Foster Dam Downstream Fish Passage Alternatives

Engineering Documentation Report *Update* 2015

Alternatives and Evaluations

Update for WATER Fish Passage Team 08 Dec 2015

This document has been prepared as an update to the WATER Fish Passage Team (FPT) on the processes being utilized in the selection of alternatives for improving downstream fish passage at Foster Dam. The information contained in this update will be presented for discussion at the December 8th WATER FPT meeting. The FPT will then be requested to formally review this information as part of their review of the revised EDR report. A schedule for completion of the revised EDR is provided at the end of this document.

The Foster Downstream Passage Alternatives Project Delivery Team (PDT) was charged with brainstorming and evaluating potential alternatives to improve downstream fish passage at Foster Dam. The purpose of the Foster Dam Downstream Passage Alternatives Engineering Documentation Report (EDR) Update is to present the processes being used to evaluate alternatives to improve downstream fish passage. The process will conclude with determination of a preferred alternative, which will be documented in the final EDR report, and be carried forward into the design documentation report (DDR) for detailed design. The process has been broken down into two stages in this update:

* Stage 1 focuses on identifying measures and alternatives. Measures are defined as the ideas that were selected for development by the PDT to improve juvenile fish passage during the evaluation phase of the project. Alternatives are defined as the groups of measures that provide a complete solution for the project.

* Stage 2 more succinctly defines evaluation criteria; provides methods to estimate biological benefits and complete a cost effectiveness analysis; and discusses how the preferred alternative will be identified.

**STAGE 1: Identifying Measures and Alternatives**

**Measures**

The measures for improving downstream fish passage at Foster Dam focus on operational measures or structural measures intended to attract and pass juvenile fish downstream of the project. The PDT will not advance options past the EDR phase that require a significant project configuration change. This section describes the measures at a conceptual level for the EDR. The following table is a listing of the measures carried through the initial evaluation process.

|  |  |
| --- | --- |
| Operational Measures |  |
| O-2a | Use spill bays 2 and 3 at low and high pool |
| O-2b | Use spill bay 4 at low and high pool |
| O-5 | Modify the temporal use of the fish weir – operate the weir year-round |
| MT-2 | Operate spill bays and shut off turbines during peak run timing |
| Structural Measures |  |
| S-4a | Modified fish weir crest shape |
| S-4c | Water cushion on spillway for fish passing a significant distance above the spillway crest |
| S-4e | Gate within the spillway gate |
| S-4f | Turbine Screens |
| EF-2 | Bypass canal with floating orifice gate |
| EF-3 | New fish weir with a capability to meet varying elevations  |
| Universally Recommended Measures | Recommended measures, or design suggestions regardless of alternative selected. |
| MP-3 | Formalize an operational debris removal program |
| MI-6 | Manage spill to minimize gas (TDG) |
| EF-14\* | Install lighting at entrance inlet to attract fish on the upstream side |
| SO-5\*\* | Build a permanent hoist over spill bay 4 to eliminate need for crane mobilization |
| SO-6\*\* | Buy a mobile crane |
| SO-7 | Buy a truck and trailer for stop log transportation |
| SO-15 | Avoid disruption of operations of the Adult Fish Facility (AFF) including attraction to the fish ladder |
| SO-16 | Install permanent fish study monitoring equipment to provide a system for ongoing research |

**Alternatives**

The Measures were combined to create the following possible Alternatives (combinations of measures). Each alternative will be evaluated in Stage 2, described below.

### Alternative 1: New Fish Weir

Construct a new fish weir with a capacity of approximately 800 to 860 cfs, a means of operating over multiple pool elevations (such as an automated floating crest), and the ability to operate year round in conjunction with or without the use of turbine flow (actual operations to be determined). The new fish weir would be used in Spill Bay 4 (or another bay TBD). Additionally, operate Spill Bays 2 and/or 3 during low pool or flood control season for fish attraction and passage. Alternative 1 combines all or some of the following eight measures:

New Fish Weir Measures

| O-2a | Use spill bays 2 and 3 at low and high pool |
| --- | --- |
| O-5 | Modify the temporal use of the fish weir or other passage routes |
| MT-2 | Operate spill bays and shut off turbines during peak run timing or longer |
| S-4a | Modified fish weir crest shape |
| S-4c | Water cushion on spillway for fish passing a significant distance above the spillway crest |
| EF-3 | New fish weir with capability to meet varying elevations |
| MT-3 | Flushing flow |
| BA-1 | Power generation alternatives |

