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5.7 TRIBUTARY STREAM STUDY (TER 7)

5.7.1 Study Objectives

The objectives of the Tributary Stream Study are to provide the following:

- Information on the location and characteristics of impediments and barriers to the movement of terrestrial analysis species dependent on tributary streams and associated riparian habitat;
- An assessment of the effects of the Lewis River Projects on tributary habitat connectivity;
- Culvert location maps and condition descriptions that can be used by operations personnel to assess needs for capital improvements; and
- Management options for meeting watershed goals for aquatic habitat connectivity.

At PacifiCorp's request, the Tributary Stream Study was expanded to provide additional information needed for a Road Management Plan being prepared to meet new Washington Department of Natural Resources (DNR) requirements for roads associated with timber management.

5.7.2 Study Area

The study area for the Tributary Stream Study includes most tributaries crossed by roads within 0.5 mile (0.8 km) of the Merwin, Yale, and Swift No. 2 projects, and within 0.25 mile (0.4 km) of the Swift No.1 Project. Tributaries only crossed by the Lewis River Road (SR 503, USFS Road 90) were not included in the study area because culverts along this road are the responsibility of the Washington State Department of Transportation (WSDOT). To provide the information needed for PacifiCorp's Road Management Plan, this study area was expanded to include road ditches on PacifiCorp lands. These culverts drain road run-off and are not necessarily associated with streams.

5.7.3 Methods

Culverts were identified through a review of existing information, including PacifiCorp road maps and DNR stream maps. Additional culverts were identified during field surveys. Field surveys included measuring and recording 23 parameters at each culvert location (Table 5.7-1).

Table 5.7-1. Parameters included in the culvert and stream surveys.

Culvert Parameters
Culvert Identification Number (This number is based on the road name/number and sequential culvert number)
Diameter
Type (metal, plastic, etc.)
Length
Gradient (% slope)
Bedload characteristics
Inlet characteristics - headwall, trash rack, erosion, catch basin, culvert condition (rust, crushed, plugged)
Outlet characteristics - shotgun, riprap, erosion, culvert condition (rust, crushed, plugged)
Inlet fill depth, slope, and vegetative cover
Outlet fill depth, slope, and vegetative cover
Wildlife passage ability (upstream, downstream, high flow passage, riparian zone passage)
Stream Parameters
Riparian vegetation width
Stream class
Bankfull depth
Bankfull width
Stream gradient (%)
Water flow (cfs)
Road Parameters
Road name (and ownership)
Width (including ditches)
Tread surface (i.e., gravel, dirt, asphalt, pumice)
Right side cutslope height and vegetative cover
Left side cutslope height and vegetative cover
Length draining into culvert

These parameters were compiled in consultation with PacifiCorp compliance staff, a fisheries biologist, and a geomorphologist. In addition to these parameters, digital photographs and global positioning system (GPS) data were taken at each culvert. Photographs included upstream and downstream shots of the drainage and the inlet and outlet of the culvert itself. Culverts at Merwin, most of Yale, and portions of Swift were surveyed in 2000, and remaining sites were surveyed in 2001 (Table 5.7-2). Applicable data were also recorded for other crossing structures, including log culverts, box culverts, fords, and vehicle bridges.

Table 5.7-2. Culvert survey dates and locations.

Dates	Location
April 4 to 6, 2000	Lake Merwin
May 16 to 19, 2000	Lake Merwin
June 1 and 2, 2000	Lake Merwin
June 20 and 21, 2000	Lake Merwin
July 25 to 28, 2000	Yale and Merwin reservoirs
November 6 to 10, 2000	Merwin, Yale, and Swift reservoirs
March 26-30, 2001	Swift and all remaining culverts

Data were transferred from Trimble GPS unit into ArcView geographic information system (GIS) software. Data were then organized and analyzed using ArcView, Excel, and Access databases. Summary information was tabulated for culvert types across the study area and among reservoirs. Culvert conditions, including percent rusted, crushed, blocked, and passage potential, were reviewed and summarized.

5.7.4 Key Questions

Results of the Tributary Stream Study can be used to address the some of the following "key" watershed questions identified during the Lewis River Cooperative Watershed Studies meetings.

- Which areas may benefit most from land acquisitions, land exchanges, conservation easements, and/or road closures, decommissioning/storm proofing, or obliteration?

  Road closure, culvert replacement, and maintenance issues are addressed by this study and are discussed in Sections 5.7.6.

- What are the effects of road/stream crossings and culverts on aquatic habitat connectivity?

  The effects of road/stream crossing and culverts on aquatic habitat were directly addressed by the design and methods of this study (Sections 5.7.3). Results and conclusions are described in Sections 5.7.5 and 5.7.6.

5.7.5 Results

In total, 284 drainage/stream crossing structures were identified and characterized in the study area – 151 at Merwin, 103 at Yale, and 30 at Swift. These structures included 277 culverts (176 stream, 95 ditch, 6 unknown), 2 fords, 4 drains, and 1 bridge. There were 184 structures surveyed (65 percent) on PacifiCorp property, including 97 stream and 78 ditch culverts, 3 unknown culvert types, 4 drains, and 2 fords. Over 82 percent of the ditch culverts and 55 percent of the 176 stream culverts are on PacifiCorp lands. Ditch culverts not on PacifiCorp lands include those along the International Paper (IP) Road and a few on private property near Lake Merwin.

Culvert, stream, road, and other parameters were summarized for all surveyed culverts, with results are presented in Table 5.7-3. Culvert locations are shown in Figure 5.7-1. In total, 1,136 digital photographs were taken of culverts in the study area. Examples are provided in Figure 5.7-2. Photos are stored on compact discs and are available from PacifiCorp.

