**STUDY CODE: JPL-XX-21-FOS**

***TITLE: Foster Dam Juvenile Passage\_Spill Ops\_\_Interim Measure #9***

**MANAGEMENT APPLICATION:** In lieu of operating the fish weir at Foster Dam, conduct interim night-time spillway operations (Interim Measure #9) for downstream fish passage. This Interim Measure #9 will be conducted annually during fall (October 1 – December 15) and spring (March 1 – June 14) starting in 2020.

**FUNDING SOURCE:** CRFM

**BIOLOGICAL OPINION ACTION:** RPAs, 4.8, 4.11, 9.3.

**BACKGROUND:** This concept paper is a research summary documenting the results from studies conducted at Foster Dam, which informed Interim Measure #9 (Willamette Valley Project Interim Measures Implementation Plan 2020).

Foster Dam has three routes for water and fish to pass the dam; turbines, spillway, and a fish weir located in Spill Bay 4 of the spillway. However, the primary route for water to pass the dam is through the turbines. The spillway is only used to pass excess water as necessary. Therefore, historically the primary route for downstream migrating fish to pass the dam is through the turbines. The fish weir was installed in 1983 and operated annually for downstream fish passage. The weir was a modified stop log with a wide horizontal notch on top that operated as a surface flow outlet in Spill Bay 4 of the spillway, with an average discharge of 250 cfs. The original operation of the weir for downstream fish passage (mainly steelhead) was for one month each year; April 15 – May 15, at a low reservoir elevation (616 ft). The Corps began operating the fish weir year-round in 2013 for fish passage and survival studies at two reservoir elevations; low winter pool at 616 ft. and high summer pool at 637 ft. These passage studies were conducted to inform structural or operational alternatives for improving downstream fish passage at the dam.

Results from multi-year studies by the Oregon Department of Fish and Wildlife (ODFW) (Romer et al 2014, 2015, 2016; Monzyk et al 2017) and Pacific Northwest National Laboratory (PNNL) (Hughes et al 2014, 2016, 2017) found large numbers of juvenile salmon and steelhead present in the reservoir and passing the dam during periods of low pool elevation (fall, winter, spring) and full pool elevation in late spring (May – mid June). Few fish passed the dam during summer months when the reservoir is at summer full pool elevation. The results from these studies also indicated the fish weir was not an effective route for fish passage, especially during low reservoir elevations, and most fish passed the dam either through the turbines or spillway, when the spillway is operated to pass excess water.

A new fish weir was designed and constructed and went into operation in March 2018. The weir is designed to have improved attraction and entrainment flows and higher discharge; with the goals of increasing passage efficiency rates, minimizing injury, and improving survival. Generally, the weir will be operated with a discharge of 530 cfs at both low winter pool and full summer pool elevations. However, the weir is designed with an operating range of 300 cfs (in dry years) to 860 cfs (to pass excess water during storm events) at the two reservoir elevations. A post-construction study was conducted during 2018 to evaluate the efficiency and effectiveness of the new fish weir at passing fish compared to other routes of passage (turbines and spillway) at the dam and overall improvements to fish passage and survival.

Results from the post construction study during 2018 indicate the fish collection efficiency substantially improved (by approximately 60%) compared to the old weir (Liss et al 2019). However, the direct injury and direct survival (48 hr post passage) study indicate a high rate of injury and mortality for both juvenile and adult fish (steelhead kelts) on the spillway ogee after passage through the weir. The rates of injuries at low pool elevation were 14% for juvenile Chinook salmon, 12% for steelhead and 8% for kelts, and 29% for juvenile Chinook salmon, 15% for steelhead and 41% for kelts at full pool elevation (Normandeau Associates 2019). Direct mortality (48 hr post passage) ranged from 2% for juveniles and 7% for kelts at low pool to 17% for juveniles and 11% for kelts at full pool (Normandeau Associates 2019).

The overall dam passage and survival (active tag) study indicate downstream survival rates of sub-yearling Chinook salmon were similar (82%) for new weir compared to the old weir at low pool, and decreased for yearling Chinook salmon (61% new weir vs 71% old weir) and steelhead (51% new weir vs 55% old weir) (Liss et al 2019). Downstream survival rates were similar for yearling Chinook salmon for new weir compared to the old weir at full pool (62% new weir vs 63% old weir) and improved for steelhead (83% new weir vs 76% old weir) (Liss et al 2019). Passage timing and distribution indicate 96-98% Chinook salmon and steelhead pass the dam at night and very few fish pass during daylight hours. Additionally, approximately 58% of fish pass the spillway compared to 20% passage through the turbines, and survival rates were higher at the spillway (68%) compared to the turbines (57%) (Hughes et al 2016, 2017; Liss et al 2019).

Research was conducted during 2016 through 2017 to evaluate the influence of Foster operations (turbine, spill and fish weir) on total dissolved gas (TDG) on river environment and fish habitat downstream of the dam. Arntzen et al (2018) found that TDG levels in the river downstream of the dam were highest (exceeding 110%) during periods when the spillway was operated by itself (i.e. with no turbine operation). However, TDG levels decreased (less than 110%) during periods of spillway, fish weir, and turbine operations (turbines were operated at 200 cfs for Station Service only). The TDG levels, even when they exceeded 110% saturation for short durations, did not appear to affect adult and juvenile salmon in the river (Arntzen et al 2018). Both of these life stages are able to seek refuge in deeper pools during periods of high TDG levels (Arntzen et al (2018). Arntzen et al (2018) suggest juvenile steelhead may be impacted because of their life stage during periods of elevated TDG levels (during periods of spillway operations without turbine operations). The results of this study informed Interim Measure #9; operate the spillway at night downstream fish passage in conjunction with turbine operations for Station Service, which will reduce TDG levels in the river.