### Alternative 2: Operational Improvements Only

Use existing operational features (e.g. operate the spill bays) to provide fish passage, perform no structural improvements. The current fish weir will not be used. Instead, one or more spill bays would be open to operational capacity as a water and fish passage route. Alternative 2 combines all or some of the following five measures:

Operational Improvements Only Measures

| O-2a | Use spill bays 2 and 3 at low and high pool |
| --- | --- |
| O-2b | Use spill bay 4 at low and high pool |
| MT-2 | Operate spill bays and shut off turbines during peak run timing |
| MT-3 | Flushing Flow |
| BA-1 | Power Generation Alternatives |

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### Alternative 3: Double Bypass Canal

Build bypass canals on both sides of the river. The north side canal would use the fish hatchery water supply pipe and requires fish screening. The south side would run a pipe through the dam routing fish through a canal all the way to the tailrace. This alternative represents a significant structural and configuration change. Alternative 3 combines 1 or both of the following 2 measures:

Double Bypass Canal Measures

| EF-2 | Bypass Canal With Floating Orifice Gate  |
| --- | --- |
| MT-3 | Flushing Flow |

### Alternative 4: Single Bypass Canal and New Fish Weir

The concept is to build a bypass canal on the south side between the left bank and before the turbines and a new weir in spill bay 2. The south side would run a pipe through the dam routing fish through a canal all the way to the tailrace. This alternative represents a significant structural and configuration change. Alternative 4 also combines all or some of the following eight measures:

Single Bypass Canal and New Fish Weir Measures

| O-2a | Use spill bays 2 and 3 at low and high pool |
| --- | --- |
| O-5 | Modify the temporal use of the fish weir  |
| S-4a | Modified fish weir crest shape |
| EF-3 | New fish weir with capability to meet varying elevations |
| MT-2 | Operate spill bays and shut off turbines during peak run timing or longer  |
| MT-3 | Flushing Flow |
| EF-2 | Bypass canal with a floating orifice gate |
| BA-1 | Power generation alternatives |

### Alternative 5: Gate within a Gate

Modify or replace a spill bay gate(s) to include weirs or ports that provide adjustable openings to accommodate varying water levels and provide a route for fish passage. Alternative 5 also combines all or some of the following four measures:

Gate within a Gate Measures

| S-4e | Gate within the spillway gate |
| --- | --- |
| MT-2 | Operate spill bays and shut off turbines during peak run timing or longer |
| MT-3 | Flushing Flow |
| BA-1 | Power generation alternatives |

### Alternative 6: Turbine Screens

Alternative 5 includes one structural measure and multiple operational measures. The operational measures are similar to Alternative 2; however, power generation would not be foregone because the penstocks would have screens installed to prevent fish from entering the penstocks and turbines. Screens would meet NMFS screening criteria. Alternative 6 also combines all or some of the following three measures.

Turbine Screens Measures

| O-2a | Use spill bays 2 and 3 at low and high pool |
| --- | --- |
| O-2b | Use spill bay 4 at low and high pool |
| MT-3 | Flushing Flow |

**STAGE 2: Determine Preferred Alternative**

Corps Planning Guidance requires an upfront examination of project goals, objectives, and constraints. The process, criteria and methods that will be used to determine a preferred alternative are described below. This process involves:

1. Defining Evaluation Criteria
2. Estimating biological benefits and impacts of alternatives
3. Completing a cost effectiveness analysis
4. Identifying a preferred alternative
5. **Define Evaluation Criteria**

The general approach to evaluate the actions includes: (1) biologically feasible and beneficial; (2) technically feasible; and (3) cost effective. General definitions and approach follows:

1. Biological Benefits:
	1. Fish passage improvements must allow sufficient passage survival so that the above dam sub-population is able to replace itself on average over time (i.e., enough adult progeny must successfully return and be transported above the dam to meet or exceed abundance of the adult generation they were produced from, allowing the population to remain stable over time).
2. Technically Feasible:
	1. Design/performance assumptions for proposed actions can be achieved with reasonable certainty.
	2. Willamette Project (WP) critical authorized purposes will not be impacted. These purposes include in particular flood risk reduction, and could also include other missions (e.g. hydropower, water supply, and recreation) depending on the specific WP project and any pre-existing regulations, guidelines, or agreements.
3. Cost Effective:
	1. Feasible actions which achieve the necessary level of benefit for the least cost will be prioritized over others.
	2. Estimated action costs must include: cost to design and construct, costs to maintain, and cost impacts to hydropower production.
4. **Estimate biological benefits and impacts of alternatives**

