# *Clear and Foster Creek Fish Passage Assessment and Prioritization Project*

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Current with the Watershed

**Clear and Foster Creek Basins Fish Passage Assessment and Prioritization project: Final Report**

# Executive Summary

The purpose of this report is to assess and prioritize fish passage in the Clear and Foster Creek basins within the greater Clackamas River Basin. The project was initiated by the Clackamas River Basin Council (CRBC) to address the fact that most information on barriers was on public roads. Although public agencies (the County and ODFW and US Forest) and one larger timber company in the basin have shown leadership and started to replace culverts they were unable to determine whether there were barriers just up stream on private roads or from private dams or diversions. In order to spend public dollars efficiently and to get a sense of biological and cost related priorities, a comprehensive approach, a watershed approach, that included the cooperation of willing private landowners and better information on natural barriers was needed to understand the real priorities for replacement. With tremendous private cooperation, fish passage information was gathered for all but a handful of artificial barriers known in the Clear and Foster Creek basins during the course of this project.

This report describes both the methods used and results for this project. Key findings of this report include:

- A total of 223 potential artificial barriers were evaluated. In the Clear and Foster Creek Basin there are a total of 159 barriers on fish bearing streams. Four of these crossings represented dams on tributary streams. Fish bearing stream status was determined by ODF interim criteria and field determinations both on this project and previously.

- Of these 159 crossings: 81 had verified fish passage blockage to some degree based on methods described in this report. Of these 81 crossings, 27 had complete blockages and 54 had partial blockages. Full fish passage blockage occurs on crossings with jumps greater than 4 feet and a culvert gradient greater than 4%. Partial fish passage blockage occurs in culverts greater than 6 inches in diameter with a slope greater than 0.5% if adequate downstream backwatering is not present.

- Of the 81 blockages, 34 are on streams that are thought to have anandromous fish species use. Anadromous fish use was determined by examining historical information regarding fish use in the Clear and Foster Creek basins and evaluating 16 key natural barriers that prevent anadromous travel. Many of these natural barriers were discovered and/or documented for the first time during summer 2002 fieldwork for this project.

- We determined the cost to fix the 81 potential blockages to fish passage. The proposed fixes include bridges, open bottom culverts and slabs, and closed bottom culverts that are embedded to imitate natural streambed conditions. A design diagram was developed to decide between options. We deferred to pre-determined county cost estimates on county

culverts found to block fish passage. The total cost of repairing the 81 fish passage blockages is over 7.2 million dollars ($US), of which nearly 5.5 million dollars are accounted for by county fix proposals. The highest replacement estimate is $732,000 and the minimum estimate for a crossing correction is $5460. Nearly 3.6 million dollars would be used to fix culvert blockages on anadromous streams. Of this 3.6 million dollars, nearly 3 million dollars is for county culverts.

- We prioritized crossings using a formula developed specifically for the Clear and Foster basin that accounts for degree of blockage, cost, amount of habitat upstream, and connectivity downstream. Details of the prioritization are given in the report. The highest priority crossings for repair are found on the main channel of Clear and Foster Creek and on key tributaries lower in the basin that do not have high gradient stretches and waterfalls. Among these are these specific situations:

  - A diversion dam on Foster Creek (FO002) that may be mitigated by developing a fish ladder below it. (Estimated cost is about $15,000)

  - A ford on Clear Creek (CL069A - not previously documented. Discovered during field work summer 2002) that is a partial fish passage blockage that could be mitigated by creating a roughened channel along part of the channel. (Estimated cost about $7,500)

  - A series of culverts on a low gradient tributary that connects directly to Clear Creek (CL069C, D, E, F on un-named stream - none were previously documented. Discovered during field work summer 2002) that can be removed or replaced. (Estimated cost about $65,000 if all culverts replaced)

  - Three culverts on Spring Creek, a high quality, low gradient tributary that drains directly into Clear Creek. One culvert (CL100) is a semi abandoned road and could probably be removed. The second culvert (CL101) is on a private paved road. The third and farthest upstream culvert (CL099) is a county crossing under Mattoon Road. The cost of removing and replacing the two private culverts is $93,000. The county culvert estimate (by the county) for replacement is $361,000.

The results from this report provide information that can be used in applying for watershed or stream improvement grants. The proposed designs are for cost estimates only. Actual replacement of these culverts will require further design work. In some cases, several alternative designs can work at a crossing with extremely different costs involved. There may be opportunities in these instances to reduce costs by using alternative designs. In other cases, more expensive designs may be proposed for concerns beyond basic fish passage.

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# Introduction

The project was initiated by Clackamas River Basin Council (CRBC) to address the fact that the vast majority of information on barriers pertains only to public roads. Although public agencies have shown leadership and started to replace culverts (the County and ODFW and US Forest) they were unable to determine whether there were barriers just up stream on private roads or dams. In order to spend public dollars efficiently and to get a sense of biological and cost related priorities, a comprehensive approach, a watershed approach, that included the cooperation of willing private landowners and better information on natural barriers was needed to understand the real priorities for replacement. For this reason, the goal of the basin stakeholders working in partnership with the CRBC was to create a truly comprehensive assessment and prioritization of public and private barriers.

The Clear and Foster Creek basin represents an important tributary of the Clackamas River which is in turn a seminal tributary of the Willamette River or even the Columbia in terms of anadromous fish production. For instance consider this quote from the late 1800's regarding the Clackamas: *"probably no tributary of the Columbia has abounded so profusely with salmon in the past years as this river (the Clackamas)"* (quoted from 1877 Fish Commission report in Taylor, 1999). The Clear and Foster Creek basins represent important tributaries of the Clackamas because they are in the lower basin downstream of the Clackamas River dams and in many stretches represent important potentially high quality relatively low gradient habitat (WPN, 2002).

Roads that cross streams with improperly designed culverts have been the cause of serious losses of fish habitat. Beechie et al. (1994) estimated the loss in fish habitat from culverts on forest roads as high as 13% of the total decrease in coho salmon summer rearing habitat in a large river basin in Washington state. This percent decrease in summer habitat was considered greater than the sum total effects of all other forest management activities combined. Conroy (1997) reported that as many as 75% of culverts in given forested drainages are either outright blockages or impediments to fish passage based on field surveys done in Washington state. Surveys of culverts for county and state roads in Oregon have found hundreds of culverts that at least partially block fish passage (Al Mirati, Oregon Department of Fish and Wildlife (ODFW), personal communication 3/99).

Because blockage of fish passage is associated with habitat loss for spawning and rearing adult and juvenile fish, 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 watershed restoration resources. There are numerous approaches to assessing and prioritizing culverts. Assessment methods range from crude (basic ODFW method in Robison et al., 1999) to more quantitative methods (Washington Department of Fish and Wildlife (WDFW), 2000; Robison et al., 2000; or Taylor and Love, 2001). Each of these field methods use different measurements because their objectives vary.

There are also several methods emerging for culvert prioritization. Some are largely qualitative (Robison et al. 1999). Some sum a number of factors (e.g., Clackamas County, OR method;

Clackamas County Fish Passage Technical Team, 2001). Other methods multiply factors (WDFW, 2000) and others use a combination of methods (Taylor and Love, 2001). Prioritization is in its early stages and is more art than objective science. Room for improvement remains, particularly in determining how to weight factors or if factors should be additive or multiplicative. Because different stakeholders have different priorities and different basins have different target fish species, at the current time, major stream basins are best served by a unique prioritization fitted to its objectives and conditions.

Because the Clackamas basin in general and the Clear and Foster basins in particular have a unique mix of species and priorities, this project has taken elements from several different methods for fish passage assessment and prioritizations and has combined them to meet basin needs. After consultation with basin stakeholders, 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 methods section of this report outlines the measurements developed to meet this overall objective and then develops assessment and prioritization methods custom fit to the unique characteristics of the Clear and Foster Creek basins. In particular, the methods section offers techniques for:

- identifying fish bearing streams and road crossings for this project;
- developing a landowner permission process to gain access to sites and develop understanding, acceptance, and support among this key stakeholder group;
- developing a field assessment protocol and fish passage analysis method that provide appropriate information to design cost analysis and prioritization methods;
- developing conceptual designs for replacement or corrective actions on culverts not providing fish passage; and
- creating a prioritization scheme that takes into account local and watershed factors as well as design and cost information.

# Methods

The two key start-up tasks completed for this project were to upgrade the map coverage to better determine fish use extent and to develop a landowner permission process. The latter was extremely important because previous comprehensive assessment efforts have been limited by lack of permission to assess fish passage at key crossings (David Evans and Associates, 2001).

## Upgrade Map Stream Coverage and get updated list of potential crossings

With a major change to the Forest Practices Act in 1994 came a mandate to determine the fish presence/absence of all forested streams on state and private forestlands. Confirmed fish use is determined by a fish presence/absence protocol that requires careful fish sampling during appropriate seasons of maximal fish use extent (ODF and ODFW, 1995). Before this mandate, fish bearing status and protections ended at the upstream boundary of what were called “class one” streams. Often, however it was well known that fish use extended upstream of the boundary. To better understand fish use on streams, Oregon Department of Forestry (ODF) conducted surveys on several townships in Western and Eastern Oregon in 1992-93 (ODF, 2001). From these surveys criteria were developed that better approximate the end of fish use for small forested streams (Table 1). Since Clear and Foster Creek belong to the “interior georegion,” upper extent of fish use is assumed to be where stream watersheds are 100 acres or less or where channel slopes exceed 20% or more. These fish use transitions were upgraded on the Clear and Foster Creek stream GIS coverage for streams that did not have the confirmed end of fish use. In addition, the “physical survey” field criteria in Table 1 and actual fish presence observations were recorded to further improve the coverage throughout the field season. The 2002 summer fish passage assessment contributed extensively to the improved understanding of approximated fish use in Clear and Foster Creek basins.

After fish use extent was upgraded, we created a list of all potential stream road crossings along with maps of crossings identified by a unique, basin-specific ID (Appendix A).

**Table 1: Summary of interim process for determining approximate upstream extent of fish use (from ODF, 2001).**

<table>
<tr><th colspan="2">Type of Barrier</th><th colspan="2">Physical Survey</th><th>Map Analysis</th></tr>
<tr><td colspan="2" rowspan="3">Falls & Chutes</td><td>Salmon & Steelhead</td><td>Resident Trout</td><td rowspan="3">Any waterfall marked on a map.</td></tr>
<tr><td>8'+</td><td>4'+</td></tr>
<tr><td colspan="2">2'+ require a jump pool 1.25 times the fall or chute height.</td></tr>
<tr><td rowspan="2">Channel Steepness</td><td>With Pools</td><td>30' or more @ 20%+</td><td>20' or more @ 20%+</td><td rowspan="2">20%+</td></tr>
<tr><td>W/O Pools</td><td>30' or more @ 12%+</td><td>20' or more @ 12%+</td></tr>
<tr><td colspan="2">Lack of Livable Space</td><td colspan="2">No pools approximately 12" or more in depth during spring spawning.</td><td>60 Acres or Less (Coast<br>80 Acres or Less (South Coast)<br>100 Acres or Less (Interior)<br>300 Acres or Less (Siskiyou)<br>350 Acres or Less (Blue Mountain and East Cascade)</td></tr>
</table>

## Landowner Participation and permission process

The Clear and Foster Creek fish passage assessment has been a unique endeavor in that it attempted to assess the total population of potential fish passage barriers within both basins. This includes potential barriers that are on private land. Typically, 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 Clear and Foster Creek basins are already involved, to varying degrees, with the proposed basin-wide fish passage assessment process. Individuals representing most public landowners in the basins have helped formulate project goals and have had an opportunity to express their desired outcomes for this project. The coordination challenge for this particular assessment, because of its watershed boundary focus, was gaining the understanding, acceptance, and support of private landowners.

“Private land” encompasses a wide range of ownership types, management objectives, and owner perceptions. In the Clear and Foster Creek basins, these include private timber companies, small woodland owners, nurseries, Christmas tree farmers, large agricultural farmers, hobby farmers, and private homeowners. To gain cooperation and earn acceptance for the fish passage assessment, each of these private interests were approached in a manner that addressed its unique concerns.

CRBC recognized that building relationships with willing landowners and their trust and confidence was key to CRBC future and success of this project. The unique process of individual organizations coming together is through the work of the Watershed Council.

Though most landowners share common concerns, we anticipated that some would weigh the potential for regulatory action more heavily than others, while others would regard the potential for financial costs as a primary issue. Others might simply resent the intrusion of a public process on their land holdings. We attempted to create a public outreach tool that would provide the information each owner required to engage in the process.

The goals for reaching out to private landowners were:
- Gaining trust
- Education
- Involvement

Trust is a critical part of a productive, long-term relationship. The consulting team recognized that by actively implementing the fish passage methodology within the Clear and Foster Creek basins, we represented the CRBC in person. Trust that had been built through hard work and time by the CRBC had to be maintained, and additional degrees of trust fostered through clear and honest communication and display of actions. Based on feedback to the CRBC and the consultants in the field, we believe this project both maintained and built trust throughout the basins and among a variety of landowners.

Direct interaction with private landowners either through personal meetings on their property and/or discussion of methods, findings, results, and solutions provided 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. During the field season significant local and site-specific knowledge was gained from the landowners. In one instance, we found a stream with five crossings on it that were previously undocumented. In another, we found an unmapped fish bearing stream and set of roads. We also found water falls, fords, and diversion dams across large streams that were previously undocumented. These important additions to the crossing population were the direct result of soliciting landowner knowledge and focused listening.

**Contact and Introduction**

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

Using the GIS data layers already assembled for the Clear and Foster Creek Basin Watershed Assessment, 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. Because GIS-based queries are only as good as the information they query and rarely is all information perfect, these postcards were also taken into the field to leave with landowners who were missed but owned land with potential fish barriers.

A few days after the postcards were received, we personally contacted landowners by phone based on their basin location and the sampling prioritization of the potential fish barrier on their property. The purpose of this phone call was to answer questions and to gain permission to access their land. We were extremely successful. Only 11 of 177 identified crossings were not visited by the field survey crew. Of these 11 all but one were on low priority streams, high in the headwaters of the basin that had resident fish only and were often above waterfalls. These crossings were not accessed because of time and budget constraints rather than landowner refusal. Only one landowner denied the project permission to survey a crossing. Basin landowner participation was outstanding.

## Field Protocol

The field protocol was divided into two levels:

- Detailed protocol: Applied to most culverts. Provided enough information to conduct detailed cost and design analyses, Many of the elements of this protocol are adapted from Dent (1999). Specifics are found in Appendix B.

- Fast protocol: Applied to lower priority culverts if the number of culverts to be field surveyed grew greater than the time allotted in the contract. Specifics are found in Appendix B.

Given project constraints, we estimated we could field survey 150 crossings using the Detailed protocol. A crossing population greater than 150 would necessitate assigning some crossings a "low priority status". This status would be given to culverts that have minimal upstream habitat and are not well connected downstream (i.e., have known barriers to fish passage downstream or are a great distance from the mainstem). Originally, we estimated a total of 147 culverts on fish bearing streams. Therefore, we did not anticipate using the Fast protocol. However, as landowners introduced us to more crossings in the field, we finished field work with a total of 189. Because field work began in the upper basin and worked toward the Clackamas, by the time the culvert population exceeded 150, we were unable to classify remaining crossings as "low priority". Therefore, we did not use the Fast protocol often.

Some crossings have no protocol information because the crossing was slated to be replaced, it was a bridge or ford and clearly passed fish, it was found to be above a fish barrier or clearly had no fish use most of the year, the county had already surveyed it, or sampling was constrained by the landowner,. For example, a large private landowner requested that they escort us to every crossing and had limited time to do so. As a result, we were unable to perform even the Fast protocol. However, the landowner has committed to replacing every crossing with fish passage problems on their land. As of July 2002, they had replaced all their culverts except for about five which were scheduled to be replaced during the 2002 August work period. We reviewed their crossings and took only pictures and very basic information on each.

### Sampling plan

The detailed method was used on approximately 69 private crossings giving adequate information to determine fish passage status and to pick a design alternative and do a preliminary cost estimate on that alternative. In addition there was similar information for over 60 county culverts. Where possible, the Fast protocol (or elements of it) was conducted on previously surveyed culverts to fill in essential information for prioritizations and design and cost analysis. Many crossings were bridges, natural fords, or open arches and did not require additional information. Crossings on the largest timber ownership were largely open bottom designs or well designed fish friendly closed bottom designs and did not demand detailed measurements.

## Barrier Determination: Hydraulic Analysis

For each crossing, field data was analyzed to determine whether it was a full, partial or non-barrier to fish passage. Barriers are defined using thresholds from the field measurement data as outlined below.

### Partial Fish Passage Blockage

For this project "partial fish passage blockage" is defined as

> stream crossings, because of their design, maintenance, or condition, that do not allow juvenile salmonid fish passage.

Based on ODFW fish passage guidelines (1997), juvenile salmon, for the most part, require:

1. two feet per second or less velocity
2. outlet perching less than 6 inches
3. little to no inlet constriction or drop
4. the culvert should be free from debris that may concentrate flow and increase velocities
5. In-culvert flow depths of 12 inches or more OR the culvert should have a simulated streambed similar to natural 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 culvert slope should not exceed 0.5%. Even if 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. Proper backwatering for culverts with greater than 0.5% slope can be determined using an estimated tailwater elevation and then inputing this value along with other key measured values into FishXing software (USFS, 1999). Generally, tailwater elevations will need to be at least 1.5 feet higher than the inlet invert elevation to provide adequate backwater on culverts greater than 1% slope and 50 feet or more in length. The exact degree of backwater, however, must be calculated because of all the possible combinations of slope, culvert length, and tailwater depth. For this analysis, the fish passage design flow was 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. 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 any outlet drop, the downstream jump pool should be 1.5 times deeper than the jump. In order to get required water depth on culverts that do not use streambed simulation designs adequate backwatering from the outlet end is needed.

3. To control constricting of flow at the inlet, the culvert diameter or span should be at least 0.5 times the width of the natural bankfull channel. The culvert should be free of large debris blockages or caved in areas that constrict flow and create high velocity areas. The culvert inlet invert should be fairly 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 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, we used the non-embedded culvert assumptions stated 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. Culvert widths between 90% and 100% cause careful evaluation of inlet constriction using inlet photos and measurements.

For baffled culverts:

1. Generally speaking, baffles or weirs should be 0.1-0.15 times the total height of the culvert. Their spacing varies with streamflow and culvert gradient. However, at least one baffle/weir should back slow water to the base of the next weir at a minimum depth of eight inches when the pool is at residual depth and under low flow conditions. When evaluating baffled culverts, it is important to record culvert gradient, weir height, and weir spacing to use in calculations to determine adequacy. Exact calculations were developed from techniques and references in Robison and Pyles (in review).

2. There should be little or no outlet drop (not greater than six inches). If the weir is placed on the edge of the outlet, that 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 of the jump pool should be at least 1.5 times as deep as the drop distance.

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 Bottom Structures:

1. Generally speaking a bridge or open bottom structure (OBS) poses no fish passage problems. An exception exists 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 event without over topping it is not likely to pose a problem. Only when there are visual indications of fish passage issues were measurements and calculations done for bridges and OBS.

2. Open bottom designs should be free of large debris that can constrict flow and cause high velocity areas inside the arch.

