Calapooia River Fish Passage Analysis and Culvert Removal Proposal

Submitted to:

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Executive Summary

The design team was asked to evaluate the last known barrier to fish passage on the Calapooia River, located in Tangent, Oregon between river miles 16 and 18. A significant impedance was identified which is preventing passage to key anadromous species. The reach does not currently meet Oregon Administrative Regulations (OAR) and National Marine Fisheries Service (NMFS) requirements for fish passage. According the analysis done using FishXing software, winter steelhead, spring chinook, and pacific lamprey were found to be insufficiently able to pass through one of the three culverts in question. Four alternatives—no action, culvert replacement, arched culvert installation and bridge construction—were assessed in terms of technical, regulatory, and economic feasibility. It is proposed that a bridge consisting of two end-to-end railroad flatcars is the most viable option for restoring fish passage, complying with Oregon Administrative Regulations, and meeting the needs of the landowner.

Introduction

The goal of this design project is to create suitable fish passage conditions for all possible flows on site, while meeting OAR/NMFS requirements and the needs of the landowner. The current culvert array is the last remaining barrier on the Calapooia River and is important to the success of anadromous fish passage. The site under inspection is in Tangent, Oregon between miles 16 and 18 of the Calapooia River. The river is directed through three adjacent culverts which support a rock road that crosses the river. According to the landowner, the culverts are known to overtop during high winter flows, accumulate large woody debris and require monthly maintenance.

A visit to the site was conducted on April 6, 2013 and the data collected was used to analyze current fish passage. FishXing modeling software was used to analyze passage for juvenile and adult winter steelhead, spring chinook, and pacific lamprey. Two key physical barriers to passage were found in initial modeling: velocity and depth. Without a new fish passage scheme at this site, fish passage along the Calapooia River will remain impeded. Several alternatives were considered to remove the barriers to passage.

Project scope

Ensuring the passage of the three aforementioned anadromous fish species is the focus of this report. First, the passability of these key species will be evaluated to determine if the culverts present a sufficient barrier to passage and are out of compliance with OAR/NMFS. Second, an alternative assessment will be conducted to determine the best course of action, including taking no action at all. Third, a preferred alternative will be selected and a design will be proposed, taking into account the hydraulics of the site reach, rough economic estimates and permitting that must be obtained.

Background and Existing Conditions

Location

The location of interest is a site on the Calapooia River, located along the property at 31886 Oregon 99E, Tangent, Oregon 97389 (Figure 1). The site contains a set of road crossing culverts that are located between river miles 16 and 18 of the Calapooia River (Figure 2), which is approximately seven miles east of Corvallis, Oregon.

Fig. 1: The river site is between mile markers 16 and 18 and the landowners property is just outside of Tangent, OR. Tangent is indicated by the pin labeled 'A,' and the location of the culvert site is located by the orange pin with no label.

Fig. 2: Aerial view of the river site of interest, located at 31886 Oregon 99E, Tangent, OR 97389. The current location of the culverts is indicated by the red box.

Watershed and Climate

The Calapooia Watershed is a sub-basin of the larger Upper Willamette Watershed and the watershed encompasses about 234,000 acres of land (Biosystems et al. 2004). The Calapooia River runs about 70 miles through the watershed, starting at the Tidbits Mountain and joining the Willamette River in Albany, OR (Figure 3). Elevations in the watershed range from about 5,000 feet to less than 200 feet at the outlet. The majority of precipitation in the watershed falls as rain and occurs between October and June (Biosystems et al. 2004).

A variety of land uses are found within the watershed, in addition to fish and wildlife habitats. Agricultural land uses and communities dominate the middle and lower areas of the watershed, while the upper watershed is mostly forested (Biosystems et al. 2004). The majority of the land encompassed by the watershed is privately owned, including the reach being assessed.

