TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

5.6 RESERVOIR FLUCTUATION STUDY (TER 6)

Water levels in all 3 of the Lewis River Project reservoirs fluctuate to some degree, both daily and seasonally, as a result of project operations for power production and flood control. Water levels in Lake Merwin are the most stable, typically fluctuating within 10 feet (3 m) of full pool over the course of a year (PacifiCorp and Cowlitz PUD 2000). Swift Reservoir, which has a major role in flood control for the Lewis River, experiences the greatest water level fluctuations, on the order of 40 to 60 feet (12 to 18 m) annually.

5.6.1 Study Objectives

The objectives of the Reservoir Fluctuation Study are as follows:

- Describe the existing shoreline habitats, the seasonal and daily water level fluctuations, and the erosion areas associated with the 3 project reservoirs;
- Identify habitats and associated wildlife use in the Swift drawdown area and describe the effects of water level fluctuations on riparian and wetland analysis species on a spatial and temporal basis;
- Characterize the water regime of Beaver Bay wetland, the only natural wetland known to be hydrologically connected to Yale Lake; and
- Describe differences in shoreline habitats between Swift Reservoir and a natural lake.

5.6.2 Study Area

The study area covers all 3 project reservoirs as well as Merrill Lake, a nearby natural lake. The effects of seasonal water level fluctuations focused on Swift Reservoir, which experiences the greatest winter drawdowns.

5.6.3 Methods

The methods for the Reservoir Fluctuation Study are described on pages TER 6-4 to TER 6-10 of the Study Plan Document (PacifiCorp and Cowlitz PUD 1999, as amended in 2000). The general approach to this study involved a combination of mapping, field surveys, and compilation of data from PacifiCorp and from other studies. The 6 tasks and associated methods for this study are described below.

5.6.3.1 Shoreline Habitat Characterization

Shoreline habitats around the 3 project reservoirs were characterized using a combination of cover type mapping and data on vegetation composition and structure. Shoreline habitat types along Swift Reservoir and Lake Merwin were mapped as part of the Vegetation Cover Type Mapping Study (see TER 1, Section 5.1). Similar maps were produced for Yale Lake as part of Yale relicensing studies (PacifiCorp 1999). The length and percent of shoreline represented by each habitat type were calculated for each reservoir. Data on the structure and composition of habitats along all 3 reservoirs were collected during the HEP study (TER 2).

5.6.3.2 Water Level Fluctuation Analyses

Data on the level, timing, and duration of annual drawdowns for the past 5 years (1997-2001) were summarized for Swift Reservoir. Annual drawdown data for Yale Lake were updated to cover this same time period. The daily fluctuation patterns were assessed on a seasonal basis for Swift Reservoir, Yale Lake, and Lake Merwin. This analysis summarized daily magnitudes of fluctuation based on reservoir level data maintained by PacifiCorp. This information was also evaluated in terms of potential effects on analysis species and wetland habitat.

The area exposed by water level fluctuations, particularly on a seasonal basis, was assessed by using a Geographic Information System (GIS) to develop a bathymetry map. The bathymetry map for Swift Reservoir was based on controlled aerial photos taken by PacifiCorp in fall 1998. The lacustrine littoral deepwater habitat (drawdown zone) was mapped by indicating full pool and reservoir levels at approximately 20-foot (6 m) increments to the typical low pool. GIS was used to develop a map of “typical drawdown zones” for Swift Reservoir and estimates of the area exposed at various reservoir water surface elevations.

A map of the drawdown zone for Yale Lake was completed in 1995 (PacifiCorp 1999), and is included in the results section of this report (Section 5.6.5) for comparison purposes. Bathymetry data are not available for Lake Merwin because seasonal water level fluctuations for this reservoir are low relative to Yale and Swift reservoirs.

5.6.3.3 Wildlife Use Assessment

Assessing the potential use of the Swift drawdown zone by wildlife, particularly analysis species, involved the following 3 steps:

- Swift drawdown area habitat surveys
- Cutbank mapping
- Wildlife effects assessment

Each of these steps is described below.

<u>Swift Drawdown Area Habitat Surveys</u>

Water levels in Swift Reservoir are generally substantially lower than full pool from October through April each year. The size of the drawdown zone at any time during this period depends on power demand, inflow, and weather. Surveys to identify any potential wildlife habitat in the Swift drawdown zone were conducted in late February and early March 2001. The reservoir water elevation during the surveys was approximately 943 feet (287 m) and represented about the lowest level reached in 2001. Surveys in February involved driving U.S. Forest Service Road 90 (FR 90) along the reservoir, stopping at select points, and viewing the drawdown area with binoculars. The area near Drift Creek could not be effectively surveyed from FR 90. This area was surveyed by helicopter in early March.

The surveys focused on identifying the following features in the drawdown zone:

- Areas of emergent vegetation that could provide forage for big game;
- Small isolated shallow pools that could attract breeding amphibians, primarily red-legged frogs (*Rana aurora*), northwestern salamanders (*Ambystoma gracile*), and Pacific tree frogs (*Hyla regilla*); and
- Areas with rock and woody debris that could provide cover for aquatic furbearers and small mammals attempting to reach the water.

These identified features were recorded on bathymetry maps of the Swift drawdown area and were entered into the GIS.

Cutbank Mapping

Cutbanks can affect access to water by wildlife even under full pool conditions. For Swift Reservoir, cutbanks were defined as areas of bare soil with >100 percent slope (>45°). Shorelines were mapped on aerial photos and classified into 4 categories: (1) not cutbank (bare soil <100 percent slope or >100 percent slope and vegetated); (2) cutbanks <2 feet (<0.6 m), (3) cutbanks 2 to 6 feet (0.6 to 1.8 m), and (4) cutbanks >6 feet (>1.8 m). Note that this is a different definition of a bank than that used for the erosion mapping/assessment (Section 5.6.3.4), which did not account for slope.

Cutbanks along Swift Reservoir were mapped on September 6 and 7, 2000. To better describe cutbank conditions, modifiers were added in the field to denote those that were composed of rock and those that were discontinuous and provided some access points.

Information from the field mapping was transferred to a GIS base map and digitized into a coverage of cutbank heights. GIS was then used to identify likely access locations along Swift Reservoir and calculate the length of shoreline that precludes wildlife access to the reservoir. The mapping effort also identified areas with evidence of aquatic or semi-aquatic mammal den sites and any locations where noxious weeds have become established in the drawdown zone.

Wildlife Effects Assessment

Literature on species habitat requirements in relation to reservoir habitats and water availability (e.g., riparian habitat use by big game, water availability for amphibian egg masses and larvae, etc.) was reviewed and used to assess the effects of reservoir fluctuations on wildlife, particularly analysis species. The data summarized for Swift Reservoir was compared to published information to qualitatively assess shoreline habitat.

5.6.3.4 Erosion Mapping/Assessment

The purpose of the erosion mapping was to identify areas along Swift Reservoir that are eroding and, if possible, estimate the amount of erosion that has occurred since construction of the reservoir. Areas of erosion have already been mapped for Lake

Merwin and Yale Lake. These maps and associated data are provided in the results section of this report (see Section 5.6.5) and are used to describe existing erosion areas and shoreline habitat conditions for these 2 reservoirs.

The investigation of shoreline erosion along Swift Reservoir included 3 main steps: (1) an analysis of aerial photographs; (2) a field survey; and (3) an analysis of data using GIS layers.

Aerial Photograph Analysis

Historic and recent aerial photographs and orthophotos of Swift Reservoir were compared to determine if areas of shoreline retreat could be measured. The goal of this portion of the analysis was to estimate shoreline retreat rates by measuring the shoreline retreat distances between known photo dates. Unfortunately, the scale and resolution of the aerial photographs and orthophotos were inadequate to provide this measurement. However, visual comparison of the 1963 and 1998 aerial photos does show erosion and rounding of promontories and small points of land that protrude into the reservoir. Selective erosion of headlands is a very common phenomenon resulting from the concentration of wave energy on the points as waves are refracted around points when approaching the shoreline.

Field Surveys

A field survey of Swift Reservoir shoreline was conducted by boat on September 6 and 7, 2000 by a geologist from Montgomery Watson Harza. The reservoir surface was at elevation 983.4 feet (300 m) during the survey, approximately 16.5 feet (5 m) below normal full pool level. During the field survey, the following information was recorded on a base map of the reservoir:

- Bank height. Ocular estimate of average height (0 feet, 0-5 feet [0-1.5 m], 5-10 feet [1.5-3 m], 10-20 feet [3-6 m], 20-40 feet [6-12 m], 40-50 feet [12-24m], 50-60 feet [24-48 m].) For the purposes of the geologic survey, a bank was defined as any unvegetated slope that extended from full pool (elevation 1,000 feet [305m]) up to a distinct vegetation line (sometimes overhanging).

- Geology (parent material) of the bank.

- Landslides and types of bank erosion were noted.

- Areas of erosion on the exposed shoreline below full pool elevations. Approximate total depth of erosion was recorded, based on exposed roots or other signs of erosion. In addition, the general size of the substrate on exposed shorelines was recorded (cobble/gravel, silt/sand/clay, bedrock) to provide an indication of the continued erodibility of the shoreline.

- Areas of deposition on the exposed shorelines. These occurred as delta deposits where tributaries enter the reservoir.

At 2 locations with eroding banks, a profile of the reservoir shoreline from water's edge to the slope at the top of the bank was measured. The profiles were chosen to intersect with multiple tree stumps with exposed roots. At each stump, the current ground level as well as former (pre-reservoir) ground level were recorded. These measurements provided an estimate of the amount of erosion since construction.

GIS Analysis

Following the field survey, the mapped information was digitized into 2 GIS layers (shoreline erosion/deposition and bank height) for analysis. This information was used to produce a map showing areas of erosion or deposition in Swift Reservoir itself between full pool and the water surface elevation at the time of the field survey. A second map was also created to depict shoreline areas above full pool that are actively eroding by type of erosion process (e.g., landslide, undercut bank, raveling bank) and approximate bank height. Surveyed profiles were entered into an Excel spreadsheet for graphing and analysis.

5.6.3.5 Drawdown/Wetland Evaluation

Field observations for other studies indicated that relatively few natural wetlands in the study area are hydrologically connected to a reservoir. One of these−the Beaver Bay wetland complex along Yale Lake−was selected to evaluate the effects of winter drawdown on wetlands. The effects of reservoir water level fluctuations on the Beaver Bay wetlands were assessed for 1 year, beginning in fall 2000. A transducer (PS 9000) with a datalogger and staff gage were each mounted on posts, set at a specific height in the water column, and calibrated to record water level in 1-inch increments. Water levels were recorded once daily in the wetland. A polycorder (Omnidata 900 Series) was used to download the data monthly.

5.6.3.6 Shoreline Habitat Assessment

Although reservoirs resemble natural lakes in some ways, a primary difference is that reservoir water levels typically fluctuate more, both in frequency and magnitude. There may be seasonal differences in fluctuation timing as well. Consequently, it is possible that the structure and composition of vegetation along reservoir shorelines differ from that of natural lakes, affecting their value as wildlife habitat. The purpose of the shoreline habitat assessment was to identify differences between Swift Reservoir and Lake Merrill, a nearby natural lake. This assessment involved an intensive vegetation sampling program and some additional mapping. The approach to this study included 5 steps, as described below.

Merrill Lake Mapping

Vegetation cover types and bank heights around Merrill Lake were mapped to provide baseline data comparable to Swift Reservoir.

Reconnaissance

The methods to sample shoreline cover types along Swift Reservoir and Merrill Lake were based on discussions with PacifiCorp, WDFW, and USFS representatives during a reconnaissance site visit on July 9-10, 2001. This trip was used to determine the width of the shoreline area to be sampled and number and placement of sampling transects and plots relative to the shorelines of the lake and reservoir. The field visit was also identified the most appropriate transect lengths and plot sizes across different cover types and slopes.

Sampling Effort and Site Selection

Results of the HEP sampling in riparian and shoreline habitats were used to estimate the sample size, or number of transects, needed for a confidence interval (CI) of ± 20% of the mean. This variability analysis indicated that several parameters had relatively low variability (total tree/shrub cover, tree cover, and tree height) and could be estimated with about 5 or 6 plots in each of the most common habitats.

Results of cover type and bank height mapping around Swift Reservoir and Merrill Lake were used to select the polygons to be sampled. Polygons were selected to represent areas with different vegetation cover types, bank heights, slopes, and aspects. Potential transect locations were marked on maps prior to the field work, but exact placement was determined in the field.

Sampling Program

The sampling program at Swift Reservoir and Merrill Lake was designed to collect descriptive and quantitative data on the physical and biological aspects of wildlife habitat. Transects were established perpendicular to the shorelines of Swift Reservoir and Merrill Lake. Each transect included 2 segments: (1) a littoral/drawdown segment that extended from the normal high water mark into the lake to the deepest edge of emergent vegetation or overhanging vegetation, whichever was greater; and (2) a shoreline segment that extended from the normal high water mark for a standard distance of 164 feet (50 m). Along each transect, the significant transition points were recorded to determine the "width" of the various habitats. In addition, the following data were recorded:

- shoreline structural data such as bank type and height
- slope and aspect
- water depth at the end of the transect
- soil texture (visual estimate of percent sand, silt, clay, rock)
- soil hydric indicator (from Munsell soil chart)
- snag and stump density
- dominant plant species in each strata and zone
- percent cover of shrubs (by species)
- percent conifer tree canopy cover
- percent deciduous tree cover

- percent cover of down wood
- percent grass and forb cover
- shrub height

Methods used to sample quantitative parameters generally followed Hays et al. (1981) and Daubenmire (1968).

Data Analysis

Data for each sampling site were summarized using Access and Statistix software. The mean, standard error, standard deviation, and minimum/maximum were calculated for each quantitative parameter across the Swift and Merrill sampling sites. Shrub species were categorized according to wetland indicator status, as obligate wetland, facultative-wetland, facultative, facultative-upland, and obligate upland (U.S. Fish and Wildlife Service [USFWS] 1996); mean canopy cover was calculated for each of these groups. This analysis provided information on the relative amount of cover provided by species with difference requirements and tolerances for moist soil or wetland conditions. Student's t-test was used to test for differences between means for Swift Reservoir and Merrill Lake (Zar 1984).

5.6.4 Key Questions

Results of the Reservoir Fluctuation Study can be used to address some of the following "key" watershed questions identified during the Lewis River Cooperative Watershed Studies meetings:

- What species are currently present in reservoir and shoreline areas?

  Project reservoirs and shorelines currently support wildlife and plant communities typical of lower elevations in western Washington. Wildlife species using open water and shoreline areas associated with Lake Merwin and Swift Reservoir are listed in TER 3; similar data are available for Yale Lake (PacifiCorp 1999). Data on habitat quality in the project vicinity for select wildlife evaluation species are summarized in TER 2. Plant communities in the project vicinity are described in TER 1 and shown on Figure 5.1-2.

  What types and amounts of habitats are currently available for aquatic and riparian species at reservoir sites?

  Riparian and aquatic habitats types and amounts in the project vicinity are described in TER 1 and shown on Figure 5.1-2. Data on habitat quantity and quality in the project vicinity for select wildlife evaluation species are summarized in TER 2.

- How does reservoir management affect existing wetlands?

  Reservoir management effects on existing wetlands are described in TER 5 (see Section 5.5.5) and are summarized in Section 5.6.5.2 of this report.

- Which species may be vulnerable to the effects of reservoir water level fluctuations?

  Species vulnerability to reservoir water level fluctuations is discussed in Section 5.6.6 of this study.

- What are the effects of reservoir water level fluctuations and shoreline exposure on riparian and emergent vegetation, aquatic macrophytes, and primary productivity?

  Effects of reservoir water level fluctuations and shoreline exposure on riparian and emergent vegetation are discussed in Section 5.6.5 and 5.6.6 of this study. None of the resource studies conducted for relicensing specifically address water level fluctuations on aquatic macrophytes and primary productivity.

- What are the effects of reservoir water level fluctuations and shoreline exposure on reproductive success and movements of amphibians or semi-aquatic mammals in and around reservoirs?

  Effects of reservoir water level fluctuations and shoreline exposure on reproductive success and movements of amphibians and semi-aquatic mammals are addressed in Section 5.6.6 of this study.

- How do water level fluctuations in reservoirs affect aquatic and terrestrial food webs in the watershed?

  The effects of water level fluctuations in reservoirs on aquatic and terrestrial food webs in the watershed are not specifically addressed by any of the studies conducted for relicensing.

- How do water level fluctuations in reservoirs affect fish-eating raptors, waterfowl, aquatic and semi-aquatic mammals, and other species using reservoir or riparian habitats?

  Effects of water level fluctuations in reservoirs on fish-eating raptors, waterfowl, aquatic and semi-aquatic mammals, and other species using reservoir or riparian habitats are addressed in Section 5.6.6 of this study.

- How do water level fluctuations affect the movements and migrations of terrestrial wildlife?

  Water level fluctuation effects on the movements and migrations of terrestrial wildlife are addressed in Section 5.6.6 of this study.

5.6.5 Results

This section summarizes the results of the 6 tasks conducted as part of the Reservoir Fluctuation Study. The first subsection (5.6.5.1) presents data on shoreline characteristics for all 3 project reservoirs. The remaining 2 sections provide the results of the assessment of water level fluctuations on wetlands associated with the reservoirs and the comparison of shoreline habitats between Swift Reservoir and Merrill Lake.

5.6.4.1 Reservoir Shoreline Characteristics

This section describes shoreline characteristics for each of the 3 project reservoirs. Shoreline characteristics include vegetation cover types, water level fluctuation patterns, and bank erosion.

Swift Reservoir

Cover types, water levels fluctuation, potential wildlife use/habitat in the associated drawdown area, as well as bank erosion areas for Swift Reservoir are summarized below.

Shoreline Cover Types – Overall, most of the approximately 35-mile (56-km) shoreline of Swift Reservoir is bordered by upland conifer forest types, primarily old-growth conifer and upland mixed forest stands, which line 32 and 20 percent, respectively of the perimeter (see TER 1, Section 5.1.5, Figure 5.1-2; and Table 5.6-1). Wetlands comprise only slightly more than 1 percent of the shoreline; riparian types occupy about 8 percent of the shoreline and are confined primarily to inlets with tributary streams, particularly Drift and Swift creeks.

Table 5.6-1. Swift Reservoir shoreline composition by cover type.

	North		South		Grand Total	
Vegetation Cover Type Code	**Length (ft)**	**%**	**Length (ft)**	**%**	**Length (ft)**	**%**
Disturbed (DI)	0	0.0	180	0.18	180	0.1
Developed (DV)	2,365	2.8	968	0.97	3,333	1.8
Mature Conifer (M)	6,821	8.1	8,412	8.45	15,229	8.3
Mid-successional Conifer Forest (MS)	6,470	7.7	3,323	3.34	9,793	5.3
Old-growth Conifer Forest (OG)	8,107	9.6	51,308	51.53	59,415	32.3
Pole Conifer Forest (P)	10,417	12.3	1,913	1.92	12,333	6.7
Palustrine Emergent Wetland (PEM)	554	0.7	0	0.00	554	0.3
Palustrine Forested Wetland (PFO)	682	0.8	322	0.32	1,004	0.5
Palustrine Scrub-shrub Wetland (PSS)	0	0.0	951	0.96	951	0.5
Residential/Recreation (RES/REC)	3,458	4.1	2,949	2.96	6,407	3.5
Riparian Deciduous Forest (RD)	1,493	1.8	5,882	5.91	7,375	4.0
Riparian Mixed Forest (RM)	4,291	5.1	2,083	2.09	6,375	3.5
Riparian Shrub (RS)	0	0.0	686	0.69	686	0.4
Riverine Unconsolidated Bottom (RUB)	374	0.4	85	0.09	463	0.3
Riverine Unconsolidated Shore (RUS)	354	0.4	131	0.13	482	0.3
Shrubland (SH)	0	0.0	262	0.26	262	0.1
Seedling/Sapling Forest (SS)	9,360	11.1	755	0.76	10,115	5.5
Sparsely Vegetation (SV)	4,193	5.0	171	0.17	4,363	2.4
Upland Deciduous Forest (UD)	4,019	4.8	3,054	3.07	7,073	3.8
Upland Mixed Forest (UM)	21,535	25.5	16,119	16.19	37,654	20.5
Grand Total	84,496	100	99,560	100	184,055	100

Shoreline composition at Swift Reservoir varies greatly between the north and south sides (see Figure 5.1-2). On the north side, upland mixed forests are dominant, occupying more than 25 percent of the shoreline; pole conifer and seedling sapling conifer occur along 12 and 11 percent, respectively (Table 5.6-1). Old-growth and mature conifer stands combined line only 18 percent of the northern shoreline. On the south side, however, old-growth and mature conifer adjoins nearly 60 percent of the reservoir, while upland mixed occurs along 16 percent. Less than 3 percent of the southern shore is bordered by pole and seedling-sapling conifer.

Data on the structure and species composition of the cover types associated with Swift Reservoir were collected as part of the HEP study (see TER 2) and are summarized in Table 5.6-2. These data were collected from a range of polygons within a cover type, some that border the reservoir, as well as others that are more distant. They do, however, give an idea of habitat structure for the cover types near the reservoir.

Table 5.6-2. Habitat characteristics of cover types associated with Swift Reservoir.

Vegetation Cover Type[1]	Tree Cover (%)[2]	Deciduous Shrub Cover (%)[2]	Snag Density (No./ac)[2]
Mature Conifer (5)	90.9 (80.5-100)	41.8 (14.4-61.2)	24.3 (0-48.5)
Mid-successional Conifer Forest (5)	88.1 (59.5-100)	29.0 (14.6-46.8)	12.9 (4.0-41.8)
Old growth Conifer Forest (6)	91.5 (70.7-100)	33.6 (23.7-50.1)	29.9 (4.0-41.8)
Pole Conifer Forest (6)	93.8 (84.8-99.3)	16.9 (0-39.2)	6.1 (0-41.8)
Palustrine Emergent Wetland (1)	14.5	11.7	47.2
Palustrine Forested Wetland (2)	57.1 (35.2-78.9)	21.2 (11.6-30.7)	16.2 (8.1-41.8)
Palustrine Scrub-shrub Wetland (1)	---	67.6	0
Riparian Deciduous Forest (4)	96.1 (84.5-100)	40.3 (15.2-70.8)	10.1 (0-40.5)
Riparian Mixed Forest (3)	93.8 (90.3-100)	54.0 (4.8-80.7)	6.8 (0-16.2)
Riparian Shrub (1)	--	48.7	0
Shrubland (1)	--	28.6	--
Seedling/Sapling Forest (5)	27.3 (0-95.5)	2.2 (0-7.6)	8.9 (0-16.2)
Upland Deciduous Forest (4)	96.8 (92.2-100)	32.6 (2.6-73.8)	24.3 (4.0-36.4)
Upland Mixed Forest (6)	90.3 (70.7-100)	23.5 (0.0-47.5)	21.7 (0-68.8)

1 Number of plots sampled is in parentheses.

2 Range is shown in parentheses.

Upland conifer stands around Swift Reservoir, regardless of age, are dominated by Douglas-fir (*Pseudotsuga mensiezii*) and/or western hemlock (*Tsuga heterophylla*). Western red cedar (*Thuja plicata*) is also common, particularly in the old-growth stands along the south side of the reservoir. Mixed stands may include all 3 conifer species as well as red alder (*Alnus rubra*) and/or big-leaf maple (*Acer macrophyllum*). Upland and riparian deciduous forests associated with Swift Reservoir are almost always dominated by red alder. Overall, tree cover is high, generally 85 percent or greater in all upland and riparian forest types except seedling/sapling conifer. Snag densities are extremely variable, with the highest numbers occurring in older conifer and upland stands (Table 5.6-2).

Deciduous shrub cover in habitats near Swift Reservoir is highest in scrub-shrub wetlands and riparian shrublands, lowest in emergent wetlands and pole conifer stands, and moderate in other types. The most common deciduous shrubs in habitats associated with the Swift Project include vine maple (*Acer circinatum*), red huckleberry (*Vaccinium parvifolium*), and hazelnet (*Corylus cornuta*). These species, in addition to salal (*Gaultheria shallon*) and Oregon grape (*Berberis nervosa*), which are not deciduous, are found in nearly all cover types except wetland. Salmonberry (*Rubus spectabilis*) is most often associated with riparian areas, wetlands, and moist upland conifer sites. Willow species (*Salix* spp.), as well as red osier dogwood (*Cornus stolonifera*) and Douglas spirea (*Spirea dougalsii*) are generally restricted to wetlands.

<u>Water Level Fluctuations</u> – Swift Reservoir has a full pool elevation of 1,000 feet (305 m) mean sea level (msl), with a surface area of about 4,634 acres (1,876 ha). The minimum pool elevation is 878 feet (286 m), which occurs rarely and is related to project testing and maintenance activities. Swift Reservoir is typically at or above an elevation of 990 feet (302 m) during the summer recreation season (PacifiCorp and Cowlitz County PUD 2000). In August or September of each year, PacifiCorp usually begins to lower Swift Reservoir to generate power and to provide winter flood storage. For the 13 years from 1989 through 2001 winter (November – February) pool elevation has averaged 969.4 feet (295 m).