**Complete fish passage blockage**

Complete fish passage blockage as defined for this project, refers to instances in which the design, maintenance, or condition of the stream crossing prevents most, if not all adult salmonids from moving upstream through the crossing structure. Complete blockage results in conditions that exceed the swimming capabilities of most adult anadromous salmonids. 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

Culvert flow depths should be 8 inches or more at higher flows or the culvert should have a streambed similar to channel conditions in the natural channel. Crossings that have complete passage blockages 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 here to distinguish between partial and complete blockage. We offer this distinction because a culvert that blocks both adult and juvenile upstream fish passage is more serious than one that only blocks juvenile upstream 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 short culverts (less than 50 feet) gradients greater than 4% (up to 6%) can be tolerated if not combined with an outlet jump. If backwatering extends to a point in the pipe with less than 50 feet remaining until the inlet opening, the pipe gradient can be as high as 6%. (*Does this work? Here is the original* - For backwatering, if downstream control is at an elevation that is equivalent to a point in the pipe with less than 50 feet distance to the inlet, the gradient can 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 remain if there was no increase in water depth from the damning effect of the downstream control point. If there is

an outlet drop greater than 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 channel bottom 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 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 material embedding it that 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 a 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 (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 (in review).

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 pose 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.

## Conceptual Designs and Cost Analysis

### Design options

The following designs constitute the majority used for this project. Because of maintenance and juvenile fish passage issues, using baffles as a possible design for replacement culverts were not considered. However, there may be situations in which a retrofit of an existing culvert with excess capacity can be proposed because of it probability for success and low cost. Designs that rely on zero slope or backwatering from downstream will not be used for replacement designs. However, there may be an existing culvert with excess capacity that could be improved with downstream backwatering as a retrofit. Situations that involve demolishing or retrofitting a dam or ford will be handled on a case-by-case basis.

The following are the most frequently used replacement options:

- **Long span steel or pre-stressed concrete bridges:** This option is usually for larger streams greater than 15-20 feet in width. This is most expensive option, but can otherwise work on all stream types. Railcar bridges are a much less expensive long span option and have often been used on private roads. However, these are narrow and until recently have not been load rated.

- **Short span concrete slab bridges and open box culverts with concrete T footings:** This option is for high gradient stream reaches with or without bedrock in the profile. Spans can reach up to 20 feet so this precludes their use on wider streams. Some engineers have modified the footing design and used road barriers in an effort to reduce costs incurred by the T footings. For streams on deep fill where a closed bottom design will not work, the concrete slab bridge or open box culvert is a low risk and cost option because the T footings can be placed at a depth more resistant to scour from channel downcutting. In addition, when a stream is at a favorable stream size, gradient and valley fill depth to place in an streambed simulation culvert, but there is a lack of overhead cover, a short concrete slab bridge may be employed to get adequate flow capacity through the crossing. The use of a multiple battery of culverts will be discouraged for low headroom situations due to maintenance issues and the difficulty in getting fish passage through them.

- **Open arch metal culverts with footings:** This option is useful for streams with bedrock at or near the streambed surface. They are usually used for higher gradient narrower stream reaches. For this project, they will only be proposed for streams flowing at or near bedrock. Open metal arches on unconsolidated fill tend to be expensive (if footings are done correctly) or are more apt to fail (if footings not established well below fill level) than the slab/box design. When using any open bottom design where the footing is in the vicinity of the active stream bed, a stream profile like those advocated for closed bottom designs (see Robison and Pyles, in review) should be done to locate the base of the footings below the potential scour zone to guard against possible stream downcutting.

- **Closed bottom metal culverts using streambed simulation:** This option works well for 0-8% gradient streams where the crossing has adequate headroom and adequate valley fill to sink the culvert into stream. For various reasons, including juvenile fish passage requirements this option will be the only closed bottom design option used for this project. For very low gradient streams the culvert will be embedded as if it were placed flat as per WDFW (1999) guidelines. For all designs the use of a streambed profile to locate the vertical level of the invert of the culvert will be used to insure that the stream will not down cut and leave the culvert exposed to an outlet jump.

There are many other design types in use including log-stringer bridges, log-culverts, vented fords, various baffle, weir and rock catching culvert designs, and many variations of open arches using metal, plastic, and fiberglass materials. Open arches and multi-plate closed bottom culverts can also be designed for spans up to 50 feet. However, some of these design types tend to be experimental and others have relatively short design life. The four options listed above are common, cost effective, and have the potential for success based on our experience in installation and design. Between now and the final report full design specifications typical of each of these four primary designs will be given in an Appendix.

**Deciding between design options**

Based on guidance in Robison et al. (1999); WDFW, (1999); and Ministry of Forests (MOF) et al. (2002) closed bottom designs using streambed simulation are recommended for streams with slopes of zero to eight percent (note: WDFW and MOF advise or prescribe use up to 6% but may allow at greater slopes if justification given). Depending on which guidance the maximum size of stream that these designs are allowed or advised on range in size from 9 to 15 feet in width. Both Robison et al. and the MOF guidance specify also that the stream should have deep unconsolidated fill. Open arches will be confined to areas of well confined bedrock. Open box or short span bridges will be the preferred option on high gradient streams between 0-15 feet perhaps up to 20 feet in width. For bankfull stream widths greater than 15-20 feet, the long-span-bridge becomes the preferred option. These design choice issues creates a decision flow-chart (Figure 1) that will be used for choosing between replacement options.

Situations that involve demolishing or retrofitting a dam or ford will be handled on a case-by-case basis.

In addition, when a stream is at a favorable stream size, gradient and valley fill depth to place in a streambed simulation culvert, but there is a lack of overhead cover, a short concrete slab bridge may be employed to get adequate flow capacity through the crossing. The use of a multiple battery of culverts will be discouraged for low headroom situations due to maintenance issues and the difficulty in getting fish passage through them. The use of rail car bridges while quite common on private lands was not considered here because of concerns regarding the lack of rate load ratings on them.

**Cost estimates for design alternatives**

Cost estimates for each of the design alternatives were developed based on the use of cost estimate guidebooks such as the Means Guide (Means firm, 2002) to heavy construction costs as well as estimated costs from actual case studies and examples. The emphasis was placed more on actual examples because the general estimating guides do not adequately estimate some of the variables of working in streams, such as considering fish protection measures. Furthermore, many of the components are not reflected in the general guidebooks. Clackamas County has allowed the use of their cost estimator for county designs. This cost estimator gives cost for fill and equipment and labor that are useful for accurately costing out county culverts. For culverts on private land, different cost estimations will be employed using provided cost analysis examples from private companies. In addition, a study done by the Forest Engineering Research Institute of Canada (Kosicki and Bennett, 2001) provides several useful cost estimates for several types of open bottom designs in British Columbia that can be used for comparison.

The cost of actual materials for pipes and open arches was adapted from culvert company tables on a cost per foot basis for the pipe and the various sizes, shapes, fittings, and treatments required. The most common pipe shapes used will be round and pipe arch. In addition, the costs of excavation and installation labor will be developed using the Clackamas County cost estimator and other sources.

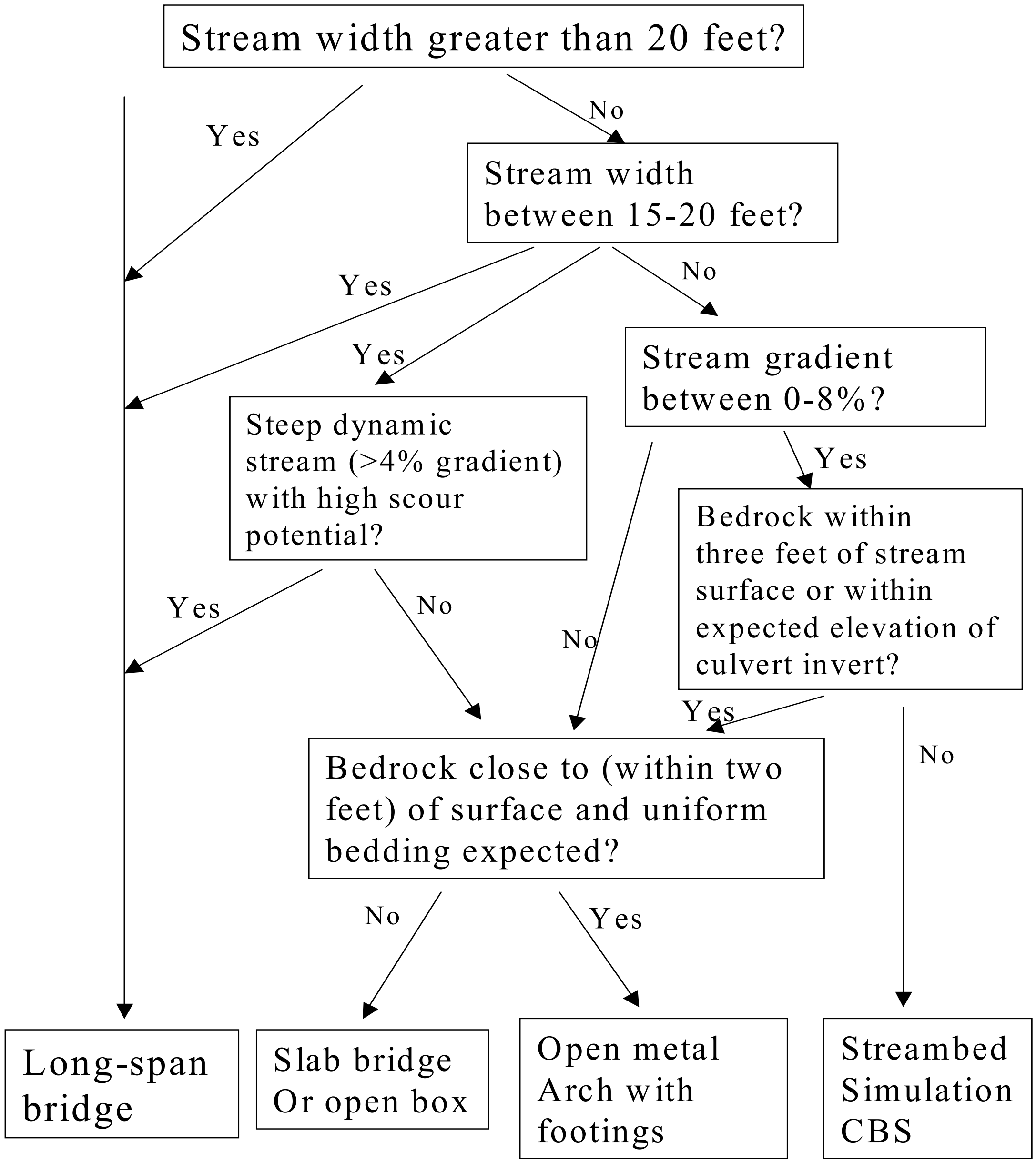


Figure 1. Design alternative decision diagram for the Clear and Foster Creek assessment/prioritization project.

The cost for short span bridges includes the slab cost, the footing cost, and the installation and design costs. These costs vary with span over stream and width of road. If the slab has cover placed over it there are additional costs for excavation and cover. These were handled using the county cost estimator and other tools

The cost for long-span bridges was based on a base cost plus a cost per span length along with the targeted width of the road. Several case study examples were gathered to estimate these costs for both steel and reinforced concrete bridges.

## Prioritization

There are two basic methods used to prioritize culverts. One system assigns a numerical value (scores) to the culvert (i.e., WDFW, 2000; Clackamas County, 2001) while the other system does not assign a value but rather places the crossings into broad priority categories based on quantitative and qualitative characteristics (Robison et. al., 1999). Some systems can use a combination of classification and scoring (David Evans Assoc., 2001). Within systems that score culverts numerically, the values assigned for different characteristics are added together (Clackamas County, 2001) or multiplied together (WDFW 2001) or there can be a combination of adding and multiplying. To more heavily weight a factor in an additive system the numbers should have a greater spread in values between favorable and unfavorable conditions. For instance in the Clackamas County system the overall weighting is a sum of:

Priority Score = (Upstream length recovered) + (Upstream Habitat Quality) + (Upstream Watershed Area) + (Barriers to Fish Passage Downstream) + (Species Known) + (Maintenance: Life expectancy of structure) + (Maintenance is the structure on 5 year paving plan) + (Cost).

Where: The crossing if prioritized is pre-assumed to block fish.
Each factor above is given a score on a range from 0-5 up to 0-30 for other factors.

In this system the two maintenance factors are more heavily swayed by giving them a range in values between 0-30 for scoring as opposed to an ecological factor like upstream length recovered that is given a range of 0-5.

In a system that multiplies factors, the key to weighting is to have a greater spread in multipliers used as a factor. In general a multiplicative factor will have the potential for more weight than an additive one. For instance the WDFW (2001) uses the formula:

Priority Index = sum for all species of quadratic ($4^{th}$) root of [(BPH) x (MDC)]

Where:
B = proportion of passage improvement (passability after vs. before project)
H = habitat gain in $m^2$

M = Mobility modifier (2 = anadromous, 1 = resident, 0 = exotic)
D = Species condition modifier (3 = critical, 2 = depressed, 1 = other)
C = Cost modifier (3 = <-100,000, 2 = 100,000-500,000, 1 = >500,000)
Note: the summation of all species is the factors are evaluated for each species affected by the crossing and then added together.

In this case the factor M – Mobility factor is weighted from 0-2 based on type of species affected by the blockage. If the species is anadromous (migrates to sea), the overall index value will double over the other values. If the species being blocked is an exotic fish, the index value will be zero. Because some factors tend to be all important such as the question "does this structure pass fish?" there is a strong argument to use a combination of both additive and multiplicative factors when using a numerical system for priority. However, the use and weighting of each factor should be carefully thought out. Because each major stream basin has a different mix of species present and land ownership patterns a strong case can be made that custom prioritization should be done on a basin-by-basin basis.

The prioritization scheme used for the Clear and Foster Creek basin is a combination of an additive and multiplicative numerical system that takes into account the species present and key ecological factors. For this analysis, the ecological were the focus to better diagnose crossings based on strictly ecological needs.

The 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 = Species downstream of crossing: 1.0 = steelhead or coho; 0.2 = resident fish only; 0 = exotics only (Streams with no fish or exotics not included in prioritization).
H = Habitat available upstream (ft).
Q = Habitat Quality index as defined by the proportion of different habitat types upstream of culvert. It a fraction of low gradient and low to moderate confinement habitat types (as defined by Watershed Professionals Network, 1999; channel habitat type section) divided by the total fish bearing length. The low gradient low to moderate confinement habitat types used were: FP1, FP2, FP3, LC, LM, MC, MH, and MM. The habitat types were taken from GIS coverage for channel habitat types developed for the Clear and Foster Creek basin watershed analysis (Watershed Professionals Network, 2002).
C = This is reflective 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.

Another equation incorporates cost using the following:

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).

# Results and Discussion

**Overview of Findings**

In the Clear and Foster Basin a total of 223 artificial barriers were evaluated to some degree (see Appendix D for listing) with 159 found on fish bearing streams as per the revised fish presence map (Appendix A) along with field determinations of fish use. Of these 159 crossings, 81 were determined to have fish passage issues (Table 2; Cost Info). Of these 81 culverts, 34 were deemed to be on streams that may be used by anadromous fish species such as steelhead trout. Anadromous fish use was determined by evaluating sources of information such as the Clackamas River Watershed Atlas (Metro, 1997) and evaluating 16 key natural barriers that prevent anadromous use in the basin. These natural barriers were discovered and/or documented during fieldwork during the summer of 2002. (See Figures 2 through 4 for locations of crossings and natural barriers in the basin.)

There were a total of 16 potential artificial barriers that were not evaluated on fish bearing streams depicted as purple in Figures 2 through 4. These barriers included the following situations:

1. CL001 Low priority on resident only
2. CL002 "
3. CL008 "
4. CL011 "
5. CL039 Very near end of fish use
6. CL040 Access issues and near end of fish use
7. CL049 Upstream of fish barrier plus access issues
8. CL061 County did not survey because they thought on private land
9. CL086 Landowner refused access because natural fish barrier at mouth of creek
10. CL094 Fish barrier at tributary mouth and resident fish only Low priority
11. CL110 Trout farm pond downstream and lack of access to pond for evaluation with little habitat upstream
12. CL126 Not allowed access by owner - Probably partially blocks fish from visual reconnaissance and would be a moderately important culvert if evaluated
13. CL134 Highly altered stream channel near end of fish use
14. CL144 Access issues and near end of fish use

15. CL145 Access issues and near end of fish use
16. CL234 Pond of Bargefield Creek blocks fish passage did not survey due to unknown status until just recently would represent an important high priority barrier if surveyed and prioritized.

Of this listing, CL234 represents the most important omission and should be considered a high priority barrier. It is unknown what degree of cooperation there would be from the landowner even though access was allowed initially to the watershed analysis team when doing a watershed tour in May. This barrier should be followed up in subsequent efforts to improve basin fish passage conditions because it has considerable habitat upstream, represents a complete blockage based on examining photos of it and is accessible to anadromous fish downstream. CL126 would be a moderate to low priority culvert but despite several attempts the landowner did not want to cooperate and allow access. The rest of the culverts would be very low priority culverts even if they blocked fish passage because they are in close proximity to a natural barrier, near the end of fish use, or have other extenuating circumstances.

Cost information was determined for fixing the 81 potential blockages to fish passage (Table 2). The proposed fixes included bridges, open bottom culverts and slabs, and closed bottom culverts that are embedded in order to imitate streambed conditions of natural streams. A design diagram (Figure 1) was developed to decide between options. In addition, pre-determined county estimates were used for county culverts that were deemed fish passage blockages. The total cost of repairing the 81 fish passage blockages is over 7.2 million dollars ($US), of which nearly 5.5 million dollars are accounted for by county fix proposals (Table 3). The highest replacement estimate is $732,000 and the minimum estimate for a crossing correction is $5460. Nearly 3.6 million dollars would be used to fix culvert blockages on anadromous streams. Of this 3.6 million dollars, nearly 3 million dollars is for county culverts.

Of these 81 streams, four were excluded from priority analysis because they did not have significant upstream resources that would be opened up if repaired. These four crossings are:

1. CL035: Little to no upstream resources
2. CL035A: Little or no upstream resources
3. CL058A: Flows into a pond with exotic fish species and has little real upstream habitat based on field reconnaissance
4. CL219: Upstream of culvert is very undefined tributary not even classified as a stream in preexisting GIS coverage.

## Prioritization

We prioritized crossings using a formula developed specifically for the Clear and Foster basin that accounts for degree of blockage, cost, amount of habitat upstream, and connectivity downstream. Details of the prioritization are given in the methods section. Table 4 ranks the culverts by their ecological "RISE" score and gives the alterative ecological + cost prioritization ranking "RISE-C" as part of the information in the Table. The highest priority crossings for repair are found on the main channel of Clear and Foster Creek and on key tributaries lower in the basin that do not have high gradient stretches and waterfalls (Table 4). Descriptions with photos for all 77 of the prioritized crossings plus other crossings are given in Appendix E. A web link is being developed to include a description page for each key selected crossing similar to Appendix E as well.

The top 9 slated for repair or replacement based only on ecological criteria are:

1. CL209: A pipe across Clear Creek that creates a drop that blocks juvenile and weak swimming fish passage
2. CL069A: A ford across Clear Creek that creates a drop that blocks juvenile and weak swimming fish passage.
3. CL088: A box culvert on Little Clear Creek that has almost 15 miles of fish bearing stream habitat upstream that blocks fish passage for most or all fish.
4. CL216: A ford on Clear Creek that has a 2 foot drop that creates a possible barrier for juvenile and weak swimming fish.
5. CL123: A two barrel culvert crossing on an unnamed tributary to Creek that blocks fish passage for juvenile and weak swimming fish.
6. FO003: A culvert that blocks fish passage on Foster Creek
7. FO002: An irrigation dam that partially blocks fish passage immediately upstream of FO003.
8. CL068: A corrugated metal pipe culvert blocking fish passage on Mosier Creek
9. CL100: Two concrete culverts on a very low use road that partially block fish passage on a large tributary to Clear creek that probably can be removed.