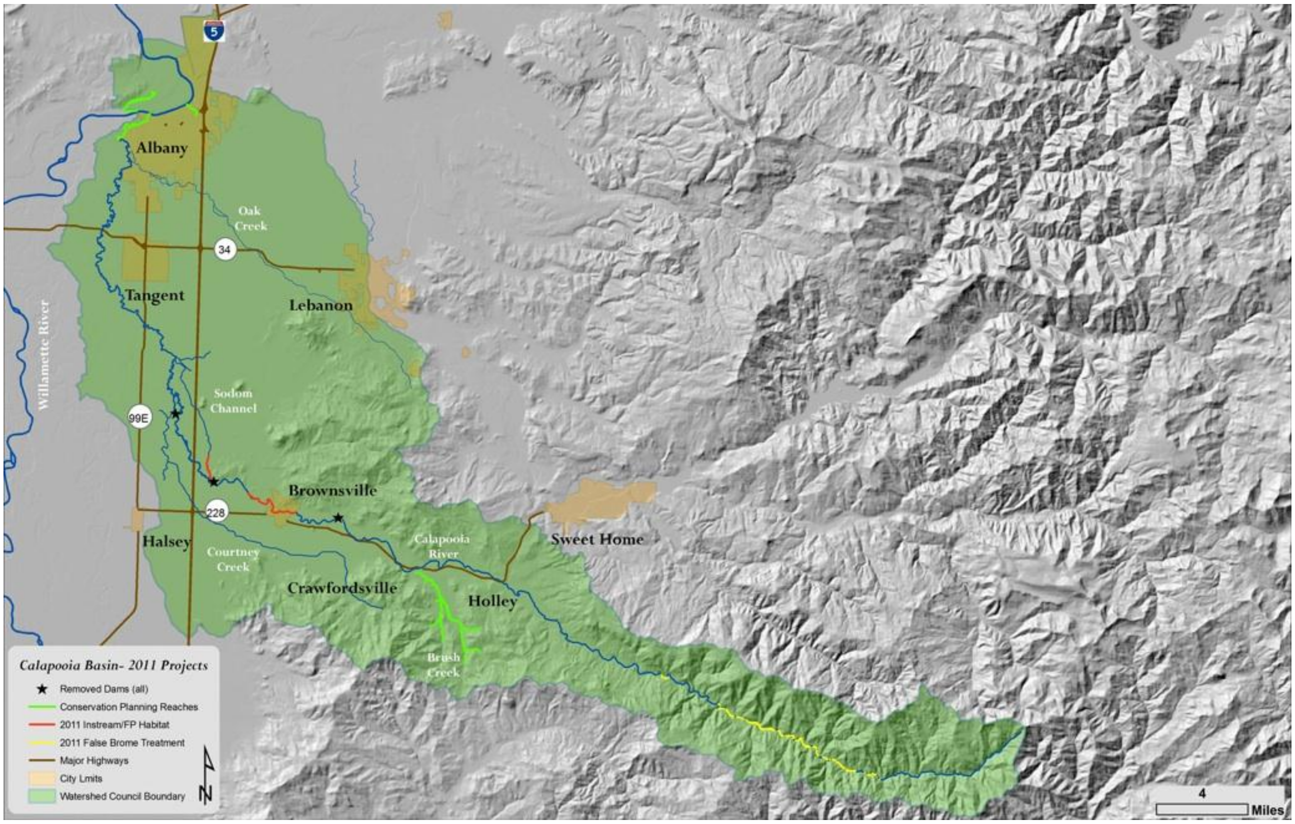

Fig. 3: The Calapooia River Watershed, map from the Calapooia Watershed Council.

Hydrology

The high and low flows that should be expected at the reach in question are summarized in Table 1. During the wettest months—typically November through April, when 90% of runoff occurs (Calapooia Watershed Council, 2013)--the average annual peak flows are to be expected. The data gathered at the Albany and Holley stations are reported in Table 2.

Table 1: Summary of 5% and 95% exceedance flows based on site hydrology

P95 (cfs)	*27*	*based on scaling between gauges for historical data and linear regression*
P5 (cfs)	*3527*	*based on scaling between gauges for historical data*
P5 (cfs)	*3950*	*based on regression equations from USGS*

Table 2: Calculated peak flow values for different recurrence intervals at the Holley and Albany gauging stations (Calapooia Watershed Council, 2013).

Recurrence interval (years)	Peak flow (cfs)	Unit peak flow (cfs/sq.mi.)
Holley gauge 2	5500	52
5	7900	75
10	9400	90
25	11300	108
50	12700	121
100	14100	134
Albany gauge 2	12500	33
5	20000	54
10	25200	68
25	31800	86
50	36900	99
100	41800	112

