DEEP, GOOSE and EAGLE CREEKS FISH PASSAGE ASSESSMENT

Prepared For

Clackamas River Basin Council

2005

Prepared By

WPN WATERSHED PROFESSIONALS NETWORK

and

Upstream Connection

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Prepared for:

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1.0 BACKGROUND AND METHODS

1.1 BACKGROUND

The Deep, Goose, and Eagle Creeks Fish Passage Assessment is the second phase of a Lower Clackamas River Basin fish passage assessment effort initiated by the Clackamas River Basin Council (CRBC). Clear and Foster Creek watershed fish passage was assessed in 2002-2003 (Robison & Walsh 2003).

The primary impetus for these projects has been to effectively and efficiently improve the habitat reach of the anadromous salmonid species that use the Clackamas River Basin. Most information on fish passage barriers, however, is on public roads. Private landowners of all sizes and management objectives also install and maintain road systems that cross the fish bearing streams of the Lower Clackamas River. Therefore, information on the status of fish passage on private land ownerships, particularly in the effort to efficiently apply public restoration funds, is critical.

Based on evidence and research summarized in the Clear and Foster Creek Fish Passage Assessment (Robison & Walsh 2003), blockage of fish passage is associated with habitat loss for spawning and rearing adult and juvenile fish, life cycle alterations, potential increases in juvenile mortality, and possible changes in stream nutrient cycling. As a result, fish passage issues can be a focal point of watershed restoration. Assessment and prioritization are critical in locating crossings and deciding which fish passage issues to focus on with limited restoration resources. Recognizing this, the CRBC integrated the fish passage assessment in Deep, Goose, and Eagle Creek basins with the watershed assessment effort in Deep and Goose Creek basins. The two projects and their results are highly complementary.

The overriding objective for this project was to:

Create an assessment and priority scheme for stream-road crossings that provides adequate information to pursue grant and other funding sources to correct the most pressing basin needs. This scheme must take both local and watershed wide issues into account in developing priority and cost information.

The steps to meet this objective were to:

- identify fish bearing streams and road crossings;
- use GIS and basin knowledge to prioritize crossings prior to entering the field;
- develop a landowner permission process to gain access to sites and develop understanding, acceptance, and support among this key stakeholder group;
- develop a field assessment protocol and fish passage analysis method that provide appropriate information to design cost analysis and prioritization methods;

- create a prioritization scheme that takes into account local and watershed factors as well as design and cost information; and

- develop conceptual designs for replacement or corrective actions and their best estimated costs on a subset of high priority culverts to be used for restoration grant and funding applications.

The Deep, Goose, and Eagle Creek fish passage assessment used the protocol foundation developed in the Clear and Foster basins (Robison & Walsh 2003) as a base from which to develop a modified field methodology. This adapted protocol had two phases. A two-phased approach allows for:

- rapid, efficient collection of quantitative crossing measures (Phase 1)

- identification of the fish passage status on a thorough population of basin crossings (Phase 1)

- prioritization using the full population of basin crossings (Phase 1)

- detailed cost and design option information on the highest priority crossings (Phase 2)

Modifications to the Clear and Foster Creek protocol were made based on lessons learned during the course of field surveying. The scientific justification of each phase of the protocol remains the same because the fish species, land uses, and project objectives are similar in throughout the Lower Clackamas River basins.

1.2 KEY START-UP ACTIVITIES

We identified three key start-up tasks.

1. Create a base map coverage of the basins based on the most accurate fish extent, stream, road, natural barrier, and ownership information available.

2. Use GIS information and other basin knowledge to pre-prioritized stream crossings.

3. Adapt the successful landowner permission process scheme used in the Clear and Foster Creek assessment to the unique needs of basin owners in Deep, Goose, and Eagle.

As in the Clear and Foster Creek assessment, the latter is extremely important as previous comprehensive assessment efforts have been damaged by lack of permission to assess fish passage status at key crossings (David Evans and Associates 2001).

1.2.1 Construct Assessment Area Base Map And Generate List Of Potential Crossings

WPN created a base map for the watershed assessment in Deep and Goose Creeks and the fish passage assessment in those basins and Eagle Creek. Included in this base map are the following features:

- Watershed boundaries
- Stream Layers
- Topographic contours
- Roads
- Major landownership divided by private, county, Metro, state, and federal
- Natural and known man-made channel barriers (waterfalls, dams, etc.)
- Upper extent fish use – both confirmed and estimated using ODF 2001 Interim End of Fish Guidance (ODF 2001)

For the purposes of the fish passage project, WPN added tax lot and unique crossing identifiers to this map for use in determining stream crossing locations and access requirements in the field.

Using this information, we sorted the stream crossing population to exclude crossings that meet the criteria in Table 1 from the sampled population. This is a necessity because the initial crossing population was estimated at 650, far beyond the scope of the project budget and timeframe.

Table 1. Policy and landscape criteria used to pre-prioritize and sub-sample the total stream crossing population.

Exclusion Criteria	Justification
Non-fish bearing reaches	Crossings and barriers on non-fish bearing reaches do not affect fish passage. Where fish presence was not verified in the field, we applied the interim ODF fish presence rules to the GIS base map. In the Interior Cascades, non-salmonid bearing status can be applied to reaches above waterfalls marked on maps, with less than 100 watershed acres above them, and/or with stream gradients over 20%.
Distance from Clackamas River	The further away a crossing is from the mainstream confluence with the Clackamas River, the less linear channel habitat exists above it, the steeper the channel gradient, the larger the substrates, and the

Exclusion Criteria	Justification
	lower the relative habitat quality of the opened reach. We surveyed all crossings within a 6 mile distance from the confluence of Deep Creek and the Clackamas and an 8 mile distance from the confluence of Eagle Creek and the Clackamas. Crossings outside this arbitrary boundary were included in the survey as time allowed.

1.2.2 Landowner Participation And Permission Process

Like the Clear and Foster Creek fish passage assessment, the Deep, Goose, and Eagle Creek fish passage assessment and prioritization effort is a unique endeavor in that it attempts to assess the total population of potential anadromous fish passage barriers. This includes potential barriers that are on private land. Most fish passage assessments are conducted by an agency or individual company that, through a commitment to common goals and objectives, has achieved internal agreement about the process and potential results. Though a convenient and logical approach based on organizational hierarchies, this method ignores the natural boundaries of watersheds and therefore, leaves the basin-wide challenge of achieving fish passage unresolved.

Public landowners in the Deep, Eagle, and Goose Creek basins have been involved, to varying degrees, with the basin fish passage assessment. The coordination challenge for this assessment, because of its watershed boundary focus, was gaining the understanding, acceptance, and support of private landowners so that they participate in the process.

"Private land" encompasses a wide range of ownership types, management objectives and owner perceptions. In the Deep, Goose, and Eagle Creek basins, these include private timber companies, small woodland owners, wholesale nurseries, Christmas tree farmers, large agricultural farmers, hobby farmers, private homeowners, industry, and development owners. To gain cooperation and earn acceptance for the fish passage assessment, these private interests must be approached in a manner that addresses its unique concerns.

Though most landowners will share the same concerns, some will weigh the potential for regulatory action more heavily than others, while others will regard the potential for financial costs as their primary issue. Others may simply resent the intrusion of a public process on their land holdings. For each instance there should be a public outreach tool that will provide the information they require to engage in the process.

The goals for reaching out to private landowners are:

- Gaining trust
- Education
- Involvement

Trust is an important part of a productive, long-term relationship. The consulting team recognized that by actively implementing the fish passage methodology within the Deep, Goose, and Eagle Creek basins, we represented the CRBC in person. Trust that has been built over time by the CRBC must be maintained and additional degrees of trust fostered through clear and honest communication and display of actions. Communication methods that hopefully fostered trust are discussed below.

Direct interaction with private landowners is an excellent opportunity for education about fish passage and habitat issues. The consulting team actively embraced sharing our technical knowledge with basin stakeholders whenever it was solicited. We also gained local and site-specific knowledge from the landowners. We encouraged this exchange wherever possible. The CRBC stands to gain from continued personal interactions in the basin as well and the consultants will make every effort to formally transfer information contributed by landowners to the Council.

Through project involvement, the consultants' hope that a greater interest in the objectives, actions, and goals of the CRBC was fostered with private landowners and that this interest will continue beyond the scope of this particular project. Any positive contributions that the consulting team made to increase landowner participation within the Council were encouraged.

To meet the fish passage assessment outreach goals, the outreach objectives related to the assessment are to:

- Establish contact and introduce the project
- Educate and exchange information
- Gain permission to examine potential fish passage barriers on the ownership
- Communicate results

1.2.2.1 Contact and Introduction

The first step was to let landowners who have potential fish barriers on their property know that the fish passage assessment is occurring, who will be conducting it, why it is being conducted, how it will be conducted, where it will be conducted, when the consulting team would like to conduct it, and what the potential outcomes of the process will be.

Using GIS data layers assembled jointly for this project and the Deep and Goose Creek basin watershed technical memorandum, we queried private properties that contain potential fish passage barriers (accomplished by overlaying stream and road layers with tax lot information). Using the list of landowners generated by this process, we sent out a postcard to each, describing, in a concise format, the information above. Included in this postcard was contact information for the CRBC, including the CRBC website address.

A few days after the postcards were likely received, we began to personally contact landowners by phone based on their basin location and the sampling prioritization of the potential fish barrier on their property. If necessary, we continued the contact and introduction phase by visiting the landowner. Though possibly not necessary from an information exchange or introduction perspective, personal visits can generate a high degree of trust which facilitates the permission process.

The consultants engaged in other general forms of introduction by contacting local organization outreach experts including those from the Oregon Department of Fish and Wildlife, Oregon Nursery and Landscape Association, Sandy and Boring Chambers of Commerce, Bureau of Land Management, and Oregon Department of Forestry to coordinate communication and project goals.

1.2.2.2 Education and Information Exchange

This phase is a continuation of the Contact and Information phase. Through personal contact and the CRBC website, we provided background information on the goals and objectives of the fish passage project, the need for the project, and the expected outcomes of the project. Personal contact, either over the phone or in person on-site, offered excellent opportunities to learn from the landowner in terms of what they have observed in local fish populations, how they have managed for fish passage, local flooding history, and what their concerns and goals are related to fish passage and road maintenance. This landowner information was recorded and, depending on its relevance, communicated directly to the CRBC, shared with the WPN watershed assessment team, and/or included in this final report.

In coordination with the CRBC, fish passage project information is added to the CRBC's website (http://www.clackamasriver.org).

1.2.2.3 Access Permission

Gaining access to private land is critical to the success of this fish passage project. Via initial contact made through postcards and phone calls and with the assistance of local basin experts from various agencies, we received landowner permission to 96% of the potential fish passage barriers on private land. Only one landowner verbally denied the survey crew access to his dam. Landowners at the other crossings did not respond to repeated attempts to contact them by mail, telephone or visits. A critical element in the success of this phase was clear communication of what the results of the survey were being used for. The consulting team strongly emphasized the non-regulatory nature of the assessment and the economic benefits that a thorough survey can offer in terms of selecting the lowest cost option necessary to successfully achieve long-term fish passage.

As needed, we also focused on the community nature of this project in that no landowner or type of ownership is being singled out. Rather, all basin residents are contributing to its outcome and success. We also appealed to the landowners' sense of place and pride in their basin by discussing the importance of fish passage for healthy fish populations throughout the basin, the understood historical reach of fish within the basin, the successful results obtained in their neighboring Clear and Foster Creek basins, and the unique opportunity this effort is offering to the Deep, Goose, and Eagle Creek basins to serve as a role model for similar Oregon Plan efforts.

While on site, we remained aware that we independently represent the CRBC. As such, we arrived as scheduled (if arrangements have been made), communicated clearly and honestly with the landowner if the opportunity arose, completed our work as quickly as possible taking only the information necessary to complete the survey, and left no evidence of our efforts except those communicated to the landowner. We provided business cards and other requested contact information to the landowner.

1.2.2.4 Results Communication

In terms of public outreach, the final tasks of a project such as this one are as important as the initial contact phases. Interested landowners will want to know what became of the information collected on their land. Providing clear and open communication of results is a critical element of fostering long-term trust and participation in the process. In addition, landowner feedback solicited at presentation meetings will be critical to improving the methodology and process for the larger basin-wide fish passage assessment. This point will be emphasized in the course of any fish passage assessment presentations.

The website is useful for communicating results and posting notices of public meetings to discuss results. Maps, results and pictures from field data were added to the online Fish Passage Tool created for the Clear and Foster Creek assessment so that landowners, agency personnel, and other interested stakeholders can examine the surveyed crossings in these five lower Clackamas River basins. We will work with the CRBC, if requested, to create a press release to send to local newspapers announcing the project results. If desired, postcards may also be sent out at the close of the project to thank landowners for their cooperation and to inform them where they can obtain the results.

1.3 FIELD PROTOCOL

The Fish Passage assessment was completed in two phases. Phase One uses a Rapid Protocol to efficiently collect crossing measures that are critical to prioritizing the full population of crossings and providing an estimate of replacement design options. Results from Phase One have been incorporated into the Deep and Goose Creeks Watersheds Technical Memorandum developed by the WPN.

