ACRONYMS AND ABBREVIATIONS

4WD	4-wheel drive
ac	acres
AD	adipose fin clipping
ADAAG	Americans with Disabilities Act Accessibility Guidelines for Buildings & Facilities
APE	Area of Potential Effect
APEA	Applicant-Prepared Environmental Assessment
ARG	Aquatics Resource Group
ATS	Advanced Telemetry Systems
ATV	all terrain vehicle
BLM	Bureau of Land Management
BP	Before Present
CCCP	Cowlitz County Comprehensive Plan
CCSCP	Cowlitz County Shoreline Management Master Program
CDF	critical dewatering flow
CIT	Cowlitz Indian Tribe
cm	centimeters
Corps	U.S. Army Corps of Engineers
CRG	Cultural Resource Group
CS plants	culturally sensitive plants
dbh	diameter at breast height
DEQ	(Oregon) Department of Environmental Quality
DNR	Washington Department of Natural Resources
DO	dissolved oxygen
DSF	day-second feet
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FCC	Freshwater Chronic Criteria
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FIRM	Flood Insurance Rate Map
FR	Forest Road
FWS	U.S. Fish and Wildlife Service
GIS	geographic information system
GPNF	Gifford Pinchot National Forest
GPS	global positioning satellite
ha	hectares
HCC	Hydro Control Center
HCP	Habitat Conservation Plan
HEP	Habitat Evaluation Procedure
Hg	mercury
HPC	Hydrometeorological Prediction Center
HPMP	Historic Properties Management Plan
HSC	Habitat suitability criteria

HSI	Habitat Suitability Index
HUD	Department of Housing and Urban Development
IDL	Instrument Detection Limits
IFIM	Instream Flow Incremental Methodology
IHA	Index of hydraulic alteration
IP	International Paper
KOP	Key Observation Point
KSFD	1,000 second feet per day
LAC	Limits of Acceptable Change
LVAD	left ventral adipose fin
LWD	large woody debris
NESC	Northwest Energy Services Company
NGO	non-governmental agency
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NOECs	No observable effects concentrations
NPDES	National Pollutant Discharge Elimination System
NPPC	Northwest Power Planning Council
NRHP	National Register of Historic Places
NRPA	National Recreation and Parks Association
NSOs	natural sequence orders
NTU	nephelometric turbidity unit
NWPP	Northwest Power Pool
NWS	National Weather Service
OAHP	Office of Archaeology and Historic Preservation
OHWL	Ordinary High Water Level
O&M	operations and maintenance
PAH	polycyclic aromatic hydrocarbon
PAOT	persons-at-one time
PCB	polychlorinated biphenyl
PCC	Portland Control Center
PHABSIM	Physical Habitat Simulation
PHS	Priority Habitat Species
PM&E	Protection, Mitigation, and Enhancement Measure
PPL	Pacific Power and Light
PSMFC	Pacific States Marine Fisheries Commission
PUD	Public Utility District
PWC	personal watercraft
QA/QC	Quality Assurance/Quality Control
QPF	Quantitative Precipitation Forecast
READ	Resource Enhancement Alternatives Document
RM	River Mile
RMAP	Road maintenance and abandonment program
ROS	Recreation Opportunity Spectrum
ROW	rights-of-way
RRG	Recreation Resource Group

RRMP	Recreation Resource Management Plan
RV	recreation vehicle
RVD	recreation visitor day
RVAD	right ventral adipose fin
SBR	Swift bypass reach
S/M species	survey and manage species
SCORP	Statewide Comprehensive Outdoor Recreation Plan
sd	standard deviation
SI	Suitability Indices
SOP	Standard Operating Procedures
SR	State Route
TCP	Traditional Cultural Property
TDG	total dissolved gas
TES	threatened, endangered, or sensitive species
TPH	total petroleum hydrocarbon
TPN	total persulfate nitrogen
TRG	Terrestrial Resource Group
TWG	Technical Work Group
TY	Target Year
USFS	United States Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VAF	velocity adjustment factors
VECC	Variable Energy Content Curves
WAC	Washington Administrative Code
WDF	Washington Department of Fisheries
WDFW	Washington Department of Fish and Wildlife
WDG	Washington Department of Game
WDOE	Washington Department of Ecology
WNHP	Washington Natural Heritage Program
WSDOT	Washington State Department of Transportation
WSEL	water surface elevation
WSWCB	Washington State Weed Control Board
WUA	Weighted Usable Area
WY	Water Year
YN	Yakama Nation

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5.9 RIPARIAN HABITAT INFORMATION SYNTHESIS (TER 9)

In the most general terms, riparian ecosystems are defined as ecotones between aquatic and upland ecosystems (Mitch and Gosselink 1986). In the western United States, however, the term riparian zone is used most often to refer to lands adjacent to rivers and streams that are at least periodically subjected to flooding (Mitch and Gosselink 1986). In their management recommendations for riparian habitats associated with perennial or intermittent streams, the Washington Department of Fish and Wildlife (WDFW) uses the following definition:

> *A riparian habitat area is defined as the area adjacent to aquatic systems with flowing water that contains elements of both aquatic and terrestrial ecosystems which mutually influence each other* (Knutson and Naef 1997)

The terms riparian habitat, riparian area, riparian ecosystem, and riparian corridor are typically used interchangeably in the literature and are used to refer to the functionally distinct area adjacent to streams (Knutson and Naef 1997). Riparian habitat starts at the ordinary high water line of a stream or river and includes that portion of the adjacent terrestrial landscape that influences the aquatic habitat by providing shade, nutrients, woody material, insects, or habitat for riparian-associated species (Knutson and Naef 1997). Riparian habitat also encompasses floodplains because these areas influence and are influenced by high water events. Riparian areas can include wetlands as well as upland plant communities that directly influence streams. Riparian habitat provides a number of important contributions to both aquatic and terrestrial ecosystems and is designated by the WDFW as a priority habitat in Washington.

5.9.1 Study Objectives

The objectives of the Riparian Habitat Information Synthesis are to:

- Describe existing riparian habitat conditions in the vicinity of the Lewis River Projects;
- Estimate the effects of possible additional flows in the Swift bypass reach and Speelyai Creek on the structure and function of riparian habitat in these areas; and
- Assess the continuing effects of the Lewis River Projects on the structure and function of riparian habitat in the study area currently and over the term of the next license.

5.9.2 Study Area

The study area for the Riparian Habitat Information Synthesis includes the following 3 stream reaches :

- The 2.6-mile (4.2 km) Swift bypass reach from the Swift No. 1 Dam to the Swift No. 2 powerhouse;
- Speelyai Creek downstream of the upper diversion to Lake Merwin (approximately 4 miles [6.4 km]) and the diversion canal into Yale Lake; and

- The Lewis River from Merwin Dam to the downstream end of Eagle Island (approximately 6 miles [9.6 km]).

5.9.3 Methods

The methods of the Riparian Habitat Information Synthesis are described below. The general approach to the study involved the use of data from a number of other relicensing studies and information from the literature. However, because the data needs varied slightly for each of the study area segments, some additional field data were collected. The 3 tasks and associated methods for this study are described below.

5.9.3.1 Describe Existing Riparian Habitat

Existing riparian habitat in the study area was described in terms of vegetation types, amount, distribution, structure, cover, and species composition.

Riparian Habitat Types, Amounts, and Distribution

The amount and distribution of vegetation cover types in riparian habitats in the study area were determined from the Vegetation Cover Type Mapping Study (TER 1). Results of the mapping study were used to calculate the amounts of various riparian vegetation cover types (e.g., mid-successional mixed conifer/deciduous forest; young deciduous forest) for each of the 3 stream reaches in the study area. Maps of the riparian areas were produced from the orthophotos and show the distribution of the various vegetation types, as well as islands, unconsolidated bars and shoreline areas, side channels, and disturbed/developed areas.

Riparian Vegetation Composition and Structure

Data on vegetation composition and structure in riparian habitats for the Swift bypass reach and on Eagle Island were provided by the HEP Study (TER 2; see Section 5.2). The following parameters were sampled at selected riparian sites in these areas in July and August 2000 or May 2001:

- Tree and shrub canopy cover
- Snag density, species, and size
- Log density, size, and species
- Dominant tree, shrub, and herbaceous species

These same parameters were sampled at 15 riparian sites along the Lewis River between Merwin Dam and Eagle Island in August 2001. Wildlife observations were recorded in all areas sampled.

Quantitative data on vegetation structure were not collected for riparian habitats along Speelyai Creek or the canal. Instead, 39 transects were surveyed to measure the width of riparian vegetation and characterize the habitat along Speelyai Creek. Transects were between 500 and 1,000 feet (152 and 305 m) apart along the creek and were distributed in 4 reaches as follows:

- 6 transects along approximately 3,500 feet (1,067 m) upstream of the Speelyai canal diversion;
- 12 transects between the Speelyai canal diversion and the State Route (SR) 503 bridge (≈1.7 miles [2.7 km]);
- 20 transects between the SR 503 bridge and the hatchery diversion (≈2.3 miles [3.7 km]); and
- 1 transect between the hatchery diversion and Lake Merwin (≈400 feet [122 m]).

Surveys were coordinated with the Stream Channel Morphology and Aquatic Habitat Study (WTS 3) sampling program and were conducted between September 26 and 29, 2000 when the flows were low enough to walk the channel. Data collected included:

- Upland vegetation types;
- Riparian vegetation types;
- Start and stop points for riparian vegetation (right bank, left bank, and islands/bars);
- Width of bankfull channel;
- Width of wetted channel;
- Distance to thalweg;
- Thalweg depth;
- Height and slope from bankfull channel to high terrace/slope;
- Dominant tree, shrub, and herbaceous species; and
- Wildlife observations.

Three other studies also provided information on existing riparian habitat conditions functions in the study area:

- The Botanical Resource Surveys (TER 4) provided information on the location of cottonwood (*Populus balsamifera trichocarpa*) stands in the Swift bypass reach and on Eagle Island.
- The Stream Channel Morphology and Aquatic Habitat Study (WTS 3) recorded the number and location of trees overhanging Swift bypass reach, the Lewis River between Merwin Dam and Eagle Island, and Speelyai Creek below the diversion. Data from these surveys provided information on the amount of large woody debris (LWD) potentially available from riparian habitat over the next license period.
- The Yale Species/Habitat Study provided data on wildlife use of riparian and aquatic habitats in the Swift bypass reach (PacifiCorp 1999). Amphibian surveys were conducted in wetlands, pools, seeps, and tributary streams. Riparian habitats along both sides of the bypass reach were also surveyed seasonally for birds; big game use was noted as well.

5.9.3.2 Effects of Additional Flows on Riparian Habitats

A new project license could include increased flows in both the Swift bypass reach and Speelyai Creek. Methods used to estimate the effects of additional flow for each of these areas are described below.

Swift Bypass Reach

Four riparian habitat transects were established as part of the Swift Bypass Reach Instream Flow Study (AQU 2) (Figure 5.9-1), which utilized the Instream Flow Incremental Methodology (IFIM). Transect locations were selected to represent different channel types and riparian habitats in the reach, and included several vegetated islands, bars, side channels, and wetlands. Transects extended from the channel bank through the riparian zone, ranging from 100 to 350 feet (30 to 107 m) in length. Standard IFIM survey methods were used to develop horizontally and vertically controlled cross sections for each transect.

On May 15, 2000, surveys were conducted along the 4 riparian transects to characterize the dominant growth form and species composition of the vegetation. These surveys also recorded habitat transition points along the transects. The transition points were based on a significant change in vegetation growth form (tree, shrub, or herbaceous), dominant species composition, substrate, or hydrology (e.g., inundated vs. dry vs. saturated). The survey in the bypass reach occurred under normal conditions (i.e., when no water was being released from Swift Dam).

Data from the riparian habitat surveys were combined with the IFIM cross-sectional data to develop profiles of riparian habitat and elevation for each transect. Actual water surface elevations were measured along each of the transects under controlled releases of 68, 134, and 290 cubic feet per second (cfs) on May 17 and 18, 2000. Transects 2, 3, and 4 were revisited on May 18 during the 290 cfs release to qualitatively assess the level of inundation in the riparian habitats.

As part of the Swift Bypass Reach Synthesis Study (WTS 4), results from the IFIM study were used to predict water levels at flows ranging from 50 to 400 cfs. Stage-discharge relationships for each of these flows were used to estimate the change in wetted perimeter and the amount of riparian habitat affected at each of the 4 transects. These results, however, could not be applied to the entire 2.6-mile (4.2 km) bypass reach. Estimating the effects on riparian habitat for the reach used data from 10 other IFIM transects, the 4 riparian transects, and the aquatic habitat mapping for this area. For each of these 14 transects, the wetted width at a 0 cfs flow release from Swift Dam was subtracted from the wetted width at 50, 100, 200, and 400 cfs to estimate the width of riparian habitat inundated by each flow. Each of the IFIM transects was assigned to represent a length of aquatic habitat, ranging from about 500 to slightly over 2,000 feet (152 to 610 m) in length. A weighted average was then used to estimate the amount of riparian habitat affected by each flow along the entire reach. Although this method produced a gross estimate of amount of riparian habitat inundated over the length of the bypass reach, it cannot distinguish effects on the different vegetation types that make up riparian habitat, nor can it predict changes due to higher water tables and increased moisture.

Speelyai Diversion

No instream flow studies were conducted for Speelyai Creek, so the approach to estimate the effects of increased flows was more qualitative than for the Swift bypass reach. Data on bankfull channel and riparian vegetation widths were used to estimate the amount of vegetation currently growing in the channel. Information from the Stream Channel Morphology and Aquatic Habitat Study (WTS 3) was then used to assess the results of removing the diversion on riparian vegetation in and adjacent to the current channel.

5.9.3.3 Assess Project Effects on Riparian Habitat

The primary approach to assessing project effects on riparian habitat along the Swift bypass reach and between Merwin Dam and Eagle Island involved comparing maps based on sets of old and new aerial photographs. Three of the 4 watershed processes studies also provided information useful in assessing project effects on riparian habitats in all 3 study reaches. These studies and the data they provided are as follows:

- The Streamflow Study (WTS 2) generated information on current and historical flows, including flood flows and spills.
- The Stream Channel Morphology and Aquatic Habitat Study (WTS 3) provided estimates of the amount of LWD in all 3 study reaches, as well as information on channel type and bed material. This study also included information on sediment input in these reaches.
- The Swift Bypass Reach Synthesis Study (WTS 4) provided more specific information on geomorphology and hydrology for the Swift bypass reach.

Data from these 3 studies, as well as information from the literature, were used to interpret some of the observed differences in riparian habitat over time and provide insight into potential changes in riparian habitat function. Details on available aerial photography and mapping for the Swift bypass reach and the lower Lewis River are provided below.

Swift Bypass Reach

The amount, type, and configuration of riparian habitats along the Swift bypass reach were mapped in 1994 as part of relicensing studies for the Yale Project. This area was subsequently subjected to very high flows from the release of water from Swift Dam during the February 1996 flood (45,000 cfs). Riparian habitat along the bypass reach was remapped using 1998 photography as part of the Vegetation Cover Type Mapping Study. A geographic information system (GIS) was used create maps and generate the acreage of each cover type in 1994 and again in 1998. The effects of flood releases from Swift Dam on the amount and type of riparian habitat in the bypass reach were estimated by comparing maps and acreages. Maps generated by the Stream Channel Morphology and Aquatic Habitat Study (WTS 2) were also used to compare the number and location of side channels, wetlands, islands, and bars.

Merwin Dam to Eagle Island

The earliest known set of aerial photographs (1:12,000) for the Lewis River between Merwin Dam and Eagle Island were taken in 1939 (Corps of Engineers). In addition, there are aerial photographs (1:12,000) of this area from 1963 to the present in approximately 5-year increments (Department of Natural Resources [DNR]), and several of these photo sets were acquired as part of the Stream Channel Morphology and Aquatic Habitat Study. Estimating project effects on the Lewis River below Merwin Dam involved mapping riparian habitat using 2 sets of these old photographs (1939 and 1963) and the most recently available photography (1996), which was updated based on field verification in 2001. A comparison of maps and acreage estimates between years allowed changes in the amount, type, and distribution of riparian habitat between Merwin Dam and Eagle Island to be tracked over time.

5.9.4 Key Questions

Results of the Riparian Habitat Information Synthesis can be used to address some of the following "key" watershed questions identified during the Lewis River Cooperative Watershed Studies meetings.

- How has the diversion of water from Speelyai Creek affected stream channel and riparian habitats in lower Speelyai Creek?

  The effects of water diversion on riparian habitats in lower Speelyai Creek are described in Sections 5.9.5 and 5.9.6.

- How do water level fluctuations affect riparian vegetation in downstream areas?

  The effects of water level changes in the Swift bypass reach and the Lewis River downstream of Merwin are discussed in Sections 5.9.5.3 and 5.9.6.

- What are the effects of different water levels on aquatic and riparian habitats and species in the Swift bypass reach?

  The effects of increased flows on riparian habitat in the Swift bypass reach are discussed in Sections 5.9.5.2 and 5.9.6.

- How does flow regulation by the hydroelectric projects affect the development and maintenance of riparian vegetation?

  The effects of the projects on the development and maintenance of riparian vegetation in the Swift bypass reach and along the Lewis River downstream of Merwin Dam are discussed in Sections 5.9.5.3. and 5.9.6.

5.9.5 Results and Discussion

Information on existing riparian habitats in the study area, the effects of increased flows in the Swift bypass reach and Speelyai Creek, and project effects on riparian habitat are summarized and presented in the following sections.

5.9.5.1 Existing Riparian Habitat

The types and amounts of the vegetation cover types in the 3 study area segments are shown in Table 5.9-1. The extent and distribution are mapped in Figures 5.9-1 through 5.9-3. Existing riparian habitats in each segment of the study area are described in detail in the following sections.

Swift Bypass Reach

The Swift bypass reach segment of the study area extends from the base of Swift Dam downstream to the Swift No. 2 powerhouse, and is bordered by the Lewis River Road or the foot of the Swift canal berm to the north. The southern boundary includes an area that extends approximately 0.5-mile (0.8 km) from the river (Figure 5.9-1). The Swift bypass reach includes 19 acres (7.7 ha) of wetlands and 106 acres (43 ha) of riparian vegetation (Table 5.9-1). These cover types represent about 15 percent of the acreage mapped in the bypass reach. The river through most of the bypass reach is bordered primarily by bands of riparian forest and shrublands. Riparian vegetation dominates the islands, bars, and low terraces within the old channel and is maintained by the current hydrological regime. Steep banks and terraces above the existing channel support upland deciduous forests at lower slope positions and conifer forest types on higher slope positions. Most of the wetlands in the bypass reach are north of the river, outside and several feet in elevation above the main channel. Although the majority of the wetlands appear to be created and maintained by seepage from the Swift canal and beaver (*Castor canadensis*) dams, there are a few that are hydrologically connected to the river.

