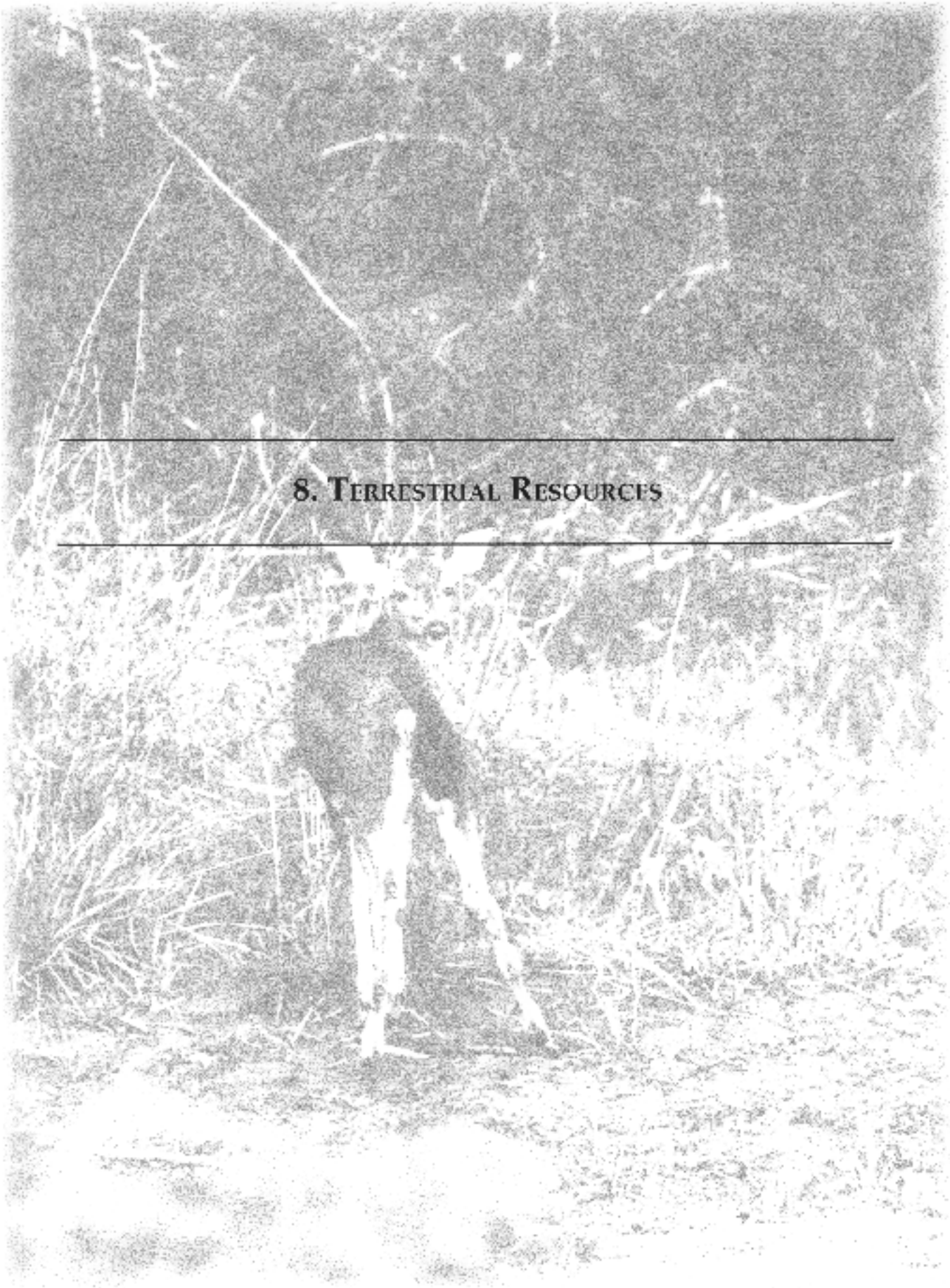


8. Terrestrial Resources

8. TERRESTRIAL RESOURCES

During the watershed analysis scoping process, two terrestrial resource issues were identified—terrestrial habitat connectivity and wildlife entrapment in project waterways. The management goals defined for these issues are:

- to maintain ***terrestrial habitat connectivity*** so that dispersal, migration, and interbreeding among subpopulations can occur.

- to create a waterway system that has insignificant effects on populations of wildlife species in the project vicinity and that minimizes ***wildlife entrapment***-related injury and mortality of individuals.

Section 8.1 provides an overview of the watershed analysis results for these issues. Study methods common to both issues are presented in Section 8.2 After this, Sections 8.3 and 8.4 describe the results of the watershed analysis for terrestrial habitat connectivity and entrapment, respectively, including additional information on methods specific to each issue.

8.1 OVERVIEW OF RESULTS

Results of the watershed analysis indicate that terrestrial habitat connectivity in the North Umpqua watershed is currently affected by project operations, timber harvest, and roads. During the next license period of 30 to 50 years, habitat is expected to continue to be reduced and fragmented because of planned timber harvest on Forest Service Matrix lands (see USDA Forest Service and USDI Bureau of Land Management 1994) in the project vicinity. In general, habitat fragmentation probably has the greatest effect on terrestrial amphibians and small mammals that have limited dispersal abilities and patchy distributions. The Terrestrial Subgroup developed nine management options for improving habitat connectivity in the project vicinity, all of which focus on providing additional and/or more suitable opportunities for wildlife to cross the waterways. The options range from improving the existing wildlife bridges to covering all gunite sections of waterway, with associated costs from approximately $150,000 to $60 million. The Terrestrial Subgroup evaluated these options and ranked them based on their potential to attain the management goal as defined in the initial cooperative scoping process. A "no-action" option was also evaluated.

Watershed analysis results indicate that the vulnerability of wildlife species in the North Umpqua River watershed to entrapment in project waterways is probably related to their movement and habitat use patterns. Species most affected are those with long generation times, limited dispersal abilities, and patchy distributions. Overall, however, the effects of entrapment on populations are unknown and entrapment data do not exist for most species other than deer and elk. It is possible that wildlife mortality from entrapment, in combination with other activities related to resource use and development, may affect populations. It is difficult to predict if entrapment will increase

in the future, but other activities that result in wildlife mortality, either directly (for example, vehicles on State Route 138) or indirectly (for example, habitat loss), are likely to increase.

The Terrestrial Subgroup developed seven management options for reducing entrapment in project waterways, particularly of small mammals and amphibians. One option includes conducting a study to determine the effects of entrapment on populations and evaluate whether providing more wildlife crossings reduces entrapment. Other options include providing escape ramps for entrapped large mammals, constructing a low barrier along gunite canal sections to prevent entrapment of small mammals and amphibians, and covering sections of gunite canal. Associated costs range from approximately $300,000 to $60 million. The Terrestrial Subgroup evaluated these options and ranked them based on their ability to attain the management goal as defined in the initial cooperative scoping process. A "no-action" option was also evaluated.

8.2 ANALYTICAL METHODS

After terrestrial resources management goals were defined, analyses were designed and conducted to describe reference and current conditions and to identify impacts and trends associated with actions that potentially affect populations of wildlife species in the project vicinity. To assist the Terrestrial Subgroup in the analysis of both habitat connectivity and entrapment, two teams of species experts were assembled—one for mammals and one for amphibians. Although the level of participation of each species expert varied, in general they assisted the Terrestrial Subgroup with the definition of the habitat connectivity and entrapment issues, identification of relevant analysis species, assessment of project effects, and formulation of potential management options. In addition, they reviewed meeting notes and scoping documents; some also provided comments on draft technical reports. Species experts included the following individuals.

Mammal Experts

Dr. Keith Aubry, USFS, Pacific Northwest Research Station, Olympia, Washington
Mr. Brian Biswell, USFS, Pacific Northwest Research Station, Olympia, Washington
Dr. John Hayes, Oregon State University, Corvallis, Oregon
Dr. Bill Zielinski, USFS, Redwood Science Laboratory, Arcata, California

Amphibian Experts

Dr. Bruce Bury, National Biological Service, Corvallis, Oregon
Dr. Marc Hayes, Portland State University, Portland, Oregon
Mr. Larry Jones, USFS, Pacific Northwest Research Station, Olympia, Washington

In the task of selecting analysis species, the experts assisted the Terrestrial Subgroup in identifying the wildlife species potentially most affected by habitat fragmentation or entrapment. The Terrestrial Subgroup judged that the needs of other species known to occur in the study area, and potentially affected by these issues, would also be met by addressing the selected analysis species. Technical Appendix 8-1 provides a description of analysis species (available on request).

For both resource issues, the Terrestrial Subgroup formulated alternative ideas for options to

meet the management goal. Several of these management options included a variety of design alternatives for new crossing structures, waterway covers, and barriers to prevent wildlife entrapment. These ideas were provided to structural engineers at Raytheon Corporation to prepare schematic drawings and estimate unit costs for various alternatives (PacifiCorp, 1997).

8.3 TERRESTRIAL HABITAT CONNECTIVITY

As defined in the initial scoping process, a management goal for the watershed is to maintain terrestrial habitat connectivity so that dispersal, migration, and interbreeding among subpopulations can occur. This goal is consistent with the Northwest Forest Plan, which specifies that Matrix forest lands provide connectivity between Late Successional Reserves. Most of the North Umpqua Hydroelectric Project is located in Matrix lands.

8.3.1 Analytical Methods

In addition to the professional judgement of the Terrestrial Subgroup and species experts (described previously in Section 8.2), the analysis of terrestrial habitat connectivity involved: (1) a review of relevant literature, existing data, and relicensing study results to define reference and current conditions and assess project impacts; and (2) a field assessment of the likely effects of project waterways on wildlife movement.

Literature and existing data review

The purpose of the literature and existing data review was to obtain available published information related to reference conditions, current conditions, and potential project impacts. Principle literature sources for estimating reference conditions related to habitat connectivity and natural stream crossings included Bilby and Ward (1989), Robinson and Beschta (1990), and Richmond and Fausch (1995). For current conditions and project impacts, primary sources of data were the results of the terrestrial resource studies conducted for relicensing the North Umpqua project (summarized in PacifiCorp 1995, Volumes 5, 33, and 34). Relicensing studies were reviewed for information related to: (1) the number and location of existing opportunities for wildlife to cross project waterways; (2) waterway structural characteristics (for example, length of each type of waterway); and (3) use of existing wildlife bridges by big game and other species. Other important sources of information on existing conditions and future trends in the North Umpqua drainage were the Northwest Forest Plan (USDA Forest Service and USDI Bureau of Land Management 1994), the Land Resource Management Plan for the Umpqua National Forest (USDA Forest Service 1990) and M. Hayes (1996). Unpublished data related to habitat connectivity available to the Terrestrial Subgroup were the preliminary results of Dr. Keith Aubry's study on fishers in the adjacent Rogue River watershed.

Field assessment

Several of the management options developed by the Terrestrial Subgroup required an estimate of the length of project waterway suitable for new crossings based on the quality of adjacent habitat. Habitat quality was based on the steepness and vegetation conditions on the cut and fill slopes adjacent to gunite canal sections of the waterway. This information was obtained from a field assessment of the 34.9 km (21.7 mi) of waterway that consist of gunite canal. Gunite canals provide the best opportunity for improving habitat connectivity by adding new crossing structures for wildlife because the top edges of this type of waterway are nearly flush with the ground surface. Waterway sections that consist of steel flumes were not included in the assessment because these sections are elevated on trestles and allow wildlife to pass underneath. Concrete flumes were also excluded from the analysis because these sections: (1) represent only about 27 percent of the waterway; (2) often transect very steep terrain that naturally prevents or inhibits wildlife movement; and (3) would be very difficult to modify to improve connectivity.

Prior to the field assessment, the Terrestrial Subgroup developed criteria to rank the suitability of sites immediately adjacent to gunite canal sections for providing small mammals and amphibians access to canal edges. These suitability criteria were based on slope and vegetation cover and are listed below.