While a ranking system can highlight some of the key culverts for replacement, it should not be followed blindly. Often times there are other factors such as watershed condition upstream or degree of cooperation that can not easily be factored into the analysis. In many cases, there are combinations of culverts that if replaced can open up considerable habitat if done concurrently.

Among some of these highest priority culverts are these specific situations that represent prime opportunities for restoration of proper passage and watershed process:

- The number one ranked crossing, CL209, is an irrigation pipe that creates a consistent drop represents a potential fish passage blockage to juvenile fish and probably can be mitigated at minimal cost.

- A diversion dam on Foster Creek (FO002; Ranked #7 RISE and #5 RISE-C) that may be mitigated by developing a fish ladder below it. (Estimated cost is about $15,000) This will be an extremely high priority if a culvert downstream (FO003; Rank #6 RISE and #43 RISE-C) is replaced

- A ford on Clear Creek (CL069A - not previously documented) was discovered during field work summer 2002 (Ranked #2 RISE and #2 RISE-C) that is a partial fish passage blockage that could be mitigated by creating a roughened channel along part of the stream channel. If this fix is attempted, some further design work should be conducted as to the best way to fix this potential problem for juvenile fish and possibly weaker swimming adult fish. (Estimated cost about $7,500)

- A series of culverts on a low gradient tributary that connects directly to Clear Creek (CL069C, D, E, F) (Estimated cost about $65,000 if all culverts replaced) both the crossings and the stream were not previously documented and were discovered during field work summer 2002. Although the crossings were only moderate in priority, ranging in rank from #41-69 RISE, the stream has extremely high quality habitat that is well shaded with water temperatures that seemed abnormally cool. This is an example of a low gradient stream directly connected to the mainstem of Clear Creek that may represent a thermal and habitat refuge that would be hard to quantify using the coarse ranking system used in this analysis.

- Three culverts on Spring Creek, a high quality, low gradient tributary that drains directly into Clear Creek. One culvert (CL100) is a semi abandoned road and could probably be removed. The second culvert (CL101) is on a private paved road. The third and farthest upstream culvert (CL099) is a county crossing under Mattoon Road. The cost of removing and replacing the two private culverts is $93,000. The county culvert estimate (by the county) for replacement is $361,000.

In contrast to these prime opportunities one culvert with a moderate ranking CL227 ranked #47 RISE empties into a pond 100 feet downstream. Even though this culvert has some upstream habitat (approximately 1400 feet; Table 4) because it drains into a pond that blocks fish it represents one of the lowest priority crossings considered. Likewise, any culvert should be evaluated where it is in the basin (Figures 2-4) and if there are other natural or human caused blockages nearby. Another example of an extremely low priority culvert is crossing CL007 (Rank #35 RISE). This culvert has a 20 foot waterfall about 40 feet downstream (Appendix E). Even though there is considerable habitat upstream there is only 40 feet of habitat downstream that will be accessed by fixing this culvert. For this reason its true priority should be at about the lowest of any considered.

A subset of these barriers represent <u>complete blockages</u> on <u>anadromous fish passage streams</u>. Even though some may have lower priorities because they have little upstream habitat, certain funding opportunities may want to focus on them because of the potential to restore anadromous fish habitat and to provide funding for crossings that are known to block both adult and juvenile fish migration.

1. CL067 - Mosier Creek round culvert with considerable potential upstream length of nearly 1 mile. Estimated cost to replace would be 133,510 more info on all the culvert in Appendix E.
2. CL068 - Also on Mosier Creek another round culvert downstream of CL067 with a potential of 1.8 miles of upstream fish bearing length.

3. CL079 – Tennings Creek with a fairly high priority rating (RISE = 18) because has over 4,000 feet of fairly low gradient habitat upstream. Out of this population this culvert represents the highest priority.

A considerable number as stated earlier represent potential blockages on anadromous fish bearing streams (34 barriers as depicted by RISE-S = 1.0 on Table 4). In addition, several stream tributaries do not show up as anadromous but may be anadromous (i.e. CL069B-D) so connectivity and potential to be anadromous should also be looked at from maps (Figures 2 through 4).

The results from this report provide information that can be used in applying for watershed or stream improvement grants. The proposed designs are for cost estimates only. Actual replacement of these culverts will require further design work. In some cases, several alternative designs can work at a crossing with extremely different costs involved. There may be opportunities in these instances to reduce costs by using alternative designs. In other cases, more expensive designs may be proposed for concerns beyond basic fish passage.

**Table 2. Cost estimates to repair or replace road stream crossings to provide for fish passage in the Clear and Foster Creek Basins.** *(Note: 1. Culverts with NA in cost categories are county culverts with pre-determined cost estimates from Clackamas County Data, Unpublished; 2. Design types are OpenSlab representing an open bottom design using a concrete slab; CBS-SS represents a conventional closed bottom culvert embedded with substrate to simulate a natural bed; RoughCh represents a designed coarse bedded channel to elevate the channel bed downstream from a sharp drop in elevation; Fishway; refers to a baffled channel to create a pathway to allow fish to get over a sharp drop in elevation; 3. Fish stream refers to affirmative fish presence according to best available information see Methods section for more information )*

| X_ID | Fish Pass? | Fish Stream?[3] | Replace?[2] | Cost Mat[1] | CostInstall | CostDesign | Contingencies | Total Cost |
|---|---|---|---|---|---|---|---|---|
| CL003 | N | 1 | OpenSlab | $129,800 | $22,600 | $5,000 | $47,220 | $204,620 |
| CL006 | N | 1 | OpenSlab | $94,800 | $22,600 | $5,000 | $35,370 | $157,770 |
| CL007 | N | 1 | OpenSlab | $94,800 | $22,600 | $5,000 | $35,370 | $157,770 |
| CL016 | N | 1 | CBS-SS | $10,000 | $5,050 | $2,200 | $5,175 | $22,425 |
| CL030 | N | 1 | CBS-SS | NA | NA | NA | NA | $95,000 |
| CL035 | P | 1 | CBS-SS | NA | NA | NA | NA | $45,000 |
| CL035A | P | 1 | CBS-SS | NA | NA | NA | NA | $70,000 |
| CL036 | N | 1 | OpenSlab | $92,400 | $24,640 | $5,000 | $36,612 | $158,652 |
| CL038 | N | 1 | CBS-SS | NA | NA | NA | NA | $203,000 |
| CL042 | P | 1 | CBS-SS | $5,670 | $5,050 | $2,200 | $3,876 | $16,796 |
| CL045 | P | 1 | CBS-SS | NA | NA | NA | NA | $71,500 |
| CL046 | P | 1 | CBS-SS | NA | NA | NA | NA | $443,000 |
| CL046B | P | 1 | OpenSlab | $60,600 | $22,290 | $5,000 | $26,577 | $114,467 |
| CL047 | P | 1 | CBS-SS | $7,150 | $5,050 | $2,200 | $4,320 | $18,720 |
| CL051 | N | 1 | CBS-SS | $3,300 | $5,050 | $2,200 | $3,165 | $13,715 |
| CL052 | P | 1 | CBS-SS | NA | NA | NA | NA | $92,000 |
| CL053A | P | 1 | CBS-SS | $3,207 | $5,050 | $2,200 | $3,137 | $13,594 |
| CL057 | P | 1 | CBS-SS | NA | NA | NA | NA | $46,000 |
| CL058B | P | 1 | CBS-SS | $2,740 | $5,050 | $2,200 | $2,997 | $12,987 |
| CL060 | N | 1 | CBS-SS | NA | NA | NA | NA | $115,000 |
| CL064 | P | 1 | CBS-SS | NA | NA | NA | NA | $36,000 |
| CL065 | P | 1 | CBS-SS | NA | NA | NA | NA | $87,000 |
| CL066 | P | 1 | CBS-SS | $10,220 | $6,700 | $3,500 | $6,126 | $26,546 |
| CL067 | N | 1 | OpenSlab | $72,400 | $25,300 | $5,000 | $30,810 | $133,510 |
| CL068 | N | 1 | OpenSlab | $129,800 | $22,600 | $5,000 | $47,220 | $204,620 |
| CL069A | P | 1 | RoughCh | $0 | $3,730 | $2,000 | $1,719 | $7,449 |
| CL069C | N | 1 | CBS-SS | $3,900 | $3,850 | $3,500 | $3,375 | $14,625 |
| CL069D | P | 1 | CBS-SS | $6,433 | $5,275 | $3,500 | $4,562 | $19,770 |
| CL069E | P | 1 | CBS-SS | $4,290 | $4,800 | $3,500 | $3,777 | $16,367 |
| CL069F | N | 1 | CBS-SS | $3,695 | $4,235 | $3,500 | $3,429 | $14,859 |
| CL069G | N | 1 | NA | | | | | |
| CL079 | P | 1 | CBS-SS | NA | NA | NA | NA | $47,500 |
| CL083 | P | 1 | CBS-SS | NA | NA | NA | NA | $56,000 |
| CL084 | N | 1 | CBS-SS | NA | NA | NA | NA | $72,500 |
| CL087 | N | 1 | CBS-SS | NA | NA | NA | NA | $100,000 |
| CL088 | N | 1 | Bridge | NA | NA | NA | NA | $605,000 |
| CL089 | P | 1 | CBS-SS | NA | NA | NA | NA | $44,500 |
| CL095 | N | 1 | CBS-SS | NA | NA | NA | NA | $135,000 |

**Table 2. Cost estimates to repair or replace road stream crossings to provide for fish passage in the Clear and Foster Creek Basins (continued)**

| X_ID | Fish Pass? | Fish? | Replace? | Cost Mat | CostInstall | CostDesign | Contingencies | Total Cost |
|---|---|---|---|---|---|---|---|---|
| CL099 | P | 1 | OpenSlab | NA | NA | NA | NA | $361,000 |
| CL100 | P | 1 | Remove | $0 | $4,200 | $0 | $1,260 | $5,460 |
| CL101 | P | 1 | OpenSlab | $39,400 | $22,990 | $5,000 | $20,217 | $87,607 |
| CL106 | P | 1 | CBS-SS | NA | NA | NA | NA | $100,000 |
| CL108 | P | 1 | CBS-SS | $4,395 | $4,235 | $3,500 | $3,639 | $15,769 |
| CL108A | N | 1 | CBS-Baffle | $8,980 | $9,100 | $4,000 | $6,624 | $28,704 |
| CL109 | P | 1 | CBS-SS | NA | NA | NA | NA | $203,000 |
| CL113 | P | 1 | CBS-SS | NA | NA | NA | NA | $44,000 |
| CL115 | P | 1 | CBS-SS | NA | NA | NA | NA | $50,000 |
| CL116 | P | 1 | CBS-SS | NA | NA | NA | NA | $50,000 |
| CL118 | N | 1 | CBS-SS | NA | NA | NA | NA | $50,000 |
| CL119 | P | 1 | CBS-SS | NA | NA | NA | NA | $443,500 |
| CL120 | P | 1 | CBS-SS | NA | NA | NA | NA | $69,500 |
| CL122 | N | 1 | CBS-SS | NA | NA | NA | NA | $85,500 |
| CL123 | P | 1 | CBS-SS | $6,720 | $4,800 | $3,500 | $4,506 | $19,526 |
| CL125 | P | 1 | CBS-SS | NA | NA | NA | NA | $50,000 |
| CL128 | P | 1 | CBS-SS | $4,099 | $4,325 | $3,500 | $3,577 | $15,501 |
| CL143 | N | 1 | OpenSlab | $32,400 | $22,990 | $5,000 | $18,117 | $78,507 |
| CL211 | N | 1 | CBS-SS | $7,605 | $4,800 | $3,500 | $4,771 | $20,676 |
| CL213 | P | 1 | CBS-SS | $5,010 | $4,800 | $3,500 | $3,993 | $17,303 |
| CL214 | P | 1 | CBS-SS | $4,170 | $4,800 | $3,500 | $3,741 | $16,211 |
| CL215 | N | 1 | CBS-SS | $3,834 | $3,850 | $2,500 | $3,055 | $13,239 |
| CL216 | P | 1 | RoughCh | $0 | $3,730 | $2,000 | $1,719 | $7,449 |
| CL217 | P | 1 | CBS-SS | $6,000 | $4,800 | $3,500 | $4,290 | $18,590 |
| CL219 | N | 1 | CBS-SS | $9,880 | $5,750 | $3,500 | $5,739 | $24,869 |
| CL220 | P | 1 | CBS-SS | $5,123 | $4,800 | $2,500 | $3,727 | $16,150 |
| CL223 | P | 1 | CBS-SS | NA | NA | NA | NA | $36,000 |
| CL224 | N | 1 | CBS-SS | NA | NA | NA | NA | $101,000 |
| CL225 | P | 1 | CBS-SS | NA | NA | NA | NA | $45,500 |
| CL226 | N | 1 | CBS-SS | NA | NA | NA | NA | $79,000 |
| CL227 | P | 1 | CBS-SS | NA | NA | NA | NA | $135,000 |
| CL228 | P | 1 | CBS-SS | $4,790 | $4,800 | $2,500 | $3,627 | $15,717 |
| CL229 | P | 1 | CBS-SS | NA | NA | NA | NA | $194,500 |
| CL230 | P | 1 | CBS-SS | NA | NA | NA | NA | $50,000 |
| CL231 | P | 1 | CBS-SS | NA | NA | NA | NA | $47,000 |
| CL232 | P | 1 | CBS-SS | NA | NA | NA | NA | $46,000 |
| CL233 | P | 1 | CBS-SS | NA | NA | NA | NA | $13,655 |
| CL209 | P | 1 | RoughCh | $0 | $3,730 | $2,000 | $1,719 | $7,449 |
| FO002 | P | 1 | Fishway | $3,500 | $3,550 | $4,500 | $3,465 | $15,015 |
| FO003 | P | 1 | Bridge | NA | NA | NA | NA | $732,000 |
| FO007 | P | 1 | CBS-SS | NA | NA | NA | NA | $74,500 |
| FO011 | P | 1 | CBS-SS | $2,440 | $3,850 | $2,500 | $2,637 | $11,427 |
| FO016 | P | 1 | CBS-SS | NA | NA | NA | NA | $70,500 |