Both riparian and upland deciduous forests in the bypass reach are characterized by a dense canopy of red alder (*Alnus rubra*) trees. Some riparian stands are distinguished by the presence of black cottonwood, some of which are quite large. Shrub canopy cover in riparian deciduous stands is moderate and consists primarily of non-native blackberry species (*Rubus discolor, R. laciniatus*) (Table 5.9-2).

Hydrophytic shrubs, such as red osier dogwood (*Cornus stolonifera*) and salmonberry (*Rubus spectabilis*), are almost completely lacking. The high flows that periodically occur in the bypass reach may create conditions favorable to non-native blackberry species, which are extremely invasive and quickly colonize disturbed areas. Shrub cover in upland deciduous forests is relatively low (Table 5.9-2) and consists of vine maple (*Acer circinatum*), Oregon grape (*Mahonia nervosa*), hazelnut (*Corylus cornuta*), and trailing blackberry (*Rubus ursinus*), all native species.

The 1 riparian mixed forest stand sampled in the bypass reach during the HEP study (TER 2) appears to be somewhat less disturbed than many of the riparian deciduous stands. This stand was characterized by a mix of cottonwood, big-leaf maple (*Acer macrophyllum*), and Douglas-fir (*Pseudotsuga menziesii*). Shrub cover was moderate and consisted primarily of native shrubs, including some red osier dogwood, a hydrophytic species.

The riparian shrub stands in the Swift bypass reach are typical of communities that occur on gravel bars and islands along rivers and streams in western Washington (Pojar and

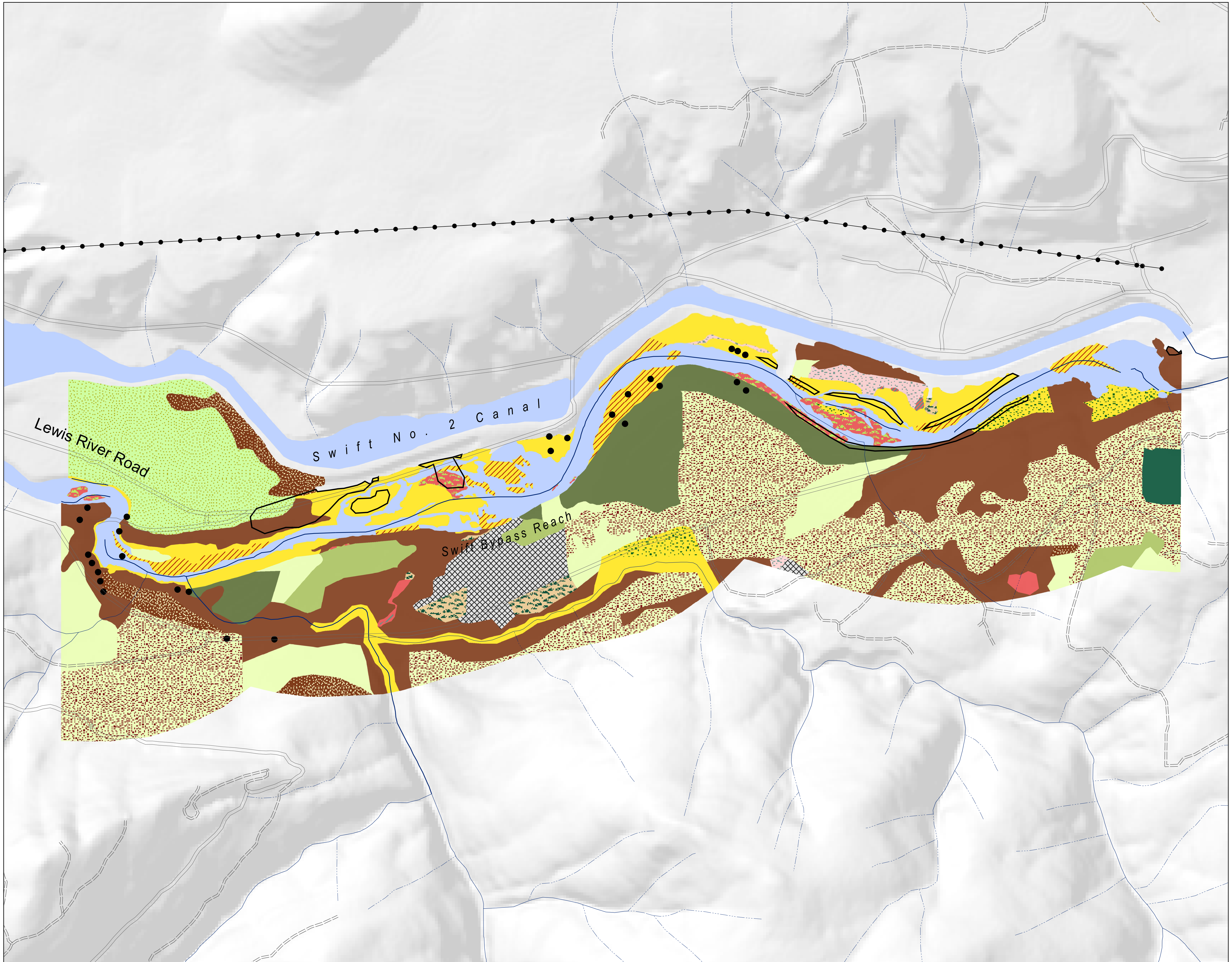
MacKinnon 1994). These areas consist of dense patches of Sitka willow (*Salix sitchensis*), a native hydrophytic shrub that can quickly colonize moist sites and withstand periods of high, swift water. The dense canopy of riparian shrubs results in very sparse herbaceous cover.

Table 5.9-1. Summary of vegetation cover types in the 3 segments of the Riparian Habitat Information Synthesis study area.

Cover Types	Swift Bypass Reach		Speelyai Creek		Lower Lewis River	
	Area (ac)	Percent of Area (%)	Area (ac)	Percent of Area (%)	Area (ac)	Percent of Area (%)
Uplands[1]						
Conifer Forest	206.9	24	359.2	26	293.3	5
Mixed Deciduous/Conifer Forest	21.0	2	382.8	27	2,246.6	38
Deciduous Forest	160.0	19	105.1	8	90.5	2
Shrublands	7.7	1	17.2	1	19.8	<1
Meadow	0	0	0	0	148.0	3
Upland Totals	**395.6**	**46**	**864.3**	**62**	**2,798.2**	**48**
Wetlands						
Palustrine Unconsolidated Bottom	0.5	<1	0	0	0	0
Palustrine Emergent Wetland	2.5	<1	1.1	<1	7.1	<1
Palustrine Scrub-shrub Wetland[2]	9.4	1	0	0	10.7	<1
Palustrine Forested Wetlands	6.4	1	6.3	<1	8.7	<1
Wetland Totals	**18.8**	**3**	**7.4**	**1**	**26.5**	<1
Riparian						
Riparian Deciduous Forest	71.0	8	158.4	11	276.0	5
Riparian Mixed Forest	14.6	2	49.5	3	258.7	4
Riparian Shrub	20.7	2	0	0	179.2	3
Riparian Grassland	0	0	0	0	10.5	<1
Riparian Totals	**106.4**	**12**	**207.9**	**14**	**724.4**	**12**
Riverine/Lacustrine						
Riverine Unconsolidated Bottom	19.3	2	0	0	317.0	5
Riverine Unconsolidated Shore	57.9	7	0	0	4.5	<1
Lacustrine Unconsolidated Bottom	0	0	12.8	1	1.0	<1
Riverine/Lascustrine Totals	**77.2**	**9**	**12.8**	**1**	**322.5**	**6**
Developed/Disturbed/Agriculture/ Sparsely Vegetated/Clearcut[1]	**252.4**	**30**	**306.7**	**22**	**1,965.5**	**34**
TOTALS	**850.4**	**100**	**1,399.1**	**100**	**5,837.1**	**100**

[1] Upland conifer and disturbed cover types were consolidated into larger groups from those used in the Vegetation Cover Type Mapping Study (see TER 1).

[2] Includes a mixed type of Palustrine Scrub-shrub/Palustrine Emergent Wetlands.



Legend

- Cottonwood Stand
- Large Cottonwood Tree

Lacustrine & Riverine

- Lacustrine & Riverine

Palustrine

- Palustrine Aquatic Bed
- Palustrine Unconsolidated Bottom
- Palustrine Emergent Wetland
- Palustrine Forested Wetland
- Palustrine Scrub Shrub Wetland
- Palustrine Scrub Shrub/Emergent Wetland

Conifer Forest

- Old-Growth Conifer Forest
- Mature Conifer Forest
- Mid-Successional Conifer Forest
- Pole Conifer Forest
- Seedling/Sapling Conifer
- Lodgepole Pine Forest
- New Clearcut

Upland Deciduous

- Upland Deciduous Forest
- Young Upland Deciduous Forest
- Oak Woodland

Riparian

- Riparian Deciduous Forest
- Riparian Deciduous Shrubland
- Riparian Mixed Forest
- Young Riparian Mixed Forest
- Riparian Grassland

Mixed Conifer/Deciduous

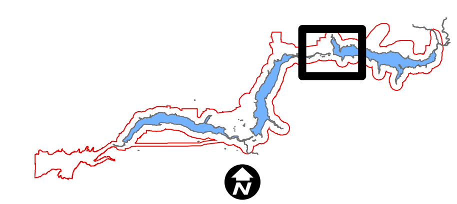
- Upland Mixed
- Young Upland Mixed

Non-Forested

- Dry Meadow/Grassland
- Pasture
- Rock Outcropping
- Rock Talus
- Shrubland

Developed and Disturbed

- Agriculture
- Residental/Disturbed/Developed
- Recreational
- Transmission Line ROW



0 460 920 1,840 Feet

1:13,000

Lewis River Hydroelectric Projects

FIGURE 5.9-1

Vegetation Cover Types in the Swift Bypass Reach

Source: EDAW, Inc., 2002

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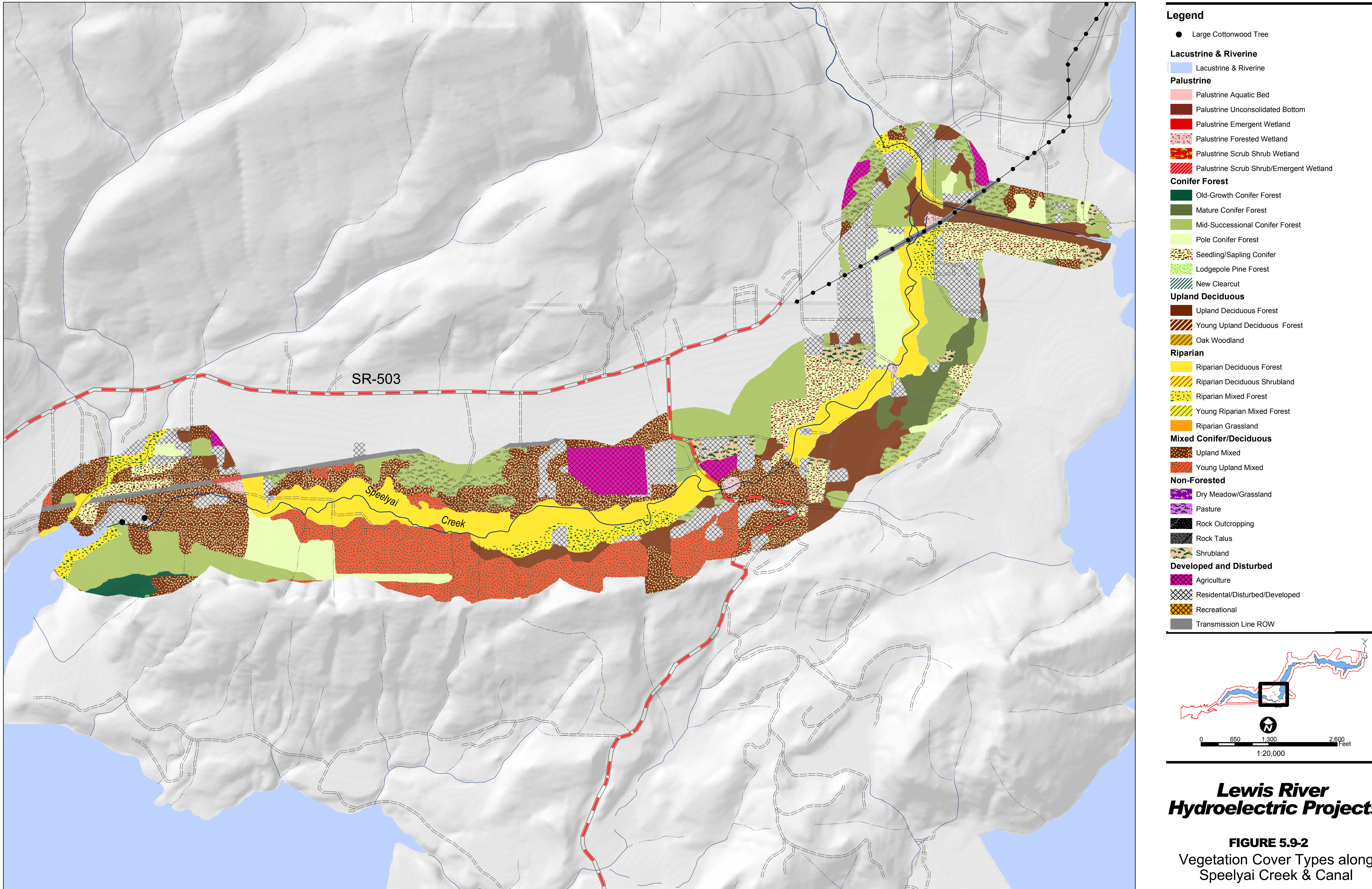

Lewis River Hydroelectric Projects

FIGURE 5.9-2
Vegetation Cover Types along Speelyai Creek & Canal

Source: EDAW, Inc., 2002

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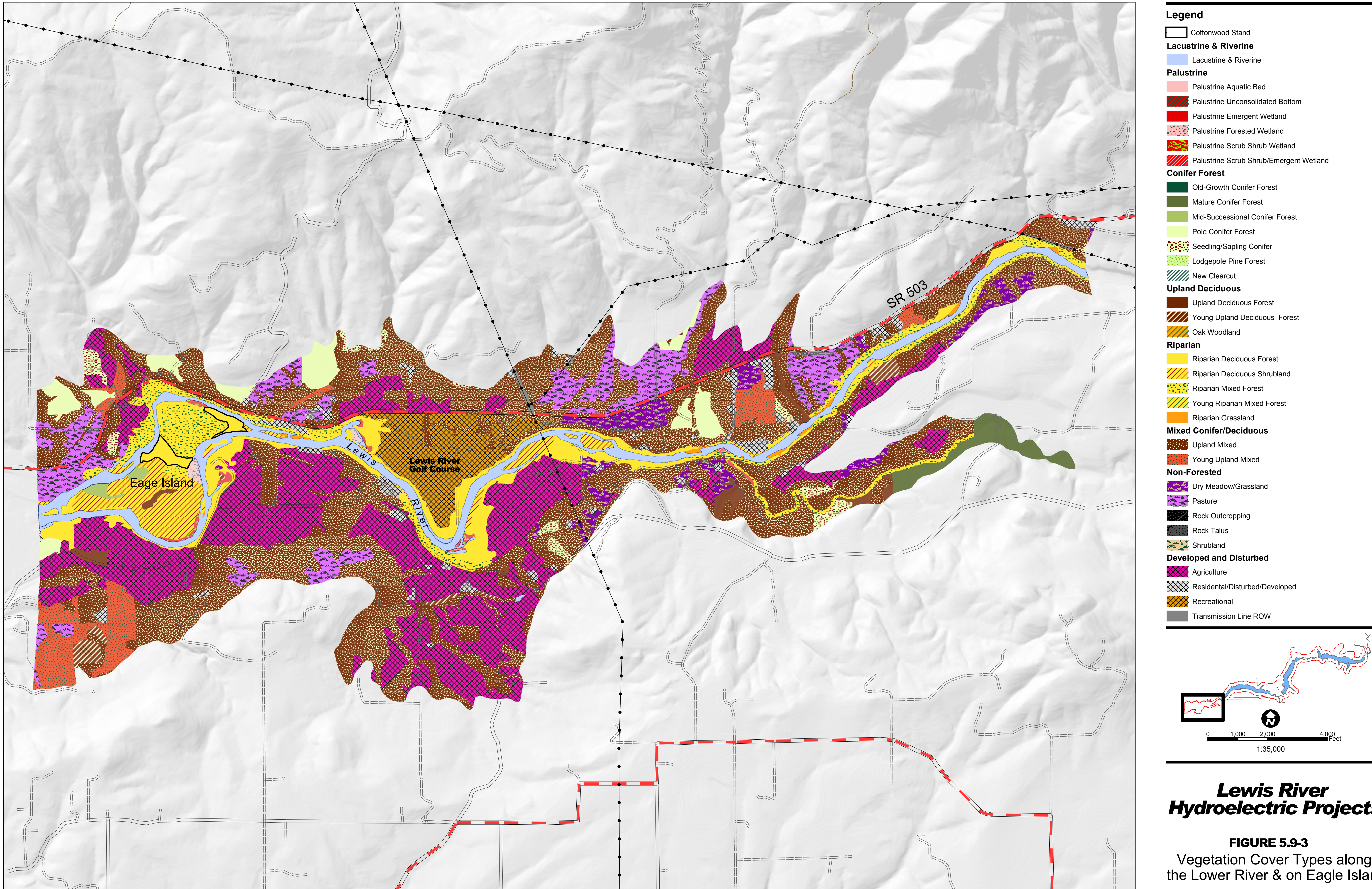

Lewis River Hydroelectric Projects

FIGURE 5.9-3
Vegetation Cover Types along the Lower River & on Eagle Island

Source: EDAW, Inc., 2002

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Table 5.9-2. Structural characteristics of riparian and wetland habitats in the Swift bypass reach[1].

Habitat Parameter	Upland Deciduous Forest[2] (n=3)	Riparian Deciduous Forest (n=5)	Riparian Mixed Forest (n=1)	Riparian Shrub (n=2)	Palustrine Scrub-shrub (n=2)	Palustrine Forest (n=2)
Mean tree canopy cover (%)	99 (98-100)	88 (77-98)	80	0	0	75 (53-98)
Mean deciduous shrub canopy cover (%)	11 (0-20)	29 (12-52)	55	66 (53-79)	85 (70-100)	14 (5-22)
Mean hydrophytic shrub canopy cover (%)	0	1 (0-3)	7	63 (47-79)	85 (70-100)	2 (0-5)
Mean combined tree/shrub cover (%)	99 (98-100)	95 (81-100)	97	66	85 (70-100)	80 (64-98)
Mean overstory tree height (ft)	75 (62-95)	72 (33-115)	105	--	--	66 (59-22)
Mean shrub height (ft)	--	5.9 (3.3-9.5)	5.9	8.2 (6.9-9.8)	7.5 (3.9-10.8)	2.3 (1.6-2.9)
Mean no. trees >20 in. dbh/ac	11 (4-24)	12 (0-32)	49	0	0	12 (0-24)
Mean no. of snags/ac	5 (0-16)	17 (0-44)	16	0	0	0
Mean no. snags >20 in. dbh/ac	1 (0-4)	0	8	0	0	0
Mean no. logs > 7 in. large-end diameter/ac	40 (16-73)	43 (20-69)	73	8 (0-16)	2 (0-4)	34 (8-61)

[1] The range of each habitat parameter is shown in parentheses.