- High suitability—adjacent slope < 70 degrees with > 50 percent vegetation cover
- Moderate suitability—adjacent slope < 70 degrees with vegetation cover between 25 and 50 percent
- Not suitable—adjacent slope either > 70 degrees or with < 25 percent vegetation cover

The field assessment was conducted by three members of the Terrestrial Subgroup and involved driving along project waterways and applying the habitat suitability criteria to each section of gunite canal. Each section was marked on maps of project waterways and assigned a suitability rank of high, moderate, or not suitable. Data from the field assessment were entered into the geographic information system (GIS) and used to calculate the amount of gunite canal by habitat suitability rank.

8.3.2 Reference Conditions

Before commercial timber harvest began and roads and hydroelectric facilities were built, there were probably few physical or ecological barriers to wildlife movement in the North Umpqua River drainage. Under reference conditions, habitat linkages were interrupted only by the rock cliffs that occur throughout the watershed and by the downstream portions of the North Umpqua River. In general, large rivers are too wide to be crossed by smaller wildlife except during extreme low flows associated with drought conditions. In the vicinity of the North Umpqua Hydroelectric Project, there were probably few riverine barriers to movement. Under reference conditions most tributary streams and the upper portions of the North Umpqua and Clearwater rivers would likely have been narrow enough for the majority of wildlife species to cross during

the late summer and fall dry season.

Under reference conditions, natural opportunities for wildlife to cross smaller streams would have been provided by large woody debris (LWD), rocks, and shallow segments. LWD would have provided crossing opportunities under winter base flow conditions; rocks and shallows would have typically been useable during low flows. Based on a review of the literature, the Terrestrial Subgroup judged that under reference conditions, the average number of natural crossing opportunities in tributary streams provided by LWD would be about 14 per mile of stream channel. This estimate of the number of LWD crossings under reference conditions was derived from the following information and analysis.

- The “desired future condition" for LWD for streams in the Umpqua National Forest is 80 pieces per mile. This estimate is believed to represent conditions that would exist in undisturbed old-growth areas in the western Cascades. (Instream LWD is defined by the USFS as being greater than 0.61 m (24 in) in diameter and 15.2 m (50 ft) in length)

- Pieces of LWD tend to occur at random intervals along and in first- and second-order streams because small streams lack the energy to redistribute large trees after they fall. Larger streams would be expected to have fewer pieces with a perpendicular orientation. Based on the literature, about 30 to 40 percent of LWD in streams with a bankfull width under 7.0 m (23 ft) would be oriented perpendicular to the stream channel (Bilby and Ward 1989, Robinson and Beschta 1990). Many of the upper headwater streams in the basin are narrower than 7 m, and some are wider; using the information from the literature allows only a rough approximation of LWD characteristics in the North Umpqua River basin under reference conditions.

- Not all of the perpendicular pieces of LWD would span the channel and provide crossing opportunities for wildlife; the smaller the stream, the higher the percentage of pieces that actually span the channel (Richmond and Fausch 1995). In streams of about 4.9 m (16 ft) bankfull width, Robinson and Beschta (1990a) found that about 80 percent of the LWD was above or beside the stream rather than within the low flow channel. This distribution is primarily due to the V-notch shape of stream channels in relatively high gradient forest streams, which prevents large trees from falling entirely within the channel unless they break up upon entry.

- If it is assumed that an undisturbed small channel would have 80 pieces of LWD, about 24 to 32 of these (30 to 40 percent) would be oriented perpendicular to the channel. Many of these pieces would likely span the small streams in the vicinity of the North Umpqua Project. If 50 percent of the pieces of LWD span the channel, there would be approximately 14 natural crossing opportunities per mile of stream channel under reference conditions. This estimate is consistent with the results of a limited field survey in the North Umpqua River watershed, which determined that there are an average of about 18 pieces of LWD that span the channel per mile of stream with bankfull widths of

less than 15.2 meters (50 feet). This frequency of LWD crossings was consistent between managed and unmanaged sites.

8.3.3 Current Conditions

Compared to reference conditions, terrestrial habitat connectivity in the North Umpqua River watershed has been reduced. Habitat fragmentation resulting from the hydroelectric project waterways prevents the unrestricted movement of nearly all terrestrial amphibian, reptile, and mammal species in the vicinity. The impact is greatest, however, on species with limited dispersal ability and patchy distribution, such as small mammals and terrestrial amphibians. Features that either prevent or hinder movement of some wildlife species are described below.

Hydroelectric facilities

There are 50.7 km (31.5 mi) of waterway and 7.2 km (4.5 mi) of above-ground penstock associated with the North Umpqua Hydroelectric Project (PacifiCorp 1995). There are four main types of waterway—concrete flume (10.1 km, or 6.3 mi), concrete/rock flume (3.7 km, or 2.3 mi), steel flume (1.9 km, or 1.2 mi), and gunite canal (34.9 km, or 21.7 mi). All of these types except steel flumes, which are elevated on trestles (25 total), represent barriers to movement by most wildlife species except birds. About 4.0 km (2.5 mi), or 29 percent, of the concrete and concrete/rock flume sections, however, bisect very steep areas that represent natural barriers to wildlife movement. Top-widths of gunite canals range from 4.7 m (15.5 ft) for the Fish Creek waterway to 8.2 m (27 ft) for the Lemolo Nos. 1 and 2 waterways.

The effects of penstocks on wildlife movement are variable and depend on location and height above the ground. An analysis of the interspersion of passable and impassable segments for various groups of species has not been conducted, but there are probably segments that interfere with movement patterns of certain species. The following information describes conditions (PacifiCorp 1995) and likely effects on wildlife movement of the 7.2 km (4.5 mi) of penstock in the study area.

- About 1.0 km (0.6 mile, or 13 percent of project penstocks), are located on cliffs, which represent natural barriers to movement. Nearly all of the Clearwater No. 2 and Fish Creek penstocks are located on cliffs.
- Of the remaining 6.3 km (3.9 mi) of penstock, 6.1 km (3.8 mi) have less than 1.2 m (4 ft) of clearance and likely present a barrier to elk movement.
- About 4.5 km (2.8 mi, or 62 percent) of penstock are positioned on footings that provide between 0.6 and 1.2 m (2 and 4 ft) of clearance, which is likely adequate for deer and smaller wildlife species to cross underneath.
- About 1.6 km (1 mile) of penstock, or 23 percent, has less than 0.6 m (2 ft) of clearance (PacifiCorp 1995) and likely precludes movement by deer. Most sections less than 2 ft are not flush with the ground surface and would therefore not create a barrier to movement by small mammals and amphibians. Sections less than 2 ft above the ground are found along

the Lemolo No. 1 penstock (0.5 km, or 0.3 mile), Soda Springs penstock (0.3 km, or 0.2 mile), and the entire Toketee penstock (0.8 km, or 0.5 mile, occurring in two separate sections).

- The Lemolo No. 1 penstock is the longest in the hydroelectric project, at about 2.3 km (1.4 mi) in length. The elevation at the bottom of the penstock varies between 0.4 m (16 in) and 3.7 m (12 ft) above the ground (J. Wieman, pers. com. 1997), and therefore restricts movement by larger animals in some sections, but probably does not restrict the movement of small animals.

Existing structures that may provide opportunities for wildlife to cross the waterway include 25 elevated flume trestle underpasses, 29 wildlife bridges, 24 vehicle bridges, and two foot bridges (Figure 8-1 and Table 8-1). Distances between adjacent crossing opportunities range from about 6.1 to 1,188.7 m (20 to 3,900 ft) (PacifiCorp 1995). Vehicle and wildlife bridges, however, may not provide suitable habitat for use by some species. The existing wildlife bridges were designed for big game and may not provide enough cover for use by amphibians and small mammals. The number and distribution of bridges are probably inadequate to provide habitat connectivity for smaller wildlife. Existing wildlife bridges were specifically located in big game habitats or travel corridors bisected by the waterway. Areas that currently have few or no crossing opportunities may be equally or more important to other wildlife.

Table 8-1. Summary of waterway crossings and underpasses

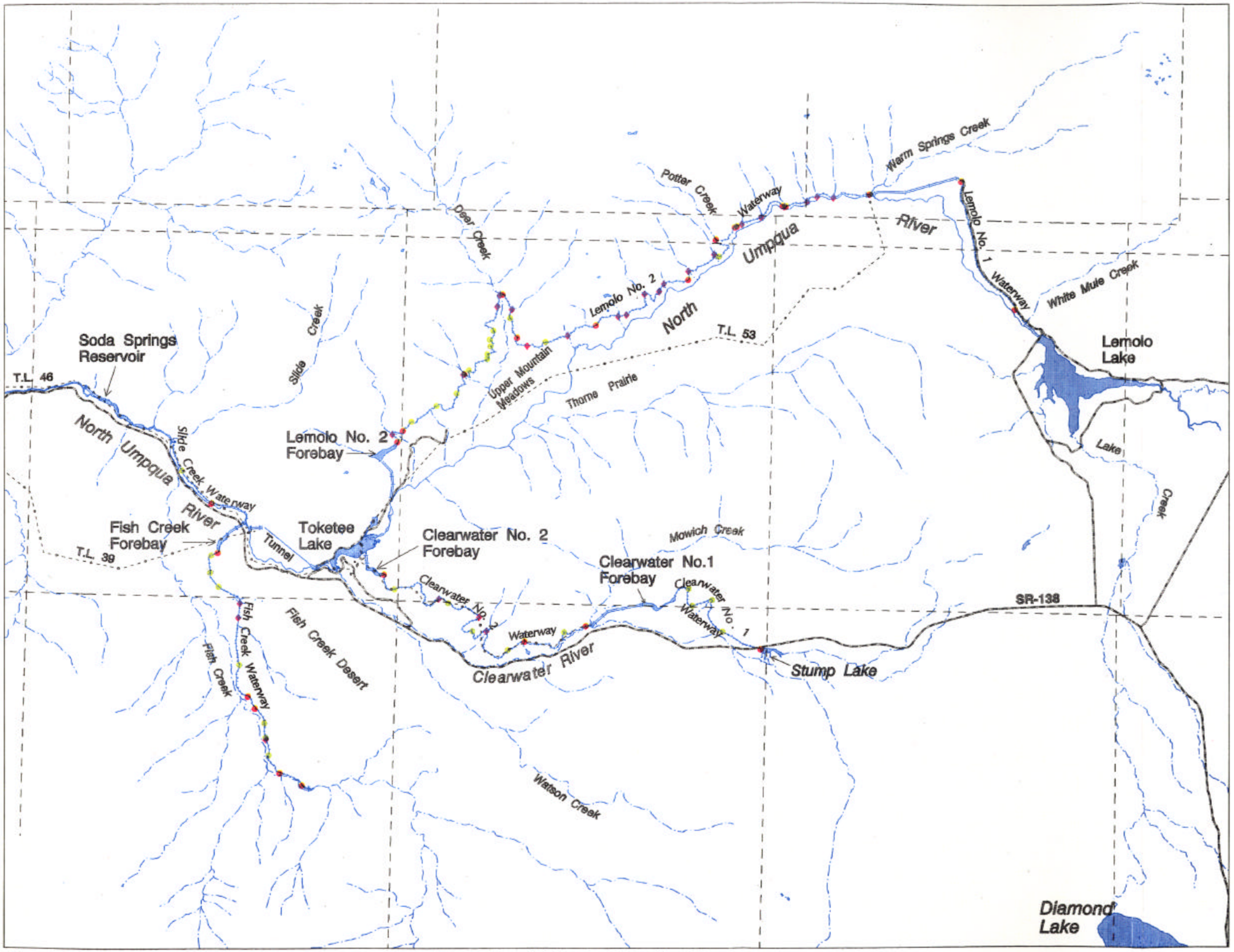
Project Development	Waterway Length (miles)	Foot Bridges	No. Flume Under-passes	Vehicle Bridges	Wildlife Bridges	Distance Between Crossing Opportunities (ft)
Clearwater No.1	2.3	0	0	1	4	1,811-3,741
Clearwater No.2	6.0	1	2	3	5	840-3,263
Fish Creek	4.8	0	3	4	7	16-3,833
Lemolo No. 1	3.1	0	0	2	0	12,831
Lemolo No. 2	13.4	1	20	13	12	20-3,120
Slide Creek	1.9	0	0	1	1	3,907
Total	31.5	2	25	24	29	