Average seasonal and daily changes in water levels for the past 5 water years (October 1, 1996 through September 30, 2001) are illustrated in Figure 5.6-1. For this period, Swift Reservoir fluctuated an average of about 9 inches (22.8 cm) or 0.78 feet (0.23 m) daily (Table 5.6-3). The change in reservoir level was 1 foot (0.3 m) or less for 72 percent of the days, and greater than 3 feet (1 m) only 2 percent of the days. In all years except 1, the maximum daily fluctuation represented an increase in reservoir water levels, most likely in response to a fall/winter storm event (Table 5.6-3).

Figure 5.6-1 shows the general trend in Swift Reservoir seasonal and daily fluctuations. Reservoir levels generally decrease in September and October as the pool is drawn down for the winter. From November through about March in most water years, pool elevations fluctuate greatly, often approaching full and then falling 30 to 40 feet (9-12 m) over a few-week period, generally in response to storm events and the need for generation. Daily water level changes during this period average at least 1 foot (0.3 m), and occasionally range considerably higher (Table 5.6-3). In April, reservoir levels increase in preparation for the recreation season. The pool generally remains close to full and relatively stable from May through August; between 1997 and 2001, water level changes for these months averaged less than 0.4 foot per day (0.13 m).

Between 1997 and 2001, the mean pool elevation of Swift Reservoir was about 979 feet (298 m), about 20 feet (6 m) less than full. On average, the pool was full (≥999 feet [304 m]) less than 30 days each year. Overall, pool levels were within the top 5 feet (1.5 m) about 30 percent of the year, the top 10 feet (3 m) at least 40 percent, and the top 20 feet (6 m) nearly 60 percent. From 1997 through 2001, the lowest annual pool elevation averaged 945 feet, ranging from 909 to 955 feet (277–291 m) (Table 5.6-4). Two of the annual low pool elevations occurred in March, 2 in November, and 1 in December. Swift

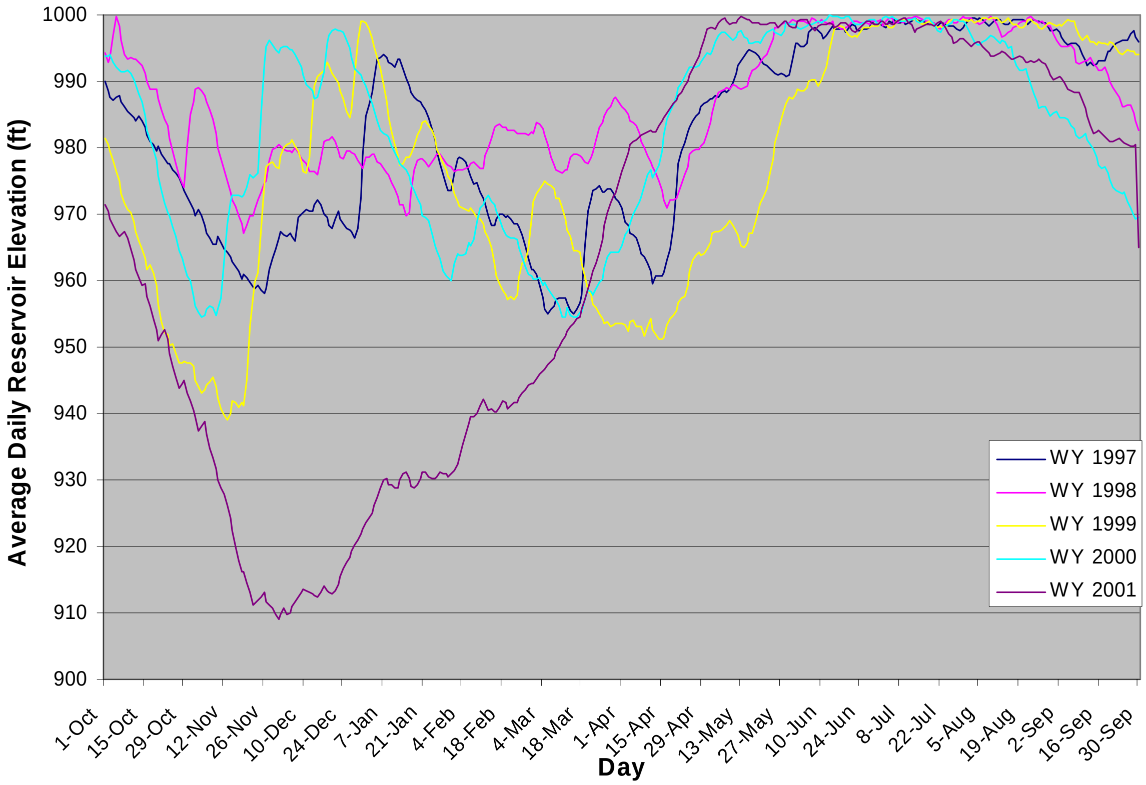


Figure 5.6-1. Swift Reservoir average daily and seasonal water elevations, water years 1997 – 2001.

Reservoir dropped below 949 feet (289 m) msl in only 2 of the last 5 water years; however, in 2001, a drought year, the pool was below this level for more than 35 percent of the year (Table 5.6-4).

Aerial photographs of Swift Reservoir were taken in 2001 when the pool elevation was 948 feet (289 m), within 3 feet (1 m) of the mean annual low pool elevation for the last 5 years. At this elevation, the reservoir surface area is about 3,254 acres (1,317 ha) and about 1,384 acres (560 ha) are exposed, primarily in the vicinity of Drift Creek and to the east (Figure 5.6-2). Compared to full pool conditions, the reservoir is therefore about 30 percent smaller at mean annual low pool. In 3 of the last 5 years, Swift Reservoir was never below 949 feet msl; only in 2001, a drought year, was the pool at or below this level for more than 7 percent of year (Table 5.6-4).

Over the past 5 years, the reservoir has been at or above an elevation of 969 feet (295 m) about 74 percent of time. This pool level has an associated surface area of 3,798 acres (1,537 ha) and a drawdown area of 837 acres (339 ha) (Figure 5.6-1). Most of the exposed area occurs in the Drift Creek vicinity and east of Swift Camp. When the reservoir is within about 10 feet (3 m) of full pool (989 feet [301 m] msl), which has occurred 40 percent of the days over the past 5 years, the water surface area covers about 4,426 acres (1,791 ha) and 209 acres (85 ha) are exposed (Figure 5.6-2). Exposed areas

Table 5.6-3. Summary of 1997-2001 daily water level fluctuations for Swift Reservoir.

Year[1]	Mean Daily Fluctuation (Range)				No. of Days with Fluctuations						Max. Daily Fluctu-ation (ft)[2]	Date of Max. Daily Fluctu-ation
	Annual	May - August	September-December	January-April	≤ 0.5 ft (%)	> 0.5 & ≤ 1 ft (%)	> 1 & ≤ 1.5 ft (%)	> 1.5 & ≤ 2 ft (%)	> 2 ft ≤ 3 ft (%)	> 3 ft (%)		
1997	0.78	0.38 (0-2.5)	0.85 (0-6.3)	1.1 (0-7.1)	167 (45.9%)	117 (32.1%)	39 (10.7%)	23 (6.3%)	8 (2.2%)	10 (2.7%)	7.2 (+)	March 18-19
1998	0.71	0.39 (0-1.7)	1.01 (0-6.1)	0.73 (0-3.2)	195 (53.6%)	68 (18.7%)	58 (15.9%)	29 (8.0%)	9 (2.5%)	5 (1.4%)	4.7 (+)	October 30-31
1999	0.93	0.53 (0-2.6)	1.23 (0-8.0)	1.02 (0-4.5)	155 (42.6%)	85 (23.4%)	50 (13.7%)	31 (8.5%)	32 (8.8%)	11 (3%)	8.1 (+)	November 20-21
2000	0.81	0.40 (0-1.5)	1.12 (0-9.0)	0.91 (02.6)	160 (44.0%)	93 (25.5%)	70 (19.2%)	22 (6.0%)	15 (4.1%)	14 (5%)	9.0 (+)	November 24-25
2001	0.71	0.33 (0-1.0)	1.03 (0-15.4)	0.77 (0-2.1)	178 (48.9%)	104 (28.6%)	44 (12.1%)	32 (8.8%)	6 (1.6%)	1 (0.3%)	15.4 (-)	September 29-30
Mean	0.78	0.41 (0-2.6)	1.05 (0-15.4)	0.91 (0-7.1)	171 (46.8%)	94 (25.6%)	52 (14.3%)	27 (7.5%)	14 (3.8%)	8 (2.2%)	8.9	--

[1] Water year begins October 1 of previous year (i.e., the 1997 water year begins on October 1, 1996).
[2] + indicates that the reservoir level increased; - indicates a drop in reservoir level.

Table 5.6-4. Summary of 1997-2001 Swift Reservoir elevations.

Year[1]	Mean Pool Elevation (ft)	Lowest Pool Elevation (ft)	Date of Lowest Pool Level	Number of Days With Pool Elevation s Below						
				999 ft msl (%)	995 ft msl (%)	989 ft msl (%)	979 ft msl (%)	969 ft msl (%)	959 ft msl (%)	949 ft msl (%)
1997	982.4	955.09	March 6	344 (94%)	254 (70%)	207 (57%)	156 (43%)	87 (24%)	19 (5%)	0 (0%)
1998	986.7	967.15	November 19	322 (88%)	254 (70%)	215 (59%)	103 (28%)	3 (1%)	0 (0%)	0 (0%)
1999	977.6	938.96	November 13	334 (92%)	257 (70%)	227 (62%)	188 (52%)	129 (35%)	75 (21%)	26 (7%)
2000	982.6	954.44	March 11	330 (90%)	268 (69%)	195 (53%)	147 (40%)	84 (23%)	29 (8%)	0 (0%)
2001	965.1	909.00	December 1	347 (95%)	266 (73%)	229 (63%)	184 (50%)	174 (48%)	156 (43%)	135 (37%)
Mean	978.9	944.92	--	335.4 (92%)	256.8 (70%)	214.6 (59%)	155.6 (43%)	95.4 (26%)	55.8 (15%)	32 (9%)

[1] Water year begins October 1 of previous year (i.e., the 1997 water year begins on October 1, 1996).

are limited to the east edge of Drift Creek, the vicinity of Swift Camp, and the far eastern end of the reservoir (Figure 5.6-2).

Potential Wildlife Habitat Use of the Swift Drawdown Area – Potential use of the Swift drawdown area by wildlife was assessed based on 2 factors: (1) cutbanks, which can limit wildlife access to water even at under nearly full pool conditions; and (2) the availability of habitat and cover in the drawdown area.

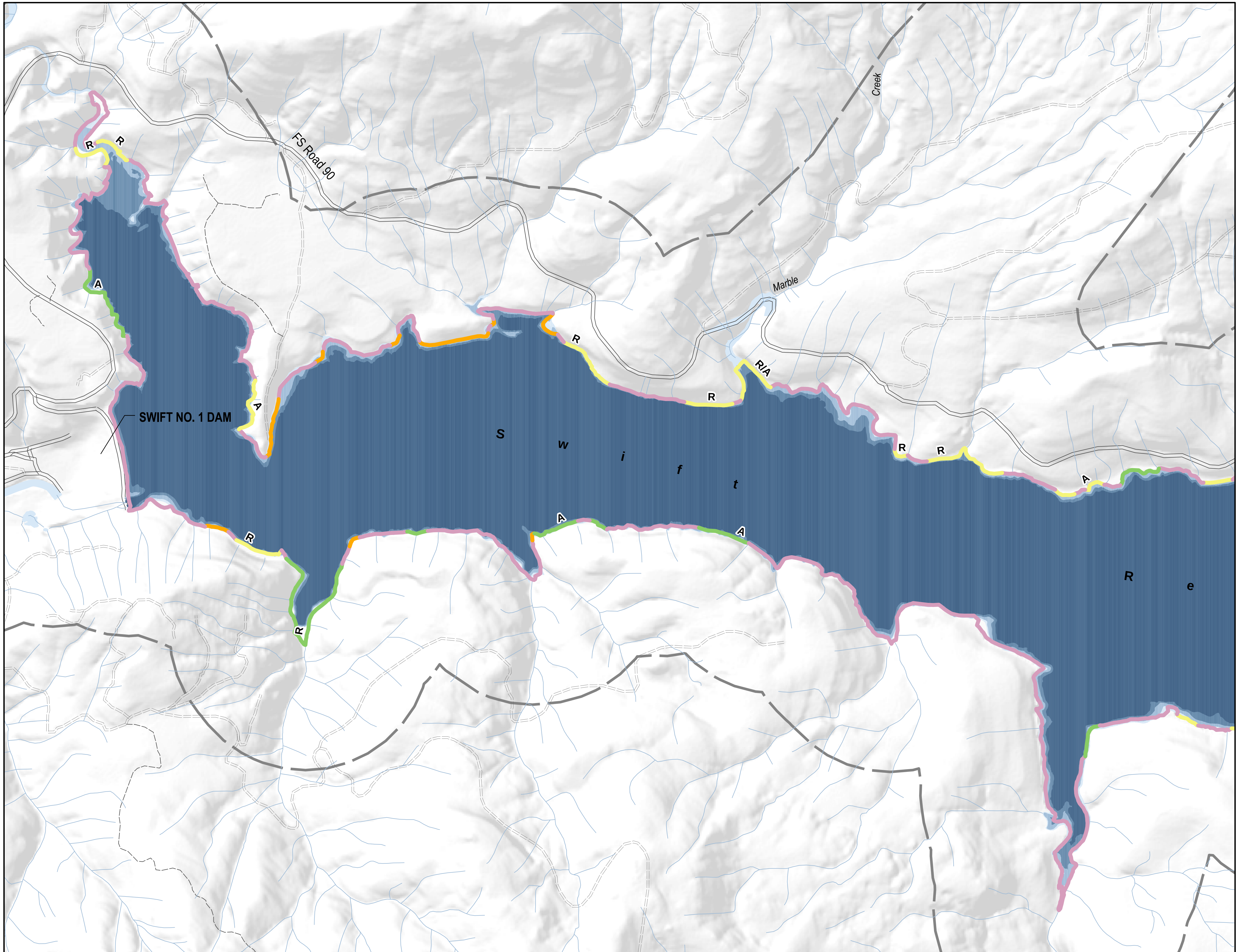
Cutbanks – Overall, cutbanks occur along about 25.5 percent of the nearly 35-mile (56-km) shoreline of Swift Reservoir (Table 5.6-5). Most cutbanks cover a short linear distance or are discontinuous, with scattered access points within a particular stretch (see Figure 5.6-2). There are, however, several shoreline sections, particularly along the northwest portion of the reservoir between Devil's Backbone and Diamond Creek, with cutbanks that greatly exceed 6 feet (1.8 m) in height and 100 percent slope (Figure 5.6-2). The 2 longest stretches of cutbank >6 feet (1.8 m) along the northwest portion of reservoir both extend for about 0.25 mile (0.4 km) (Figure 5.6-2). However, access to the water for medium and large mammals is probably not limited by cutbanks along Swift Reservoir.

Table 5.6-5. Summary of cutbank distances along Swift Reservoir[1].

Cutbank Category Description	Cutbank Category Map Designation	Linear Distance (Feet)	Percent of Total Shoreline Distance
No Cutbank	Category 1	135,533	74.2%
Cutbank < 2 ft	Category 2	5,502	3.0%
Cutbank < 2 ft, not continuous	Category 2A	2,720	1.5%
Cutbank < 2 ft, rock	Category 2R	8,517	4.7%
Cutbank < 2 ft, not continuous & rock	Category 2R/A	1,781	1.0%
	Total Category 2	18,520	10.2%
Cutbank 2-6 ft	Category 3	6,339	3.5%
Cutbank 2-6 ft, not continuous	Category 3A	5,381	2.9%
Cutbank 2-6 ft, rock	Category 3R	4,150	2.3%
	Total Category 3	**15,869**	**8.7%**
Cutbank > 6 ft	Category 4	11,541	6.3%
Cutbank > 6 ft, rock	Category 4R	1,138	0.6%
	Total Category 4	**12,680**	**6.9%**

[1] Total shoreline length = 182,602 ft (34.6 miles)

Potential Wildlife Habitat in the Drawdown Area – During surveys conducted in early March 2001, only 1 small isolated shallow pool and 1 area of vegetation were observed within the drawdown zone. Both of these areas were located in the Swift Creek inlet; the pool was located very close to the water level at the time of the survey and was very silty. It was not considered potential habitat for breeding amphibians. It does not appear that there is any suitable habitat for breeding amphibians within the Swift Reservoir drawdown area. In many locations, however, the drawdown area appears to contain



Legend

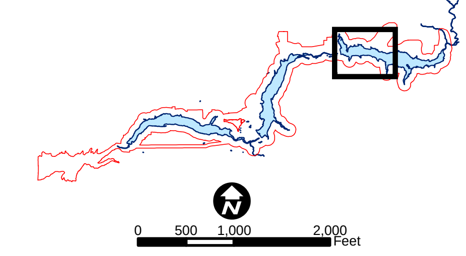
Swift Reservoir Bathymetry & Surface Area*

- 1000 ft (Full Pool) = 4,635 acres
- 990 ft = 4,426 acres
- 970 ft = 3,798 acres
- 948 ft = 3,254 acres

Cutbank Height & Condition

- < 2 ft
- 2 - 6 ft
- > 6 ft
- No Cutbank
- A Not Continuous
- R Rock
- Primary Road
- Secondary Road
- Light Duty Road
- Unimproved Road
- Trail
- Railroad
- Stream
- Other Open Water
- Study Area Boundary

* Reservoir surface area for the various pool levels was calculated from bathymetry data using GIS and does not necessarily match data presented in other studies or documents.



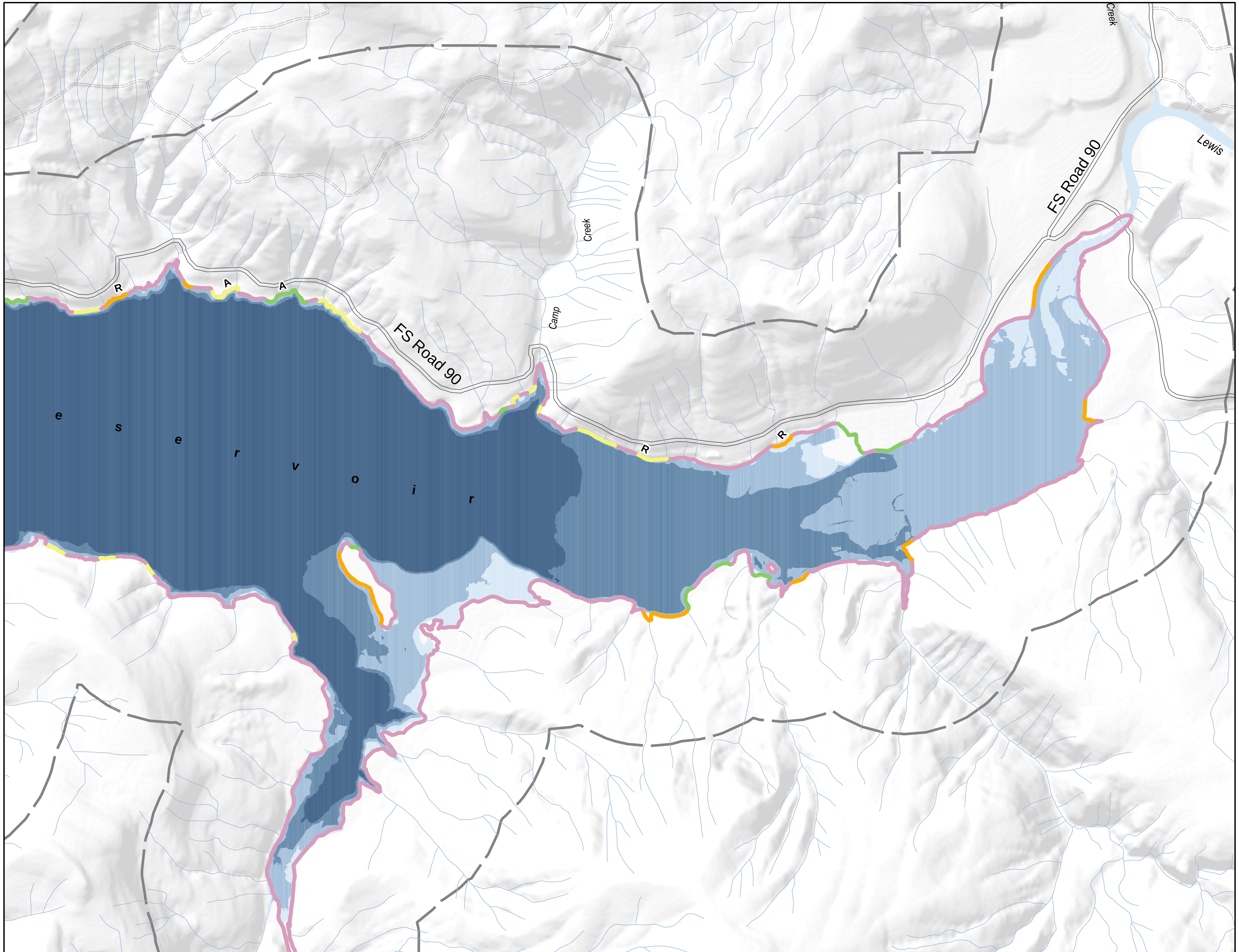
Lewis River Hydroelectric Projects

FIGURE 5.6-2 (1 of 2)

Swift Reservoir Drawdown Zones and Cutbanks

Source: EDAW, Inc., 2002

P:\8e30501\GIS\mxd\Figure5.6-2.mxd



Legend

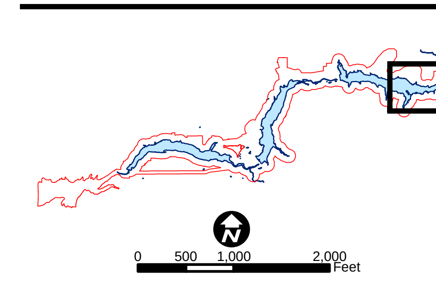
Swift Reservoir Bathymetry & Surface Area*

- 1000 ft (Full Pool) = 4,635 acres
- 990 ft = 4,426 acres
- 970 ft = 3,798 acres
- 948 ft = 3,254 acres

Cutbank Height & Condition

- < 2 ft
- 2 - 6 ft
- > 6 ft
- No Cutbank
- A Not Continuous
- R Rock
- Primary Road
- Secondary Road
- Light Duty Road
- Unimproved Road
- Trail
- Railroad
- Stream
- Other Open Water
- Study Area Boundary

* Reservoir surface area for the various pool levels was calculated from bathymetry data using GIS and does not necessarily match data presented in other studies or documents.



Lewis River Hydroelectric Projects

FIGURE 5.6-2 (2 of 2)

Swift Reservoir Drawdown Zones and Cutbanks

Source: EDAW, Inc., 2002

P:\8e30501\GIS\mxd\Figure5.6-2.mxd

substantial amounts of woody debris and large rocks that could provide cover to small and medium sized mammals attempting to access the water during low pool conditions (Figure 5.6-3).

Shoreline Erosion – The investigation of shoreline erosion and deposition at Swift Reservoir was aimed at answering several questions regarding the effects of water level fluctuations on different resources:

- How fast are shorelines eroding and by what type of erosion process (landslides, raveling, undercutting, and block failure)?
- How much terrestrial habitat will be lost during the period of the new license as a result of shoreline erosion?
- How much sediment will be added to Swift Reservoir from shoreline erosion over the period of the new license and how will it affect turbidity levels in the lake?

Erosion and Deposition below Full Pool – Areas of erosion and deposition between full pool (elevation 1,000 ft [333 m]) and the water level at the time of the field survey (elevation 983.4 [300 m]) are shown on Figure 5.6-4. The width of the mapped areas is related to the steepness of the shoreline; steep slopes will have relatively little exposed area on the map compared to gently sloping benches (such as the area near Drift Creek) where wide areas will be exposed. The map shows the substrate of exposed shorelines (bedrock, cobble, sand, silt) as well as the total estimated depth of erosion (in feet) for each unit. Erosion depth estimates were based on measurement of exposed tree roots and represent total erosion since the reservoir was filled (1958).

Areas mapped as underlain by bedrock will have little if any future erosion below full pool because the erodible soil mantle has been removed. Bedrock areas dominate the southwestern quarter of the reservoir. Shoreline areas with cobble banks are less erodible than silty or sandy banks since the wave energy and magnitudes in Swift Reservoir are generally not large enough to move cobble-sized particles. The cobbles thus form a protective layer over the underlying sediments. Areas underlain by silt and sand are more susceptible to future erosion; however, the majority of these areas are in protected coves or on the flat bench near Drift Creek, and are not exposed to the full force of wind waves.

Future erosion of areas below full pool can only occur when these areas are exposed, typically during fall and winter drawdowns. Areas that are below water at any given time are protected from erosion. The primary erosion mechanism on exposed shoreline areas is wave erosion. A given point on the shore is subjected to waves when the reservoir level is at that elevation.