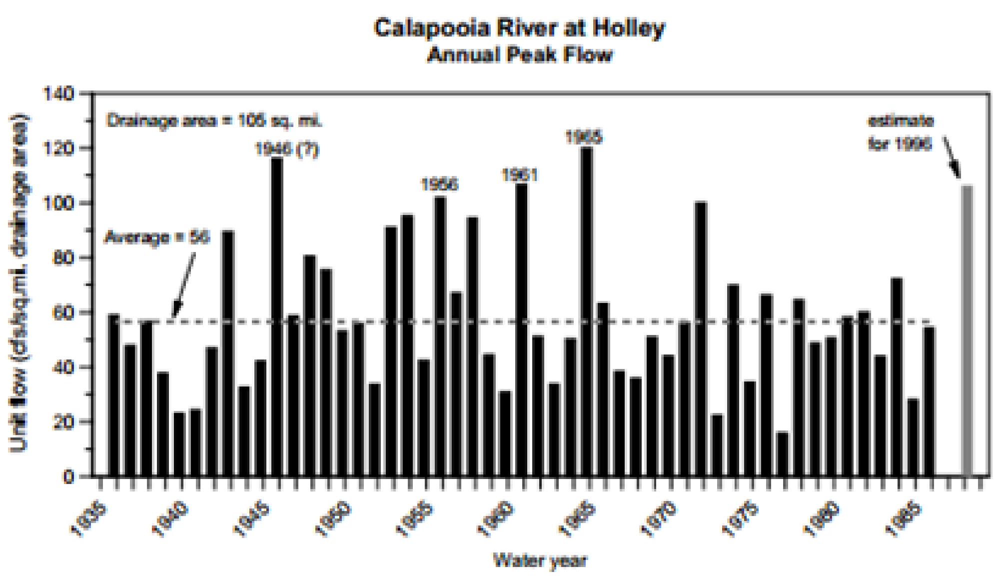

Fig. 4: Annual peak flows at the Holley gauging station (Calapooia Watershed Council).

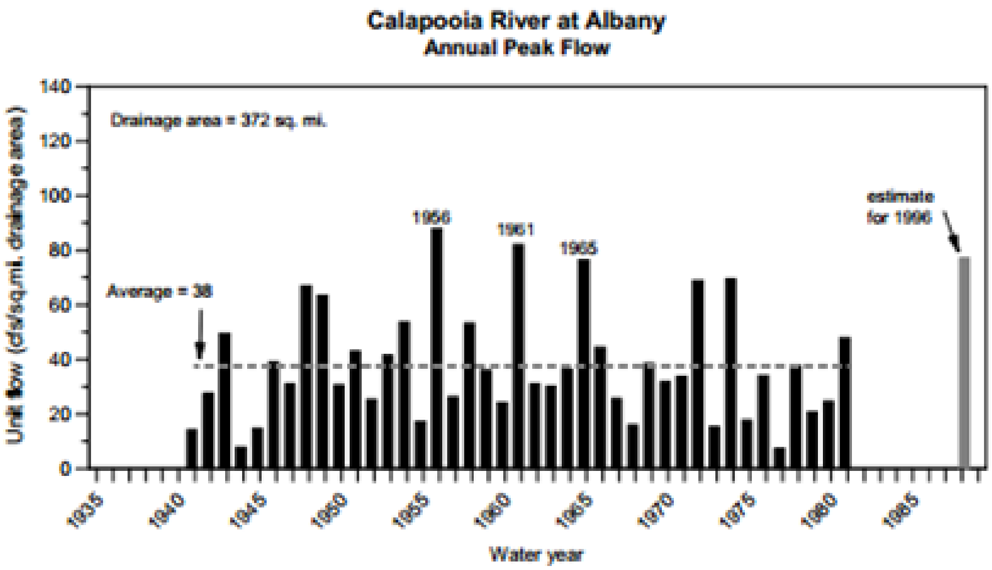

Fig. 5: Annual peak flows at the Albany gauging station (Calapooia Watershed Council).

These peak flows are important to consider in the design process, as they must be accommodated to ensure fish passage. Low flows will occur during construction and should be noted for that reason. The model implemented here will assess these peak flows to determine if the proposed design is in compliance with OAR/NMFS criteria.

Fish Presence and Use

There are three anadromous fish species of concern on site: winter steelhead, spring chinook, and pacific lamprey. These migratory species must navigate long stretches of the Calapooia to successfully reproduce. They are given special consideration because their existence in rivers depends on their reproductive success which can be limited by barriers such as the culverts at this site. The initial modeling of the existing site conditions and regulations for fish passage of these species were used as guidance in determining the best alternative to implement on site.