[2] Upland deciduous forests were included because they represent riparian habitat in higher areas along the existing channel and are often intermixed with riparian deciduous forests.

Palustrine forested wetlands in the Swift bypass reach are generally dominated by red alder, although a few western red cedar (*Thuja plicata*) occur as well. Shrub cover is low and the understory consists primarily of grasses, sedges (*Carex* spp.), rushes (*Juncus* spp.) and forbs. Pockets of water appear to persist year round. In contrast, the palustrine scrub-shrub wetlands in the bypass reach support dense stands of hydrophytic shrubs, primarily willow (*Salix* spp.) and red-osier dogwood, and have a relatively sparse cover of herbaceous species.

Surveys conducted during the Stream Channel Morphology and Aquatic Habitat Study documented about 21.2 pieces of LWD per mile (12.7/km) in the Swift bypass reach (Table 5.9-3). Most of these were relatively small (<12 inches [30 cm] diameter) and found in the lower portion of the reach. The surveys did not record any large trees (>24 inches [61 cm] diameter) leaning over the bankfull channel, suggesting that the riparian habitat bordering the channel will not contribute much LWD in the near future. Three beaver dams were documented on or near the bypass reach channel; these are in addition to those associated with the wetlands that occur between Swift canal and the bypass reach.

Table 5.9-3. Large woody debris in the Swift bypass reach[1].

Reach	Large Woody Debris											Root-wads or Jams	Beaver Dams
	Class 4[2]			Class 3[2]			Class 2[2]		Class 1[2]		Instream LWD/ mi. [6]		
	Wet[3]	Bnk[4]	Pot[5]	Wet[3]	Bnk[4]	Pot[5]	Wet[3]	Bnk[4]	Wet[3]	Bnk[4]			
Confined (0.66 mi.)	0	0	0	0	0	0	3	7	3	27	60.6	1 Jam	
Unconfined (0.85 mi.)	0	0	0	0	0	0	0	0	0	12	14.1	2 Jams	1
Mod confined (0.47 mi.)	0	0	0	0	0	0	0	0	1	1	4.3		2
Upper confined (0.57 mi.)	0	0	0	0	0	0	0	0	0	0	0.0		
Total (2.55 mi.)	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**7**	**4**	**40**	**21.2**	**3 Jams**	**3 Dams**

[1] Source: Data provided by Montgomery Watson Harza
[2] Large woody debris: 4= >36 inches diameter, > 50 feet long; 3= >24 inches diameter, >50 feet long; 2= >12 inches diameter, >25 feet long; 1= >6 inches diameter, >25 feet long.
[3] Wet = Within wetted channel
[4] Bnk = Within bankfull channel (exclusive of those counted in wetted channel)
[5] Pot = Potential; standing but leaning over bankfull channel. Quantified only for trees larger than 24 in. dbh.
[6] Includes wetted and bankfull channel; excluded potential. Total is not additive; calculated on length of entire reach.

The habitats in the Swift bypass reach support a variety of wildlife species typical of riparian areas in western Washington. Surveys conducted in the 1996 and 1997 breeding seasons documented 46 avian species using the riparian deciduous forests in the bypass reach. Mean breeding season species richness was higher than any of the upland types surveyed in the vicinity of the Yale Project, but lower than forested wetlands (PacifiCorp 1999). The wetlands in the Swift bypass reach are used for breeding by 4 amphibian species, including the red-legged frog (*Rana aurora*), rough-skinned newt (*Taricha granulosa*), Pacific chorus frog (*Hyla regilla*), and northwestern salamander (*Ambystoma gracile*). The Swift bypass reach area also receives heavy use by black-tailed deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*), and beaver are active in the wetlands.

Eight priority species, as designated by the WDFW, have been observed in the bypass reach—the bald eagle (*Haliaeetus leucocephalus*), osprey (*Pandion haliaetus*), wood duck (*Aix sponsa*), pileated woodpecker (*Dryocopus pileatus*), great blue heron (*Ardea herodias*), Cascade torrent salamander (*Rhyacotriton cascadae*), black-tailed deer, and elk. The Cascade torrent salamander and pileated woodpecker are also candidates for state listing as threatened or endangered. Over 50 torrent salamanders were observed in a single 0.2-acre (0.1 ha) seep near the bridge at the west end of they bypass reach.

Speelyai Creek

The Speelyai Creek segment of the study area covers the land within 0.25 mile (0.4 km) on either side of the creek and 0.125 mile (0.2 km) on either side of the canal (Figure 5.9-2). About 1,399 acres (566 ha) of land were mapped within 0.25 mile (0.4 km) of the creek, including 208 acres (84 ha) of riparian vegetation and 7 acres (2.3 ha) of wetland (14 percent of the mapped area) (Table 5.9-1). Speelyai Creek below the upper diversion has a very low gradient and supports a very high density of beaver dams, especially downstream of the SR 503 bridge. Consequently, most of the creek is bordered by a complex of riparian and wetland habitats that are very difficult to separate into different types. Results of the surveys to characterize the stream and riparian habitats associated with 4 reaches of Speelyai Creek, as well as information on the habitats associated with the canal, are presented below.

Upstream of the Speelyai Canal Diversion

Upstream of the upper Speelyai diversion, the bankfull channel width averages 46.2 ± 20.7 feet (14.1 ± 6.3 m) (mean ± standard deviation); the wetted channel comprises approximately 48 percent of the bankfull channel width (Table 5.9-4). Since the survey was conducted under low flow conditions, the large amount of exposed channel and the lack of vegetation in the channel suggest that the creek carries substantial flows at other times of the year. Thalweg depth averaged 2.3 feet (0.7 m) and ranged from 1.4 to 2.9 feet (0.4 to 0.9 m). Riparian habitat bordering 3,500 feet (1,067 m) of Speelyai Creek upstream of the canal diversion consists of unconsolidated riverine shoreline and upland forest types, primarily deciduous and mixed conifer/deciduous stands. Riparian vegetation typical of low gradient streams in western Washington is almost non-existent. There was almost no riparian vegetation growing in the channel below bankfull (Table 5.9-4). A few locations support a thin band of willow or alder shrubs on gravel berms just above the bankfull channel. Overall, the width of riparian vegetation averages only 7.1 ±11.3 feet (2.2 ±3.4 m) for both banks combined (Table 5.9-4). The relative lack of riparian vegetation appears to be due to a combination of confined topography and frequent peak flows that prevent deposition of fine sediments, scour vegetation, and erode stream banks (see photos below). The entire channel consists of unconsolidated cobble, with few areas suitable for vegetation establishment.

Table 5.9-4. Summary of Speelyai Creek channel and riparian habitat characteristics.

Creek Segment	Right Bank Riparian Width (ft)	Left Bank Riparian Width (ft)	Total Riparian Veg. Width (ft)	Riparian Vegetation Width in Channel (ft)	Bankfull Channel Width (ft)	Wetted Channel (ft)	Right Bank Distance to Thalweg (ft)	Thalweg Depth (ft)	Right Bank Height (ft)	Left Bank Height (ft)
Upstream of Speelyai Canal Diversion (n=6)										
Mean	5.7	0.4	7.1	1.4	46.2	22.4	24.5	2.3	3.4	5.6
St. Dev.	11.3	1.1	11.3	2.4	20.7	8.6	11.0	0.6	2.0	2.0
Range	0-13.11	0-2.6	0-28.2	0.0-5.9	14.1-77.1	10.2-31.5	4.9-36.1	1.4-2.9	1.8-7.4	2.4-7.9
Between Diversion and SR 503 Bridge (n=12)										
Mean	7.3	9.6	20.1	10.1	27.3	15.4	15.2	1.7	4.1	3.3
St. Dev.	5.9	9.3	12.7	14.1	15.7	8.0	10.2	1.3	5.1	2.2
Range	1.3-17.7	1.6-36.4	6.2-49.5	0.7-47.9	12.1-59.4	5.9-33.1	4.9-33.1	0.58-5.4	0.82-17.8	0.25-5.9
Between SR 503 Bridge and Hatchery (n=20)										
Mean	39.9	47.1	86.9	17.0	51.7	38.7	27.7	2.7	4.4	5.2
St. Dev.	62.6	80.3	122.8	10.1	15.1	13.3	16.5	0.9	3.7	6.0
Range	2.9-282.8	1.3-302	10.4-524	3.6-38.4	24.6-82	19.7-67.3	7.5-67.6	1.1-4.0	0-11.2	0-26.4
Below Hatchery (n=1)										
Value	21.0	78.7	99.7	10.8	32.5	19.4	12.8	2.3	10.0	1.3

Erosion upstream of Speelyai canal diversion

Channel upstream of Speelyai canal diversion

This section of Speelyai Creek also has very steep banks, which in some places are vertical, undercut, and over 7 feet (2.1 m) high. There is very little level or gradually sloping land between bankfull and the high terrace that would experience the seasonal flooding or elevated groundwater levels needed to support significant amounts of riparian vegetation. In addition, there are no beaver dams or adjacent wetlands. There are, however, a few side channels, as well as about 77 pieces of LWD per mile (46/km) and a number of logjams and root wads (Table 5.9-5), all of which moderate flow velocities and trap sediment.

Table 5.9-5. Large woody debris in Speelyai Creek[1].

Reach	Large Woody Debris											Root-wads or Jams	Beaver Dams
	Class 4[2]			Class 3[2]			Class 2[2]		Class 1[2]		Instream LWD /mi.[6]		
	Wet[3]	Bnk[4]	Pot[5]	Wet[3]	Bnk[4]	Pot[5]	Wet[3]	Bnk[4]	Wet[3]	Bnk[4]			
Hatchery to SR 503 (2.63 mi.)	15	5	16	27	4	65	112	40	175	44	160.5	12 RW, 8 Jams	28
SR 503 to upper diversion (1.69 mi.)	4	4	11	2	3	8	16	1	9	5	26.0	5 RW, 1 Jam	20
Lower Speelyai Total (4.32 mi.)	**19**	**9**	**27**	**29**	**7**	**73**	**128**	**41**	**184**	**49**	**107.9**	**17 RW, 9 Jams**	**48**
Stream above the diversion (0.66 mi.)	0	2	5	3	10	7	1	15	4	16	76.6	8 RW, 2 Jams	None

[1] Source: Data provided by Montgomery Watson Harza
[2] Large woody debris: 4= >36 inches diameter, > 50 feet long; 3= >24 inches diameter, >50 feet long; 2= >12 inches diameter, >25 feet long; 1= >6 inches diameter, >25 feet long.
[3] Wet = Within wetted channel.
[4] Bnk = Within bankfull channel (exclusive of those counted in wetted channel).
[5] Pot = Potential; standing but leaning over bankfull channel. Quantified only for trees larger than 24 in. dbh.
[6] Includes wetted and bankfull channel; excluded potential. Total is not additive; calculated on length of entire reach.

Speelyai Canal

There is no riparian or wetland vegetation along Speelyai canal; both sides are bordered by upland deciduous forest. There is also a dirt road along the west side of the canal, which is lined with Scot's broom (*Cytisus scoparius*), and several residential developments on the east side. The canal is about 20 to 40 feet (6 to 12 m) below the grade of the adjacent land, with sides that get steeper and higher toward the reservoir.

Downstream of the Speelyai Canal Diversion

In general, the entire length of Speelyai Creek downstream of the canal diversion is bordered by riparian deciduous and riparian mixed forest stands. The riparian deciduous stands are dominated by red alder but also support a few big-leaf maple (*Acer macrophyllum*) trees. The age of most stands was estimated to be about 15-25 years.

Riparian mixed stands usually consisted of western red cedar and red alder. The few riparian conifer stands were composed exclusively of western red cedar. Typical understory species included salmonberry, jewelweed (*Impatiens noli-tangere*), reed canarygrass (*Phalaris arundiacea*), and sedges. In some areas, the riparian habitats along the creek have been altered by houses or other structures. Houses and trailers occur in about 5 clusters downstream of the canal diversion; several of these structures are very close to the edge of the channel.

Overall, channel width and the amount of adjacent riparian vegetation increased with increasing distance from the canal diversion. Beaver dams were common from approximately 1 mile (1.6 km) downstream of the canal diversion to about 0.25 mile (0.4 km) above the hatchery diversion. Many of these dams were old and showed no signs of recent activity but still created substantial pools. The diversity of instream habitats in Speelyai Creek downstream of the canal diversion also support a variety of aquatic plant species, none of which were noted upstream of the diversion. Species observed included the following:

- Narrow-leaved bur reed (*Sparganium angustifolium*)
- Floating-leaved pondweed (*Potamogeton natans*)
- Grass-leaved pondweed (*Potamogeton gramineus*)
- Diverse-leaved water-starwort (*Callitriche heterophylla*)
- White water buttercup (*Ranunculus aquatilis*)
- Common duckweed (*Lemna minor*)
- Water moss (*Fontinalis antipyretica*)
- Tapegrass (*Vallisneria americana*)

Wildlife species observed along the creek included the red-legged frog (6 adults), tree frog, belted kingfisher (*Ceryle alcyon*), American dipper (*Cinclus mexicanus*), Steller's jay (*Cyanocitta stelleri*), ruffed grouse (*Bonasa umbellus*), golden crowned kinglet (*Regulus satrapa*), Swainson's thrush (*Catharus ustulatus*), song sparrow (*Amphispiza belli*), winter wren (*Troglodytes troglodytes*), black-capped chickadee (*Parus atricapillus*), killdeer (*Charadrius vociferus*), Cooper's hawk (*Accipiter cooperii*), red-tailed hawk (*Buteo jamaicensis*), elk, black-tailed deer, raccoon (*Procyon lotor*), and beaver.

Downstream of the Speelyai canal diversion, the creek was classified into 3 segments based on general channel form and location relative to the hatchery diversion. Data for each of these are summarized below.

Speelyai Canal Diversion to Route 503 Bridge – The 1.7-mile (2.7 km) reach between the canal diversion and the SR 503 bridge exhibits a gradual increase of water in the channel. This reach has only 2 small noticeable tributaries but includes at least 20 beaver ponds (>11.8/mile [7.4/km]), several of which are associated with extensive off-channel wetlands. The channel in this reach frequently splits around bare gravel bars or vegetated islands. A number of the channel splits appear to be the result of beaver dams, but others are associated with logjams or differential changes in the channel bed.

Riparian habitat downstream of Beaver Pond Rd.

Development upstream of SR 503 bridge

The bankfull width of the channel between the canal diversion and the SR 503 bridge averages 27.3 ±15.7 feet (8.3 ± 4.8 m), which is substantially narrower than the width upstream of the diversion (Table 5.9-4), likely the result of lower overall flows. The wetted channel under low flow conditions covers approximately 56 percent of the entire channel width. This reach is bordered by substantially more riparian vegetation than upstream of the diversion, averaging 20.1 ± 12.7 feet (6.1 ± 3.9 m) for both sides combined. On average, there are about 10.1 ± 14.1 feet (3.1 ± 4.3 m) of riparian vegetation growing in the channel between the bankfull and wetted levels. There are also some off-channel areas with well-developed riparian and wetland habitats, some of which include houses (see photos above). Much of the upper half of this reach (from approximately the transmission line right-of-way [ROW] to Beaver Pond Road) is bordered by clearcuts. Although most of these occur on terraces above the riparian zone, some have clearly resulted in erosion and contributed sediment to the creek.

SR 503 Bridge to the Hatchery Diversion – The 2.3-mile (3.8 km) reach between the SR 503 bridge and the hatchery diversion has the widest bankfull channel of all Speelyai Creek reaches, averaging 51.7 ±15.1 feet (15.8 ± 4.6 m) (Table 5.9-4). Approximately 75 percent of the total channel width has surface water present during low flow conditions, and most of the remainder is vegetated, suggesting that water levels in this reach are very stable. The average width of the band of riparian vegetation growing below bankfull level is 17 ±10.1 feet (5.2 ±3.1 m). In-channel vegetation throughout this reach is dominated by jewelweed, which grows prolifically on gravel bars, along shorelines, and in shallow water. Although jewelweed was noted upstream of the SR 503 bridge, it appeared to be much less common.

This lower section of Speelyai Creek has more than 28 beaver dams (>10.8/mile [6.7/km]), which created complex, and often very wide, areas of riparian habitat (see photo below). There are also large amounts of instream wood, logjams, and root wads (Table 5.9-5). The combined width of riparian vegetation along both sides of this reach averages 86.9 ±123 feet (26.5 ± 37.4 m) and ranges up to 524 feet (160 m) just below the SR 503 bridge (Table 5.9-4). In this area, the combination of a series of beaver dams and flat topography has resulted in a large, complex of wetlands and stands of riparian deciduous forest.

Beaver dam downstream of SR 503 bridge

Hatchery Diversion to Lake Merwin – Only 1 transect was surveyed downstream of the fish hatchery diversion. This plot had a 32.5-foot (9.9 m) wide channel that was 60 percent wet on the survey date. Riparian vegetation was well developed and totaled 99.7 feet (30.4 m) wide, both sides combined.

Lower Lewis River

The lower Lewis River segment of the study area extends along the Lewis River from about 0.5 mile (0.8 km) below Merwin Dam downstream to Eagle Island. This approximately 6-mile (9.6 km) segment is bordered by the 240-foot (73-m) contour line on both sides of the river. From the dam to about 3 miles (4.8 km) downstream, the Lewis River channel is confined to a canyon with steep sides that rise more than 100 feet (30 m) above the water surface. Some of the canyon walls are vertical rock walls with very little vegetation; most, however, support riparian deciduous or mixed conifer/ deciduous forest stands. The channel in the lower half of the reach is less confined, with the adjacent terrain consisting of rolling hills and bottomlands. This section of the reach includes more islands and gravel bars than the upper 3 miles (4.8 km). It is also bordered by more development, including a golf course, a campground, and numerous residences. Over 42 percent of the area mapped along the lower Lewis River has been affected by some kind of development (Figure 5.9-3).

Approximately 276 acres (112 ha) of riparian deciduous forests were mapped along the lower Lewis River segment of the study area. Of this amount, 65 acres (26 ha), or 23 percent, is found on or adjacent to Eagle Island. Riparian deciduous forest stands along the lower Lewis River are dominated by red alder but also include substantial amounts of big-leaf maple, cottonwood, and green ash (*Fraxinus latifolia*). Tree cover is moderately high, with mean overstory height approaching 90 feet (27 m) (Table 5.9-6).