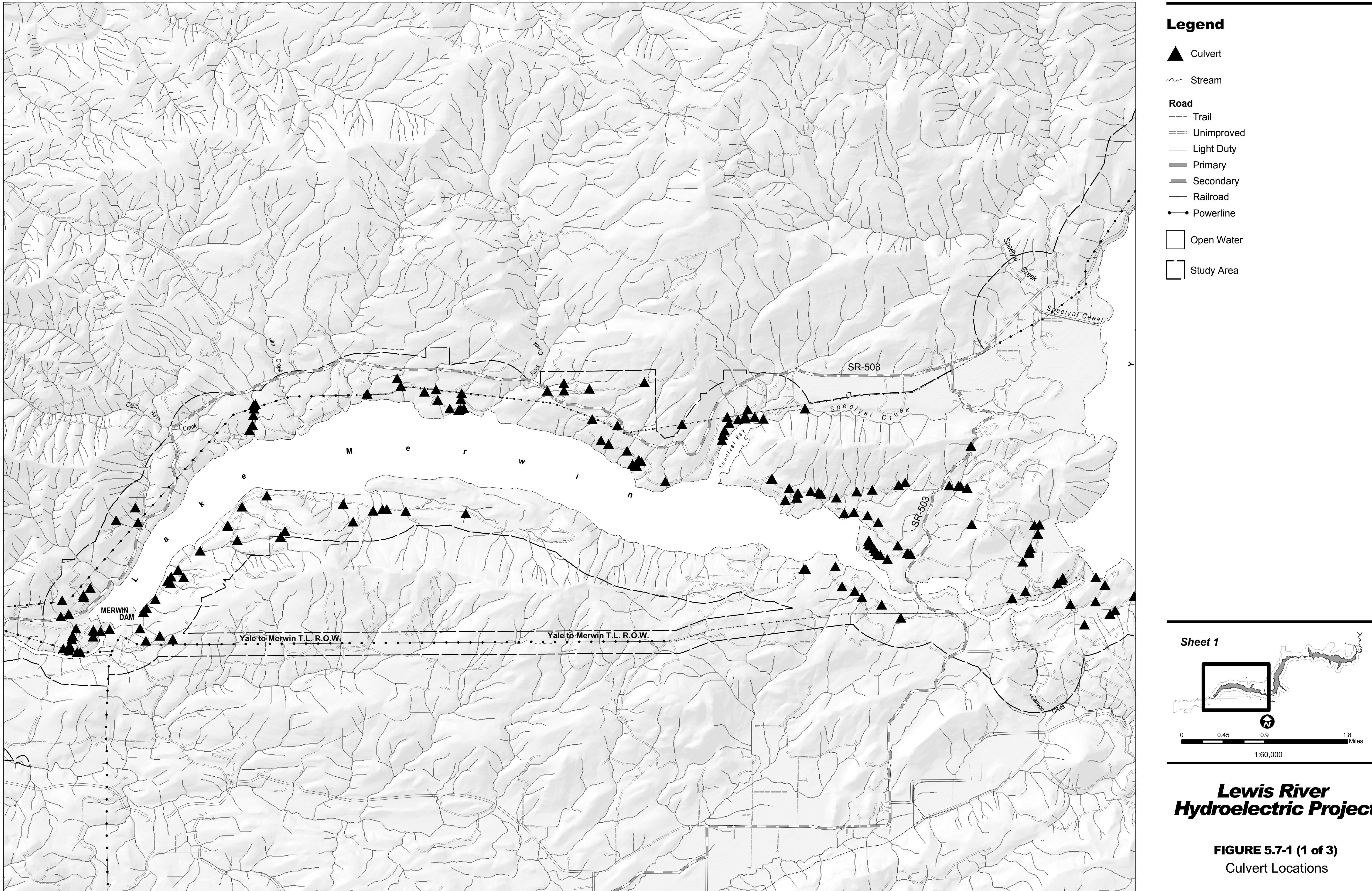
Photo of culvert m170c4 inlet

Photo looking upstream of culvert m170c4

Photo of culvert m170c4 outlet

Photo looking downstream of culvert m170c4

Figure 5.7-2. Examples of 4 photographs taken at each culvert site.



Source: EDAW, Inc., 2001

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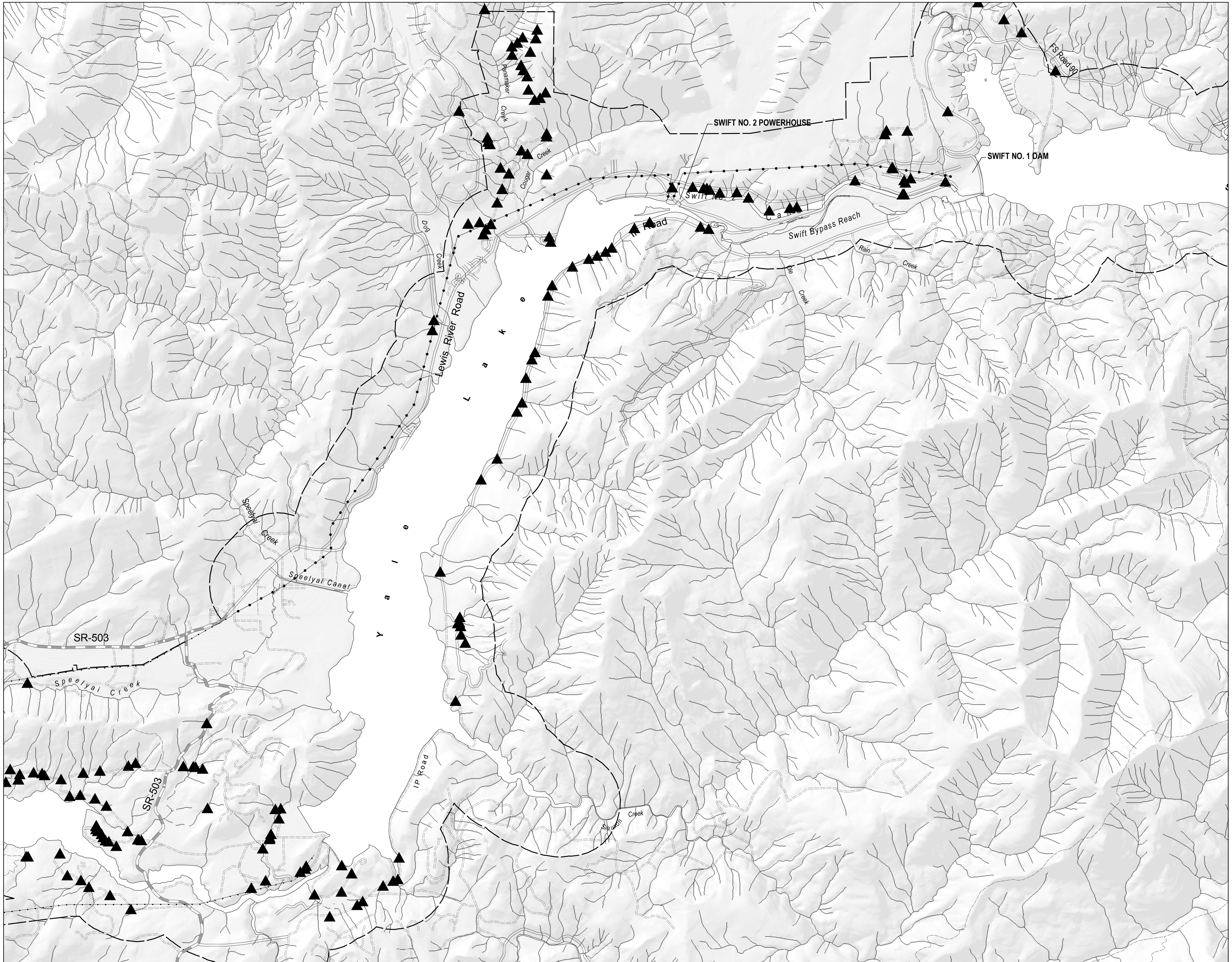
Lewis River Hydroelectric Projects