Existing Culverts

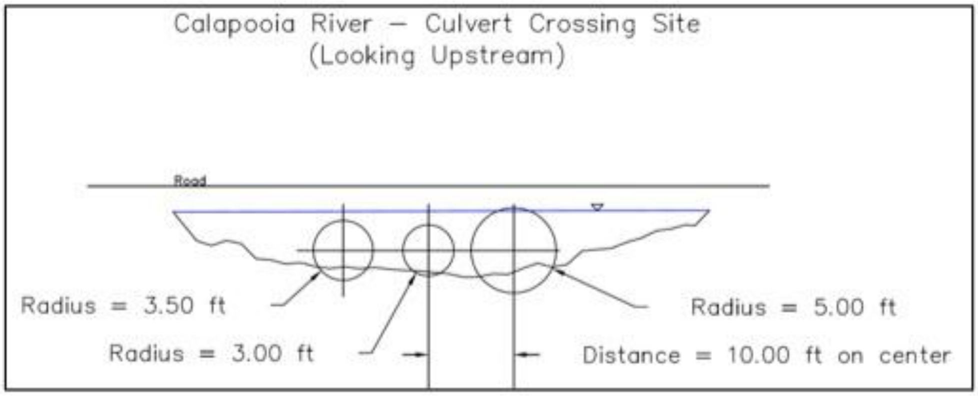

Fig. 6: Downstream cross-section of current culvert location and culvert crossing orientation.

There are currently three corrugated metal, embedded culverts on site. Their diameters are 6, 7 and 10 feet (Figure 6). Currently, the river reliably fills and overtops the culverts for at least part of the year during high flows. Table 3 details the characteristics of the current culverts on site and Figure 6 shows the downstream cross-section of the site and culvert orientation.

Table 3: Current culvert characteristics measured during site visit on April 6, 2013.The characteristics were used in the FishXing model.

Number of Culverts	***1***	***2***	***3***
Culvert Diameter (ft)	10	6	7
Culvert Material	Corrugated metal	Corrugated metal	Corrugated metal
Entrance	Projecting	Projecting	Projecting
Installation	Not embedded	Not embedded	Not embedded
Culvert roughness	0.024	0.024	0.024
Culvert length (ft)	41	37	50
Culvert Slope	0.71%	0.71%	0.71%

Data collected at the site visit, on April 6, 2013, and USGS stream gauging data was used to model the current conditions of the site for fish passage, using FishXing software. A 95% exceedance flow of 9.2 cfs and a 5% exceedance flow of 6,277 cfs were used in analysis. It was found that fish passage barriers were present for all three fish species, with the main barriers being velocity and depth. Table 4 shows the percent passability of each culvert for each fish species, as determined by FishXing.

Table 4: Percent passability of each culvert, determined using FishXing software and the input data collected during the site visit in April, 2013.

Fish Type	*Chinook*	*Steelhead*	*Lamprey*
Culvert 1 (%)	100%	100%	96%
Culvert 2 (%)	47%	47%	44%
Culvert 3 (%)	77%	76%	75%

Fish Passage Criteria and Flows

All OAR/NMFS fish passage criteria apply in the implementation of fish passage along the Calapooia River, in accordance with the OAR Division 412 Fish Passage document (OAR, 2006) and NMFS Anadromous Salmonid Passage Facility Design document (NMFS, 2008). Pertinent regulations are listed in Table 5.

Table 5: OAR and NMFS fish passage criteria for streambed simulation culverts.

Criteria	*OAR Requirements*	*NMFS Requirements*
Min. Water Depth	0.5 feet	6 inches
Min. Culvert Width	1 feet	4 feet
Length	No limit	Less than 150 feet (otherwise consider bridge)
Embedment Depth	20% of structure height; maximum depth of 50% of structure height	Culvert bottom should be buried into the streambed no less than 20% of the culvert height at the outlet and no more than 40% of the culvert height at the inlet
Structural Integrity	100-yr return interval storm	50-yr return interval storm

Fish passage flows are defined in OAR 635-412-0005 as the range of flows bound by the 95 percent and 5 percent exceedance flows. The high fish passage design flow is taken from the mean daily stream discharge that is exceeded 5 percent of the time during the period of life cycle needs for native fish. Low fish passage design flow is also taken from the mean daily average stream discharge, but exceeds 95 percent of the time and excludes days with no flow. NMFS's fish passage design flow criteria is determined by summarizing the past 25 years of the mean daily stream flows occurring during the fish passing season.

Alternative Assessment

Alternative 1: No action

The first option considered in this design project was to remain with the current culvert setup on site, making no changes. However, the ‘do nothing’ alternative does not address the current issues on site, nor does it meet the criteria of the design project, specifically the OAR regulations. The landowner is not required to make changes at the site, however the barrier to fish passage must be addressed and so the design team found this option to be not a viable at this time.