Shrub cover is also moderately high and consists primarily of native species, including snowberry (*Symphoricarpos albus*), ninebark (*Physocarpus capitatus*), rose (*Rosa* spp.), salmonberry, and hazelnut (*Corylus cornuta*). A few riparian areas have been invaded by Himalayan blackberry (*Rubus discolor*) and Scot's broom, but these species were not common. Herbaceous cover is moderate, and many stands consist of native species such as trailing blackberry, piggy-back plant (*Tolmiea menziesii*), sword fern (*Polystichum munitum*), lady fern (*Athyrium filix-femina*), and stinging nettle (*Urtica dioica*). However, some stands consist primarily of exotic and/or invasive native species, such as English ivy (*Hedera helix*), wild cucumber (*Echinocystis lobata*), common cocklebur (*Xanthium strumarium*), horsetail (*Equisetum* sp.), and wall lettuce (*Lactuca muralis*).

Starting at about 0.75 mile (1.2 km) below the dam, riparian mixed conifer/deciduous stands cover the steep slopes bordering the Lewis River for much of a 2-mile (3.2 km) reach (Figure 5.9-3). This forest type becomes less common as slopes moderate along the lower half of the segment, but relatively large stands do occur on Eagle Island and across the river from the golf course. About 259 acres (105 ha) of riparian mixed forest were mapped along the lower river and cover about 4 percent of the lands in this reach. This type has a very high tree canopy cover and is dominated by red alder, big-leaf maple, and western red cedar. Most stands appear to be relatively mature, as indicated by a mean overstory height approaching 100 feet (30 m) and a high number of large trees (>20 inches [51 cm] diameter). Shrub cover is moderate and consists primarily of the same native species found in riparian deciduous stands. The most common hydrophytic shrub species is salmonberry. Herbaceous cover in most riparian mixed stands is high, with a species composition similar to that found in riparian deciduous stands.

Riparian shrublands occur on islands and cobble bars in the lower river reach, which appears to be seasonally flooded in most years from spring run off and winter floods. These areas are characterized by dense patches of shrubs interspersed with small open areas, which results in a moderate shrub canopy cover overall (Table 5.9-6). Dominant shrubs are generally hydrophytic, reflecting a hydrological regime of frequent flooding. Cobble bars and small, low islands are covered almost exclusively by willow and red-osier dogwood. Islands large enough to have areas a few feet above normal high water support a greater diversity of shrub species, including ninebark and snowberry, as well as seedling cottonwood and green ash. Open patches within riparian shrublands along the lower river are either bare or covered by reed canarygrass or a mixture of forbs and sedges.

A few acres of riparian grasslands occur along the lower river, generally at the edges of small islands or bordering areas of unconsolidated shoreline. These areas appear to be flooded annually, probably from winter through spring, with herbaceous vegetation establishing once water levels have receded. Flood events large enough to move substrate probably scour much of the vegetation from riparian grasslands. All of the riparian grasslands sampled along the lower river were dominated by reed canarygrass, as well as a variety of other exotic and/or invasive species such as Japanese knotweed (*Polygonum cuspidatum*), St. John's wort (*Hypericum formosum*), and jewelweed.

Table 5.9-6. Structural characteristics of riparian and wetland habitats along the lower Lewis River and Eagle Island[1].

Habitat Parameter	Lower Lewis River Shorelines				Eagle Island		
	Riparian Deciduous Forest (n=6)	Riparian Mixed Forest (n=5)	Riparian Shrub (n=4)	Riparian Grass (n=3)	Riparian Deciduous Forest (n=3)	Riparian Mixed Forest (n=1)	Riparian Shrub (n=1)
Mean tree canopy cover (%)	79 (48-96)	92 (85-97)	0	0	67 (56-83)	70	0
Mean deciduous shrub canopy cover (%)	64 (42-95)	35 (15-53)	49 (13-82)	9 (5-16)	67 (50-78)	73	50
Mean hydrophytic shrub canopy cover (%)	16 (0-33)	16 (0-30)	45 (4-77)	4 (3-4)	10 (0-17)	19	40
Mean combined tree/shrub cover (%)	92 (82-99)	99 (96-100)	49 (13-82)	9.1 (5-16)	86 (70-99)	96	50
Mean overstory tree height (ft)	87 (74-102)	96 (75-107)	--	--	67 (59-75)	118	--
Mean shrub height (ft)	5.9 (3.3-9.8)	6.7 (5.2-8.2)	9.2 (5.9-12)	--	5.6 (4.9-6.6)	7.5	6.9
Mean no. trees >20 inches dbh/ac	5 (0-16)	28 (12-44)	0	0	19 (8-32)	12	0
Mean no. of snags/ac	13 (6-17)	5 (0-12)	0	0	16 (8-24)	12	0
Mean no. snags >20 in. dbh/ac	0.7 (0-4)	0.8 (0-4)	0	0	4	0	0
Mean no. logs > 7 in. large-end diameter/ac	26 (0-77)	24 (16-28)	7 (0-20)	0	38 (25-61)	16	4
Mean grass cover (%)	10 (0-52)	8 (2-18)	50 (10-80)	55 (26-75)	--	--	--
Mean forb cover (%)	33 (5-72)	62 (42-80)	16 (5-29)	22 (13-31)	--	--	--

[1] The range of each habitat parameter is shown in parentheses. Means with no ranges indicate that the parameter was recorded in only 1 plot. Dashes indicate that the parameter was not sampled.

There are relatively few wetlands along the lower river, and 46 percent of the 27 acres (11 ha) that do occur are found on Eagle Island. Most of the remainder are associated with a tributary stream and backwater area just downstream from the Lewis River Golf Course (Figure 5.9-3). Palustrine emergent wetlands are the most common type.

Surveys conducted during the Stream Channel Morphology and Aquatic Habitat Assessment documented about 15.4 pieces of LWD per mile (9.2/km) in the lower Lewis River reach (Table 5.9-7). LWD <12 inches (38 cm) diameter were not counted along this reach because small pieces are generally not retained in higher order streams (Helfield and Naiman 2001). The amount of wood recorded in the lower half of the reach, which is unconfined, is more than double the amount in the more confined upper half, and most of pieces were moderately large (>12 to 36 inches [30-91 cm] diameter). Both reaches had a number of trees leaning over the bankfull channel, indicating that riparian habitat along the lower river potentially contributes LWD. There were no beaver dams or logjams recorded in the lower river reach, but there were a number of root wads.

Table 5.9-7. Large woody debris in the lower Lewis River[1].

Reach	Large Woody Debris											Root-wads or Jams	Beaver Dams
	Class 4[2]			Class 3[2]			Class 2[2]		Class 1[2]		Instream LWD /mi [6]		
	Wet[3]	Bnk[4]	Pot[5]	Wet[3]	Bnk[4]	Pot[5]	Wet[3]	Bnk[4]	Wet[3]	Bnk[4]			
Confined (4.5 mi.)	0	0	4	2	1	41	28	12	nc	nc	9.6	10 RW	None
Unconfined (5.2 mi.)	0	0	0	11	0	21	95	0	nc	nc	20.4	26 RW	None
Total (9.7 mi.)	**0**	**0**	**4**	**13**	**1**	**62**	**123**	**12**	**nc**	**nc**	**15.4**	**36 RW**	**None**

[1] Source: Provided by Montgomery Watson Harza
[2] Large woody debris: 4= >36 inches diameter, > 50 feet long; 3= >24 inches diameter, >50 feet long; 2= >12 inches diameter, >25 feet long; 1= >6 inches diameter, >25 feet long.
[3] Wet = Within wetted channel.
[4] Bnk = Within bankfull channel (exclusive of those counted in wetted channel).
[5] Pot = Potential; standing but leaning over bankfull channel. Quantified only for trees larger than 24 in. dbh.
[6] Includes wetted and bankfull channel; excluded potential. Total is not additive; calculated on length of entire reach.
nc = not counted.

There were no specific surveys conducted for wildlife along the lower river and Eagle Island; most of the vegetation sampling occurred in the summer, outside of the breeding bird season. Nonetheless, 10 species were observed during the vegetation sampling, including the red-legged frog, great blue heron, common merganser (*Mergus merganser*), bald eagle, black-capped chickadee, Pacific-slope flycatcher (*Empidonax difficilis*), song sparrow, cedar waxwing (*Bombycilla cedrorum*), beaver, and black-tailed deer.

5.9.5.2 Effects of Additional Flows

The relicensing process could result in increased flows in the Swift bypass reach and Speelyai Creek. Potential effects of additional flows on the riparian habitats associated with each of these stream reaches are described below.

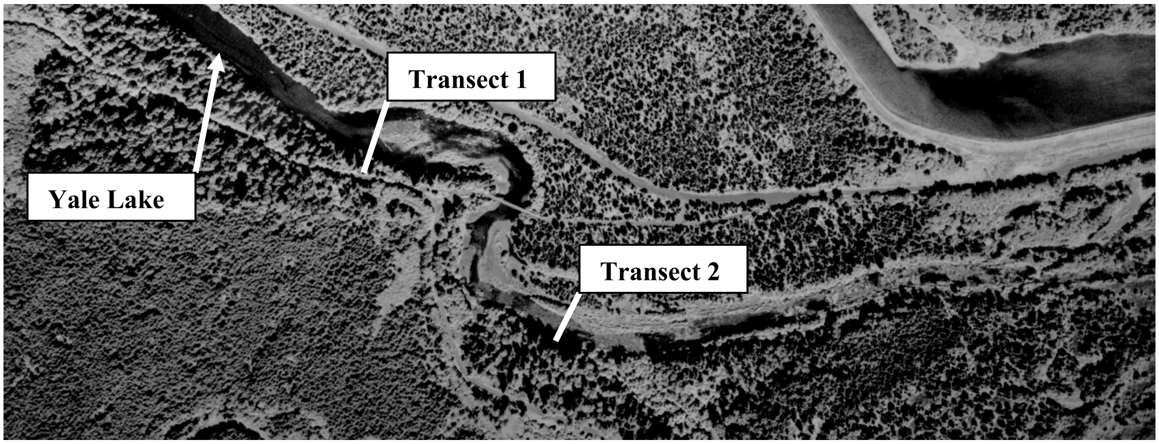
Swift Bypass Reach

Two different approaches were used to assess the effects of increased flows on riparian habitat in the Swift bypass reach. The first method involved direct measurements at 4 riparian transects at 3 different controlled releases (68, 134, and 290 cfs). This method demonstrated the effects of each flow level on riparian habitat in specific locations, but not the entire reach. The second approach extrapolated results from the IFIM Study (AQU 2) to predict water levels at flows ranging from 50 to 400 cfs to estimate effects on riparian habitat for the entire reach (see Section 5.9.3). Results of each of these methods are presented in the following 2 sections.

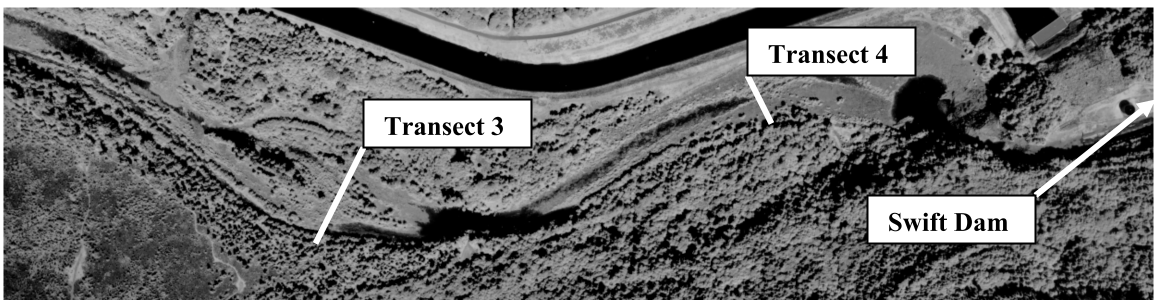
Direct Effects From Controlled Releases

The effects of the controlled releases on each of the 4 transects are summarized below.

Riparian Transect No. 1. Riparian Transect No. 1 is located slightly downstream from the bridge at the upstream end of Yale Lake, and is bordered by a steep basalt canyon (Figure 5.9-4). Riparian habitat data were collected along the left bank (facing upstream) and on a mid-channel bar.



Downstream portion of Swift bypass reach.



Upstream portion of Swift bypass reach.

Figure 5.9-4. Location of riparian transects in the Swift bypass reach.

Alder stand along Transect No. 1

Left Bank. Vegetation along the left bank of Transect No. 1 was divided into 3 major zones: (1) a band of red alder with salmonberry, lady fern, three-square bulrush (*Scirpus americanus*), rushes, and trailing blackberry; (2) a bench of talus with lady fern and reed canarygrass; and (3) a steep bedrock/talus area with red alder and moss (Figure 5.9-5). The lowermost alder-dominated zone is about 25.5 feet (7.8 m) wide and extends from approximately 0.8 foot (0.25 m) below to 1.3 feet (0.4 m) above normal water surface level. The IFIM data indicate that a small berm forms the shoreline within this zone. The middle zone is approximately 21.2 feet (6.5 m) wide and is 1.3 to 2 feet (0.4 to 0.6 m) above the normal water surface level. The uppermost zone is 36.4 feet (11 m) long and ranges between 2 and 11.1 feet (0.6 and 3.4 m) above the current water level.

The IFIM Study measurements show that the water level would increase 0.4, 0.6, and 0.8 feet (0.12, 0.18, and 0.24 m) under releases of 68, 134, and 290 cfs (1.9, 3.8, and 8.2 m3/s), respectively. None of these flows would, by themselves, eliminate much riparian vegetation; the 290 cfs (8.2 m3/s) release would inundate about 5 feet (1.5 m) or about 20 percent of the alder habitat along the shore (Figure 5.9-5). At the same time, the higher water level would probably raise groundwater below the flat bench from the current level of 1.3 to 2 feet (0.4 to 0.6 m) to 0.5 to 1.2 feet (0.15 m to 0.4 m) below the surface. This increased moisture could result in changes in plant species composition.

Mid-channel Bar. Riparian Transect No. 1 crosses the downstream end of a mid-channel bar. The portion of the bar crossed by the transect was approximately 40.7 feet (12.4 m) wide and composed of the following 3 distinct zones: (1) 10 feet (3 m) of unvegetated boulders/cobble; (2) 4.6 feet (1.4 m) of herbaceous vegetation dominated by reed canarygrass, velvet-grass (*Holcus mollis*), and mint (*Mentha* sp.); and (3) 26.2 feet (8 m) of dense willow, alder, and salmonberry, with an understory of coltsfoot (*Petasites palmatus*) and candyflower (*Claytonia siberica*).

These vegetation zones could not be matched exactly to the IFIM data because the deep right bank channel could not be crossed without a boat. However, it appears that the bar is located at elevations between 89.1 and 95.8 feet (27 and 29 m) (uncorrected) compared to the 0 cfs release water level of 93.1 feet (28 m) in the main channel and 89.1 feet (27 m) in the small side channel along the extreme right bank. An additional 290 cfs would increase the water level by about 0.6 foot (0.2 m) on the bar and would likely inundate about 6 feet (2 m), or approximately 15 percent of the bar. The increased water levels could also flood the rooting zone of plants at higher elevations and cause some to die out and/or be replaced by species that can tolerate wetter conditions.

<u>Riparian Transect No. 2</u>. Riparian Transect No. 2 is located approximately 0.1 mile (0.2 km) upstream of the bridge at the upper end of Yale Lake, just upstream of a sharp northerly bend in the river (Figure 5.9-4). In all, the transect covered 289 feet (88 m) between the upland end and the left bank (looking upstream) of the main river channel. The transect crosses 1 small side channel near the riparian/upland boundary. Much of the vegetation consists of species that occur both in upland and riparian habitats. Riparian shrubs and trees (salmonberry, willow, and alder) occupy nearly 108 feet (33 m), or 37 percent, of this transect (Figure 5.9-6). A combination of willow and alder shrubs are found in a 41 foot (12 m) wide band immediately adjacent to the main channel. The willows range between 0 and 3.7 feet (1.1 m) above the normal water surface level. Alder shrubs dominate a 29 foot (8.8 m) wide band just upslope of the willows. Mature cottonwood trees occupy a zone that is 22 feet (6.7 m) wide and 5 to 6 feet (1.5 to 2 m) above the 0 cfs release water level (Figure 5.9-6). The highest zones along the transect have been severely scoured and have large accumulations of coarse woody material, presumably deposited by the 1996 flood. Most of this zone is infested with Scot's broom.

Increasing releases to 290 cfs raised the water levels by about 1.2 feet (0.4 m) in the river channel. This increase would flood approximately 6.5 feet (2 m) (horizontal distance) or 16 percent of the willow/alder shrubs along the left bank of the main channel (Figure 5.9-6). The increase would also inundate about 1.8 feet (0.5 m) of salmonberry-dominated shorelines along the side channel. The increased water levels could increase cover of

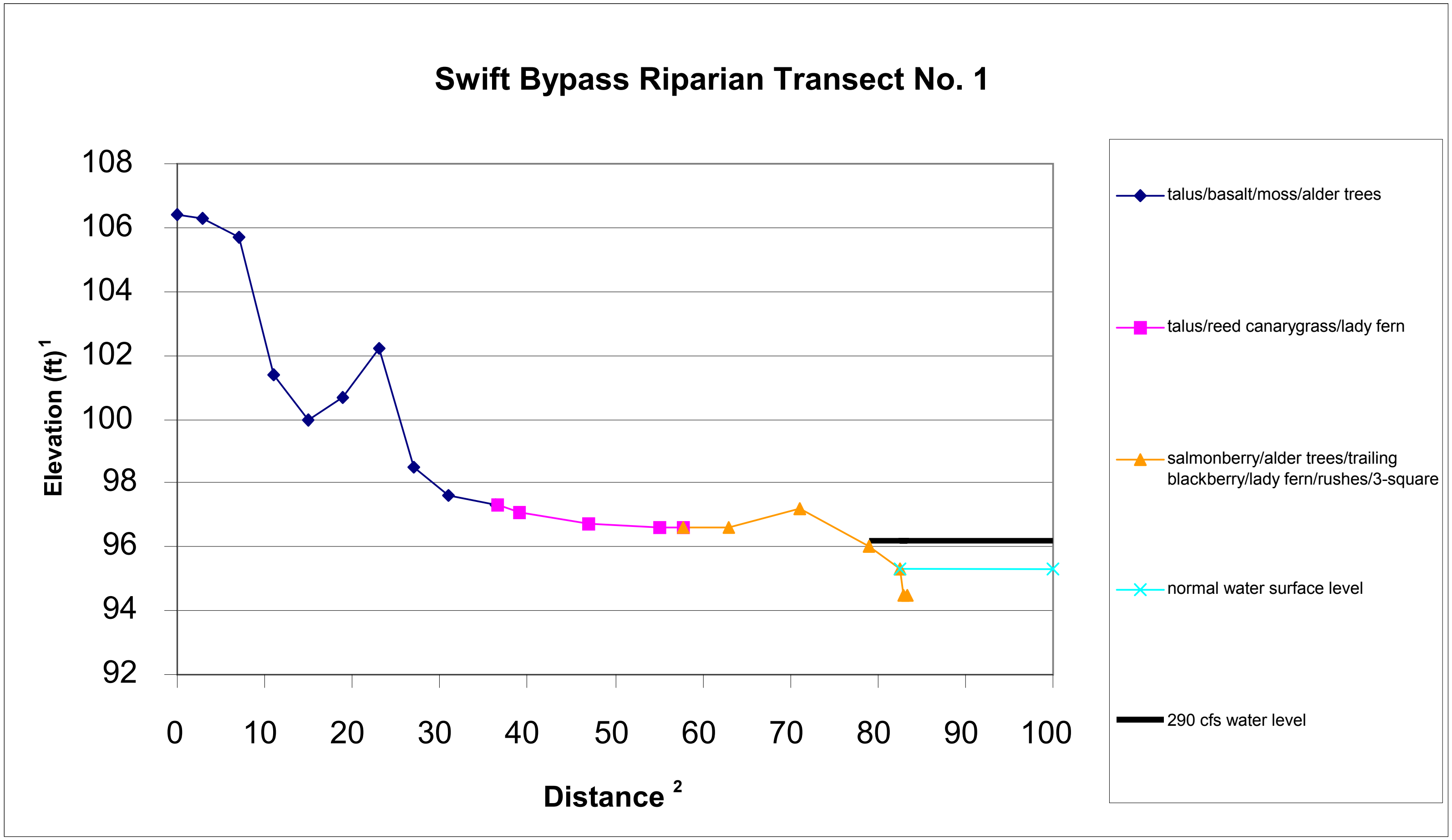


Figure 5.9-5. Vegetation cross section along left bank of Swift bypass reach Riparian Transect No. 1 with normal surface and 290 cfs release water levels.