FIGURE 5.7-1 (1 of 3)

Culvert Locations



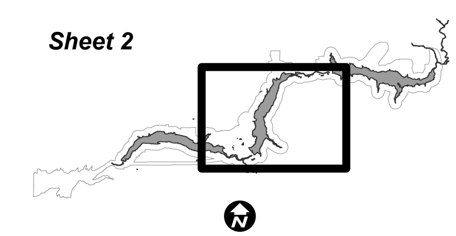
Legend

- Culvert
- Stream

Road

- Trail
- Unimproved
- Light Duty
- Primary
- Secondary
- Railroad
- Powerline
- Open Water
- Study Area

Sheet 2



0 0.45 0.9 1.8 Miles

1:60,000

Lewis River Hydroelectric Projects

FIGURE 5.7-1 (2 of 3)

Culvert Locations

Source: EDAW, Inc., 2001

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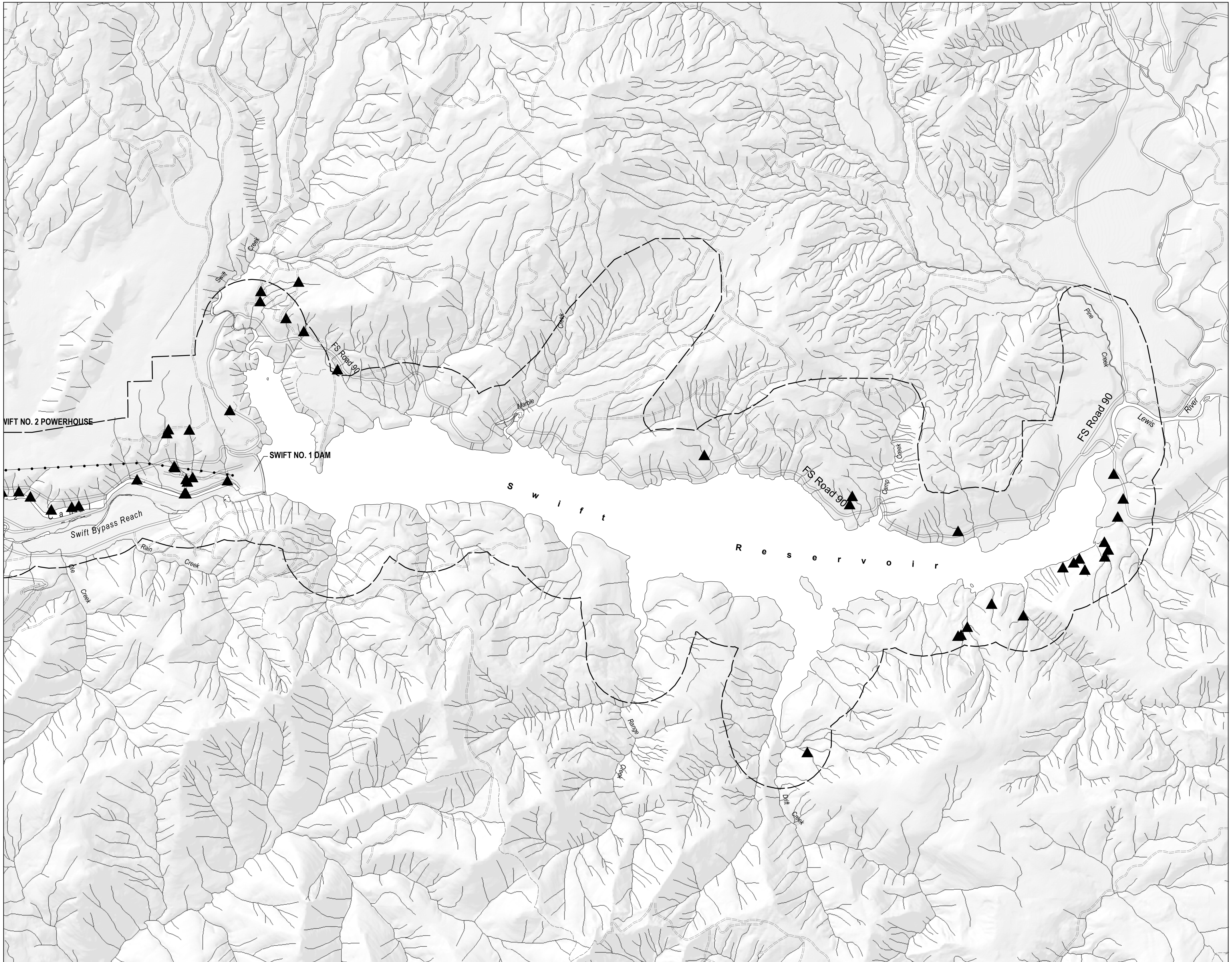

Source: EDAW, Inc., 2001

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Legend

- ▲ Culvert
- Stream

Road

- Trail
- Unimproved
- Light Duty
- Primary
- Secondary
- Railroad
- Powerline
- Open Water
- Study Area

Sheet 3

0 0.45 0.9 1.8 Miles

1:60,000

Lewis River Hydroelectric Projects

FIGURE 5.7-1 (3 of 3)

Culvert Locations

Table 5.7-3. Culvert parameter summary.