In Phase Two field work is completed to develop stream profiles and road elevations for those crossings identified as the highest priority for fish passage restoration. Phase Two uses the elevation/stream profile protocol developed for the Clear and Foster Creeks Fish Passage Assessment Detailed Protocol with minor modifications. Results from Phase Two's intensive examination of a subset of high priority stream crossings will allow the CRBC to compete for grant applications necessary to take corrective action.

Based on lessons learned after applying the field protocol developed for the fish passage assessment in Clear and Foster Creeks (Robison & Walsh 2003), we developed a refined version of that project's Fast Protocol to:

- record quantitative crossing measurements that identify the highest priority crossings in the three basins
- reduce field survey costs and time at each crossing by more than half
- sample a larger crossing population: a necessary effort because of increased road densities

The Clear and Foster Creek Fast Protocol was proposed for use on low priority and previously surveyed culverts with missing information. Low priority status was assigned to culverts that had minimal upstream habitat and were not well connected downstream (i.e., have blocking culverts downstream or at a great distance from the mainstem). After examining the final results achieved using the Clear and Foster Detailed Protocol and those that would be gained from the Fast Protocol, we determined that a modified version of the Fast Protocol could be applied to surveying a full population of culverts without compromising the accuracy of a prioritization process designed to identify the highest priority stream crossings. More detail was added to the Fast Protocol while allowing it to remain a single-person protocol that could be accomplished in 15-60 minutes per crossing.

1.3.1 Field Methods

The field form and abbreviated code sheet is provided in Appendix A.

1.3.1.1 General Information Taken For Each Culvert Crossing

Crossing number – A unique number for each crossing taken from base map.

Stream name – Taken from maps. If creek has no name, then identify based on tributary status (e.g., T T Tickle would be a tributary of a tributary of Tickle Creek).

Road name - The road name should be the name by which the road is best known. This can be a proper name or number. If the name is unknown it can be named after a landmark (perhaps after a nearby stream, harvest unit, or ranch) or road type.

GPS – The coordinates of the culvert will be recorded using a recreational grade global positioning system (GPS). The GPS reading can be compared to those developed by GIS to check accuracy or to add a previously unknown crossing to the GIS base map. Waypoints were recorded and stored on the GPS unit rather than transcribed to the field sheets.

Photo documentation: #1 looking upstream with potential outlet drop in photo, #2 inside the barrel looking upstream, and #3 looking downstream at inlet. These photos can be invaluable when unsure of recorded data for one reason or another.

1.3.1.2 Step 1. Structure and Outlet Measures

Crossing type:

- RC Round Culvert (Closed bottom structure, CBS)
- PA Pipe Arch (CBS)
- OA Open-Arch (Open bottom structure, OBS)
- BR Bridge
- FD Ford
- OB Open Box (OBS)
- LG Log Culvert (OBS)
- BX Box or rectangular (CBS)
- OT Other

Culvert condition: Number of years of life estimated for the culvert. 0, +5, +10, +20.

If the culvert is a CBS or OBS then take the following measurements at the outlet side:

Outlet drop (in): This is estimated using a meter stick from the invert of the culvert outlet to the residual water surface. See Figure 1 for information on residual pool concepts. This measurement is for CBS only.

Culvert Diameter (in):

Round – measure diameter (in) with tape or meter stick and length (ft) by summing the width of the road with the length of pipe from road edge to inlet and outlet (measured with tape).

Arch – measure span (in), rise (in) and length (ft).

Culvert slope (%): Measured with an electronic clinometer[1]. Looking upstream in the culvert with the electronic clinometer, measure the slope of the culvert by aligning the recorder's eye at

[1] ±1% accuracy.

a common spot such as a bolt line or the top of the culvert and sighting up to its corresponding common spot at the inlet. Take three measurements and use the average of the three. If the slope is ±0.2% around 0.5%, flag crossing as one to return to with a transit/laser level for more accurate slope determination. See *Repeat Level 1 Visit* for protocol details.

Debris in culvert (%): Percent measure of the blockage of the culvert invert diameter by debris.

Culvert shape intact (yes/no): Indicate if the culvert is crushed, dented, or otherwise compromised.

Residual pool depth (in): Measured at the deepest part of the pool downstream of the culvert to the residual water surface.

Visible bedrock (yes/no): If bedrock is visible on the stream bottom within 30 feet of the outlet, note it here.

If there is a downstream weir or a riffle backing water into the culvert take the following measurements. Mitigation structures are installed downstream of culverts to back water into them or to retain sediment. The riffle or weir/riffle crest should be within 2-4 channel widths of the culvert outlet in distance.

Outlet mitigation structure type:

- GW Gabion weirs
- RW Rock weirs
- WD Woody debris
- WR Wood and rock
- NO None
- OT Other, explain (i.e. a riffle backing water into pipe)

Backwatering (ft): Estimated length of backwatering within the pipe from the outlet due to a downstream weir at the time of measurement. If the backwatering spans the entire culvert then put the length of the culvert.

Distance between outlet mitigation and crossing (ft): Measured from the outlet to the mitigation structure/downstream control with tape. If there are multiple structures, document the average distance between them.

Outlet mitigation drop (in): A measure of the difference in the height between the outlet invert and the downstream control at the mitigation structure (Figure 1). At a CBS with any evidence of backwatering and a culvert slope of 3% or less, cease measurements, flag crossing and measure on a return trip with a transit/laser level. See *Repeat Level 1 Visit* for protocol details. For other CBS and all OBS, measure at first visit using an electronic clinometer. Measure three times and average the readings. If the primary downstream control is higher than the outlet invert, this measure will be negative. If more than one structure (multiple weirs) exists, take a height measure between each structure. Treat the previous structure as if it were the outlet invert.

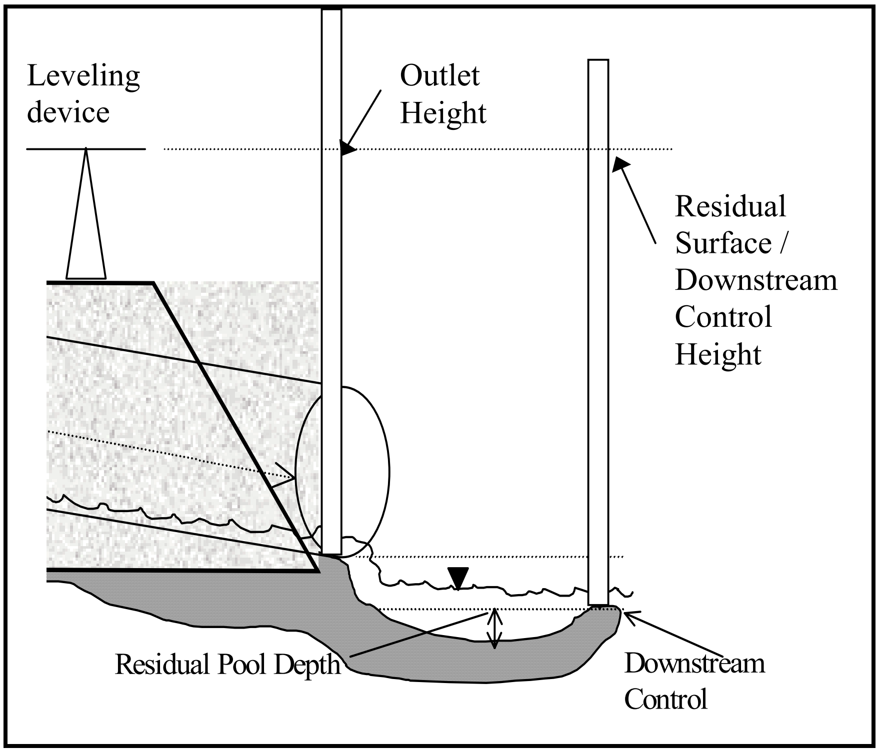


Figure 1. Residual pool schematic using downstream weir height (Robison et. al., 2000)

<u>If the culvert is a CBS and the outlet drop is greater than 2 feet or the culvert slope is greater than 3% with no substrate embedding in the culvert then cease measurements on Step 1 – The culvert will not likely pass adult fish and will not pass juvenile fish.</u> This will probably constitute the majority of CBS culverts installed previous to 1994.

If the culvert is OBS then the following should be taken:

Footing condition: described as

- ST Stable (no scour near edges)
- ER Eroding (scour near edges but OBS not cantering or deforming)
- FL Failing (scour plus deformation)

1.3.1.3 Step 2. Barrel Measurements Inside Culverts

Embedded Culverts

Sediment pattern (code): For natural-bed or embedded structure designs, gives a qualitative description of how material is arranged in the structure. Use NA for structures that are not designed to collect sediment (baffled culvert, bridge).

- SS Simulated streambed (channel type forms such as bars and sinuosity, material contiguous bed material)
- CR Contiguous rock fill (rock contiguous throughout the structure)
- IN Contiguous rock fill in culvert except within 1-3 meters of the inlet which is bare or has sparse rock cover.
- SR Sparse rock fill (rock in culvert but not contiguous)
- NM No material in culvert
- NA Not applicable

Bed material in structure (code): For embedded or streambed simulation designs enter the predominant size of material (Table 2) for the length of the crossing. There may be more than one but no more than three. Double circle the predominant material when more than one. Use NA for structures that are not designed to collect sediment (baffled culvert or culvert placed flat) and NO if there is no material in the culvert.

Table 2. Codes used for size classification of material used in road fill armor, road surface armor, stream crossing structures, and channel substrate (Kaufmann and Robison 1998).

Code	Material	Size description
BD	Bedrock	Bigger than a car/continuous layer (>12 ft)
BL	Boulders	Basketball to car-sized (1 foot – 12 feet)
CB	Cobble	Tennis ball to basketball (3 inches – 12 inches)
GR	Gravel	Ladybug to tennis ball (0.1 inches – 3 inches)
FN	Fines	Silt/clay muck to visible particle; gritty - sand
NO	---	None
NA	---	Not applicable

Baffled/embedded culverts

Baffle design:

- WB Weir baffles
- OF Offset weir
- PW Prior design notch weir
- NW Notch Weir
- SR Sediment Rack
- OW 1 Outlet Weir only
- MW Multiple weirs downstream from culvert
- OT Other
- NO None

If NO, skip to Step 3.

Distance between baffles (ft): Average for multiple weirs.

Distance between last baffle and outlet (ft): Measured from the base of the last baffle to the outer edge of the culvert.

Height of baffle (in): Measured at the highest point of the baffle above the invert of the culvert.

Depth of baffle notch (in): Measured from top of baffle to base of notch.

1.3.1.4 Step 3. Inlet measurements on upstream side of culvert

Inlet drop (in): Measure inlet drop with meter stick. An inlet drop is when the bed of the stream upstream of the culvert is at greater elevation than the invert or simulated bed/embedded bed of the culvert. Take for CBS culverts only.

Inlet design (code):

- NM Not mitered.
- MI Mitered

- WW10-30 Wing-wall with 10-30º
- WW30-70 Wing-wall with 30-70º
- HW Headwall
- OT Other

Evidence of accelerated sediment deposition (yes/no): If it appears that sediment is backing up behind the inlet (indicated by bar formation, change in substrate, or other evidence of accelerated deposition) note it here.

Visible bedrock (yes/no): If bedrock is visible on the stream bottom within 30 feet of the crossing, note it here.

1.3.1.5 Step 4. Road and Overflow Dip Measures

Road fill armor (code): Using the codes in Table 2 classify the size of material used for armoring the road fill on the upstream and downstream side of the crossing.

Road slope (%): Measure with an electronic clinometer from center line in road in both directions from the crossing. Do three times each direction and average reading to estimate the curvature of the road as it enters and leaves the crossing. This helps determine if the road can be lowered or raised to provide more headroom if needed.

Road width (ft): Measure the width of the road following the line of the culvert or bridge that passes underneath.

1.3.1.6 Overflow Dip Measures

Overflow dip presence (yes/no): Overflow dips may be used on roads built on wide flood plains or in other situations (Figure 2). Indicate whether an overflow dip is present and document with additional photos.

Overflow dip road surface armor (code): Using the codes in Table 2 classify the size of material used to armor the road surface of the dip (may be more than one, but no more than three).

Overflow dip road fill armor (code): Using the codes in Table 2 classify the size of material used to armor the road fill associated with the dip (may be more than one but no more than three). This is recorded separately for the downstream and upstream sides of the crossing.

Overflow dip road surface condition:

- ST Stable

- ER Eroding
- FL Failing

Overflow dip road fill condition:

- ST Stable
- ER Eroding
- FL Failing

Distance from dip to structure (ft): Measured from the center of the crossing structure to the lowest point in the dip.