[1] Elevations are standardized to 100 feet; corrected elevations (above sea level) are not available for this transect.
[2] Linear distance along the transect starting at farthest point from the main channel left bank.

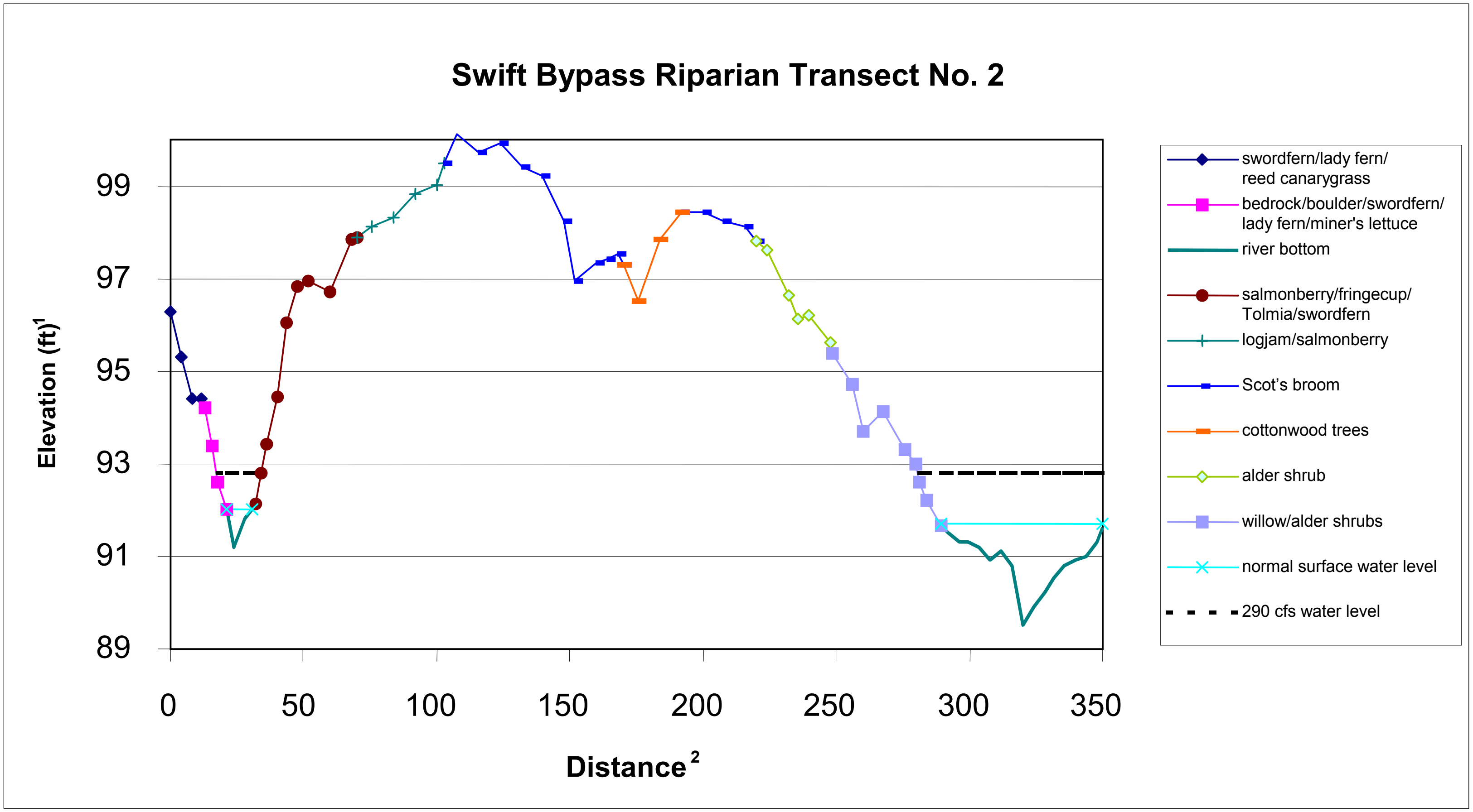


Figure 5.9-6. Vegetation cross section along left bank of Swift bypass reach Riparian Transect No. 2 with normal surface and 290 cfs release water levels.

[1] Elevations are standardized to 100 feet; corrected elevations (above sea level) range from 500.5 to 511.1 feet.
[2] Linear distance along the transect starting at farthest point from the main channel left bank.

hydrophytic plant species at the higher elevations along the transect. No data were collected on the right bank, but it appears that approximately 10 feet (3 m) of riparian habitat would be inundated by a 290 cfs release.

Riparian habitat along Transect No. 2

Scot's broom infestation along Transect No. 2

Riparian Transect No. 3. Riparian Transect No. 3 is located just upstream of the Swift canal overflow spillway (Figure 5.9-4). The site has a wide area of riparian habitat on the left bank (looking upstream) which is situated on the inside of a northerly bend in the river channel. The transect extends 229 feet (70 m) from the upland "pin" to the left bank of the main channel (Figure 5.9-4). The transect crosses a 50 foot (15 m) wide side channel that was approximately 50 feet (15 m) from the upstream end of the transect. The water level in this side channel was less than the normal surface water level and was nearly 9 feet (2.8 m) lower than the water level in the main channel. This lower water level is likely due to some type of hydrological control (e.g., bedload deposits) upstream of the transect that keeps water from flowing into the side channel, except at extremely high flows.

Flooded riparian shrubs along Transect No. 3 during a 300 cfs release

A 38-foot-wide (12 m) band of alder and willow shrubs borders the main channel and is within 2 feet (0.7 m) of the water surface elevation; a portion of the band has a saturated substrate (Figure 5.9-7). Immediately adjacent to this densely vegetated band is a 69-foot-wide (21 m) zone dominated by Scot's broom and Himalayan blackberry. The-10-foot-high (3 m) embankment along the right bank of the side channel is vegetated with alder trees; the left side also supports alder but includes areas of Scot's broom and blackberry as well.

The IFIM Study predicts that a 290 cfs release would increase the water level in the main channel by approximately 2.7 feet (0.8 m) from the normal water surface level (Figure 5.9-4). However, the water level in the side channel would only increase by approximately 2.4 inches (6.1 cm). It is possible that a permanent increase in the main channel minimum flow would result in accretion flow into the side channel as ground-water levels rise. A 290 cfs increase would inundate essentially all of the willow/alder

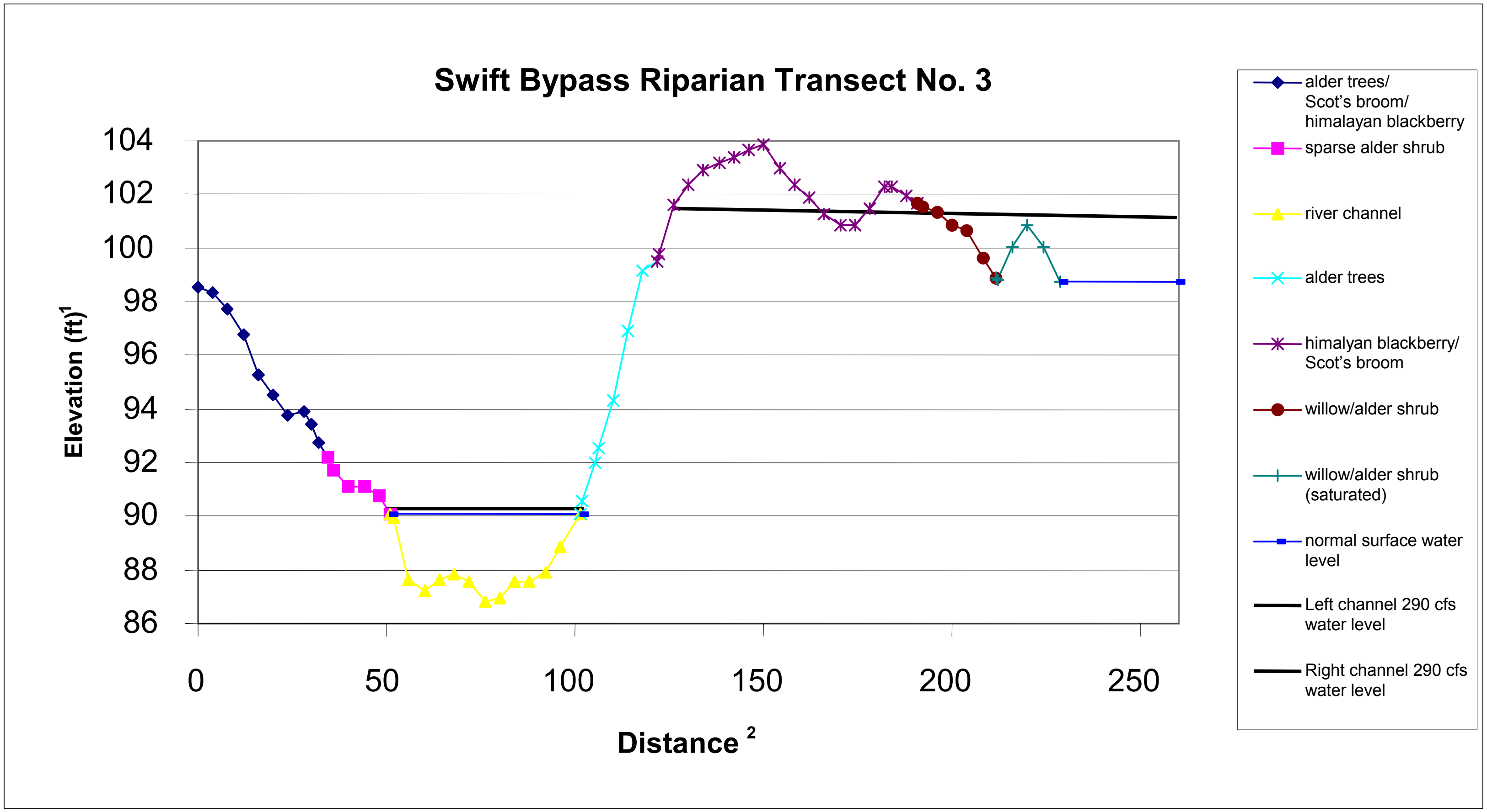


Figure 5.9-7. Vegetation cross section along left bank of Swift bypass reach Riparian Transect No. 3 with normal and 290 cfs release water levels.

[1] Elevations are standardized to 100 feet: corrected elevations (above sea level) range from 555.0 to 573.0 feet.
[2] Linear distance along the transect starting at farthest point from the main channel left bank.

shrub zone and about 12 feet (3.7 m) or 17 percent of the adjacent Scot's broom/blackberry band. During the May 18, 2000 inspection of Transect No. 3, the band of willow and alder shrubs was flooded to depths of between 0.6 and 2.5 feet (0.2 and 0.8 m). Many of the shrubs were bent over by the increased flows. The 290 cfs release also created a new 5-foot-wide (1.5 m) side channel at the base of the adjacent Scot's broom/blackberry band.

<u>Riparian Transect No. 4</u>. Transect 4 is near the stream gaging station just downstream of Swift Dam (Figure 5.9-4). The channel is not divided, and the left bank is confined by the artificially contoured slope of the Swift canal. Numerous large boulders occur along the transect line. The transect on the left bank was 27 feet (8.2 m) long. An 11-foot-wide (3.4 m) band of willow borders the river channel and extends from the water's edge to about 2 feet (0.6 m) above that level (Figure 5.9-8). The remainder of the transect is dominated by boulders and various upland herbaceous plant species.

Increasing flows by 290 cfs raises the water level at Transect No. 4 by 2.6 feet (0.8 m), and inundates the entire shrub community, as well as a small portion of the toe slope of the Swift canal (Figure 5.9-8). On May 18, 2000 when 290 cfs flows were released from Swift Dam, the shrub zone was flooded to a depth of 0.4 feet (0.1 m) (Figure 5.9-8).

Riparian habitat at Transect No. 4

Side channel along Transect No. 4

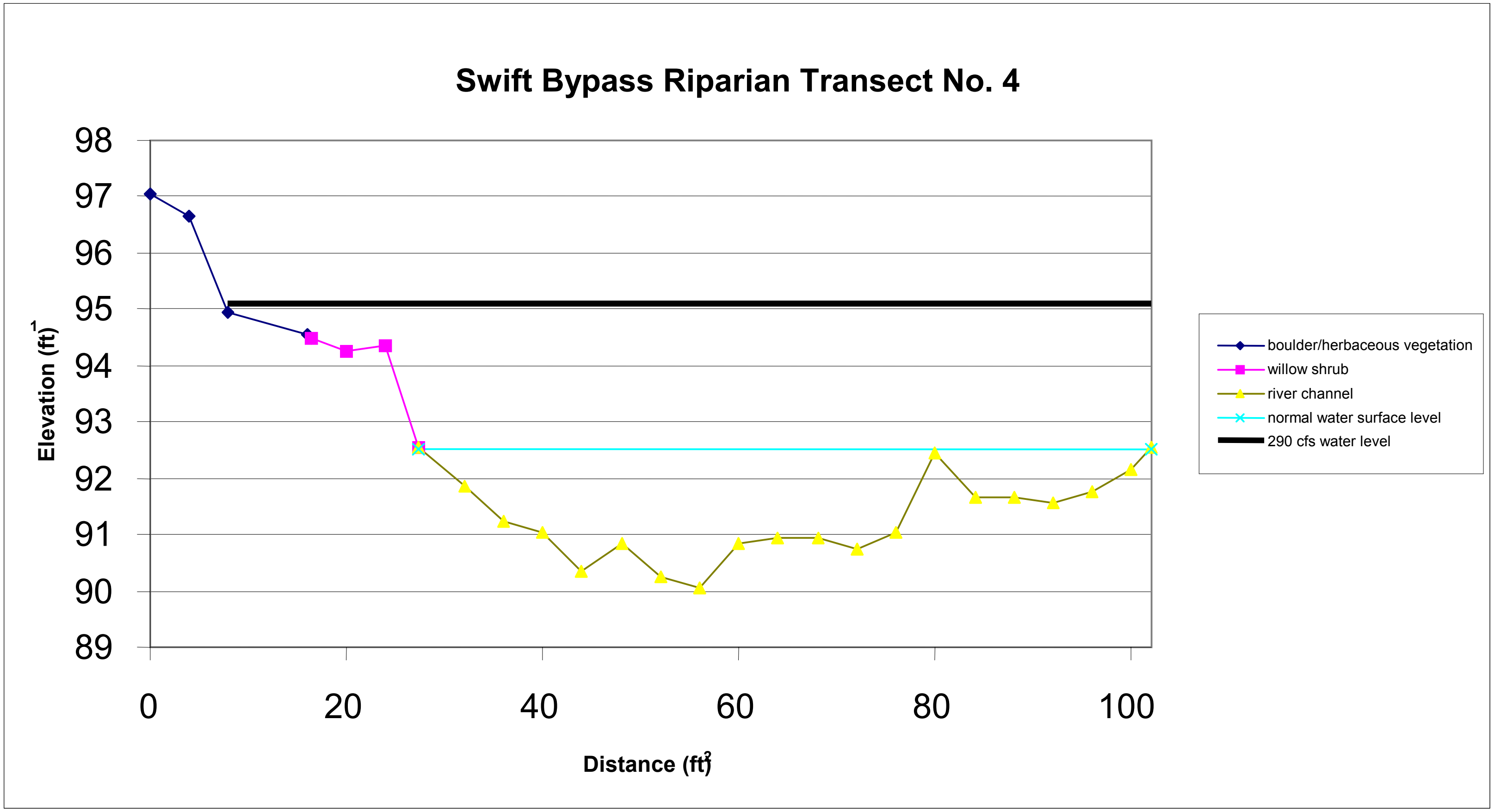


Figure 5.9-8. Vegetation cross section along left bank of Swift bypass reach Riparian Transect No. 4 with normal surface and 290 cfs release water levels.

[1] Elevations are standardized to 100 feet; corrected elevations (above sea level) are not yet available for this transect.
[2] Linear distance along the transect starting at farthest point from the main channel left bank.

Estimated Effects from Higher Flows

Data from the IFIM Study were used to predict water levels at flows ranging from 50 to 400 cfs and to estimate the effects on riparian habitat in the Swift bypass reach. Based on this approach, flow releases of 50, 100, 200, and 400 cfs into the bypass reach would inundate about 5, 8, 11, and 16 acres (2, 3, 4, and 6 ha) of riparian habitat, respectively. If the entire area affected by each of these flows currently supports riparian vegetation, the loss of 5 to 16 acres (2 and 6 ha) of habitat would affect about 5 to 15 percent of the existing 106 acres (43 ha) of riparian vegetation in the reach. However, it is very likely that some adjacent uplands, particularly areas with low topographic relief, would be affected by higher moister levels associated with increased flows. These areas would eventually support species tolerant of wetter conditions and typical of riparian areas. Consequently, there may be little if any net loss of riparian vegetation in the bypass reach from flow releases between 50 and 200 cfs.