A Corps Foster Fish Weir engineering team is working on design improvements to the fish weir to improve fish passage and survival. In the interim, in lieu of operating the fish weir, Interim Measure #9 prescribing night-time spillway operations during spring and fall months for downstream fish passage will be implemented in 2020. This night-time spill operation is based on results from Hughes et al (2016, 2017) and Liss et al (2019) that indicate 96-98% of juvenile Chinook salmon and steelhead pass the dam at night and the spillway is a safer and preferred route of passage over the turbines.

Interim Measure #9 prescribes the spillway will be operated nightly from 7:00 PM to 7:00 AM from October 1 - December 15 and March 1 - June 15 for downstream fish passage, and during this nighttime spill operation (7:00 PM to 7:00 AM), the turbines will be operated at limited capacity for station service power only. The turbines will be operated at full generation capacity during daylight hours (7:00 AM to 7:00 PM) when very few fish are passing the dam and the spillway may be operated to pass excess water as necessary. This Interim Measure #9 will be coordinated with Interim Measure #10 to ensure the operations are balanced for both juvenile downstream and adult upstream passage at Foster Dam.

According to Interim Measure #9, no additional research (RM&E) “is necessary for this spill operation because data is available to demonstrate this operation is a safe downstream passage route for outmigrating fish. Research conducted to evaluate routes of passage at Foster Dam indicate juvenile salmon and steelhead pass the dam during nighttime hours and the spillway is the preferred route when the fish weir is not operated.” (Willamette Valley Project Interim Measures Implementation Plan, Interim Measure #9 2020).

**REFERENCES**

Romer JD, FR Monzyk, R Emig, and TA Friesen. 2014. *Juvenile Salmonid Outmigration Monitoring at Willamette Valley Project Reservoirs*. Annual report for 2013 submitted to the U.S. Army Corps of Engineers, Portland District, Portland, Oregon, by the Oregon Department of Fish and Wildlife, Corvallis, Oregon.

Romer JD, FR Monzyk, R Emig, and TA Friesen. 2015. *Juvenile Salmonid Outmigration Monitoring at Willamette Valley Project Reservoirs*. Annual report for 2014 submitted to the U.S. Army Corps of Engineers, Portland District, Portland, Oregon, by the Oregon Department of Fish and Wildlife, Corvallis, Oregon.

Romer JD, FR Monzyk, R Emig, and TA Friesen. 2016. *Juvenile Salmonid Outmigration Monitoring at Willamette Valley Project Reservoirs*. Annual report for 2015 submitted to the U.S. Army Corps of Engineers, Portland District, Portland, Oregon, by the Oregon Department of Fish and Wildlife, Corvallis, Oregon.

Monzyk FR, JD Romer, R Emig, and TA Friesen. 2017. *Downstream Movement and Foster dam Passage of Juvenile Winter Steelhead in the South Santiam River*. Final report submitted to the U.S. Army Corps of Engineers, Portland District, Portland, Oregon, by the Oregon Department of Fish and Wildlife, Corvallis, Oregon.

Hughes JS, J Kim, JA Vazquez, and GE Johnson. 2014. Hydroacoustic evaluation of juvenile salmonid passage and distribution at Foster Dam, 2013-2014. PNNL-23645. Final report submitted to the U. S. Army Corps of Engineers, Portland, Oregon. Pacific Northwest National Laboratory, Richland, WA.

Hughes JS, BJ Bellgraph, J Kim, CV Vernon, EF Fischer, ED Green, SA Liss, KA Deters, and GE Johnson. 2016. *Evaluation of Juvenile Salmonid Passage and Behavior at Foster Dam Using Radio Telemetry, 2015.* PNNL-25253. Final report submitted by the Pacific Northwest National Laboratory to the U.S. Army Corps of Engineers, Portland, Oregon.

Hughes JS, SA Liss, RJ Flaherty, ES Fischer, BJ Bellgraph, CV Vernon, and GE Johnson. 2017. *Evaluation of Juvenile Salmonid Passage and Behavior at Foster Dam Using Radio Telemetry, 2016.* PNNL-26416. Final report submitted by the Pacific Northwest National Laboratory to the U.S. Army Corps of Engineers, Portland, Oregon.

Liss SA, KR Znotinas, JS Hughes, BJ Bellgraph, CR Vernon, RA Harnish, ES Fischer, and SE Blackburn. 2020. *Evaluation of Foster Dam Juvenile Fish Passage, 2018.* PNNL-29587. Final report submitted by the Pacific Northwest National Laboratory to the U.S. Army Corps of Engineers, Portland, Oregon.

USACE 2020. *Willamette Valley Project Interim Measures Implementation Plan.* U.S. Army Corps of Engineers, Portland, Oregon

**ODFW Comments:**

From May – August, operations should NOT start at 7pm as it is not dark at 7pm at this time of year. Consequently, juvenile Chinook would not be expected to be passing at that time, and beginning the operation that early may negatively impact the angler success for retaining hatchery Chinook downstream. Instead, operations should be more closely tied to the photoperiod, such as beginning at 8pm in May and at 9pm June – August, to successfully pass juvenile Chinook and allow for retention of hatchery adults downstream. If the operation is not anticipated to affect downstream flows or temperatures which may affect angling success, please provide that documentation.

NMFS Comments:

As the backup for passage until the 2018 weir has been replaced, there is no RME. Need a timeline for how long this is expected.