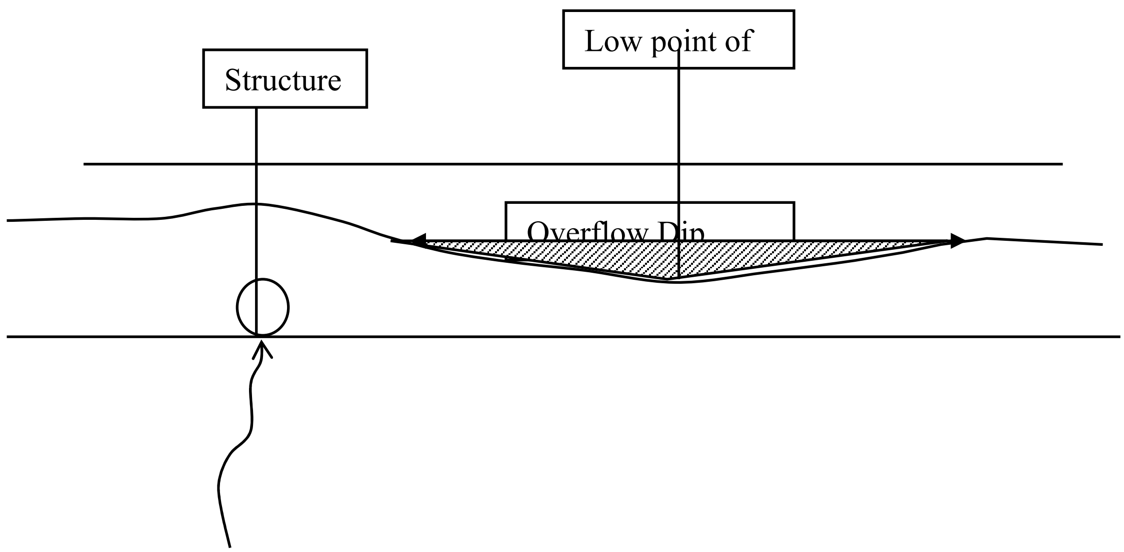


Figure 2. Over flow dip schematic (adapted from Dent 1999).

1.3.1.7 Step 5. Channel and Valley Measures

Bankfull channel width (ft): Measured at the average annual high water mark upstream from the influence of the culvert inlet/outlet. Measure at 10 and 20 feet upstream/downstream of inlet/outlet influence and estimate for remainder of visible channel.

Channel substrate (code): Upstream of the influence of the culvert inlet, characterize the size of the channel substrate using the codes described in Table 2. Double circle the most predominate size followed by other sizes.

Channel gradient (%): Using the electronic clinometer, measure the slope of the channel upstream of the inlet and downstream of the outlet. Measure three times and average reading.

Stream/valley fill (code): This refers to the layers of unconsolidated gravel, sand cobble, and other sediment that lie over the top of the bedrock. It is measured from the parent material or bedrock to the top of the deposit.

- NF No fill: (mostly bedrock channel, possibly point bar deposits and terrace-like sediment deposits < 5 feet high, may be valley- wall constrained)
- SF Shallow fill: (limited bedrock plus cobble/gravel/sand channel with narrow floodplain and terraces 5-10 feet high)
- DF Deep Fill: (no bedrock showing in channel, broad, well-developed floodplain)

Valley type (code):

- NV Less than 3 x channel width or < 100 feet (on a side)
- WV Wide valley: greater than 3 x channel width or >100 feet (on a side)

1.3.1.8 Measures for Bridges and Fords

Bridges:
Bridge Type:

- LS Log stringer
- RR Railroad Car
- MI Metal I-beam
- CC Concrete
- OT Other Describe in comments

Bridge Span (ft): Measured from one side of the stream to the other (Figure 3).

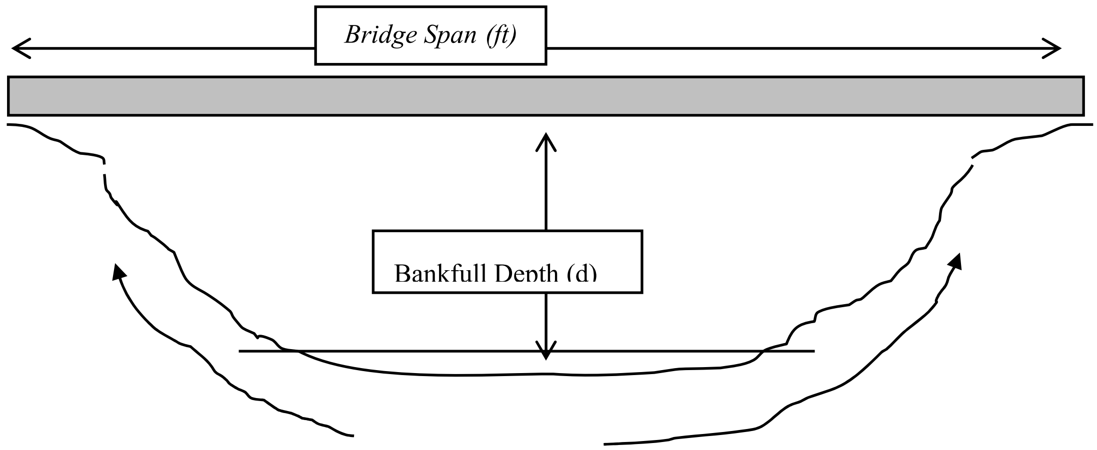


Figure 3. Schematic of measurements needed for calculating flow capacity of bridge design (from Dent 1999).

Bridge Abutment condition: described as

- ST Stable (no scour near edges)
- ER Eroding (scour near edges but OBS not cantering or deforming)
- FL Failing (scour plus deformation)

1.3.1.9 Ford/Dam Measures

Fords will only be measured if hardened and there is obvious indication of a drop or a section of high velocity water across the ford. Dams should be rare but are important to measure because of their potential to disrupt fish passage.

Jump (in): Measured from top of hardened ford or diversion dam to residual water surface.

Residual Flow Depth (in): Measured at the deepest point in the ford/dam top to the residual water surface. This represents the depth of tailwater over the ford or dam top. It will often be zero.

Residual Pool Depth (in): Measured at the deepest part of the pool downstream of the ford or dam to the residual water surface.

Material Size used for the ford upstream, at the crossing and downstream of the ford or dam (code): Characterize the size of material in each location as described in Table 2. There can be more than one but no more than three. Double circle the predominant type when more than one.

Ford or dam top surface condition: Describe the section of road draining into the ford or material on the dam top as:

- GD Good
- RU Rutted
- GU Gullied
- FL Failing

1.3.1.10 Repeat Level 1 Visit

If a CBS is found to have a slope between 0.4% and 0.6% as measured by the electronic clinometer, the crew will highlight the crossing number on the datasheet and add the crossing number to a spreadsheet list of crossings to revisit after the first complete round of crossing surveys. The protocol used on the repeat visit will collect the same variables as the first survey using a laser level or auto level that measures elevation more accurately. Critical calculated variables will be culvert slope, fill height, and outlet drop.

Measuring Crossing Elevations with a Transit/Laser Level

Use a laser level and stadia rod. Crew will record elevations at the a) road surface at both sides of the road edge, b) inlet, c) outlet, d) low point of downstream pool, e) the crest of a downstream riffle or weir, and f) a "relative base elevation". Mark the base elevation with a stake and flagging and write the Crossing ID on each with a Sharpie® marker. Use the crossing profile datasheet (Appendix A) to fill in the appropriate elevations and distances for each measure.

The outlet drop is the difference in elevation between the downstream weir crest and the invert elevation at the outlet. By dividing elevation difference between inlet and outlet by culvert length the culvert slope can be determined. This measure should be used as a check of the quality of the clinometer measures. Backwater, outlet drop, inlet drop, and culvert depth (fill height) calculations can be done with these elevations as well. Where the culvert inlet is beveled, take care to ensure that the measured culvert length corresponds to the length over which the transit level measurements were observed. All elevations should be relative to a base elevation given at the road surface. The difference between the road surface elevations and the average elevation of the culvert inlet and outlet represents the fill height. All these parameters can be calculated on a spreadsheet.

1.4 BARRIER DETERMINATION: HYDRAULIC ANALYSIS

For each crossing, field data was analyzed as to whether it is a full, partial, or non-barrier to fish passage. Barriers were defined by using thresholds from the field measurement data as outlined below. The criteria used below are identical to the criteria used in the Clear and Foster Creek 2002 Fish Passage Assessment. It is repeated here for clarification and project understanding.

1.4.1 Partial Fish Passage Blockage

For this project "partial fish passage blockage" is defined as: stream crossings that, because of their design, maintenance, or condition, are not allowing for juvenile salmonid fish passage. According to the ODFW guidelines (ODFW 1997), juvenile salmon, for the most part, require:

- two feet per second or less velocity
- outlet perching less than 6 inches
- little to no inlet constriction or drop
- the culvert should be free from debris that may concentrate flow and increase velocities
- in-culvert flow depths should be 12 inches or more or the culvert should have a simulated natural streambed similar to surrounding channel conditions.

In terms of measured crossing dimensions, partial fish passage blockage would occur if the following conditions are not met. Much of these conditions are taken and adapted from Robison et.al. (1999).

For bare (non-embedded) culverts:

1. Unless backwatered properly the slope should not exceed 0.5%. Even at 0.5% slope or less the culvert inlet invert should be placed six inches lower in elevation than the height of the downstream riffle or weir height. Therefore, all culverts should have some degree of backwatering. Backwatering properly for culverts of greater than 0.5% slope will be determined using an estimated tailwater elevation and then input this value along with other key measured values into FishXing software (USFS 1999) to evaluate if the backwatering is adequate. Generally, there will have to be a tailwater elevation of at least 1.5 feet greater than the invert of the inlet to have adequate backwater on culverts greater than 1% slope that are 50 feet or more in length. However, the exact degree of backwater must be calculated because of all the possible combinations of slope, culvert length, and tailwater depth. For this analysis, the fish passage design flow will be determined via accepted methods in ODFW (1997).

2. The outlet drop or any associated weir drop should be no more than 0.5 feet from the culvert outlet lip to the residual pool water elevation. If there is any outlet drop, the residual pool for the downstream jump pool should be 1.5 times deeper than the jump. For culverts that do not use streambed simulation designs, in order to get required water depth, adequate backwatering from the outlet is needed.

3. To control constricting of flow at the inlet, the culvert diameter or span should be at least 0.5 times the natural bankfull channel width. The culvert should be free of large debris blockages or cave in areas that constrict flow and make for high velocity areas. There should be little or no inlet drop such that the flow drop as water enters the inlet is less

than a few inches. The culvert inlet invert should be about level with the channel bed immediately upstream.

4. The culvert should be less than 100 feet long.

For embedded culverts:

1. The culvert should have a variety of material embedded in it that forms a simulated natural channel inside the culvert. The material should in most places be a foot or more deep and there should be evidence of deposition and reworking of smaller material. If material is lacking, we will use the assumptions for the non-embedded culvert above.

2. There should be no outlet drop.

3. The inlet should have sediment in it and there should be no sudden drop in bed elevation at the inlet. The culvert width should also at least 90% of the average bankfull channel width to prevent channel constriction, channel scour, and drops from occurring at the inlet. Even if greater than 90% but less than 100% inlet constriction will be carefully reviewed by evaluating inlet photos and measurements.

For baffled culverts:

1. Generally speaking, the baffles/weirs should be 0.1-0.15 times the total height of the culvert. The spacing varies with stream flow and culvert gradient. Baffles should be set up such that at least one baffle/weir at low flow backwaters at least eight inches of water to the base of the next baffle/weir when the pool is at residual conditions. When evaluating baffled culverts it is important to measure culvert gradient, weir height, and weir spacing to use in calculations to determine adequacy. The exact calculations will be determined as needed and developed from techniques and references in Robison & Pyles (no date, in review).

2. There should be little or no outlet drop (no more than six inches). If the weir is placed on the edge of the outlet, the drop should be calculated from the residual pool water level to the top of the weir. If there is a small drop the residual pool should be at least 1.5 times as deep as the drop height.

3. There should be little or no inlet drop and the top weir should backwater into the upstream natural channel.

For bridges and open bottom structures:

1. Generally speaking a bridge or open bottom structure poses no fish passage problems. An exception is when a bridge/OBS is undersized and flowing on bedrock. In these instances the bridge or arch may constrict flow and blow out boulders and cobbles leaving a bedrock chute. For calculation purposes, if the bridge/OBS can pass a fifty-

year flood flow without over topping it should not present a problem. Calculations will be done for bridges and OBS only if there are visual indications of fish passage issues.

2. OBS should be free of large debris that may constrict flow and cause high velocity areas inside the arch.

1.4.2 Complete Fish Passage Blockage

Complete fish passage blockage, for this project, refers to instances in which the design, maintenance, or condition of the stream crossing is such that most (if not all) adult salmonids cannot move upstream through the crossing structure. Blockage would result in conditions that exceed most adult anadromous salmonid fish swimming capabilities. These can be:

- culvert water velocities in excess of 10 feet per second
- outlet drops over 4 feet or over 1 foot without adequate jump pools
- extreme inlet drops or material in the culvert that cause severe barriers.

Flow depths should be eight inches or more in the culvert at higher flows or the culvert should have a simulated natural streambed like those in the surrounding channel. Crossings that block fish passage would also have measurements outside of the following conditions. These measurements are not intended for use as standard guidelines for adult fish passage. They are simply used to make a distinction between complete and partial blockage. We offer this distinction because a culvert that blocks both adult and juvenile upstream fish passage is more serious than one that only prevents upstream juvenile fish passage. This distinction is an important factor in prioritization.

For bare (non-embedded) culverts:

1. Culvert slope should not exceed 4% unless there is backwatering or unless the culvert is less than 50 feet long. For culverts less than 50 feet long, gradients greater than 4% (up to 6%) can be tolerated if not combined with an outlet jump. When backwatering is present, if the downstream control is at an elevation that is equivalent to a point in the pipe less than 50 feet away from the inlet, the gradient may be up to 6%.