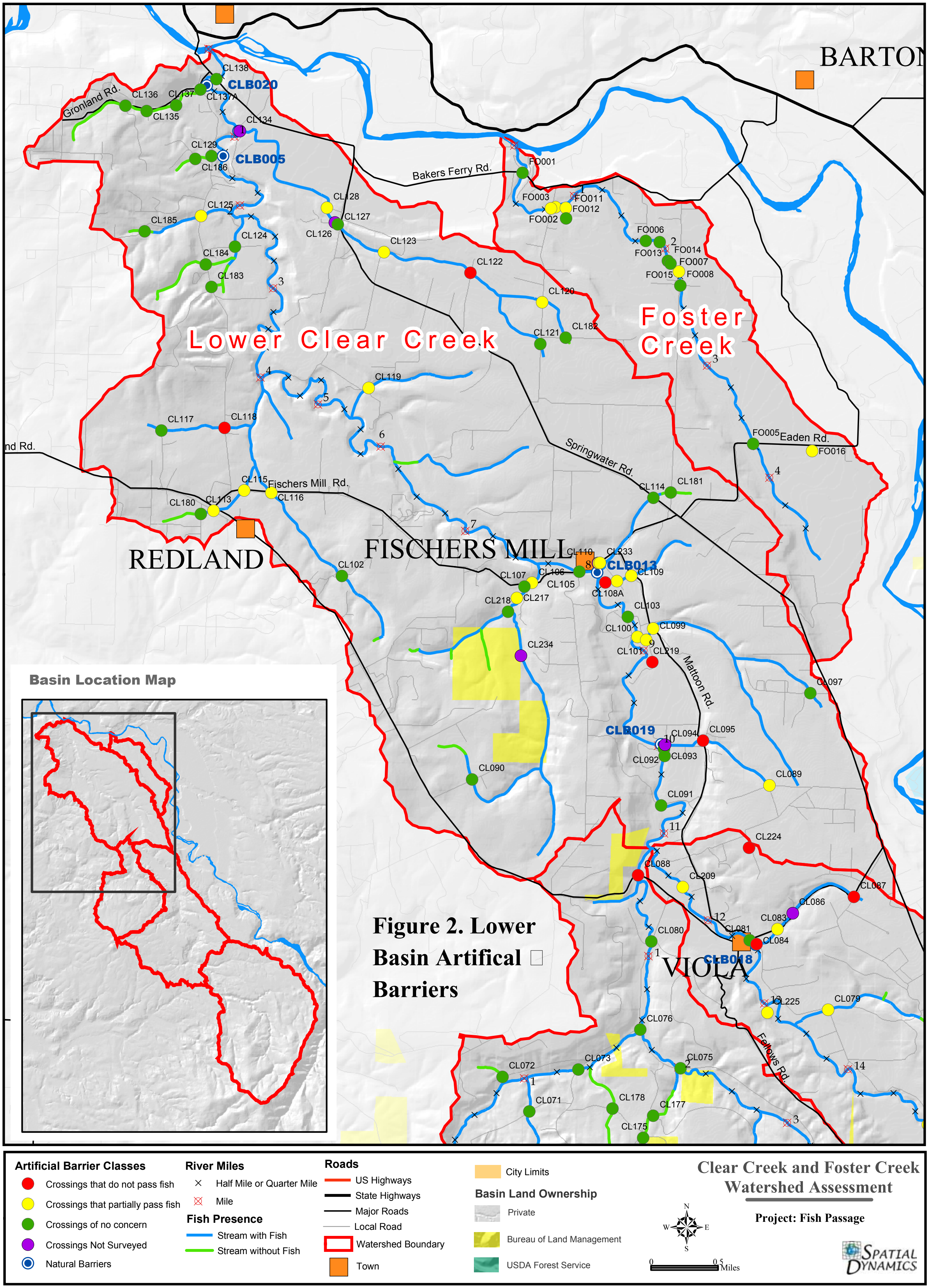


**Figure 2. Lower Basin Artifical Barriers**

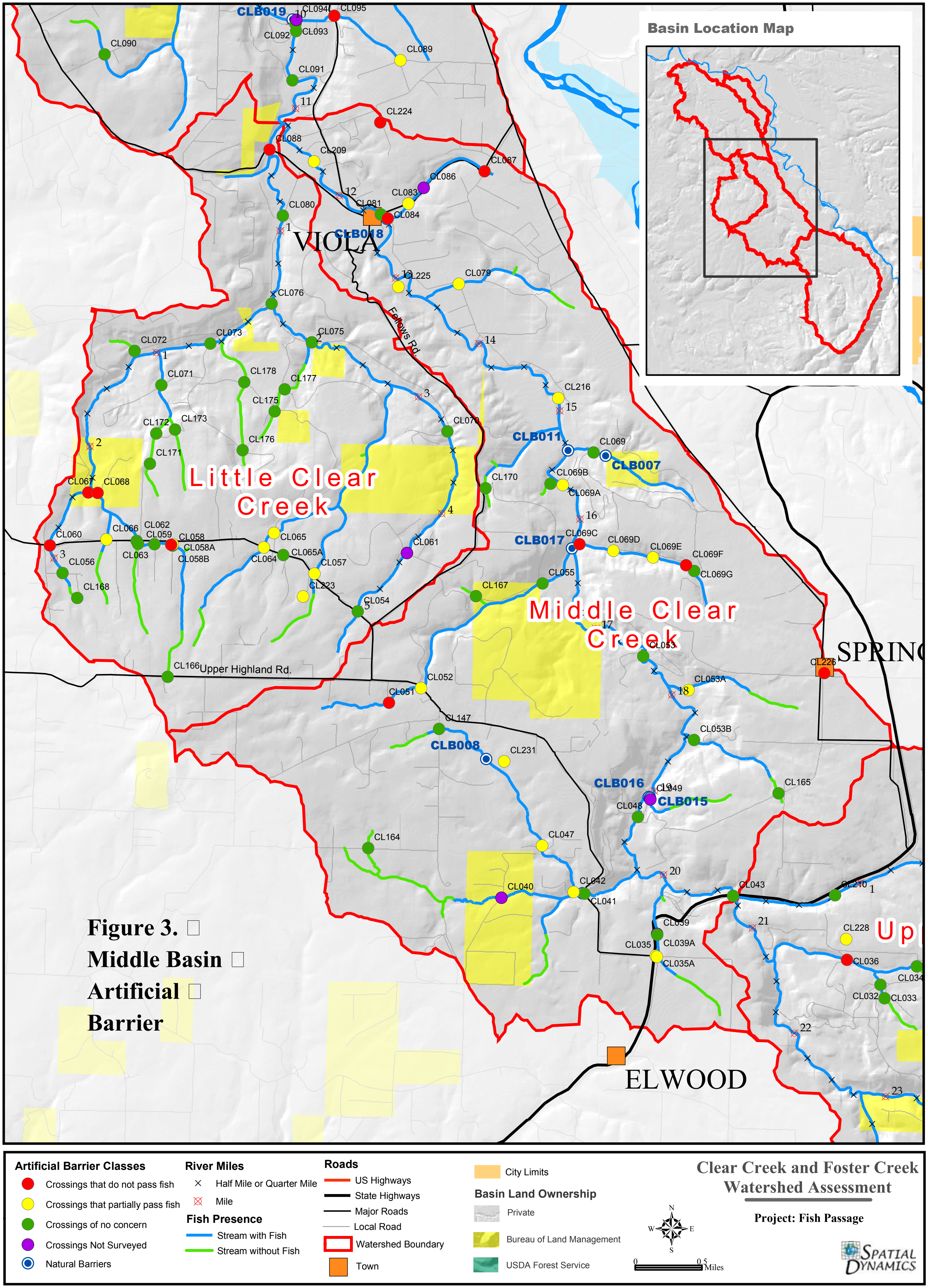


**Figure 3. Middle Basin Artificial Barrier**

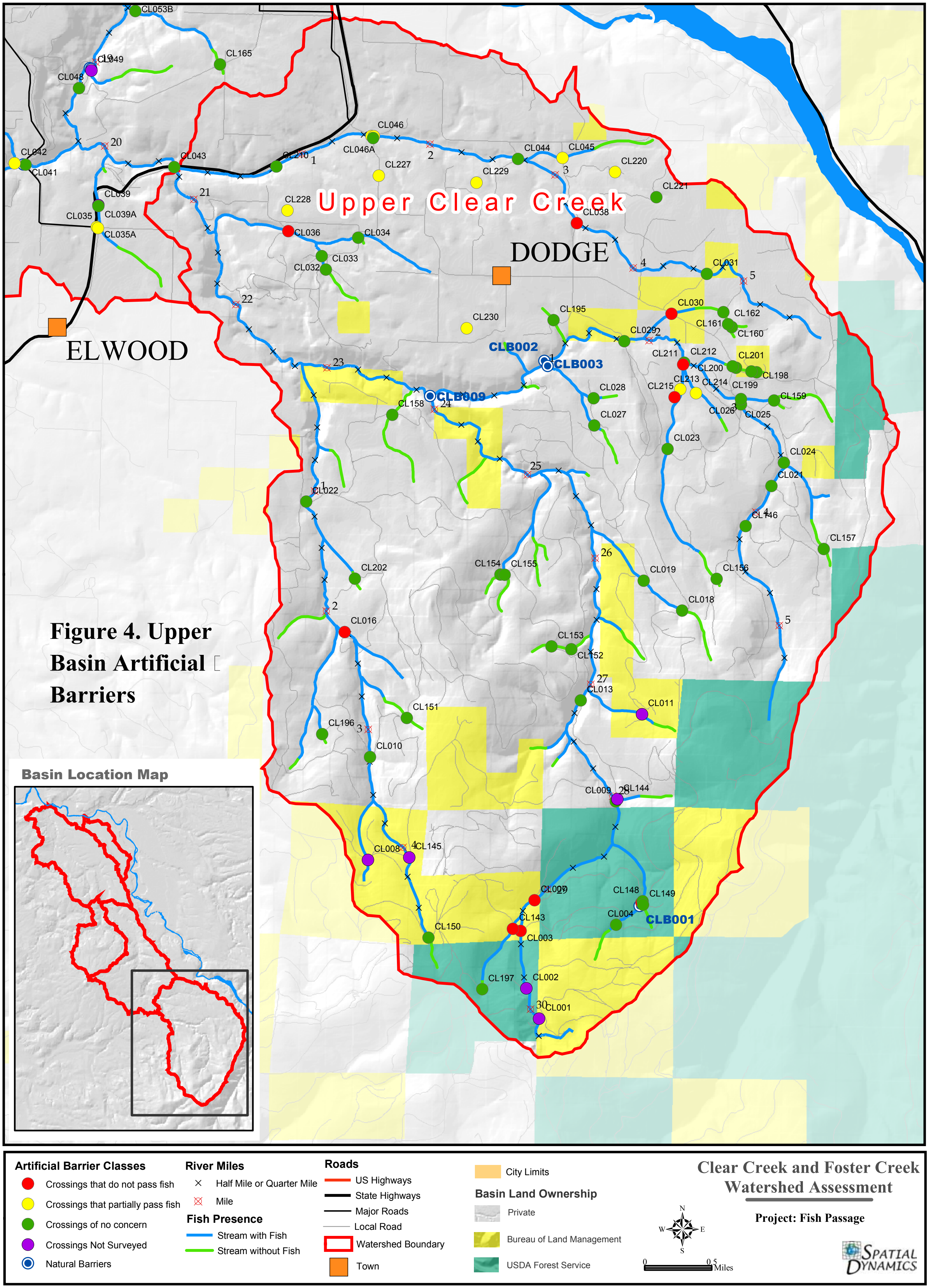


Figure 4. Upper Basin Artificial Barriers

**Table 3. Summary of costs for fixes and replacements for fish passage situations.**

| | |
|---|---|
| Total Number of Fixes = | 81 |
| Cost of Fixes on Anadromous = | $3,601,532 |
| Cost of Fixes on Resident only = | $3,658,054 |
| Total | $7,259,586 |
| | |
| County Culverts Number | 43 |
| Anadromous Costs = | $2,986,717 |
| Resident Only Costs = | $2,506,547 |
| Total = | $5,493,264 |
| | |
| Max Fix Cost | $732,000 |
| Min Fix Cost | $5,460 |
| Average Cost | $92,733 |

**Table 4. Prioritization data for 77 road stream crossings deemed to have fish passage issues.** *(Notes: The various components such as RISE B ect… their derivation is in Methods section. Rank of RISE is the priority ranking based on ecological criteria Rise-EQ and EQC is the numerical scores from the two equations.)*

| Rank Rise | X_ID | Fix | Span (ft) | RISE-B | RISE-S | RISE-H | RISE-Q | RISE-C | RISE-Cost | RISE-EQ | RISE-EQC | Rank Rise-C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CL209 | RoughCh | 10 | 0.5 | 1.0 | 341210 | 1.6 | 1743 | $7,449 | 279569 | 37.5 | 1 |
| 2 | CL069A | RoughCh | 10 | 0.5 | 1.0 | 299340 | 1.6 | 1300 | $7,449 | 246800 | 33.1 | 2 |
| 3 | CL088 | Bridge | 40 | 0.5 | 1.0 | 77786 | 1.7 | 1768 | $605,000 | 68416 | 0.1 | 18 |
| 4 | CL216 | RoughCh | 10 | 0.5 | 0.2 | 312948 | 1.6 | 1387 | $7,449 | 51137 | 6.9 | 3 |
| 5 | CL123 | CBS-SS | 8 | 1.0 | 1.0 | 11957 | 1.9 | 2701 | $19,526 | 25715 | 1.3 | 6 |
| 6 | FO003 | Bridge | 30 | 0.5 | 1.0 | 21059 | 1.9 | 2892 | $732,000 | 21642 | 0.0 | 43 |
| 7 | FO002 | Fishway | 7 | 0.5 | 1.0 | 20921 | 1.9 | 2888 | $15,015 | 21502 | 1.4 | 5 |
| 8 | CL068 | OpenSlab | 25 | 1.0 | 1.0 | 9584 | 1.7 | 1358 | $204,620 | 17472 | 0.1 | 24 |
| 9 | CL100 | Remove | | 0.5 | 1.0 | 14823 | 2.0 | 2055 | $5,460 | 15850 | 2.9 | 4 |
| 10 | CL101 | OpenSlab | 25 | 0.5 | 1.0 | 14390 | 2.0 | 2046 | $87,607 | 15413 | 0.2 | 13 |
| 11 | CL099 | OpenSlab | 25 | 0.5 | 1.0 | 13898 | 2.0 | 2035 | $361,000 | 14915 | 0.0 | 36 |
| 12 | CL067 | OpenSlab | 12 | 1.0 | 1.0 | 4785 | 1.9 | 1360 | $133,510 | 10242 | 0.1 | 26 |
| 13 | CL122 | CBS-SS | 6 | 0.5 | 1.0 | 8285 | 1.9 | 2624 | $85,500 | 9147 | 0.1 | 19 |
| 14 | CL116 | CBS-SS | 6 | 0.5 | 1.0 | 7710 | 2.0 | 2456 | $50,000 | 8857 | 0.2 | 12 |
| 15 | CL106 | CBS-SS | 14 | 1.0 | 0.2 | 21039 | 1.7 | 2165 | $100,000 | 7541 | 0.1 | 27 |
| 16 | CL217 | CBS-SS | 10 | 1.0 | 0.2 | 20001 | 1.7 | 2145 | $18,590 | 7122 | 0.4 | 8 |
| 17 | CL042 | CBS-SS | 10 | 1.0 | 0.2 | 17120 | 2.0 | 806 | $16,796 | 7009 | 0.4 | 7 |
| 18 | CL079 | CBS-SS | 5 | 1.0 | 1.0 | 4212 | 1.3 | 1521 | $47,500 | 6987 | 0.1 | 15 |
| 19 | CL119 | CBS-SS | 15 | 0.5 | 1.0 | 4402 | 2.0 | 2410 | $443,500 | 5607 | 0.0 | 57 |
| 20 | CL046 | CBS-SS | 15 | 0.5 | 0.2 | 25549 | 2.0 | 592 | $443,000 | 5108 | 0.0 | 60 |
| 21 | CL046B | OpenSlab | 15 | 0.5 | 0.2 | 25440 | 2.0 | 590 | $114,467 | 5086 | 0.0 | 34 |
| 22 | CL038 | CBS-SS | 8 | 1.0 | 0.2 | 12678 | 2.0 | 376 | $203,000 | 5025 | 0.0 | 45 |
| 23 | CL016 | CBS-SS | 12 | 1.0 | 0.2 | 20470 | 1.1 | 289 | $22,425 | 4578 | 0.2 | 11 |
| 24 | CL118 | CBS-SS | 6 | 0.5 | 1.0 | 3277 | 2.0 | 2494 | $50,000 | 4471 | 0.1 | 21 |

**Table 4. Prioritization data for 77 road stream crossings deemed to have fish passage issues. (Cont.)**
*(Notes: The various components such as RISE B ect… their derivation is in Methods section. Rank of RISE is the priority ranking based on ecological criteria Rise-EQ and EQC is the numerical scores from the two equations.)*

| Rank Rise | X_ID | Fix | Span (ft) | RISE-B | RISE-S | RISE-H | RISE-Q | RISE-C | RISE-Cost | RISE-EQ | RISE-EQC | Rank Rise-C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | CL211 | CBS-SS | 11 | 1.0 | 0.2 | 10802 | 2.0 | 142 | $20,676 | 4349 | 0.2 | 9 |
| 26 | CL232 | CBS-SS | 4 | 0.5 | 1.0 | 3719 | 1.6 | 2129 | $46,000 | 4045 | 0.1 | 23 |
| 27 | CL125 | CBS-SS | 7 | 0.5 | 1.0 | 2170 | 2.0 | 2797 | $50,000 | 3558 | 0.1 | 28 |
| 28 | CL083 | CBS-SS | 6 | 0.5 | 1.0 | 4332 | 1.1 | 1630 | $56,000 | 3208 | 0.1 | 32 |
| 29 | CL115 | CBS-SS | 5 | 0.5 | 1.0 | 1956 | 2.0 | 2460 | $50,000 | 3186 | 0.1 | 30 |
| 30 | CL128 | CBS-SS | 6 | 0.5 | 0.2 | 14934 | 1.9 | 2763 | $15,501 | 3173 | 0.2 | 10 |
| 31 | CL047 | CBS-SS | 12 | 1.0 | 0.2 | 7383 | 2.0 | 750 | $18,720 | 3103 | 0.2 | 14 |
| 32 | CL120 | CBS-SS | 5 | 0.5 | 1.0 | 1774 | 2.0 | 2558 | $69,500 | 3053 | 0.0 | 35 |
| 33 | CL036 | OpenSlab | 25 | 1.0 | 0.2 | 7516 | 1.8 | 620 | $158,652 | 2892 | 0.0 | 52 |
| 34 | FO007 | CBS-SS | 7 | 0.5 | 0.2 | 13601 | 1.9 | 2737 | $74,500 | 2821 | 0.0 | 38 |
| 35 | CL007 | OpenSlab | 20 | 1.0 | 0.2 | 10765 | 1.3 | -172 | $157,770 | 2660 | 0.0 | 53 |
| 36 | CL060 | CBS-SS | 8 | 0.5 | 1.0 | 1936 | 1.9 | 1299 | $115,000 | 2509 | 0.0 | 50 |
| 37 | CL065 | CBS-SS | 7 | 1.0 | 0.2 | 4447 | 2.0 | 1306 | $87,000 | 2040 | 0.0 | 47 |
| 38 | CL087 | CBS-SS | 6 | 1.0 | 1.0 | 462 | 1.0 | 1549 | $100,000 | 2011 | 0.0 | 51 |
| 39 | CL108 | CBS-SS | 9 | 1.0 | 0.2 | 3677 | 2.0 | 2113 | $15,769 | 1893 | 0.1 | 16 |
| 40 | CL069C | CBS-SS | 10 | 1.0 | 0.2 | 6791 | 1.1 | 1241 | $14,625 | 1731 | 0.1 | 17 |
| 41 | CL003 | OpenSlab | 25 | 1.0 | 0.2 | 6140 | 1.4 | -203 | $204,620 | 1728 | 0.0 | 66 |
| 42 | CL229 | CBS-SS | 10 | 0.5 | 1.0 | 1980 | 1.5 | 477 | $194,500 | 1724 | 0.0 | 65 |
| 43 | CL045 | CBS-SS | 7 | 0.5 | 1.0 | 1457 | 2.0 | 421 | $71,500 | 1668 | 0.0 | 48 |
| 44 | CL213 | CBS-SS | 9 | 0.5 | 0.2 | 7252 | 2.0 | 121 | $17,303 | 1462 | 0.1 | 25 |
| 45 | CL214 | CBS-SS | 7 | 0.5 | 1.0 | 1378 | 2.0 | 115 | $16,211 | 1435 | 0.1 | 22 |
| 46 | CL215 | CBS-SS | 9 | 0.5 | 0.2 | 6884 | 2.0 | 109 | $13,239 | 1388 | 0.1 | 20 |
| 47 | CL224 | CBS-SS | 6 | 0.5 | 1.0 | 686 | 1.5 | 1673 | $101,000 | 1351 | 0.0 | 56 |
| 48 | CL108A | CBS-Baffle | 5 | 0.5 | 0.2 | 4136 | 2.0 | 2123 | $28,704 | 1039 | 0.0 | 40 |
| 49 | CL052 | CBS-SS | 6 | 0.5 | 0.2 | 4514 | 2.0 | 1046 | $92,000 | 1007 | 0.0 | 62 |
| 50 | CL089 | CBS-SS | 5 | 0.5 | 1.0 | 123 | 1.0 | 1821 | $44,500 | 972 | 0.0 | 49 |
| 51 | CL084 | CBS-SS | 7 | 0.5 | 0.2 | 5632 | 1.3 | 1653 | $72,500 | 904 | 0.0 | 59 |
| 52 | CL058B | CBS-SS | 4 | 0.5 | 0.2 | 3792 | 2.0 | 1269 | $12,987 | 885 | 0.1 | 29 |
| 53 | CL064 | CBS-SS | 5 | 0.5 | 0.2 | 3706 | 2.0 | 1290 | $36,000 | 870 | 0.0 | 46 |
| 54 | CL109 | CBS-SS | 8 | 0.5 | 0.2 | 3075 | 2.0 | 2100 | $203,000 | 825 | 0.0 | 72 |
| 55 | CL233 | CBS-SS | 4 | 0.5 | 0.2 | 3651 | 1.6 | 2128 | $13,655 | 802 | 0.1 | 31 |
| 56 | CL069D | CBS-SS | 8 | 0.5 | 0.2 | 5438 | 1.1 | 1212 | $19,770 | 727 | 0.0 | 39 |
| 57 | CL051 | CBS-SS | 6 | 0.5 | 0.2 | 3000 | 2.0 | 1014 | $13,715 | 701 | 0.1 | 33 |
| 58 | CL113 | CBS-SS | 5 | 1.0 | 0.2 | 435 | 2.0 | 2429 | $44,000 | 660 | 0.0 | 54 |
| 59 | CL069E | CBS-SS | 8 | 0.5 | 0.2 | 3814 | 1.2 | 1177 | $16,367 | 561 | 0.0 | 42 |
| 60 | CL095 | CBS-SS | 6 | 0.5 | 0.2 | 3392 | 1.0 | 1888 | $135,000 | 528 | 0.0 | 74 |
| 61 | CL225 | CBS-SS | 4 | 1.0 | 0.2 | 634 | 1.5 | 1565 | $45,500 | 503 | 0.0 | 61 |
| 62 | CL223 | CBS-SS | 4 | 1.0 | 0.2 | 818 | 1.5 | 1271 | $36,000 | 500 | 0.0 | 55 |
| 63 | CL053A | CBS-SS | 8 | 0.5 | 0.2 | 2830 | 1.3 | 1048 | $13,594 | 471 | 0.0 | 41 |
| 64 | CL143 | OpenSlab | 20 | 1.0 | 0.2 | 2533 | 1.0 | -203 | $78,507 | 466 | 0.0 | 69 |
| 65 | FO016 | CBS-SS | 7 | 0.5 | 0.2 | 1346 | 1.5 | 2529 | $70,500 | 455 | 0.0 | 68 |