North Umpqua Hydroelectric Project

PACIFICORP

Figure 8-1

Existing Wildlife Crossing Opportunities



Map prepared by: VESTRA MapMaker, Redding, CA July 06, 1994 Copyright (C) 1994 PacifiCorp NAD83, Int. Feet, OR State Plane, S. Zone

Legend

- Wildlife Bridge
- Vehicle Bridge
- Flume Trestle
- Foot Bridge
- Transmission Line
- Road, State Highway
- Road, Class 2
- Township/Range Line
- Stream-Perennial
- River, Lake, Pond & Reservoir
- Penstock & Spillway
- Waterway

Map Location

NORTH

0 1 2 3 Miles

(Scale 1:96,000)

Timber harvest

Of the 1,029,449 acres in the Umpqua National Forest, 729,042 acres (71 percent) are considered suitable for timber production (USDA Forest Service 1990). Many areas have been clear-cut and stands in various successional stages occur throughout the North Umpqua River watershed. Recent clear-cuts likely hinder the movement of some wildlife, reduce the amount of mature forested habitat, and decrease the recruitment of LWD. Timber harvest and removal programs have also reduced the amount of LWD in many streams. About 480 hectares (1,200 acres) per year will be harvested within the study area from Umpqua National Forest and Bureau of Land Management lands, mostly within "Matrix" lands (as defined by USDA Forest Service and USDI Bureau of Land Management 1994), (J. Wieman, pers. com. 1997). However, none of this area will be harvested with the clear-cutting prescriptions applied in the past. Under the most intensive harvest prescription, 15 percent of the timber volume will be retained in each harvest unit on Forest Service and Bureau of Land Management lands. Other areas on federal lands will be harvested with thinning prescriptions that leave considerably more residual volume. The standards and guidelines in the Northwest Forest Plan also require retention of coarse woody debris—at least 73 lineal m (240 ft) of logs greater than 51 cm (20 in) in diameter per acre (USDA Forest Service and USDI Bureau of Land Management 1994).

Roads

Based on data from the Forest Service and Bureau of Land Management, there are about 4,872 km (3,028 mi) of road within the boundaries of the North Umpqua watershed. About 322 km (200 mi), or six percent, of these roads are associated with the North Umpqua Hydroelectric Project. Of these 200 mi, approximately half are required exclusively for the project; the other half are used jointly by the Forest Service and PacifiCorp. Based on traffic volume and width, State Route 138 probably represents the most significant road obstacle to wildlife movement in the watershed. Roads increase habitat fragmentation and reduce suitability of adjacent habitats. Most Forest Service roads and roads associated with the hydroelectric project are fairly narrow and unpaved and probably reduce but do not completely prevent movement by most species. However, it is possible that these roads hinder movement by terrestrial amphibians under dry conditions. In addition, some wildlife, such as big game, are known to avoid habitats adjacent to roads (Witmer et al. 1985).

8.3.4 Impacts and Trends

Existing barriers in the North Umpqua River watershed, including the project waterways, recent clear-cuts, and roads, preclude wildlife from unrestricted movement throughout the landscape. Continued timber harvest from matrix lands within the watershed is expected to decrease habitat connectivity from current conditions, with or without actions designed to offset the effects of the hydroelectric facilities. Measures implemented by the Forest Service to meet the standards and guidelines outlined in the Northwest Forest Plan (USDA Forest Service and USDI Bureau of Land Management 1994) will help to minimize the ecological impacts of timber harvest. These measures include the following: (1) road closure and restoration; (2) smaller harvest units; (3)

retention of snags, woody debris, and 15 percent of the green trees in harvest units; and (4) recovery and/or maintenance of Riparian Reserves that allow wildlife to move between large blocks of habitat (see Section 3, Aquatic and Riparian Habitat Connectivity, for a discussion of Riparian Reserves).

Under current conditions, the waterways associated with the North Umpqua Hydroelectric Project fragment habitat and reduce habitat capability, a trend which will continue for the subsequent 30- to 50-year license term if the project facilities remain in place. For some species, the project waterways may only hinder movement, requiring more energy to travel to an existing crossing opportunity. For other wildlife, the waterway may represent a complete barrier to movement, resulting in isolation of subpopulations. Intermediate effects may include reduced home range size, decreased habitat availability, and lower dispersal rates. Potential effects of the waterway on terrestrial habitat connectivity for the analysis species are summarized below.

Elk and deer

Populations of elk and deer, as well as other large mammals such as cougars, black bears, and coyotes, are probably less affected by project waterways than smaller mammals or amphibians. Project waterways do not prevent movement throughout the landscape by these two species, but may alter movement patterns or corridors, which may make individual animals more susceptible to predation or hunting mortality. Relicensing studies demonstrate that big game and other large mammals use the existing wildlife and vehicle bridges to cross the waterways, and elk have been observed jumping over gunite sections (PacifiCorp 1995). Well-used game trails lead to most of the wildlife bridges and are evident under the elevated flume trestles. Obvious game trails also parallel many sections of waterway and it appears that deer and elk travel along the waterway until they can cross on a bridge or under a flume trestle. However, heavy snow accumulation probably makes the wildlife bridges difficult for deer and elk to use at times during the winter, which may change the movement patterns of these species and increase the likelihood that they inadvertently enter the waterway and become entrapped (see Section 8.4 for information on wildlife entrapment into project waterways).

American Marten, fisher, and wolverine

Like the larger mammals discussed above, the American marten and fisher are wide-ranging species with relatively large home ranges (Buskirk and Ruggiero 1994, Powell and Zielinski 1994) and it is unlikely that the waterways represent barriers to these species. Wolverine are also wide-ranging; their distribution and movements are believed to be primarily limited by human activity (Banci 1994). However, the effects of the waterways on the movements of this species is unknown.

During relicensing studies, marten tracks were recorded on one wildlife bridge, and the species experts on the Terrestrial Subgroup believe that the existing crossing opportunities provide at least adequate habitat connectivity for marten and fisher. Martens typically use higher elevations than fishers because they are smaller and travel more easily in snow. In a study conducted on the

Umpqua National Forest, martens were detected at 16 bait stations between 1524 and 1829 m (5,000 and 6,000) ft elevation; the one fisher observation occurred at 1315 m (4,315 ft) elevation (Farrell et al. 1996). The Clearwater No. 1 and Lemolo No. 1 developments are located within habitat typically used by martens. The waterways for these developments are relatively short and do not block access to the majority of the upper elevation habitat in the watershed. Conversely, most project facilities are well within habitat potentially used by fishers in the North Umpqua River watershed. However, studies in the adjacent Rogue River drainage indicate that waterways probably do not limit fisher home range or movement. These studies have documented home ranges of two fishers that include lands on both sides of the waterway for PacifiCorp's Prospect Hydroelectric Project. This waterway is fenced for most of its length and, like North Umpqua project waterways, has a number of elevated sections and wildlife bridges; there are at least three elevated sections that fishers are known to cross (K. Aubry, pers. com. 1996).

Ringtail

As a medium-sized mammal, the ringtail has the ability to move across longer distances than smaller species. However, this species has a relatively small home range (approximately 2.6 sq km, or 1 sq mile for males; less for females); greater distances are covered during the breeding season but are usually restricted to a single drainage (T.Farrell pers com. 1997). Although very little is known about ringtails in the project vicinity, the species is known to occur along the North Umpqua River from Winchester to Toketee (T. Farrell pers com. 1997). This species would probably use existing crossings, and it is likely that the waterways pose an impediment but not a barrier to movement.

Terrestrial amphibians and small mammals

Habitat fragmentation probably has the greatest effect on terrestrial amphibians and small mammals, which typically have limited dispersal abilities and are often patchily distributed. The terrestrial amphibians and small mammals selected as analysis species all lack the ability to move large distances but represent a range of distribution patterns. The red tree vole in particular tends to occur in very clumped populations within suitable habitat (B. Biswell, pers. com. 1996). The suitable habitat of the clouded salamander is typically patchy, leading to a patchy distribution of the species (Gilbert and Allwine 1991, Nussbaum et. al. 1983, Amphibian Working Group 1996). Western red-backed voles are generally more widely distributed within suitable habitat (Mammal Working Group 1996); nonetheless, they are considered to be sensitive to habitat fragmentation.

Based on the professional judgement of the species experts, the project waterways would probably not substantially fragment the habitat of small mammals and terrestrial amphibians if suitable and frequent crossing structures existed. Voles and other small mammals have been observed crossing streams on logs and roads; amphibians are frequently observed on roads on rainy nights. It is unknown, however, if small mammals and amphibians use the existing wildlife, road, and foot bridges over project waterways. Lack of cover and suitable microclimate at the approaches to some bridges and on the bridges themselves may deter animals from using them or may make the animals vulnerable to predation while crossing (M. Hayes 1996). In addition, the

approach to some of the existing wildlife bridges may act as drift fences that redirect small animals into the waterways rather than onto the bridges (see Section 8.4 for information on wildlife entrapment into project waterways). The 25 flume trestles probably provide the only suitable opportunities for these species to cross project waterways.

Terrestrial mollusks

Several species of terrestrial mollusks that may be sensitive to forest fragmentation potentially occur in the study area. However, very little is known about their distribution, habitat requirements, and vulnerability to the types of impediments and barriers that occur in the study area.

8.3.5 Management Options

In addition to the "no-action" option, nine specific management options—five single-action options and four combinations—were evaluated for addressing terrestrial habitat connectivity for wildlife. These management options focus on project waterways; improvements to penstocks in selected locations could increase habitat connectivity for large animals, particularly elk, as well as for small animals in locations where the penstock is on or very close to the ground. The guidelines for crossing frequency applied to waterways could also be applied to penstocks. Improvements are likely to be relatively minor actions (for example, cutting a ditch perpendicular to the penstock) and can be added to any option selected by the Resource Team.

The following section presents the ten management options for terrestrial habitat connectivity that were developed and evaluated by the Terrestrial Subgroup. Table 8-2 lists these management options and summarizes the benefits and costs associated with each, along with preliminary rankings by the Terrestrial Subgroup of the ability of each options to meet the defined management goal. Detailed information on cost estimation is provided in Attachment 8-1 (cost per unit included materials, equipment, and labor for construction and installation) The costs associated with each option are estimates and are presented primarily for comparison purposes. More accurate estimates will be prepared for the Resource Team as needed to facilitate decision-making. A comparative discussion of the costs and benefits of each option is presented at the end of this section.

Options other than those presented in this section to meet the management goal are possible and can be developed by combining fewer or more of the components (such as wildlife bridges) described in Options 2 through 10. Likewise, the monitoring plans for a given option can be made less or more intensive based on the desired degree of certainty that the implemented option will be successful. The Resource Team, in consultation with the Scientific Team, will determine what combination of measures and monitoring best address the management goal for terrestrial habitat connectivity.

Table 8-2. Comparison of benefits and costs of management options for terrestrial habitat connectivity.

Management Option	Gain for Large Mammals	Gain for Marten, Fisher, Wolverine & Ringtail	Gain for Small Mammals & Amphibians	Construc-tion & Installation Costs ($)	Testing & Monitor-ing Costs ($)	Total Cost ($)	Relative Rank	Ranked Ability to Meet Mgmt Goals
1. No Action	0	0	0	0	0	0	1	1
Single Action Options								
2. Install New 8-Foot Wide Wildlife Bridges	+26 crossings	+26 crossings	0	122,000	27,000	149,000	2	5
3. Expand Existing Wildlife Bridges to 12 Feet	0	0	+29 crossings	114,000	92,000	206,000	2	5
4. Install New 12-Foot Wide Wildlife Bridges	+26 crossings	+26 crossings	+26 crossings	160,000	106,000	266,000	3	30
5. Install 1- to 2- Foot Wide Crossing Structures	0	+238 crossings	+238 crossings	245,000 to 906,000	168,000	413,000 to 1,073,000	3	10-30[1]
6. Cover Gunite Waterway Sections	+21.7 miles	+21.7 miles	+21.7 miles	23,946,000 to 57,861,000	0	23,946,000 to 57,860,000	8	100
Combination Options								
7. Expand Existing Wildlife Bridges to 12 Feet Wide and Install New 12-Foot Wide Wildlife Bridges (Options 3+4)	+26 crossings	+26 crossings	+55 crossings	274,000	198,000	471,954	4	40

[1] A range is given for this option because a range of opinions was held by the Terrestrial Subgroup.