2. The outlet drop should be no more than 4 feet from the culvert outlet lip to the residual pool water elevation. The residual pool is defined as the pool that would be left over if there was no flowing water created by the damning effect of the downstream control point. If there is outlet drop over 6 inches, the residual pool for the downstream jump pool should be at least 1.5 times the height of the drop or 2 feet deep (whichever is less).

3. The inlet should not radically constrict the stream (i.e., 50% or greater than the average channel width) and there should be no evidence of a drop in the streambed between the upstream streambed and the invert of the inlet. The culvert can be deemed a fish passage

blockage if the constriction is 50%-90% and there is evidence of a radical drop in the streambed at the inlet of more than 1 foot then unless the culvert is less than 30 feet. Under this combination of conditions, the fish will be exhausted and will have difficulty moving through the resulting extremely high velocity water.

4. The culvert should be less than 200 feet long.

For embedded culverts:

1. The culvert should have a variety of embedded material to form a simulated natural channel inside the culvert. The material should in most places be a foot or more deep and there should be evidence of deposition and reworking of smaller material. If material is lacking, use the assumptions for the non-embedded culvert above.

2. There should be minimal outlet drop of less than 1 foot.

3. Upstream of the inlet, the channel width should taper and not experience a sudden drop at the inlet. The culvert width should also be at least 1/2 the bankfull channel width to prevent radical channel constriction and drops from occurring at the inlet, even if the rest of the culvert has bed material present. If there is a radical inlet jump, refer to assumptions for bare culverts above.

For baffled culverts:

1. Generally speaking, the baffles or weirs should be 0.1-0.15 times the total height of the culvert. Spacing varies with streamflow and culvert gradient. However, each baffle/weir should back slow water to the base of the next upstream weir. When evaluating baffled culverts, it is important to record culvert gradient, weir height, and weir spacing to use in calculations to determine adequacy. More information on calculating weir spacing is found in Robison et. al. (1999) and Robison and Pyles (no date, in review). Baffles should be free of debris and sediment to function properly. Sometimes even when weirs are not optimally spaced, the culvert can still pass at least adult fish. However, if culvert baffle(s) are ripped out or not functioning properly, they may pose a blockage problem. Once again, as with the juvenile provisions, methods for calculating velocities, depths, and energy dissipation were developed from information in Robison and Pyles

2. The outlet drop should be no more than 4 feet. If the weir is put at the edge of the outlet the drop should be measured from the residual pool water level to the top of the weir or weir notch level. If there is a drop, the residual pool for the jump pool should be at least 1.5 times as deep as the drop distance or two feet deep (whichever is less).

3. There should be little or no inlet drop and the top weir should back water into the upstream natural channel.

For Bridges and Open Arch Culverts:

1. Generally speaking a bridge or open arch poses no fish passage problems. An exception exists when a bridge or arch is undersized and flowing on bedrock. In these instances the bridge or arch may constrict flow and blow out boulders and cobbles leaving a bedrock chute. For calculation purposes if the bridge/arch can pass a fifty-year flood flow or more it should not pose a problem.

2. Open arches should be free of large debris that may constrict flow and cause high velocity areas inside the arch. However, the constriction will likely be quite severe. Complete blockages occur only at velocities over 15-20 feet per second or more.

1.5 CONCEPTUAL DESIGNS AND COST ANALYSIS

1.5.1 Culvert Replacement Design Options

The crossing design options considered for Deep, Goose, and Eagle Creeks are similar to those that were used in the Clear and Foster Creek 2002 Fish Passage Assessment. (Robison & Walsh 2003). The primary difference is that we simplified the Culvert Replacement Design decision tree (Figure 5) in comparison to the decision criteria used in the Clear and Foster Creek report. This change is based on our experience with other fish passage inventory projects.

There are many different design options and variations of structures that can be used at a site. Road use, cost, haul distance, site access, depth of fill, soil competence, channel configuration, and many other factors need to be considered prior to implementing a design solution. The following replacement recommendations are conceptual and are intended only for the purpose of evaluating the relative replacement options among the stream crossings evaluated in this inventory. A qualified civil engineer should be consulted for development of a site-specific design for any stream crossing.

Four basic replacement design options were considered:

1) Closed Bottom Metal Culverts (CBM);
2) Open Bottom Arch (Arch);
3) Open Bottom Low Profile Arch (Arch –Low) or Box Culvert; and
4) Bridges.

These options and their application to different situations are described in Figure 4.

Other general solutions for retrofitting existing structures were not considered for the conceptual design process. In some situations, existing structures can be potentially repaired by installing baffles or downstream control structures. These retrofits however require more detailed analysis than can be completed at this scale of effort.

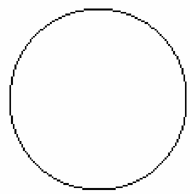
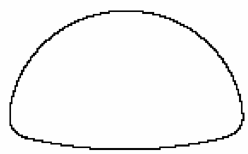
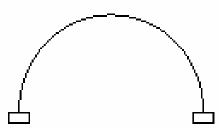
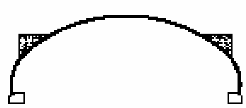
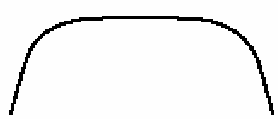
Culvert Shape	Application
Shapes Round 	• Small stream channels (< 10 ft BFW) • Low gradient (< 4 % grade) • Limited by high cover requirements. • One piece (up to 40 ft), easy to haul and install for stream simulation under approx. 12 ft diameter pipes.
Pipe-Arch 	• Small stream channels (< 10 ft BFW) • Low gradient (< 4 % grade) • Used to reduce cover requirements. • One piece (up to 40 ft), easy to haul and install for stream simulation under approx. 12 ft diameter pipes.
Arch (single radius) 	• Small stream channels (< 10 ft BFW) • Higher gradient (> 4 % grade) • Structural plate hauled in sections. • Requires footings, hauled in or poured in place.
Low-Profile Arch * 	• Low profile accommodate larger structure with reduced cover requirements. • Large stream channels (10 -17 ft BFW) • Higher gradient (> 4 % grade) • Structural plate hauled in sections. • Requires footings, hauled in or poured in place.
Box Culvert 	• Similar application to Low-Profile Arch. • Applicable to paved surfaces with no required fill cover.

Figure 4. General Replacement Designs for Culverts and Applications.

There are three general design approaches used to replace fish passage barriers at road crossings (WDFW 2003):

1) No slope;
2) Hydraulic design; and
3) Stream simulation.

The No Slope Design approach is most effective for relatively short culverts at low-gradient sites. The Hydraulic Design approach requires hydrologic and open-channel hydraulic calculations, and may not meet current fish passage requirements which emphasize juvenile fish passage. The Stream-Simulation approach uses a countersunk culvert or open bottom arch to construct an artificial stream channel inside the culvert, thereby providing passage for any size fish migrating through the reach. In general Stream-Simulation design is the most widely accepted design approach since it mimics the natural stream channel assuring passage for all life history stages over a range of flows.

Closed Bottom Metal Culverts using streambed simulation

Metal culverts with either a round or pipe arch cross-section can provide a satisfactory replacement option for channels that have a bankfull width of less than ten feet and a channel bed slope of less than four percent. A recommended maximum channel bank full width of ten feet will result in a structure span of 12 feet from the sizing criteria described in the following section. This recommended maximum is based on height of fill concerns for structures of this size, and the logistical difficulties of transporting wider structures from the place of fabrication to the installation location. A maximum bed slope of four percent is recommended for this replacement alternative due to the difficulty of maintaining a fish passable situation through long culverts with steep slopes because of the potential for non-uniform bed mobilization within the culvert barrel. The culvert should be sized as described in Section 1.5.2, and embedded below the channel bed between 20% and 50% of the culvert height. This allows the movement of stream bedload material to form a stable channel bed through the culvert that simulates the natural channel above and below the culvert.

This option is an economical replacement solution within the recommended guidelines. The materials are typically readily available and can be installed with locally available contractors. Also, as the material is available in lengths of up to 40 feet (longer lengths present transportation difficulties), replacement can typically take place fairly rapidly, limiting the impact to the traveling public.

Open Bottom Structural Arch with Footings

Metal open bottom structural arches with concrete footings provide a replacement option where channel bed slopes exceed four percent or for bankfull widths between 10 and 17 feet. This results in a structure span of 12 to approximately 20 feet based on the sizing criteria in Section 1.5.2. Structural metal arches are available as a single radius arch for smaller applications or where height of fill concerns are not an issue. For wider bankfull widths (typically greater than ten feet), a low-profile or multiple radius arch may present a better solution as the height of fill requirements will be less than a single radius arch. Footings for an arch structure are typically concrete, and they can either be poured on-site or pre-cast off-site and delivered to the project in sections.

This replacement option will require additional engineering design as compared to a closed bottom metal culvert. A limited geotechnical investigation should be completed to provide for an adequate footing design for the structure. This could either be in the form of a soils investigation and design report, or a more conservative footing design could be developed using the Uniform Building Code. The decision between utilizing one approach over the other should be based on the volume and type of traffic anticipated at the crossing, site constraints, and project budget. A more intensive design could yield substantial material and construction cost savings, especially for longer crossings. In addition to the footing analysis, a scour analysis should be completed on the structure to ensure that the footings are constructed far enough below the channel bed to prevent undercutting during high water events. Typically, increased engineering analysis should be provided for higher volume and/or load carrying roads.

Structural arches, even in larger dimensions, are easily transported as they are shipped in pieces that are bolted together at the site. Construction is more labor intensive as compared to metal culverts due to the need to assemble the structure on-site and to construct footings. Typically, installation can be completed by locally available contractors.

Bridges

Bridges come in several forms, and include short span concrete bridges, open bottom concrete box culverts with concrete footings (stiff-legged box), and long span steel or pre-stressed concrete bridges. Due to the relatively higher cost of these structures compared to other options, short span concrete bridges or open bottom box culverts are only recommended for limited applications. These include high volume paved roads where height of fill concerns present an issue, and where closed bottom metal culverts are not practical. A typical maximum span for this type of structure is approximately 20 feet, making it applicable for a stream crossing with a bankfull width of 17 feet, based on the sizing criteria in the following section. For wider stream crossings (bankfull width greater than 17 feet), a long span steel or pre-stressed concrete bridge is the recommended replacement option, unless it can be shown through further analysis that a shorter span structure can meet the fish passage goals of the crossing.

Engineering requirements for the short span or open bottom concrete box culvert options will be similar to the open bottom structural arch, with the addition of a structural design for the bridge itself. The engineering requirements for the long span options will be considerably greater, as a thorough geotechnical investigation, structural design, and a footing scour analysis will all be necessary to complete a proper design to protect the welfare of the public.

Smaller structures (12-foot span or less) can be constructed elsewhere in sections and transported to the site via truck. Larger span steel bridges can also be hauled in pieces and assembled on site. Depending on the construction method, large span concrete bridges can be cast off-site and delivered in sections, but will often require specialty transporting equipment and large cranes for placement. The other alternative is to cast the bridge at the site. Transportation of the reinforcing steel and formwork should be straightforward; however, depending upon the remoteness of the location and the quantity and delivery rate of concrete required, it may be difficult to provide adequate pre-mixed concrete to the site.

The complexity of the replacement project will vary based on the size of the structure and the Method of construction selected. Smaller structures should typically be able to be constructed with minimum construction oversight and locally available contractors. However, a large bridge project will require considerable construction oversight, and may require contractors proficient in that type of work and specialty equipment that may not be locally available.

Weirs, Dams and Other Structures

Construction of rock weirs that include passage slots can effectively replace the existing concrete weirs observed in the project area. A slotted weir can afford both up and down stream passage through a slot (i.e. depression) constructed into each rock weir. These slots can also help move sediment through the system during a range of runoff events.

A weir structure accommodating one vertical foot of water surface change has been anticipated in the selected locations. Grade control, consisting of a subsurface weir downstream of any weir or series of weirs will also be constructed to protect against potential channel incision.

Successful construction of each weir will require adequately sizing the material to withstand design high water events for each channel segment. Keying of the structure into both the channel bottoms and the stream banks will be necessary to help withstand high water effects. Material quantities will be significant in order to accommodate weir keying. Rock material is apparently available for weir construction, based on conversations with material suppliers operating in the project area.

Barriers five feet or more in elevation will require construction of alternate concrete fishways. Costs for these structures have been estimated based on historic costs for structures built previously in the Yakima Basin. Costs for these projects dating back to 1988, averaged between $50,000 and $100,000 per vertical foot of drop per fishway. Recent consultation and the limited amount of data available for these larger barriers led to the assumption that a cost of $100,000 per vertical foot of drop is reasonable for budgetary purposes at this time.

1.5.2 Sizing the Replacement Structure

The general approach for sizing structures to achieve streambed simulation is based on the recommendations provided in Design of Road Culverts for Fish Passage (WDFW 2003). The Washington State guidance recommends a span width based on a multiplier of the bankfull width. This is a conservative approach used when detailed hydrologic analysis and engineering are not completed. The 20 % factor (1.2 multiplier) plus the extra 2-foot factor add significantly to the designed size of the replacement culvert increasing the cost dramatically. Based on our prior experience, and since there are no specific sizing criteria in the State of Oregon, we have elected to leave off the 2-foot factor for this purpose of this conceptual design approach. In our experience the 2-foot factor adds significantly to the cost of a replacement structure with a minimal corresponding benefit to fish passage. Further, bankfull channel widths were conservatively measured during the field evaluation process. In designing a specific site, the structure size can be increased or decreased to reflect local considerations and appropriate engineering expertise.