The amount of future erosion in the areas below full pool is a function of 3 primary factors:

- How often the reservoir remains at different elevations in relation to when storms or winds that cause waves occur;
- The exposure of that location to waves (i.e., on a point or in a protected cove); and
- The erodibility of the substrate (depends on grain size and hillslope gradient of exposed areas).

In general, the rate of future erosion on non-bedrock areas will be similar to past erosion patterns, so areas mapped with 0-3 feet (0-0.9 m) of erosion are expected to erode more slowly than those mapped with 5-7 feet (1.5-2.1 m) of past erosion, and future erosion rates are expected to be slower than past rates since many areas are now armored.

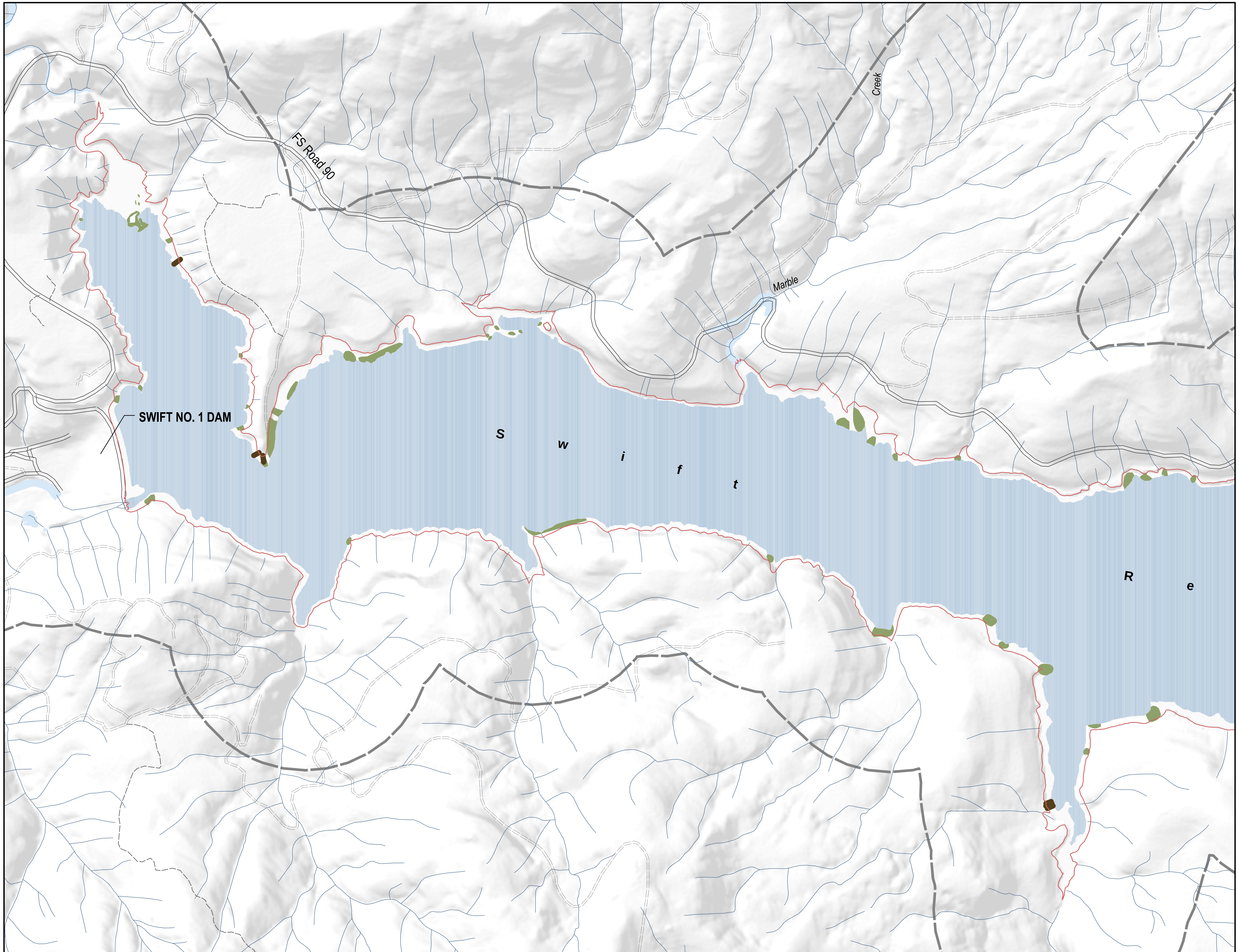
Bank Heights – Swift Reservoir bank heights are shown in Figure 5.6-5 and Table 5.6-6. Mapped geologic units are also shown on Figure 5.6-5 since the underlying geology strongly influences erodible reservoir banks area.

Table 5.6-6. Swift Reservoir shoreline length by bank height.

Bank Height (feet)	Reservoir Shoreline Length (miles)*	Percent of Total Reservoir Length
0	12.5	37%
0-5	7.5	22%
5-10	9.3	28%
10-20	3.7	11%
20-40	0.4	1%
40-50	0.1	0%
50-60	0.4	1%
Total	33.9	100%

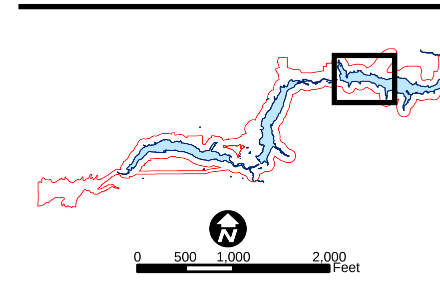
* Note: shoreline length based on GIS database; may vary slightly from other reported lengths since the dam was not considered a shoreline in this analysis

Approximately one-third (37 percent) of the Swift shoreline has no bank. Most of these areas occur in coves and inlets or along areas of very stable bedrock. Fifty-nine percent of the shoreline has either no banks or low banks up to 5 feet (1.5 m) high, mostly in coves or at the head of the reservoir. Another 28 percent of the reservoir has banks of 5 to 10 feet (1.5 to 3 m) in height. These occur primarily along exposed shorelines



Legend

- Exposed Logs
- Cover Substrate Exposed Below Full Pool
- 1000 ft (Full Pool)
- 948 ft Pool
- Other Open Water
- Primary Road
- Secondary Road
- Light Duty Road
- Unimproved Road
- Trail
- Railroad
- Stream
- Study Area Boundary



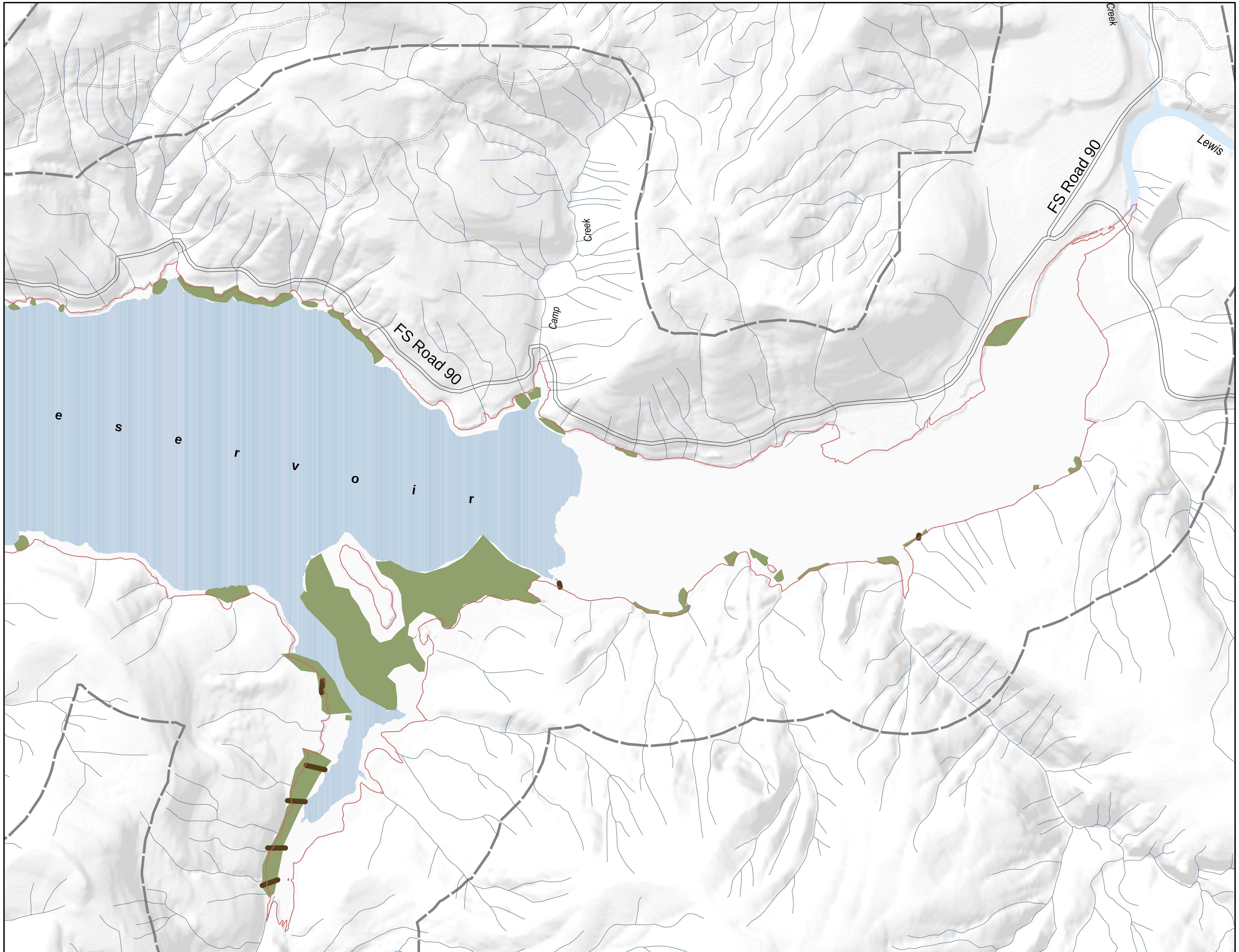
Lewis River Hydroelectric Projects

FIGURE 5.6-3 (1 of 2)

Swift Reservoir Areas of Down Wood and Boulders Between Full and Low Pool Levels

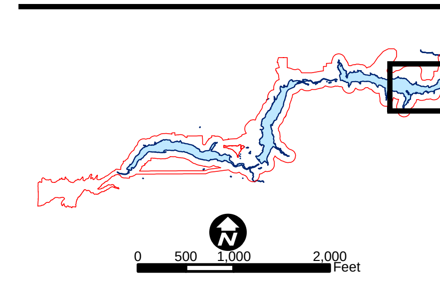
Source: EDAW, Inc., 2002

P:\8e30501\GIS\mxd\Figure5.6-3.mxd



Legend

- Exposed Logs
- Cover Substrate Exposed Below Full Pool
- 1000 ft (Full Pool)
- 948 ft Pool
- Other Open Water
- Primary Road
- Secondary Road
- Light Duty Road
- Unimproved Road
- Trail
- Railroad
- Stream
- Study Area Boundary



Lewis River Hydroelectric Projects

FIGURE 5.6-3 (2 of 2)

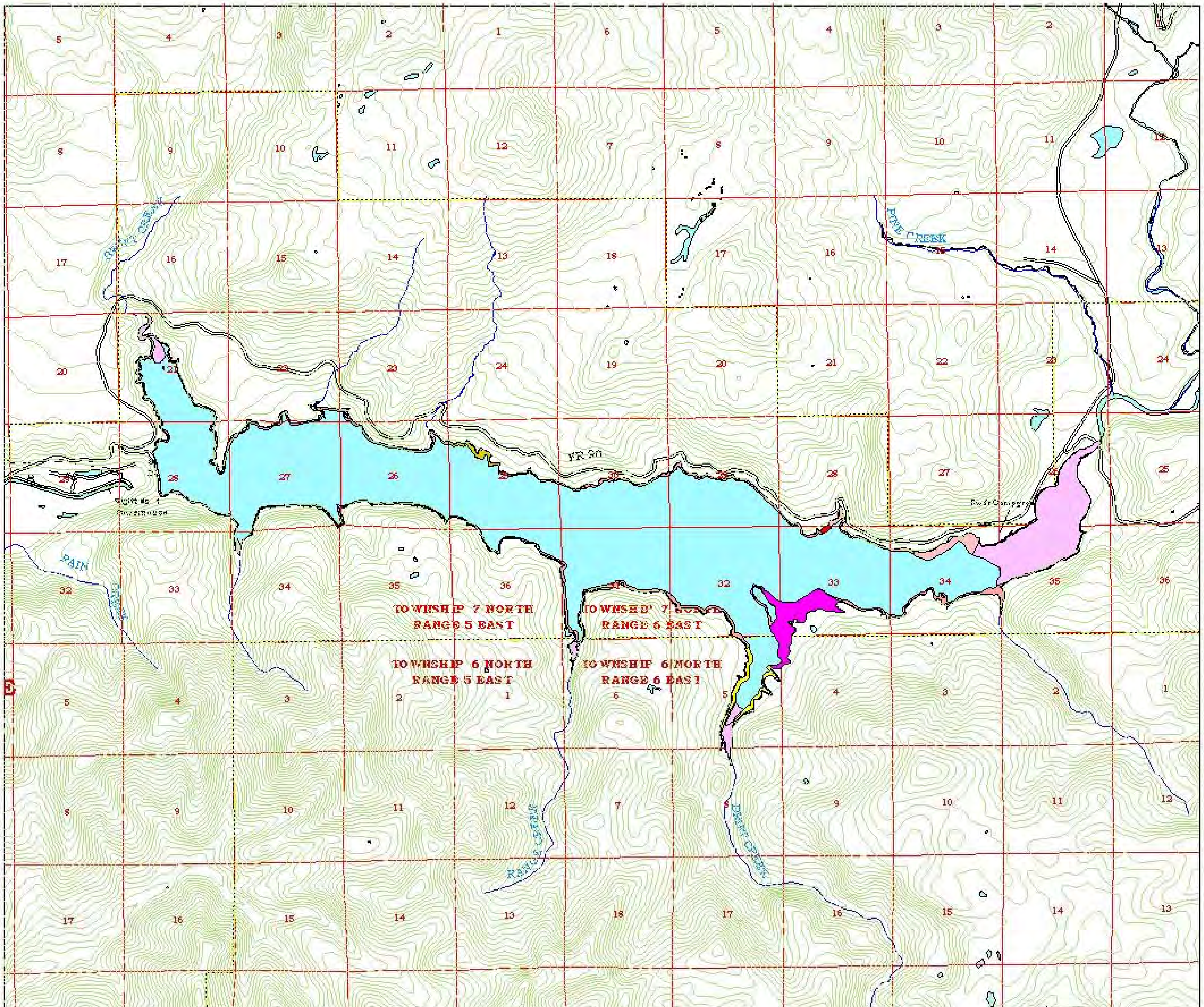
Swift Reservoir Areas of Down Wood and Boulders Between Full and Low Pool Levels

Source: EDAW, Inc., 2002

P:\8e30501\GIS\mxd\Figure5.6-3.mxd

Lewis River
Hydroelectric Projects
Figure 5.6-4

Areas of Erosion and Deposition Mapped in Swift Reservoir



Substrate and Feet of Past Erosion

- Bedrock
- Bedrock 1-3
- Bedrock 3-5
- Cobbles 1-3
- Cobbles 3-5
- Cobbles 5-10
- Cobble/Boulder 0-3
- Cobble/Boulder 3-5
- Cobble/Bedrock
- Cobble/Gravel/Sand
- Cobble/Silt
- Sand 0-3
- Silt
- Silt 0-3
- Silt 3-5
- Silt 5-7
- Silt/Cobble 1-3
- Silt/Cobble 3-5
- Silt/Sand
- Silt/Sand/Cobble

- Township
- Section
- Deposition (deltas)

Gifford Pinchot National Forest Boundary
Transmission Lines

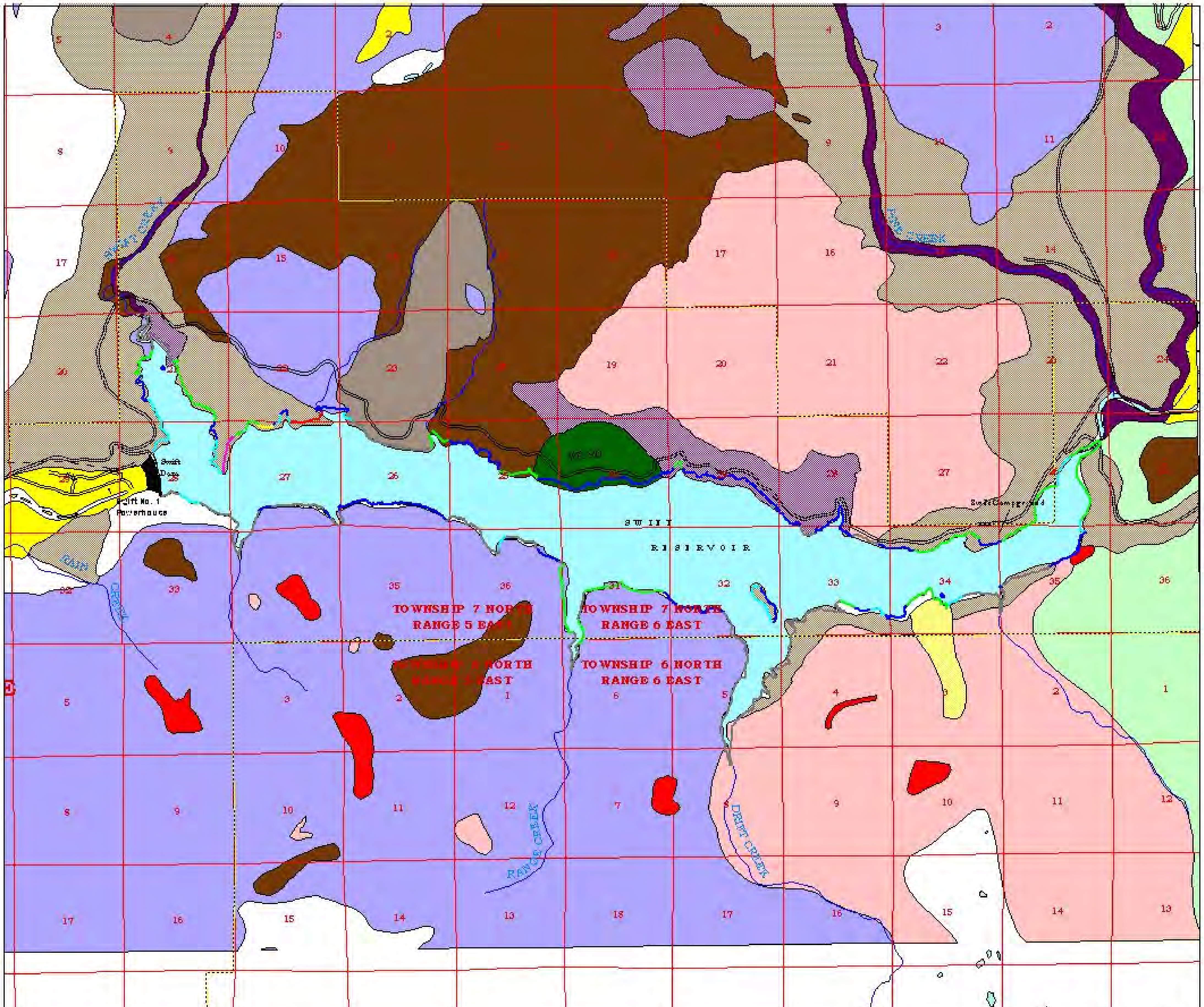
1 0 1 2 Miles

GIS PACIFICORP

h:/proj_wrk/mapapps/lewisriver/lndusemgnt_nt.apr
January 24, 2002

Lewis River
Hydroelectric Projects
Figure 5.6-5

Swift Reservoir Bank Heights and Geology



Township
Section

Geology
- Eocene Tuff
- Miocene/Oligocene Andesite
- Miocene/Oligocene Lahars
- Miocene/Oligocene Tuff
- Diorite/Granodiorite
- Oligocene/Eocene Volcaniclastics
- River alluvium
- Fill (Swift Dam)
- Landslide deposites
- Quaternary andesite flows
- Quaternary basalt flows
- Quaternary volcaniclastics
- Recent lahars
- Lakes

Bank Heights
- No Bank
- Bank is less than 5 feet high
- Bank is 5 to 10 feet hig
- Bank is 10 to 20 feet high
- Bank is 20 to 40 feet high
- Bank is 40 to 50 feet high
- Bank is 50 to 60 feet high

Gifford Pinchot National Forest Boundary
Transmission Lines

1 0 1 2 Miles

PACIFICORP
Geographic Information System

b:\proj_wtl\mapapr\lewisriver\propertyindusemgnt_nt.apr
February 14, 2003

underlain by competent (hard rock) bedrock and represent erosion of the soil mantle. Areas with banks over 10 feet (3 m) high are underlain by Quaternary (geologically young) unconsolidated deposits that are erodible. The most erosive unit is labeled Qvc1sh on Figure 5.6-5, and is a young volcaniclastic deposit originating from Mount St. Helens. This unit is composed of ash, rocks, and debris resulting from a volcanic mudflow. It forms the distinctive white cliffs evident from the Swift Dam overlook and along Devil's Backbone.

The majority of shoreline bank erosion occurs by wave undercutting at full pool levels, which results in calving of blocks of shoreline and toppling of trees on the top of these blocks. Most of the geologic units are capable of holding steep banks (even the very erodible volcaniclastic deposits) and do not appear to be susceptible to extensive raveling. A few young landslides were noted around the reservoir shoreline, but landslides do not appear to be a major erosion mechanism.

Estimate of Lost Upland Habitat – To estimate potential loss of upland habitat from shoreline retreat during the term of the new license, past shoreline retreat was investigated. Because the scale and resolution of historic and recent aerial photographs and orthophotos were not sufficient to allow measurement of shoreline retreat, a different approach based on measurement of shoreline profiles was used.

Two profiles were measured in Swift Reservoir during the field survey - one on the east side of the Range Creek embayment and the other at Swift Campground. These locations were chosen because a profile could be measured that passed through several tree stumps with exposed roots, allowing the former ground surface to be projected (Figures 5.6-6 and 5.6-7). The 2 profiles show the shoreline at the time of the survey (heavy black line); the projected original shoreline, based on the depth of erosion measured at the tree stumps (light gray line); and the projected original shoreline, based on an extension of the upland hillslope gradient out into the reservoir (dotted line).

Several observations can be made based on the graphs. First, the length of lost shoreline habitat (distance of shoreline retreat) can be measured as the slope distance between the current top of the bank and the point in space where the projected shoreline intersects the full pool elevation line (i.e., 22 feet [6.7 m] in the Range Creek profile and 27 feet [8.2 m] in the Swift Campground profile).

Second, the projected hillslope based on tree stump measurements is nearly identical to the projected hillslope based on an extension of the upland hillslope gradient. This means that to extrapolate the results of these 2 profiles to other locations with different bank heights and upland hillslope gradients, a simple geometric relationship can be used:

Distance of shoreline retreat = bank height / [sin (slope angle)]

This relationship was used to make a chart of shoreline retreat distances by bank height and upland hillslope gradient (Table 5.6-7). As shown in Table 5.6-7, for a given slope angle, the shoreline retreat distance increases with increasing bank height, and for a given bank height, the shoreline retreat distance decreases with increasing slope gradient.

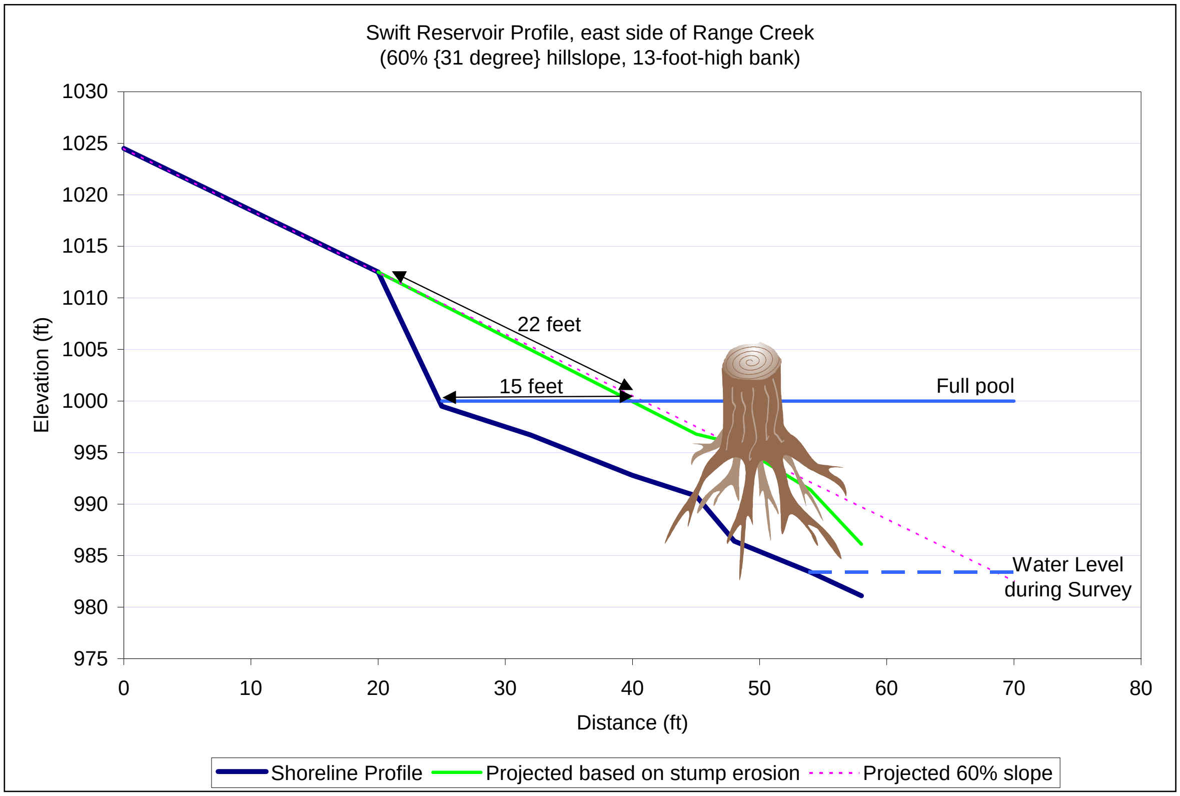


Figure 5.6-6. Shoreline profile measured near Range Creek.