To check the acreage estimates from the larger IFIM data set, we also used data from the 4 riparian habitat transects to approximate the loss for the entire reach under the 290 cfs controlled release. We assumed that the amount of riparian vegetation inundated at each of the 4 transects was representative of the amount affected in roughly one-quarter of the reach. Based on this approach, approximately 12 acres (5 ha) of riparian vegetation in the reach would be inundated by a release of 290 cfs. This estimate compares favorably to the 11 and 16 acres (4 and 6 ha) calculated for flows of 200 and 400 cfs, respectively.

It is also likely that higher flows, particularly 400 cfs, would result in the formation of additional side channels in the bypass reach. A new side channel was observed at Riparian Transect 3 during the controlled release of 290 cfs.

<u>Speelyai Creek</u>

As part of the relicensing process, 3 different flow options are being considered for Speelyai Creek:

- Current operation – all flow from the creek is directed into Yale Lake at the upper diversion;
- Operation according to the existing water right – the upper diversion would be operated according to the existing water right, which means that up to 15 cfs (0.4 m^3/sec) of flow would not be diverted at the upper diversion; and
- Operation without the upper diversion – The upper diversion would be removed.

Above the upper diversion, Speelyai Creek has a wide channel confined by steep banks and is bordered by very little riparian vegetation. The creek is considered "flashy," meaning that it has very high peak flows relative to low flows, and flows increase and decrease quickly. The flashy nature of the creek is probably one of the main reasons for the lack of riparian vegetation. High flows during storm events and spring runoff scour vegetation, removing tree and shrub seedlings. Currently, high flows from upper Speelyai Creek are diverted into Yale Lake, protecting the lower portion of the creek, which is primarily spring fed. Consequently, a substantial amount of riparian vegetation has established within the old bankfull channel in the lower reach in the years since the diversion has been in place. Removing the upper diversion would greatly increase flows in lower Speelyai Creek during the winter and storm events, and it is expected that this section would soon resemble the upper portion. Gradients in both sections are similar, and high flow events would likely remove most of the existing beaver dams and associated wetlands and much of the riparian vegetation currently growing within the bankfull channel. The amount of riparian/wetland vegetation currently associated with the lower portions of the creek would probably be permanently reduced because of the loss of vegetation currently growing within the bankfull channel. Riparian vegetation growing on benches outside the bankfull channel would be less affected.

Operating the upper Speelyai diversion according to the existing water right would add up to 15 cfs to the lower portion of the creek. Winter flows would increase from about 30 cfs to about 45 cfs; summer flows would increase from the current 6-10 cfs to 20-25 cfs (see AQU 9). The expected stage change associated with an increased flow of 15 cfs is only about 1 inch (2.5 cm) in the summer and 4 inches (10 cm) in the winter; associated wetted channel width would increase from 2 to 5 feet (0.6 to 1.5 m) between summer and winter (see AQU 9). Existing vegetation growing within 2 feet (0.6 m) of the channel would be permanently inundated, and alder trees and shrubs in this zone would probably die. Riparian vegetation can generally withstand some inundation, particularly in the winter and spring, so vegetation between 3 and 5 feet from the channel would be maintained and possibly enhanced. If all riparian vegetation within 2 feet (0.6 m) of the current wetted channel below the upper diversion were permanently lost, the acreage of this community type along lower Speelyai Creek would decrease by 2 acres (0.8 ha).

5.9.5.3 Project Effects on Riparian Habitat

Riparian habitats perform a number of important functions, including the following (Knutson and Naef 1997; Diaz and Mellen 1996):

- Streambank stabilization
- Flow moderation and flood control
- Stream temperature moderation
- Sediment control
- Stream pollution control
- Wildlife habitat

In addition, riparian habitats contribute to the aquatic food web and stream structural diversity (LWD, side channels). The effects of the Lewis River Projects on riparian habitat extent, composition, and function are summarized below for the Swift bypass reach, the river below Merwin Dam, and Speelyai Creek. The roles of riparian habitat in flow moderation and flood control, sediment control, and stream pollution control are not included in the discussion because these are important on a watershed scale than a reach scale. In addition, the project exerts a major influence on flow, flood, and sediment control in the Lewis river basin.

Swift Bypass Reach

Swift Dam has had 2 primary effects on flows in the Swift bypass reach that have in turn influenced riparian habitat. First, under normal operating conditions, the dam deprives the reach of water. Prior to dam construction, base flows in this reach were generally between 500 and 1,000 cfs. Flows during spring run off were generally greater than 2,000 cfs, with 50 percent exceedence flows in the range of 4,500 cfs (see WTS 4). Currently, the only water in the Swift bypass reach comes from accretion and tributary inflow. In most years, flows upstream of Ole Creek range between about 3 and 8 cfs.

The second effect of the Swift Dam is spill, which results in high flows through the bypass reach. Spills over 30,000 cfs have occurred 3 times since 1959 during extreme high flow events. The most recent instance was a spill of 45,000 cfs during a rain-on-snow event in February 1996 (see WTS 4). In general, spills over 5,000 cfs (141.6 m^3/sec) occur every few years; flows of this magnitude occurred almost annually prior to the dam.

Effects on Riparian Habitat Extent and Type

As a result of the greatly reduced flows, riparian vegetation has encroached into the channel bed formerly occupied by the river, and this area is currently lined with riparian deciduous forest and shrub stands (see Figure 5.9-1). Old side channels are also filled with riparian vegetation. This observation is consistent with data from some large rivers in other regions of the United States where dams have resulted in downstream channel narrowing and subsequent colonization by trees (Friedman et al. 1998; Collier et al. 1996, Poff et al. 1997). In addition, low flows in the bypass reach have probably decreased the extent of the wetted channel and floodplain hyporheic zones and associated soil moisture. Thus, floodplain terraces and wetlands that previously supported species tolerant of higher soil moisture may now be much drier and provide habitat only for upland plants. The net gain or loss of riparian vegetation in the bypass reach, however, is impossible to determine without pre-project data.

Extreme floods, from either natural events or spill, can have a devastating effect on vegetation, at least in the short term. To estimate the effects of large spill events on vegetation in the Swift bypass reach, maps of this area before and after the 1996 high flow event were compared (Figure 5.9-9). The amounts of the various vegetation types in the bypass reach in 1995 compared to 2000 are shown in Table 5.9-8. The 1995 and 2000 mapping are not completely comparable because of differences in the cover type classification systems. For example, the only riparian type shown on the 1995 map is riparian mixed forest; there are 3 riparian type designations in 2000. It is likely that at least some of the area typed as upland deciduous forest in 1995 was actually riparian. It also appears that some of the area typed as palustrine scrub-shrub wetland in 1995 was designated as riparian shrub in 2000 (Figure 5.9-9).

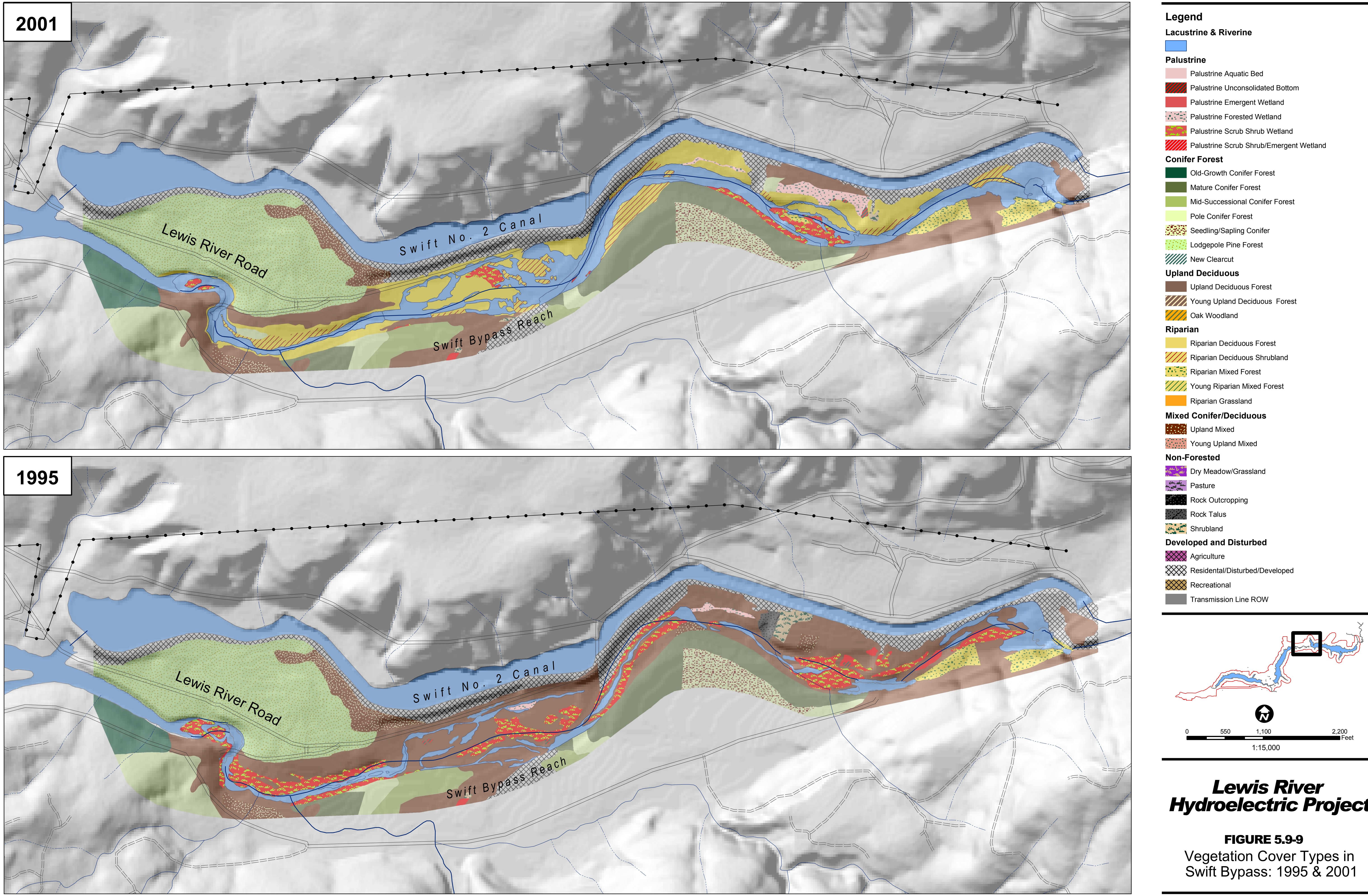
Overall, there was a net loss of about 31 acres (13 ha) of riparian and/or upland deciduous forest between 1995 and 2000, and the combined area of wetland and riparian shrub declined by over 9 acres. There was also a net gain of nearly 49 acres (20 ha) of riverine unconsolidated shore (Table 5.9-8). It is likely that scouring from flood waters was responsible for the loss of the deciduous forest and at least some of the wetland/

riparian scrub-shrub habitat. Some of the sites that previously supported deciduous forest may have recolonized by riparian shrubs. However, it appears that a number of areas that supported scrub-shrub and deciduous forest in 1995 are now represented by unconsolidated shore that does not yet support vegetation (Figure 5.9-9).

Table 5.9-8. Comparison of acreage in the Swift bypass reach pre- and post-1996 flood.

Cover Types	Acreage		Acreage Change
	1995	2000	
Conifer Forest			
Old-Growth Forest (OG)	12.95	12.95	0
Mature Conifer Forest (M)	38.90	41.49	+2.6
Mid-Successional Conifer Forest (MS)	12.58	12.58	0
Pole Conifer Forest (P)	28.38	30.37	+2.0
Seedling/Sapling (SS)	14.31	13.84	-0.5
Lodgepole Pine Forest (LP)	93.74	94.06	0.3
Conifer Subtotal	**200.86**	**205.29**	**+4.4**
Upland Deciduous & Mixed Forests			
Upland Deciduous Forest (UD)[1]	153.89	67.89	-86.0
Upland Mixed Forest (UM)	17.66	13.09	-4.6
Upland Deciduous & Mixed Forests Subtotal	**171.55**	**80.98**	**-90.6**
Other Undisturbed Uplands			
Shrub (SH)	3.10	0.88	-2.2
Sparsely Vegetated (SV)	1.13	1.63	+0.5
Rock Talus (RT)	2.08	0.00	-2.1
Other Undisturbed Uplands Subtotal	**6.31**	**2.51**	**-3.8**
Riparian Types			
Riparian Deciduous Forest (RD)[1]	0	54.52	+54.5
Riparian Mixed Forest (RM)	8.40	9.27	+0.9
Riparian Shrub (RS)[2]	0	20.74	+20.7
Riparian Subtotal	**8.40**	**84.53**	**+76.1**
Wetland Types			
Palustrine Emergent Wetland (PEM)	2.27	0.29	-2.0
Palustrine Forested Wetland (PFO)	1.80	5.89	+4.1
Palustrine Scrub-Shrub Wetland (PSS)[2]	39.44	9.43	-30.0
Palustrine Unconsolidated Bottom (PUB)	0.37	0.36	0
Wetland Subtotal	**43.88**	**15.97**	**-27.90**
Lake and Riverine			
Riverine Unconsolidated Bottom (RUB)	27.88	19.26	-8.6
Riverine Unconsolidated Shore (RUS)	9.17	57.94	+48.8
Lacustrine Unconsolidated Bottom (LUB)	0.16	0.34	+0.2
Lake and Riverine Subtotal	**37.21**	**77.54**	**+40.4**
Developed / Disturbed			
Disturbed (DI)	4.84	4.84	0
Developed (DV)	50.41	51.77	+1.4
Developed/Disturbed Subtotal	**55.25**	**56.61**	**+1.4**
Grand Total	**523.56**	**523.56**	

[1] Riparian and upland deciduous forest types should be combined for comparison purposes.
[2] At least some areas types as PSS in 1995 were probably RS.



Lewis River Hydroelectric Projects

FIGURE 5.9-9
Vegetation Cover Types in Swift Bypass: 1995 & 2001

Source: EDAW, Inc., 2001

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High flow events through the bypass reach are not caused by Swift Dam. In fact, dams moderate the effects of flood events downstream (Collier et al. 1996). Prior to construction of the dam, flows of 35,600 cfs through what is now the bypass reach occurred about once every 10 years, with flows of 43,000 cfs recurring every 20 years or so (see WTS-4). The difference now is that the active channel through the bypass reach is narrower and encroached by vegetation. Thus, when large spill events occur, they overtop the banks at lower flows and inundate and/or scour all the vegetation that has established within the bankfull channel since the last high flow.

Riparian habitats are created and maintained by changes in flow and associated disturbances (Poff et al. 1997; Hall 1988). In western Washington disturbed sites and newly developed stream bars are usually quickly colonized by red alder, a pioneer species that can survive periods of low-intensity inundation (Agee 1988). In general, sites that experience high flows every few decades or so do not support conifer species and are dominated by alder (Diaz and Mellen 1996). Thus, spills through the bypass reach have contributed to a riparian community along the active channel that is and will always be dominated by red alder. In fact, deciduous forests consisting mostly of alder currently represent 67 percent of the riparian vegetation in the reach, with mixed conifer-deciduous stands representing only 14 percent (see Table 5.9-1). The few stands of mixed riparian conifer-deciduous or upland conifer that occur near the active channel are found above steep banks in areas where the bypass reach is confined (see Figure 5.9-1) and have probably not been flooded since the dam was constructed.

Prior to construction of the Swift projects, alder probably also lined the active channel, but conifer and mixed stands likely dominated the slopes and benches above the river. Red alder is ubiquitous in western Washington and typically borders river and stream reaches in areas prone to annual high flows (Knutson and Naef 1997). However, the combination of high spill events and lower base flows has probably increased the proportion of alder in the near-channel area of the bypass reach and reduced the amount of conifers.

Another result of high flow events is that scoured areas, particularly those at higher elevations outside the active channel, are susceptible to colonization by weedy, invasive species. There are a number of sites in the bypass reach that currently support, monocultures of Scot's broom, an introduced species that can quickly establish on dry sunny sites. In addition, deciduous shrub cover in many of the alder-dominated forest stands consists primarily of Himalayan blackberry, another introduced species that invades moist, disturbed substrates. Shrub cover is relatively low and native hydrophytic shrub species are almost completely lacking.

Effects on Riparian Habitat Function

The main effect of the project on riparian habitat in the Swift bypass reach has been an increase in the amount of vegetation growing within the bankfull channel; periodic spill events keep this vegetation in an early forest successional stage dominated by red alder. The effects of these changes on various riparian habitat functions are described below.

<u>Aquatic Food Web</u> – A mixture of both conifer and deciduous litter provides optimal year-round instream food for fish and aquatic invertebrates (Knutson and Naef 1997).

Deciduous leaves have a large surface area and decompose quickly, providing food during the summer and fall. Conifer needles break down more slowly, providing a constant food base throughout the year (Knutson and Naef 1997). In small streams that are generally completely shaded by streamside vegetation, litter is the primary energy source. However, as stream size increases and becomes too wide to be completely shaded, the importance of terrestrial organic matter decreases, and algae and other aquatic plants provide more significant input to the system (Bilby 1988).

The Swift bypass reach is not currently completely shaded by vegetation, despite its narrower active channel and border of trees. It was probably less shaded under pre-project conditions when the channel was wider. Algae, however, are currently abundant on the instream rocks during the summer months in the bypass reach. Thus, while the project may have resulted in less conifer litter reaching the river in this reach, it is likely that the primary productivity during the summer months is dominated by instream plants (e.g., algae), which are still abundant.

Structural Diversity – Side channels and wetlands provide structural diversity in streams, but in western Washington, logs, root wads, and tree limbs contribute approximately 70 percent of the instream structural diversity (Knutson and Naef 1997). The most valuable type of woody debris, particularly for fish habitat, is provided by large logs, generally greater than 20 inches (51 cm) in diameter (Knutson and Naef 1997). Large logs, especially those with an attached root wad, are also key to forming debris jams. Depending on its location and composition, a debris jam can act as a barrier to high velocity flows, reduce erosion, resist channel migration, and affect floodplain formation (Abbe and Montgomery 1997). On average, the majority of LWD is recruited from forests within 150 feet (45 m) of the stream channel (Knutson and Naef 1997). The woody debris contributed by riparian stands less than 40 years old is generally smaller is diameter and not likely to accumulate and form stable habitat features needed by fish (Franklin et al. 1981 in Knutson and Naef 1997).