Management Option	Gain for Large Mammals	Gain for Marten, Fisher, Wolverine & Ringtail	Gain for Small Mammals & Amphibians	Construc-tion & Installation Costs ($)	Testing & Monitor-ing Costs ($)	Total Cost ($)	Relative Rank	Ranked Ability to Meet Mgmt Goals
8. Install New 12-Foot Wide Wildlife Bridges and 1- to 2- Foot Crossing Structures (Options 4+5)	+26 crossings	+264 crossings	+238 crossings	405,000 to 1,066,000	274,000	679,000 to 1,340,000	5	60
9. Expand Existing Wildlife Bridges to 12 Feet Wide, Install New 12-Foot Wide Wildlife Bridges and 1 to 2- Foot Crossing Structures (Options 3+4+5)	+26 crossings	+264 crossings	+293 crossings	518,000 to 1,179,000	367,000	885,000 to 1,545,000	6	70
10. Cover Portions of Gunite Canal Sections and Install New 12-Foot Wide Wildlife Bridges and 1 to 2- Foot Crossing Structures in Selected Locations	+6.8 miles and +5 crossings	+6.8 miles and +117 crossings	+6.8 miles and +117 crossings	7,644,000 to 18,583,000	171,000	7,815,000 to 18,754,000	7	90

Management Option 1: No action

Under the "no action" option, no new measures to improve terrestrial habitat connectivity would be implemented.

Physical description
The existing structures that provide opportunities for wildlife to cross the waterways would be maintained. These include 29 wildlife bridges (8 ft wide), 24 vehicle bridges, two foot bridges, and 25 flume trestle underpasses.

Achievement of management goal
The "no action" option would not likely meet the management goals of maintaining terrestrial habitat connectivity and landscape linkages for all wildlife species. Big game and larger mammals would continue to use the existing bridges and flume trestle underpasses to cross project waterways; the 25 flume trestle underpasses would continue to provide the only suitable crossing opportunities for many small mammals and amphibian species.

Potential monitoring strategy
No monitoring would be required under Option 1 because no new actions would be taken under this option, and previous studies already provide information on the use of the existing wildlife crossings.

Cost
There would be no cost associated with Option 1.

SINGLE-ACTION OPTIONS

Management Option 2: Install new 2.4-m (8-ft) wildlife bridges

Management Option 2 would involve installation of 26 new, 8-ft wide wildlife bridges across project waterways, as proposed in PacifiCorp's license application for the North Umpqua Project (PacifiCorp 1995). Installation of bridges and underpasses is a common and effective method of facilitating movement of some species through areas bisected by waterways (Fry 1983, Fry et. al 1984, White 1984, Miller 1986). An analysis conducted during relicensing identified 26 specific location where additional bridges would improve connectivity for big game (PacifiCorp 1995). Deer will use bridges 4 to 6 ft wide (Miller 1986) but 8 ft is the recommended minimum (Lathum and Verzuh 1971).

Physical description
As proposed in the relicensing application, the new wildlife bridges would be designed primarily for big game use and would be 8 ft wide, with dirt surfaces and bollards to prevent vehicle access. Bridges would be located according to the criteria developed in the license application and would result in three new crossing opportunities along Fish Creek, two along Clearwater No. 1, seven along Clearwater No. 2, and 14 along Lemolo No. 2 (PacifiCorp 1995). Installation of the new

bridges would reduce the distance between most crossing opportunities to about 152 m (500 ft), substantially less than the 400 m (1,312 ft) maximum distance between bridges recommended for deer in the literature (Thelander et al. 1985).

Achievement of management goal
The management goal would be partially met by Management Option 2. The most suitable opportunities for small mammals and amphibians to cross project waterways would continue to be provided only by the 25 flume trestle underpasses. However, the new bridges would improve habitat connectivity for species that can travel relatively long distances and cross areas with little cover, including big game and other large and medium-sized mammals.

Potential monitoring strategy
The purpose of the monitoring program for Option 2 would be to determine use of the new bridges. Monitoring would be accomplished by counting tracks on the new bridges and mapping game trails adjacent to the waterway. Track counts would be initiated one year following installation to allow wildlife to habituate to the locations of the new bridges, and would be conducted four times per year (once per season) for two years. To gain a better understanding of connectivity throughout the project vicinity, track counts would also be conducted on existing wildlife bridges. In addition, game trails would be mapped and compared to those recorded prior to installation of the new bridges. Because the objectives of Management Option 2 are directed primarily at big game and because the proposed bridge design was evaluated as part of relicensing studies, the monitoring for this option could be less intensive than for some of the other options.

At the completion of the monitoring program (three years after installation), PacifiCorp would meet with biologists from the Oregon Department of Fish and Wildlife and Forest Service and/or other species experts to review the track count and game trail data. The results of this assessment would be used to determine whether the additional bridges provide sufficient crossing opportunities for big game and larger mammals.

Costs
The total cost of Management Option 2 is estimated at $149,000 (see Attachment 8-1 for costing details).

Management Option 3: Expand existing wildlife bridges to 3.7 m (12 ft)

Management Option 3 involves modifying the 29 existing wildlife bridges to provide waterway crossing opportunities for small mammals and terrestrial amphibians.

Physical description
Under Management Option 3, a 1.2-m (4-ft) wide extension (precast concrete slab) would be added to one side of each wildlife bridge. This extension would be covered with native soil and debris (for example, bark and twigs). A log (about 0.4 m [14 in] in diameter) would also be placed on the extension to provide additional cover. It is unknown whether vegetation would

establish itself on the crossing structure. Schematic drawings and detailed information are provided in PacifiCorp (1997).

Achievement of management goal

Overall, Management Option 3 would improve habitat connectivity for small mammals and amphibians but not for big game or large mammals. Currently, the most suitable opportunities for small mammals and amphibians to cross project waterways are provided by the 25 flume trestle underpasses. Modification of the existing wildlife bridges would make these structures more suitable for use by smaller wildlife, providing an additional 29 crossings opportunities. However, the distance between crossing opportunities would still be substantial. Data collected during relicensing studies indicate that 63 percent of all crossing opportunities, including vehicle and foot bridges, are greater than 400 m (1,312 ft) apart, an interval recommended in the literature as the maximum distance between bridges for deer (Thelander et al.1985), which are much wider-ranging than small mammals and amphibians.

Potential monitoring strategy

The purpose of the monitoring program for Option 3 would be to determine if the modified wildlife bridges are used by small mammals and amphibians. Monitoring would involve one or more of the following methods: (1) track plates at both ends of the 1.2-meter (4-foot) wide extensions; (2) traps in the center or at the ends of the extensions; and (3) remote cameras or video stations to record use. Monitoring would most likely involve a step-wise process. First, traps and/or track plates would be set; if these methods adequately document use, no additional monitoring techniques would be necessary. Traps and/or track plates would be monitored five times per week during the fall dispersal period (September to October) and spring (March to May) and would be used over a two-year period. Data collection would begin the year following installation to allow wildlife to habituate to the extensions. If little or no use is observed, remote cameras or video stations would be installed to collect data on the behavior of wildlife that approach the structures. Data would be collected during the fall and spring for one year and used to modify the design of the extension.

Costs

The total cost of Management Option 3 is estimated at $206,000 (see Attachment 8-1 for costing details).

Management Option 4: Install new 12-ft wide wildlife bridges

Management Option 4 would install 26 new wildlife bridges designed to provide waterway crossing opportunities for all wildlife—small mammals and terrestrial amphibians—as well as big game.

Physical description

Under Management Options 4, the new wildlife bridges would be 3.7 m (12 ft) wide; 2.4 m (8 ft) of which would be designed primarily for big game use with a smooth dirt surface. The remaining 1.2 m (4 ft) would be covered with native soil, debris (for example, bark and twigs), and a log

(about 0.4 m [14 in] in diameter). Bollards would prevent vehicle access. Schematic drawings and detailed information are provided in PacifiCorp (1997). Bridges would be located according to the criteria developed in the license application and would result in three new crossing opportunities along Fish Creek, two along Clearwater No. 1, seven along Clearwater No. 2, and 14 along Lemolo No. 2 (PacifiCorp 1995).

Achievement of management goal

Compared to Management Option 3, Option 4 would similarly improve habitat connectivity for small mammals and amphibians while also increasing connectivity for large wildlife. The installation of new 12-ft wide bridges would provide an additional 26 crossings opportunities for smaller wildlife as well as big game and large mammals. In addition, the new bridges would greatly reduce the average distance between crossing opportunities for big game and large mammals. The distance between crossing opportunities for small mammals and amphibians would be less than it is currently, but would still be substantial because the existing wildlife bridges are probably not suitable for these species.

Potential monitoring strategy

The purpose of the monitoring program for Option 4 would be to determine if the new wildlife bridges are used by small mammals and amphibians as well as big game. Estimated monitoring costs for this option are based on the following assumptions. Monitoring would involve a combination of the methods described for Management Options 2 and 3, including the following: (1) track counts and game trail mapping to determine big game use; (2) track plates or traps to document use by amphibians and small mammals; and (3) remote cameras or video stations, if necessary, to collect data on the behavior of wildlife that approach the structures. Results could be used to either modify the bridge design to improve use by small mammals and amphibians or relocate new bridges in areas used by big game.

Costs

The total cost of Management Option 4 is estimated at $266,000 (see Attachment 8-1 for costing details).

Management Option 5: Install 0.3- to 0.6-meter (1- to 2-ft) wide crossing structures

Management Option 5 involves constructing and installing waterway crossing structures that are 1- to 2-ft in width and designed specifically for use by terrestrial amphibians and small mammals. These structures would be constructed independently of wildlife bridges for big game.

Physical description

The Terrestrial Subgroup developed five conceptual design alternatives for 1- to 2-ft wide crossing structures potentially suitable for small mammals and terrestrial amphibians; schematic drawings and detailed information were provided by an engineering analysis (PacifiCorp 1997). Each design alternative is briefly summarized in Table 8-3 in terms of durability, aesthetics, constructability, and unit cost.

Table 8-3. Cost, durability, aesthetics, and constructability of five alternative crossing structure designs for small mammals and amphibians.

Conceptual Design Alternative	Structure Width (inches)	Unit Cost ($)[1]	Durability[2]	Aesthetics[3]	Construct-ability[4]
1. Wide flange steel beam	10	2,342	High	Low	Difficult
2. Treated timber bridge	4	1,026	Medium	Medium	Moderate
3. Timber log bridge	24	1,591	Low	High	Easy
4. Half barrel pipe	8	3,801	High	Low	Difficult
5. Treated timber beam	12	3,005	Medium	Medium	Moderate

[1] Unit Cost=Includes materials, transportation to site, site preparation, and installation; does not include mobilization costs.
[2] High = Long-term decay resistance; Medium = Decay retardant; Low = Will decay
[3] High = Color, structure, and materials mimic surroundings; Medium = Color and materials blend with surroundings; Low = Color and material contrasts with surroundings
[4] Easy, moderate, difficult based on labor, equipment, and availability of materials.

The field assessment of waterway suitability for new crossing structures (see Section 8.3.1) indicated that approximately 21.9 km (13.6 mi, or 63 percent), of the 34.9 km (21.7 mi) of gunite canal have adjacent habitat that is highly suitable for small mammals and amphibians to access the canal edges (Table 8-4). Another 5.6 km (3.5 mi, or 16 percent) of gunite canal have moderately suitable habitat on adjacent slopes. The best approach to making the waterway "porous" to all wildlife may be to locate additional crossing structures at some minimum spacing along highly suitable sections and in clusters, wherever possible, along moderately suitable sections. Specific locations for new crossings may include known sites of potential habitat for some species, such as riparian areas or intermittent streams, that are bisected by waterways.

Table 8-4. Suitability of slopes immediately adjacent to gunite canal sections for providing access to small mammals and amphibians.