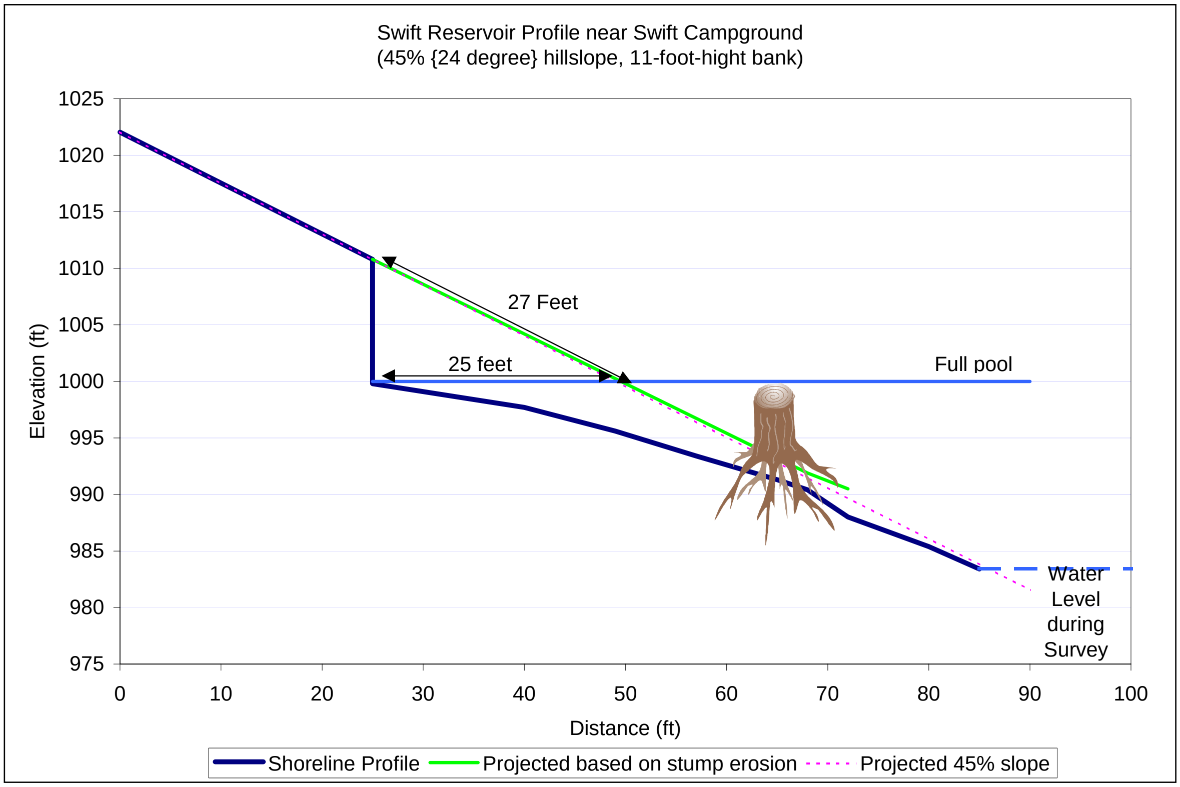


Figure 5.6-7. Shoreline profile measured near Swift Campground.

Table 5.6-7. Shoreline retreat distances (in feet) for specified bank heights and slope angles.

Hillslope Angle (degrees)	Bank Height (ft)							
	5	10	15	20	30	40	50	60
10	57	115	172	229	344	459	574	688
20	19	39	58	77	116	155	193	232
30	12	24	35	47	71	95	118	142
40	8	16	23	31	47	62	78	93
50	6	12	17	23	35	46	58	69
60	5	10	16	21	31	41	52	62
70	5	10	15	20	30	40	50	60

The results in Table 5.6-7 were used in conjunction with GIS maps of the lengths of Swift Reservoir shoreline in different bank height and hillslope gradient classes to estimate the total amount of lost upland habitat that has occurred since Swift Reservoir was filled. Table 5.6-8 shows the lengths of Swift Reservoir shoreline in each of the different bank height/ hillslope gradient categories. This information was obtained by overlaying the bank height map (Figure 5.6-5) with a hillslope gradient map.

Table 5.6-8. Swift Reservoir shoreline length (in miles) by bank height and hillslope gradient classes.

Hillslope Gradient (degrees)	Bank Height (ft)							
	0	0-5	5-10	10-20	20-40	40-50	50-60	Total
0-10	-	0.3	-	0.0	-	-	-	0.3
10-20	0.1	-	0.2	-	-	-	-	0.3
20-30	-	0.5	0.4	-	-	-	-	0.9
30-50	3.9	1.7	1.0	0.2	-	0.1	-	7.0
50-70	6.1	4.8	6.9	3.3	0.4	-	0.4	21.9
over 70	2.3	0.2	0.9	0.1	-	-	-	3.5
Total	12.5	7.5	9.3	3.7	0.4	0.1	0.4	33.9

Table 5.6-9 shows the resulting estimated acres of upland habitat that have been lost around Swift Reservoir since it was filled in 1958. Approximately 28.5 acres (11.5 ha) have been lost, mostly along banks with heights of 5-20 feet (1.5-6 m) and hillslope gradients of 50-70 degrees. It is likely that shoreline retreat rates will be the same or less in the future, since as a bank retreats, it becomes higher and more material needs to be removed per foot of shoreline retreat.

If monitoring of future loss of upland habitat is desired, it is recommended that benchmarks be staked in upland areas near banks where erosion may be expected, based on shoreline geology and structure. Measurement to the top edge of the bank could be resurveyed periodically. Based on the anticipated slow retreat rates (the highest estimated rates are an average of 1-2 feet/year [0.3-0.6 m/yr] over the past 43 years, with future rates likely slower) and likely episodic nature of the erosion as a result of the undercutting and calving process, a minimum of 5-10 years of monitoring would likely be necessary before long-term future trends could be established. Measuring retreat rates in areas of lower hillslope

Table 5.6-9. Estimated acres of lost upland habitat, Swift Reservoir 1958-2000.

Hillslope Gradient (degrees)	Bank Height (ft)							
	0	0-5	5-10	10-20	20-40	40-50	50-60	Total
0-10	-	0.9	-	0.5	-	-	-	1.4
10-20	-	-	0.6	-	-	-	-	0.6
20-30	-	0.4	0.8	-	-	-	-	1.2
30-50	-	0.8	1.4	0.6	-	1.2	-	4.1
50-70	-	1.7	7.2	7.0	1.5	-	2.7	20.2
over 70	-	0.1	0.8	0.2	-	-	-	1.0
Total	-	3.8	10.9	8.3	1.5	1.2	2.7	28.5

gradient or near areas of concern (e.g., Swift Campground) would likely produce the most measurable results in the shortest amount of time.

Estimate of Bank Erosion Volume – The volume of material eroded from the retreating shorelines and deposited in Swift Reservoir was estimated by multiplying the average cross-sectional area of lost shoreline for each bank height/hillslope gradient class times the length of shoreline in each class. An estimated 210,000 cubic yards (160,556 m^3) of sediment have eroded from shoreline areas since 1958, or an average of approximately 5,000 cubic yards/year (3,823 m^3/yr). This is in comparison to a minimum of 10 million cubic yards (7.6 million m^3) of sediment supplied to the reservoir from Clearwater Creek and the Muddy River between 1982-1990 (average of nearly 1 million cubic yards/year [760,000 m^3/yr]), with an unknown, but likely very large amount of sediment delivered immediately following the eruption from Mount St. Helens, and in the period since 1990 (Dinehart 1997). The estimated original storage volume of Swift Reservoir was 1.2 billion cubic yards (917 million m^3).

Yale Lake

Characteristics of Yale Lake shoreline habitats, water levels, bank erosion areas, and drawdown zone are summarized below.

Shoreline Cover Types – Overall, most of the approximately 27-mile (45-km) shoreline of Yale Lake is bordered by upland deciduous forest stands, which line over 40 percent of the shoreline (see Figure 5.1-2; Table 5.6-10). Mixed conifer-deciduous forest stands and mid-successional conifer stands border another 20 and 16 percent, respectively. There is very little old growth or mature conifer adjoining the reservoir. Wetlands and riparian types, which are primarily limited to Beaver Bay and Cougar Creek, respectively, comprise less than 3 percent of the shoreline.

Shoreline composition at Yale Lake varies greatly between the north and south sides (see Figure 5.1-2). On the north side, upland mixed and deciduous forests are nearly co-dominant, occupying 22 and 25 percent of the shoreline, respectively. Mid-successional conifer stands and recreational facilities occur along 15 and 14 percent, respectively (Table 5.6-10). Upland deciduous forest is by far the most dominant shoreline cover type

Table 5.6-10. Yale Lake shoreline composition by cover type.

	North		South		Grand Total	
Vegetation Cover Type Code	**Length (ft)**	**%**	**Length (ft)**	**%**	**Length (ft)**	**%**
Disturbed (DI)	2,004	3.0		0.0	2,004	1.4
Developed (DV)	4,315	6.5	1,109	1.4	5,424	3.8
Lacustrine Unconsolidated Bottom (LUB)	790	1.2	245	0.3	1,035	0.7
Mature Conifer (M)	2,871	4.3	3,042	3.9	5,913	4.1
Mid-successional Conifer Forest (MS)	10,190	15.4	13,657	17.7	23,847	16.6
Old growth Conifer Forest (OG)	0	0.0	1,640	2.1	1,640	1.1
Pole Conifer Forest (P)	0	0.0	480	0.6	480	0.3
Palustrine Emergent Wetland (PEM)	3,352	5.1	23	0.0	3,375	2.4
Palustrine Scrub-shrub Wetland (PSS)	0	0.0	22	0.0	22	<0.1
Recreation (REC)	9,300	14.1	0	0.0	9,300	6.5
Residential (RES)	956	1.4	0	0.0	956	0.7
Riparian Deciduous Forest (RD)	414	0.6	0	0.0	414	0.3
Rock Outcrop (RO)	738	1.1	0	0.0	738	0.5
Upland Deciduous Forest (UD)	16,494	25.0	43,021	55.6	59,515	41.5
Upland Mixed Forest (UM)	14,619	22.1	14,130	18.3	28,749	20.0
Grand Total	66,041	100	77,369	100	143,410	100

on the south side of Yale Lake, bordering 55 percent. Mid-successional and mixed conifer stands each line about 18 percent of the southern shore.

Data on the structure of the various cover types associated with Yale Lake are summarized in Table 5.6-11. As for Swift Reservoir, these data were collected from a range of distances from the reservoir; they do, however, give some idea of habitat structure for the cover types along the shoreline. The upland deciduous forest stands around Yale Lake are dominated by red alder. Conifer stands support a mixture of Douglas-fir and/or western hemlock, with some western red cedar also occurring. Tree cover is high, exceeding 80 percent in all forested cover types; snag density is variable, but relatively high for mature and old-growth conifer stands.

Average deciduous shrub cover is moderate in most of the cover types surrounding Yale Lake, ranging from a low of 13 percent in palustrine emergent wetlands to a high of 57 percent in mid-successional conifer stands (Table 5.6-11). Dominant shrubs include vine maple, Oregon grape, and most of the other shrub species typical to lower elevations in western Washington. Cascara (*Rhamnus purshiana*), oceanspray (*Holodiscus discolor*), and Indian plum (*Oemleria cerasiformis*) occur more often in the vicinity of Yale Lake than around Swift Reservoir.

<u>Water Level Fluctuations</u> – Yale Lake has a full pool elevation of 490 feet (149 m), with a surface area of about 3,780 acres (1,555 ha). The minimum pool elevation is 430 feet (131 m), which occurs rarely and is related to project testing and maintenance activities (PacifiCorp and Cowlitz County PUD 2000). During the summer recreation season, Yale Lake is generally at or above 480 feet (149 m) msl. In September of each year, PacifiCorp begins to lower Yale Lake to schedule system generation and provide flood

Table 5.6-11. Habitat characteristics of cover types associated with Yale Lake.

Vegetation Cover Type[1]	Tree Cover (%)[2]	Deciduous Shrub Cover (%)[2]	Snag Density (No./ac)[2]
Mature Conifer (4)	80.5 (57.0-100)	50.8 (10.9-91.4)	22.3 (8.1-36.4)
Mid-successional Conifer Forest (9)	95.5 (69.9-96.7)	57.0 (22.1-87.8)	12.1 (0-20.2)
Old growth Conifer Forest (3)	81.7 (68.6-91.1)	24.5 (6.6-48.5)	20.2 (8.1-40.5)
Pole Conifer Forest (5)	95.1 (81.4-100)	13.6 (0-22.5)	14.5 (0-32.4)
Palustrine Emergent Wetland (3)	--	12.6 (0.0-30.2)	0
Palustrine Scrub-shrub Wetland (2)	--	35.9 (21.7-50.0)	8.1 (0-16.2)
Riparian Deciduous Forest (1)	100	46.9	56.7
Upland Deciduous Forest (7)	85.8 (58.2-97.7)	49.1 (4.3-77.5)	9.2 (0-20.2)
Upland Mixed Forest (5)	90.3 (78.4-100)	25.8 (7.0-58.6)	15.5 (0-20.2)

1 Number of plots sampled is in parentheses.

2 Range is shown in parentheses.

storage. For the 13 years from 1989 through 2001 winter (November – February) pool elevation has averaged 474.5 feet (145 m).

Mean daily and seasonal water levels changes for the 1997 – 2001 water years are illustrated in Figure 5.6-8. For this period, Yale Lake fluctuated an average of about 8 inches (20 cm), or 0.66 foot (0.2 m) daily (Table 5.6-12). The change in reservoir level was generally 1 foot (0.3 m) or less for 77 percent of the days and greater than 3 feet (1 m) less then 1 percent of the days (Table 5.6-12).

Figure 5.6-8 illustrates the general trend in Yale Lake annual and daily fluctuations. Reservoir levels generally decrease in September and October as the pool is drawn down for the winter. From November through about March, pool elevations fluctuate greatly within about a 20-foot (6-m) range , but rarely reach full. Daily water level changes during this period average 0.8 foot (0.2 m), and occasionally range considerably higher (Table 5.6-12). In April, reservoir levels increase in preparation for the recreation season. The pool generally remains close to full and relatively stable from May through August; between 1997 and 2001, water level changes for these months averaged less than 0.5-foot per day (0.15 m).

Between 1997 and 2001, the mean pool elevation of Yale Lake was about 478 feet (146 m) msl, about 12 feet (4 m) less than full (Table 5.6-13). On average, the pool was full (≥ 489 feet [149 m] msl) only 25 days each year. Overall, pool levels were within the top 5 feet (1.5 m) 29 to 42 percent of the year, and within the top 10 feet (3 m) nearly 50 percent of the time. From 1997-2001, the lowest annual pool elevation averaged 457 feet (139 m) and ranged from 449.8 to 462.8 feet (137-141 m) (Table 5.6-13). Three of the annual low pool elevations occurred in February, 1 in November, and 1 in April. Yale Lake dropped below 459 feet (140 m) msl in 3 of the last 5 water years; in 2001, a drought year, the pool was below this level for more about 12 percent, or 1.5 months, of the year (Table 5.6-13).

Aerial photographs of Yale Lake were taken in 1997 when the pool elevation was 474 feet (144 m), within 3 feet (1 m) of the mean annual winter pool elevation from 1989

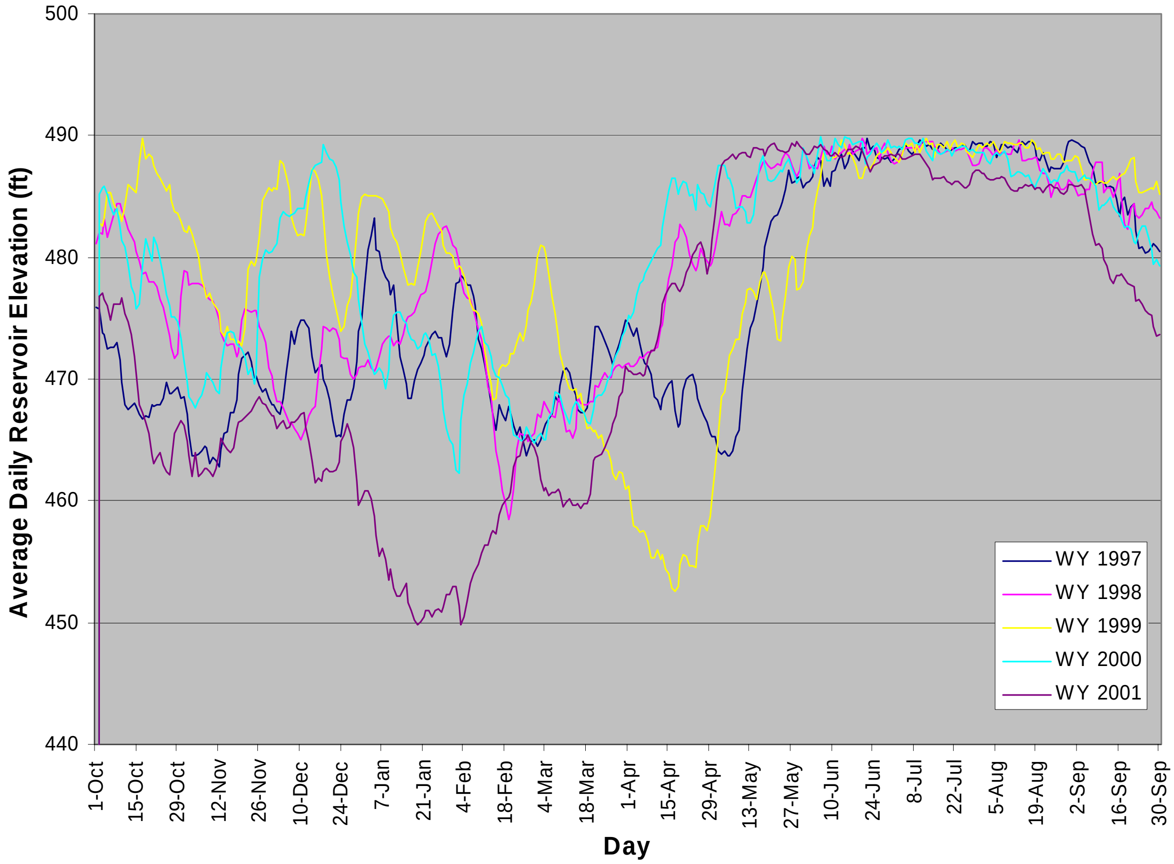


Figure 5.6-8 Yale Lake average daily and seasonal water elevations, water years 1997 – 2001.

through 2001. At this elevation, about 435 acres (176 ha) are exposed, which represents about 11 percent of the reservoir surface area (PacifiCorp 1999). A bathymetry map indicates that the vast majority of the drawdown area is narrow and relatively steep, but there are several areas where the exposed lake bed is flat and wide (Figure 5.6-9). These larger areas include the following:

- 0.8 mile (1.3 km) of the western shore south of Speelyai Canal;
- 1.1 miles (1.8 km) of the northwestern shore area immediately south and north of Yale Park;
- 2.1 miles (3.4 km) of the northern shore, form Beaver Bay to west of Cougar Creek;
- 0.4 mile (0.6 km) of shoreline along the small island at the upstream end of the reservoir; and
- 1.2 miles (1.9 km) of the eastern shoreline directly across from the confluence of Speelyai Canal with Yale Lake.

Table 5.6-12. Summary of 1997-2001 daily water level fluctuations for Yale Lake.

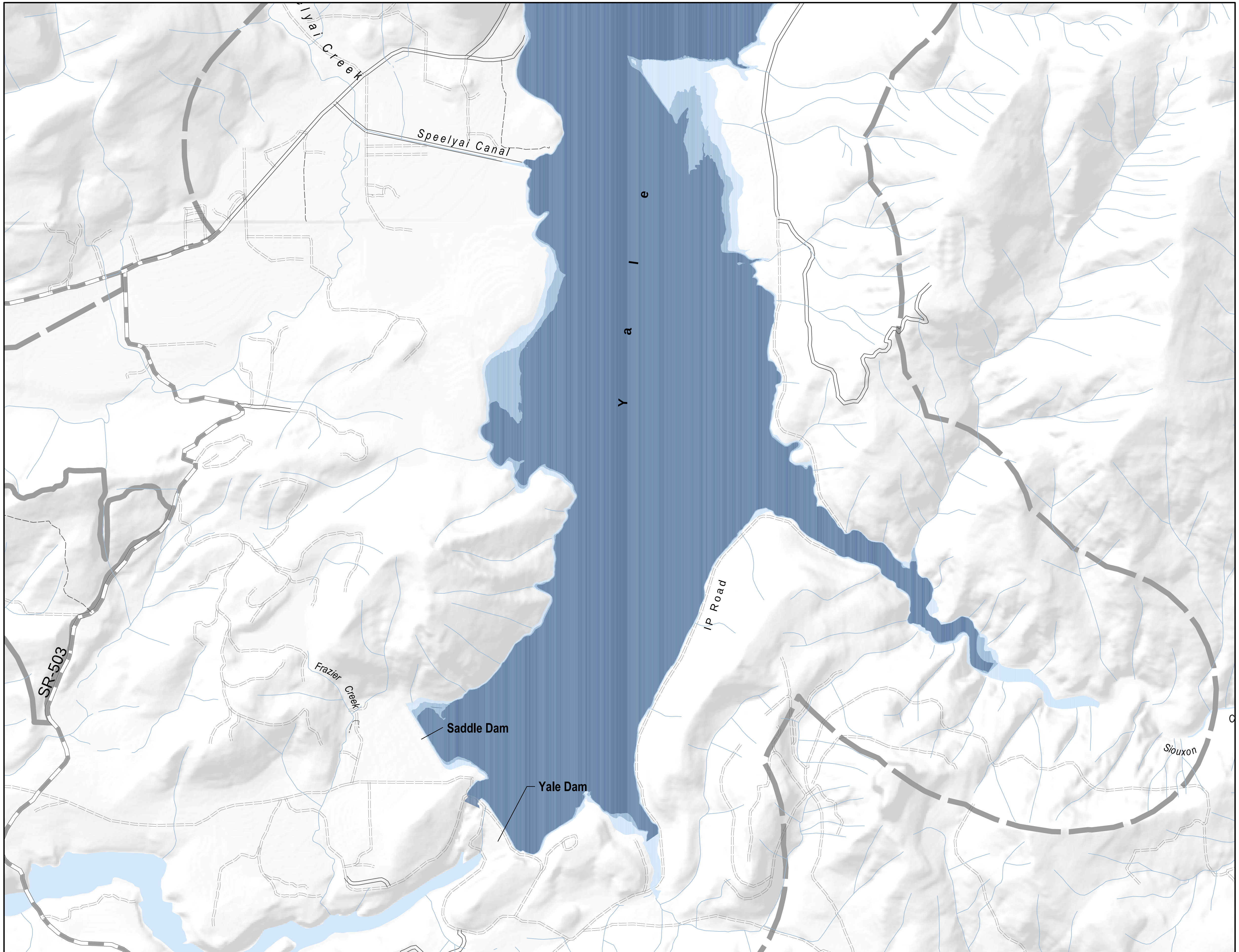
Year[1]	Mean Daily Fluctuation (Range)				No. of Days with Fluctuations						Max. Daily Fluctu-ation (ft)[2]	Date of Max. Daily Fluctu-ation
	Annual	May - August	Sept. - Dec.	Jan. - April	≤ 0.5 ft (%)	> 0.5 & ≤ 1 ft (%)	> 1 & ≤ 1.5 ft (%)	> 1.5 & ≤ 2 ft (%)	> 2 ft ≤ 3 ft (%)	> 3 ft (%)		
1997	0.73	0.53 (0-3.3)	0.75 (0-3.4)	0.91 (0-3.0)	174 (47.8%)	92 (25.3%)	59 (16.2%)	17 (4.7%)	19 (5.2%)	3 (0.8%)	3.3 (+)	May 9-10
1998	0.61	0.42 (0-1.8)	0.69 (0-4.7)	0.72 (0-3.2)	197 (54.1%)	96 (26.4%)	42 (11.5%)	13 (3.6%)	14 (3.8%)	2 (0.5%)	4.7 (-)	October 29-30
1999	0.74	0.74 (0-3.2)	0.82 (0-4.7)	0.78 (0-2.7)	174 (47.8%)	94 (25.8%)	48 (13.2%)	24 (6.6%)	20 (5.5%)	4 (1.1%)	4.7 (-)	November 20-21
2000	0.70	0.47 (0-2.5)	0.85 (0-7.8)	0.78 (0-4.3)	175 (47.9%)	100 (27.4%)	51 (14.0%)	25 (6.8%)	11 (3.0%)	3 (0.8%)	7.8 (-)	November 24-25
2001	0.54	0.23 (0-1.5)	0.67 (0-2.8)	0.70 (0-2.7)	227 (62.4%)	79 (21.7%)	26 (7.1%)	23 (6.3%)	9 (2.5%)	0 (0.0%)	2.8 (+)	December 27-28
Mean	0.66	0.48 (0-2.5)	0. 76 (0-4.7)	0.78 (0-3.2)	189 (51.9%)	92 (25.3%)	45 (12.4%)	20 (5.6%)	15 (4.0%)	2 (0.7%)	4.7	--

[1] Water year begins October 1 of previous year (i.e., the 1997 water year begins on October 1, 1996).
[2] + indicates that the reservoir level increased; - indicates a drop in reservoir level.