Parameter	Ditch Culverts[1] (N= 95)	Stream Culverts[1,2] (N= 176)	All Culverts[3,4] (N = 271)
Culvert Diameter[3]	N=91	N=175	N=260
Average:	1.4 ft	2.2 ft	1.9 ft
Range:	0.6 to 2.4 ft	1 to 10 ft	0.6 to 10 ft
Culvert Type	N=91	N=176	N=267
Round Metal:	78 (85.7%)	152 (86.4%)	230 (86.1%)
Round Plastic:	12 (13.2%)	15 (8.5%)	27 (10.1%)
Log:	0	3 (1.7%)	3 (1.1%)
Round Concrete:	1 (1.1%)	3 (1.7%)	4 (1.5%)
Box:	0	1 (0.6%)	1 (0.4%)
Other:	0	2 (1.1%)	2 (0.7%)
Culvert Length[5]	N=88	N=171	N=259
Average:	35.8 ft	42 ft	40.1ft
Range:	7.2 to 110.9 ft	4.3 to 143 ft	4.3 to 143 ft
Culvert Gradient	N=95	N=176	N=271
Average:	6.5%	7.6%	7.4%
Range:	0 to 27%	0 to 47%	0 to 47%
Bedload Present	N=95	N=176	N=271
	34 (35.8%)	40 (22.7%)	74 (27.3%)
Inlet Condition - Erosion	N=95	N=176	N=271
	23 (24.2%)	76 (43.2%)	99 (36.5%)
Inlet Condition - Rust	N=95	N=176	N=271
	36 (37.9%)	90 (51.1%)	126 (46.5%)
Inlet Condition - Crushed	N=94	N=175	N=269
Number Crushed:	35 (37.2%)	42 (24%)	77 (28.6%)
Number Crushed > 50%:	2 (2.1%)	2 (< 0.1%)	4 (1.5%)
Average Percent Crushed:	7.5 %	4.8%	5.6%
Range:	0 to 85%	0 to 80%	0 to 85%
Inlet Condition - Plugged	N=90	N=171	N=271
Number Plugged:	51 (56.7%)	85 (49.7%)	136 (50.2%)
Number Plugged > 50%:	24 (26.7%)	27 (15.8%)	51 (18.8%)
Average Percent Plugged:	25.5%	16.6%	19.1%
Range:	0 to 100%	0 to 100%	0 to 100%
Outlet Condition - Erosion	N=91	N=174	N=265
	27 (29.7%)	84 (48.3%)	111 (41.9%)
Outlet Condition - Rusted	N=87	N=169	N=256
	44 (50.6%)	95 (56.2%)	139 (54.3%)
Outlet Condition - Crushed	N=90	N=175	N=275
Number Crushed:	27 (30%)	22 (12.6%)	49 (18.5%)
Number Crushed > 50%:	3 (3.3%)	1 (< 0.1%)	4 (1.5%)
Average Percent Crushed:	6.8%	2.7%	4%
Range:	0 to 90%	0 to 90%	0 to 90%
Outlet Condition - Plugged	N=90	N=175	N=265
Number Plugged:	39 (43.3%)	20 (11.4%)	59 (22.3%)
Number Plugged > 50%:	14 (15.6%)	8 (4.6%)	22 (8.3%)
Average Percent Plugged:	15.6%	5%	8.5%
Range:	0 to 85%	0 to 100%	0 to 100%
Outlet Shotgun (Drop)	N=91	N=175	N=266
Number with Shotguns:	32 (35.2%)	122 (69.7%)	154 (57.9%)
Average Shotgun Height:	1.3 ft	1.4 ft	1.4 ft
Range:	0 to 39.4 ft	0 to 11.8 ft	0 to 39.4 ft

Table 5.7-3. Culvert parameter summary (cont.).

Parameter[1]	Ditch Culverts (N= 95)	Stream Culverts[2] (N= 176)	All Culverts[3] (N = 284)
Culvert Inlet Side Fill	N=91	N=176	N=267
Average Depth:	1.9 ft	3.2 ft	2.8 ft
Range of Depth:	0 to 55.8 ft	0 to 17.2 ft	0 to 55.8 ft
Average Gradient:	20.1%	29.1%	25.8 %
Range of Gradient:	0 to 90%	0 to 100%	0 to 100%
Average Vegetative Cover:	77.8%	86.4%	83.3%
Range of Vegetative Cover:	0 to 100%	0 to 100%	0 to 100%
Culvert Outlet Side Fill	N=91	N=176	N=267
Average Depth:	3.3 ft	4.8 ft	4.2ft
Range of Depth:	0 to 108.3 ft	0 to 29.5 ft	0 to 108.3ft
Average Slope:	18.3%	36.1%	28.6%
Range of Slope:	0 to 100%	0 to 100%	0 to 100%
Average Vegetative Cover:	76.1%	84.6%	80.6%
Range of Vegetative Cover:	0 to 100%	0 to 100%	0 to 100%
Wildlife Passage - Percent of Culverts with:			
No Upstream Passage:	52.1%	81%	69.7%
No Downstream Passage:	31.5%	24.2%	25.6%
No High Flow Passage:	76.9%	87%	82.4%
No Riparian Zone Passage:	NA	11%	10.6%
Riparian Zone Width		N=154	
Average:	NA	35.7 ft	NA
Range:		0 to 164 ft	
Stream Bankfull Depth		N=154	
Average:	NA	1.3 ft	NA
Range:		0 to 7.5 ft	
Stream Bankfull Width		N=154	
Average:	NA	8.1 ft	NA
Range:		0 to 34.8 ft	
Stream Gradient		N=154	
Average:	NA	18.1 %	NA
Range:		0 to 85 %	

1 Sample sizes are shown because not all parameters were measured for all culverts (e.g., diameters could not be measured for buried culvert openings).
2 Stream culverts include culverts that drain wetlands and seeps as well as streams.
3 Unless otherwise noted, data for the box culvert were included in the summary statistics.
4 A total of 277 culverts were identified (95 ditch, 176 stream, and 6 unidentified). Data for the 6 unidentified culverts were not included in the summary statistics.
5 Excludes data for the box culvert (length and diameter were very different from stream culverts).

5.7.5.1 Stream Culverts

Stream culverts were defined to include those that drain streams, wetlands, and seeps. Surveys identified 176 stream culverts, 97 (55 percent) of which were on PacifiCorp land. Of these 176 stream culverts, 95, 57, and 24 were associated with the Merwin, Yale, and Swift No.1 projects, respectively. Twenty-six (15 percent) of the stream culverts were dry at the time of data collection. Information on culvert and stream parameters are summarized below.