**Table 4. Prioritization data for 77 road stream crossings deemed to have fish passage issues. (Cont.)**
*(Notes: The various components such as RISE B ect… their derivation is in Methods section. Rank of RISE is the priority ranking based on ecological criteria Rise-EQ and EQC is the numerical scores from the two equations.)*

| Rank Rise | X_ID | Fix | Span (ft) | RISE-B | RISE-S | RISE-H | RISE-Q | RISE-C | RISE-Cost | RISE-EQ | RISE-EQC | Rank Rise-C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 66 | CL030 | CBS-SS | 5 | 1.0 | 0.2 | 1023 | 2.0 | 163 | $95,000 | 442 | 0.0 | 71 |
| 67 | FO011 | CBS-SS | 5 | 0.5 | 0.2 | 1010 | 1.5 | 2876 | $11,427 | 439 | 0.0 | 37 |
| 68 | CL069F | CBS-SS | 8 | 0.5 | 0.2 | 2394 | 1.3 | 1149 | $14,859 | 417 | 0.0 | 44 |
| 69 | CL006 | OpenSlab | 20 | 1.0 | 0.2 | 1692 | 1.0 | -153 | $157,770 | 308 | 0.0 | 76 |
| 70 | CL057 | CBS-SS | 5 | 0.5 | 0.2 | 875 | 2.0 | 1298 | $46,000 | 303 | 0.0 | 67 |
| 71 | CL066 | CBS-SS | 7 | 0.5 | 0.2 | 668 | 2.0 | 1313 | $26,546 | 265 | 0.0 | 64 |
| 72 | CL230 | CBS-SS | 6 | 1.0 | 0.2 | 528 | 1.5 | 415 | $50,000 | 241 | 0.0 | 70 |
| 73 | CL226 | CBS-SS | 6 | 0.5 | 0.2 | 924 | 1.5 | 922 | $79,000 | 231 | 0.0 | 75 |
| 74 | CL220 | CBS-SS | 7 | 0.5 | 0.2 | 1102 | 1.5 | 368 | $16,150 | 202 | 0.0 | 58 |
| 75 | CL231 | CBS-SS | 5 | 0.5 | 0.2 | 792 | 1.5 | 664 | $47,000 | 185 | 0.0 | 73 |
| 76 | CL228 | CBS-SS | 6 | 1.0 | 0.2 | 132 | 1.5 | 616 | $15,717 | 163 | 0.0 | 63 |
| 77 | CL227 | CBS-SS | 6 | 0.5 | 0.2 | 502 | 1.5 | 569 | $135,000 | 132 | 0.0 | 77 |

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# Appendix A

Basin Maps

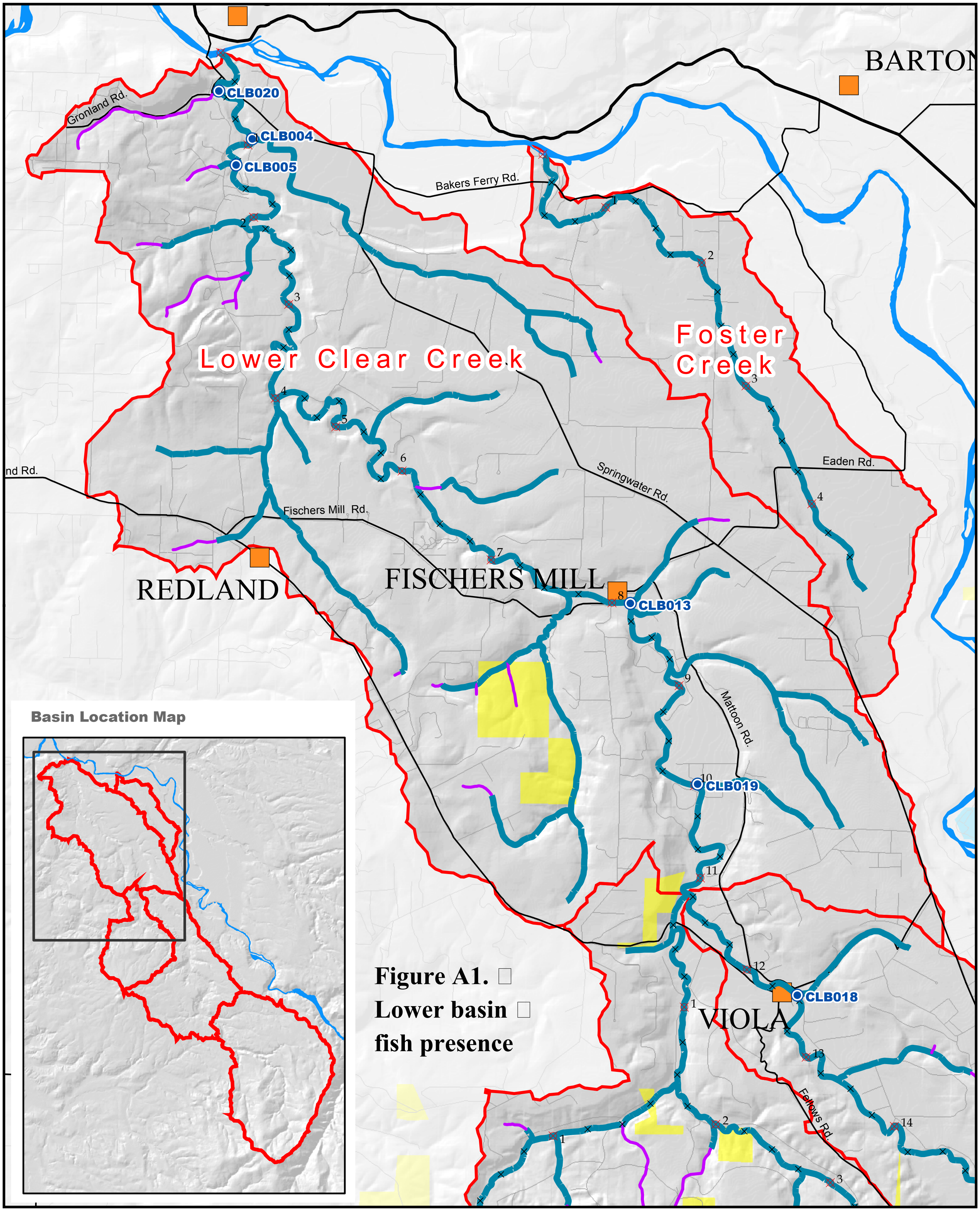



Figure A1. Lower basin fish presence



Clear Creek and Foster Creek Watershed Assessment

Project: Fish Distribution

Spatial Dynamics

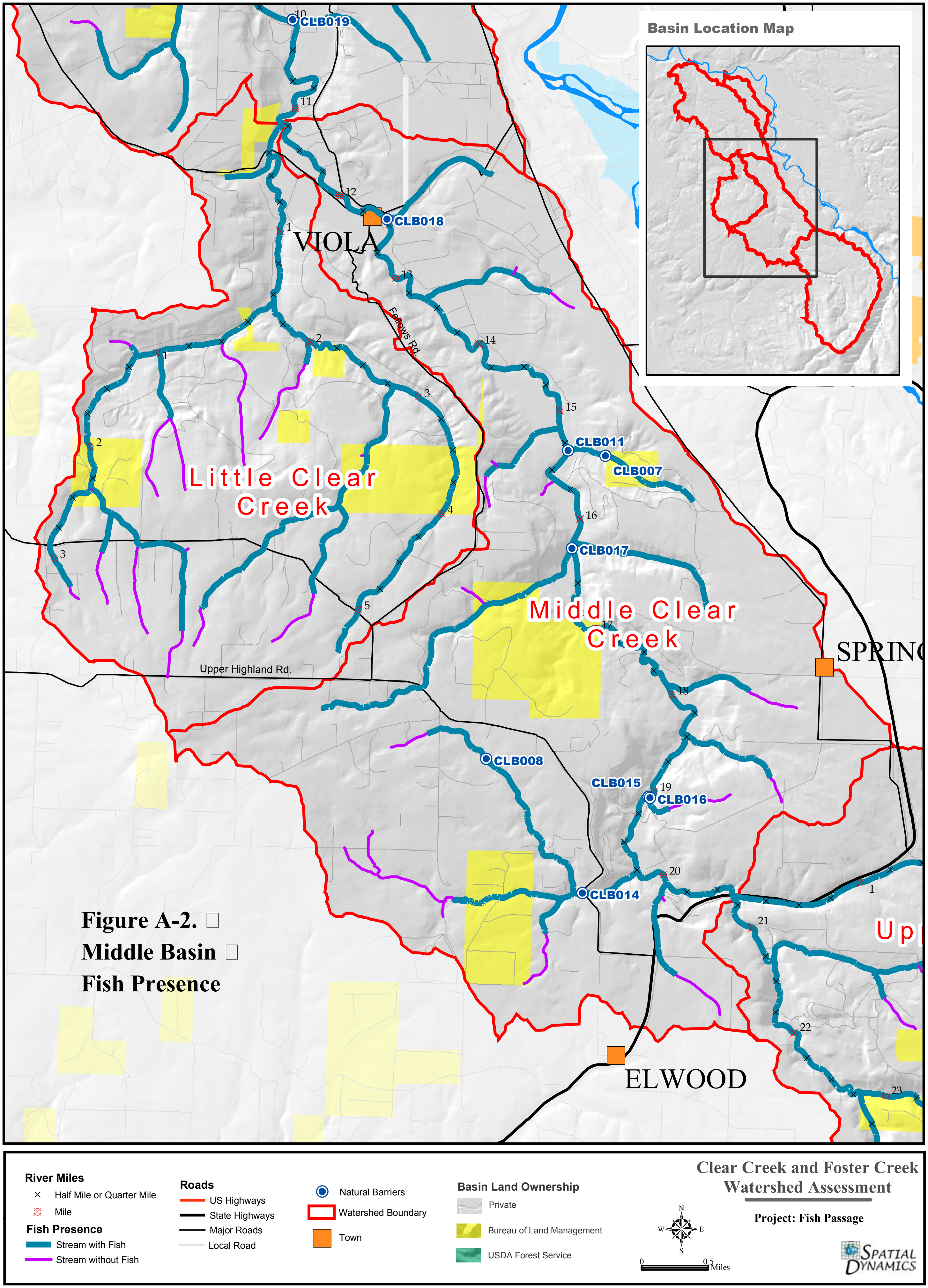
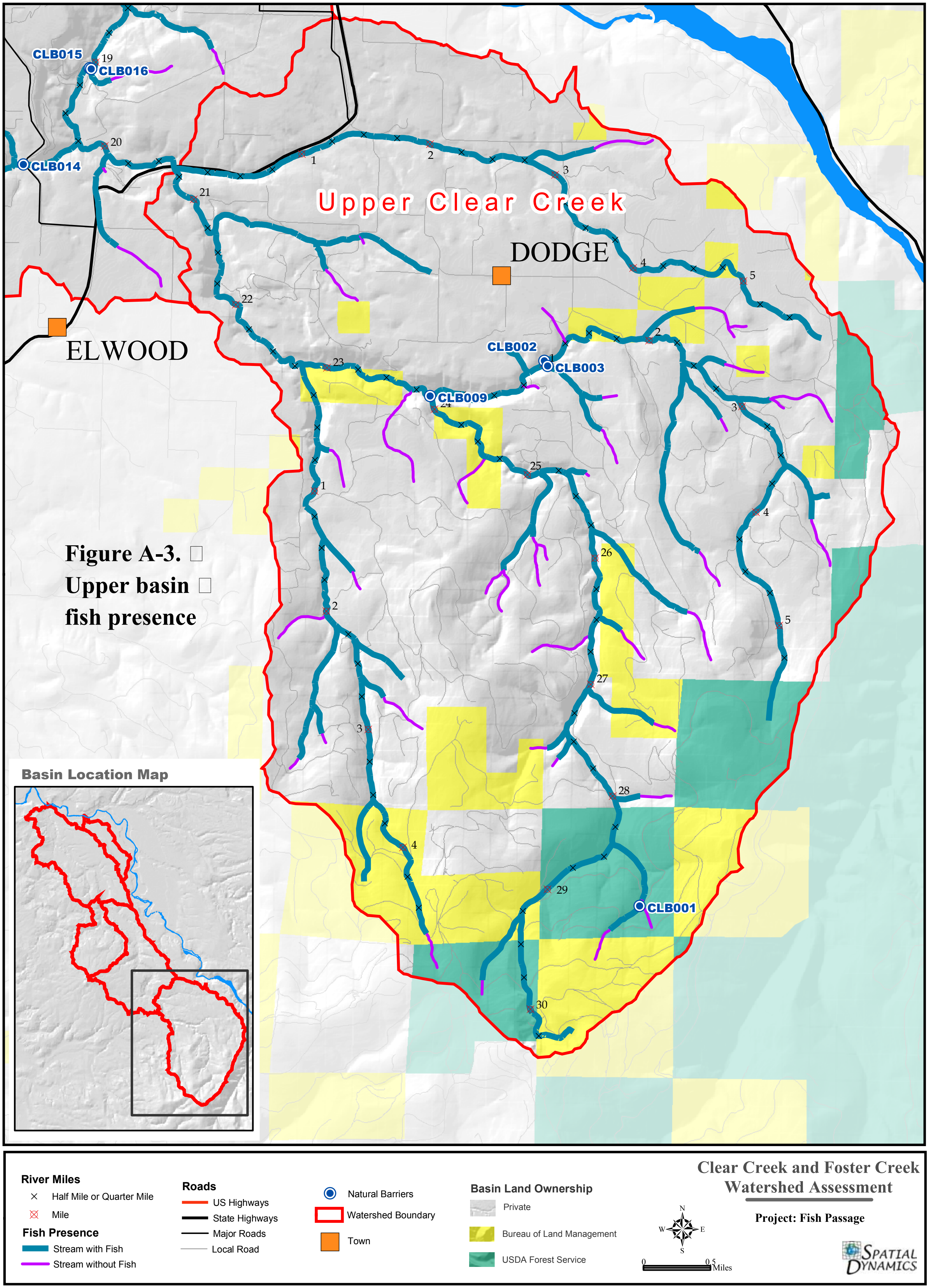



**Figure A-2. Middle Basin Fish Presence**



Upper Clear Creek
DODGE
ELWOOD
CLB015
CLB016
CLB014
CLB002
CLB003
CLB009
CLB001
Figure A-3.
Upper basin
fish presence
Basin Location Map
River Miles
Half Mile or Quarter Mile
Mile
Fish Presence
Stream with Fish
Stream without Fish
Roads
US Highways
State Highways
Major Roads
Local Road
Natural Barriers
Watershed Boundary
Town
Basin Land Ownership
Private
Bureau of Land Management
USDA Forest Service
N
W
E
S
0
0.5
Miles
Clear Creek and Foster Creek
Watershed Assessment
Project: Fish Passage
Spatial Dynamics

# Appendix B: Detailed and Fast Protocols

**Detailed protocol**

The detailed protocol consists of the following measurements. The form and abbreviated code sheet are given in Appendix C.

***Crew Name*** – Name of crew member(s) taking measurements

***Crossing Number*** – A unique number for each crossing surveyed taken from developed base map.

***Stream Name*** – Taken from maps. If no-name creek then state what creek it is tributary to (such as "Trib. to Bear Cr.")

***Road Name/ID*** - 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 unkown it can be named after a landmark (perhaps after a nearby stream, harvest unit, or ranch).

***UTM/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 and if at right location.

***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.

**Structure Information Measures**

| | | |
|---|---|---|
| ***Crossing Type (code):*** | 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 |

See Table B-1 for descriptions regarding these types.

**Culvert Measurements CBS and OBS**
***Structure size*** - Diameter (in) and length (ft) for round culvert,
- Rise and span and length (in, in & ft) for arches,

- Span (ft) for bridge or ford.

***Culvert Elevations****:* Measured with a transit level. Crew will record the elevations at the (a) road surface at mid road, b) inlet invert, (c) outlet invert, (d) low point of a downstream pool and (d) the crest of a downstream riffle or weir (Figure 1). By dividing elevation difference between inlet and outlet by culvert length the culvert slope can be determined as a check of the quality of the measures. The riffle or weir/riffle crest should be within 2-4 channel widths of the culvert outlet in distance. For a description of culvert characteristics see Figure 2.

The amount of outlet drop is the difference in elevation between the downstream weir crest and the invert elevation at the outlet. Backwater and culvert depth calculations can be done with these elevations as well. Where the culvert inlet is beveled, care must be taken 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 elevation and the average elevation of the culvert inlet and outlet represents the fill height. All these parameters can be calculated on a spreadsheet.

***Culvert condition:*** will be described as:

GD good,
MD mechanical damage,
RS rusted, bottom out,
CL collapsed or
OT other (specify).

***Footing condition*****:** for open-bottom structures **(OBS)** will be described as

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

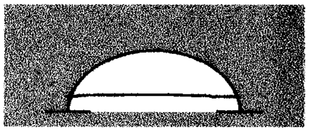
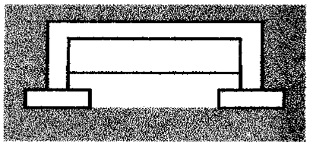
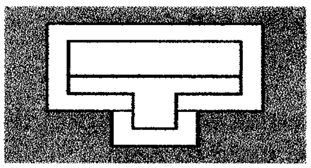
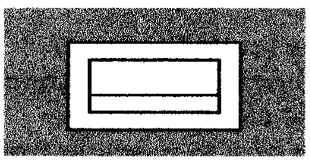
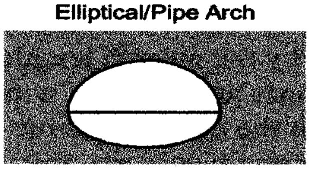
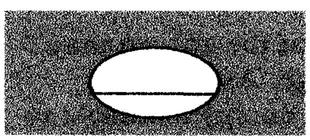
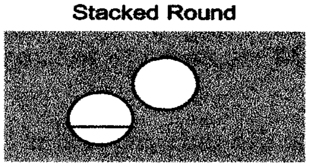
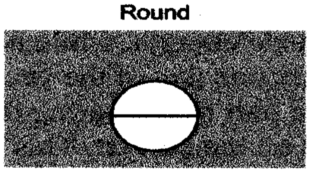
**Downstream Weirs**

***Downstream weir type***

| | |
|---|---|
| GW | Gabion weirs |
| RW | Rock weirs |
| WD | Woody debris |
| WR | Wood and rock |
| NO | None |
| OT | Other, explain |

Note: Mitigation structures are installed downstream of culverts to back water into the culverts or to retain sediment. If there is water backing at least into the outlet of the weir a channel cross-section should be taken of the downstream riffle or weir similar to that done for bridges below. In fact the length and depth measurements for bridges form can be used for this with proper notation for what it is for in making comments on the form.