Project Development	High Suitability (miles)	Moderate Suitability (miles)	Unsuitable (miles)	Total (miles)
Clearwater No.1	2.3	0	0	2.3
Clearwater No.2	1.6	0.8	1.1	3.5
Fish Creek	1.9	0.2	0.8	2.9
Lemolo No. 1	1.7	1.0	0.1	2.8
Lemolo No. 2	5.2	1.5	2.6	9.3
Slide Creek	0.9	0	0	0.9
Total	13.6	3.5	4.6	21.7

A conservative management approach might be to install the number of crossing structures along the waterways that would mimic the frequency of stream crossing opportunities that occur under reference conditions in the North Umpqua River watershed. However, the value of these crossings for wildlife is not "all-or-nothing"; providing new crossings would certainly improve conditions, even if the number of crossings is less than might be ideal. Based on data from the

literature and assuming that 50 percent of the LWD in small streams spans the channel, the number of natural stream crossings in the watershed may be about 14 per mile (see Section 8.3.2). For the purposes of estimation, if 14 crossings were installed along each of the 27 km (17 mi) of gunite canal that has highly or moderately suitable adjacent access habitat for small mammals and amphibians an additional 238 crossing opportunities would be provided for these species.

Achievement of management goal

The addition of structures specifically designed to provide crossing opportunities for small mammals and amphibians would be expected to increase habitat connectivity for these species. There is, however, some uncertainty that some species would use these smaller structures to cross the waterway. According to several of the species experts for the Terrestrial Subgroup, small and medium-sized mammals are known to cross streams on logs, many of which are relatively small in diameter. However, nothing is known about the suitability of these structures for amphibians, particularly over streams the width of the project canals. The proposed testing program described below would determine use of alterative designs by various species groups.

If one or more design alternative proves suitable and approximately 238 crossing structures were installed, Management Option 5 would provide amphibians and small mammals with 9.5 times more opportunities to cross the waterway than are currently provided by the 25 flume trestle underpasses. It is possible that these types of crossing would also be suitable for medium-sized wildlife such as marten, fisher, and wolverine. There would be no improvement in habitat connectivity for big game or large mammals under Management Option 5.

Alternative design testing program

Since very little is known about the use of crossing structures by small mammals and amphibians, a testing program would be conducted to identify the design or designs that appear to be most suitable for these species. Data from the testing program would also be used to modify structure design as necessary. The testing program would provide the same information as a monitoring and adaptive management plan, but would take place prior to full-scale construction and installation. The testing program would include the following four steps.

> Step 1. Test Location Screening. The GIS and existing data on vegetation types adjacent to the waterways would be used to identify areas with a high probability of supporting a number of small mammal and terrestrial amphibian species. In the project vicinity, mesic Douglas-fir stands at lower elevations probably represent the best habitat for these taxa. As a preliminary proposal, three areas with a high probability of supporting small mammals and terrestrial amphibians would be selected for trapping, one each along the Fish Creek, Clearwater No. 2, and Lemolo No. 2 waterways.
>
> Step 2. Test Location Trapping. The purpose of the trapping program would be to ensure that small mammals and amphibians are present in the locations selected to test the new crossing prototypes. Trapping would identify the species composition and relative abundance of small mammal and amphibian communities adjacent to both sides of the canal. Traps would be set along transects parallel to the waterway; the first transect

would be as close to the waterway as possible. Trapping would be conducted over two periods—once in early spring (wet season) and once in the late summer (dry season). Details of the trapping design and analysis would be developed in conjunction with species experts. If trapping at a selected location indicates that relatively few small mammals or amphibians are present, trapping would be repeated at alternative sites.

Step 3. Testing. Prototypes of the new crossings would be constructed and installed at the three selected test sites. Testing would involve one or more of the following methods: (1) track plates at the ends of each structure; (2) remote cameras or video stations to record wildlife that use the crossings; and (3) traps. Traps and/or track plates would be set in the center or at the ends of the five design prototypes in all three test sites. Traps and/or track plates would be checked daily during the fall dispersal period (September and October) and spring (March and May) over a two-year period. Data collection would begin the year following installation to allow wildlife to habituate to the crossings. In addition, remote cameras or video stations would be installed at each of the three sites and used to collect data on the behavior of wildlife that approach the structures. Data from the various crossing structure prototypes would be compared in terms of numbers of species and crossing frequency and would be used to select or modify one or more design alternatives.

Step 4. Crossing Design Selection. Information from the testing program would be used to select the 1- to 2-ft wide crossing structure design(s) to be installed along waterways. Test program results might also suggest modifications in design and placement of the structures along the waterway. In the event that a number of crossing structure prototypes work equally well, the least expensive design would be selected for installation.

Potential monitoring strategy

The design alternative testing program should result in adequate assurance that the new structures are effectively providing opportunities for small mammals and terrestrial amphibians to move throughout the project vicinity, thereby reducing habitat fragmentation for these species.

Costs

The total cost of Management Option 5 is estimated to range from $ 413,000 - $1,073,000 depending on the design alternative (see Appendix 8-1 for costing details).

Management Option 6: Cover gunite canal sections of waterway

Management Option 6 involves covering all 34.9 km (21.7 mi) of gunite canal, or about 69 percent of the project waterways.

Physical description

The engineering analysis identified four conceptual design alternatives for canal covers, including precast concrete panels, steel plates, circular corrugated metal pipe, and corrugated metal pipe arch. Schematic drawings and estimated costs are provided in PacifiCorp (1997). Each design

alternative is briefly described in Table 8-5 in terms of aesthetics, constructability, damage risk, accessibility, and average unit cost. Actual costs would be dependent on soils and adjacent terrain and vary by development (PacifiCorp 1997).

Table 8-5. Average cost, damage risk, accessibility, aesthetics, and constructability of alternative canal cover designs.

Conceptual Design Alternative	Average Unit Cost[1] ($/lineal ft)	Damage Risk[2]	Accessibility[3]	Aesthetics[4]	Construct-ability[5]
1. Precast concrete panels	209	Moderate	Moderate	Medium	Moderate
2. Steel plate panels	505	Moderate	Moderate	Low	Moderate
3. Circular corrugated metal pipe with earthfill	352	Low	Difficult	High	Difficult
4. Corrugated metal pipe-arch with earthfill	393	Low	Difficult	High	Difficult

[1] Unit Cost=Includes materials, transportation to site, site preparation, installation and mobilization; weighted average based on unit cost per development and length of gunite canal per development.
[2] Damage risk associated with slough/debris flows, corrosion, and animals
[3] Accessibility based on ease of maintenance
[4] High = Color, structure, and materials mimic surroundings; Medium = Color and materials blend with surroundings; Low = Color and material contrasts with surroundings
[5] Easy, moderate, difficult based on labor, equipment, and availability of materials

Achievement of management goal

Management Option 6 would greatly improve habitat connectivity for all wildlife in the project vicinity. This option would eliminate about 34.9 km (21.7 mi, or 69 percent) of the waterway that currently acts as a barrier to movement; only 13.8 km (8.6 mi, or 27 percent of the waterway) of concrete flume would remain. In addition, it is possible that covering portions of the waterway may result in decreased maintenance costs. There are, however, a few drawbacks associated with Option 6. Big game can and do occasionally enter a few sections of concrete flume (for example, when it is adjacent to steep slopes). If the gunite canals are covered these animals would have no chance of escape. In addition, fish salvage activities (as they are currently conducted) that occur in waterways during routine project maintenance may be impossible. These problems may be easily surmountable, however, and Option 6 would best meet the management goal of improving habitat connectivity.

Potential monitoring strategy

Because of the high level of certainty that this option would achieve management goals for terrestrial habitat connectivity, no monitoring other than routine facilities maintenance would be required for Management Option 6.

Costs

The cost of Management Option 6 depends on the canal cover design selected and would range

from $23,946,000 for concrete panels (lowest cost alternative) to $57,861,000 for steel panels (highest cost alternative) (see Attachment 8-1 for costing details).

COMBINATION ACTIONS

Management Option 7: Expand existing wildlife bridges to 12-ft wide and install new 12-ft wide wildlife bridges

Management Option 7 is a combination of Options 3 and 4.

Physical description
Under Management Option 7, 4-ft wide extensions would be added to the 29 existing wildlife bridges to make them more suitable for use by small mammals and amphibians. An additional 26 wildlife bridges, each 12 ft wide and suitable for use by all wildlife, would also be installed. New bridges would be located according to the criteria developed in the license application (PacifiCorp 1995). Schematic drawings and detailed information are provided in PacifiCorp (1977).

Achievement of management goal
Management Option 7 would provide greater habitat connectivity for small mammals and amphibians than Options 3 or 4 separately. The improvement to connectivity for big game would be identical to Option 4 and greater than Option 3. Modification of the 29 existing bridges and installation of 26 new 12-ft wide bridges would provide additional crossing opportunities for all wildlife—26 new opportunities for big game and larger mammals and 55 for small mammals and terrestrial amphibians. As a result, the distance between most adjacent crossing opportunities would be reduced to 152 m (500 ft) or less for all wildlife.

Potential monitoring strategy
The purpose of the monitoring program for Option 7 would be to determine use of the 29 expanded and 26 new wildlife bridges. Monitoring would involve a combination of the methods described for Management Options 3 and 4, including: 1) track counts and game trail mapping to determine big game use; 2) track plates or traps to document use by amphibians and small mammals; and 3) remote cameras or video stations, if necessary, to collect data on the behavior of wildlife that approach the structures. Results would be used to either modify the bridge design to improve use by small mammals or amphibians or relocate new bridges in areas used by big game (see Options 3 and 4 for details).

Costs
The total cost of Management Option 7 is estimated at $472,000 (see Attachment 8-1 for costing details).

Management Option 8: Install additional 12-ft wide wildlife bridges and 1- to 2-ft wide crossing structures

Management Option 8 is a combination of Options 4 and 5.

Physical description
Management Option 8 involves installation of 26 new 12-ft wide bridges for big game and 238 crossing structures designed specifically for small mammals and amphibians (1- to 2-ft wide). As discussed under Option 5, the number of crossings for small mammals and amphibians could be varied; providing fewer than 238 crossings could still be beneficial for wildlife.

Achievement of management goal
Management Option 8 would increase habitat connectivity in the project vicinity for all wildlife-big game as well as smaller species.

Alternative design testing program
Management Option 8 would require a program to test alternative crossing structures designs for use by small mammals and amphibians. This program would be identical to that described for Management Option 5.

Potential monitoring strategy
The monitoring plan for Option 8 would be identical to that of Option 4.

Costs
The cost of Management Option 8 is estimated as the combined costs of Options 4 ($266,000) and 5 ($413,000 to $1,073,000) and thus is estimated to range from $679,000 to $1,340,000 (see Attachment 8-1 for costing details).

Management Option 9: Expand existing wildlife bridges to 12-ft wide and install new 12-ft wide wildlife bridges and 1- to 2-ft wide crossing structures

Management Option 9 is a combination of Options 5 and 7 (which represents a combination of Options 3 and 4).

Physical description
Management Option 9 involves three components: (1) expansion of the existing wildlife bridges from 8 ft to 12 ft; (2) installation of 26 new 12-ft wide bridges; and (3) installation of 238 crossing structures, each 1 to 2 ft wide and designed specifically for small mammals and amphibians. As discussed under Option 5, the number of crossings for small mammals and amphibians could be varied; providing fewer than 238 crossings would still be beneficial for wildlife.

Achievement of management goal
Management Option 9 would increase habitat connectivity in the project vicinity for all wildlife—

big game as well as smaller species. With the exception of covering all or portions of the gunite canal sections of the waterway (Options 6 and 10), Management Option 9 would provide more opportunities for wildlife to cross project waterways than any other option.

Alternative design testing program
Management Option 9 would require a program to test alternative crossing structures designs for use by small mammals and amphibians. This program would be identical to that described for Management Option 5.

Potential monitoring strategy
The monitoring plan for Option 8 would be identical to that of Option 7, which represents a combination of Options and 3 and 4 and the associated economies of scale.

Costs
The total cost of Management Option 9 is the combined costs of Options 5 ($413,000 to $1,073,000) and 7 ($472,000) and thus is estimated to range from $885,000 to $1,545,000 (see Attachment 8-1 for costing details).

Management Option 10: Cover portions of gunite canal sections and install new 12-ft wide wildlife bridges and 1 to 2-ft wide crossing structures in selected locations

Management Option 10 combines Option 8 (which is a combination of Options 4 and 5) with covering selected sections of gunite canal.