Culvert Size and Condition

Stream culvert sizes in the study area were variable, ranging in diameter from about 1 to 10 feet (0.3 to 3 m) and in length from 4.3 to 143 feet (1.3 to 43.6 m) (Figure 5.7-3 and Table 5.7-3). The majority of culverts, however, are 1 to 2 feet (0.3 to 0.6 m) in diameter and average 42 feet (12.8 m) in length.

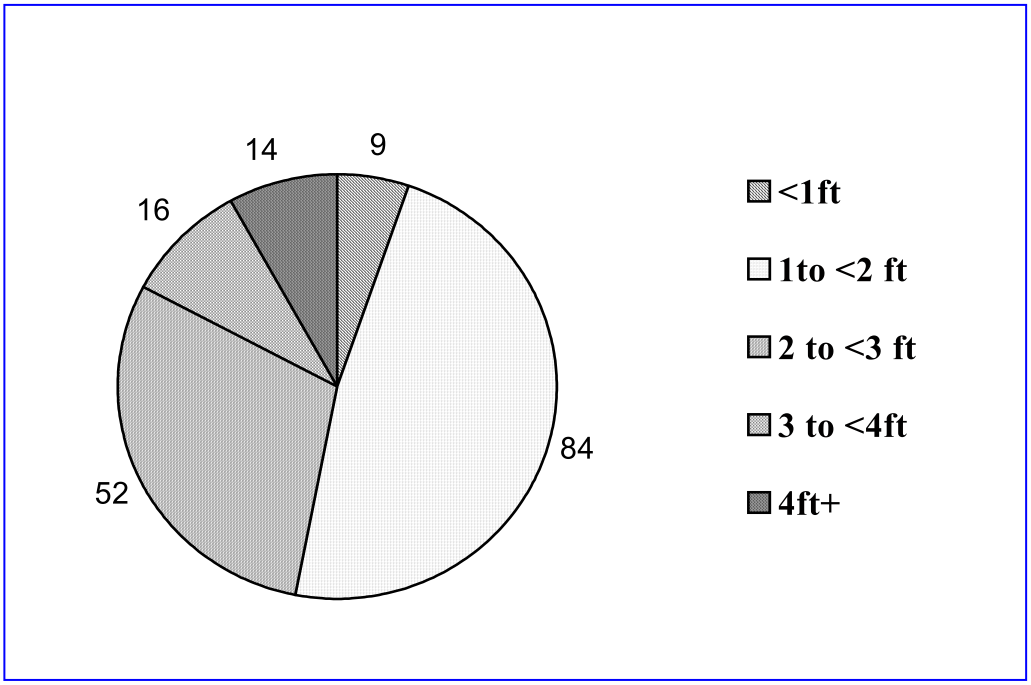

Figure 5.7-3. Stream culvert diameter, 2000-2001 data (N=175).

Overall, 78 percent of stream culvert inlets and 62 percent of the outlets show signs of rusting, crushing, and/or plugging (Figures 5.7-4 and 5.7-5). An example of a culvert with some rust, crushing, and plugging is shown in Figure 5.7-6.

Of the 153 stream culverts (87 percent of the total stream culverts) showing some level of damage or deterioration, 82 (54 percent) are on PacifiCorp property. Rust is found on at least one end of 112 (73 percent) of the stream culverts; 57 (70 percent) of these are on PacifiCorp property.

Plugged and crushed culverts are a more significant concern than rusted culverts because they can result in flooding and erosion. Over 62 percent of culvert inlets were at least partially crushed or plugged, as were 20 percent of the outlets. Three culverts had either inlets or outlets that were crushed more than 50 percent. Plugging is a more extensive problem; 27 stream culvert inlets and 8 outlets were more than 50 percent plugged. Crushed and plugged culverts are also problematic for the passage of small mammals and amphibians.

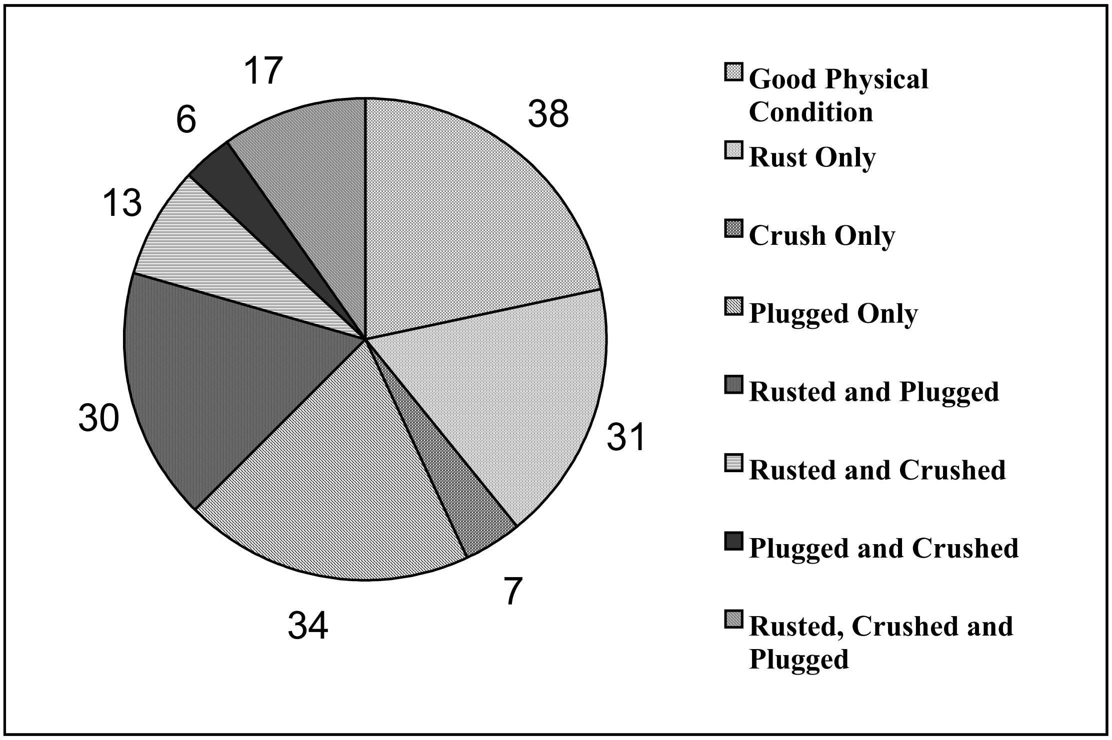

Figure 5.7-4. Stream culvert inlet condition, 2000-2001 data (N=176).