Table B-1. Culvert types (taken without modification from Parker, 2000)

| Type of culvert | Fisheries considerations | Hydraulic considerations |
|---|---|---|
| Open Bottom Arch  | • If properly designed and installed it does not limit fish passage.<br>• Retains natural stream substrate.<br>• Water velocity not significantly changed. | • Wide bottom enables passage of high flows while minimizing increases in flow depth.<br>• Large waterway opening for low clearance installations. |
| Open Bottom Box  | • If properly designed and installed it does not limit fish passage.<br>• Retains natural stream substrate.<br>• Water velocity not significantly changed. | • Can be designed to maintain normal width of the stream channel. |
| Trough Box  | • Can be designed to provide fish passage.<br>• Trough concentrates water maintaining fish passage even at low flows.<br>• Baffles can easily be installed. | • Can be designed to maintain normal width of the stream channel.<br>• Trough can fill with bed load material and create a maintenance problem. |
| Box  | • Acceptable for use with approved design in stream channel.<br>• Limits fish passage during low flow due to decreased flow depths.<br>• Baffles can easily be installed. | • Can be designed to maintain normal width of fish-bearing streams. |
| Elliptical/Pipe Arch  | • Acceptable for use with approved design in fish-bearing streams.<br>• Can be designed to retain some stream substrate.<br>• Wide flat profile makes it possible to improve fish passage by backwatering the structure. | • Wide bottom of culvert enables passage of high flows while minimizing increases in flow depth.<br>• Large waterway opening for a low clearance installation. |
| Oval  | • Avoid use in fish-bearing streams or incorporate appropriate design modifications.<br>• Represents a compromise between pipe arch and round.<br>• Stream substrate not easily retained in culvert. | • Squat profile useful in low fill situations.<br>• Shape results in deeper water depth than pipe arch, but does not offer as broad a bottom area. |
| Stacked Round  | • Allows for fish passage during a wider range of flows than a single culvert. | • Same hydraulic properties as type of single culvert used (e.g., round, box). |
| Round  | • Avoid use where fish passage is important.<br>• Incorporate approved design modifications to permit fish passage.<br>• High velocity and other hydraulic properties greatly discourage fish passage.<br>• Baffles are difficult to install. | • Generally constricts stream width and creates high flow velocities with increased chance of scour.<br>• Concentrates water during low flows. |

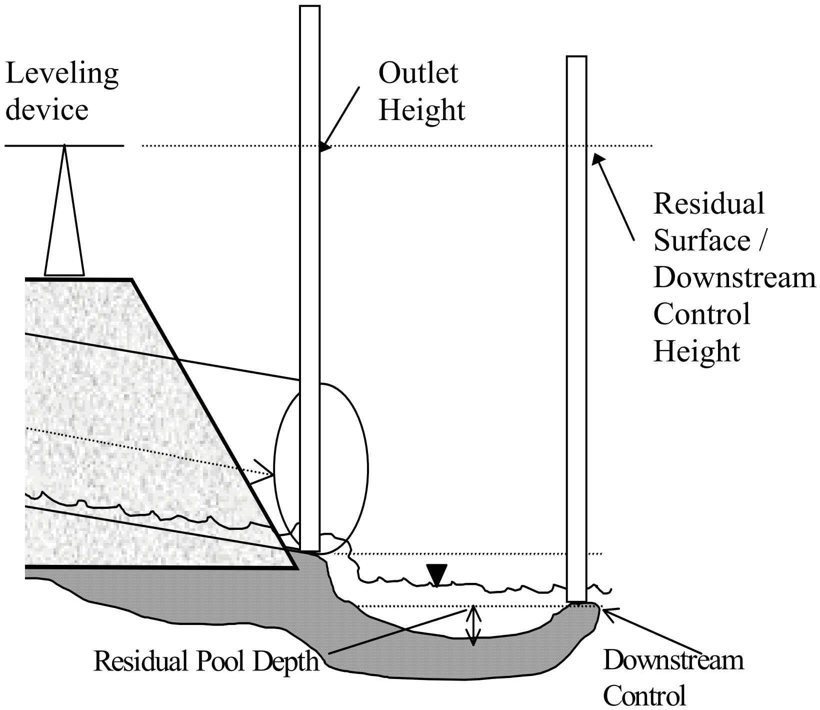
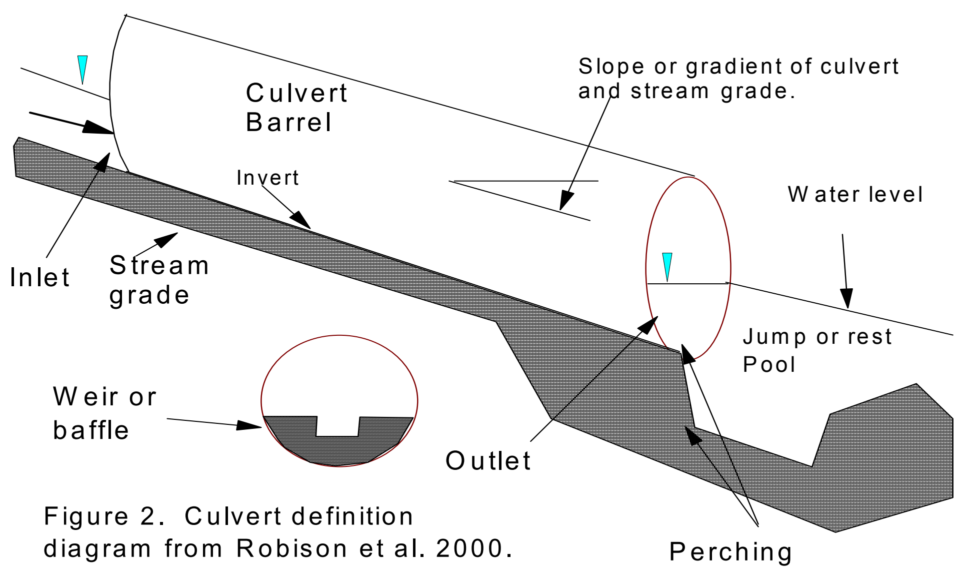



Figure B-1. Residual pool schematic using downstream weir height (Robison et al., 2000)



***Weir Condition:***

| | |
|---|---|
| ST | Stable |
| BE | Bank erosion around structure |
| UC | Actively undercutting structure |
| SD | Sediment deposition behind structures has filled to elevation of outlet |
| OT | Other (explain) |

***Weir Dewatering*****:** Yes or No (Y/N) is the weir dry on its crest at time of measure.

***Backwatering (ft):*** Length of backwatering within the pipe due to outlet mitigation at the time of measurement. This is used as a check against the relative elevation measures taken above. If you show a relative elevation of a downstream weir as greater than that of the inlet elevation of the culvert and the culvert has no backwatering even when water is flowing, there is something wrong with the elevation measurements.

***Weir drop (in):*** Measured from the residual water surface of the structure to the residual water surface below the structure. If more than one structure (multiple weirs) there will be a measure between each structure.

***Distance between outlet mitigation and crossing (ft):*** Measured from the outlet to the mitigation structure. If there are multiple structures crew will document average distance between them and their number.

**Embedded or Streambed Simulation Designs**

***Sediment pattern (code):*** For natural-bed or countersunk structure designs give 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 document the predominant size of material (listed in Table 2) for the length of the crossing. There may be more than one but no more than three. 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.

***Depth of embedding at outlet (in):*** Measure the difference in elevation between the average surface of the embedded streambed and the invert within the first 0-10 feet from the culvert outlet. When the culvert is deeply embedded you can measure/determine diameter or rise of culvert and then measure opening height and subtract to get the embedding depth.

***Depth of embedding culvert barrel (in):*** Measure the difference in elevation between the average surface of the embedded streambed and the invert of the culvert in the interior of the culvert beyond the inlet area and outlet area.

***Depth of embedding culvert inlet (in):*** Measure the average difference in elevation between the average surface of the embedded streambed and the invert of the culvert within the first 0-3 meters distance of the culvert inlet.

Table B-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 |

**Inlet Measures**

***Inlet opening (%)*****:** As compared to design opening area. Estimate the percent opening left as compared to an undamaged inlet.

***Inlet design (code)*****:**

| | | |
|---|---|---|
| NM | Not mitered. |
| MI | Mitered |
| OT | Other |

***Inlet Drop (Yes/No):*** Note if there is an inlet drop. 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.

**Baffled/embedded culverts:**

***Baffle design:***

| | |
|---|---|
| WB | Weir baffles |
| OF | Offset weir |
| PW | Porior design notch weir (Notch weir angled 45$^{o}$ downstream.) |
| NW | Notch Weir |
| SR | Sediment Rack |
| OW | 1 Outlet Weir only |
| MW | Multiple weirs (downstream from culvert outlet) |
| OT | Other |
| NO | None |

If none is the answer the next measures/estimates can be skipped.

***Distance between baffles/weirs (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.

**Road Fill Measures**

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

**Bridges:**

Please note bridges will not be measured unless serious visual indicators of abnormally narrow span as compared to stream width is encountered causing a potential fish passage problem.

***Bridge Type:***

| | | |
|---|---|---|
| ***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 B-3).

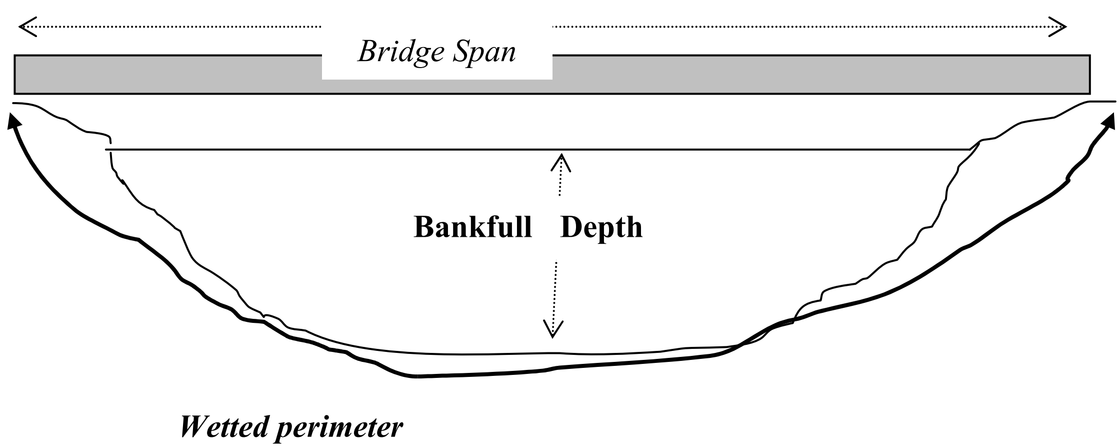



Figure B-3. Schematic of measurements needed for calculating flow capacity of bridge design (from Dent, 1999)

***Opening depth* (ft):** Measured from channel bed to the bottom of the bridge (this measure will be used to calculate wetted perimeter and cross-sectional area) every 15 cm on streams with a wetted width less than 3 m and every 30 cm on streams 3 m and greater.

***Increment (in):*** Record the increment used to measure depth. This will be in equal distances from the left bank. Use increment of 15 cm or 30 cm based on stream width as outlined above.

***Bridge 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)

**Ford/Dam Measures**

Fords will only be measured if they are hardened and creating a noticeable drop of high velocity stretch along their length. Generally speaking these should be rare measurements. Likewise, dam measurements should be rare but are important because of their potential to disrupt fish passage.

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

***Residual Pool Depth (in):*** Measured at the deepest point in the pool downstream of the for or dam when present to the residual water surface (See Figure 1).

***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 B-2. There can be more than one but no more than three.

***Road surface condition*:** Describe the section of road draining into the stream crossing as:

GD Good
RU Rutted
GU Gullied
FL Failing

**Channel and Valley Measures**

***Elevation Profile:*** (Check off on form and put measures in comments or separate sheet) This measure represents the elevation of the streambed taken generally 100 feet upstream and downstream of a culvert. Depending on channel conditions the length of this measurement can be expanded or contracted. If it appears that the inlet is backing up sediment due to bar formation or other evidence of accelerated deposition, the profile will have to 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. To get a profile use a transit level to measure a section upstream from the culvert by taking elevation differences over a channel length. A way of doing this is to establish a "relative base elevation" perhaps on the crown of the road surface 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 6-10 feet. The measurements should be set-up to be plotted on an x-y graph using a spreadsheet and in format look something like this:

| Length | Elevation (ft) | Comment |
|---|---|---|
| 0 | 100.00 | Inlet invert of the culvert |
| -0.1 | 100.20 | Upstream of inlet on channel bed |
| -3.0 | 100.45 | Riffle Crest |
| -4.5 | 100.25 | Bottom of Pool |
| " | " | " Series of measures" |
| -50 | 104.25 | Upstream end of measures |
| 20 | 99.00 | Outlet Invert |
| 21 | 98.1 | Bottom of Downstream pool |
| 23 | 98.9 | Riffle Crest elevation |
| " | " | "Series of Measures" |
| 70 | 96.80 | Downstream end of measures |

The measures can be taken in comments or on separate sheet. The final profile would look something like what is in Figure B-4. The ideal elevation of the invert of the culvert can be determined by looking at the minimum bed elevations and plotting a line as done in Figure B-4.

In taking elevational measurements it will be important to get the elevation of the inlet and outlet along with the elevation of the downstream and upstream side of the road surface to estimate fill height. Another important measurement for some crossings will be to take a measurement of the road centerline elevation at the culvert crossing and take a measurement 30-40 feet in each direction along the road centerline profile to get an indication of the curvature of the road into the crossing. This will indicate if the road can be lowered at all or can be raised up to provide more headroom if needed. These measurements should be taken along with streambed profile measurements described above.

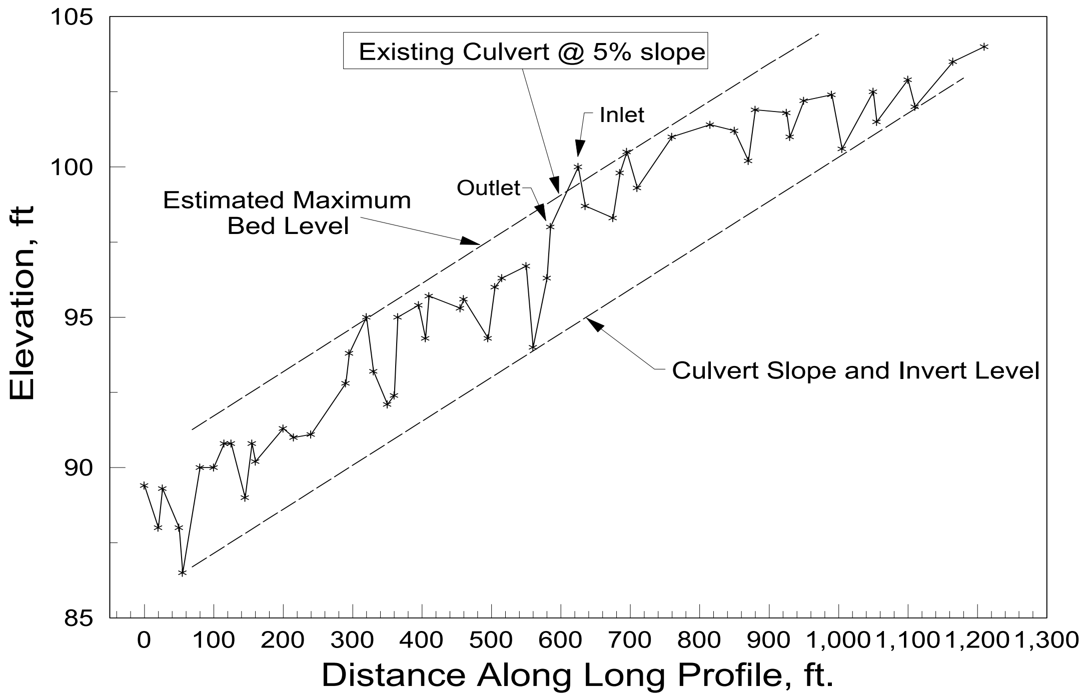



Figure B-4. Culvert elevation profile (from Reba, 2002)

***Channel Substrate:*** Upstream of the influence of the culvert inlet, characterize the size of the channel substrate using the codes described in Table B-2. Put down the most predominate size followed by other sizes.

***Bankfull flow width (ft)*****:** Measured at the average annual high water mark upstream from the influence of the culvert inlet. See lectures on how to measure this. This is measured at 10 points along the stream at distance of one channel width apart.

***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)

**Overflow Dip Measures**

***Overflow dip****:* May be used on roads built on wide flood plains or in other situations (Figure B-5) (use NA if not present). Using a transit level the crew will measure the elevation of the structure, the lowest elevation of the dip, and the elevation of the lowest point controlling the capacity of the overflow dip. The width of the overflow dip is measured from the height of the lowest point controlling the overflow dip capacity to the opposite side of the dip.

***Overflow dip road surface armor (code):*** Using the codes in Table 3, 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 size:*** Using the codes in Table 3, 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 codes). 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 |

***Dip width (ft)*:** Measured from the height of the lowest point controlling the overflow dip capacity to the opposite side of the dip.

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

***Dip low point (ft):*** Lowest point elevation in the overflow dip relative to the crossing structure as measured with the level.

***Dip control point (ft):*** Lowest point elevation of the two upper boundaries of the overflow dip controlling the capacity of the overflow dip.

***Overflow maximum depth (ft):*** The difference between the height of the culvert bottom and the height of the bottom of the overflow dip.

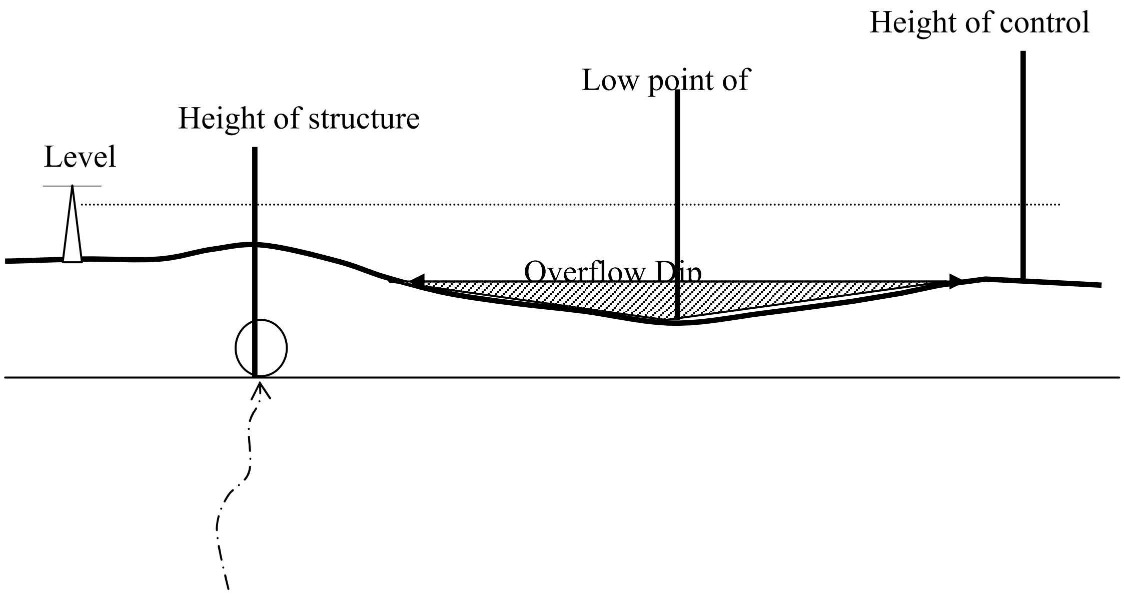



Figure B-5 – Over flow dip schematic (adapted from Dent, 1999)

**Fast Protocol Field Methods**

**General information taken for each Culvert Crossing**

***Crew Name*** – Name of crew member(s) taking measurements

***Crossing Number*** – A unique number for each crossing surveyed taken from developed base map.

***Stream Name*** – Taken from maps if no-name creek then state what creek it is tributary to (such as "Trib. to Bear Cr.")

***Road Name/ID*** - 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 unkown it can be named after a landmark (perhaps after a nearby stream, harvest unit, or ranch).