Alternative 2: Arched culvert installation

The second option explored was an arch culvert to replace the three culverts on site and to address the associated passability issues. According to the Pacific Corrugated Pipe company, the largest arch culvert available is 12’ in diameter. This renders this alternative infeasible given the bankfull width of the reach in question exceeds 50 feet in normal high flows. In addition to this obvious non-starter, open bottom culverts are typically used in lower flow situations. If half arch culverts are overtopped they can fail dramatically; this risk is not easily addressed for our design period. Although half arches are less structurally sound than circular culverts, it is conceivable that a sufficient load capacity could be achieved, but the greater issue is the unavailability of a large enough culvert to accommodate the width of the reach.

Alternative 3: Culvert replacement

Alternative 3 considers the feasibility of replacing the current road-crossing culvert array, with new culverts that meet fish passage criteria and adhere to flood capacity considerations. Fish passability for new culvert arrangements were evaluated using FishXing v3.0.17, and resulted in an overall need for larger diameter culverts. Suitable culvert replacements can be designed to allow for adequate passage; however, the disadvantages of this option are numerous. It would be difficult to justify excavating the currently defective culverts only to replace them with more—albeit new and larger—culverts. This alternative was specifically discouraged by the landowner. Permitting difficulty, maintenance frequency, and landowner preference, make this alternative infeasible.

Alternative 4: Bridge construction

The fourth alternative is to replace the current culverts and build a bridge. The width of the channel makes a railroad flatcar bridge the best option. Railroad flatcars are available for purchase from the Rick Franklin Corporation. The structure will span the channel and would support a roadway over the water body; it would move large debris, decreasing maintenance. This option preserves the natural fluvial flow of the river, and is able to hold the necessary weight for transportation across the channel. The cost for this alternative may be lower than other bridge designs since the materials used are salvaged.

Preferred Alternative: Railroad flatcar bridge

The proposed plan for modeling and analysis of the final design will be focused on alternative 4, the railroad flatcar bridge. This alternative meets all OAR regulations, creates a suitable fish passage, and meets the needs of the client.

Proposed Design

Rail flatcars are readily available, easy to install and much more economically feasible than a traditional bridge design. These bridges have low maintenance demands and offsite construction eliminates downtime at the building site, which is important at the project site because we want to minimize the interruption of fish passage as much as possible during the design implementation (RFC, 2013).

The landowner’s desire to be able to drive up to 100,000 pounds of equipment over the bridge will be met, as rail flatcar bridges are installed to provide HS-25 load capacity, which has an inventory rating of 45 tons, or 90,000 pounds, and an operational rating of 75 tons, or 150,000 pounds (WDOT, 1998).

Hydraulic design

In order to exhibit that the proposed design will meet OAR and NMFS fish passage requirements, a preliminary hydraulics study was conducted using the one-dimensional hydraulic modeling program, HEC-RAS (USACE, 2010). Figures 7 and 8 below show a section view of the proposed design and site layout, respectively. For the proposed design, OAR requirements need to be satisfied. Figure 7 shows that the proposed bridge spans the active channel width, and also that the low chord of the structure has a vertical clearance of 3.0 ft (0.9144 m) from the elevation of the ordinary high water level elevation (72.7 m).

Figure 9 shows a cross-sectional view of the HEC-RAS model at the upstream end of the bridge crossing. The 5% and 95% exceedance flows (Table 1) were tested with the proposed bridge design to ensure OAR compliance. Water surface elevation profiles for both flows are shown in Figure 9 and also shows that the minimum depth requirement of 0.5 ft is met.