The specific criteria and assumptions to be used to evaluate Foster downstream passage alternatives, and a summary of the methods to be applied to estimate benefits and impacts are summarized below:

1. *Actions will meet dam safety requirements, and not result in a reduction to the Corps flood risk management mission.* To assess and implement alternatives for BiOp implementation, it was assumed that the selected plan or suite of plans will not result in a reduction to the Corps flood risk management mission. If an alternative results in an increase in flood risk or flood impacts as analyzed, it will be flagged for further discussion to mitigate flood risk or dam safety concerns. Assessing changes to operational regimes will be necessary to meet Corps dam safety requirements.

Flood risk management analyses will be conducted using the results of reservoir simulation modeling and regulation expertise. Measures will be modeled using ResSim. The results of these model runs will then be compared to the results of the baseline (current conditions) to identify changes to FRM operations. Within the ResSim model, downstream control point rules will be in place specifying regulation goals for key gage locations called control points. The Willamette projects operated to meet FRM goals at these control points individually and as a system. Therefore, when one project is modified in an operational scenario, another project was adjusted to try to meet the specified control point goal. With other projects able to compensate partially for a change in one project’s operation, the impact to flooding will be assessed at the control point (i.e., was the system able to maintain flows at a control point below key thresholds). The FRM impact assessment procedure is shown below.

1. Compare the number of occurrences that a control point flow is above the regulation goal under the operational scenario to the baseline values).
	1. The ResSim period of record output will be post-processed to count the number of days the regulation goals is exceeded each year and statistics will be computed on these counts.
	2. Compare the 5% exceedance counts. The 5% exceedance was selected because it represents a relatively infrequent occurrence. The 5% exceedance count is the value, in number of days (or more) a year, that the control point flow exceeded the regulation goal for 5% of the years in the POR (4 years of the 73-year POR). These 4 years may have more days above the regulation goal than reported in the 5% exceedance count.
	3. The 5% exceedance should incorporate most of the large flow events. There may be occasion to use the 1% exceedance values.
2. Compare the 5% exceedance peak flow under the operational scenario to the baseline values.
	1. The 5% exceedance should incorporate most of the large flow events. There may be occasion to use the 1% exceedance peak flows.
	2. The ResSim flows are also daily peaks and do not truly represent the instantaneous peak of the flood event. The focus will be on differences in peak flows between the baseline and operational scenario.
	3. Because there was both model error and potentially gage error, a difference of 5% in the peak flows was considered no change.
3. If either the duration a control point exceeded the regulation goal or the magnitude of the peak flow were higher under the alternative being simulated than the baseline, then the alternative will be flagged for further consideration of possible mitigation costs or acceptability.
4. If there is a strong biological support for retaining an alternative that was flagged for consideration, then a more detailed analysis would need to be conducted with individual flood events on an hourly time step.

There are concerns and limitations with the existing equipment at each Willamette system dam that must be considered with regard to operations and dam safety. Impacts to dam safety will be addressed during the work of the specific design teams (i.e., the teams will not design a structure that does not meet dam safety standards). In addition, dam safety requirements, such as the restrictions to spillway gate operations and minimum and maximum gate openings, will be incorporated into the operational alternative evaluations through ResSim to ensure that alternatives carried forward comply with dam safety requirements. Alternatives not meeting dam safety requirements will not be included in design team recommendations or brought forward for inclusion as alternatives for final design. Design teams will explore dam safety implications in more detail for those alternatives carried forward for final design. A Potential Failure Modes Analysis (ER 1110-2-1156) will be required to ensure that any dam modifications do not increase the overall incremental risk of the project to be greater than tolerable guidelines. The USACE Risk Management Center may have involvement if significant modifications are required. This will be determined by the Portland District Dam Safety Officer.

1. *Any above-dam fish reintroduction efforts must reach “replacement.”* Fish passage improvements must allow sufficient passage survival so that the above dam sub-population is able to replace itself on average over time (i.e., enough adult progeny must successfully return and be transported above the dam to meet or exceed abundance of the adult generation they were produced from, allowing the population to remain stable over time).