The amount of LWD in the Swift bypass reach is low. In total, 54 pieces of wood between 6 and 24 inches (15 and 24 cm) diameter were recorded in the entire bypass reach, or roughly 21.2 pieces per mile (12.7/km) (see Table 5.9-3). The majority of the wood was in the lower portion of the reach, downstream from Ole Creek. No pieces greater than 24 inches (61 cm) diameter were noted and only 2 log jams were recorded. Although direct comparisons to streams that have a similar channel size and adjacent vegetation structure are not possible, there are some data available for other larger western Washington drainages. For example, selected reaches of the Stillaguamish, Snohomish, and Nisqually rivers averaged 87, 193, and 225 pieces of wood per mile (52, 116, and 135 pieces/km) greater than 6 inches (15 cm) diameter. In southwestern Washington, streams similar in size to the Swift bypass reach (about 61 feet [19 m]) through old-growth stands retained LWD that averaged about 26 inches (65 cm) in diameter, and occurred at a frequency of about 321 pieces per mile (Bilby and Ward 1987 *in* Bilby 1988).

The project has had 3 major effects of the ability of riparian habitat in the Swift bypass reach to provide structural diversity.

- First, high spill events from Swift Dam have resulted in a riparian habitat structure that contributes very little to LWD. Most of the riparian habitat within 150 feet (45 m) of the active channel through the Swift bypass reach is dominated by small alder, generally less than 40 years old and in the range of 7 to 13 inches (18 to 33 cm) dbh. Black cottonwood, which intermixes with alder in some riparian areas in the bypass reach, grows faster than alder and can reach a diameter of 20 inches (51 cm) in about 30 years (Cowlitz Falls HEP Study). Red alder growing farther away from the active channel tends to be larger, in the range of 10 to 36 inches (23 to 91 cm) dbh (Harlow et al. 1979). The larger cottonwoods in the bypass reach also generally occur at some distance from the active channel (see Figure 5.9-1). Riparian deciduous stands in the bypass reach currently have an average of only 12 trees per acre >20 inches dbh (29 trees/ha >51 cm dbh). Conversely, the 1 riparian mixed stand sampled in the bypass reach had 49 trees per acre >20 inches dbh (121 trees per ha >51 cm dbh). The 2 types had a similar number of logs and small snags (see Table 5.9-2).

- Second, Swift Dam blocks the downstream passage of wood into the bypass reach. The lack of wood from upstream coupled with low local recruitment restricts the formation of log jams which contribute to floodplain development.

- And finally, the encroachment of vegetation into side channels has also decreased the ability of riparian habitat to contribute to structural diversity in the bypass reach.

<u>Nutrient Exchange</u> - As a result of the project, much of the Swift bypass reach is lined by red alder, which is a nitrogen-fixing species. Root nodules convert nitrogen in the air to soil nitrogen, most of which is released to the soil through decomposition of leaf litter (Arno and Hammerly 1977). Nitrogen in the litter layer of riparian alder stands can be 1.5 to 3 times higher than the amounts found in riparian sites dominated by conifer species (Cederholm et at. 2000). As a result, soils in riparian alder stands have high levels of nitrogen and increased nitrogen delivery to the adjacent stream channel. Higher stream nitrogen levels may elevate aquatic primary productivity and decomposition, increasing the available food for the invertebrate community, and thereby potentially increasing food availability for fish and wildlife (Cederholm et at. 2000). Thus, the project may be at least partially responsible for the higher levels of nitrogen exchange in riparian habitats and the associated productivity effects in invertebrate, fish, and wildlife communities.

<u>Stream Temperature Control</u> – Stream temperature is moderated by shade from adjacent vegetation, especially trees. However, the influence of shading from vegetation decreases with increasing stream size (Bilby 1988), and has relatively little effect on water temperatures in streams over 50 feet (15 m) wide (Knutson and Naef 1997). Data from the Aquatic Habitat Surveys (see WTS 3) indicate that the existing active channel through the bypass reach averages about 61 feet (19 m) and is greater than 50 feet (15 m) in most locations. The river through the bypass reach would be wider without the project.

Consequently, the project has had no effect on the role of riparian vegetation in the bypass reach in moderating water temperatures.

Streambank Stabilization – Riparian vegetation protects streambanks from surface erosion, bank erosion, slides, and debris flows (Diaz and Mellen 1996). Tree and shrub roots and stems hold soil, and down wood and litter intercept surface flow. In general, riparian vegetation in the bypass reach appears able to provide streambank stabilization under normal flow conditions and flows resulting from small spill events. Large spill events, however, periodically remove areas of riparian vegetation, creating disturbed sites that may be subject to erosion over the next several years. Although scoured/disturbed sites are typically colonized quickly by willow and alder, seedlings and small shrubs do not provide much erosion control. While fast growing, these species need to reach a certain size and/or density to provide adequate bank stabilization. By removing trees and shrubs, high spill events increase the amount of time that the active channel through the bypass reach is bordered by early successional vegetation, and thus periodically reduces the ability of riparian habitat to stabilize stream banks.

Wildlife Habitat – Riparian habitats are used by approximately 85 percent of Washington's terrestrial vertebrates for at least some life requisites (Knutson and Naef 1997). Riparian areas are generally structurally and ecologically complex, which results in their use by a diversity of wildlife species. In addition to providing abundant food sources and water, riparian areas are also used as travel corridors (Knutson and Naef 1997).

The riparian and wetland habitats in the Swift bypass reach supported a greater number of wildlife species than any other area surveyed during the Yale relicensing surveys (PacifiCorp 1999). The mix of wetlands, forest types, and shrublands clearly provides habitat for a diversity of species. High flow events here, however, probably affected the quality of some areas of wildlife habitat provided by the bypass reach. Possibly the result of scouring, many upland and riparian deciduous forest stands in the reach lack a well-developed shrub layer. In other stands, the shrub layer is dominated by Himalayan black-berry, an invasive non-native species that colonizes disturbed, moist areas. Several sites in open and drier areas that were scoured by the high flows in 1996 are dominated by Scot's broom instead of native shrubs. As a result, birds and other species that rely on native shrubs for food, cover, and breeding habitat may not be as prevalent in the bypass reach area as they would be otherwise.

Speelyai Creek

All flow from Speelyai Creek is currently diverted into Yale Lake. Effects on riparian habitat extent, type, and function are summarized in the 2 following sections.

Effects on Riparian Habitat Extent and Type

Like the Swift bypass reach, the primary results of reduced flows in the creek are channel narrowing and encroachment of riparian vegetation into the channel. However, unlike the bypass reach, Speelyai Creek below the diversion is almost completely protected from high flow events. High flows which appear to scour the upper portion of the creek almost annually are now diverted into Yale Lake. Overall, the project has reduced the level of disturbance downstream of the diversion, changing the nature of Speelyai Creek and the associated riparian habitat. Consistent base flows and the lack of scouring flows has resulted in stable riparian habitat conditions, which support wetlands and dense stands of deciduous trees. Stable flows and lack of disturbance probably preclude the establishment of cottonwood along lower Speelyai Creek, but this species was not observed along the upper portion either, possibly because scouring, bankfull flows occur too often to allow establishment. In addition, the lack of flooding has allowed development to occur in places along the creek, resulting in the loss or degradation of some habitat.

Effects on Riparian Habitat Function

The main effect of the project on riparian habitat along lower Speelyai Creek has been an increase in the amount of vegetation growing within the bankfull channel and the protection of this area from most high flow events. The effects of these changes on various riparian habitat functions are described below.

Aquatic Food Web – The wetted channel of Speelyai Creek upstream of the diversion averages about 22 feet (8 m) wide and is only 48 percent of the bankfull width of 46 feet (14 m). Adjacent trees and shrubs do not overhang the wetted channel in most locations, and leaf litter falls between the bankfull and normal summer low flow channel. Thus, although riparian habitat upstream of the diversion includes a mix of conifer and deciduous species, its contribution to aquatic food webs is dependent on stream stage and probably limited during the summer months when flows are low.

Conversely, the wetted channel along lower Speelyai Creek averages about 15 feet (4.6 m) wide between the diversion and the SR 503 bridge, and averages almost 39 feet (12 m) in width below the bridge. The wetted channel widths in these reaches represent 55 and 75 percent of bankfull widths, respectively. Because much of the bankfull channel supports vegetation, the wetted channel throughout much of this reach is almost completely shaded by an overhead canopy of red alder, although shrubs and conifers provide canopy cover in some locations. The project has probably resulted in an overall increase in the amount of leaf litter input to the stream below the diversion; however, much of this increase is deciduous leaf litter, which decomposes quickly and makes the biggest contribution to aquatic food webs during the summer and fall months. A mixture of both conifer and deciduous litter provides optimal year-round instream food for fish and aquatic invertebrates (Knutson and Naef 1997).

Structural Diversity – In general, the effects of the diversion on the instream structural diversity of Speelyai Creek include the following: (1) an increase in the overall amount of LWD in the stream, particularly the wetted channel; (2) a decrease proportion of pieces over 24 inches (61 cm) in diameter; (3) an increase in contribution of alder growing within the bankfull channel to instream wood; and (4) an increase in the number of side channels and beaver dams.

Speelyai Creek is a smaller stream than the Swift bypass reach and the amount of structural diversity provided by LWD would be expected to be greater, as would the contribution of riparian habitat to LWD. Surveys along the creek above the diversion recorded approximately 76.6 pieces of LWD/mile (47.9/km), with 30 percent of the pieces greater than 24 inches (61 cm) in diameter. However, only 16 percent of the pieces were within the wetted channel (see Table 5.9-5). Additional structural diversity was provided by about 12 root wads and 3 log jams per mile (7.5 and 1.9 per km) and several side channels. Forests within 150 feet (46 m) of the upper portion of the creek include deciduous, mixed conifer-deciduous, and mid-successional conifer stands.

LWD downstream of the diversion averaged 107.9 pieces/mile (67.4/km), with 14 percent greater than 24 inches in diameter and 77 percent within the wetted channel. Numerous side channels, as well as approximately 4 root wads, 2 log jams, and 11.4 beaver dams per mile (2.5, 1.2, and 7.1 per km), provide additional instream structural diversity (see Table 5.9-5). Although most of the Speelyai Creek downstream of the diversion is bordered by alder, riparian deciduous forest on either side of the wetted channel averages only about 7 to 9 feet (2.1 to 2.7 m) wide upstream of the Highway 503 bridge and 40 to 47 feet (12 to 14 m) wide downstream (see Table 5.9-4). Consequently, at least some LWD is recruited from adjacent upland forest types within 150 feet (46 m) of the stream, which including deciduous, mixed conifer-deciduous, and pole conifer stands.

Streambank Stabilization – The steep, unvegetated slopes and cutbanks along portions of upper Speelyai Creek suggest that the stream is actively migrating within the bankfull channel. Riparian vegetation is very limited and generally not functioning to stabilize streambanks in many areas. Stable flows below the diversion have resulted in increased riparian vegetation, particularly in the bankfull channel, and most steep banks support shrubs and forbs. It appears the project has enabled riparian vegetation along the lower portion of the creek to provide streambank stabilization.

Stream Temperature Control – Speelyai Creek above the upper diversion has a bankfull width of 46 feet and a wetted channel width of 22 feet during the summer/fall (Table 5.9-4). Riparian trees and shrubs are generally lacking, and vegetation clearly has very little influence on moderating streamflow temperatures in this reach. Below the diversion, the wetted channel averages 15 to 39 feet wide and represents a greater proportion of the bankfull channel. Much of lower Speelyai Creek is completely shaded by red alder and shrubs; the few open areas are generally associated with large beaver ponds. Consequently, riparian vegetation in and along the lower portion of the creek, which has increased as a result of the diversion, probably plays a substantial role in moderating water temperatures.

Wildlife Habitat – Riparian habitat along upper Speelyai Creek consists mostly of upland forest communities. Conversely, riparian habitats along the lower portion of the creek include wetlands and riparian forest communities, as well as uplands. Although wildlife surveys were not conducted along Speelyai Creek, the greater diversity of habitats below the diversion would be expected to result in a higher species richness in this area compared to the upper portion of the creek. Consequently, the project may result in a greater diversity of wildlife habitats along the creek. However, the more stable flows have also made it possible for residences to be built along the creek, which may affect wildlife habitat quality in places.

Lower Lewis River

The Lewis River Projects have had 4 major effects on flows in the Lewis River downstream of Merwin Dam. Compared to pre-project conditions, the dams have moderated flood magnitude, slightly increased mean fall/winter flows (October-February), slightly decreased spring flows (April-June), and augmented late summer flows (see WTS 2 and AQU 3).

Effects on Riparian Habitat Extent and Type

To identify how riparian habitat below Merwin Dam has changed since project construction, the area between the dam and Eagle Island was mapped on aerial photographs taken in 1939 and 1963, and compared to the cover type mapping of this area from 2001. The mapped area extends to approximately the 240-foot (73-m) contour and encompasses most of the readily identifiable floodplain. Maps for 1939 and 1963 are shown in Figure 5.9-10; see Figure 5.9-3 for 2001 mapping.

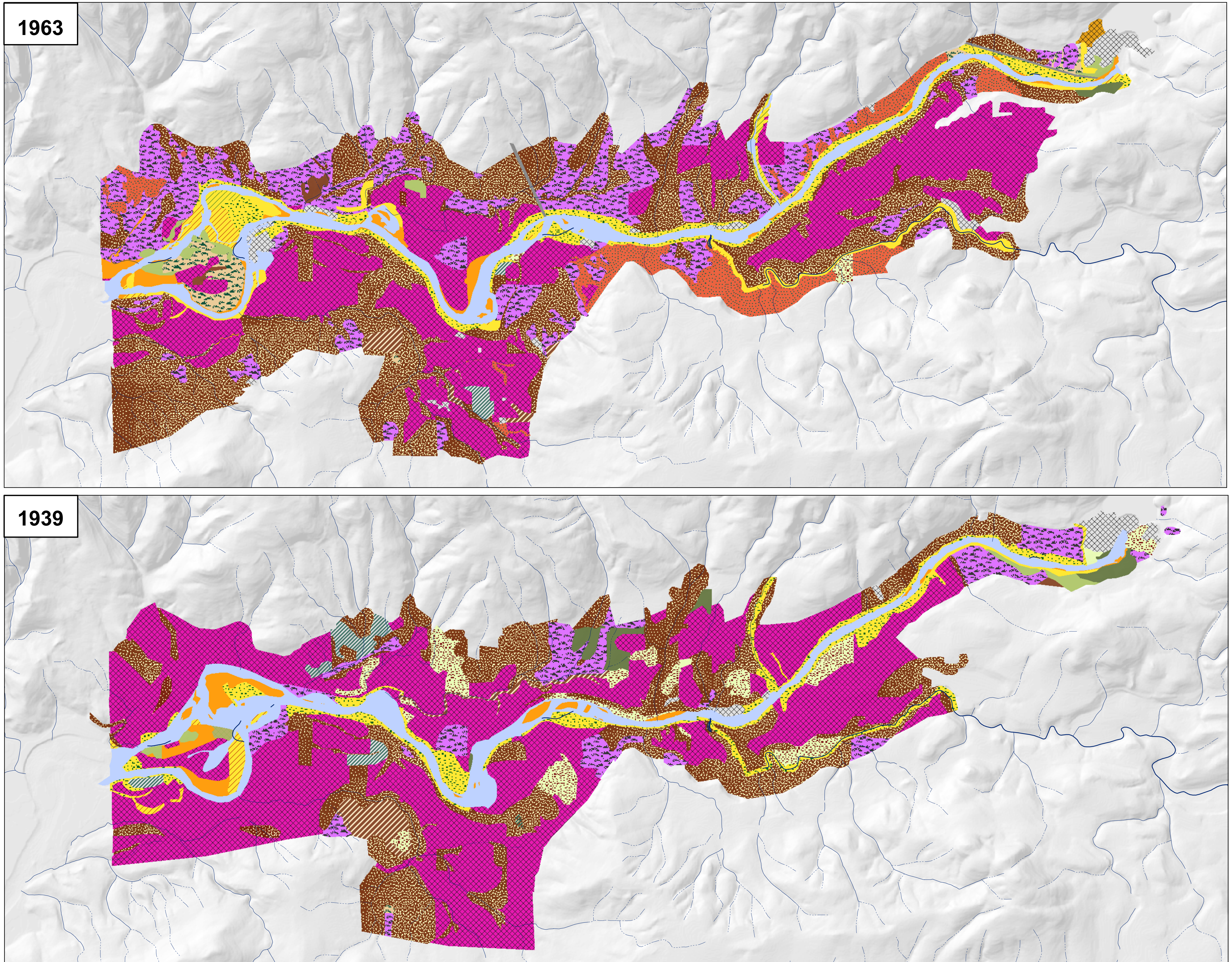
Direct comparison of some cover types between years is limited by the relatively poor resolution and small scale of the older photography. Wetlands were virtually impossible to identify on the 1939 and 1963 photographs. Other cover types that were particularly difficult to distinguish included the following: (1) riparian and upland mixed forest types; (2) deciduous forest and forest stands with a young conifer or deciduous component; and (3) riparian grass and riparian shrub. In addition, the lack of comparable landmarks between 1939, 1963, and 2001 also resulted in less accurate polygon boundaries on the orthophotos. Nonetheless, the comparisons between years identified some trends. Cover type areas are summarized in Table 5.9-9.

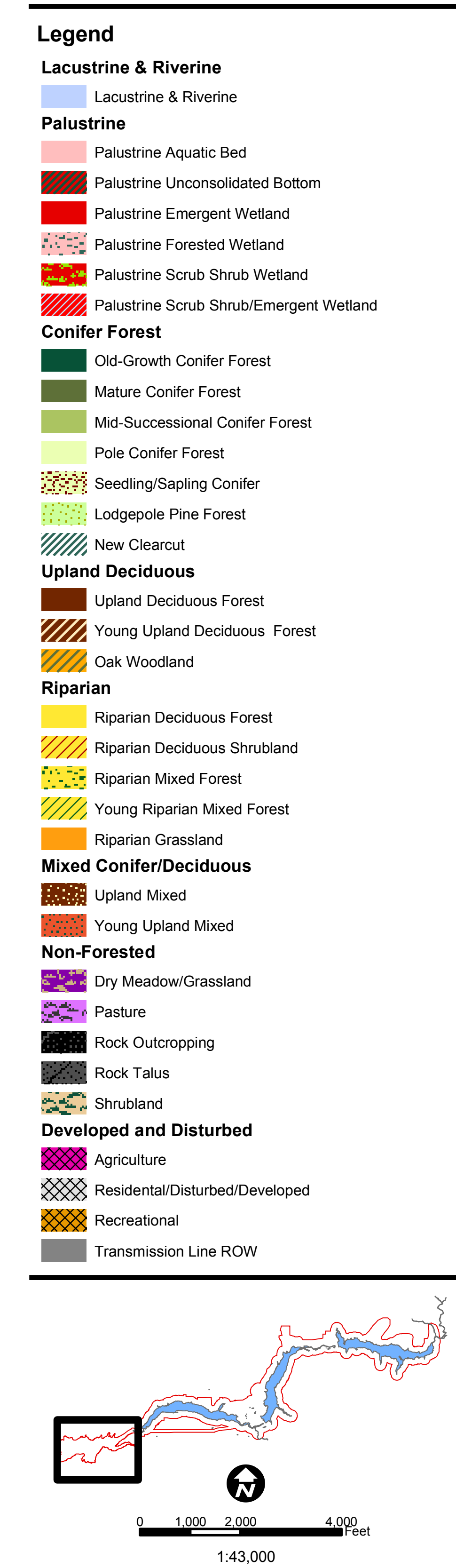
Table 5.9-9. Comparison of cover types between Merwin Dam and Eagle Island.