Physical description
Management Option 10 involves 3 components: (1) covering sections of gunite canal along the Lemolo No. 2 and Clearwater No. 2 waterways that have highly suitable adjacent access habitat for small mammals and amphibians; (2) installation of five new 12-ft wide bridges along the Clearwater No. 1 and Fish Creek waterways, as is currently proposed in the license applications; and (3) installation of 1- to 2-ft wide crossing structures along gunite canal sections with highly and moderately suitable access habitat for small mammals and amphibians adjacent to the Clearwater No. 1, Lemolo No. 1, Fish Creek, and Slide Creek waterways (14 per mile). Details for each project development are provided in Table 8-6.

Table 8-6. Details of Management Option 10 by project development.

Project Development	Miles of Gunite Canal Covered	No. New 12-Foot Wide Bridges	No. of 1 to 2-Foot Wide Crossing Structures
Clearwater No. 1	0	2	32
Clearwater No. 2	1.6	0	0
Fish Creek	0	3	29
Lemolo No. 1	0	0	38
Lemolo No. 2	5.2	0	0
Slide Creek	0	0	13
Total	6.8	5	112

The Lemolo No. 2 and Clearwater No. 2 canal sections were selected for covering for two primary reasons. First, these developments have the longest waterways and bisect lower-elevation habitats that support more species than the lodgepole pine habitats that border the higher elevation waterways (Lemolo No. 1 and Clearwater No. 1). In addition, the Lemolo No. 2 and Clearwater No. 2 waterways closely parallel the North Umpqua and Clearwater rivers in many places, severing linkages between upland and riparian habitats.

Achievement of management goal

Management Option 10 would increase habitat connectivity in the project vicinity for all wildlife—big game as well as smaller species. With the exception of covering all of the gunite canal associated with the project (Option 6), Management Option 10 would provide more opportunities for wildlife to cross project waterways than any other option.

Alternative design testing program

Management Option 10 would require a program to test alternative crossing structures designs for use by small mammals and amphibians. This program would be identical to that described for Management Option 5.

Potential monitoring strategy

The monitoring plan for Option 10 would be identical to that of Option 2, but would involve fewer bridges and therefore require less time.

Costs

The total cost of Management Option 10 is estimated to range from $7,816,000 to $18,753,000, depending on the various design alternatives selected for canal covers and 1- to 2-ft wide crossing structures (see Attachment 8-1 for costing details).

Management option cost-benefit summary

The costs and benefits of the ten management options are summarized in Table 8-2. These cost figures likely represent minimums for each management option, because they do not include the costs of any adaptive management actions that could result from data obtained from monitoring

studies. Several of the management options summarized in this table represent certain combinations of actions and numbers of crossings; additional options can be developed based on different combinations of actions and numbers of crossings. The associated costs would change as the options are tailored to increase or decrease the magnitude or complexity of the management actions. Increasing or decreasing the intensity of the monitoring and/or testing programs described for each of the management options would also change the associated costs.

The Terrestrial Subgroup ranked each of the management options using one set of criteria and two different ranking methods. Ranking criteria were: (1) the frequency of crossing opportunities provided by the option; (2) the number of species groups for which the option improves connectivity; and (3) confidence in the suitability of the crossing type or types included in the option for most species groups. The first ranking method involved comparing the management options in terms of their relative ability to improve terrestrial habitat connectivity over current conditions. The option that was believed to improve terrestrial habitat connectivity the most was given the highest rank; conversely, the option believed to provide the least improvement was assigned a rank of 1. Although there are 10 management options, 8 represents the highest comparative rank because the Terrestrial Subgroup believed that several options were very similar (see Table 8-2). The second ranking method involved an assessment of the relative ability of each management option to meet the management goals and standards as well as guidelines of the Northwest Forest Plan. The option that came closest to restoring habitat linkages affected by project waterways to the greatest extent possible, was determined to fully meet the management goal and was assigned a rank of 100 (Table 8-2). Options that do not fully meet the management goal were assigned ranks from 1 to 99, depending on the number and suitability of crossing structures and the number of species group for which habitat linkages would be increased.

8.3.6 Overlapping Issues

The problem of wildlife entrapment is believed to be related to terrestrial habitat connectivity because animals may fall into canals when they attempt to cross the waterway where no bridge, underpass, or other crossing structure exists. In addition, some options that address terrestrial habitat connectivity may also enhance riparian habitat connectivity.

8.4 WILDLIFE ENTRAPMENT

As defined in the initial scoping process, a management goal for the watershed is to create a waterway system that has insignificant effects on populations of wildlife species in the project vicinity and that minimizes entrapment-related injury and mortality of individuals animals.

8.4.1 Analytical Methods

All terrestrial amphibian, reptile, and mammal species in the vicinity of the North Umpqua Project are potentially affected by entrapment in waterways. The effect is probably most detrimental, however, to species with long generation times, limited dispersal ability, and/or low population

densities and patchy distribution.

In addition to the methods described previously (professional judgement and engineering analysis) in Section 8.2, the analysis of entrapment included a review of relevant literature, existing data, and relicensing study results. The purpose of reviewing literature and existing data was to obtain information related to reference conditions, current conditions and potential project impacts within the North Umpqua River watershed. Primary sources of data, particularly for current conditions, were the results of the terrestrial resource studies conducted in support of relicensing the North Umpqua Project and summarized in PacifiCorp 1995 (Volumes 5, 33, and 34). The license application was reviewed for the following information relating to entrapment: (1) records on the species and number of individuals entrapped; (2) waterway structural characteristics (e.g. length of gunite canal); and (3) the locations of existing wildlife escapes. Other key sources of information on current conditions as well as reference conditions and future trends in the North Umpqua drainage, were the Northwest Forest Plan (USDA Forest Service and USDI Bureau of Land Management 1994) and the Land Resource Management Plan for the Umpqua National Forest (USDA Forest Service 1990).

8.4.2 Reference Conditions

Prior to construction of the North Umpqua Hydroelectric Project, there were probably no sources of entrapment comparable to the waterways in the North Umpqua River watershed. Under reference conditions, wildlife may have occasionally entered streams or rivers in flood stage and been swept downstream, unable to escape due to high velocities and cold temperatures. Although such conditions would kill some number of individuals of any given species, it is unlikely that populations were affected.

8.4.3 Current Conditions

Compared to reference conditions, waterways associated with the North Umpqua Project have increased the potential for entrapment and related mortality. Based on data collected by PacifiCorp between 1983 and 1993, approximately 11 deer and four elk die annually in project waterways; indirect losses of stressed or injured animals that escape the waterway may also occur but numbers are unknown. Mortality varies from year to year and appears to be highest when deep snow causes large concentrations of big game to use habitats near the waterways (PacifiCorp 1995). Because of larger resident populations and smaller body size, deer are more susceptible to entrapment and mortality compared to elk. Direct observation and tracks also indicate that elk can avoid entrapment by jumping over canals in places; successfully jumping over canals is more difficult for deer, which are significantly smaller (PacifiCorp 1995). The Fish Creek, Clearwater No. 2, and Lemolo No. 2 waterways cause the most big game mortality, probably due to the heavy use that habitats adjacent to these areas receive during the winter.

Overall, the degree to which species other than big game are entrapped by project waterways is unknown. Other wildlife species, including small mammals, amphibians, and reptiles occur adjacent to the waterways and are potentially affected by entrapment. PacifiCorp's data on

entrapment indicate that one cougar and one beaver have been killed in the Slide Creek waterway since 1983. Small mammals, amphibians, and reptiles are not well represented in the entrapment data because their small size precludes easy observation in waterways or capture on trash racks, which is where project operators record the majority of entrapment-related mortality.

No studies of wildlife entrapment in water project canals for a similar situation to the North Umpqua have been conducted. A study conducted after construction of the Central Arizona Project (CAP) indicated that entrapment in canals can be a source of substantial mortality for small mammals and reptiles. There are, however, several significant differences between the CAP and the North Umpqua Project. First, the CAP traverses an extremely arid landscape and several studies suggest that big game entrapment may be related to attempts to use the canal as a source of drinking water (Busch et. al 1984). It is possible that other wildlife in arid areas are attracted to canals as water sources and become entrapped. Second, the CAP study was conducted for several weeks immediately following the start of canal operations, a time which is likely to show the greatest rates of entrapment because wildlife have not habituated to this new feature on the landscape. Conversely, waterways associated with the North Umpqua Project have been in place for 50 years. Although summers can be dry in the North Umpqua River watershed, it is unlikely that wildlife typically attempt to drink from project waterways because streams and other water sources are widespread in the vicinity. Entrapment in the North Umpqua Hydroelectric Project waterways is most likely associated with wildlife movement, dispersal, and predator avoidance.

8.4.4 Ecological Impacts

The effects of current levels of entrapment on wildlife populations are unknown because no studies have been conducted for the North Umpqua Hydroelectric Project. The professional opinions of the members of the Terrestrial Subgroup regarding the potential impacts of entrapment were mixed. Several, but not all, of the species experts in the subgroup believed that the primary effects of entrapment on wildlife occurred 50 years ago when the project was first constructed, and that ongoing entrapment may not significantly affect current populations. However, because of the uncertainty associated with this assessment, some members of the subgroup judged that it was most appropriate to assume that significant impacts on populations may be occurring.

There are, in addition to entrapment, a number of other activities associated with human development and use of natural resources that potentially affect wildlife populations in the North Umpqua River watershed. Direct sources of wildlife mortality include vehicle collisions, particularly on State Route 138; hunting (for big game only) and trapping. Habitat loss probably represents the most significant indirect effect on wildlife populations. Hunting and trapping are not anticipated to increase in the relatively near future (USDA Forest Service 1990). Traffic on State Route 138, however, is likely to increase and will probably result in higher rates of wildlife-vehicle collisions and greater mortality. In addition, recreation-related development and timber harvest in the North Umpqua River watershed are projected to continue through the next relicensing period, resulting in habitat loss and decreased carrying capacity for some species.

Over the next 30 years it is difficult to predict if wildlife mortality from entrapment will change significantly from current conditions or if any changes will affect populations. Wildlife mortality from entrapment may increase or decrease depending on changes in adjacent habitat conditions and project operations; population effects may result from the cumulative effects of entrapment, other sources of mortality, and habitat loss. As proposed in the license application, PacifiCorp is considering nighttime shutdowns of several of the up-river developments, including Clearwater No. 1 and Lemolo Nos. 1 and 2 to provide for better operational efficiency. Nighttime shutdowns would result in substantially decreased flows in the waterways associated with these developments. At this time it is unknown whether nighttime shutdowns will occur, the specific developments that would be affected, and whether or not decreased flows in the waterway would affect mortality due to entrapment.

8.4.5 Management Options

Seven different management options—five single-action options and two combinations—were evaluated, in addition to a "no-action" option, for addressing wildlife entrapment in project waterways. The following section presents the eight management options to reduce entrapment that were developed and evaluated by the Terrestrial Subgroup. Table 8-7 lists these management options and summarizes the benefits and costs associated with each, along with preliminary rankings by the Terrestrial Subgroup of the ability of each options to meet the defined management goal. Detailed information on cost estimation is provided in Attachment 8-1; the costs associated with each option are estimates and are presented primarily for comparison purposes. More accurate estimates will be prepared for the Resource Team as needed to facilitate decision-making. A comparative discussion of the costs and benefits of each option is presented at the end of this section.

In addition to these options presented in this section, others are possible and can be constructed by combining fewer or more of the components (such as escape structures). Likewise, the monitoring plans for a given option can be made less or more intensive, based on the desired degree of certainty that the implemented option will be successful. The Resource Team of the watershed analysis, in consultation with the Scientific Team, will determine the combination of measures and monitoring that best address the management goals for entrapment.

Management Option 1: No action

Under the "no action" option, no new measures to reduce entrapment would be implemented.

Physical description
The existing structures that provide opportunities for wildlife to move throughout the North Umpqua River watershed without entering the waterways would be maintained. These include 29 wildlife bridges (8 ft wide), 24 vehicle bridges, 2 foot bridges, and 25 flume trestle underpasses.