Equation A: *Span Width = 1.2 x Bankfull Width + 2 feet* (WDFW, 2003)
Equation B: Span Width = 1.2 x Bankfull Width (This Project)

1.5.3 Selecting a Design Option

Figure 5 illustrates the selection criteria based on bankfull width and channel slope.

Closed Metal Bottom Culverts – Stream Simulation Design are a cost-effective solution for bankfull widths less than 10 feet and at low gradients. The maximum size is based on consideration of hauling, construction, and ability to develop a stream simulation for these channel dimensions. For channels with bankfull widths less than 10 feet and gradients over 4%, an Open Bottom Arch is required. For bankfull widths over 10 feet a Low Profile Arch is used to achieve the required fill depth and avoid raising the road surface elevation. Above 17 feet bankfull width, Open Bottom Arches become impractical and a bridge is required. There are many options for bridges including prefab structures that require minimal engineering design, but all bridges require design review by a civil engineer.

The potential depth of fill material influences the size of pipe that can be installed at a site, and therefore the selection of the design solution. This particularly applies to the use of a circular Closed Bottom Metal Culvert, since there may be insufficient height to cover the pipe with fill material. Where bedrock is at the surface or is shallow, a Closed Bottom Metal Culvert cannot be countersunk to achieve a stream simulation channel. These factors need to be evaluated further for any specific site where a Closed Bottom Metal Culvert is suggested as the design solution.

The conceptual design recommendations are developed to help guide planning for replacing a fish passage barrier. The user of this information should be aware of the possible sources of error that may influence the selection of a replacement option.

- Field measurement of bankfull width depends on the visual indicators of bankfull at a site, which can be highly misleading due to localized effects due to the existing culvert, road prism, grazing impacts, or experience of the individual observer. As can be noted in the Decision Flow Chart, the bankfull width is the primary determinant of the replacement option.
- Measurement of channel gradient are sensitive to the individual selection of the channel reach measured and the channel features selected to measure gradient.
- The geomorphology of the stream reach and contributing watershed are not evaluated effectively during an inventory level assessment. The replacement option may not be appropriate when this larger perspective is taken into consideration.

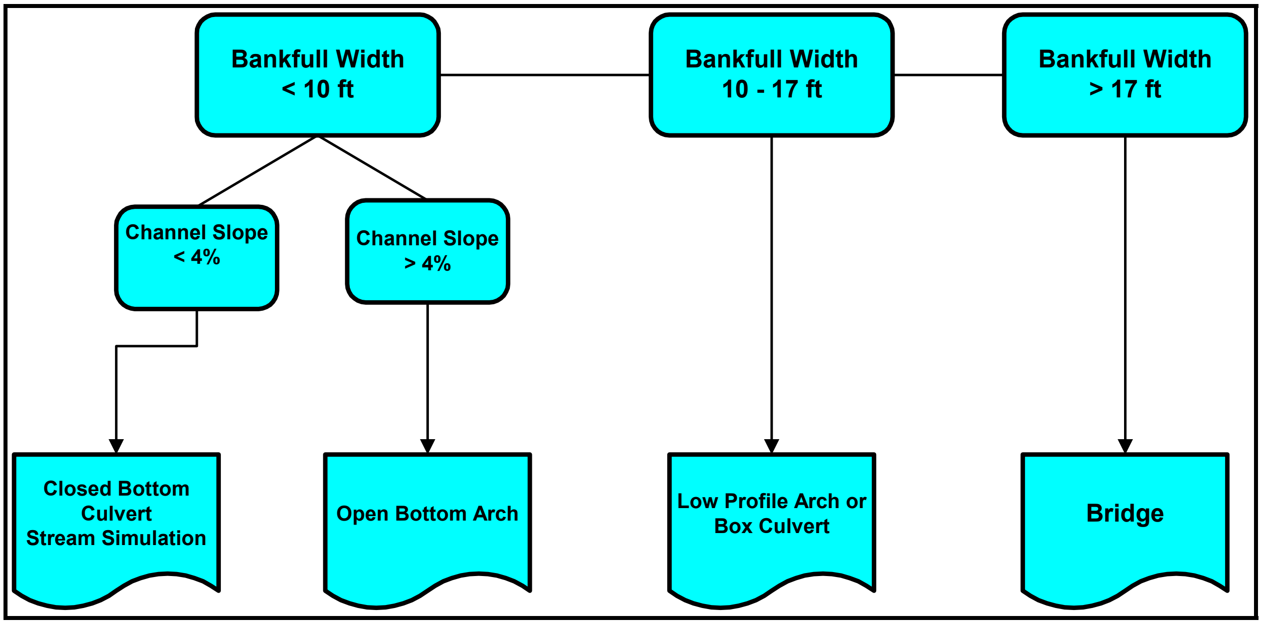


Figure 5. Culvert Replacement Design Decision Flow Chart.

1.5.4 Cost estimates for design alternatives

Construction cost estimates were developed for each structure surveyed in the Level 2 survey where feasible. In a few cases, access was not provided, so we made cost estimates using the existing information. The cost estimates are summarized in a table for Deep Creek and one for the Eagle Creek watershed in Appendix C. The cost assumptions and calculations are detailed in electronic spreadsheets labeled as Appendix D and provided on CD Rom disks.

The purpose of the estimated total project cost is to provide a general cost comparison relative to other projects contained within the report. Local variations may occur over time that may materially affect each individual estimated total project cost and the cost would have to be updated accordingly. In general, varying field conditions are accommodated within the cost estimates through the application of various adjustments and/or cost factors for critical construction variables. The remainder of this section provides a general description of the approach to estimating the total costs.

The Total Project Costs are comprised of the following cost categories: Demolition, Materials, Installation, Additional Cost Factors calculated as a multiplier (fill height, utilities, traffic control), and Design costs. Design fees are estimated utilizing generally accepted cost curves developed and total estimated costs are indexed to a nationally recognized cost index.

Demolition costs are estimated on a calculated volume of material based on the depth of fill and the length of the structure to be replaced. Demolition costs included excavation, haul and disposal. The assumption is made that no hazardous materials are encountered during the demolition process.

Construction costs include materials and installation. Structural material costs were previously obtained from local manufacturers and updated in August 2005 for use in these estimates. Using a general rule of thumb that installation costs are roughly equivalent to material costs, a total material and installation cost is calculated. Recognizing the complexity of culvert replacement and the typical complications involved with running water, a cost associated with water control is also included in the "Total Base Construction Cost."

Additional Cost Factors are included as multiplicative factors to account for existing utilities, height of cover (depth of fill), and traffic control.

In the case of utilities, where no utilities are assumed to be present (i.e., an isolated local road), the assigned multiplicative factor is 1.0 (absence of underground utilities assumes no increase in cost). On lightly traveled public roads, a limited presence of underground utilities is assumed and the multiplicative factor is 1.25 (a 25% increase in cost due to potential conflicts with cabled and buried utilities such as power, fiber optic, telephone, sewer, water, and gas). On major roads (State Highway 26), a significant presence of underground utilities is assumed (personal communication with Clackamas County personnel) and the multiplicative factor is 1.50 (a 50% increase in cost due to potential conflicts with cabled and buried utilities, such as power, fiber optic, telephone, sewer, water, and gas).

Excavations greater than five feet in depth presently require greater safety precautions than those five feet or less in depth. Therefore, for excavations five feet or less, the multiplicative factor is assumed to be 1.0 (no increase in cost due to the depth of excavation). Excavations greater than five feet are assigned a multiplicative factor of 1.1 (a 10% increase in project costs due to the additional safety precautions).

Traffic control is the third multiplicative cost factor included, with three categories evaluated. For low volume, private roads with alternative access routes, a cost factor of 1.0 (no increase in cost) is assigned. For moderate volume roads with no alternate access routes, the cost factor is increased to 1.1 (a 10% increase due to the need to deal with significantly more vehicles and providing for limited vehicular access). High volume public roads include a 1.2 cost factor (a 20% increase due to significantly more vehicles and continual access during construction).

Design costs are estimated based on cost curves provided by the American Society of Civil Engineers ASCE 2003). Generally, for the size of projects design costs historically vary between 20 and 30 percent of construction costs. For the purposes of this report, design costs are estimated at 25% of construction costs. Design costs, as defined by ASCE, include investigations, studies, preliminary design, final design, and construction services.

A number of the assessment projects were categorized as "Special Cases," as culvert replacements or bridge construction inadequately describes these projects. Special cases include replacement of existing concrete weirs with rock weirs designed to allow fish passage and construction of new or replacement of existing fish ladders with alternate fishways.

As of the week of August 22-29, 2005, the Engineering News Record Construction August 2005 Index Value stands at 7478.51 (http://enr.construction.com/features/coneco/subs/recentindexes.asp).

As a very general guideline, when costs presented within this report are evaluated in the future, an updated Index Value should be appropriately applied.

1.6 PRIORITIZATION

We used the same prioritization methods applied in the 2002 Clear and Foster Creek Fish Passage Assessment to maintain consistency between the studies and other assessments that may occur in the future. The prioritization process used in Clear and Foster Creek successfully identified those key stream crossings that were the greatest barriers to improving fish use in the two basins. For Phase One, crossings are prioritized solely based on habitat factors and do not include cost. In Phase Two, prioritization will include crossing replacement cost as a determining factor.

There are two basic methods used to prioritize culverts: one which assigns a numerical score to each culvert and one that places each culvert into broad priority categories based on quantitative and qualitative characteristics. For more information on prioritization systems please see WDFW (2000), Clackamas County (2001), Robison et. al. (1999), David Evans Assoc. (2001), and Robison & Walsh (2003).

The preliminary system that has been adapted for used in Deep, Goose, and Eagle Creeks' assessment is a combination of an additive and multiplicative numerical system that takes into account the condition of the barrier and key ecological factors.

The proposed ecological priority system:

Replacement Index Score Ecological [RISE] = {B * S * [(H*Q) + C)]}

Where:

> B = Degree of barrier with 1.0 = complete barrier, 0.5 = juvenile barrier, and 0 = not a barrier (see previous section for more information on partial vs. complete barrier)
>
> S = Fish species downstream of crossing: 1.0 = salmonids; 0.2 = resident fish only; 0 = exotics only (streams with no fish or exotics are not included in the prioritization).
>
> H = Habitat available upstream (ft)
>
> Q = Habitat Quality index as defined by the proportion of different habitat types upstream of culvert. It is a fraction equal to the length of low gradient low to moderate confinement habitat types upstream of the crossing (as defined by Watershed Professionals Network (1999); channel habitat type section) divided by the total fish bearing length upstream of the crossing. The low gradient low to moderate confinement habitat types used were: FP1, FP2, FP3, LC, LM, MC, MH, and MM. The habitat types will be taken from GIS coverage for channel habitat types that will be developed for the Deep and Goose Creek basin watershed technical memorandum.

C = A measure of the closeness of the crossing to the mainstem of the Clackamas River. It is calculated by subtracting the distance between the crossing and the Clackamas River in feet from 150,000 feet and then dividing this distance by 50. In effect, this gives a stream immediately adjacent to the Clackamas River the equivalent of 1500 feet of high quality habitat upstream in comparison with the H and Q values above.

The proposed maintenance priority scoring system that will be used in Phase Two is:

Replacement Index Score Ecological with cost [RISE-C] = RISE / Cost

Where:

Cost = the replacement cost in dollars based on estimated cost of replacement design (see previous section for more information on cost estimates and conceptual design choices).

1.7 PHASE 2 METHODOLOGY

After completion of Phase One, 34 of the highest priority crossings were revisited to collect the stream profile and crossing/road elevation data necessary to recommend specific design options with associated cost estimates. This information will be used by the CRBC in competing for grant funds to repair, replace, or correct the highest priority crossings.

1.7.1 Stream Profile Protocol

This measures the elevation change of the streambed 100 feet upstream and downstream of a culvert. Depending on channel conditions, we may expand the length over which this measure is recorded. If it appears that the inlet is backing up sediment such as bar formation or other evidence of accelerated deposition, the profile will be extended up to 500 feet or more upstream of the culvert. If the downstream section shows evidence of culvert induced incision the profile may need to be extended as well. We will rarely sample less than 100 feet unless visibility makes further measurements impossible to take or a natural barrier to fish passage is discovered.