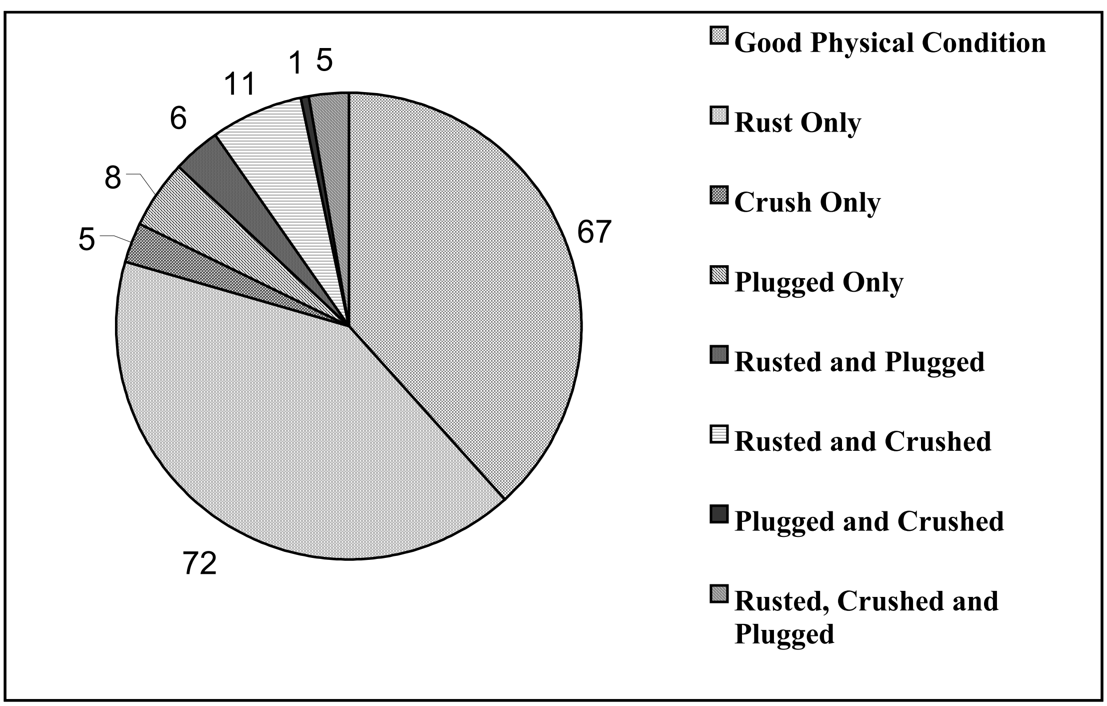

Figure 5.7-5. Stream culvert outlet condition, 2000-2001 data (N= 175).

Figure 5.7-6. Culvert with a rusted, crushed, and plugged outlet.

When compared to all stream culverts in the study area, those on PacifiCorp show a higher level of plugging and a lower level of crushing (Table 5.7-4).

Table 5.7-4. Crushed and plugged stream culverts.

Parameters	Entire Study Area	PacifiCorp Land
Inlet Condition - Crushed	N=175	N=97
Number Crushed:	42 (24%)	15 (15%)
Number Crushed >/= 50%:	6 (6.6%)	2 (2%)
Average Percent Crushed:	4.8%	3.3%
Range:	0 to 80%	0 to 50%
Inlet Condition - Plugged	N=171	N=97
Number Plugged:	85 (49.7%)	49 (51%)
Number Plugged > 50%:	27 (15.8%)	17 (18%)
Average Percent Plugged:	16.6%	18.7
Range:	0 to 100%	0 to 100%
Outlet Condition - Crushed	N=175	N=97
Number Crushed:	22 (12.6%)	9 (9%)
Number Crushed > 50%:	3 (1.7%)	2 (2%)
Average Percent Crushed:	2.7%	2.58%
Range:	0 to 90%	0 to 90%
Outlet Condition - Plugged	N=175	N=97
Number Plugged:	20 (11.4%)	12 (12%)
Number Plugged > 50%:	8 (4.6%)	3 (3%)
Average Percent Plugged:	5%	5%
Range:	0 to 100%	0 to 100%

In addition to plastic and metal culverts, there are also 3 log culverts and 1 box culvert in streambeds on PacifiCorp land. One of the log culverts is associated with the Yale Project and is located on a tributary of Panamaker Creek. The other 2 are associated with the Merwin Project; 1 is located at on a side road off Buncombe Hollow Road, and the other is in the Woodland Park area. The single box culvert is on a little-used dead-end road that crosses Dry Creek, near the Swift No. 2 powerhouse. This box culvert is large, with an opening of 10 feet (3 m) and a length of 188 feet (36 m). The configuration of the culvert causes water to drop about 3.9 feet (1.2 m), which makes the channel impassable to many small mammal and amphibian species.

Culvert Outlet Drop

Over 70 percent of the stream culverts surveyed had a drop from the outlet to the ground (Table 5.7-3 and Figure 5.7-7). An outlet drop example is shown in Figure 5.7-8.

