.

Photo 6: Rockfall adjacent (east side and north end, south-facing wall) to Weir 116. Larger rock pieces blocking weir opening (opening is not visible due to blockage). Heavy vegetation and overhanging rock mass shown at top of photo.

Photo 7: Close-up view of rockfall pile, north fish ladder, south-facing wall, east side/north end of Weir 116.

Photo 8: Close-up of pocket left from rockfall, overhanging rock mass, and tree root system near top and north end of Weir 116, north fish ladder.