Table 5.6-13. Summary of 1997-2001 Yale Lake elevations.

Year[1]	Mean Pool Elevation (ft)	Lowest Pool Elevation (ft)	Date of Lowest Pool Level	Number of Days With Pool Elevations Below				
				489 ft msl (%)	485 ft msl (%)	479 ft msl (%)	469 ft msl (%)	459 ft msl (%)
1997	476.52	462.77	November 12	326 (89%)	258 (71%)	224 (61%)	126 (35%)	0 (0%)
1998	479.17	458.41	February 19	346 (95%)	239 (65%)	181 (50%)	56 (15%)	2 (1%)
1999	479.54	452.54	April 16	336 (92%)	211 (58%)	150 (41%)	58 (16%)	27 (7%)
2000	480.19	462.3	February 1	353 (93%)	215 (59%)	150 (41%)	79 (22%)	0 (0%)
2001	473.27	449.82	February 2	340 (96%)	239 (65%)	226 (62%)	166 (45%)	44 (12%)
Mean	477.74	457.17	--	340.2 (93%)	232.4 (64%)	186.2 (51%)	97.0 (27%)	14.6 (4%)

[1] Water year begins October 1 of previous year (i.e., the 1997 water year begins on October 1, 1996).

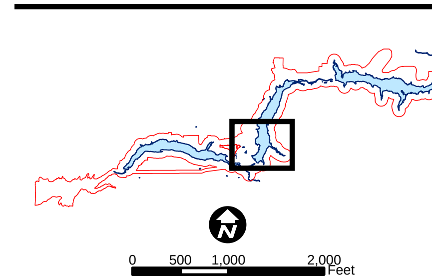


Legend

Yale Lake Bathymetry & Surface Area *

- 490 ft (Full Pool) = 3,796 acres
- 480 ft = 3,536 acres
- 474 ft = 3,361 acres
- Primary Road
- Secondary Road
- Light Duty Road
- Unimproved Road
- Trail
- Railroad
- Stream
- Other Open Water
- Study Area

* Reservoir surface area for the various pool levels was calculated from bathymetry data using GIS and does not necessarily match data presented in other studies or documents.



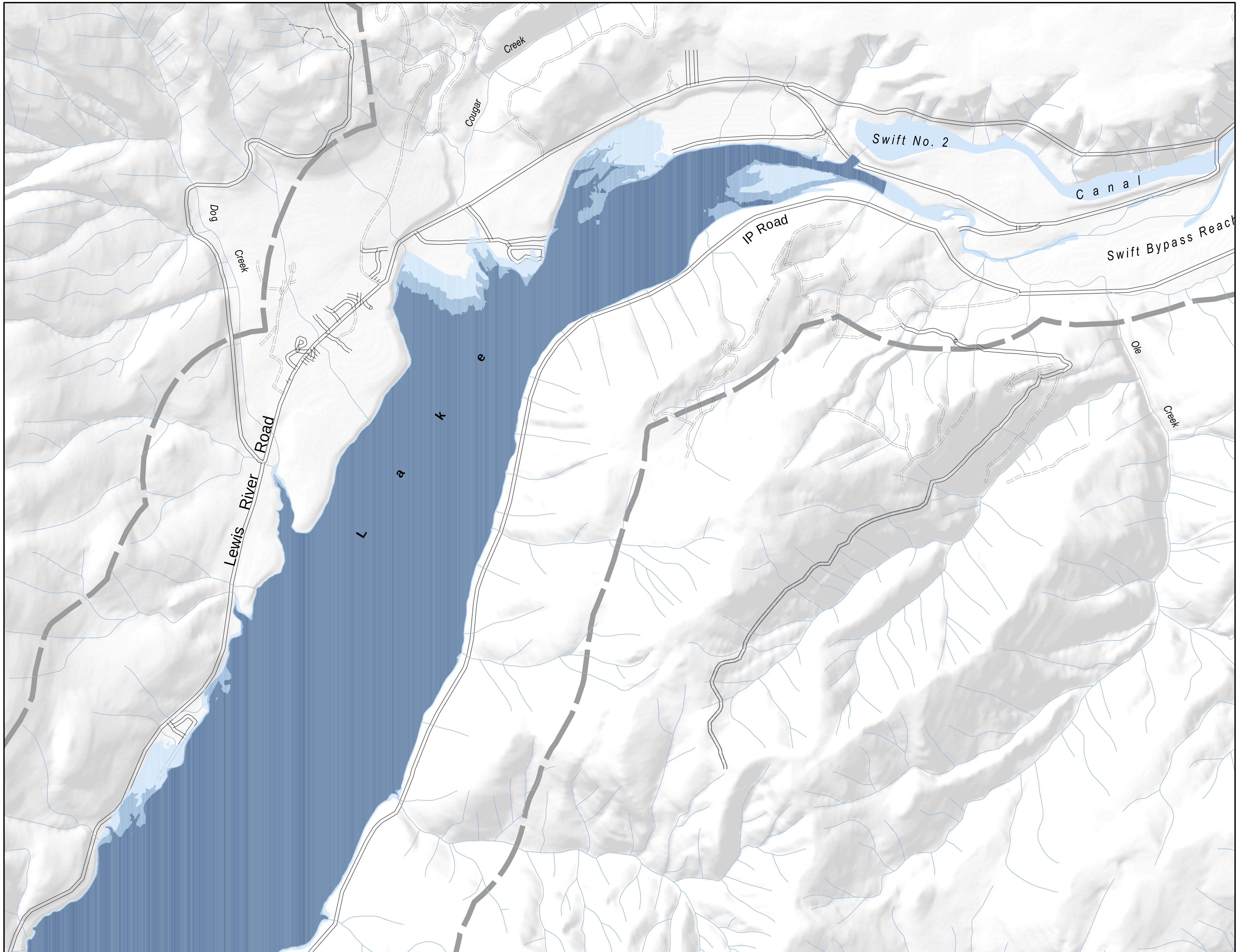
Lewis River Hydroelectric Projects

FIGURE 5.6-9 (1 of 2)

Yale Lake Drawdown Zone

Source: EDAW, Inc., 2002

P:\8e30501\GIS\mxd\Figure5.6-9.mxd

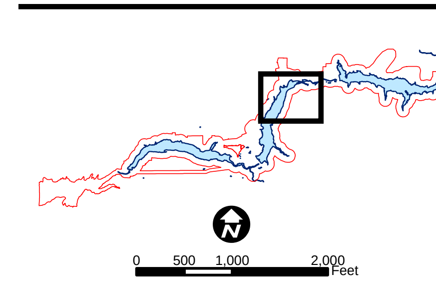


Legend

Yale Lake Bathymetry & Surface Area *

- 490 ft (Full Pool) = 3,796 acres
- 480 ft = 3,536 acres
- 474 ft = 3,361 acres
- Primary Road
- Secondary Road
- Light Duty Road
- Unimproved Road
- Trail
- Railroad
- Stream
- Other Open Water
- Study Area

* Reservoir surface area for the various pool levels was calculated from bathymetry data using GIS and does not necessarily match data presented in other studies or documents.



Lewis River Hydroelectric Projects

FIGURE 5.6-9 (2 of 2)

Yale Lake Drawdown Zone

Source: EDAW, Inc., 2002

P:\8e30501\GIS\mxd\Figure5.6-9.mxd

Over the past 5 years, Yale Lake has been at an elevation of about 479 feet (146 m), or about 10 feet (3 m) below full pool, about 50 percent of the time. This pool level has an associated surface area of 3,536 acres (1,430 ha) and a drawdown area of about 260 acres (105 ha). Most of the exposed area occurs in a thin band around the reservoir edge, with slightly larger areas near Yale Park and Siouxon Flats (Figure 5.6-9). To estimate the size of the drawdown area below 974 feet msl, a regression equation was developed:

$$y=12,740-26(x)$$

where "y" is the area of drawdown zone in acres and "x" is the lake level in feet. This equation assumes a linear relationship between reservoir elevation and drawdown area. Using this equation, about 1,040 acres (420 ha) would be exposed at an elevation of about 450 feet (137 m), which represents the lowest level of Yale Lake in the last 5 years.

<u>Potential Wildlife Habitat Use of the Yale Lake Drawdown Area</u> – The Yale Project relicensing studies included cutbank mapping and surveys to determine use of the Yale Lake drawdown area by wildlife. Results of these studies are documented in PacifiCorp (1999).

<u>Shoreline Erosion and Bank Heights</u> – The investigation of shoreline erosion and deposition at Yale Lake was conducted to assess the type of erosional processes (landslides, raveling, undercutting, and block failure) that occur along the reservoir.

Erosion and Deposition below Full Pool – Areas of erosion and deposition in Yale Lake between full pool elevation (490 ft [149 m]) and the water level water level at the time of the field survey elevation (469 ft [143 m)] are shown on Figure 5.6-10. The map shows the substrate of exposed shorelines (bedrock, cobble, sand, silt) as well as the total estimated depth of erosion (in feet) for each unit since the reservoir was filled in 1962.

Areas underlain by bedrock will have little if any future erosion below full pool because the erodible soil mantle has been removed. However, very little bedrock is exposed along the Yale Lake shoreline. Shoreline areas with cobble banks are less erodible than silty or sandy banks since the wave energy and magnitudes in the reservoir are generally not large enough to move cobble-sized particles. The cobbles thus form a protective layer over the underlying sediments. Areas underlain by silt and sand are more susceptible to future erosion; however, the majority of these areas are in protected coves, or on flat benches like those identified in the vicinity of Cougar Park and along the western shore approximately 2.5 miles (4.0 km) north of the Saddle Dam.

Bank Heights – Yale Lake bank heights are shown in Figure 5.6-11 and Table 5.6-14. Mapped geologic units are also shown on Figure 5.6-9 since the underlying geology strongly influences bank erosion.

Roughly 79 percent of the Yale shoreline has a bank height between 0 and 5 feet (0 and 1.5 m). About 14 percent of the shoreline has heights banks over 15 feet (4.6 m), most of which are underlain by Quaternary (geologically young) unconsolidated deposits that are erodible. The most erosive unit is labeled Qvc1sh on Figure 5.6-11, and is a young volcaniclastic deposit originating from Mount St. Helens. This unit is composed of ash, rocks, and debris resulting from a volcanic mudflow. This unit forms the pumice cliffs along portions of the western shore of Yale Lake.

Table 5.6-14. Yale Lake shoreline length by bank height.

Bank Height (feet)	Reservoir Shoreline Length (miles)	Percent of Total Reservoir Length
0-5	19.9	79%
5-10	1.1	4%
10-15	0.7	3%
15-20	3.4	14%
Total	**25.1**	**100%**

As at Swift Reservoir, the majority of shoreline bank erosion along Yale Lake occurs by wave undercutting at the higher pool levels, which results in calving of blocks of shoreline. Most of the geologic units bordering Yale Lake are capable of holding steep banks and do not appear to be susceptible to extensive raveling. Landslides do not appear to be a major erosion mechanism along the Yale Lake shoreline.

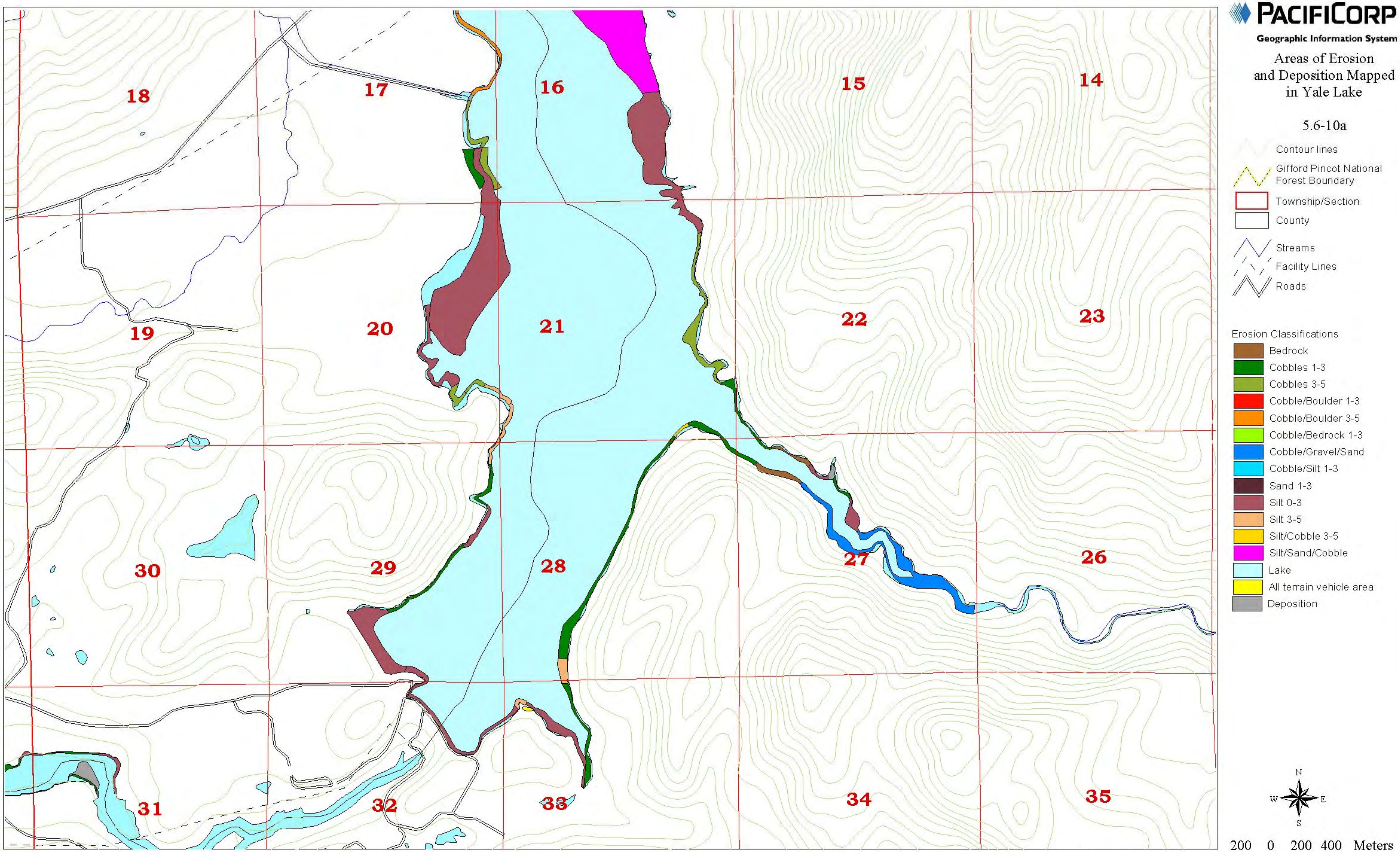
Lake Merwin

Characteristics of Lake Merwin shoreline habitats, water levels, bank erosion areas, and drawdown zone are summarized below.

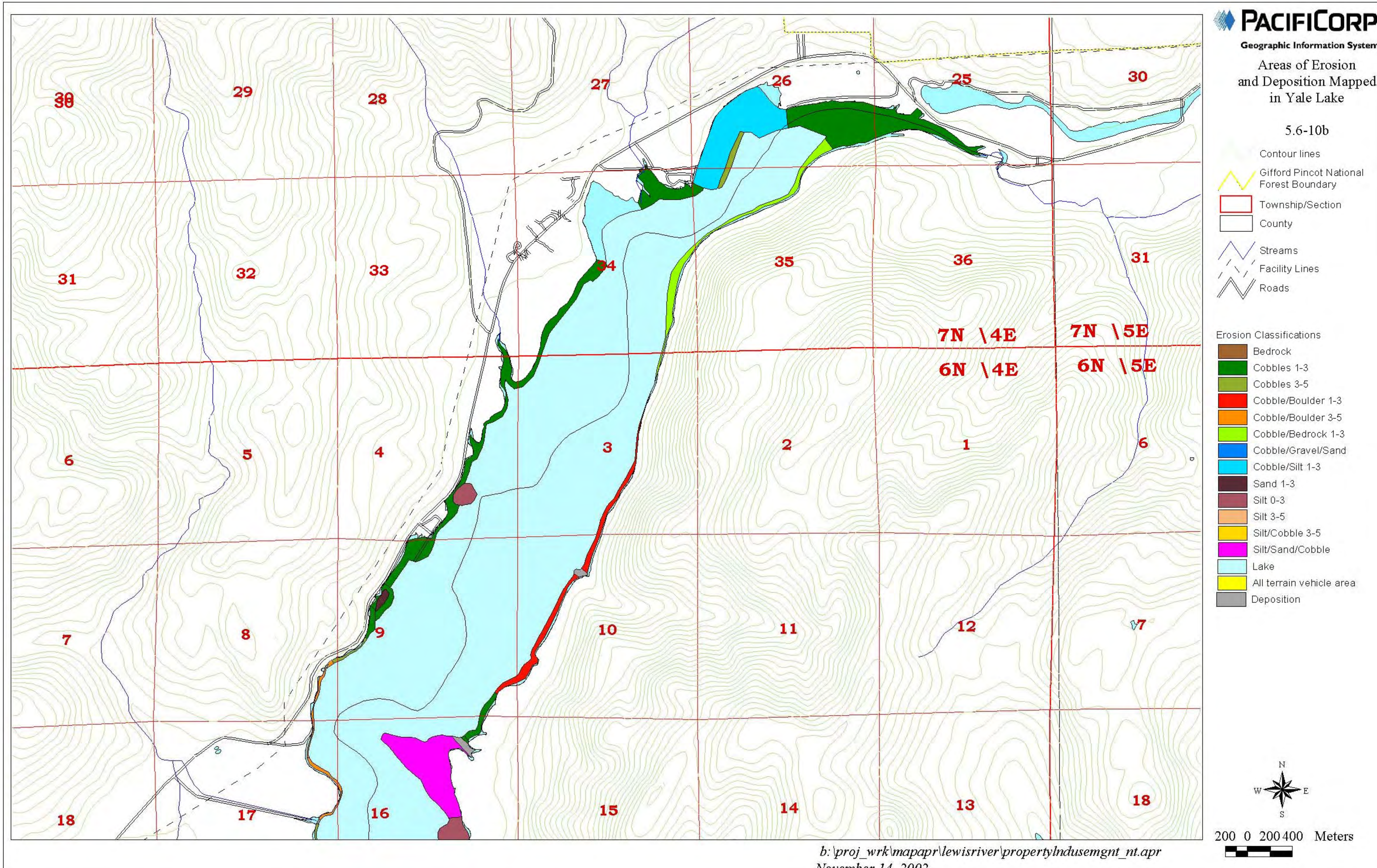
Shoreline Cover Types – The approximately 32-mile (51-km) shoreline of Lake Merwin is bordered primarily by upland mixed conifer-deciduous forest stands, which line more than 35 percent of the reservoir perimeter (see Figure 5.1-2; Table 5.6-15). Mid-successional and mature stands border another 26 and 12 percent, respectively. There is no old-growth conifer adjoining the reservoir. Wetlands are very limited; riparian types, which are associated with Speelyai and Cresap bays, comprise about 7 percent of the shoreline.

Unlike Swift Reservoir and Yale Lake, the vegetation types composing the north and south shores of Lake Merwin are fairly similar (see Figure 5.1-2, Table 5.6-15). Upland mixed and mid-successional forests dominate both sides, together occupying 62 and 67 percent of the north and south shorelines, respectively. There is, however, more mature conifer along the south shoreline (22 percent) and more upland deciduous forest along the north side (14 percent). Most residential and recreational development occurs along the northern shoreline of Lake Merwin.

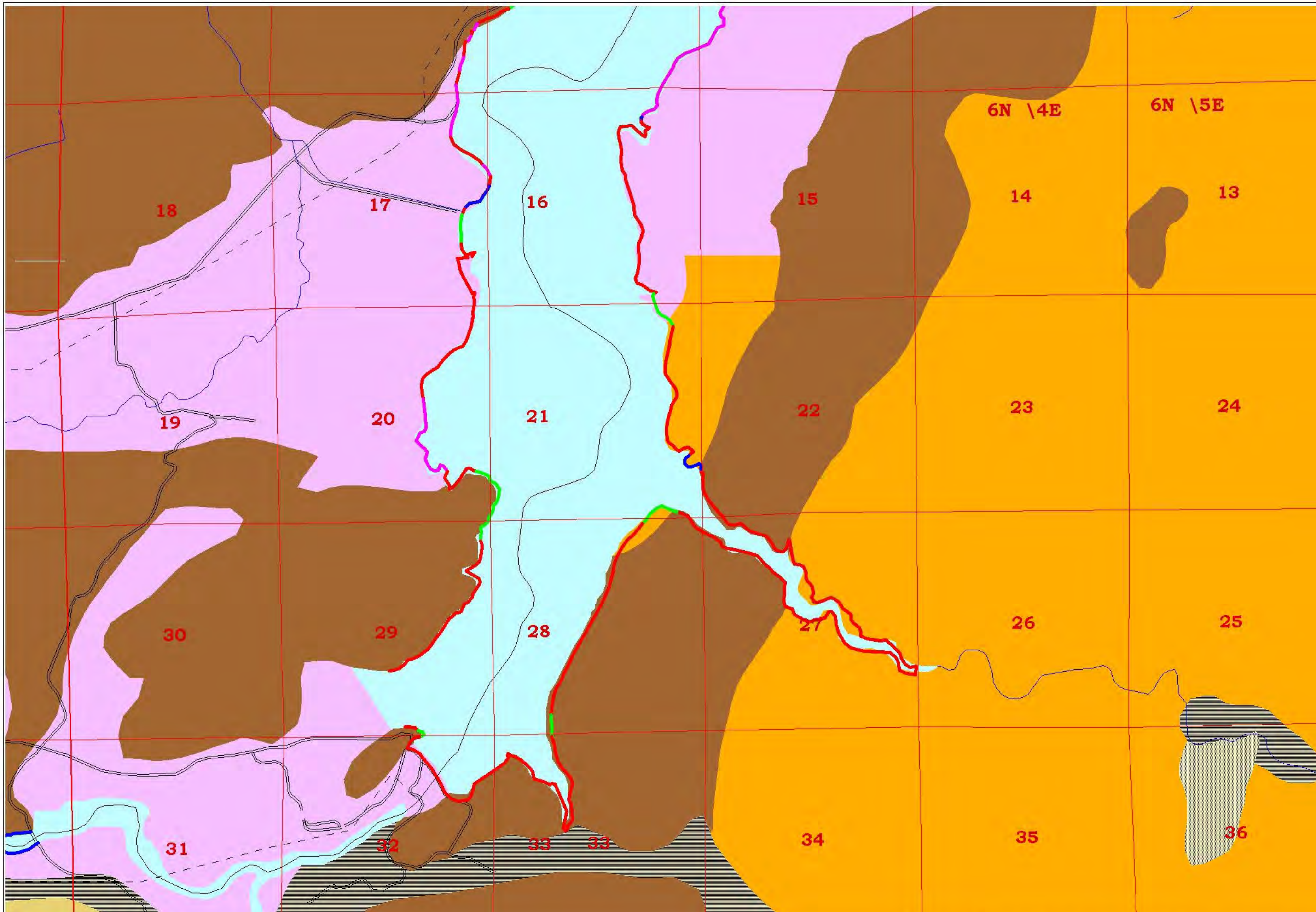
Data on the structure and species composition of the cover types associated with Lake Merwin are summarized in Table 5.6-16. As for Swift Reservoir and Yale Lake, these data were collected from a range of distances from the reservoir; they do, however, give some idea of habitat structure for the cover types along the shoreline. Upland mixed stands, which are prevalent around Lake Merwin, usually consist of Douglas-fir, western hemlock, and big-leaf maple. The upland deciduous forest stands support a mixture of big-leaf maple and red alder, and occasionally some large bitter cherry (*Prunus*



b:\proj_wrk\mapapr\lewisriver\propertylndusemgnt_nt.apr
November 14, 2002



b:\proj_wrk\mapapr\lewisriver\propertylndusemgnt_nt.apr
November 14, 2002



PACIFICORP
Geographic Information System

Yale Lake Bank
Heights and Geology

Figure 5.6-11a

Gifford Pincot National Forest Boundary
Township/Section
County
Streams
Facility Lines
Roads