***UTM/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 and if at right location.

***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

| | | |
|---|---|---|
| ***Crossing Type (code):*** | 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 |

See Table B-1 for descriptions regarding these types.

**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 ruler or meter stick from the invert of the culvert to the residual water surface. See Figure 2 for information on residual pool concepts. This measurement is for CBS only.

***Culvert Gradient (%)*****:** Looking upstream in the culvert with an abney level or clinometer measure the slope of the culvert by sighting on a common spot in the culvert such as bolt line or the top of the culvert upstream.

***Culvert Dimenisions*****:** For round Diameter (in) measure with tape or meter stick and length (ft) visually estimate. For other shapes span (in), rise (in) measured and then culvert length visually estimated.

***Culvert Condition*****:** New – Bright galvanized steel
Aged – Brightness worn away
Old – Rusting and thinning of culvert
Det – Holes in culvert severe rusting

If the culvert is CBS and drop is greater than 2 feet or the culvert slope is greater than 3% with no substrate embedding the culvert **then cease measurements** – The culvert will not likely pass adult fish and will not pass juvenile fish. This will probably constitute the majority of CBS culverts installed previous to 1994. If a culvert has 3% gradient and significant backwatering into it from a downstream weir (i.e., all the way to near the inlet) then continue measurements. If the backwatering is just into the outlet then cease.

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

***Footing condition*****:** For open-bottom structures **(OBS)** will be described as

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

**For both OBS and CBS take the following:**

| | | |
|---|---|---|
| *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) |

If there is a weir downstream or a riffle backing water into the culvert take the following measurements.

***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 estimated length of the culvert as the degree of backwatering.

***Outlet mitigation drop (in):*** Estimated from the residual water surface of the structure to the residual water surface below the structure. If more than one structure (multiple weirs) there will be a measure between each structure.

***Distance between outlet mitigation and crossing (ft):*** Measured from the outlet to the mitigation structure, if there are multiple structures crew will document average distance between them and their number.

***Bankfull width*:** Estimated on the outlet side

**Step 2 – Barrel Measurements Inside Culverts**

**Embedded Culverts:**
***Sediment pattern (code):*** For natural-bed or embedded structure designs give 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 |

***Sediment size inside culvert (code):*** From codes in Table B-2. Can circle up to three. Double circle the predominant type.

**Baffled/embedded culverts:**

| | | |
|---|---|---|
| ***Baffle design:*** | WB | Weir baffles |
| | OF | Offset weir |
| | PW | Porior 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 none is the answer the next estimates can be skipped.

***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.

**Step 3 Inlet Measurements on upstream side of culvert**

***Inlet Drop (Yes/No):*** Note if there is an inlet drop. 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.

***Bankfull width:*** Estimated on the inlet side use tape and take a couple of measures.

**Measures for Bridges and Fords with Fast Protocol**

**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 2).

***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) |

***Bankfull width (ft):*** See advanced on how to measure take in at least three spots and average.

**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.

***Jump (in):*** Measured from outlet to residual water surface.

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

***Residual Pool Depth (in)*****:** Measured at the deepest part of the pool downstream of the crossing when present to the residual water surface.

***Material Type:*** **Rock, Other (explain)**

***Material Size used for the ford upstream, at the crossing and downstream of the crossing (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.

***Ford or dam top surface condition*****:** Describe the section of road draining into the stream crossing or dam as:

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

# Appendix C: Field Forms

Detailed measurements field form

Crew Name ______________________ Date____________Crossing Number _________________

Stream Name________________________________Road Name __________________________

UTM/GPS______________________________Photos Outlet__ Barrel__ Inlet__

Crossing Type (Circle) RC PA OA BR FD OB LG BX OT ____________________________

Structure Size Dia. (in)______ Span (in)_____ Rise (in)______ Length (ft) _______ Road width (ft)____

**Culvert** Elev. a – Road (ft)____ b – Inlet (ft)_____ c – Outlet (ft) ____ d – Pool (ft) ___ e – Weir _____

Culvert Condition (Circle) GD MD RS CL OT ________________________________________

Footing Condition for OBS (Circle) ST ER FL OT ______________________________________

Downstream Weir type (circle): GW RW WD WR NO OT ___________________________

Weir Condition (circle): ST BE UC SD OT ______________________ Weir De-water (circle) Y / N

Backwatering (ft) __________ Weir Drop (in) _________ Dist Cross-Weir (ft) ________

Embedding in Culvert (circle): SS CR IN SR NM NA

Bed material size in culvert (circle): BD BL CB GR FN NO NA

Embed depth Outlet (in)________ Barrel (in)_______ Inlet (in) _______

Inlet Opening % _________ Inlet Design (circle) NM MI OT___________ Inlet Drop (circle): Y / N

Baffle Design (circle): WB OF PW NW MW SR OW NO OT __________________________

Dist. between baffles(ft) _____ Dist. last baffle(ft) ______ Baffle Hgt.(in) ______ Notch Dep.(in)_____

Road fill armor code (circle): BD BL CB GR FN NO NA

**Bridge** Type (circle): LS RR MI CC OT___________________________ Bridge Span (ft) ______

Bridge Open Dep (ft) ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ Increment (in) _____

Bridge Footing Condition (circle): ST ER FL

**Ford/Dam** (F/D) Jump (in)_____ Residual Pool Dep. (in) _______ Circle ford or dam

**F/D** bed mat.(circle):Upstream: BD BL CB GR FN NO NA On F/D: BD BL CB GR FN NO NA

D.S. of F/D: BD BL CB GR FN NO NA F/D Road Surface Condition (circle): GD RU GU

Detailed **Monitoring Protocol Field Form Page 2 Channel and Dip Measures**

**Elevation Profile**__ (use comments) Bankfull Wid. (ft) ____ (1) ____ (2) ____ (3) ____ (4) ____ (5) ____ (6) ____ (7) ____ (8) ___ (9) ____ (10)

Stream Substrate (circle): BD BL CB GR FN NO NA Stream Valley Fill Code(circle): NF SF DF

Valley Type (circle): NV WV

**Overflow Dip**(circle): Y / N

Overflow Dip road surface armor size (circle): BD BL CB GR FN NO NA

Overflow Dip road fill armor size downstream side (circle): BD BL CB GR FN NO NA

Overflow Dip road surface condition: ST ER FL

Overflow Dip road fill condition: ST ER FL

Dip Width (ft): _____ Dist. dip to structure (ft):______ Dip low point (ft): ______ Dip control point (ft) ____

Overflow depth (ft) ___________

## Comments about Crossing:

**Fast Monitoring Protocol Field Form Culvert – Ford/Dam – Bridge Measures**

Crew Name ________________________ Date_____________Crossing Number ___________________

Stream Name___________________________________Road Name ____________________________

UTM/GPS_________________________________Photos Outlet__ Barrel__ Inlet__

*Crossing Type (Circle)*: RC PA OA BR FD OB LG BX OT ______________________________

*Outlet Drop (in):*_________ *Culvert Gradient (%)*________*Stream Gradient Outlet Side (%)*_________

**Culvert Dimensions:**
*Structure Size Dia. (in)*_______ *Span (in)*______ *Rise (in)*_______ *Length (ft)* ___________

*Culvert Condition* – Culvert Condition (Circle): New Aged Old Det.

Footing Condition for OBS (Circle) ST ER FL OT ___________________________________________

Downstream Weir type (circle): GW RW WD WR NO OT ______________________________

Backwatering (ft) ____ Outlet Mitigation Drop (in) _____ Dist Cross-Weir (ft) ______ B.F. Width (ft) _____

Sediment pattern in culvert (circle): SS CR IN SR NM NA

Sediment Size in culvert(circle): BD BL CB GR FN NO NA

Baffle Design (circle): WB OF PW NW MW SR OW NO OT ____________________________

Dist. between baffles(ft) ______ Dist. last baffle(ft) _______ Baffle Hgt.(in) _______ Notch Dep.(in)______

Inlet Drop (circle): Y / N Stream bankfull width (ft) ___________*Stream Gradient inlet side (%)*_______

**Bridge** Type (circle): LS RR MI CC OT________________________ Bridge Span (ft) _______

Bridge Footing Condition (circle): ST ER FL Bankfull Width _______ ________ _______

**Ford/Dam** Jump (in)______ Residual Pool Dep. (in) ________ (Circle dam or ford)

F/D bed mat.(circle):Upstream: BD BL CB GR FN NO NA On F/D: BD BL CB GR FN NO NA

D.S. of F/D: BD BL CB GR FN NO NA Road Surface into F/D Condition (circle): GD RU GU FL

Comments about Crossing:

## Appendix C cont. Code Sheet for Forms:

### *Crossing Type (circle):*

**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:
**GD** good,
**MD** mechanical damage,
**RS** rusted, bottom out,
**CL** collapsed or
**OT** other (specify).

***Footing condition*: (OBS Only)**
**ST** Stable (no scour near edges)
**ER** Eroding (scour near edges but OBS not cantering or deforming)
**FL** Failing (scour plus deformation)

***Downstream weir type***
**GW** Gabion weirs
RW Rock weirs
**WD** Woody debris
**WR** Wood and rock
**NO** None
**OT** Other, explain

### *Weir Condition:*

**ST** Stable
**BE** Bank erosion around structure
**UC** Actively undercutting structure
**SD** Sediment deposition behind structures has filled to elevation of outlet
**OT** Other (explain)

***Sediment pattern (code):* (Embedding in Culvert)**
**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 (Table 2) (Also Road surface, stream substrate)**
**BD** Bedrock; Bigger than a car/continuous layer (>12 ft)
**BL** Boulders; Basketball to car-sized (1-12 ft)
**CB** Cobble; Tennis ball to basketball (3 in – 1 foot)
**GR** Gravel; Ladybug to tennis ball (.1 in – 3 in)
**FN** Fines; Silt/clay muck to visible particle; gritty - sand
**NO** ---; None
**NA** ---; Not applicable

***Baffle design:***
**WB** Weir baffles
**OF** Offset weir
**PW** Porior design notch weir (Notch weir angled 45$^{o}$ downstream.)
**NW** Notch Weir
**SR** Sediment Rack
**OW** 1 Outlet Weir only
**MW** Multiple weirs (downstream from culvert outlet)
**OT** Other
**NO** None

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

***Bridge Footing condition*:**
**ST** Stable (no scour near edges)
**ER** Eroding (scour near edges but OBS not cantering or deforming)
**FL** Failing (scour plus deformation)

***Road surface condition*:**
**GD** Good
**RU** Rutted
**GU** Gullied
**FL** Failing

***Stream/valley fill (code)*:**
**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)

***Overflow dip road surface condition*:**
**ST** Stable
**ER** Eroding
**FL** Failing

# Appendix D – Listing of all culverts

*Notes: 1. Fish? 0 = No fish; 1 = Fish; 2. Fish Passage U = Undetermined, N = No passage; P = Partial Passage; and Y = Complete Fish Passage; 3. ODF Stream is a classed as a stream on available GIS coverage; 4. US Len is estimated length of stream channel upstream from crossing.*

| | X_ID | Sub watershed name | ODF Str?[3] | Fish?[1] | Pass-able?[2] | WS Area (acres) | US Len (ft) | US Fish Len (ft) |
|---|---|---|---|---|---|---|---|---|
| 1 | CL001 | Upper Clear Creek | TRUE | 1 | U | 78 | 2428 | 2428 |
| 2 | CL002 | Upper Clear Creek | TRUE | 1 | U | 110 | 3809 | 3809 |
| 3 | CL003 | Upper Clear Creek | TRUE | 1 | N | 212 | 6140 | 6140 |
| 4 | CL004 | Upper Clear Creek | TRUE | 1 | U | 112 | 1743 | 390 |
| 5 | CL006 | Upper Clear Creek | TRUE | 1 | N | 215 | 3045 | 1692 |
| 6 | CL007 | Upper Clear Creek | TRUE | 1 | N | 499 | 11321 | 10765 |
| 7 | CL008 | Upper Clear Creek | TRUE | 1 | U | 55 | 990 | 990 |
| 8 | CL009 | Upper Clear Creek | TRUE | 1 | Y | 1826 | 26373 | 22052 |
| 9 | CL010 | Upper Clear Creek | TRUE | 1 | Y | 795 | 12914 | 11459 |
| 10 | CL011 | Upper Clear Creek | TRUE | 1 | U | 131 | 1549 | 639 |
| 11 | CL013 | Upper Clear Creek | TRUE | 1 | Y | 2796 | 34239 | 28892 |
| 12 | CL016 | Upper Clear Creek | TRUE | 1 | N | 1407 | 23981 | 20470 |
| 13 | CL018 | Upper Clear Creek | TRUE | 1 | U | 136 | 2523 | 266 |
| 14 | CL019 | Upper Clear Creek | TRUE | 1 | U | 247 | 4526 | 2269 |
| 15 | CL020 | Upper Clear Creek | FALSE | 1 | U | | | |
| 16 | CL021 | Upper Clear Creek | TRUE | 1 | Y | 763 | 10500 | 10500 |
| 17 | CL022 | Upper Clear Creek | TRUE | 1 | Y | 2403 | 42464 | 34967 |
| 18 | CL023 | Upper Clear Creek | TRUE | 1 | Y | 328 | 6364 | 4776 |
| 19 | CL024 | Upper Clear Creek | TRUE | 1 | Y | 1189 | 16949 | 14943 |
| 20 | CL025 | Upper Clear Creek | TRUE | 1 | Y | 1297 | 20014 | 18007 |
| 21 | CL026 | Upper Clear Creek | TRUE | 1 | Y | 376 | 4928 | 1236 |
| 22 | CL027 | Upper Clear Creek | TRUE | 1 | Y | 74 | 1918 | 434 |
| 23 | CL028 | Upper Clear Creek | TRUE | 1 | Y | 39 | 1006 | 451 |
| 24 | CL029 | Upper Clear Creek | TRUE | 1 | Y | 2733 | 52423 | 40113 |
| 25 | CL030 | Upper Clear Creek | TRUE | 1 | N | 145 | 3976 | 1023 |
| 26 | CL031 | Upper Clear Creek | TRUE | 1 | Y | 423 | 6438 | 6438 |
| 27 | CL032 | Upper Clear Creek | TRUE | 1 | Y | 309 | 2472 | 674 |
| 28 | CL033 | Upper Clear Creek | TRUE | 1 | Y | 288 | 1897 | 99 |
| 29 | CL034 | Upper Clear Creek | TRUE | 1 | Y | 341 | 3683 | 3383 |
| 30 | CL035 | Middle Clear Creek | TRUE | 1 | P | 2 | 0 | 0 |
| 31 | CL035A | Middle Clear Creek | TRUE | 1 | P | 74 | 0 | 0 |
| 32 | CL036 | Upper Clear Creek | TRUE | 1 | N | 839 | 9614 | 7516 |
| 33 | CL038 | Upper Clear Creek | TRUE | 1 | N | 820 | 12678 | 12678 |
| 34 | CL039 | Middle Clear Creek | FALSE | 0 | U | 0 | 0 | 0 |
| 35 | CL039A | Middle Clear Creek | FALSE | 0 | U | 0 | 0 | 0 |
| 36 | CL040 | Middle Clear Creek | TRUE | 1 | U | 771 | 10345 | 2352 |
| 37 | CL041 | Middle Clear Creek | TRUE | 1 | U | 2574 | 29798 | 17629 |
| 38 | CL042 | Middle Clear Creek | TRUE | 1 | P | 2556 | 29290 | 17120 |

# Appendix D – Listing of all culverts (continued)

*Notes: 1. Fish? 0 = No fish; 1 = Fish; 2. Fish Passage U = Undetermined, N = No passage; P = Partial Passage; and Y = Complete Fish Passage; 3. ODF Stream is a classed as a stream on available GIS coverage; 4. US Len is estimated length of stream channel upstream from crossing.*

| | X_ID | Sub watershed name | ODF Str?[3] | Fish?[1] | Pass-able?[2] | WS Area (acres) | US Len (ft) | US Fish Len (ft) |
|---|---|---|---|---|---|---|---|---|
| 39 | CL043 | Middle Clear Creek | TRUE | 1 | Y | 17318 | 275872 | 219486 |
| 40 | CL044 | Upper Clear Creek | TRUE | 1 | U | 1448 | 21838 | 19457 |
| 41 | CL045 | Upper Clear Creek | TRUE | 1 | P | 365 | 3839 | 1457 |
| 42 | CL046 | Upper Clear Creek | TRUE | 1 | P | 2431 | 27930 | 25549 |
| 43 | CL046A | Upper Clear Creek | FALSE | 1 | Y | 137 | 0 | 0 |
| 44 | CL046B | Upper Clear Creek | TRUE | 1 | P | 2428 | 27822 | 25440 |
| 45 | CL047 | Middle Clear Creek | TRUE | 1 | P | 1045 | 8956 | 7383 |
| 46 | CL048 | Middle Clear Creek | TRUE | 1 | Y | 20951 | 322054 | 250851 |
| 47 | CL049 | Middle Clear Creek | TRUE | 0 | U | 21240 | 326892 | 253114 |
| 48 | CL051 | Middle Clear Creek | TRUE | 1 | N | 329 | 3000 | 3000 |
| 49 | CL052 | Middle Clear Creek | TRUE | 1 | P | 0 | 4514 | 4514 |
| 50 | CL053 | Middle Clear Creek | TRUE | 1 | Y | 22623 | 345827 | 268906 |
| 51 | CL053A | Middle Clear Creek | TRUE | 1 | P | 337 | 4872 | 2830 |
| 52 | CL053B | Middle Clear Creek | TRUE | 1 | Y | 452 | 4953 | 3853 |
| 53 | CL054 | Little Clear Creek | TRUE | 1 | U | 257 | 1951 | 1951 |
| 54 | CL055 | Middle Clear Creek | TRUE | 1 | Y | 0 | 12885 | 11683 |
| 55 | CL056 | Little Clear Creek | TRUE | 0 | U | 184 | 1357 | 719 |
| 56 | CL057 | Little Clear Creek | TRUE | 1 | P | 147 | 3585 | 875 |
| 57 | CL058 | Little Clear Creek | TRUE | 1 | Y | 225 | 6017 | 3757 |
| 58 | CL058A | Little Clear Creek | FALSE | 0 | N | 0 | 0 | 0 |
| 59 | CL058B | Little Clear Creek | TRUE | 1 | P | 229 | 6052 | 3792 |
| 60 | CL059 | Little Clear Creek | TRUE | 1 | Y | 264 | 6785 | 4525 |
| 61 | CL060 | Little Clear Creek | TRUE | 1 | N | 231 | 2573 | 1936 |
| 62 | CL061 | Little Clear Creek | TRUE | 1 | U | 384 | 5195 | 5195 |
| 63 | CL062 | Little Clear Creek | TRUE | 1 | Y | 427 | 11194 | 5319 |
| 64 | CL063 | Little Clear Creek | TRUE | 1 | Y | 424 | 11062 | 5188 |
| 65 | CL064 | Little Clear Creek | TRUE | 1 | P | 219 | 5293 | 3706 |
| 66 | CL065 | Little Clear Creek | TRUE | 1 | P | 238 | 6034 | 4447 |
| 67 | CL065A | Little Clear Creek | FALSE | 0 | U | 125 | 0 | 0 |
| 68 | CL066 | Little Clear Creek | TRUE | 1 | P | 125 | 2748 | 668 |
| 69 | CL067 | Little Clear Creek | TRUE | 1 | N | 334 | 5422 | 4785 |
| 70 | CL068 | Little Clear Creek | TRUE | 1 | N | 645 | 17538 | 9584 |
| 71 | CL069 | Middle Clear Creek | TRUE | 0 | U | 512 | 4686 | 4686 |
| 72 | CL069A | Middle Clear Creek | TRUE | 1 | P | 25089 | 377463 | 299340 |
| 73 | CL069B | Middle Clear Creek | TRUE | 0 | U | 27 | 682 | 0 |
| 74 | CL069C | Middle Clear Creek | TRUE | 1 | N | 510 | 6791 | 6791 |
| 75 | CL069D | Middle Clear Creek | TRUE | 1 | P | 472 | 5438 | 5438 |
| 76 | CL069E | Middle Clear Creek | TRUE | 1 | P | 385 | 3814 | 3814 |
| 77 | CL069F | Middle Clear Creek | TRUE | 1 | N | 292 | 2394 | 2394 |