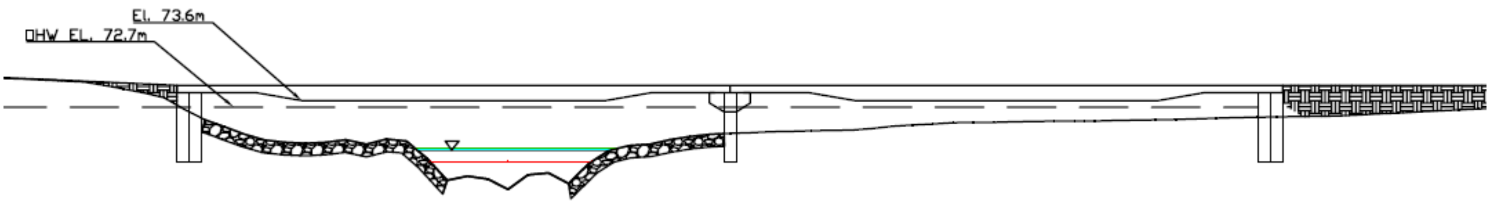

Fig. 7: Proposed bridge design section view at Calapooia River crossing

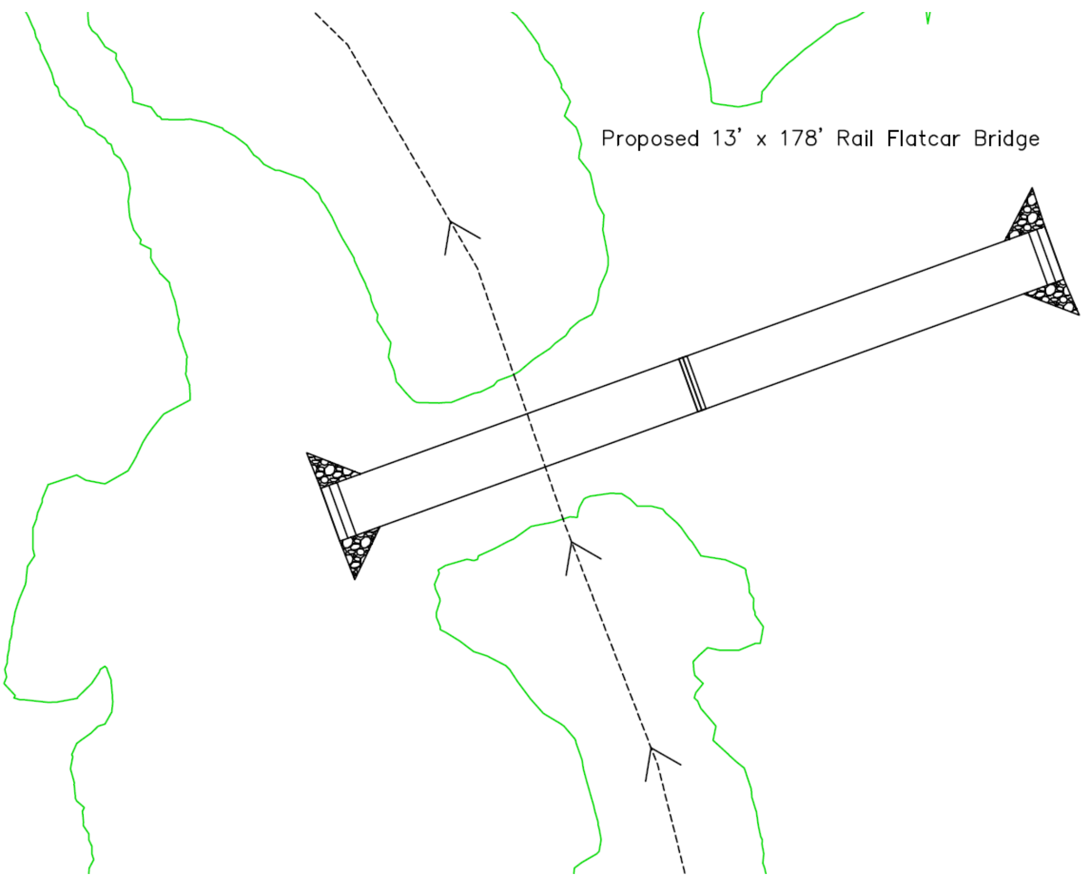

Fig. 8: Site layout of culvert-crossing topographic contours and proposed bridge design