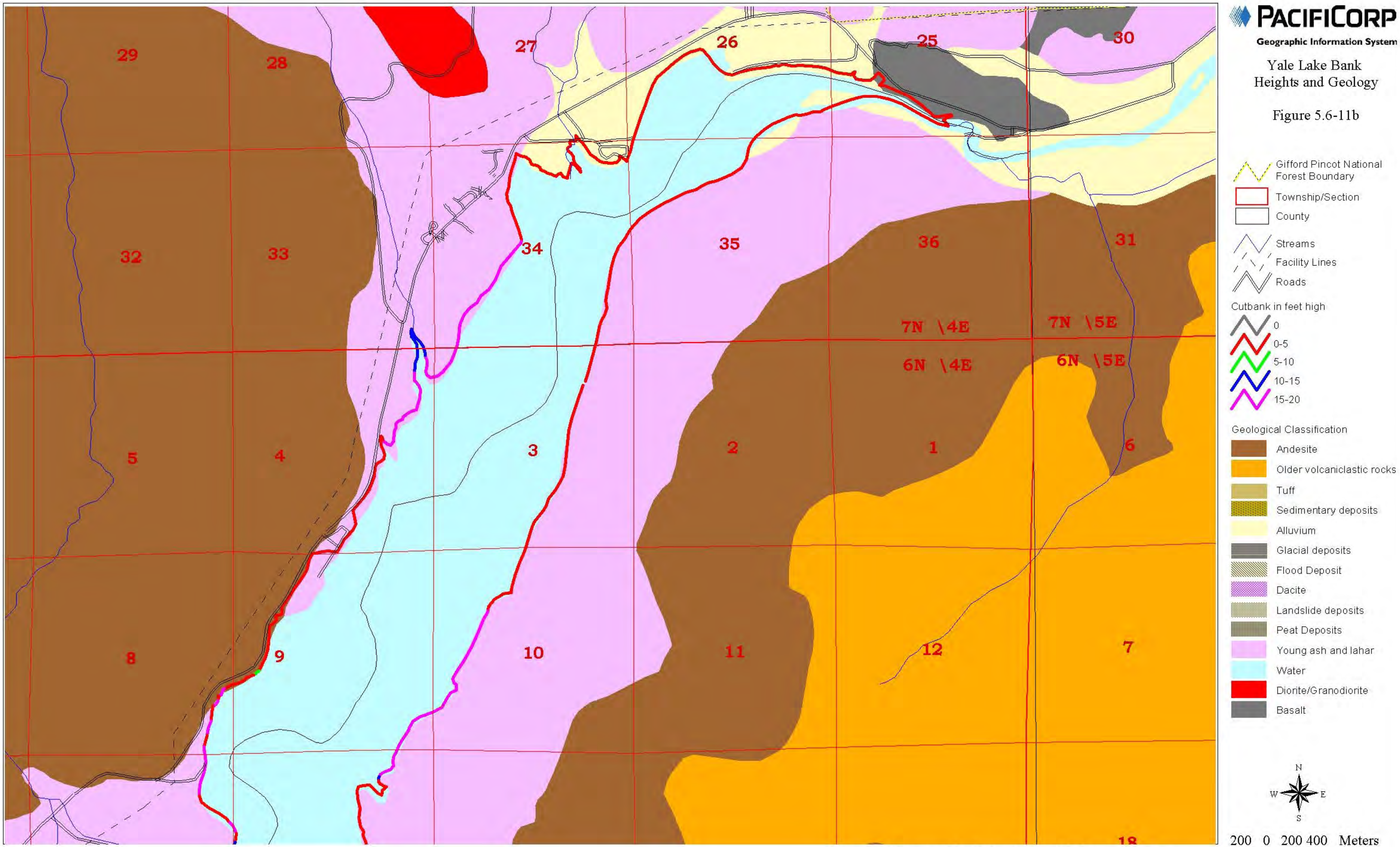
Cutbank in feet high
0
0-5
5-10
10-15
15-20

Geological Classification
Andesite
Older volcaniclastic rocks
Tuff
Sedimentary deposits
Alluvium
Glacial deposits
Flood Deposit
Dacite
Landslide deposits
Peat Deposits
Young ash and lahar
Water
Diorite/Granodiorite
Basalt

N
W E
S

200 0 200 400 Meters

b:\proj_wrk\mapapr\lewisriver\propertylndusemgnt_nt.apr
November 14, 2002



b:\proj_wrk\mapapr\lewisriver\propertylndusemgnt_nt.apr
November 14, 2002

Table 5.6-15. Lake Merwin shoreline composition by cover type.

Vegetation Cover Type Code	North		South		Grand Total	
	Length (ft)	%	Length (ft)	%	Length (ft)	%
Developed (DV)	1,873.2	2.0	1,536.1	2.0	3,409.3	2.0
Lacustrine Unconsolidated Bottom (LUB)	846.0	0.9	0	0.0	846.0	0.5
Mature Conifer (M)	4,609.2	4.8	16,486.7	21.8	21,096.0	12.4
Meadow (MD)	169.1	0.2	0	0.0	169.1	0.1
Mid-successional Conifer Forest (MS)	26,895.9	28.3	17,676.6	23.4	44,572.5	26.1
Pole Conifer Forest (P)	820.6	0.9	0	0.0	820.6	0.5
Palustrine Emergent Wetland (PEM)	170.6	0.2	477.2	0.6	647.8	0.4
Recreation (REC)	2,558.2	2.7	125.5	0.2	2,683.7	1.6
Residential (RES)	2,720.8	2.9	0	0.0	2,720.8	1.6
Riparian Deciduous Forest (RD)	6,276.5	6.6	2,960.0	3.9	9,236.5	5.4
Riparian Mixed Forest (RM)	3,106.2	3.3	67.2	0.1	3,173.4	1.9
Riverine Unconsolidated Bottom (RUB)	0	0.0	68.1	0.1	68.1	<0.1
Rock Talus (RT)	0	0.0	104.0	0.1	104.0	0.1
Upland Deciduous Forest (UD)	13,077.0	13.8	3,772.8	5.0	16,849.9	9.9
Upland Mixed Forest (UM)	31,692.0	33.3	32,227.2	42.6	63,919.2	37.4
Grand Total	95,080.1	100.0	75,615.8	100.0	170,695.8	100.0

Table 5.6-16. Habitat characteristics of cover types associated with Lake Merwin.

Vegetation Cover Type[1]	Tree Cover (%)[2]	Deciduous Shrub Cover (%)[2]	Snag Density (No./ac)[2]
Mature Conifer (4)	93.6 (83.2-99.0)	61.5 (19.9-100)	19.2 (12.1-28.3)
Mid-successional Conifer Forest (11)	80.3 (38.2-100)	33.3 (0-55.9)	25.0 (8.1-89.1)
Pole Conifer Forest (8)	96.0 (86.1-100)	15.1 (0-56.6)	8.6 (0-40.5)
Palustrine Emergent Wetland (2)	7.4	0	0
Riparian Deciduous Forest (2)	86.9 (80.3-93.6)	42.4 (41.2-43.5)	16.2 (8.1-24.3)
Riparian Mixed Forest (3)	81.3 (63.6-100)	60.8 (29.5-96.2)	17.5 (4.0-36.4)
Upland Deciduous Forest (6)	90.5 (68.0-100)	54.1 (12.5-106.4)	21.6 (0-89.1)
Upland Mixed Forest (10)	92.8 (86.1-100)	36.4 (0-75.5.6)	11.9 (0-20.2)

[1] Number of plots sampled is in parentheses.
[2] Range is shown in parentheses.

emarginata) trees. Conifer stands are dominated by Douglas-fir and/or western hemlock, and include some western red cedar. Tree cover is relatively high, exceeding 80 percent in all forested cover types; snag density is moderate to high.

Deciduous shrub cover is moderate to moderately high for most forested cover types associated with Lake Merwin. Pole stands, which are often characterized by a low, dense conifer cover, have relatively low shrub cover. Vine maple and Oregon grape are some of the most dominant shrubs in upland conifer stands around the reservoir, although drier sites also support snowberry (*Symphoricarpus alba*). Moister sites, particularly along the shoreline, are often dominated by salmonberry and some elderberry (*Sambucus racemosa*).

Water Level Fluctuations – Lake Merwin has a full pool elevation of 239.6 feet (73 m), with a surface area of about 3,863 acres (1,573 ha). The minimum pool elevation is 165 feet (50 m), which occurs rarely and is related to project testing and maintenance activities (PacifiCorp and Cowlitz County PUD 2000). During the summer recreation season, Lake Merwin is typically at or above an elevation of 235 feet (72 m). PacifiCorp does not lower Lake Merwin in the winter.

Mean daily water levels changes in Lake Merwin for the 1997 – 2001 water years are illustrated in Figure 5.6-12. For this period, Lake Merwin fluctuated an average of about 8 inches (20 cm) or 0.66 foot (0.2 m) daily (Table 5.6-17). The change in reservoir level was generally 1 foot (0.3 m) or less for 78 percent of the days and greater than 3 feet (1 m) less than 1 percent of the days (Table 5.6-17).

Compared to the other 2 project reservoirs, Lake Merwin is relatively stable on a seasonal basis; mean annual daily fluctuations are similar to Yale Lake and less than Swift Reservoir (Figure 5.6-12). The reservoir level typically fluctuates between 234 and 238 feet (71 and 72 m) msl through most of the summer months (May – September). Over the past 5 years, daily water changes during this period have averaged about 6 inches (15.2 cm) or 0.5 foot (0.15 m) (Table 5.6-17). Fluctuations are greater the remainder of the year, generally between 225 and 238 feet (69 and 71 m) msl. Daily water level changes during this period average between 0.6 and 0.8 foot (0.2 m), but are rarely greater than 2 feet (0.6 m) (Table 5.6-17).

Between 1997 and 2001, the mean pool elevation of Lake Merwin was about 234 feet (71 m) msl, about 5 feet (1.5 m) less than full (Table 5.6-18). On average, the pool was completely full (≥239 feet [73 m] msl) only about 1 week each year. However, pool levels were within the top 2 feet (0.6 m) about 30 percent of the year, and within the top 5 feet (3 m) nearly 60 percent of the time. From 1997-2001, the lowest annual pool elevation averaged 222 feet (68 m) and ranged from 214.8 to 227.6 feet (65 - 69 m) (Table 5.6-18). All of the annual low pool elevations occurred between September and February. Lake Merwin dropped below 220 feet (67 m) msl in only 1 of the last 5 water years (Table 5.6-18). Because Lake Merwin is not annually drawn down for the winter, there is no bathymetry available.

Potential Wildlife Habitat Use of the Lake Merwin Drawdown Area – Unlike Swift Reservoir and Yale Lake, which have winter drawdowns of 20 and 30 feet (6 and 9 m), respectively, Lake Merwin is not drawn down in the winter. Thus, studies were not conducted to document cutbanks or wildlife use of a drawdown area.

Shoreline Erosion and Bank Heights – Information on erosional processes and bank height for Lake Merwin is summarized below.

Erosion and Deposition below Full Pool – The Lake Merwin investigation was completed at 2 reservoir elevations. The eastern roughly one-quarter (Speelyai Creek eastward) of the reservoir was surveyed at a pool elevation of 233 feet (71 m) (October 13, 1999), and the reminder of the reservoir shoreline was surveyed at a pool elevation of 235 feet (72 m) (May 23, 2002). Areas of erosion and deposition between full pool (elevation 239 feet [73 m]) and the water level at the time of the field surveys are shown

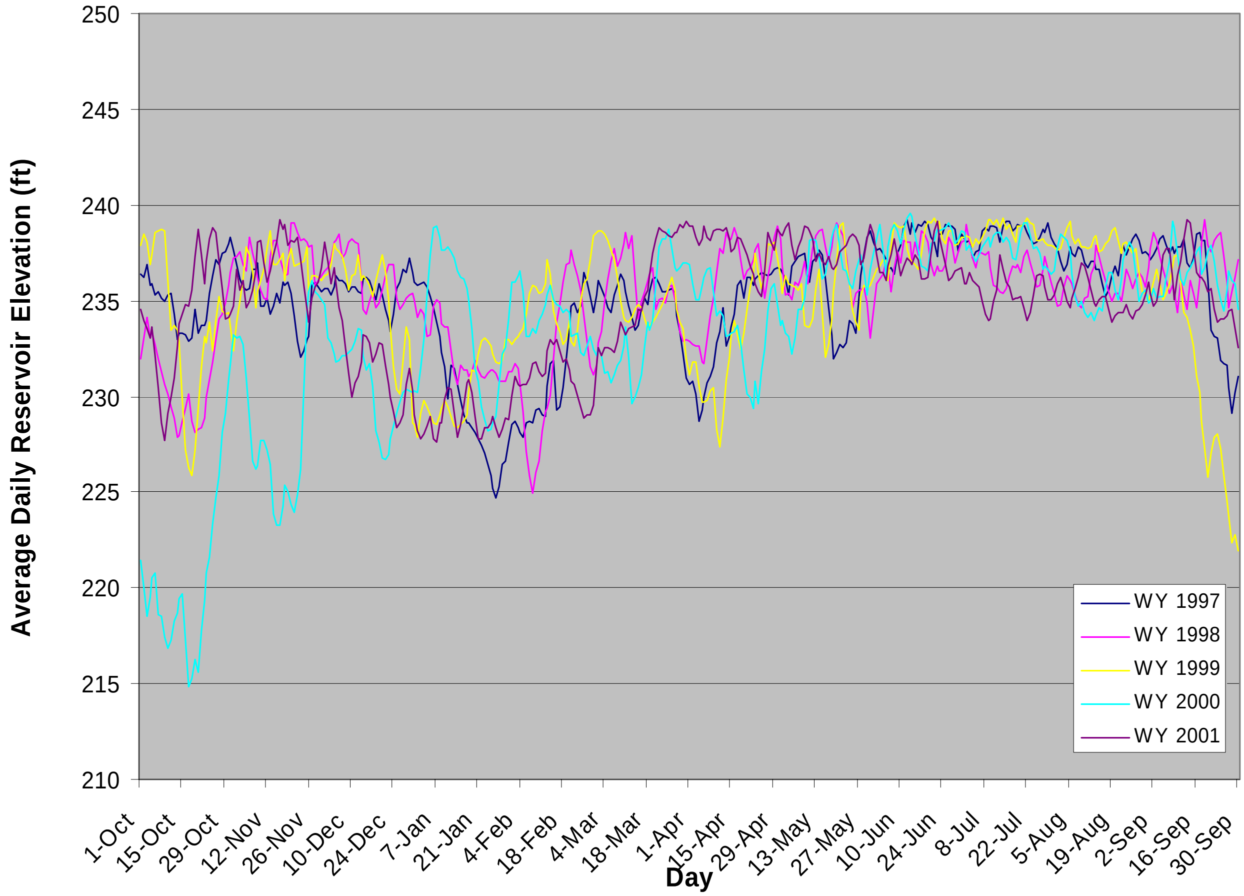


Figure 5.6-12. Lake Merwin average daily and seasonal water elevations, water years 1997 – 2001.

on Figure 5.6-13. The map shows the substrate of exposed shorelines (bedrock, cobble, sand, silt) as well as the estimated depth of erosion (in feet) for each unit since the reservoir was filled in 1931.

Much of the western third of Lake Merwin is underlain by bedrock, primarily basalt and andesite flows (OEvba(g) on Figure 5.6-13), and it experiences little or no erosion. Shoreline areas with cobble banks are less erodible than silty or sandy banks since the wave energy and magnitudes in Lake Merwin are generally not large enough to move cobble-sized particles. Areas underlain by silt and sand are more susceptible to future erosion; however, the majority of these areas are in protected inlets, such as the Speelyai Creek area, or on flat benches like those north of Buncombe Hollow Creek. An area northwest of the Cresap Bay Campground and several areas to the west and east of the State Highway 503 bridge at the east end of the reservoir are predominantly underlain by silt or sand and would be expected to be susceptible to erosion/deposition. However, the near shore sediments in these areas were submerged on May 23, 2002 and could not be surveyed.

Table 5.6-17. Summary of 1997-2001 daily water level fluctuations for Lake Merwin.

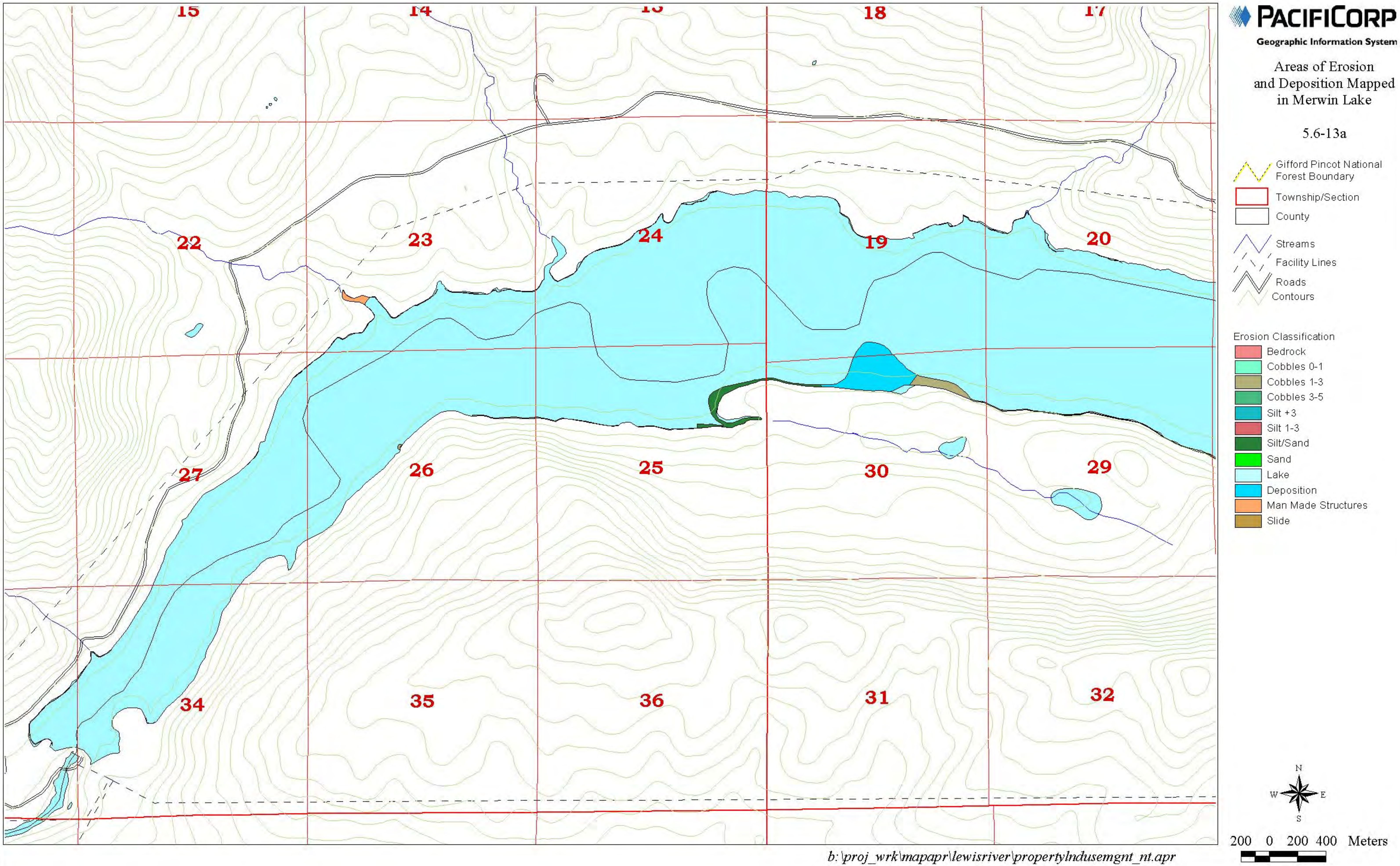
Year[1]	Mean Daily Fluctuation (Range)				No. of Days with Fluctuations						Max. Daily Fluctu-ation (ft)[2]	Date of Max. Daily Fluctu-ation
	Annual	May - August	Sept. - Dec.	Jan. - April	≤ 0.5 ft (%)	> 0.5 & ≤ 1 ft (%)	> 1 & ≤ 1.5 ft (%)	> 1.5 & ≤ 2 ft (%)	> 2 ft ≤ 3 ft (%)	> 3 ft (%)		
1997	0.54	0.47 (0-1.9)	0.54 (0-2.7)	0.60 (0-2.5)	208 (57.1%)	99 (27.2%)	41 (11.3%)	10 (2.7%)	6 (1.6%)	0 (0.0%)	2.7 (+)	September 20-21
1998	0.67	0.60 (0-1.8)	0.68 (0-2.7)	0.71 (0-2.2)	144 (39.6%)	141 (38.7%)	57 (15.7%)	15 (4.1%)	7 (1.9%)	0 (0.0%)	2.7 (-)	November 19-20
1999	0.67	0.52 (0-2.3)	0.90 (0-4.4)	0.60 (0-2.2)	180 (49.5%)	97 (26.6%)	54 (14.8%)	18 (4.9%)	14 (3.8%)	1 (0.3%)	4.4 (+)	December 29-30
2000	0.71	0.57 (0-1.6)	0.85 (0-4.2)	0.72 (0-2.4)	168 (46.0%)	101 (27.7%)	60 (16.4%)	19 (5.2%)	15 (4.1%)	2 (0.5%)	4.2 (-)	November 24-25
2001	0.60	0.48 (0-1.9)	0.83 (0-1.9)	0.49 (0-2.1)	174 (47.8%)	111 (30.5%)	66 (18.1%)	11 (3.0%)	2 (0.5%)	0 (0.0%)	2.1 (-)	February 28-March 1
Mean	0.64	0.53 (0-1.9)	0. 76 (0-3.1)	0.62 (0-2.3)	175 (47.9%)	110 (30.1%)	56 (15.3%)	15 (4.0%)	9 (2.4%)	1 (0.2%)	3.2	--

[1] Water year begins October 1 of previous year (i.e., the 1997 water year begins on October 1, 1996).
[2] + indicates that the reservoir level increased; - indicates a drop in reservoir level.

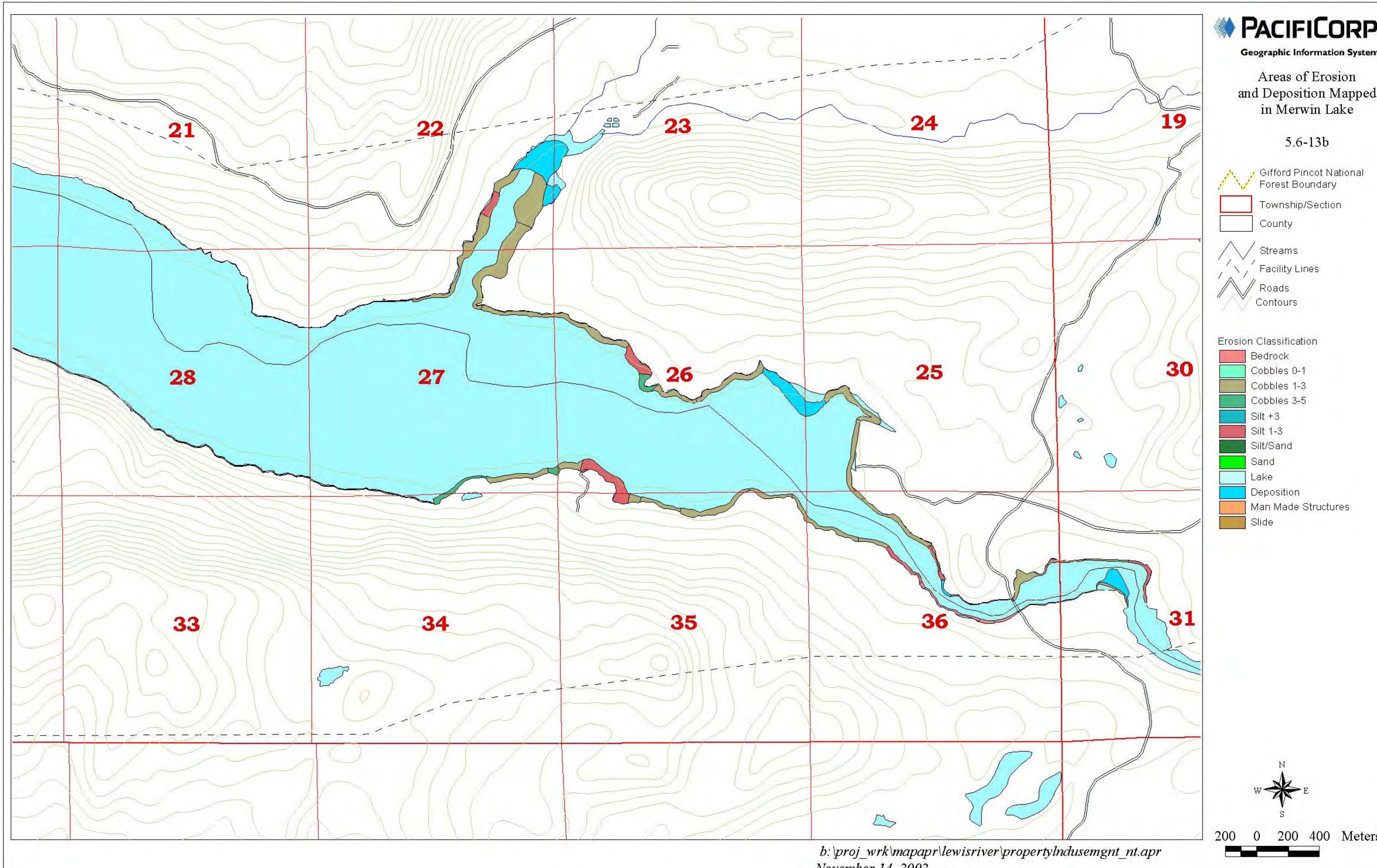
Table 5.6-18. Summary of 1997-2001 Lake Merwin elevations.