An analysis will be conducted using output from Species Lifecycle Analysis Module (SLAM) to estimate whether or not each fish population could successfully replace itself under the assumed fish passage alternatives. The SLAM model was developed by NWFSC and parameterized with regional input. Several workshops (8) were conducted with WATER in 2014 to discuss model input assumptions and provide guidance on model results. Model documentation products were shared with the WATER during review by the Independent Scientific Advisory Board (ISAB).

Development of the SLAM models and biological assumptions are documented in NWFSC (2015); any updates will be documented in the EDR.

The Fish Benefit Workbook (FBW) spreadsheet tool was developed by the Corps and used to estimate annual dam passage survival for juvenile Chinook salmon and steelhead at each dam under existing and alternative reservoir, discharge, and passage route conditions (Corps 2015). The Fish Benefits Workbook methodology and input parameters were discussed at WATER Fish Passage Team (FPT) meetings and multiple regional workshops. FBW documentation was reviewed by the Region and the model framework was reviewed by the ISAB. Additionally, model parameter assumptions were provided by WATER and used to test the FBW tool. Development and assumptions used in the FBW to evaluate Foster downstream fish passage alternatives will be documented in the EDR.

For the above dam population component, the replacement ratio will be computed for each year using the current natural origin spawners (spawning adults) divided by the (natural origin + hatchery origin spawners) from 4 years prior (their parents). The 5-year running average will also be computed to look at the replacement from the cohort perspective. The SLAM output provides estimates of hatchery origin spawners and natural origin spawners for each year from 1-105 in the simulation. To verify whether or not an alternative resulted in population replacement above a dam, multiple aspects will be checked including:

* The average replacement ratio - above 90% (meets replacement) and above 85% (nearly meets replacement).
* The percent of time the 5-year running average was above 95% - more than 70% of the time (meets replacement) and more than 60% of the time (nearly meets replacement).
1. *Phased Approach is Preferred.* To reduce risks and apply information gained during the design and implementation steps, a phased approach will be considered where feasible, and appropriate, for each alternative. This approach provides important phased prototyping steps to help lower risks and improve chances of reaching biological goals.
2. *Actions should be cost-effective, including consideration of hydropower impacts.* Some alternatives will provide similar levels of benefits, and the least expensive, feasible alternative should be prioritized. Implementation of the RPA will be costly and it must be done in a cost-effective manner. Development of a cost-effective plan, or suite of plans, is an opportunity for the region and nation to improve the probability of long-term survival of ESA-listed species, while using available resources wisely.

Hydropower impacts will be jointly estimated by the Corps and BPA. To the extent power production in the Willamette Valley is already optimized as part of the federal power system, any change in operations resulting from the alternatives being evaluated may entail non-optimal power production. If an alternative is found to reduce the social value of hydropower production, then an estimate will be made of the losses in monetary terms. Bonneville Power Administration will estimate these losses. The monetary loss estimate will use the same underlying parameters and assumptions (discount rate, planning horizon, constant price levels) as the rest of the analysis. The hydropower losses will be present valued to a common point in time for each operational alternative.

The BPA will use the Hydro System Simulation (HYDSIM) model, in conjunction with the ResSim model, to estimate hydropower impacts. The HYDSIM model simulates power production for the month-to-month operation of the Pacific Northwest hydropower system. The HYDSIM model will be used by BPA to post-process the ResSim modeling to capture hydropower impacts. The lost average megawatts (aMW) of generation will be combined with forecast market price estimates to estimate the lost hydropower by alternative. The lost aMW will also be used as input for the power value analysis, discussed below.

A power value analysis (PVA) will be used by BPA to evaluate the financial impact of each alternative or combination of alternatives. Preliminary PVA analysis by BPA indicates that the Power Value will likely be negative. The PVA quantifies the costs and benefits of hydropower operations at each Corps Willamette power plant over a 20-year time horizon, given a set of assumptions about future investment and further operational restrictions at the facilities. Only the costs and benefits associated with hydropower production will be captured in the PVA. Monetized impacts of each alternative will then be compared to a baseline value in order to calculate the economic effect and the carbon dioxide emission rates for replacement generation for lost hydropower.

1. **Complete Cost-Effective Analysis**

Benefits for baseline and alternatives were measured based on the extent each fish population was estimated to meet the *replacement* criteria. Because benefits are not in dollar terms, a cost-benefit analysis was not provided. In lieu of a cost-benefit analysis, a cost-effectiveness analysis will be conducted to compare costs and outputs of the alternative combinations for the system.