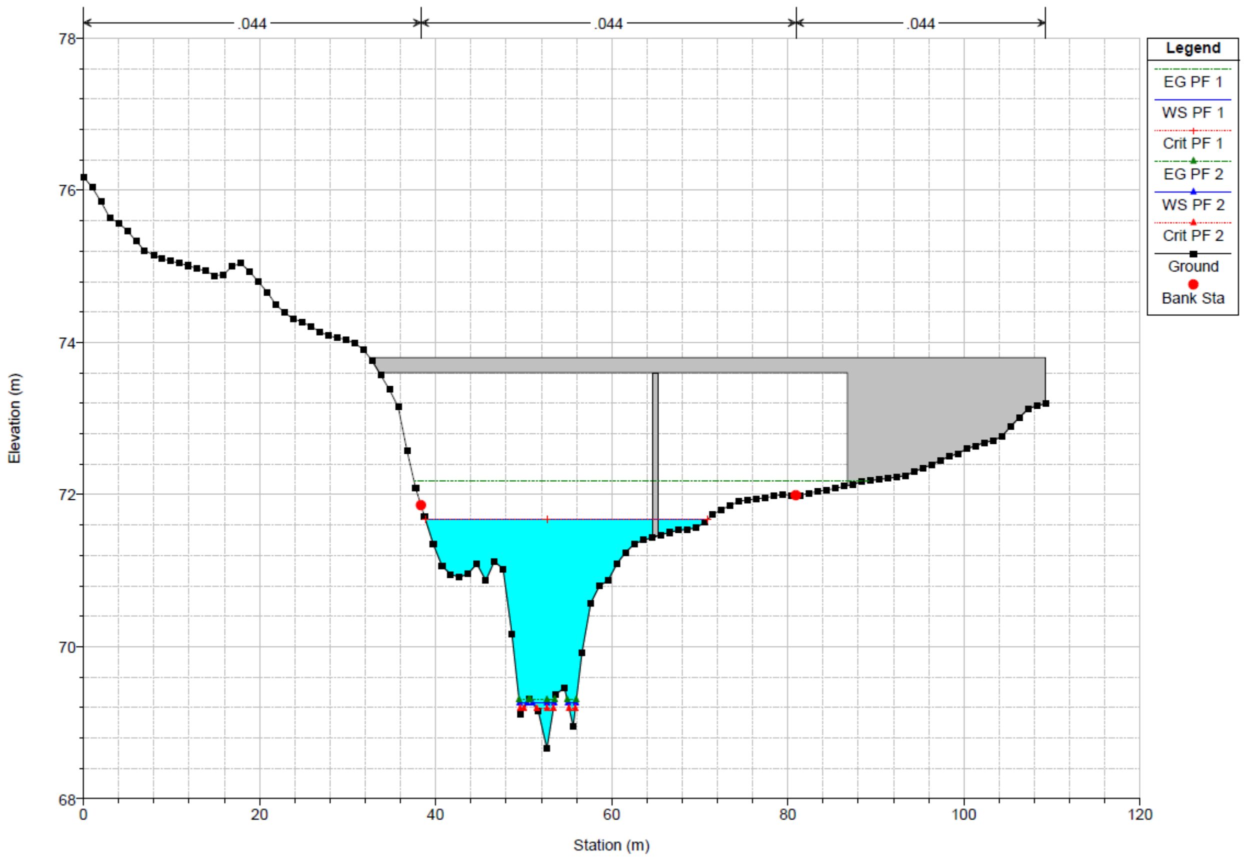

Fig. 9: 5% (PF 1) and 95% (PF 2) exceedance flow water surface elevation with proposed bridge design.

Grade Control Features

The need for grade control structures can be determined by analyzing the outlet scour and current channel incision. Figure 9 illustrates the two-dimensional slope of the streambed, with the red point representing the current location of the culverts. As the figure shows, the slopes, analyzed from riffle to riffle or pool to pool, are relatively similar upstream and downstream of the culverts. This similarity in slope shows that there is no present potential for head-cutting of the stream and therefore grade control structures are not necessary at this site. Additionally, riffles may be considered natural grade control structures. There are several riffles on the stretch of the Calapooia that is of interest that will act as grade control structures should the need for them arise in the future.

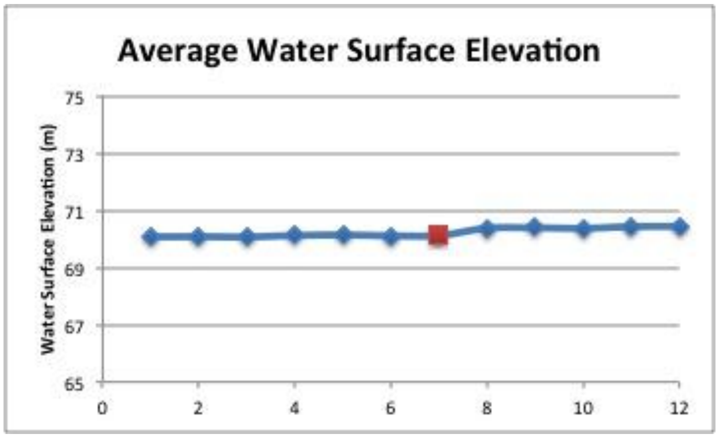

Fig. 10: This graph shows the average water surface elevation upstream and downstream of the culverts, with the culvert location represented by the red point. As the figure shows, there is no appreciable difference in water surface elevation on either side of the culvert, therefore grade control should not be an issue when removing the culverts.