Year[1]	Mean Pool Elevation (ft)	Lowest Pool Elevation (ft)	Date of Lowest Pool Level	Number of Days With Pool Elevation s Below					
				239 ft msl (%)	237 ft msl (%)	235 ft msl (%)	230 ft msl (%)	225 ft msl (%)	220 ft msl (%)
1997	235.12	224.72	January 27	359 (98%)	253 (69%)	126 (35%)	36 (10%)	4 (1%)	0 (0%)
1998	235.28	224.98	February 8	361 (99%)	261 (72%)	121 (33%)	21 (6%)	1 (0%)	0 (0%)
1999	234.93	221.96	September 30	352 (96%)	238 (65%)	150 (41%)	44 (12%)	5 (1%)	0 (0%)
2000	233.35	214.83	October 17	358 (98%)	270 (74%)	185 (51%)	67 (18%)	33 (9%)	19 (5%)
2001	234.8	227.61	January 7	359 (98%)	258 (71%)	161 (44%)	42 (12%)	0 (0%)	0 (0%)
Mean	234.70	222.82	--	357.2 (98%)	255.8 (70%)	148.4 (41%)	41.8 (27%)	8.4 (2%)	3.6 (1.0%)

[1] Water year begins October 1 of previous year (i.e.,. the 1997 water year begins on October 1, 1996).



b:\proj_wrk\mapapr\lewisriver\propertylndusemgnt_nt.apr
November 14, 2002



b:\proj_wrk\mapapr\lewisriver\propertylndusemgnt_nt.apr
November 14, 2002

Bank Heights – Lake Merwin bank heights are shown in Figure 5.6-14 and Table 5.6-19. Mapped geologic units are also shown on Figure 5.6-14 since the underlying geology strongly influences erodible reservoir banks area.

Table 5.6-19. Lake Merwin shoreline length by bank height.

Bank Height (feet)	Reservoir Shoreline Length (miles)	Percent of Total Reservoir Length
Developed Shoreline	1.3	5%
0-5	13.6	54%
5-10	6.0	24%
10-15	3.7	15%
15-20	0.7	3%
Total	**25.3**	**100%**

About 54 percent of the Lake Merwin shoreline has bank heights ranging from 0 to 5 feet (1.5 m). Most of these areas occur along areas of very stable bedrock. Twenty-four percent of the shoreline has banks between 5 and 10 feet (1.5 and 3 m) high. Another 15 percent of the reservoir has banks of 10 to 15 feet (3 m to 4.5 m) in height. Only 3 percent of the reservoir has banks over 15 feet (4.6 m) high. Roughly 5 percent of the Lake Merwin shoreline is developed and includes structures such as wood bulkheads, which have altered the reservoir banks.

The majority of shoreline bank erosion occurs by wave undercutting at full pool levels, which results in calving of blocks of shoreline and toppling of trees on the top of these blocks. Most of the geologic units are capable of holding steep banks and do not appear to be susceptible to extensive raveling. Landslides do not appear to be a major erosion mechanism along the Lake Merwin shoreline.

5.6.3.2 Reservoir Fluctuation Effects on Wetlands

There are about 272 acres (110 ha) of wetlands associated with the 4 Lewis River Projects (see TER 1 and TER 5). There are 7 wetlands with evidence of a direct hydrological connection to the reservoirs:

- Swift: Drift Creek mouth wetland
- Yale: Beaver Bay, IP, and Yale Park wetlands
- Merwin: Speelyai Point, Riparian Bridge, and Buncombe Hollow wetlands

In total, these wetlands represent 58.9 acres (23.8 ha), or about 21 percent of the wetland acreage associated with the projects. Additional information on the location, size, and characteristics of these wetlands can be found in TER 5, Figure 5.5-1, and Table 5.5-2. Of these 7 wetlands, Beaver Bay is fed by several tributary streams and does not appear to be greatly affected by reservoir drawdowns, partially due to beaver dams which maintain water table. The IP wetland also receives tributary input but requires a beaver dam or other structure to maintain water levels during winter drawdown. Water levels in Beaver Bay are stable enough to support red-legged frogs, which are generally sensitive to water fluctuations during late winter-early spring (Richter and Azous 1995).

To get a better idea of how reservoir fluctuations affect the Beaver Bay wetlands in particular, PacifiCorp installed a transducer in September 2000, and daily water levels were recorded through September 2001. However, the transducer appears to have experienced a number of operational failures over this time period. The results of monthly staff gage readings from Beaver Bay wetland and the water elevation data for Yale Lake (September 2000-September 2001) are presented in Section 5.5.4.3 of TER 5; similar data for 1997-1998 can be found in PacifiCorp (1999). In general, it appears that Yale Lake hydrology had the greatest influence on Beaver Bay wetland water levels during times of low precipitation and inflow. In a year of monitoring, the greatest change in wetland water levels occurred between August 27 and September 27, 2001. During this 1-month period, Yale Lake dropped from 485 ft msl to 474 ft msl (148 to 144 m msl), a decrease of 11 feet (3.4 m). At the same time, water levels in Beaver Bay wetland decreased by 15 inches (138 cm) (see Section 5.5.4.3 in TER 5).

5.6.5.3 Swift Reservoir-Merrill Lake Shoreline Vegetation Comparison

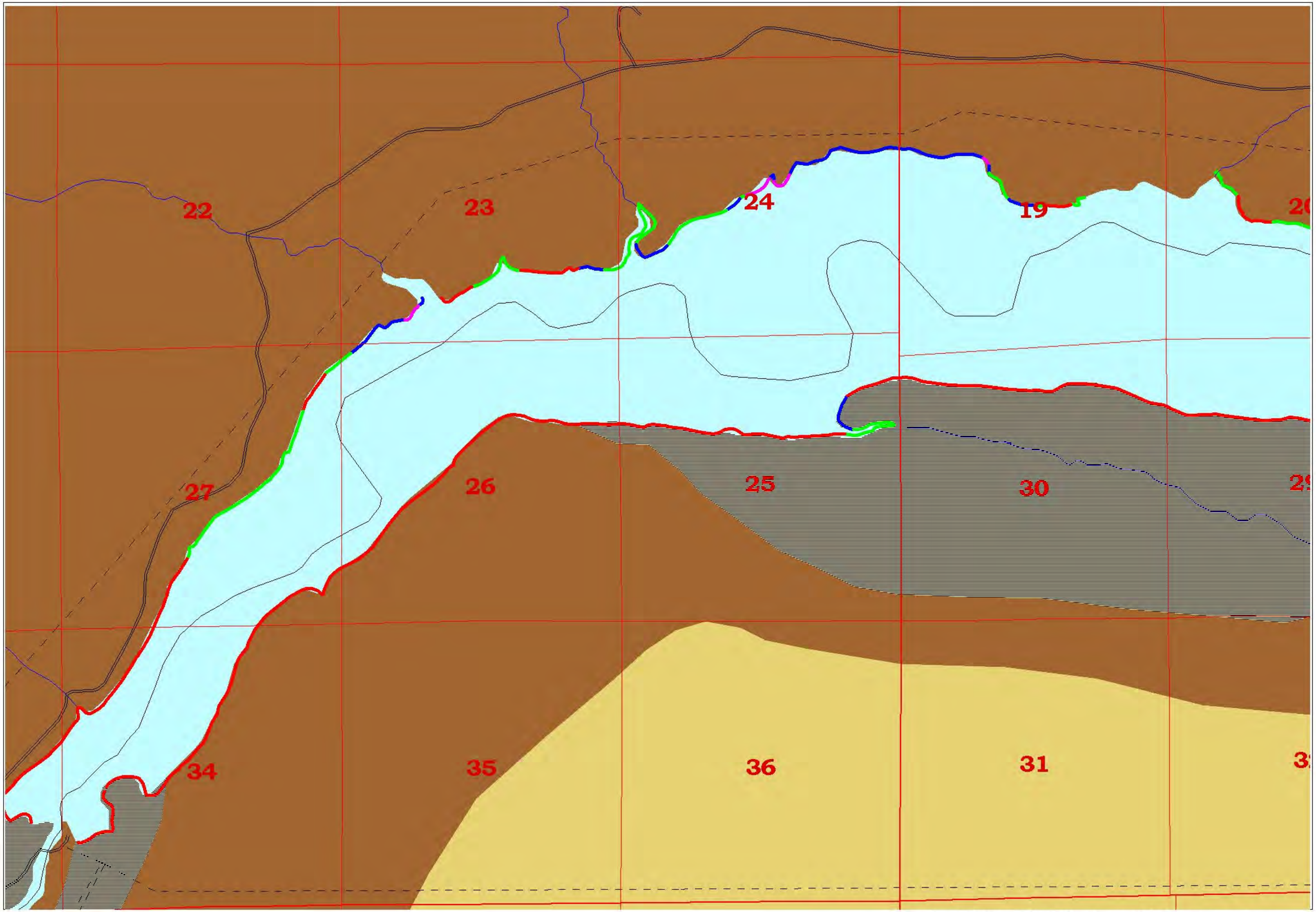
The results of the cover type mapping and sampling along the shorelines of Swift Reservoir and Merrill Lake are summarized below.

Shoreline Cover Types

The cover types surrounding Swift Reservoir and Merrill Lake were mapped in September 1999 and June 2001, respectively. Merrill Lake is the largest natural lake in the Lewis River basin; with a surface area of about 281 acres (114 ha), however, it is only 7 percent the size of Swift Reservoir, which is 4,634 acres (1,876 ha). Although Merrill Lake is about 450 feet higher in elevation than Swift Reservoir (1,450 feet [450 m] vs 1,000 feet [307 m] msl), the surrounding vegetation cover types and associated plant species appear to be similar. Like Swift Reservoir, much of the land near Merrill Lake is owned by private timber companies, although a number of parcels are managed by the Washington Department of Natural Resources (DNR).

Approximately 95 percent of Merrill Lake is bordered by riparian or wetland vegetation (Table 5.6-20). A large palustrine emergent wetland at the northern end of the lake represents more than 15 percent of the shoreline, and riparian shrubland lines much of the remainder (Figure 5.6-15). The upland habitats beyond the shoreline, but within about 200 feet (60 m) or so of the water, consist mostly of mature conifer, upland deciduous, and upland mixed forests (Table 5.6-21, Figure 5.6-15).

In contrast, Swift Reservoir is bordered primarily by upland vegetation cover types, with riparian shrublands and emergent wetlands combined representing less than 1 percent of the shoreline (see Table 5.6-1). Over half of the Swift Reservoir shoreline consists of old-growth conifer and upland mixed forest types, and there is generally very little difference between shoreline habitats and those farther from the water (see Figure 5.1-2 in TER 1).



PACIFICORP
Geographic Information System

Merwin Lake Bank
Heights and Geology

5.6-14a

Gifford Pincot National Forest Boundary
Township/Section
County
Streams
Facility Lines
Roads

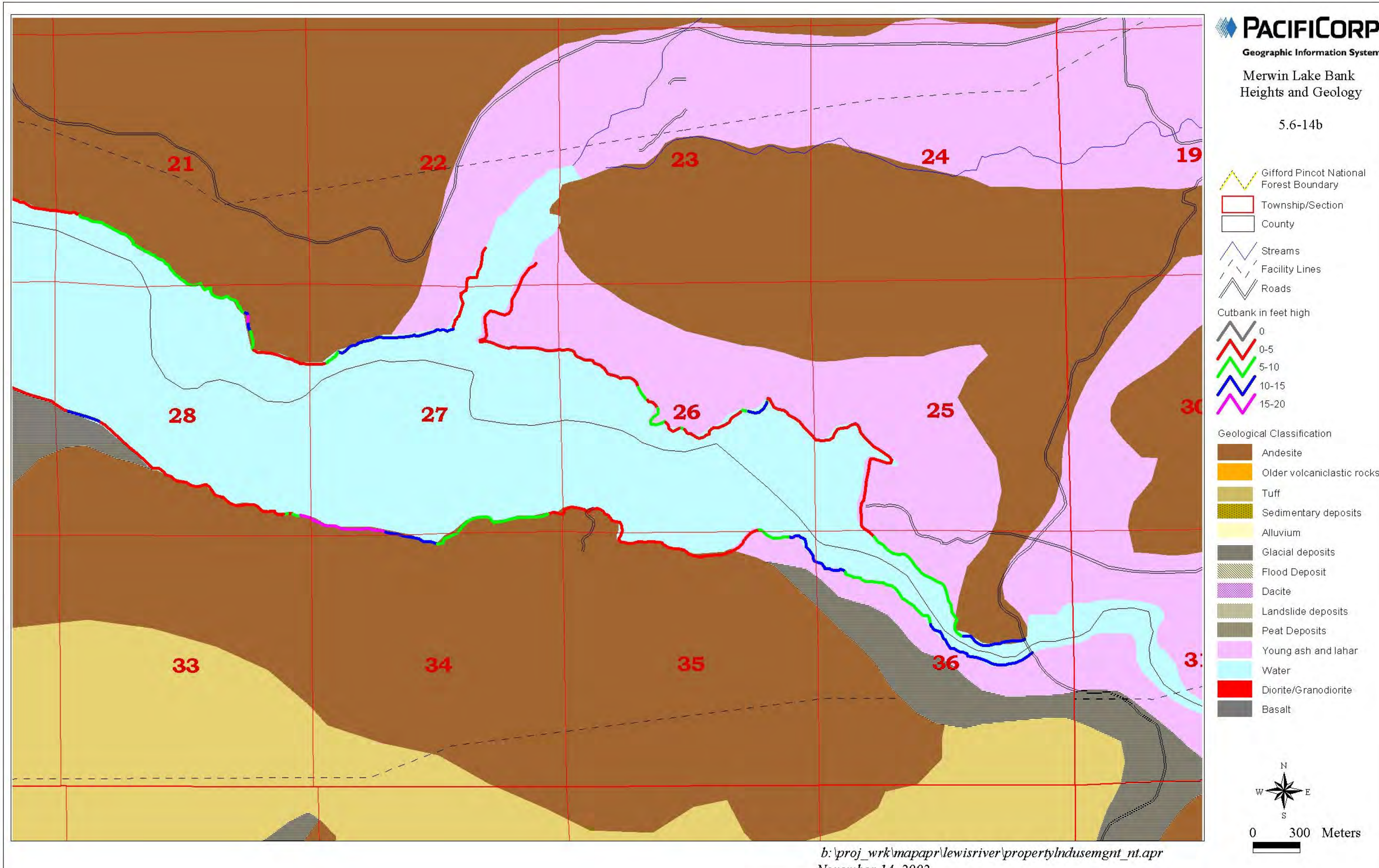
Cutbank in feet high
0
0-5
5-10
10-15
15-20

Geological Classification
Andesite
Older volcaniclastic rocks
Tuff
Sedimentary deposits
Alluvium
Glacial deposits
Flood Deposit
Dacite
Landslide deposits
Peat Deposits
Young ash and lahar
Water
Diorite/Granodiorite
Basalt

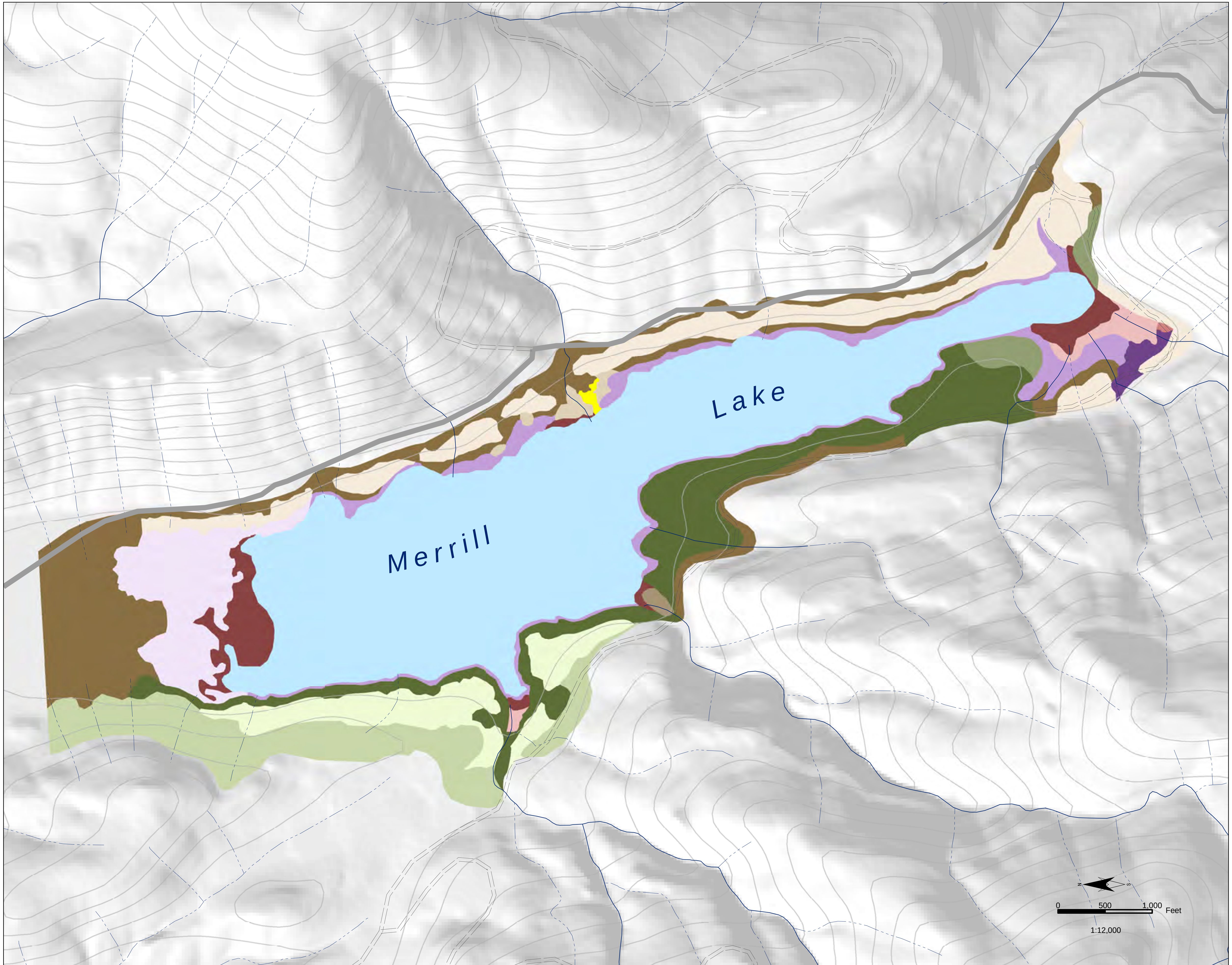
N
W E
S

0 300 Meters

b:\proj_wrk\mapapr\lewisriver\propertylndusemgnt_nt.apr
November 14, 2002

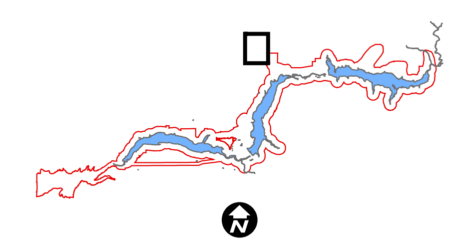


b:\proj_wrk\mapapr\lewisriver\propertylndusemgnt_nt.apr
November 14, 2002



Legend

- Mature Conifer Forest
- Mid-Successional Conifer Forest
- Pole Conifer Forest
- Seedling-Sapling Forest
- Upland Deciduous Forest
- Young Upland Deciduous Forest
- Cottonwood
- Upland Mixed Forest
- Palustrine Emergent Wetland
- Palustrine Forested Wetland
- Palustrine Scrub-Shrub Wetland
- Riparian Deciduous Forest
- Riparian Shrub
- Riparian Shrub/Palustrine Scrub-Shrub
- Disturbed
- Open Water
- Contour Line
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Light Duty Road
- Unimproved Road



Lewis River Hydroelectric Projects

FIGURE 5.6-15

Vegetation Cover Types in the Merrill Lake Vicinity

Source: EDAW, Inc., 2002

P:\8e30501\GIS\mxd\Figure5.6-15.mxd

Table 5.6-20 Merrill Lake shoreline composition (adjacent to lake).

Vegetation Cover Type	Length (ft)	%
Disturbed (DI)	95	0.4
Palustrine Emergent (PEM) – below normal summer water level	872	3.3
Mature Conifer Forest (M)	7	0.0
Palustrine Emergent Wetland (PEM)	4,088	15.5
Riparian Shrub (RS)	20,103	76.0
Riparian Shrub/Palustrine Shrub (RS/PSS)	883	3.3
Upland Deciduous Forest (UD)	292	1.1
Upland Mixed Forest (UM)	105	0.4
Grand Total	26,444	100.0

Table 5.6-21. Merrill Lake upland habitat composition (excluding the riparian and wetland band immediately adjoining the lake).

Vegetation Cover Type	Length (ft)	%
Cottonwood (CW)	1,532	4.4
Disturbed (DI)	190	0.6
Mature Conifer Forest (M)	13,580	39.4
Mid-successional Conifer Forest (MS)	1,775	5.1
Riparian Deciduous Forest (RD)	994	2.9
Upland Deciduous Forest (UD)	10,224	29.6
Upland Mixed Forest (UM)	5,807	16.8
Young Upland Deciduous Forest (YUD)	410	1.2
Grand Total	34,513	100.0

Shoreline Habitat Characteristics

Field sampling around both Lake Merrill and Swift Reservoir was conducted in late July 2001, and was focused on the most common upland and/or riparian cover types either along or near the shoreline. Transects were established in 1 to 8 polygons of each of the cover types selected for sampling and distributed by side of each waterbody, where possible. In total, 37 and 23 transects were sampled at Swift Reservoir and Merrill Lake, respectively. Sample sizes were not equal between the 2 waterbodies because of differences in shoreline length and the number and extent of cover types represented at each. The number of transects established in each cover type along Merrill Lake and Swift Reservoir is as follows:

- Swift Reservoir: 8 old-growth/mature conifer forest; 6 mid-successional conifer forest, 6 upland mixed, 5 pole/seedling-sapling, 8 upland deciduous, and 4 riparian mixed/deciduous forest.

- Merrill Lake: 5 old-growth/mature; 6 upland mixed, 4 upland deciduous, 1 cottonwood forest; 2 riparian deciduous forest; 4 riparian shrubland; and 1 palustrine shrub wetland.

Each of the transects established in the 60 polygons selected for sampling was divided into a littoral/drawdown segment (below normal high water) and shoreline segment that extends from the normal high water mark for a standard distance of 164 feet (50 m). Characteristics of each of these zones are summarized below.

Littoral/Drawdown Habitats – Some of the most obvious differences in shoreline habitats between Swift Reservoir and Merrill Lake are reflected by the extent, characteristics, and periodicity of areas exposed by seasonal changes in water levels. Like most natural lakes in western Washington, water levels in Merrill Lake gradually recede over the course of the dry summer months, as evaporation and outflow exceed input from rainfall and runoff. Sampling at Merrill Lake, which occurred in late July 2001, documented a littoral zone that averaged 65 feet (20 m) in width, and ranged from 0 to 220 feet (0-67 m) wide, depending on shoreline slope, which averaged about 15 degrees (33 percent). Mean cover of grass/sedge and forb species in this zone was 8 and 7 percent, respectively (Table 5.6-22). Common species include sedges, particularly large-awn sedge (Carex macrochaeta) and creeping buttercup (Ranunculus flammula).

In contrast to Lake Merrill, water levels in Swift Reservoir are generally maintained as close as possible to full pool from June through August, with drawdown beginning in September (see Figure 5.6-1, Section 5.6.5.1). This pattern is typical for most reservoirs used for power production, flood control, and recreation. The drawdown zone in Swift Reservoir in July 2001 averaged 14 feet (4.3 m) in width and ranged from 0 to 56 feet (0-17 m) wide (Table 5.6-22). Most of the drawdown zone was steep, with slopes averaging 29 degrees (64 percent) and did not support any vegetation, although some cover was provided by overhanging trees (mostly alder) and shrubs.