To develop a profile, we will use a transit/laser level to measure upstream and downstream from the culvert by taking elevation differences over a channel length. For this protocol, we will establish a relative base elevation at some stable point at the road level and take all other measurements of elevation relative to this. The measurements of elevation should at a minimum be taken at every significant bed high and low elevation such as the crest of a riffle or the bottom of a pool. The distance between measures should seldom be over 10 feet. The measurements will be plotted on an x-y graph using a spreadsheet and in format look like the following list:

Length	Elevation (ft)	Comment
0	100.00	Inlet invert of the culvert (US_0)
-0.1	100.20	Upstream of inlet on channel bed (US_1)
-3.0	100.45	Riffle Crest (US_3)
-4.5	100.25	Bottom of Pool (US_2)
"	"	"Series of measures" (US_4…)
-50	104.25	Upstream end of measures (US_X)
20	99.00	Outlet Invert (DS_0)
21	98.1	Bottom of Downstream pool (DS_1)
23	98.9	Riffle Crest elevation (DS_2)
"	"	"Series of Measures" (DS_3…)
70	96.80	Downstream end of measures (DS_X)
NA	111.00	Relative base measurement (BM)
15	104.00	Downstream edge of the road (RD_1)
5	105.00	Upstream edge of the road (RD_2)
50	113.25	Distance up the road surface (RD_3)
50	115.60	Distance up road surface in opposite direction (RD_4)

The measures will be recorded on a crossing profile data sheet. The final profile would look something like Figure 6. The ideal elevation of the invert of the culvert can be determined by looking at the minimum bed elevations and plotting a line as in Figure 6.

In taking elevation measurements it is important to record accurate inlet and outlet elevations along with the elevation of the downstream and upstream side of the road surface to estimate fill height (RD_1 and RD_2). Another important measurement will be to measure the road elevation 30-50 feet in each direction from the crossing road centerline to get an indication of the curvature of the road into the crossing (RD_3 and RD_4). This will indicate if the road can be lowered or raised to provide more headroom if needed. These measurements should be taken along with streambed profile measurements described above.

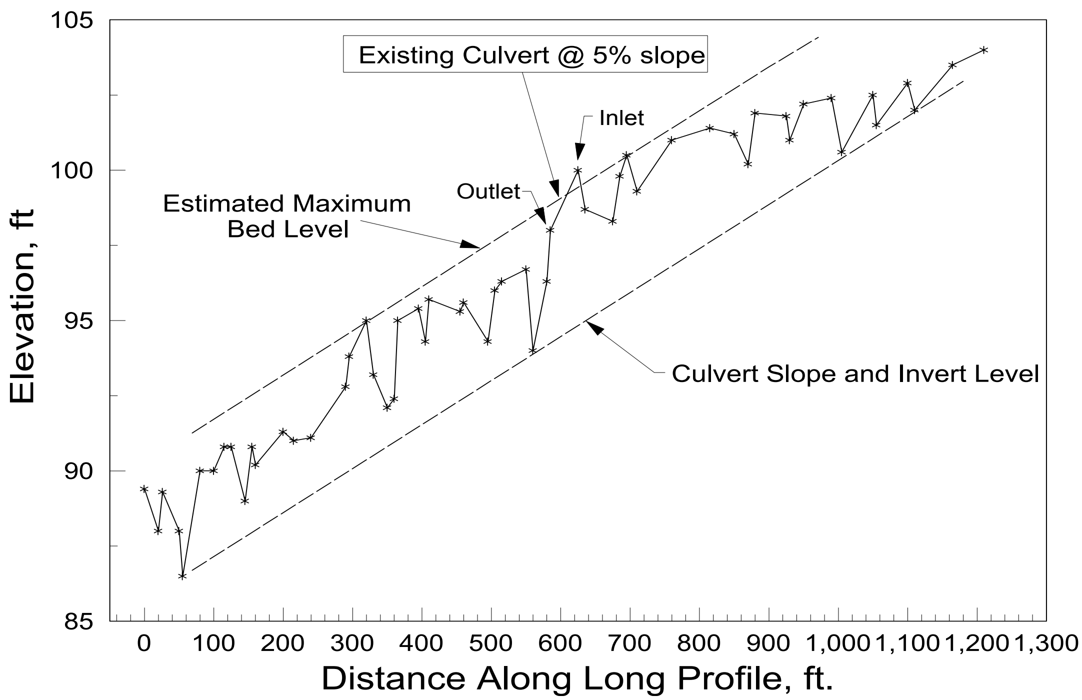


Figure 6. Culvert elevation profile (from Reba 2002).

2.0 RESULTS

2.1 DEEP AND GOOSE CREEK WATERSHEDS

Natural barriers to fish migration such as waterfalls, steep cascades, or bedrock chutes are uncommon in the Deep and Goose Creek watersheds. Watershed geology and topography do not favor these features. Though other forms of natural barriers such as seasonal flow restrictions and decreasing channel size do impede salmonid and resident fish migration, barriers introduced by roads, water impoundment, or landowner alterations are much more common blockages to upstream and downstream movement.

2.1.1 Level 1 Field Assessment Results

In the Deep and Goose Creek watersheds, 55% of the surveyed barriers were on private ownerships. County ownership made up 35% of the barriers and 10% were on state-owned roads. These percentages are characteristic of ownership representation in other lower Clackamas River watersheds such as Clear and Foster Creeks (Robison and Walsh 2003). Regardless, it is essential to the success of a fish passage assessment effort to survey passage barriers on all landownership types.

293 total potential barriers were examined in the Deep, Goose, and Eagle Creek watersheds in the Lower Clackamas River Basin. Of these, 163 potential instream barriers were surveyed in late summer and fall of 2003. We did not survey 130 possible barriers because they were situated on non-fish bearing and/or headwater reaches. Assessment of fish passage on 109 barriers in the Deep and Goose Creek watersheds is presented here. Of the 109 barriers surveyed in Deep and Goose Creek watersheds, 21 were found to completely block and 28 to partially block passage to salmonids and resident fish species. One of these is a natural barrier near the mouth of Noyer Creek and 9 were on non-fish bearing reaches.

The remaining 39 were prioritized in order of the severity their blockage has on limiting fish movement (***Refer to Appendix B, Table A***). 18 of the 39 barriers partially or completely block *salmonid* passage. Based on the prioritization methods presented elsewhere in this report, barriers to salmonid species will have a higher priority than barriers that affect only resident fish species. The locations of the instream barriers can be found on the fish passage map (*Map 1: Fish Passage Barrier Map)* and on the web-based Fish Passage Tool located on the Clackamas River Basin Council webpage (http://clackamasriver.org).

2.1.2 Outcome of Prioritization and Level 2 Assessment of Costs

Prioritization is based on a barrier's distance from the Clackamas River, the length and quality of potential habitat upstream, the general types of fish that use the stream reach (salmonids, resident, exotic), and the habitat quality of the reach. Results of prioritization using only these ecological (fish habitat) factors are listed in the tables in Appendix B. The stream crossings are ranked from highest to lowest in Appendix B based solely on the amount of high quality habitat (RISE-EQ) made available above the culvert.

The estimated cost of repair/replacement for selected high priority barriers are listed in Appendix C. The barriers are listed by rank based on the amount of habitat accessed (RISE-EQ) in combination with lowest cost. (The reader should understand that this ranking does not address all the feasible design solutions nor all the possible reasons for ranking projects, but rather provides only an initial ranking based on an objective process. The spreadsheets provide an easy means for the user to make adjustments in consideration of other factors.) Replacement projects are evaluated considering both habitat values and cost in Table 3.

Table 3. Deep and Goose Creek Watershed Replacement Ranking.

Crossing ID	Stream Name	Replacement Structure	Total Project Cost ($)	RISE-EQ	Rank Habitat Only	Score Rise/Cost	Rank with Cost
DPD01	NF Deep	Removal	13,000	63,245	1	486.5	1
DP026A	NF Deep	Bridge	265,000	61,331	2	23.1	12
DPD02 alt	NF Deep	Constructed bypass channel/weirs	100,000	57,953	3	58.0	4
DPD02	NF Deep	Fish ladder	600,000	57,953	4	9.7	18
DPD05Top	Deep	Fish ladder	3,000,000	41,529	5	1.4	22
DPD05Bot	Deep	4-6 rock wiers	19,000	--	--	--	--
DP037	NF Deep	Bridge	369,000	40,610	6	11.0	17
DP069	Tickle	Low Profile Arch	36,000	40,002	7	111.1	3
DP074	Tickle	Low Profile Arch	30,000	37,491	8	125.0	2
DP083	Deep	Bridge	161,000	37,486	9	23.3	10
DP079	Tickle	Low Profile Arch	115,000	21,865	10	19.0	14
DP116	Tickle	Bridge	515,000	20,980	11	4.1	20
DP056	Dolan	Low Profile Arch	53,000	20,390	12	38.5	6
DPD06	Deep	Fish ladder	1,600,000	19,402	13	1.2	23
DP061A	Tickle	Bridge	255,000	17,729	14	7.0	19
GS002	Goose	Low Profile Arch	46,000	16,863	15	36.7	7
DP065	Tickle	Low Profile Arch	88,000	15,263	16	17.3	16
DP126	Tickle	Low Profile Arch	84,000	14,767	17	17.6	15
DP068BBot	Tickle	Fish Ladder	800,000	13,231	18	1.7	21
GS006B	Goose	Low Profile Arch	40,000	12,972	19	32.4	8
GS006A	Goose	Low Profile Arch	24,000	12,953	20	54.0	5
GS007A	Goose	Low Profile Arch	60,000	12,662	21	21.1	13
DP076	Tickle	Low Profile Arch	1,670,000	11,962	22	0.7	24
DP081	Tickle	Low Profile Arch	46,000	10,708	23	23.3	11
DP154	Tickle	Low Profile Arch	35,000	10,171	24	29.1	9

The projects are ranked in Table 3 by salmonid fisheries habitat value (*Rank Habitat Only*) using the summary factor, RISE-EQ. The rank for the projects when including consideration of cost is shown in the last column (*Rank with Cost*). The resulting project rank is highly sensitive to the cost estimate; the rank may change dramatically if a lower cost alternative is identified as a result of a site specific engineering alternatives design analysis. This is particularly the case with the existing dams and weirs. The cost of replacing fish ladders using current specifications is very expensive. Evaluating more cost-effective solutions requires engineering design analysis beyond the scope of this project. (Note: This table is provided to the CRBC in MS Excel format. If other less costly solutions to the dams and weirs (removal, operational solutions, bypass channels etc.) are identified, the ranking table can readily be updated to reflect these revised cost estimates.)

None of the five top priority barriers in the Deep and Goose Creek watersheds are a complete blockage to fish passage. All are partial barriers that block passage to at least juvenile and weak swimming salmonids at some point during the year. Of the top 10, only two are complete barriers. The ten barriers identified as the highest priority are listed below:

Crossing DPD01 – This is a concrete weir maintained by a Clackamas County wastewater treatment facility outside of Boring on the North Fork Deep Creek. The County has used the weir in the past to measure flows required to meet NPDES permitting requirements. This requirement was dropped in 2004 (Personal communication with the Clackamas County, WES, Plant Operator) therefore, the weir is no longer needed and can be removed. The 27 foot wide weir spans the creek just downstream of the bridge on Ritchey Road. The weir is a partial barrier to juvenile fish because of the jump height and the width of the concrete barrier. In addition, the weir's footing on each bank is eroding.

	DPD01	
Design Solution	**Estimated 2005 Cost**	**Score (Rise/Cost)**
Removal	$13,000	487

Crossing DP026A – This crossing is an unused bridge/culvert on the North Fork Deep Creek, not far upstream from the wastewater facility's weir. It is on privately-owned, industrial property. The bridge portion of the crossing is a log-spanner with approximately 15 feet of fill and vegetation growing on top. A 6-foot diameter metal culvert sits underneath the log spanners. The pipe has become a partial barrier because a beaver dam and other debris have blocked its inlet resulting in a 2.5-foot jump that fish have to clear to exit the pipe.

	DP026A	
Design Solution	**Estimated 2005 Cost**	**Score (Rise/Cost)**
Bridge	$265,000	23

Crossing DPD02 – This barrier is a dam on private property on the North Fork Deep Creek upstream of DPD01 and DP026A. It is a partial barrier to fish passage from June to October when the landowner has the spillboards in place. The landowner manages the spillboards by removing them in early October and installing them after mid-June. When the spillboards are out this crossing does not represent a barrier to fish passage. Two design solutions were evaluated to estimate repair costs: 1) Replacing the fish ladder, which is very expensive, and 2) Constructing a by-pass channel. Further investigation is required to determine if a by-pass reach is a viable option. A third non-construction option is to develop a specific operational agreement with the dam operator. Operational changes may suffice to provide fish passage, however the solution is dependent on the operator and does not provide a permanent long term solution.

	DPD02	
Design Solution	**Estimated 2005 Cost**	**Score (Rise/Cost)**
1. Replace Fish Ladder	$600,000	9.7
2. Constructed By-pass	$100,000	58

Crossing DPD05 – This is a 30-foot high dam with a fish ladder running up its face and four weirs downstream that raise the channel on Deep Creek. It is on private property. The weirs are partial barriers because each weir rises one to two feet above the water level and is 2-feet wide at the top. The fish ladder jump pools are 5-feet long, which can be short depending on the fish species and size. The fish ladder's jump heights are also tall at 1.2 feet. The landowner is interested in working with the council and the Oregon Department of Fish and Wildlife to improve the barrier as much as possible. The estimated cost to replace the fish ladder is prohibitively expensive, but does display the potential cost for this alternative. The cost estimate was based on actual experience with such structures in other river basins. The actual cost will depend on a site specific engineering design analysis. Other less costly alternatives (removal, constructed by-pass reach, or modifications of the existing ladder) may be identified during the design analysis.