OAR/NMFS Requirements

There are several necessary requirements that a bridge must meet. First, the bridge must be equal to or greater than the active channel width and there must be at least 3 feet of vertical clearance from the active channel elevation up to the inside top of the structure. An average water depth and stream velocity must be maintained with a slope equal to the surrounding streambed profile and the streambed must contain large, partially buried rocks if the bridge is greater than 40 feet in length. Finally, to assure the streambed is maintained through time the bridge should be composed of natural materials and allow large debris to pass at all flows.

Project constraints and timeline

The initial constraints—being able to transport heavy machinery across the bridge, ensuring fish passage underneath the bridge and complying with regulations—seem to be adequately met by this design. The remaining constraints are time and permitting. The in water working period will occur from June 1st to October 15th (for projects below Holley, including this one). Before construction can occur, the relevant permits must be obtained. The following sections detail the permits that will be needed to complete this project.

Permitting Information

A removal-fill permit for a wetland delineation and determination of ordinary high water is needed from the Oregon Division of State Lands (DSL) and Army Corps of Engineers (COE). This insures that the project is an 'in-water' project and must be accepted by DSL and the COE. Since the site location on the Calapooia River is not within a federally navigable waterway, it falls under section 404 of the Clean Water Act and is administered by the COE.

The COE also issues 'Nationwide Permits'(NWP), which is a general permit that authorizes activities across the country. The project addresses replacement of structure and fish passage. Aquatic Habitat Restoration, Establishment, and Enhancement Activities (NW -27) or Maintenance (NW-03) is where the project will most likely be applicable. The COE will review and determine at that time if it will be authorized.

Since the site location is located on an archeological site, permits are required in the state of Oregon because excavation, destruction, or alteration on public and private lands is prohibited. Cultural resources are important to the tribal nation and the state's history. The Oregon Department of Environmental Quality administers the ORS 358.905-358.962 permit where significant archeological artifacts are protected on public and private lands. Since the site location is located on private land, this permit applies to the project and will be needed before any excavation is done.

Cost Estimate

The major costs associated with this design include the rail flatcar, concrete abutments, large boulders, removal of the culverts, labor, and permitting associated costs. The rail flatcar and concrete abutments are available through the Rick Franklin Corporation, based in Lebanon, OR, and the large boulders will be incorporated in the design to meet OAR standards. Permitting costs include not only the permits themselves, but also work associated with site assessment to fulfill requirements.

Rail flatcars are available in three lengths—40, 50, 60, and 90 feet—from the Rick Franklin Corporation. As described in the report, two 89 foot cars will be used to build the bridge structure. Deck options include wood or steel cars, and the steel option will be implemented as it will better withstand frequent inundation, as the bridge is designed to be overtopped at high flows. Steel decks cost $650 per foot, so the cost of the rail flatcar for the entire project will be about $116,000. The cars are typically 13 feet wide, which should be sufficient at our site to allow for the passage of farm equipment and people, the two main sources of traffic across the river at this location. The company providing the rail flatcars is based out of Lebanon, Oregon, so shipping should be relatively inexpensive, compared to bringing the cars in from out of state.

Costs for the other major financial factors in the project will be largely dependent upon the final design specifications. Depending upon the permits that are required, it can be expected that permitting and associated surveying work could be around $100,000 or about half of the overall project cost (Calapooia Watershed Council).

The Oregon Watershed Enhancement Board (OWEB) is the primary funding source for fish passage projects and the organization has funded rail flatcar bridges in the past. By showing that this design is the most financially feasible option for ensured fish passage on site, there is no anticipated issue with gaining funding for the project.

Summary

In assessing fish passage on the Calapooia River, four alternatives were explored to determine the best option for removing barriers to fish passage for Chinook, Steelhead, and Lamprey. The first alternative to do nothing did not meet the criteria of creating fish passage and the possibilities of installing new, larger culverts or an open bottomed culvert were unsuitable for the site. The design team decided on a rail flatcar bridge, for its ability to create fish passage in the most economically feasible way. Two 89' rail flatcars will be laid end-to-end to provide passage across the river for the landowner and his heavy machinery and to meet all OAR regulations.

The design team believes that a rail flatcar bridge is the most effective option for meeting the objectives of this design project. The bridge will ensure fish passage for Chinook, Steelhead, and Lamprey and comply with all OAR regulations. In addition, the design will pass debris at both high and low flows and can accommodate loadings of well over 100,000 pounds, meeting the expectations of the land owner. The design is expected to meet all permitting regulations associated with such a design

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