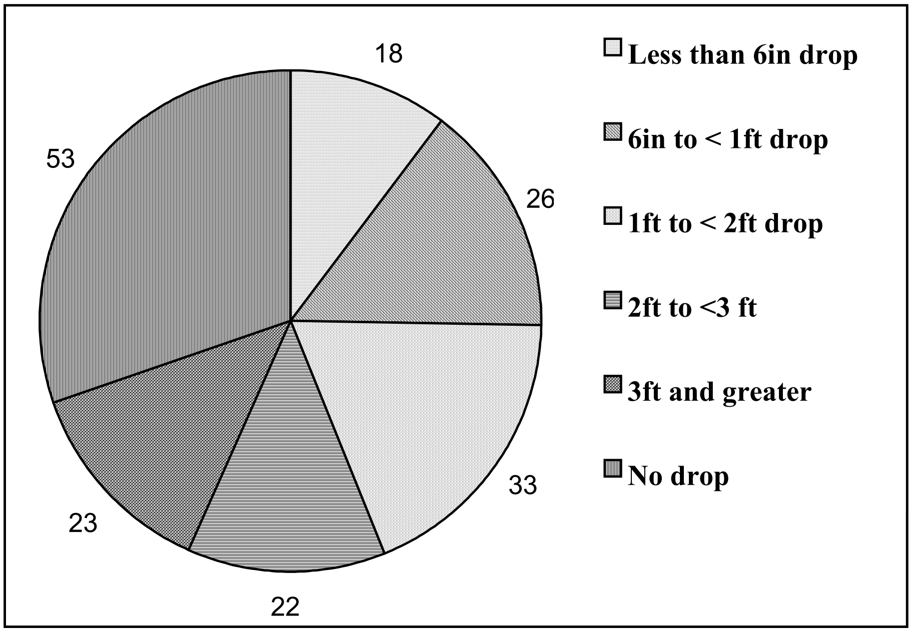

Figure 5.7-7. Stream culvert outlet drop (shotgun), 2000-2001 data (N=175).

Figure 5.7-8. Photo of outlet drop.

Excessive drop presents a migration barrier for fish and can restrict the movement of some aquatic and riparian dependent wildlife species, especially upstream. Outlet drops averaged 1.4 feet (0.44 m) and ranged up to 11.8 feet (3.6 m). Fifty-nine percent of outlets had drops greater than 6 inches (15.2 cm), and 26 percent had drops more than 2 feet (0.6 m). None of the 3 log culverts have drops.

Bedload

The presence of bedload is an important feature of stream culverts because it provides potential resting places for fish and wildlife. It also dissipates stream energy, thus moderating flow. All log culverts surveyed were built over the existing streambed and result in little disturbance of natural bedload. Overall, only about 23 percent of the stream culverts identified during the study contained bedload.

Erosion

Evidence of either bowl or gully erosion was recorded at 43 percent of stream culvert inlets and 48 percent of the outlets. Sedimentation as a result of culvert-induced erosion can be harmful to aquatic ecosystems and can increase the likelihood that a culvert will develop a shotgun drop or become blocked.

Culvert Gradient

Stream culvert gradients in the study area ranged from 0 to 47 percent, with an average of 8 percent. Culverts with high gradients are likely to increase the probability for debris slides.

Wildlife Passage

Over 80 percent of the stream culverts surveyed would be full of water under high flow conditions and would not be usable by small mammals and amphibians. In addition to restricting wildlife passage at high flows, the Washington Department of Fish and Wildlife (WDFW) considers undersized culverts to be a potential trigger for debris slides and build-up (WDFW 1999). Debris problems can damage or destroy culverts and associated roads, and can increase erosion and sedimentation in riparian areas.

Even at low flows, the ability of many culverts to provide passage for small mammals and amphibians is not reliable. Drop and crushed or plugged culverts prevent small mammal and amphibian upstream passage at over 80 percent of the stream culverts, and downstream passage at 24 percent of the culverts. Despite these problems, the fill associated with most stream culverts supports vegetation that would likely provide enough cover for many wildlife species able to leave the streambed and move around the culvert. In these cases, the width of the associated road may be more problematic. In some cases, however, large amounts of fill can be detrimental because it is a source of debris and can funnel this material down steep slopes (Knutson and Naef 1997).

Of all culvert types, log culverts probably provide the best opportunities for small mammals and amphibians to move along riparian corridors and streams. Most log culverts are quite large, have a low gradient, and generally have bedload. Since log culverts also represent in-stream wood, they may also provide cover habitat for some amphibian species.

5.7.5.2 Ditch Culverts

Surveys during the 2000 and 2001 field season identified 95 ditch culverts which drain run-off along and under roads. Seventy-eight of the surveyed ditch culverts are on PacifiCorp property and are associated with Lake Merwin and Yale Lake. Overall, ditch culverts were smaller in diameter and length than stream culverts (Table 5.7-3). Like the stream culverts, the majority (86 percent) of ditch culverts were metal.

Of the 95 ditch culverts, 79 (83%) had some form of damage (rust, crushed, or plugged) at either the inlet or outlet. Compared to stream culverts, a slightly lower percentage (69 compared to 78 percent) of ditch culvert inlets and a greater percentage of outlets (69 compared to 62 percent) are rusted, crushed, and/or plugged. Crushed and plugged culverts are a more degraded condition than rusted culverts. Ditch culvert outlets were more likely to be crushed or plugged (52 percent of outlets) than stream culverts; inlet condition was similar between ditches and streams.

As might be expected, the ditch culverts had shorter outlet drops than stream culverts. They also have a greater likelihood of containing bedload. Outlet erosion was found to be less for ditches, and culvert gradients were also lower. In general, ditch culverts appeared to be more passable for small mammals and amphibians compared to stream culverts because passage under high flow conditions and upstream movement was less impeded. However, downstream passage was found to be a greater problem for ditches compared to streams (32 percent compared to 24 percent).

5.7.5.3 Other Drainage Structures

Other stream and drainage structures surveyed during the study included 4 drains and 2 fords. The fords cross streams, whereas the drains collect stormwater run-off from roads. All of these structures are located on PacifiCorp property on lands surrounding Lake Merwin.

<u>Drains</u>

The 4 drains surveyed are located at Cresap Bay Campground (Merwin Road M180). These structures are grated at the inlets and drain water into an underground drainage system. These drains are completely inaccessible to wildlife passage or use.

<u>Fords</u>

Fords are located on Merwin Road M80-2, in the Woodland Park area, and on Merwin Road M170-1, which is east of Speelyai Bay. Neither of these fords impedes wildlife passage but may result in increased erosion.

5.7.6 Discussion

Road construction is the most common form of habitat alteration of the past century (Trombulak and Fissell 2000). A major ramification of road construction in the Pacific Northwest is the construction of water crossings over rivers, streams, and creeks. The associated culverts can have important impacts on fish and wildlife habitat, primarily through the creation of movement barriers. Much has been learned in recent years about the impacts of culverts on fish migration, and many regulating state and federal agencies are now altering their specifications and requirements for culvert design to enhance fish survival. Other species are also affected by culverts—particularly wildlife that primarily use streams and waterways for movement and habitat. Culverts can act as barriers to amphibians and small mammals that travel stream corridors (Trombulak and Frissell 2000).