	DPD05	
Design Solution	**Estimated 2005 Cost**	**Score (Rise/Cost)**
Replace Fish Ladder	$3 Million	1.4
Alternate	Requires a site specific design	

Crossing DP037 – This crossing is a box culvert on the North Fork Deep Creek that runs underneath Highway 26. It is a partial barrier to passage because of a high outlet drop, borderline box slope, and long length. In addition, because of a concrete wall through its center, it could be a velocity barrier at high flows.

	DP037	

Design Solution	Estimated 2005 Cost	Score (Rise/Cost)
Bridge	$369,000	11

Crossing DP069 – This is a crossing on Tickle Creek near the Sandy wastewater treatment facility on private property, though the waster water treatment facility likely has an easement to use of the road. The crossing has three culverts. All three are partial to complete barriers to fish passage. The two culverts that receive the most flow have slopes at or over 4%. The third culvert is less steep at 2%, but is also above the water level from summer through late fall. It and the middle culvert are rusted through their bottoms.

	DP069	
Design Solution	**Estimated 2005 Cost**	**Score (Rise/Cost)**
Low Profile Arch	$36,000	111

Crossing DP074 – This crossing on Tickle Creek is a combination dam and pipe culvert on private property. The crossing is a partial barrier because the culvert has a steep slope combined with a hydraulically challenging inlet created by the dam.

	DP074	
Design Solution	**Estimated 2005 Cost**	**Score (Rise/Cost)**
Low Profile Arch	$30,000	125

Crossing DP083 – This crossing is a double culvert crossing immediately upstream of DPD05 on Deep Creek. Though the road is marked on the GIS road layer as a Clackamas County easement, local residents and the County have treated it as a private road. It is a barrier for juvenile and/or weaker swimming fish because of the pipe slope and flow constriction.

	DP083	
Design Solution	**Estimated 2005 Cost**	**Score (Rise/Cost)**
Bridge	$161,000	23

Crossing DP079 – This crossing is a box culvert underneath SE Orient Road on a tributary of Tickle Creek. It is a complete barrier to fish passage because of its steep gradient, length, and potential high velocities caused by constricted flow.

	DP079	
Design Solution	**Estimated 2005 Cost**	**Score (Rise/Cost)**
Low Profile Arch	$115,000	119

Crossing DP116 – This crossing is a concrete box culvert on Tickle Creek that has been identified by the ODFW as a barrier. It runs under State Highway 211. The fish passage survey found this crossing to be a complete barrier. It has a high outlet jump, steep slope, long length, and narrow width which could cause velocity issues.

	DP083	
Design Solution	**Estimated 2005 Cost**	**Score (Rise/Cost)**
Bridge	$515,000	4.1

2.2 EAGLE CREEK WATERSHED

Unlike Deep and Goose Creek watersheds, Eagle Creek watershed's geology and topography result in more natural barriers to salmonids and resident fish migration, particularly in the upper reaches of Eagle Creek. However, residents and land managers have introduced numerous additional barriers to the watershed through road construction, channel alteration, and instream water impoundment.

2.2.1 Level 1 Assessment Results

Of the 54 barriers surveyed in Eagle Creek watershed, 11 were found to partially and 15 to completely block passage to salmonids and resident fish species. Of these 26, 3 are natural barriers. The 23 artificial barriers have been prioritized in order of the severe effect their blockage has on limiting available salmonid habitat. 10 of the 23 partially or completely block salmonid passage. The locations of these instream barriers can be found on the fish passage map (*Map 1: Fish Passage Barrier Map)*. The prioritization and initial recommended replacement design for the Eagle Creek watershed is listed in ***Appendix B, Table B.***

As in Deep and Goose Creek watersheds, barriers occur on all ownerships. Though the US Forest Service and Bureau of Land Management own more acreage in the Eagle Creek watershed, only 2% of the crossings were surveyed on this ownership. Most of the federal land holdings occur in the upper portion of Eagle Creek and contain few crossings. Four significant and successive waterfall barriers occur downstream of these crossings. Therefore, the majority of the federal crossings were identified as low priority and were not surveyed. County ownership accounts for 55% of the stream crossings, 39% exist on private ownership, and 3.7% are found on state-owned land.

2.2.2 Outcome of Prioritization and Level 2 Assessment of Costs

Results of prioritization using only these ecological (fish habitat) factors are listed in the tables in Appendix B. The stream crossings are ranked from highest to lowest in Appendix B based solely on the amount of high quality habitat (RISE-EQ) made available above the culvert.

The estimated cost of repair/replacement for selected high priority barriers are listed in Appendix C. The barriers are listed by rank based on the amount of habitat accessed (RISE-EQ) in combination with lowest cost.

Replacement projects are evaluated considering both habitat values and cost in Table 4. The projects are ranked in the table by salmonid fisheries habitat value (*Rank Habitat Only*) using the summary factor, RISE-EQ. The rank for the projects when including consideration of cost is shown in the last column (*Rank with Cost*). The resulting project rank is highly sensitive to the cost estimate; the rank may change dramatically if a lower cost alternative is identified for the fish ladder as a result of a site specific engineering alternatives design analysis. (Note: This table is provided to the CRBC in MS Excel format. If other less costly solutions to the fish ladder (removal, operational solutions, bypass channels etc.) is identified, the ranking table can readily be updated to reflect these revised cost estimates.)

Table 4. Eagle Creek Watershed Replacement Ranking.

Crossing ID	Stream Name	Replacement Structure	Total Project Cost ($)	RISE-EQ	Rank Habitat Only	Score Rise/Cost	Rank with Cost
EG084	NF Eagle	Assume Fish Ladder	No data	85,714	1	--	
EG009B Alt	Currin	Constructed bypass channel/weirs	100,000	79,670	2	79.7	2
EG009B	Currin	Fish Ladder	600,000	79,670	3	13.3	8
EG008	Currin	Bridge	260,000	57,822	4	22.2	6
EG071	Delph	Bridge	115,000	39,853	5	34.7	3
EG079	Little Eagle	Low Profile Arch	74,000	20,936	6	28.3	4
EG009	Currin	Culvert Stream Simulation	23,000	19,767	7	85.9	1
EG089	NF Eagle	Bridge	159,000	18,680	8	11.7	9
EG061	NF Eagle	Bridge	201,000	17,523	9	8.7	10
EG063	Bear	Culvert Stream Simulation	68,000	11,531	10	17.0	7
EG079C	Little Eagle	Low Profile Arch	38,000	10,195	11	26.8	5

Crossing EG084 – This crossing is the highest priority crossing in Eagle Creek based solely on habitat value. It is a large concrete dam on private ownership that stretches across the North Fork Eagle Creek. When the spillboards are not managed, it is a complete barrier. It is not certain if the landowner removes the spillboards during salmonids migration. They were present and installed to a height of approximately 6-8 feet on October 1, 2004. In high flows, even with spillboard management, this crossing may be a velocity barrier. Access was not allowed by the landowner so we do not have sufficient information to propose a desgin solution.

Crossing EG009B – This crossing is a waterfall structure constructed on private ownership low on Currin Creek. It is a complete barrier to fish passage. Two design solutions were evaluated: 1) Replacing the fish ladder which is expensive, and 2) Constructing a by-pass reach. Either solution requires a site-specific engineering design analysis.

	DPD05	
Design Solution	**Estimated 2005 Cost**	**Score (Rise/Cost)**
Replace Fish Ladder	$600,000	13
Constructed By-pass	$100,000	80

Crossing EG008 – This crossing on a privately maintained road is a partial barrier on lower Currin Creek with three culverts. One of the three culverts is a complete barrier and the other two are partial barriers because of a high outlet jump height and steep culvert slope.

	EG008	
Design Solution	**Estimated 2005 Cost**	**Score (Rise/Cost)**
Bridge	$260,000	22

Crossing EG071 – This County crossing is a complete barrier on Delph Creek under Porter Road. The crossing has two culverts that have high outlet jumps, a shallow outlet pool, and steep slopes.

	EG071	
Design Solution	**Estimated 2005 Cost**	**Score (Rise/Cost)**
Bridge	$115,000	35

Crossing EG079 – This crossing is a complete barrier on Little Eagle Creek on private ownership. The landowner has created a backwatering solution that might improve passage and has plans to monitor it. The owners are aware of the fish passage problem.

	EG079	
Design Solution	**Estimated 2005 Cost**	**Score (Rise/Cost)**
Low Profile Arch	$74,000	28

Crossing EG009 – This crossing is a partial barrier on Talons Road over Currin Creek. It is a double culvert crossing with a high outlet jump and borderline culvert slopes. The crossing is not of adequate size to handle the seasonal flows and routinely backs up over the road.

	EG009	
Design Solution	**Estimated 2005 Cost**	**Score (Rise/Cost)**
Stream Simulation Culvert	$23,000	85

Crossing EG089 – This crossing is a complete barrier on Delph Creek on private ownership. It is a double culvert crossing with steep slopes and flow constriction that could create velocity barriers.

	EG089	
Design Solution	**Estimated 2005 Cost**	**Score (Rise/Cost)**
Bridge	$159,000	11

Crossing EG061 – This crossing is a partial barrier on a tributary to North Fork Eagle Creek under Clausen Road. Both culverts have fairly high outlet jumps and steep slopes.

	EG061	
Design Solution	**Estimated 2005 Cost**	**Score (Rise/Cost)**
Bridge	$201,000	8.7

Crossing EG063 – This crossing is a complete barrier to passage on Bear Creek under Kleinsmith Road. Though it has a fairly long length and is undersized compared to the average bankfull channel width, the primary cause of blockage to passage is a boulder strengthened wood barrier at the inlet that creates a ponding feature for the neighbor's landscaping. Removal of this barricade would facilitate fish passage, dropping this crossings priority ranking considerably.

	EG063	
Design Solution	**Estimated 2005 Cost**	**Score (Rise/Cost)**
Stream Simulation Culvert	$68,000	17

Crossing EG079C – This culvert on a tributary of the North Fork Eagle Creek is a complete barrier. However, it is ranked 10th because it has no low-moderate channel habitat type reaches upstream of it. It is a barrier because it has a steep culvert slope and a moderate outlet jump that empties out onto a 35 foot bedrock chute.

	EG079C	
Design Solution	**Estimated 2005 Cost**	**Score (Rise/Cost)**
Low Profile Arch	$38,000	27

The highest priority fish passage barrier based solely on habitat value is the dam on the North Fork of Eagle Creek (Crossing EG084). This crossing poses the greatest challenge to repair, primarily because the landowner is uncooperative, according to neighbors, resource managers, and as experienced during this survey. No one knows for certain whether the dam is permitted or installed legally. There is anecdotal historical information from neighbors that the mainstem and tributaries upstream of this dam were, at one time, highly productive salmonid habitat. Each person that we talked to remarked that the installation of the dam coincided with the observed absence of salmon.

The second highest priority barrier, EG009B, is a manmade waterfall barrier on lower Currin Creek. Currin Creek appears to have adequate if not excellent salmonid habitat for 10.5 miles upstream of this barrier. The water fall is actually one part of a three part structure that includes an infilled channel area, the main waterfall, and a bridge-dam type structure. The infilled channel area is the first downstream channel modification. Though it does permit fish passage, it is riprapped by hundreds of tires and at least two concrete filled cars that the owner embedded in the channel. Many of these tires were observed over 1000 feet downstream. A neighbor informed us that the owner and builder of the waterfall died in spring 2003 and that his children were uncertain about what to do with the property.

The third highest priority barrier in Eagle Creek blew out in the 1996 flood almost killing a local resident who was near it watching the high flows. It appears that it was repaired with some of the same culvert pieces that had originally blown out. The road slope leading down in to and out of this crossing is quite steep and might necessitate a more costly replacement option. This crossing would need to be replaced at the same time or before EG009B upstream.

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4.0 APPENDICES

APPENDIX A. FISH PASSAGE ASSESSMENT PROJECT: FIELD FORMS

Deep/Goose/Eagle Creek Fish Passage: Level One

CrossingID: ____________ Date: ____________ Photo numbers: ____________
Stream Name: ____________ Road Name: ____________
GPS: MP/County marker:

Structure Measures
Type: ____________
If OBS - Footing condition: ST ER FL
Condition (yrs): ____________
Diameter (ft): ____________ or ________ w ________ h
Slope (%): / / = avg

Outlet Measures
Length to fill (ft): ____________
Outlet drop (ft): ____________
Residual Pool Dpth (ft): ____________
Bedrock visible? yes no
Outlet mitigation type: NO GW RW WD WR OT
Backwater length (ft): ____________
Distance to outlet mitigation (ft): ________
NO? Outlet mitigation drop (ft):

Barrel Measures
Blockage (%): ____________ Shape Intact? yes no
Embedded Sediment Pattern: NM NA SS CR IN SR
Embedded Material:
Baffle? No Yes - go to back of page

Inlet Measures
Length to fill (ft): ____________
Inlet drop (ft): ____________
Inlet design: NM MI WW10-30 WW30-70 HW OT
Accelerated sediment deposit? yes no Bedrock visible? yes no

Road Measures
Road fill armor: ____________ Road slope (%): Up: Down:
Road width (ft): Overflow dip present? No Yes - go to back of page

Channel and Valley Measures
BFW (ft): Up: / / Down: / /
Substrate: ____________
Gradient (%): ____________
Stream/Valley fill: DF SF NF
Valley type: WV NV

Bridge Measures - on back **Ford/Dam Measures** - on back
Notes: (space on back)

CrossingID: ____________ **Date:** ____________________________

Baffle Specifics

Baffle design: WB OF PW NW SR OW MW OT

Distance between baffles (ft): ___________

Distance between last baffle and outlet (ft): ___

Baffle Height (ft): ________

Depth of baffle notch (in):

Overflow Dip Specifics

Overflow dip road **surface** armor: ___________

Overflow dip road **fill** armor: ___________

Overflow dip surface condition: ST ER FL

Overflow dip **fill** condition: ST ER FL

Distance from dip to structure (ft):

Bridge Measures

Type: LS RR MI CC OT

Span (ft): ____________

Abutment condition: ST ER FL

Ford Measures

Jump height (ft):

Residual pool depth (ft): ______________

Upstream material size: ______________

Crossing material size: ______________

Downstream material size: ______________

Surface condition: GD RU GU FL

Additional Notes:

APPENDIX B. LEVEL I ASSESSMENT PRIORITIZATION RESULTS AND PRELIMINARY DESIGN RECOMMENDATIONS.