Table 8-7. Comparison of benefits and costs of management options for wildlife entrapment

Management Option	Less Entrap-ment of Large Mammals	Less Entrap-ment of Marten, Fisher, Wolverine & Ringtail	Less Entrap-ment of Small Mammals & Amphibians	Construc-tion & Installation Costs ($)	Testing & Monitor-ing Costs ($)	Total Cost ($)	Compar-ative Rank	Ranked Ability to Meet Mgmt. Goals
1. No Action	0	0	0	0	0	0	1	1
Single Action Options								
2. Install Escape Ramps and Incorporate a Passive Escape Design in Selected Portions of Gunite Canal	Likely	Possibly	Not likely	241,000	55,000	296,000	2	10
3. Conduct a Study of the Effectiveness of Wildlife Bridges to Reduce Entrapment	?	?	?	(none)	155,000 to 926,000	?	4?	35?
4. Construct a "Lip" Along Suitable Gunite Canal Sections	Not likely	Possibly	Likely	988,000 to 1,617,000	79,000	$1,068,000 to $1,696,000	5	65
5. Construct a Canal "lip" in Association with 12-Foot Wide Wildlife Bridges	Not likely	Possibly	Likely	39,000 to 120,000	70,000	109,000 to 190,000	3	20
6. Cover Gunite Waterway Sections	Definitely	Definitely	Definitely	23,946,000 to 57,861,000	0	23,946,000 to 57,861,000	8	100

Management Option	Less Entrap-ment of Large Mammals	Less Entrap-ment of Marten, Fisher, Wolverine & Ringtail	Less Entrap-ment of Small Mammals & Amphibians	Construc-tion & Installation Costs ($)	Testing & Monitor-ing Costs ($)	Total Cost ($)	Compar-ative Rank	Ranked Ability to Meet Mgmt. Goals
Combination Options								
7. Construct a "Lip" Along Suitable Gunite Canal Sections, Install Escape Ramps, and Incorporate a Passive Escape Design in Selected Sections of the Fish Creek Waterway (2+4)	Likely	Possibly	Likely	1,229,000 to 1,858,000	134,000	1,364,000 to 1,992,000	6	75
8. Cover Portions of Gunite Canal Sections and Construct a "Lip" in Association with 12-Foot Wide Wildlife Bridges.	Definitely	Definitely	Definitely	7,543,000 to 18,251,000	70,000	7,613,000 to 18,322,000	7	80

Achievement of management goal
The "no action" option is not likely to meet the management goal of creating a waterway system that has insignificant effects on populations of wildlife and minimizes entrapment-related injury and mortality. It is not known if it would meet the goal of having a system that has insignificant effects on wildlife populations because there are no data on whether the waterways are currently having such effects.

Potential monitoring strategy
Because no new actions would be taken under Option 1 no monitoring would be required.

Cost
There would be no cost associated with Option 1.

SINGLE-ACTION OPTIONS

Management Option 2: Install escape ramps and incorporate a passive escape design in selected sections of gunite canal

Management Option 2 would involve installation of 11 new escape ramps along project waterways and modification of 305 m (1,000 ft) of canal to incorporate a passive escape design. These measures were both proposed in PacifiCorp's license application for the North Umpqua Project (PacifiCorp 1995). Properly designed escapes, when combined with deflection booms, have been shown to effectively reduce wildlife mortality, particularly that of deer, resulting from entrapment in canals (Fry 1983, 1984, Miller 1986, Horak and Olson 1981, Krausman and Rautenstrauch 1984, Lathum and Verzuh 1971).

Physical description
As proposed in the relicensing application, the new wildlife escapes would be ramps designed primarily for big game use and would be combined with deflection booms. Eleven escapes would be constructed—five at the transitions between Fish Creek, Clearwater Nos. 1 and 2, Lemolo Nos. 1 and 2 waterways and their respective forebays (including the proposed Lemolo No. 1 forebay expansion) and six at sites preceding hazard locations such as steel trestles and long sections of concrete flume. Escapes at the forebay/waterway transitions would allow wildlife to exit waterways before encountering the forebay energy dissipating structures. These structures result in turbulent water that can cause weakened animals to drown. A prototype escape was constructed at the Fish Creek waterway/forebay transition in 1996 but has not yet been tested.

The passive escape design proposed by PacifiCorp would consist of a large step midway up one side of the canal wall for at least 61 m (200 ft), allowing animal to exit with any amount of water. This design would be incorporated into five sections of the Fish Creek waterway for a total of 305 m (1,000 ft). This waterway was selected because it has: (1) the highest big game mortality of any development; (2) long sections of gunite canal through areas that are heavily used by deer and elk during the winter; and (3) sections of gunite canal that are scheduled for upgrading.

Achievement of management goal
The management goal for reducing entrapment would be partially met by Management Option 2. The new escape ramps and passive escape design would reduce entrapment-related mortality by providing more opportunities for wildlife, particularly large and medium-sized mammals, to exit waterways. These structures, however, would probably not reduce entrapment or provide suitable escape opportunities for small mammals or amphibians.

Potential testing program
Because very little is known about the use of escape ramps and/or the proposed passive escape design for wildlife, a testing program would be conducted to determine use and identify potential design modifications. The testing program would provide the same information as a monitoring and adaptive management plan, but would take place prior to full-scale construction and installation. Testing would be accomplished by installing video stations to collect data on the behavior of entrapped wildlife that approach the escape currently in place at the Fish Creek waterway/forebay transition and one section of canal with the passive escape design. Given the difficulty of observing small wildlife in the high velocity flows of the waterways, this method is expected to document use only by large and medium-sized mammals.

Potential monitoring strategy
The testing program should result in adequate assurance that the new escapes and passive escape design effectively providing opportunities for wildlife to exit the waterways. PacifiCorp's current program of tracking mortality of big game in project waterways would continue throughout the new license period.

Costs
The total cost of Management Option 2 is estimated at $296,000 (see Attachment 8-1 for costing details).

Management Option 3: Conduct a study of the effectiveness of wildlife bridges to reduce entrapment

Several of the species experts for the Terrestrial Subgroup suggested that entrapment might be reduced by increasing the number of opportunities for wildlife to cross project waterways. Management Option 3 involves testing this hypothesis by conducting a study of entrapment in conjunction with any of the management options for terrestrial habitat connectivity that includes expansion of existing bridges or installation of new bridges and/or 1- to 2-ft wide crossing structures (Terrestrial Habitat Connectivity Options 2-5 and 7-9).

Physical description
Management Option 3 assumes that the Resource Team has selected one of the eight options for improving terrestrial habitat connectivity and consists of the following four steps.

- Design and conduct a study to determine current baseline levels of wildlife entrapment in project waterways.

- Estimate the significance of entrapment effects on species populations based on observed levels of entrapment.

- Implement management option selected to improve terrestrial habitat connectivity.

- If the baseline study indicates potentially significant population affects from entrapment, conduct follow-up study to determine entrapment levels with expanded and/or new wildlife bridges or crossing structures.

Each of these steps is described below.

Step 1: Conduct Baseline Entrapment Study. The most comprehensive way to study entrapment probably involves installation of nets, similar to the ones used in PacifiCorp's fish entrainment work, in each of the six project waterways with open waterways. These nets would be installed in eight locations—the penstock entrances for the Lemolo No. 1 and Slide Creek developments and the diversion/waterway and waterway/forebay transitions for the Lemolo No. 2, Clearwater Nos. 1 and 2 and Fish Creek developments. Nets in these locations would allow wildlife entrapment in waterways to be distinguished from those entrained at diversion points. The study would be conducted for one year and would involve checking the nets at least once per day. Nets may need to be removed or monitored more frequently during storm events when there is a high probability of debris clogging the nets, resulting in water overtopping the canal. Nets at waterway/forebay transitions are of particular concern because the entire canal would drain after plant shutdown and there is no nearby spillway to divert the flows. There are existing overflow chutes on the Lemolo No. 2 and Fish Creek waterways which might be good sites for net placement.

Another method for studying entrapment would involve installation of pitfall traps along the edges of the canals. This study would be designed in conjunction with the species experts for the Terrestrial Subgroup. It is likely that traps would be installed only along portions of the 27 km (17 mi) of gunite canal that have adjacent slopes with habitat that is highly or moderately suitable for small mammals and amphibians to access canal edges (See Table 8-3); actual trap locations would be determined using a stratified sampling design. About 9 m (30 ft) of drift fence would be installed with each trap (Jones et al. 1996). Traps would be checked daily during the spring, summer, and fall. The primary disadvantage of this method is that the traps would capture all small mammals and amphibians that venture to the canal edge, not just those that would become entrapped. In addition, pitfall traps would not provide any information on entrapment of medium-sized mammals. However, this method is likely to be considerably less expensive than nets and would not interfere with project operations.

Step 2: Estimate Entrapment Effects of Populations. One of the most difficult aspects of

Option 3 will be interpreting the study results and evaluating whether or not entrapment significantly effects wildlife populations. This step will involve consulting with the species experts of the Terrestrial Subgroup to interpret results and may require additional studies to estimate population parameters of species found to be entrapped before significance can be estimated. Population studies would probably require several years of intensive trapping in habitats adjacent to the waterways using mark-recapture techniques.

Step 3: Implement Terrestrial Habitat Connectivity Management Option. Following the study to estimate baseline entrapment, the management option selected to improve terrestrial habitat connectivity would be implemented, regardless of study results. Bridges could be installed concurrently with any additional studies needed to estimate the significance of entrapment on populations.

Step 4: Determine Entrapment Levels Following Installation or Modification of Wildlife Bridges or Crossing Structures. If the baseline study demonstrates that large numbers of small mammals or amphibians are entrapped in project waterways and if follow-up studies indicate that effects on populations are significant, the entrapment study described above in Step 1 would be repeated to assess the effects of improved terrestrial habitat connectivity on entrapment. Results of this study would then be used to determine if additional measures are needed to reduce entrapment.

Achievement of management goal

Option 3 probably represents the most scientifically credible approach to determining the effects of entrapment on wildlife populations and, if necessary, identifying measures to reduce effects. Depending on study results and the measures selected to reduce entrapment, if necessary, Option 3 may fully meet the management goal of minimizing entrapment-related mortality and significant effects on wildlife populations. There is, however, a fair amount of uncertainty associated with this option, particularly if study results indicate that entrapment has significant effects on populations that are not reduced by improved habitat connectivity.

Potential monitoring strategy

If the results of the entrapment and/or population studies indicate that no additional measures are needed to reduce entrapment, there will be no monitoring for Option 3. Otherwise, the monitoring strategy for Option 3 will depend on the measures selected to reduce entrapment.

Cost

The costs of Management Option 3 are extremely variable and difficult to estimate. Costs and assumptions listed below are associated only with the entrapment studies and do not include any measures for reducing entrapment. The Resource Team may decide that studies should be more or less intensive, a decision that would increase or decrease costs. Costs for the studies are estimated to range from $155,000 to $926,000; the low figure represents the cost of using pitfall traps to conduct baseline studies with straightforward results that indicate that entrapment does not have significant affects on wildlife populations. The substantially higher figure is the estimated costs of baseline studies with results that require population studies to estimate

significance (Steps 1 and 2) and further study to evaluate the effects of new bridges or crossing structures on reducing entrapment (Step 4) (see Attachment 8-1 for costing details).

Management Option 4: Construct a "lip" along suitable gunite canal sections

Management Option 4 involves construction of a low barrier along gunite canal sections to prevent or discourage small wildlife species from entering.

Physical Description
The Terrestrial Subgroup developed two different conceptual designs for a low barrier, or "lip", that would be constructed along suitable sections of gunite canal; schematic drawings and detailed information were provided by an engineering analysis (PacifiCorp 1997). Each design alternative is briefly described below.

- PVC/Plastic Edging—PVC or plastic edging with U/V protection would be embedded at the gunite-soil interface at the top of the canal and would extend from 8 to 12 in above the canal edge. Nails would be used to secure the PVC or plastic to the gunite and this type of barrier would be easy to install and replace.

- Guardrail and Steel Post Edging—Steel posts would be used to secure a galvanized guardrail into soil about 1 ft away from the edge of gunite canal. The guardrail would extend about 0.3 m (12 in above the canal edge and would be moderately easy to install and replace.