The inventory conducted in 2000-2001 found that 82 percent of stream and ditch culverts within the study area are currently blocked, rusted, crushed, or have large drops, all of which limit riparian and aquatic connectivity. Wildlife cannot move through the majority of stream and ditch culverts in the study area. Other culverts are likely to become blocked in the future, or are not usable by wildlife during periods of high rainfall.

In addition to damage and outlet drop, other factors such as culvert material (plastic, metal), the bedload, or nearby vegetation could affect the ability of small mammals and amphibians to move through culverts. Very few of the culverts mimic natural stream conditions. The ability of particular wildlife species to move through a culvert depends on its life history requirements, habitat needs, and size. Though amphibians generally do not travel large distances, stream corridors are important to the breeding biology and early development of a number of species, with a few spending their entire life in aquatic/ riparian systems. The Pacific giant salamander (*Dicamptodon tenebrosus*), torrent salamander (*Rhyacotriton* sp.), Cope's giant salamander (*D. copei*), and tailed frog (*Ascaphus truei*) depend on stream corridors for some or all of their life stages.

Amphibian use of stream habitats is affected by water temperature, streambed substrate, water clarity, woody debris, and moisture along stream edges (CARCNET 2002; Knutson and Naef 1997; Leonard et al. 1993). Small mammals, such as water voles (*Microtus richardsoni*) and water shrews (*Sorex bendirii*), as well as beaver (*Castor canadensis*), marten (*Martes americana*), and river otter (*Lutra canadensis*), are known to use stream corridors for travel (Knutson and Naef 1997). Mammal movements along and in streams are affected by woody debris, streamside vegetation, and edge habitat, among others (Knutson and Naef 1997).

Depending on the availability of cover provided by rock and vegetation near a culvert and the associated road fill slope, most small mammals and adult amphibians may be able to move around culvert and over the road. Although roads do not represent an absolute physical barrier to dispersing amphibians, road kill is a significant source of mortality for some amphibians, particularly salamanders (deMaynadier and Hunter 2001). However, most of the roads in the study area receive relatively little vehicle use.

Because of their limited range and mobility, as well as their vulnerability to habitat changes, amphibians and small mammals are particularly sensitive to modifications of riparian habitat (Knutson and Naef 1997). Metal culverts can reduce stream temperatures more than concrete and plastic materials, which could reduce amphibian and mammal movement (CARCNET 2002). Increased sedimentation in streams as the result of erosion around culverts may affect the tailed frog; populations of this species decrease with the increased sedimentation and water temperatures associated with road construction (Leonard et al. 1993).

Even in the absence of wildlife movement concerns, many of the culverts in the study area need maintenance or replacement. Culverts plugged with debris are at high risk of being washed out (Baker and Votapka 1990). Small streams are particularly vulnerable to impacts from modifications (Knutson and Naef 1997). Washouts can cause major habitat and roadway damage (Baker and Votapka 1990). According to Washington State legislation, bridges and bottomless arch culverts are preferred stream crossing structures, especially for salmon-bearing streams and creeks (WAC 220-110-070). These structures maintain streambed habitat and do not constrict or alter flows as much as traditional culverts.

PacifiCorp is complying with the Washington Department of Natural Resources' (DNR) Road Maintenance and Abandonment Program (RMAP). The road and culvert inventories will be used to develop a maintenance schedule that meets current state regulations. In general, many of the stream culverts in the study area are damaged or too small. Repair and replacement are needed, with priority placed on currently plugged and blocked culverts. Culverts with large outlet drops should be addressed next, followed by those that are not likely to sustain 100-year flood events. All repair and replacement actions need to be tailored for site-specific conditions (i.e., culvert, road conditions, slopes, and stream attributes). Management options for meeting watershed goals for aquatic habitat connectivity follow the RMAP and include the following:

- Replace damaged and nonfunctioning traditional metal culverts with bridges or bottomless arch culverts where feasible. Replace other nonfunctioning culverts with larger culverts. New culverts should be placed in a way that minimizes changes to streamflows and gradient. Culverts placed with the bottom buried into the streambed are preferred to those placed on top of the streambed.

- Stream crossings should be designed to withstand 100-year peak flow events and to meet Forest Practice Rules (Knutson and Naef 1997).

- All culverts should have a minimum diameter of 24 inches (0.6 m) as required by the WAC rules for perennial streams (Knutson and Naef 1997).

- Deep road fill, over 6 ft (1.8 m), should be avoided where streams are at risk of conveying debris flow to the crossing (Knutson and Naef 1997).

- Limit the use of culverts through a landscape-level evaluation of road planning and route selection.

- The use of metal culverts should be limited. Concrete and plastic have been found to maintain temperatures at lower and steadier rates than metal and thus promote amphibian use of culverts (CARCNET 2002).

- Use fish baffles in culverts, where feasible, to slow flows and enhance movement of amphibians and other small wildlife species through culverts.

- Where feasible, place culverts at the same grade as the streambed or use the no slope technique outlined in Fish Passage Design at Road Culverts (WDFW 1999).

5.7.7 Schedule

The Tributary Stream Study is complete.

5.7.8 References

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5.7.9 Comments and Responses on Draft Report

This section presents stakeholder comments provided on the draft report, followed by the Licensees' responses. The final column presents any follow-up comment offered by the stakeholder and in some cases, in italics, a response from the Licensees.

Commenter	Volume	Page/ Paragraph	Statement	Comment	Response	Response to Responses
WDFW – KAREN KLOEMPKEN	2	TER 07	Stream Culverts.	There isn't enough raw data in the report to perform an adequate analysis. Culverts that are replaced should not have any outlet drop, preventing fish, amphibian, or small mammal passage.	The information presented in the report was not intended to be used to identify specific culverts for replacement. PacifiCorp has the full electronic database with information on all culverts included in the study. This database can be used in the future to prioritize culverts for replacement.	
WDFW – KAREN KLOEMPKEN	2	TER 07	Assessment of effects of Lewis River Projects on tributary habitat connectivity.	Where is the assessment of the effects of the Lewis River Projects on tributary habitat connectivity?	This assessment is presented for small mammals and amphibians in Section 5.7.6.	
WDFW – CURT LEIGH	2	TER 07 Sec. 5.7	Tributary streams.	Culverts need identification of changes needed. Short on recommendations.	The information presented in the report was not intended to be used to identify specific culverts for replacement. PacifiCorp has the full electronic database with information on all culverts included in the study. This database can be used in the future to prioritize culverts for replacement or repair.	