Prioritization ranking for complete and partial fish passage barriers in Deep, Goose, and Eagle Creek basins. Design recommendations are offered as an initial solution based only on Phase One survey results.

WHERE A LEVEL II SURVEY WAS COMPLETED, THE INITIAL REPLACEMENT/REPAIR SOLUTION IS SUPERCEDED BY THE RECOMMENDED DESIGN SOLUTION BASED ON THE LEVEL II SURVEY – SEE APPENDIX C.

Notes: RISE-B = barrier status (1 – complete, 0.5 – partial); RISE-S = species (1 – salmonids, 0.5 – resident fish); RISE-H = length (ft) of habitat upstream; RISE-Q = proportion of low-moderate gradient channel habitat types upstream to total length of available habitat; RISE-C = proximity to Clackamas River (ft).

A. Deep and Goose Creek Watershed Barrier Rankings

Rank	CrossingID	RISE-B	RISE-S	RISE-H	RISE-Q	RISE-C	RISE-EQ	Initial Design Recommendation
1	DPD01	0.5	1	89399	1.4	2500	63245	removal
2	DP026A	0.5	1	87504	1.4	2462	61331	removal / routine maintenance
3	DPD02	0.5	1	83960	1.4	2391	57953	landowner education
4	DPD05	0.5	1	44274	1.8	2028	41529	Retrofit fish ladder / weirs
5	DP037	0.5	1	55724	1.4	2294	40610	long span bridge
6	DP069	0.5	1	40657	1.9	2233	40002	slab bridge
7	DP074	0.5	1	38171	1.9	2183	37491	slab bridge
8	DP083	0.5	1	39920	1.8	2004	37486	open box
9	DP079	1	1	13275	1.5	2137	21865	open box
10	DP116	1	0.5	21009	1.9	1869	20980	long span bridge
11	DP056	0.5	1	26581	1.5	2183	20390	slab bridge
12	DPD06	1	0.5	19750	1.9	2060	19402	land owner education / channel work
13	DP061A	1	0.5	17379	1.9	2260	17729	open metal arch
14	GS002	0.5	1	24150	1.3	2925	16863	slab bridge
15	DP065	1	0.5	14938	1.9	2212	15263	open metal arch
16	DP126	1	0.5	14838	1.9	1786	14767	slab bridge
17	DP068BBot	1	0.5	12926	1.9	2171	13231	channel restoration
18	GS006B	0.5	1	18077	1.3	2803	12972	slab bridge / open box
19	GS006A	0.5	1	18040	1.3	2802	12953	slab bridge / open box
20	GS007A	0.5	1	17470	1.3	2791	12662	removal of dam structures
21	DP076	0.5	1	14294	1.5	2157	11962	monitoring
22	DP081	0.5	1	13053	1.5	2133	10708	simulated

Rank	CrossingID	RISE-B	RISE-S	RISE-H	RISE-Q	RISE-C	RISE-EQ	Initial Design Recommendation
								streambed closed bottom structure
23	DP154	0.5	0.5	20680	1.9	2079	10171	simulated streambed closed bottom structure
24	DP130	1	0.5	9600	1.9	1682	10082	simulated streambed closed bottom structure
25	DP061	0.5	0.5	18780	1.9	2289	9572	slab bridge
26	DP045	0.2	1	29650	1.5	2244	9396	simulated streambed closed bottom structure
27	DP101	0.5	0.5	15854	1.7	1976	7284	slab bridge
28	DP048	0.5	0.5	18092	1.4	2215	6807	simulated streambed closed bottom structure
29	DP072A	1	0.5	5869	1.9	2115	6727	long span bridge
30	DP129A	1	0.5	7120	1.6	1626	6594	fish ladder
31	DP115	0.5	0.5	12132	1.8	1908	5854	simulated streambed closed bottom structure
32	GS007	0.5	0.5	15289	1.3	2747	5775	long span bridge
33	DP070	0.5	0.5	7841	1.9	2155	4341	simulated streambed closed bottom structure
34	DP028	0.5	0.5	7448	1.6	2497	3664	simulated streambed closed bottom structure
35	DP072	0.5	0.5	6119	1.9	2120	3490	simulated streambed closed bottom structure
36	DP129	0.5	0.5	6784	1.6	1620	3127	open metal arch
37	DP073	0.5	0.5	6129	1.0	2070	2050	open metal arch
38	DP062A	1	0.5	0	1.0	2305	1152	None
39	DP021	0.5	0.5	1	1.0	2609	652	simulated streambed closed bottom structure

B. Eagle Creek Watershed Barrier Rankings

Rank	CrossingID	RISE-B	RISE-S	RISE-H	RISE-Q	RISE-C	RISE-EQ	Initial Design Recommendation
1	EG084	1	1	58867	1.4	1589	85714	removal
2	EG009B	1	1	55553	1.4	2764	79670	removal
3	EG008	0.7	1	57374	1.4	2796	57822	long span bridge
4	EG071	1	1	24001	1.6	1557	39853	long span bridge
5	EG079	1	1	19268	1.0	1668	20936	open metal arch
6	EG009	0.5	0.5	54964	1.4	2753	19767	slab bridge
7	EG089	1	1	11733	1.5	1382	18680	open metal arch
8	EG061	0.5	1	25922	1.3	1961	17523	long span bridge
9	EG063	1	0.5	15255	1.4	1988	11531	open metal arch
10	EG079C	1	1	8407	1.0	1788	10195	open metal arch
11	EG068	1	0.5	12439	1.5	1932	10095	long span bridge
12	EG057	0.5	0.5	16202	1.8	1827	7740	simulated streambed closed bottom structure
13	EG064	1	0.5	5907	2.0	1861	6837	simulated streambed closed bottom structure
14	EG065	0.5	0.5	13363	1.4	1950	5283	open metal arch
15	EG069	0.5	0.5	11981	1.5	1923	4930	simulated streambed closed bottom structure
16	EG095	1	0.5	6090	1.0	1577	3833	slab bridge
17	EG097	1	0.5	6169	1.0	1271	3720	simulated streambed closed bottom structure
18	EG050	1	0.5	4840	1.0	2192	3516	open metal arch
19	EG075	0.5	0.5	5956	2.0	1679	3398	simulated streambed closed bottom structure
20	EG090	1	0.5	3167	1.0	1568	2368	slab bridge
21	EG079B	0.5	0.5	6428	1.0	1769	2049	simulated streambed closed bottom structure
22	EG098	1	0.5	837	1.0	1396	1117	slab bridge
23	EG101	1	0.5	290	1.0	1352	821	open box

APPENDIX C. RECOMMENDED DESIGN SOLUTION AND ESTIMATED COST OF REPAIR/REPLACEMENT FOR A SELECTED SUBSET OF FISH PASSAGE BARRIERS.

Table C-1: Deep Creek Watershed Replacement Costs and Ranking.

Crossing ID	Stream Name	RISE	Score Rise/Cost	Replacement Structure	Base Construction Cost ($)	Utilities Factor	Height of Cover	Traffic Factor	Total Construction ($)	Design ($)	Total Project ($)
DPD01	NF Deep	63,245	486.5	**Removal**					10,000	2,500	13,000
DP074	Tickle	37,491	125.0	**Low Profile Arch**	22,000	1	1.1	1	24,000	6,000	30,000
DP069	Tickle	40,002	111.1	**Low Profile Arch**	23,000	1.25	1	1	29,000	7,000	36,000
DPD02 alt	NF Deep	57,953	58.0	**Constructed bypass channel/weirs**	(see spreadsheet)	na	na	na			100,000
GS006A	Goose	12,953	54.0	**Low Profile Arch**	14,000	1	1.1	1.2	19,000	5,000	24,000
DP056	Dolan	20,390	38.5	**Low Profile Arch**	42,000	1	1	1	42,000	11,000	53,000
GS002	Goose	16,863	36.7	**Low Profile Arch**	37,000	1	1	1	37,000	9,000	46,000
GS006B	Goose	12,972	32.4	**Low Profile Arch**	23,000	1.25	1	1.1	32,000	8,000	40,000
DP154	Tickle	10,171	29.1	**Low Profile Arch**	28,000	1	1	1	28,000	7,000	35,000
DP083	Deep	37,486	23.3	**Bridge**	94,000	1.3		1.1	129,000	32,000	161,000
DP081	Tickle	10,708	23.3	**Low Profile Arch**	27,000	1.25	1	1.1	37,000	9,000	46,000
DP026A	NF Deep	61,331	23.1	**Bridge**	212,000	1.0		1.0	212,000	53,000	265,000

Crossing ID	Stream Name	RISE	Score Rise/Cost	Replacement Structure	Base Construction Cost ($)	Utilities Factor	Height of Cover	Traffic Factor	Total Construction ($)	Design ($)	Total Project ($)
GS007A	Goose	12,662	21.1	**Low Profile Arch**	32,000	1.25	1	1.2	48,000	12,000	60,000
DP079	Tickle	21,865	19.0	**Low Profile Arch**	56,000	1.25	1.1	1.2	92,000	23,000	115,000
DP126	Tickle	14,767	17.6	**Low Profile Arch**	49,000	1.25	1	1.1	67,000	17,000	84,000
DP065	Tickle	15,263	17.3	**Low Profile Arch**	51,000	1.25	1.1	1	70,000	18,000	88,000
DP037	NF Deep	40,610	11.0	**Bridge**	164,000	1.5		1.2	295,000	74,000	369,000
DPD02	NF Deep	57,953	9.7	**Fish ladder**	(see spreadsheet)	na	na	na			600,000
DP061A	Tickle	17,729	7.0	**Bridge**	204,000	1.0		1.0	204,000	51,000	255,000
DP116	Tickle	20,980	4.1	**Bridge**	229,000	1.5		1.2	412,000	103,000	515,000
DP068BBot	Tickle	13,231	1.7	**Fish Ladder**	(see spreadsheet)	na	na	na			800,000
DPD05Top	Deep	41,529	1.4	**Fish ladder**	(see spreadsheet)	na		na			3,000,000
DPD05Bot	Deep	--	na	**4-6 rock wiers**	(see spreadsheet)	na		na	15,000	3,750	19,000
DPD06	Deep	19,402	1.2	**Fish ladder**	(see spreadsheet)	na		na			1,600,000
DP076	Tickle	11,962	0.7	**Low Profile Arch**	793,000	1.5	1.1	1.2	1,570,000	100,000	1,670,000

Table C-2: Eagle Creek Watershed Replacement Costs and Ranking.

Crossing ID	Stream Name	RISE	Score Rise/Cost	Replacement Structure	Base Construction Cost ($)	Utilities Factor	Height of Cover	Traffic Factor	Total Construction ($)	Design ($)	Total Project ($)
EG084	NF Eagle	85,714	na	**Assume Fish Ladder**						**Insufficient data**	
EG009	Currin	19,767	85.9	**Culvert Stream Simulation**	14,000	1.25	1	1	18,000	5,000	23,000
EG009B Alt	Currin	79,670	79.7	**Constructed bypass channel/weirs**							100,000
EG071	Delph	39,853	34.7	**Bridge**	92,000	1.0		1.0	92,000	23,000	115,000
EG079	Little Eagle	20,936	28.3	**Low Profile Arch**	45,000	1	1.1	1.2	59,000	15,000	74,000
EG079C	Little Eagle	10,195	26.8	**Low Profile Arch**	25,000	1	1	1.2	30,000	8,000	38,000
EG008	Currin	57,822	22.2	**Bridge**	166,000	1.25		1.0	208,000	52,000	260,000
EG063	Bear	11,531	17.0	**Culvert Stream Simulation**	39,000	1.25	1	1.1	54,000	14,000	68,000
EG009B	Currin	79,670	13.3	**Fish Ladder**							600,000
EG089	NF Eagle	18,680	11.7	**Bridge**	115,000	1.0		1.1	127,000	32,000	159,000
EG061	NF Eagle	17,523	8.7	**Bridge**	117,000	1.25		1.1	16,100	40,000	201,000

APPENDIX D: COST ESTIMATES AND ASSUMPTIONS.

Cost assumptions are in MS Excel Spreadsheets provided to the Clackamas River Basin Council on CD disks. Please note: Costs are based on 2005 base. Please refer to the text for the method of updating this cost into the future based on standard engineering practice.