The "lip" would be installed along only the 27 km (17 mi) of gunite canal that have adjacent slopes with habitat that is highly or moderately suitable for small mammals and amphibians to access the canal edges (see Table 8-3). However, the value of these small barriers in preventing entrapment is not "all-or-nothing"; constructing a "lip" would certainly improve conditions, even if not for the entire length of potential suitable canal. Both "lip" designs are potentially subject to damage by big game or vehicles and may fill in with debris over time, particularly in areas with steep slopes adjacent to canal edges. In addition, it is possible that either lip design could result in injury to big game, particularly to individuals startled by vehicles on adjacent roads.

Achievement of management goal
The addition of a PVC or guardrail barrier along 27 km (17 mi) of gunite canal would be expected to substantially reduce entrapment of small mammals and amphibians and associated mortality. Option 4, however, would not decrease entrapment of larger wildlife species.

Alternative design testing program
A testing program could be conducted to determine if one of the two design alternatives for the canal "lip" better prevents or discourages small mammals or amphibians from entering project waterways. The testing program would be conducted along three selected sections of the waterway and would involve use of video cameras to record the behavior of small mammals or

amphibians as they approached the two barrier designs.

Test locations would be selected based on data from a trapping program to ensure that the sections of canal selected for testing are bordered by habitats that support small mammals and/or amphibians. The test program would be conducted in the spring, summer, and fall of the two years following installation of prototypes of each design at the three sites. Data from the testing program would also be used to select or modify the "lip" structure designs as necessary. The testing program would provide the same information as a monitoring and adaptive management plan, but would take place prior to full-scale construction and installation.

Potential monitoring strategy
The testing program should result in adequate assurance that the canal "lip" is effectively reducing entrapment of small mammals and amphibians in project waterways.

Costs
The total cost of Management Option 4 is estimated to range from $1,068,000 - $1,696,000, depending on the design alternative (see Attachment 8-1 for costing details).

Management Option 5: Construct a canal "lip" in association with 12-ft wide wildlife bridges

Management Option 5 is similar to Option 4 but involves construction of the canal "lip" only in association with 12-foot wildlife bridges.

Physical description
Management Option 5 would involve installing one of the two canal "lip" designs in conjunction with proposed 12 ft wide wildlife bridges, as included in the management options for terrestrial habitat connectivity. The "lip" would be expected to act as a drift fence, directing smaller wildlife that are attempting to cross the canal onto the bridge and thereby preventing entrapment. The number of bridges that would be modified to include the "lip" range from the existing 29 (Terrestrial Habitat Connectivity Option 3; see Section 8.3.5), to 55 if any of the options involving installation of 26 new bridges are selected to improve terrestrial habitat connectivity, (Options 4, 7, 8, 9, and 10; see Section 8.3.5). Approximately 37 m (120 ft) of canal "lip" would be installed for each bridge—18 m (60 feet) per side, extending 9 m (30 ft) up- and downstream.

Achievement of management goal
Management Option 5 would reduce entrapment of small mammals and amphibians that enter the waterway near the 12-ft bridges and would help to direct these species onto the wildlife bridges (thus improving terrestrial habitat connectivity for those species as well). It is less likely to meet the management goal than Option 4 because the lip would be constructed only in association with the 12-ft wide bridges (30 ft on the left and right side of the bridges, on both sides of the waterway, totalling 120 ft per bridge), rather than along all suitable portions of the gunite canals. It would probably not reduce entrapment of deer and elk, and may have only a limited effect on medium-sized animals such as marten, fisher, wolverine, and ringtail.

Alternative design testing program
A testing program similar to Option 4 will be conducted to determine if one of the two design alternatives for the canal "lip" better prevents small mammals or amphibians becoming entrapped in project waterways near the wildlife bridges. The testing program would be conducted in association with six bridges, three per design alternative, and would involve use of video cameras to record the behavior of small mammals or amphibians as they approach bridges with the two barrier designs.

Test locations would be selected based on data from a trapping program to ensure that the bridges selected for testing are bordered by habitats that support small mammals and/or amphibians. The test program would be conducted in the spring, summer, and fall of the two years following installation of prototypes of each design at the three sites. Data from the testing program would also be used to select or modify the "lip" structure designs as necessary. The testing program would provide the same information as a monitoring and adaptive management plan, but would take place prior to full-scale construction and installation.

Potential monitoring strategy
The testing program should result in adequate assurance that the canal "lip" is effectively reducing entrapment of small mammals and amphibians when used in conjunction with wildlife bridges.

Costs
The total cost of Management Option 5 is estimated to range from $109,000 to $190,000 depending on the design alternative and the number of bridges involved (see Attachment 8-1 for costing details).

Management Option 6: Cover gunite canal sections of waterway

Management Option 6 involves covering all 34.9 km (21.7 mi) of gunite canal, or about 69 percent of the project waterways.

Physical description
Management Option 6 for reducing entrapment is identical to Management Option 6 for improving terrestrial habitat connectivity. As described in Section 8.3.5, there are four conceptual design alternatives for canal covers, including precast concrete panels, steel plates, circular corrugated metal pipe, and corrugated metal pipe arch. Schematic drawings and estimated costs are provided in PacifiCorp (1997).

Achievement of management goal
Management Option 6 would eliminate entrapment of most smaller wildlife species in project waterways as well as greatly improve terrestrial habitat connectivity in the project vicinity. This option would cover all of the gunite canal, which represents the waterway sections that are easiest for wildlife to enter; only 15.8 km (9.8 mi, or 31 percent of the waterway), of concrete flume would remain. Some wildlife, particularly big game, can and do occasionally enter a few sections

of concrete flume at sites with steep slopes. Unless barriers are constructed at such sites to prevent entrapment, there is the potential for wildlife to become entrapped and be unable to escape because of the canal cover, unless functional escapes can be provided in the waterways immediately above covered sections. In addition, fish salvage activities that occur during routine project maintenance may be impossible as currently conducted; however, the necessity and procedure for these salvage activities may change with the new project license. Of all the options, Option 6 probably best meets the management goal of reducing entrapment to insignificant levels and minimizing entrapment-related mortality.

Potential monitoring strategy
Because of the high level of certainty that this option would achieve management goals for entrapment, no monitoring would be required for Management Option 6.

Costs
The cost of Management Option 6 depends on the canal cover design selected and is estimated to range from $23,946,384 for concrete panels (lowest cost alternative) to $57,860,880 for steel panels (highest cost alternative) (see Attachment 8-1 for costing details).

COMBINATION OPTIONS

Management Option 7: Construct a "lip" along suitable gunite canal sections, install escape ramps and incorporate a passive escape design in selected sections of Fish Creek

Management Option 7 is a combination of Options 2 and 4.

Physical description
Management Option 7 involves three components: (1) a "lip" along 27 km (17 mi) of gunite canal to prevent small mammals and amphibians from becoming entrapped; (2) 11 new escapes for big game; and (3) incorporation of a passive escape design into 305 m (1,000 ft) of gunite canal along the Fish Creek waterway. As discussed under Option 4, the construction of the "lip" along less than the 17 mi of would still be beneficial for wildlife.

Achievement of management goal
Management Option 7 would likely decrease entrapment for all wildlife—big game as well as smaller species.

Alternative design testing program
Management Option 7 would require three testing programs—one for each of the component. The program to test the effectiveness of the "lip" in preventing entrapment of small mammals and amphibians would be identical to that described for Management Option 4. The programs to test use of the escapes and passive escape design would be the same as that described for Management Option 2.

Potential monitoring strategy
The testing programs planned for Option 7 should provide the adequate assurance that the canal "lip" and new escapes are adequately reducing entrapment in project waterways. PacifiCorp's current program of tracking mortality of big game in project waterways would continue throughout the new license.

Costs
The cost of Management Option 7 is estimated as the combined costs of Options 2 ($296,000) and 4 ($1,068,000 to $1,696,000) and thus is expected to range from $1,364,000 to $1,992,000 (see Attachment 8-1 for costing details).

Management Option 8: Cover portions of gunite canal sections and construct a "lip" in association with 12-ft wide wildlife bridges

Management Option 8 combines Management Option 5 with covering selected sections of gunite canal.

Physical Description
Management Option 8 involves 2 components: (1) covering sections of gunite canal along the Lemolo No. 2 and Clearwater No. 2 waterways with adjacent highly suitable access habitat for small mammals and amphibians; and (2) installing one of the two canal "lip" designs in conjunction with existing or proposed 12-ft wide wildlife bridges, as included in the management options for terrestrial habitat connectivity. A total of 10.9 km (6.8 mi) of gunite canal would be covered along the Lemolo No. 2 and Clearwater No. 2 waterways; the rationale for selecting these canal sections is described in Management Option 10 for improving terrestrial habitat connectivity (see Section 8.3.5). As described for Option 5, the "lip" would be expected to act as a drift fence, directing smaller wildlife that are attempting to cross the canal onto the bridge and thereby preventing entrapment. The number of bridges that would be modified to include the"lip" range from the existing 29 to 55 and approximately 120 ft of canal "lip" would be installed for each bridge.

Achievement of management goal
Management Option 8 would be expected to decrease entrapment in project waterways for all species as well as to increase habitat connectivity in the project vicinity for big game and smaller species. With the exception of covering all of the gunite canal associated with the project (Option 6), Management Option 8 would decrease entrapment more than any other option.

Alternative design testing program
Management Option 8 would require a program to test the effectiveness of the two different canal "lip" designs in preventing small mammals and amphibians from becoming entrapped. This program would be similar to that described for Management Option 5 but test locations would be confined to wildlife bridges along the Clearwater No. 1, Lemolo No. 1, Fish Creek, or Slide Creek waterways.

Potential monitoring strategy
The testing program for the canal "lip" should provide the adequate assurance that this structure is adequately reducing entrapment of small mammals and amphibians in project waterways. In addition, because of the high level of certainty that covering 10.9 km (6.8 mi) of gunite canal option would come close to achieving the management goals for entrapment, no monitoring would be required. PacifiCorp's current program of tracking mortality of big game in project waterways would continue throughout the new license for the Clearwater No. 1, Lemolo No. 1, Fish Creek, and Slide Creek developments.

Costs
The cost of Management Option 8 is estimated as the combined cost of Option 5 ($109,000 to $190,000) and the cost of covering 11 km (6.8 mi) of gunite canal at a unit cost of $20 to $500 per lineal ft ($7,504,000 to $18,132,000). Thus the total cost is expected to range from $7,613,000 to $18,322,000 depending on the designs selected for the lip and canal covers, and the number of wildlife bridges included (see Attachment 8-1 for costing details).

Management option cost-benefit summary

The costs and benefits of the eight management options are summarized in Table 8-7. These cost figures likely represent minimums for each management option because they do not include the costs of any adaptive management actions that could result from data obtained from testing or monitoring. Several of the management options summarized in this table represent certain combinations of actions; additional options can be developed based on different combinations of actions. The associated costs would change as the options are tailored to increase or decrease the magnitude or complexity of the management actions. Increasing or decreasing the intensity of the monitoring and/or testing programs described for each of the management options would also change the associated costs.

The Terrestrial Subgroup ranked each of the management options using one set of criteria and two different ranking methods. Criteria were as follows: (1) the number of species groups for which the option reduces entrapment; and (2) confidence in the methods included in the option to reduce entrapment. The first ranking method involved comparing the management options in terms of their ability to reduce entrapment relative to current conditions. The option that was believed to reduce entrapment the most was given the highest number; conversely, the option believed to decrease entrapment the least was assigned a rank of 1 (Table 8-7). The second ranking method involved an assessment of the relative ability of each management option to meet the management goals and standards and guidelines of the Northwest Forest Plan. The option that came closest to eliminating entrapment, to the greatest extent possible, was determined to fully meet the management goal and was assigned a rank of 100 (Table 8-7). Options that do not fully meet the management goal were assigned ranks from 1 to 99, depending on the level of confidence that entrapment would be reduced, and the number of species groups affected.

8.4.6 Overlapping Issues

The issue of terrestrial habitat connectivity is believed to be related to entrapment because animals may fall into canals when they attempt to cross the waterway where no bridge, underpass, or other crossing opportunity exists. The entrapment issue is also related to the riparian connectivity issue because options that reduce entrapment and provide terrestrial connectivity may be implemented to enhance riparian connectivity as well (such as installing wildlife bridges near streams).