# Appendix D – Listing of all culverts (continued)

*Notes: 1. Fish? 0 = No fish; 1 = Fish; 2. Fish Passage U = Undetermined, N = No passage; P = Partial Passage; and Y = Complete Fish Passage; 3. ODF Stream is a classed as a stream on available GIS coverage; 4. US Len is estimated length of stream channel upstream from crossing.*

| | X_ID | Sub watershed name | ODF Str?[3] | Fish?[1] | Pass-able?[2] | WS Area (acres) | US Len (ft) | US Fish Len (ft) |
|---|---|---|---|---|---|---|---|---|
| 78 | CL069G | Middle Clear Creek | TRUE | 1 | N | 275 | 2041 | 2041 |
| 79 | CL070 | Little Clear Creek | TRUE | 1 | Y | 775 | 10775 | 10775 |
| 80 | CL071 | Little Clear Creek | TRUE | 1 | Y | 208 | 7913 | 1569 |
| 81 | CL072 | Little Clear Creek | TRUE | 0 | N | 82 | 1214 | 360 |
| 82 | CL073 | Little Clear Creek | TRUE | 1 | Y | 1808 | 43007 | 27169 |
| 83 | CL075 | Little Clear Creek | TRUE | 1 | Y | 2410 | 39500 | 34986 |
| 84 | CL076 | Little Clear Creek | TRUE | 1 | Y | 2873 | 46468 | 38221 |
| 85 | CL077 | Unkown (see map) | FALSE | 1 | Y | NA | NA | NA |
| 86 | CL079 | Middle Clear Creek | TRUE | 1 | P | 330 | 5578 | 4212 |
| 87 | CL080 | Little Clear Creek | TRUE | 1 | Y | 5347 | 101642 | 72121 |
| 88 | CL081 | Middle Clear Creek | TRUE | 1 | Y | 27898 | 419027 | 337205 |
| 89 | CL083 | Middle Clear Creek | TRUE | 1 | P | 341 | 4332 | 4332 |
| 90 | CL084 | Middle Clear Creek | TRUE | 1 | N | 27872 | 418747 | 336926 |
| 91 | CL086 | Middle Clear Creek | TRUE | 1 | U | 286 | 3477 | 3477 |
| 92 | CL087 | Middle Clear Creek | TRUE | 1 | N | 143 | 462 | 462 |
| 93 | CL088 | Little Clear Creek | TRUE | 1 | N | 5705 | 107307 | 77786 |
| 94 | CL089 | Lower Clear Creek | TRUE | 1 | P | 132 | 123 | 123 |
| 95 | CL090 | Lower Clear Creek | TRUE | 0 | U | 176 | 2310 | 1087 |
| 96 | CL091 | Lower Clear Creek | TRUE | 1 | Y | 34289 | 537548 | 426206 |
| 97 | CL092 | Lower Clear Creek | TRUE | 1 | Y | 34506 | 539904 | 428561 |
| 98 | CL093 | Lower Clear Creek | TRUE | 1 | Y | 34495 | 539604 | 428261 |
| 99 | CL094 | Lower Clear Creek | TRUE | 1 | U | 252 | 4949 | 4949 |
| 100 | CL095 | Lower Clear Creek | TRUE | 1 | N | 244 | 3392 | 3392 |
| 101 | CL097 | Lower Clear Creek | TRUE | 0 | U | 256 | 817 | 817 |
| 102 | CL099 | Lower Clear Creek | TRUE | 1 | P | 973 | 13898 | 13898 |
| 103 | CL100 | Lower Clear Creek | TRUE | 1 | P | 982 | 14823 | 14823 |
| 104 | CL101 | Lower Clear Creek | TRUE | 1 | P | 980 | 14390 | 14390 |
| 105 | CL102 | Lower Clear Creek | TRUE | 1 | Y | 215 | 3579 | 3340 |
| 106 | CL103 | Lower Clear Creek | TRUE | 1 | Y | 36342 | 567168 | 455825 |
| 107 | CL105 | Lower Clear Creek | TRUE | 1 | Y | 37071 | 580439 | 467930 |
| 108 | CL106 | Lower Clear Creek | TRUE | 1 | P | 1803 | 24662 | 21039 |
| 109 | CL107 | Lower Clear Creek | TRUE | 1 | Y | 1786 | 24269 | 20646 |
| 110 | CL108 | Lower Clear Creek | TRUE | 1 | P | 343 | 3677 | 3677 |
| 111 | CL108A | Lower Clear Creek | TRUE | 1 | N | 363 | 4136 | 4136 |
| 112 | CL109 | Lower Clear Creek | TRUE | 1 | P | 331 | 3075 | 3075 |
| 113 | CL110 | Lower Clear Creek | FALSE | 0 | U | 0 | NA | NA |
| 114 | CL113 | Lower Clear Creek | TRUE | 1 | P | 205 | 2133 | 435 |
| 115 | CL114 | Lower Clear Creek | TRUE | 0 | U | 123 | 1606 | 440 |
| 116 | CL115 | Lower Clear Creek | TRUE | 1 | P | 270 | 3655 | 1956 |

# Appendix D – Listing of all culverts (continued)

*Notes: 1. Fish? 0 = No fish; 1 = Fish; 2. Fish Passage U = Undetermined, N = No passage; P = Partial Passage; and Y = Complete Fish Passage; 3. ODF Stream is a classed as a stream on available GIS coverage; 4. US Len is estimated length of stream channel upstream from crossing.*

| | X_ID | Sub watershed name | ODF Str?[3] | Fish?[1] | Pass-able?[2] | WS Area (acres) | US Len (ft) | US Fish Len (ft) |
|---|---|---|---|---|---|---|---|---|
| 117 | CL116 | Lower Clear Creek | TRUE | 1 | P | 446 | 7949 | 7710 |
| 118 | CL117 | Lower Clear Creek | TRUE | 0 | U | 230 | 724 | 724 |
| 119 | CL118 | Lower Clear Creek | TRUE | 1 | N | 363 | 3277 | 3277 |
| 120 | CL119 | Lower Clear Creek | TRUE | 1 | P | 459 | 4402 | 4402 |
| 121 | CL120 | Lower Clear Creek | TRUE | 1 | P | 171 | 2234 | 1774 |
| 122 | CL121 | Lower Clear Creek | TRUE | 0 | U | 31 | 645 | 645 |
| 123 | CL122 | Lower Clear Creek | TRUE | 1 | N | 429 | 8745 | 8285 |
| 124 | CL123 | Lower Clear Creek | TRUE | 1 | P | 733 | 12417 | 11957 |
| 125 | CL124 | Lower Clear Creek | TRUE | 1 | Y | 219 | 6500 | 937 |
| 126 | CL125 | Lower Clear Creek | TRUE | 1 | P | 211 | 3066 | 2170 |
| 127 | CL126 | Lower Clear Creek | TRUE | 1 | Y | 864 | 14748 | 14288 |
| 128 | CL127 | Lower Clear Creek | TRUE | 1 | Y | 859 | 14621 | 14161 |
| 129 | CL128 | Lower Clear Creek | TRUE | 1 | P | 880 | 15394 | 14934 |
| 130 | CL129 | Lower Clear Creek | TRUE | 1 | U | 102 | 1631 | 274 |
| 131 | CL134 | Lower Clear Creek | TRUE | 1 | U | 1232 | 21363 | 20903 |
| 132 | CL135 | Lower Clear Creek | TRUE | 0 | U | 221 | 3838 | 2607 |
| 133 | CL136 | Lower Clear Creek | TRUE | 0 | U | 178 | 2979 | 1748 |
| 134 | CL137 | Lower Clear Creek | TRUE | 0 | N | 249 | 4993 | 3762 |
| 135 | CL137A | Lower Clear Creek | TRUE | 0 | Y | 403 | 6068 | 4178 |
| 136 | CL138 | Lower Clear Creek | TRUE | 1 | Y | 46333 | 724206 | 594629 |
| 137 | CL143 | Upper Clear Creek | TRUE | 1 | N | 135 | 3088 | 2533 |
| 138 | CL144 | Upper Clear Creek | TRUE | 1 | U | 1826 | 26373 | 22052 |
| 139 | CL145 | Upper Clear Creek | TRUE | 1 | U | 274 | 4775 | 3319 |
| 140 | CL146 | Upper Clear Creek | TRUE | 1 | Y | 613 | 8572 | 8572 |
| 141 | CL147 | Middle Clear Creek | TRUE | 0 | U | 325 | 2202 | 630 |
| 142 | CL148 | Upper Clear Creek | FALSE | 0 | U | 0 | NA | NA |
| 143 | CL149 | Upper Clear Creek | TRUE | 0 | U | 60 | 944 | 0 |
| 144 | CL150 | Upper Clear Creek | TRUE | 0 | U | 95 | 1359 | 0 |
| 145 | CL151 | Upper Clear Creek | TRUE | 0 | U | 47 | 831 | 0 |
| 146 | CL152 | Upper Clear Creek | TRUE | 0 | U | 66 | 1712 | 0 |
| 147 | CL153 | Upper Clear Creek | TRUE | 0 | U | 35 | 942 | 0 |
| 148 | CL154 | Upper Clear Creek | TRUE | 0 | U | 129 | 1046 | 0 |
| 149 | CL155 | Upper Clear Creek | TRUE | 0 | U | 150 | 1733 | 0 |
| 150 | CL156 | Upper Clear Creek | TRUE | 0 | U | 10 | 387 | 0 |
| 151 | CL157 | Upper Clear Creek | TRUE | 0 | U | 142 | 785 | 0 |
| 152 | CL158 | Upper Clear Creek | TRUE | 0 | U | 160 | 3429 | 0 |
| 153 | CL159 | Upper Clear Creek | TRUE | 0 | U | 48 | 564 | 0 |
| 154 | CL160 | Upper Clear Creek | TRUE | 0 | U | 17 | 619 | 0 |
| 155 | CL161 | Upper Clear Creek | TRUE | 0 | U | 55 | 1892 | 0 |

# Appendix D – Listing of all culverts (continued)

*Notes: 1. Fish? 0 = No fish; 1 = Fish; 2. Fish Passage U = Undetermined, N = No passage; P = Partial Passage; and Y = Complete Fish Passage; 3. ODF Stream is a classed as a stream on available GIS coverage; 4. US Len is estimated length of stream channel upstream from crossing.*

| | X_ID | Sub watershed name | ODF Str?[3] | Fish?[1] | Pass-able?[2] | WS Area (acres) | US Len (ft) | US Fish Len (ft) |
|---|---|---|---|---|---|---|---|---|
| 156 | CL162 | Upper Clear Creek | TRUE | 0 | U | 47 | 1381 | 0 |
| 157 | CL164 | Middle Clear Creek | TRUE | 0 | U | 84 | 776 | 0 |
| 158 | CL165 | Middle Clear Creek | TRUE | 0 | U | 8 | 503 | 0 |
| 159 | CL166 | Little Clear Creek | TRUE | 0 | U | 50 | 124 | 0 |
| 160 | CL167 | Middle Clear Creek | TRUE | 0 | U | 93 | 723 | 0 |
| 161 | CL168 | Little Clear Creek | TRUE | 0 | U | 92 | 176 | 0 |
| 162 | CL169 | Little Clear Creek | TRUE | 0 | U | 89 | 3565 | 0 |
| 163 | CL170 | Middle Clear Creek | TRUE | 0 | U | 93 | 840 | 0 |
| 164 | CL171 | Little Clear Creek | TRUE | 0 | U | 51 | 1498 | 0 |
| 165 | CL172 | Little Clear Creek | TRUE | 0 | U | 69 | 2720 | 0 |
| 166 | CL173 | Little Clear Creek | TRUE | 0 | U | 89 | 2505 | 0 |
| 167 | CL175 | Little Clear Creek | TRUE | 0 | U | 126 | 1325 | 0 |
| 168 | CL176 | Little Clear Creek | TRUE | 0 | U | 42 | 660 | 0 |
| 169 | CL177 | Little Clear Creek | TRUE | 0 | U | 141 | 2324 | 0 |
| 170 | CL178 | Little Clear Creek | TRUE | 0 | U | 115 | 3440 | 0 |
| 171 | CL180 | Lower Clear Creek | TRUE | 0 | U | 85 | 1622 | 0 |
| 172 | CL181 | Lower Clear Creek | TRUE | 0 | U | 95 | 909 | 0 |
| 173 | CL182 | Lower Clear Creek | TRUE | 0 | U | 98 | 348 | 0 |
| 174 | CL183 | Lower Clear Creek | TRUE | 0 | U | 8 | 133 | 0 |
| 175 | CL184 | Lower Clear Creek | TRUE | 0 | U | 74 | 2869 | 0 |
| 176 | CL185 | Lower Clear Creek | TRUE | 0 | U | 78 | 718 | 0 |
| 177 | CL186 | Lower Clear Creek | TRUE | 0 | U | 94 | 952 | 0 |
| 178 | CL195 | Upper Clear Creek | TRUE | 0 | U | 130 | 710 | 0 |
| 179 | CL196 | Upper Clear Creek | TRUE | 0 | U | 20 | 459 | 66 |
| 180 | CL197 | Upper Clear Creek | TRUE | 0 | U | 10 | 333 | 0 |
| 181 | CL198 | Upper Clear Creek | TRUE | 0 | U | 18 | 363 | 0 |
| 182 | CL199 | Upper Clear Creek | TRUE | 0 | U | 19 | 563 | 0 |
| 183 | CL200 | Upper Clear Creek | TRUE | 0 | U | 24 | 1162 | 0 |
| 184 | CL201 | Upper Clear Creek | TRUE | 0 | U | 26 | 1350 | 0 |
| 185 | CL202 | Upper Clear Creek | TRUE | 0 | U | 7 | 553 | 0 |
| 186 | CL209 | Middle Clear Creek | TRUE | 1 | P | 28254 | 423031 | 341210 |
| 187 | CL210 | Upper Clear Creek | FALSE | 0 | U | 0 | NA | NA |
| 188 | CL211 | Upper Clear Creek | TRUE | 1 | N | 599 | 12931 | 10802 |
| 189 | CL212 | Upper Clear Creek | TRUE | 1 | Y | 1785 | 30697 | 23468 |
| 190 | CL213 | Upper Clear Creek | TRUE | 1 | P | 444 | 8840 | 7252 |
| 191 | CL214 | Upper Clear Creek | TRUE | 1 | P | 127 | 1918 | 1378 |
| 192 | CL215 | Upper Clear Creek | TRUE | 1 | N | 428 | 8472 | 6884 |
| 193 | CL216 | Middle Clear Creek | TRUE | 1 | P | 26075 | 393403 | 312948 |
| 194 | CL217 | Lower Clear Creek | TRUE | 1 | P | 1660 | 23624 | 20001 |

# Appendix D – Listing of all culverts (continued)

*Notes: 1. Fish? 0 = No fish; 1 = Fish; 2. Fish Passage U = Undetermined, N = No passage; P = Partial Passage; and Y = Complete Fish Passage; 3. ODF Stream is a classed as a stream on available GIS coverage; 4. US Len is estimated length of stream channel upstream from crossing. 5. Because these streams were not on coverage upstream length was obtained from Clackamas County information and upstream fish was estimated from air photo information for fish passage calculations*

| | X_ID | Sub watershed name | ODF Str?[3] | Fish?[1] | Pass-able?[2] | WS Area (acres) | US Len (ft) | US Fish Len (ft) |
|---|---|---|---|---|---|---|---|---|
| 195 | CL218 | Lower Clear Creek | TRUE | 1 | Y | 463 | 6567 | 4166 |
| 196 | CL219 | Lower Clear Creek | FALSE | 1 | N | 17 | NA | NA[5] |
| 197 | CL220 | Upper Clear Creek | FALSE | 1 | P | 145 | NA | NA[5] |
| 198 | CL221 | Upper Clear Creek | FALSE | 1 | Y | 66 | NA | NA |
| 199 | CL223 | Little Clear Creek | FALSE | 1 | P | 145 | 1637 | NA[5] |
| 200 | CL224 | Middle Clear Creek | FALSE | 1 | N | 71 | 1373 | NA[5] |
| 201 | CL225 | Middle Clear Creek | FALSE | 1 | P | 42 | 1268 | NA[5] |
| 202 | CL226 | Middle Clear Creek | FALSE | 1 | N | 82 | 1848 | NA[5] |
| 203 | CL227 | Upper Clear Creek | FALSE | 1 | P | 56 | 1003 | NA[5] |
| 204 | CL228 | Upper Clear Creek | FALSE | 1 | P | 40 | 264 | NA[5] |
| 205 | CL229 | Upper Clear Creek | FALSE | 1 | P | 250 | 3960 | NA[5] |
| 206 | CL230 | Upper Clear Creek | FALSE | 1 | P | 114 | 1056 | NA[5] |
| 207 | CL231 | Middle Clear Creek | FALSE | 1 | P | 60 | 1584 | NA[5] |
| 208 | CL232 | Lower Clear Creek | TRUE | 1 | P | 189 | 4886 | 3719 |
| 209 | CL233 | Lower Clear Creek | TRUE | 1 | P | 189 | 5342 | 3651 |
| 210 | CL234 | Bargefield Creek | TRUE | 1 | N | NA | NA | NA |
| 211 | FO001 | Foster Creek | TRUE | 1 | Y | 2086 | 23915 | 23915 |
| 212 | FO002 | Foster Creek | TRUE | 1 | P | 1962 | 20921 | 20921 |
| 213 | FO003 | Foster Creek | TRUE | 1 | P | 1963 | 21059 | 21059 |
| 214 | FO005 | Foster Creek | TRUE | 1 | Y | 427 | 5670 | 5670 |
| 215 | FO006 | Foster Creek | TRUE | 1 | Y | 1452 | 15657 | 15657 |
| 216 | FO007 | Foster Creek | TRUE | 1 | P | 1293 | 13601 | 13601 |
| 217 | FO008 | Foster Creek | TRUE | 1 | Y | 1273 | 13026 | 13026 |
| 218 | FO011 | Foster Creek | FALSE | 1 | P | 131 | NA[5] | NA[5] |
| 219 | FO012 | Foster Creek | FALSE | 1 | Y | 76 | NA | NA |
| 220 | FO013 | Foster Creek | FALSE | 1 | Y | 0 | NA | NA |
| 221 | FO014 | Foster Creek | FALSE | 1 | Y | 0 | NA | NA |
| 222 | FO015 | Foster Creek | FALSE | 1 | Y | 0 | NA | NA |
| 223 | FO016 | Foster Creek | FALSE | 1 | P | 18 | NA[5] | NA[5] |

# Appendix E.

# Information on selected culverts