Table 5.6-22. Littoral/Drawdown habitat characteristics for Merrill Lake and Swift Reservoir (mean +/- standard deviation).

Habitat Parameter	Merrill Lake (N=23)	Swift Reservoir (N=37)
Zone Width (ft)	65.6 (±62.3)***	14.1 (±11.8)***
Zone Slope (°)	15 (±11.7)**	29 (±22.2)**
Grass/Sedge Canopy Cover (%)	8 (±13.7)^	0^
Forb Canopy Cover	7 (±13.4)^	0^
No. of Snags (No./ac)	0.52 (±2.5)^	0^
No. of Stumps (No./ac)	15.4 (±26.1)	27.1 (±61.5)

*** Significantly different (p<0.001, 2 sample t-test) between Merrill Lake and Swift Reservoir.

** Significantly different (p<0.005, 2 sample t-test) between Merrill Lake and Swift Reservoir.

^ Not enough variation to report a difference.

Shoreline – For all sites sampled at Merrill Lake and Swift Reservoir, the 164-foot (50-m) shoreline transect segment from the normal high water into the adjacent uplands was further divided into 2 general zones based on vegetation. This step involved determining the transitions from: (1) lacustrine unconsolidated shore (generally mud or cobble flats with sparse vegetation) to vegetation; and (2) distinctly riparian vegetation to vegetation consisting primarily of upland species. Riparian vegetation was defined by the dominance of facultative wetland and/or facultative plant species (see definitions in the footnote of Table 5.6-24), as determined by the USFWS (1996). The riparian zone for both waterbodies was defined to include areas of lacustrine unconsolidated shore and in combination with areas of predominantly riparian vegetation. The width of the riparian zone along Merrill Lake averages about 80 feet (24.4 m); thus, nearly half of the area within 164 feet (50 m) of the normal high water mark is either unconsolidated shoreline or supports predominantly wetland, facultative wetland, and facultative plant species (see definitions in the footnote of Table 5.6-24). At Swift Reservoir, the mean riparian zone width is 23 feet (7 m), which represents only about 14 percent of the area within 164 feet (50 m) of normal high water. The mean riparian zone widths at Merrill Lake and Swift Reservoir are significantly different (Table 5.6-23).

Table 5.6-23. Shoreline habitat characteristics for Merrill Lake and Swift Reservoir (mean +/- standard deviation).

Habitat Parameter	Merrill Lake (N=23)	Swift Reservoir (N=37)
Riparian Zone Width (ft)	80 (±56)***	23 (±42)***
Upland Slope (°)	16 (±10.7)*	35.0 (±22.2)*
Conifer Tree Canopy Cover (%)	18.3 (±22.7) *	36.3 (±29.8)*
Deciduous Tree Canopy Cover (%)	20.2 (±20.7)**	40.1 (±33.7)**
Shrub Canopy Cover (%)	39.0 (±17.8)	43.3 (±24.8)
Grass/Sedge Canopy Cover (%)	4.0 (±8.2)	2.2 (5±.9)
Forb Canopy Cover	12.2 (±13.0)**	31.4 (±22.1)**
No. of Snags (No./ac)	5.6 (±11.3)	6.0 (±9.6)
No. of Stumps (No./ac)	13.0 (±15.0)	20.5 (±26.8)

*** Significantly different ($p<0.001$, 2 sample t-test)

** Significantly different ($p<0.01$, 2 sample t-test)

* Significantly different ($p<0.05$, 2 sample t-test)

Vegetation cover was not estimated separately for the riparian zone because of substantial differences in the width and composition of this zone. For all transects sampled, regardless of vegetation type, habitat within 164 feet (50 m) of the normal high water mark shows some significant differences between Merrill Lake and Swift Reservoir (Table 5.6-23). Overall, mean canopy coverage provided by shrubs and grasses is similar between the 2 waterbodies. However, Swift Reservoir supports a significantly higher shoreline cover of deciduous and conifer trees, as well as forbs, than does Merrill Lake. These results are not surprising since Merrill Lake has a wide riparian zone that is generally dominated by shrubs (see Figure 5.6-15); trees typically do not occur until about 80 feet (24 m) from the water (range = 70-164 feet [3-50 m]. At Swift Reservoir, the riparian zone is very narrow and trees, as well as shrubs, generally grow nearly to the edge of the normal high water mark.

Despite the similarities in total shrub canopy cover between the shorelines of Merrill Lake and Swift Reservoir, shrub species composition is quite different (Table 5.6-24), although species richness is virtually the same (20 species at Merrill Lake and 22 at Swift Reservoir). There are 9 shrub species that occur around Swift Reservoir but not at

Table 5.6-24. Shrub cover composition and frequency along Lake Merrill and Swift Reservoir shorelines.

			Merrill Lake					Swift Reservoir				
Species	**Common Name**	**Wetland Status**[1]	**Constancy**	**Mean**	**St. Dev.**	**Min**	**Max**	**Constancy**	**Mean**	**St. Dev.**	**Min**	**Max**
Acer circinatum	Vine maple	FAC	0.48	4.5	4.6	0.1	15.1	0.84	16.1	14.4	1.2	53.5
Alnus rubra	Red alder	FAC	0.13	5.9	4.9	0.6	10.2	0.16	9.5	13.3	0.9	35.8
Crataegus douglasii	Black hawthorn	FAC	0.04	21.2	3.7	1	10.0	0.00	0.0		0	0
Marah oreganos	Bigroot	FAC	0.17	0.8	0.4	0.6	1.4	0.11	10.4	10.0	2.2	24
Oplopanix horridus	Devil's club	FAC	0.00	0.0		0	0	0.08	3.4	2.7	0.4	5.4
Rhamnus purshiana	Cascara	FAC	0.00	0.0		0	0	0.05	4.0	0.1	4	4.1
Rubus parviflorus	Thimbleberry	FAC	0.00	0.0		0	0	0.05	4.1	5.4	0.3	7.9
Rubus spectabilis	Salmonberry	FAC	0.00	0.0		0	0	0.16	6.33	7.2	0.4	19.5
Acer macrophylum	Big-leaf maple	FACU	0.04	2.9		2.9	2.9	0.05	2.7	2.8	0.8	4.7
Berberis nervosa	Cascade Oregon grape	FACU	0.22	1.0	1.0	0.4	2.8	0.65	7.0	7.7	0.3	29.1
Corylus cornuta	Hazelnut	FACU	0.22	3.50	3.0	1	7.7	0.49	3.9	3.3	0.2	10.1
Cytisus scoparius	Scot's broom	FACU	0.00	0.0		0	0	0.03	0.4		0.4	0.4
Gaultheria shallon	Salal	FACU	0.30	8.5	7.8	0.2	23.2	0.41	9.7	10.0	0.5	39.4
Oemleria cerasiformis	Indian plum	FACU	0.00	0.0		0	0	0.05	3.9	2.2	2.4	5.5
Prunus sp.	Cherry species	FACU	0.04	6.6		6.6	6.6	0.00	0.0		0	0
Rosa sp.	Rose species	FACU	0.00	0.0		0	0	0.14	0.8	0.6	0.3	1.8
Rubus laciniatus	Evergreen blackberry	FACU	0.04	1.0		1	1	0.03	1.1		1.1	1.1
Rubus leucodermis	Blackcap	FACU	0.00	0.0		0	0	0.03	0.3		0.3	0.3
Rubus ursinus	Trailing blackberry	FACU	0.39	4.3	4.2	0.1	12.2	0.30	5.1	5.6	0.2	17.6
Symphoricarpos albus	Common snowberry	FACU	0.09	0.7	0.7	0.2	1.2	0.03	2.1		2.1	2.1
Tsuga heterophylla	Western hemlock	FACU	0.04	2.6		2.6	2.6	0.00	0.0		0	0
Vaccinium membranaceum	Big huckleberry	FACU	0.09	5.15	0.1	5.1	5.2	0.00	0.0		0	0
Cornus stolonifera	Red-osier dogwood	FACW	0.78	13.1	14.1	0.4	50	0.00	0.0		0	0
Salix lucida	Pacific willow	FACW	0.61	13.8	19.6	0.2	74.8	0.00	0.0		0	0
Salix sitchensis	Sitka willow	FACW	0.48	16.4	21.0	1.6	74.8	0.00	0.0		0	0
Spiraea douglasii	Douglas spirea	FACW	0.57	7.3	7.2	0.4	22.8	0.03	10.5		10.5	10.5
Cornus nuttallii	Pacific dogwood	UPL	0.04	1.7		1.7	1.7	0.16	2.1	1.9	0.2	4.5
Holodiscus discolor	Oceanspray	UPL	0.00	0.0		0	0	0.08	5.5	5.8	2.1	12.2
Vaccinium parvifolium	Red huckleberry	UPL	0.30	1.8	1.1	0.6	3.7	0.51	2.4	2.7	0.1	11.1

[1] Wetland indicator status: (USFWS 1996: http://plants.usda.gov/plants/wetinfo.html).
FAC = Facultative – Equally likely to occur in wetlands or non-wetlands (estimated probability = 34-66%).
FACU = Facultative Upland – Usually occurs in non-wetlands (estimated probability = 67-99%) but occasionally found in wetlands (estimated probability = 1-33%).
FACW = Facultative Wetland – Usually occurs in wetlands (estimated probability = 67-99%) but occasionally found in non-wetlands.
UPL = Obligate Upland – Almost always occurs in non-wetlands (estimated probability = 99%).

Merrill Lake, and 6 that were found at Merrill Lake but not at Swift Reservoir. The 2 waterbodies had 15 shrub species in common (Table 5.6-24).

Overall, the Merrill Lake shoreline has a higher number and cover of species more tolerant of wet conditions than does Swift Reservoir (Table 5.6-24; Figure 5.6-16). Over 68 percent of the shoreline shrub cover at Merrill Lake is provided by 4 facultative wetland species. Red-osier dogwood, a facultative wetland species, occurred along 78 percent of the transects sampled, where it provided a mean cover of 13 percent. Three other facultative wetland species occurred at frequencies ranging from 48 to 61 percent (Table 5.6-24). At Swift Reservoir, less than 61 percent of the shoreline shrub cover is facultative wetland species; 18 facultative and facultative upland species provide 94 percent of the shrub cover (Figure 5.6-16). Vine maple is the most frequently occurring shrub species; this facultative species was recorded along 84 percent of the transects sampled, where it provided a mean cover of 16 percent. Oregon grape, an upland species, is the second most common species, and was found along about 49 percent of the transects (Table 5.6-24). The proportional contribution of facultative wetland, facultative, and facultative upland species to total shrub cover is significantly different between Swift Reservoir and Merrill Lake (Figure 5.6-16).

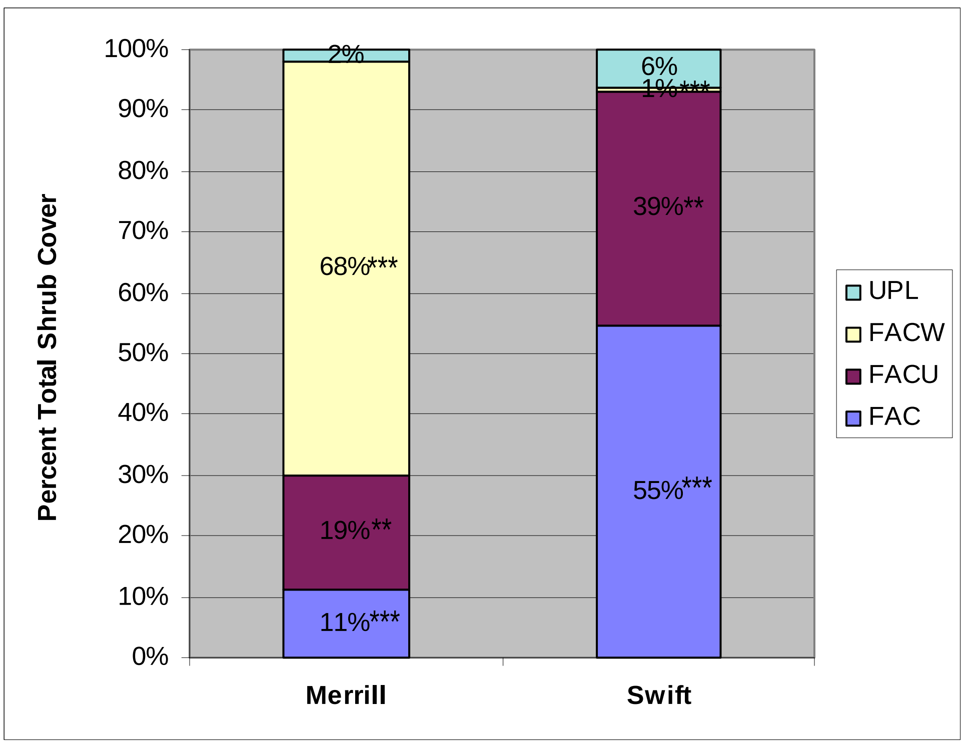


Figure 5.6-16. Percent of total shrub cover composition along Swift Reservoir and Merrill Lake shorelines by wetland indicator status.
(UPL=upland; FACW=facultative wetland; FACU=facultative upland; FAC=facultative).
*** $p<0.0001$; ** $p<0.005$

In addition to comparing general shoreline vegetation characteristics between Swift Reservoir and Merrill Lake, differences within the same vegetation type were assessed where possible. This analysis was limited to those types where at least 3 transects were sampled at each of the 2 waterbodies, and included the following:

- Old-growth/mature conifer forest (Swift - 8 transects, Merrill-5 transects)
- upland mixed conifer forest (6 transects at both Swift and Merrill)
- upland deciduous forest (Swift – 6 transects, Merrill - 4 transects)
- riparian deciduous forest type (Swift – 4 transects, Merrill – 3 transects).

Overall, there were very few significant differences in the habitat provided by the same vegetation cover type between Merrill Lake and Swift Reservoir (Table 5.6-23). Riparian deciduous stands at Swift Reservoir had significantly greater forb and deciduous tree cover than those along the Merrill Lake shoreline. Old-growth/mature stands along the Swift Reservoir shoreline also had significantly higher forb cover than those at Merrill Lake. Grass, shrub, conifer, and down wood cover were not significantly different within the same vegetation type between the 2 waterbodies.

5.6.6 Discussion

The 3 Lewis River Project reservoirs and their associated shorelines vary greatly in their characteristics. The most remote of the reservoirs, Swift Reservoir receives the least recreational use and has the greatest seasonal water level changes about 30 to 40 feet (9 to 12 m), on average. Only about 5 percent of the shoreline is affected by recreation, residential, or other development. Swift Reservoir is also bordered by some of the least disturbed upland forest habitat; over 50 percent of the shoreline consists of old-growth conifer and upland mixed stands. Conversely, Lake Merwin has the lowest seasonal water level changes, only about 5 feet (1.5 m) on average. With much of the shoreline managed as part of the Merwin Wildlife Habitat Management Plan (PacifiCorp 1990), the shoreline of Lake Merwin is also relatively undeveloped (≈5 percent), although recreational use is higher than at Swift Reservoir. About 60 percent is bordered by upland mixed and mid-successional forest stands. Yale Lake fluctuates about 12 feet (3.6 m) seasonally, more than Lake Merwin, but substantially less than Swift Reservoir. Compared to the other 2 reservoirs, shoreline development is highest at Yale—about 11 percent. About 60 percent of the Yale Lake is bordered by upland deciduous forest and mixed conifer stands. None of the reservoir shorelines include large amounts of wetlands, but the greatest number and diversity of hydrologically connected wetlands are associated with Yale Lake. All of the reservoirs exhibit some amount of shoreline erosion, with bank heights greater than 5 feet (1.5 m) occurring along 21 percent of the Yale Lake shoreline and slightly more than 40 percent of both the Swift and Merwin shorelines.

Based on the comparison of Swift Reservoir and Merrill Lake and information from the literature, it is clear that there are some substantial differences between the shorelines of reservoirs and natural lakes, most of which are related to hydrology. As found in Canada (Hill et al. 1998), and adjusted to the Pacific Northwest, there are, in general 3 main differences in the seasonal fluctuation patterns of unregulated and regulated lakes:

- Timing – In natural lakes, water levels begin to drop in the late spring or early summer, reaching a minimum in early fall (Hill et al. 1998). Conversely, water levels in reservoirs used for flood control, recreation, and hydropower, such as Swift Reservoir and Yale Lake, typically begin to decrease in late summer, with the lowest levels occurring in the winter, well outside the growing season.

- Amplitude – Reservoirs generally have a much greater absolute change in seasonal water levels change than do natural lakes. Of the lakes studied by Hill et al. (1998), the greatest water level change over the course of the summer was 3.5 feet (1.1 m). This contrasted with a 7.2-foot (2.2 m) drop in water levels in a comparably sized reservoir. Seasonal water level changes for Merrill Lake are unknown but are probably in the range of 3 to 5 feet (1 to 1.5 m) in most years. Seasonal water level changes are much greater for all 3 project reservoirs.

- Variability – Variation in water level changes between years is generally much greater for reservoirs than for natural systems. Over a period of several years, fluctuations for a large natural lake in Canada were within about 0.8 feet (0.24 m) of the mean water level, compared to ±3 feet (1 m) for a similar sized reservoir (Hill et al. 1998). Although the variation in seasonal water level changes between years for Merrill Lake is not known, between year variation for the project reservoirs can be as great as 10 feet (3 m) or more.

In terms of habitat, there were 4 substantial differences between Swift Reservoir and Merrill Lake. Compared to Merrill Lake, Swift Reservoir had the following characteristics:

- The virtual absence of a vegetated littoral zone;

- An extremely narrow zone of riparian vegetation;

- A low cover and frequency of shoreline shrubs that are tolerant of hydrophytic conditions; and

- A higher shoreline cover of forbs, and deciduous and conifer trees.

The large seasonal water level fluctuations in reservoirs appears to select against many wetland species because the upper shoreline zones are too dry to support these species (Hill et al. 1998). At Swift Reservoir, drawdown timing, substrate, and slope likely result in relatively xeric conditions in the upper portion of the drawdown zone. However, Hill et al. (1998) also found that the amplitude of water level changes in natural lakes may be one of the best predictors of species richness for both common and rare shoreline plants. Since water level changes are generally related to catchment basin size, large natural lakes generally support a greater number of shoreline forb species than do smaller lakes. Large reservoirs as a group are more like high catchment area natural lakes and found to support nearly double the numbers and frequencies of annuals than small natural lakes (Hill et al. 1998).

It is difficult to determine how the different shoreline habitats provided by Swift Reservoir and Merrill Lake affect wildlife use. The littoral zone of natural lakes may be used as breeding habitat for some amphibian species. It probably also provides foraging habitat for birds, such as sparrows and flycatchers, that either feed on seeds from the sedges and grasses or on insects that emerge from the mudflats and shallow water. Since this area is generally under water in the spring, it would not be expected to provide breeding bird habitat or to be used by small mammals. Littoral zone habitat is not provided by Swift Reservoir. Merrill Lake and Swift Reservoir have a similar cover and number of shrub species; thus, both would be expected to support birds that nest and forage in shrubs. However, Merrill Lake would be preferred by species that require hydrophytic shrubs and are typically associated with riparian habitats, such as such as the yellow *(Dendroica petechia)* and Wilson's warblers *(Wilsonia pusilla)*. The higher cover of trees near the water at Swift Reservoir may favor use by species more typically associated with western Washington forest habitats. In addition, the forests bordering Swift Reservoir may provide more suitable habitat for cavity-nesting species such as tree swallows *(Tachycineta bicolor)*, violet green swallows *(T. thalassina)*, and common mergansers *(Mergus merganser)*. Relative use of Merrill Lake and Swift Reservoir by waterfowl is unknown. Both waterbodies support nesting osprey *(Pandion haliaetus);* bald eagles *(Haliaeetus leucocephalus)* forage in Swift Reservoir and nest in the adjacent old-growth forest; their use of habitats associated with Merrill Lake is unknown.

Probably the most significant difference between the project reservoirs and natural lakes is the seasonal drawdown that begins in late summer and persists through the winter into spring. In addition to precluding the development of a vegetated littoral zone and limiting the establishment of typically riparian vegetation, the large barren area created by drawdown may represent a barrier to wildlife trying to reach the water. This barrier is probably greatest in areas with steep slopes and during the winter when water levels are at their lowest. The barrier effect of the drawdown zone on various species is unknown, but is likely to be negligible for birds, bats, and most small mammal species; moderate for large mammals; and greatest for medium-sized mammals. Birds fly to obtain water, and most small mammals have limited needs for free water. Fossorial mammals in humid environments have minimal pulmoncutaneous water loss and obtain most of their moisture needs from food (Vaughan 1978). Relicensing studies conducted at Yale Lake documented tracks from deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), and coyote (*Canus latrans*) in the drawdown zone, suggesting that these species can readily reach the water, although steep slopes may prevent access in some locations. The lack of cover in some portion of the drawdown zone may make medium-sized mammals, such as rabbits (*Lepus americanus*), mink (*Mustla vison*), and raccoons (*Procyon lotor*), more vulnerable to predation, but there are areas where boulders and down wood provide cover. The amplitude of seasonal drawdown, combined with a relatively uniform shoreline that offers little protection from wave action, probably precludes use of the project reservoirs by beaver (*Castor canadensis*) and muskrat (*Ondatra zibethicus*) (Allen 1983).

There are 7 native amphibian species in the Lewis River basin that use stillwater ponds for breeding—the red-legged frog, Cascades frog (*R. cascadae*), Pacific tree frog (*Hyla regilla*), Northwestern salamander (*Ambystoma gracile*), long-toed salamander (*A. macrodactylum*), western toad *(Bufo boreas)* and rough skinned newt (*Taricha* *granulose*) (PacifiCorp and Cowltiz PUD 2002; PacifiCorp 1999). All of these species have been recorded in wetlands and ponds in the project vicinity. In general, the reservoirs do not represent suitable breeding habitat for these species since all require shallow water and submerged vegetation or debris for egg attachment. However, dozens of larval and juvenile western toads were observed in swales below the normal high water level on the south shore of Swift Reservoir near the Drift Creek inlet in late July 2001 (see TER 5). Thus, it is possible that there are a few sites associated with reservoir shorelines that provide suitable breeding habitat for some species in some years.

Although Merrill Lake was not surveyed for amphibians, the vegetated shallow littoral zone may provide suitable breeding habitat for a number of species.

Individual amphibians sometimes breed in areas of ponded water, such as puddles in roads, that do not remain suitable habitat throughout the larval stage. Rough-skinned newts were observed in a small pool of water in the Yale Lake drawdown zone during field studies in March 1997 (PacifiCorp 1999), habitat that would have been inundated as water levels increased. Although it was not possible to conduct complete searches of the Swift Reservoir drawdown zone under various conditions, only 1 small pool was noted during surveys in February and March 2001 when the reservoir was about 60 feet (18 m) below full. Located near the inlet of Swift Creek, the water in the pool was very muddy and did not appear suitable to attract breeding amphibians. In general, most of the Swift Reservoir drawdown zone, particularly in the western two-thirds of the reservoir, is too steep to pond water. Under certain condition, pools may occur in the flatter area in the eastern portion of the drawdown zone, but none were observed during the surveys in February and March 2001.

5.6.7 References

Allen, A.W. 1983. Habitat suitability index models: beaver. Habitat Evaluation Procedures Group. Western Energy and Land Use Team U.S. Fish and Wildlife Service, Fort Collins, Colorado. FWS/OBS-82/10.30.

Dinehart, R.L. 1997. Sediment transport at gaging stations near Mount St. Helens, Washington, 1980-1990, Data collection and analysis. USGS Professional Paper 1573.

Hill, N.N., P.A. Keddy, and I.C. Wisheu. 1988. A hydrological model for predicting the effects of dams on the shoreline vegetation of lakes and reservoirs. Environmental Management. 22:5 (723-736).

PacifiCorp. 1991. Merwin Wildlife Habitat Management Plan (MWHMP). Portland, Oregon.

PacifiCorp. 1999. Final technical report for terrestrial resources. Yale Hydroelectric Project. Portland, OR. April 1999.

PacifiCorp and Cowlitz PUD. 1999. Study Plan Document for the Lewis River Hydroelectric Projects. Draft. Portland, OR, and Longview, WA. October 29, 1999, as amended in 2000.

PacifiCorp and Cowlitz PUD. 2000. Initial Information Package for the Lewis River Hydroelectric Projects. Portland, OR and Longview, WA. March 2000.

PacifiCorp and Cowlitz PUD. 2002. 2001 Draft technical report. Lewis River Hydroelectric Projects. Draft. Portland, OR, and Longview, WA. April 2002.

Richter, K.O. and A.L. Azons. 1995. Amphibian Occurrence and Wetland Characteristics in the Puget Sound Basin. Wetlands 15(3): 305-312.

USFWS. 1996. 1996 National List of Vascular Plants that Occur in Wetlands. http://plants.usda.gov/plants/cgi-bin/wetland.cgi.

Vaughan, T.A. 1978. Mammology. Holt, Rinehart and Winston. Philadelphia, PA. 522 pp.

Zar, J.H. 1984. Biostatistical Analysis. Prentice-Hall, Inc. Engelwood Cliffs, NJ. 718 pp.