The costs of alternatives or combinations of alternatives will be in monetary terms. Project first costs including design, construction, supervision and administration, engineering during construction and O&M costs will be in monetary terms at a fixed price level (2014 dollars). If construction extended over a multiple-year period, interest during construction will be calculated and added. The costs will be present valued to the base year. The O&M costs will be estimated over the project life and present-valued back to the base year. The average annual equivalent values will be shown for these costs. The period of analysis will be the same for all alternatives, 2015 through 2064 where 2015 was the base year.

Opportunity costs such as forgone hydropower and recreation losses will be assessed for alternatives in comparison to the without-project condition, with hydropower in dollar terms and recreation impacts in non-monetary terms. Hydropower impacts will be considered with stakeholder input from BPA, primarily as a threshold limit. Recreation impacts will not be included in the total costs for the cost-effectiveness analysis but will be represented as other impacts for consideration.

The non-monetary fish benefits of each measure will be weighed against the costs of the measures. The analysis will generally follow the cost-effective analysis procedures laid out in *Cost Effectiveness Analysis for Environmental Planning: Nine Easy Steps* (Corps 1994). Cost effectiveness analysis identifies projects that minimize cost for a given level of output or maximize output for a given cost. Also, the focus will be on monetized costs—construction, O&M and hydropower impacts. The main analysis steps include:

* Display outputs and costs.
* Eliminate economically inefficient solutions. Re-order the list in ascending order and identify the least cost solution for each level of output, dropping the inefficient cases.
* Eliminate ineffective solutions. Conduct a pair-wise comparison of remaining outputs and monetary costs to identify and delete those solutions that will produce less output at equal or greater costs than subsequently ranked solutions.
* Calculate Average Costs. Divide cost by output to find average total cost and display output, total cost, and average cost for cost-effective solutions.
* Calculate cost-effectiveness as average cost per unit of output
1. **Identify Preferred Alternative**

The most cost effective alternatives will be compared considering biological benefit, feasibility, and costs. Examples of how analysis results and other supporting information will be summarized to support a decision are presented below. The preferred alternative will be based on extent criteria are met, and confidence in the assumptions made. The least expensive, feasible alternative will be prioritized.

**Next Steps**

The information contained in this update will be presented for discussion at the December 8th WATER FPT meeting. The FPT will be requested to formally review this information as part of the revised EDR report. The updated EDR report will contain the following information:

* Update measures and alternatives using current information
* Evaluate alternatives
	+ Estimate biological benefit (replacement analysis and downstream passage survival)
	+ Assess impacts (hydropower, flood risk management)
	+ Update costs of alternatives
* Complete Cost-effectiveness analysis
* Identified alternative to carry forward for review

The updated draft EDR will be completed in February, 2016 and distributed to the FPT for review.

Example Format for the Summary of Results for Foster Dam Downstream Fish Passage Alternatives

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Alternative Name** | **Biological Benefits (**replace-ment) | **Investment (Costs)** | **Impacts** | **Results** |
|   |  | Project First Costs (Total CRFM) ($ MIL) | Additional O&M (PV) ($ MIL) | Lost Hydropower ($ MIL) | Total Life Cycle (Project First Costs + O&M) in $ MIL | Flood Risk Management Impact (Y/N) | Total Recreation Impact (Y/N) | Water Supply Impact (Y/N) | Hydropower Impacts (Y/N) | Cost Effectiveness(Project Lifecycle Cost over Change in Biological Benefit) | Projected Stakeholder Impact |
|  |  |
| Spring Chinook  | Winter steelhead |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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Example Summary of Replacement Analysis for South Santiam Chinook salmon Above Foster Dam

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **SLAM Alternative** | **AVER** | **Count > 1** | **Median** | **Percent Time >1** | **Percent Time >.95** | **Ave of Running Ave** | **Replacement****Status** |
| Baseline |  |  |  |  |  |  |  |
| Alternative 1 |  |  |  |  |  |  |  |
| Alternative 2 |  |  |  |  |  |  |  |
| Alternative 3 |  |  |  |  |  |  |  |
| Alternative 4 |  |  |  |  |  |  |  |
| Alternative 5 |  |  |  |  |  |  |  |
| Alternative 6 |  |  |  |  |  |  |  |

DRAFT Fish Benefits Workbook Results for Chinook at Foster Dam



 Identifies alternatives that were previously sent to SLAM and analyzed by NOAA NWFSC.

DRAFT Fish Benefits Workbook Results for Steelhead at Foster Dam



 Identifies alternatives that were previously sent to SLAM and analyzed by NOAA NWFSC.