Cover Type	Acre (ac)		
	1939	**1963**	**2001**
Conifer Forest			
Mature Conifer Forest (M)	46.5	0	32.0
Mid-Successional Conifer Forest (MS)	25.0	46.5	13.1
Pole Conifer Forest (P)	2.9	0	137.0
Seedling Sapling (SS)	254.1	14.7	60.8
Seedling/Sapling - new (SS1)	75.2	25.1	0
Conifer Subtotal	**403.6**	**86.3**	**242.9**
Upland Deciduous & Mixed Forests			
Upland Deciduous (UD)	0	22.6	133.6
Young Upland Deciduous (YUD)	88.5	35.7	22.4
Upland Mixed Forest (UM)	374.2	1,646.0	1,833.1
Upland Mixed Forest - thinned (UM-t)	869.3	23.4	0
Young Upland Mixed Forest (YUM)	0	326.3	105.2
Deciduous & Mixed Forest Subtotal	**1,332.1**	**2,054.1**	**2,094.3**

Table 5.9-9. Comparison of cover types between Merwin Dam and Eagle Island (cont.).

Cover Type	Acre (ac)		
	1939	**1963**	**2001**
Other Undisturbed Uplands			
Upland Shrub (SH)	0	3.2	4.8
Other Upland Shrub Subtotal	0.0	3.2	4.8
Riparian Types			
Riparian Mixed Forest (RM)	52.1	253.5	287.0
Riparian Mixed Forest - thinned (RM-t)	262.4	23.2	0
Young Riparian Mixed Forest (YRM)	0	33.6	0
Riparian Deciduous Forest (RD)	10.7	91.4	290.1
Riparian Shrub (RS)	43.2	57.2	196.3
Riparian Grass (RG)	112.5	190.7	13.3
Riparian Subtotal	**480.9**	**649.6**	**786.8**
Wetlands Types			
Palustrine Emergent Wetland (PEM)	0	0.9	4.5
Palustrine Forested Wetland (PFO)	0	0	10.9
Palustrine Shrub-Scrub (PSS)	0	0	8.9
Palustrine Unconsolidated Bottom (PUB)	0	0	1.0
Wetland Subtotal	**0.0**	**0.9**	**25.3**
Riverine			
Riverine Unconsolidated Bottom (RUB)	340.8	385.7	313.7
Riverine Unconsolidated Shore (RUS)	186.5	62.9	7.2
Riverine Subtotal	**527.3**	**448.6**	**320.8**
Developed/Disturbed			
Agricultural (AG)	2,530.7	1,364.2	1,198.7
Pasture (PA)	268.7	896.3	527.2
Disturbed (DI)	0	2.8	1.9
Developed (DV)	9.2	28.9	11.9
Recreation (REC)	0	0	130.7
Residential (RES)	13.3	20.6	210.8
Right-of-Way (ROW)	0	10.3	9.8
Developed/Disturbed Subtotal	**2,821.9**	**2,323.1**	**2,091.0**
Grand Total	**5,565.8**	**5,565.8**	**5,565.8**





Lewis River Hydroelectric Projects

FIGURE 5.9-10
Vegetation Cover Types along the Lower Lewis River: 1939 & 1963

Source: EDAW, Inc., 2002

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In general, the amount of riparian vegetation in the lower river channel has increased since 1939, and the amount of riverine habitat has decreased by approximately 206 acres (Table 5.9-9). This finding is consistent with data from other large rivers where dams have resulted in downstream channel narrowing and subsequent colonization by trees (Friedman et al. 1998; Collier et al. 1996; Poff et al. 1997). While it is difficult to track specific acreage changes between types by year, there are several apparent trends:

- Riparian vegetation increased by about 306 acres between 1939 and 2001, with the greatest change seen in the riparian deciduous forest types, which gained 279 acres (113 ha) in this period. While some of this acreage increase may have resulted from the succession of riparian grassland and shrub types to forest, it is apparent from the photographs that a large amount of this area had been logged and was being farmed in 1939.

- Between 1939 and 2001, riverine unconsolidated shore decreased from 186 to 7 acres (75 to 2.8 ha), a loss of 179 acres (72 ha). A large amount of this area now supports riparian shrubs, which increased by 153 acres (62 ha) in this period.

- In 1939, the main channel of the river was on the north side of Eagle Island; in 2001 the main channel is on the south sided. In 1939, much of the south side of the island was occupied by a large, unvegetated gravel bar. By 1963 there was a gravel mining operation on the island. Currently, most of this area is covered by riparian mixed conifer-deciduous forest stands. The old channel between the north and south half of the island had filled in by 1974 (see WTS 3) and by 2001 was barely discernable through a dense stand of riparian forest.

- Conifer forests declined substantially (79 percent) along the Lewis River between 1939 and 1963, primarily due to logging and conversion to agriculture. Between 1963 and 2001, the area of conifer increased, as some stands replanted with conifers grew to pole size. Other regenerating areas supported mixed or deciduous stands in 2001.

- Like many other rural areas in western Washington, the amount of land in agriculture decreased along the Lewis River. In 1939, 45 percent of the land within the 240-foot (73 m) contour along the both sides of the river was farmed, with another 5 percent in pasture. By 2001, only 22 percent of the land in this area was classified as agriculture; 9 percent is now pasture. Much of the agricultural land has reconverted to forest and now supports deciduous and mixed conifer-deciduous stands.

- As expected, development between the dam and Eagle Island increased between 1939 and 1963, although not substantially. Developed and residential lands in 1939 represented less than 1 percent of the land along the lower river, and there was very little change in over the next 24 years. By 2001, however, the combined acreage of developed, recreational, and residential had increased to 6 percent of the land in the reach, with 2 percent represented by the Lewis River Golf Course. Most of this development is concentrated in the 2 miles (3.2 km) or so upstream of Eagle Island.

Effects on Riparian Habitat Function

The Lewis River downstream of Merwin Dam is a large river. As stream size increases, the aquatic system influences a progressively larger amount of adjacent riparian habitat (Bilby 1988; Knutson and Naef 1997), particularly in areas of low relief. In the confined reach below the dam, bankfull widths average 300 to 350 feet (91 to 107 m), and the wetted channel has an average range of 224 to 270 feet (62 to 82 m) (see WTS 3). The channel narrows slightly in the unconfined reach farther downstream of the dam, with bankfull widths averaging 253 to 296 feet (77 to 90 m) and wetted widths in the range of 210 to 230 feet (64 to 70 m).

Aquatic Food Web – Although riparian forests border much of the Lewis River between Merwin Dam and Eagle Island, very little vegetation overhangs the channel. In a river of this size, algae and aquatic plants probably provide more energy than does leaf litter (Bilby 1988). Since the size of the Lewis River limits the role of riparian habitat in contributing to the aquatic food web, the project has not affected this function.

Structural Diversity – In general, greater amounts of woody debris accumulate in small streams than in larger ones, and the influence of this material on structural diversity and function is likewise less (Bilby 1988). Nonetheless, LWD in larger rivers may help create and maintain floodplain habitat. An investigation of the Willamette River suggested that logs from the dense riparian forests that bordered the river drifted together, cut off channels, encouraged sediment deposition and willow thickets, and helped maintain a wide floodplain with multiple channels, sloughs, and backwater areas (Sedell and Froggatt 1984 *in* Agee 1988). Removal of LWD from the river, as well as logging and channelization, resulted in loss of floodplain habitat (Sedell and Froggart 1984 *in* Agee 1988).

A recent study on the Queets River, a large river on the Olympic Peninsula, demonstrated how LWD influences floodplain and riparian forest development (Abbe and Montgomery 1996). Individual pieces of LWD , or random accumulations of logs, have relatively little effect on riparian habitat development. However, a log jam formed on the apex of a bar (bar apex jam) reduces channel width, thereby providing a barrier to high velocity flows, creating sites of sediment aggradation that can lead to floodplain formation (Abbe and Montgomery 1996). These structures also resist channel migration over time and therefore protect the riparian habitat that develops. A jam buried in the sediments may continue to function as a hydraulic structure even if re-exposed, explaining the presence of old-growth riparian forest stands in areas otherwise characterized by frequent channel meandering and disturbance (Abbe and Montgomery 1996). The development of bar apex jam requires deposition of a "key member", typically a large log with an attached root wad facing upstream, on the apex of a bar. LWD which would otherwise be flushed downstream is then deposited against the key member forming the jam. The rate at which the jam and its associated bar grows depends on the size and rate of LWD recruitment to the channel upstream of the jam and sediment transport through the reach (Abbe and Montgomery 1996).

The Lewis River below Merwin Dam has very little LWD. No log jams and only 15.4 pieces per mile (9.2/km) of LWD were recorded during surveys of this reach, most in the range of 12 to 24 inches (30 to 60 cm) in diameter. In comparison, substantially more LWD was recorded in 3 large rivers that empty into Puget Sound, Washington. Selected reaches in the Snohomish, Stilliquamish, and Nisqually rivers averaged 193, 87, and 2,333 pieces of wood per mile (116, 52, and 1,400 per km), respectively, greater than 6 inches (15 cm) diameter and 6 feet (2 m) long (Collins et al. 2002). Like the Lewis River, neither the Snohomish or Stilliquamish rivers had significant amounts of wood in jams. In contrast, however, 90 percent of the LWD pieces Nisqually River were in jams(Collins et al. 2002). The near absence of log jams in the Snohomish and Stilliquamish rivers has been attributed to 3 factors:

- The removal of large wood in the late 1800s and early 1900s by the Corps of Engineers and early settlers to reduce flooding and improve navigation;
- The lack of mature riparian forests for more than a century, which has resulted in riparian stands that are dominated by smaller, more transportable, and less decay-resistant hardwoods; and
- Lower LWD recruitment rates because leveed rivers cannot laterally erode their floodplains (Collins et al. 2002).

In contrast, the 6.6-mile (11 km) reach of the Nisqually River included in the study consisted of mature riparian forest that was not leveed. These forest stands contributed long, large-diameter logs with attached root balls that became key members of jams (Collins et al. 2002). Since the Nisqually River has 2 upstream dams and the Snohomish and Stilliquamish rivers have none, the study suggests that local wood recruitment is very important to the formation of jams and the accumulation of LWD (Collins et al. 2002).

The ability of riparian habitat along the lower Lewis River to contribute to structural diversity in terms of providing LWD is clearly affected by a number of factors, some directly related to the projects, and others that are indirect. Because Merwin Dam blocks the transport of LWD from upstream sources, the riparian forest stands along the lower river are currently the only source of LWD to this reach. There are actually more riparian forest stands along the lower river now than in 1939, some with fairly large trees within 150 feet (45 m) of the channel (see Tables 5.9-1 and 5.5-9), but the contribution of existing stands to LWD is unknown. Nonetheless, levees, as well as residential, agricultural, and recreational development along the lower river have, and will continue to affect the ability of riparian habitat to provide wood, particularly in the unconfined reaches downstream of the Lewis River Hatchery. These activities affect riparian stand age, as well as the amount, size, and longevity of any instream wood. While the existing wood in the river may provide some fish habitat, it does not contribute to the development of floodplain habitat or aquatic structural diversity.

Overall, the project has probably had a larger role in blocking the transport of LWD into the lower river than it has had in influencing the ability of riparian habitat along this reach to supply wood. However, the lack of exposed bars resulting from decreased sediment supply to the unconfined reaches, coupled with a moderated flood magnitude, may decease the ability of this area to support cottonwood stands over the long term. This species requires bare mineral substrate and moist conditions to germinate (Scott et al. 1997). The loss of cottonwood would deprive this reach of 1 of the few remaining sources of LWD.

Streambank Stabilization – There are some very steep slopes along the lower Lewis River, particularly in the confined reach below the dam. These areas support riparian mixed forests, and the banks and slopes appear stable. There are, however, a few locations farther downstream with steep exposed cutbanks. The narrow band of vegetation at the base of these slopes does not stabilize these banks. In most locations, however, it appears that riparian vegetation along the reach is able to provide streambank stabilization and the project has not negatively affected this function.

Stream Temperature Control – The Lewis River below Merwin Dam is very wide and, consequently, riparian vegetation does not moderate water temperatures to any large degree. River size—not the project—has the greatest effect on the role of riparian habitat in water temperature moderation.

Wildlife Habitat – There are currently over 780 acres (316 ha) of riparian vegetation along the Lewis River from Merwin Dam to Eagle Island. Many of the riparian forest stands support well-developed shrub understories and some fairly large trees, and provide habitat for a number of wildlife species. In general, the riparian forests and shrub stands provide some of the best remaining natural wildlife habitat in an area where nearly 40 percent of the land is developed/disturbed by farming, residences, or recreation. Eagle Island in particular represents important wildlife habitat because it is protected—both legally and physically. The surrounding water and the dense vegetation on this island discourages access, and there is very little evidence that anyone ventures further than the immediate shoreline area.

The flood control provided by the project, in combination with local zoning practices, has allowed much of the land below the Lewis River hatchery to be developed for farming, residences, or recreation. These developments have reduced the amount and quality of wildlife habitat. Without changes in zoning, the quantity and quality of riparian habitat along the lower river will continue to decrease.

5.9.5.4 Conclusions

Substantial amounts of riparian vegetation and habitat are associated with the lower Lewis River, Speelyai Creek, and the Swift bypass reach. General conclusions of the Riparian Habitat Synthesis Study are summarized below:

- The Lewis River Projects have resulted in the encroachment of riparian vegetation into the channels of the lower Lewis River, Speelyai Creek, and the Swift bypass reach. There has also been some channel narrowing, particularly downstream of Merwin Dam.

- Overall, the effects of the projects on riparian habitat function depend on location, topography, channel morphology, and hydrology. The projects have probably had the greatest effect on the ability of riparian habitat to provide LWD, particularly in the Swift bypass reach. Swift Dam blocks the downstream passage of wood into the bypass reach. In addition, periodic high spill events, as well as logging, have resulted in adjacent riparian habitat that contributes little LWD. The lack of wood from upstream coupled with low local recruitment, restricts the formation of log jams which would contribute to floodplain development in this reach. The projects also block the passage of wood and sediment into the Lewis River below Merwin Dam. In this area, local recruitment of LWD has been reduced by logging and by residential, agricultural, and recreational development. The development of new floodplain/riparian habitat from log jams along the lower Lewis River over the next license period is unlikely.

- The increased flows considered for the Swift bypass reach would have little effect on riparian habitat, as would operating the upper Speelyai diversion according to the existing water right. Removing the diversion, however, would substantially change riparian habitat composition and function along the lower portion of the creek.

- Although not pristine, riparian areas along Speelyai Creek, the Swift bypass reach, and lower Lewis River provide habitat for a wide variety of wildlife. Protection of these habitats will become increasingly important over the next license period as development continues to increase in the basin.

5.9.6 Schedule

The Riparian Habitat Information Synthesis is complete.

5.9.7 References

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5.9.8 Comments and Responses on Draft Report

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

Commenter	Volume	Page/ Paragraph	Statement	Comment	Response	Response to Responses
WDFW – CURT LEIGH	2	TER 09 Sec. 5-9	Riparian Habitat Synthesis Table 5.9-1.	What are the thirty acres of developed/agriculture land in Swift Bypass reach? Also emergent/shrub scrub wetland and footnote.	There is a large parcel of disturbed land on the south side of the Swift bypass reach. See Figure 5.9-1 for the location of this parcel, as well as emergent/shrub scrub wetlands.	
J. Sampson, Technical Advisor to the Conservation Groups	2	TER 09-41 para 2	"The most valuable type of woody debris is provided by logs greater than 51 cm in diameter."	This statement is so general as to be inaccurate. All sizes of wood contribute to the amount of organic matter in the stream, which is an important consideration in the Pacific Northwest where most streams, including the lower Lewis, can be classified as oligotrophic (Welch et al. 1998; WAQ 1). In addition to its role in providing allochthonous matter, small wood interacts with larger wood to form debris jams which play a major role in development of flood plains and in channel morphology (Abbe and Montgomery 1996), even in large channels. The statement should be made more specific so that its meaning is accurate, and substantiated with relevant citations.	The text has been revised to state the importance of large logs for fish habitat and for the creation of debris jams. Nonetheless, this statement does not negate the role of smaller wood in the system. Without large logs, or key members, smaller wood has nothing to rack against (Abbe and Montgomery 1996). Small wood is also generally more available in western WA rivers (Collins et al 2001), including the Lewis River. Key members, however, typically represent the largest trees in the channel margin forest (Abbe and Montgomery 1996).	

Commenter	Volume	Page/ Paragraph	Statement	Comment	Response	Response to Responses
WDFW – CURT LEIGH	2	TER 09-42	Steam temps.	Stream temperatures are influenced by more than just vegetation quantity and stream velocity. Also influenced by rock exposed to solar radiation.	This section focuses on the effects of the project on riparian habitat. Although lower flows in the bypass reach may expose more rock and influence water temperatures, this process does not affect the ability of riparian vegetation to provide shade and moderate temperatures.	
J. Sampson, Technical Advisor to the Conservation Groups	2	TER 09-42 para 2	"Large spill events [in the Swift bypass] however, may temporarily reduce the ability of riparian habitat in this reach to stabilize stream banks."	This statement is incomplete as a descriptor of the role of large spill events on the functionality of riparian areas closest to the active channel in the Swift bypass reach. There is a good discussion beginning on page TER 9-36 describing impacts of spill events, but this characterization of their effects is not complete. It should be modified as follows (underlined text should be added): "Large spill events <u>in the Swift bypass</u> <u>periodically destroy large areas of colonizing riparian plants. As a result, large areas of the riparian community currently in the reach are repeatedly "re-set" in successional terms. Woody plant species are therefore not allowed to reach a size sufficient to stabilize banks in the reach against impacts of very high flows. Thus</u>, spill flows reduce the ability of riparian habitat in this reach to stabilize stream banks."	Comment noted. Text has been expanded to provide a more complete description. However, tree and shrub size, per se, does not guarantee stream bank stabilization. The rooting structure of individual species is probably more important. Willow shrub communities, for example, can be very effective at bank stabilization, even within a few years of establishment. Similarly, very high flows can and do remove large trees. Thus it is not accurate to say that woody plants are not allowed to reach a size sufficient of size to provide bank stabilization. It is primarily a rate or frequency issue.	

Commenter	Volume	Page/ Paragraph	Statement	Comment	Response	Response to Responses
J. Sampson, Technical Advisor to the Conservation Groups	2	TER 09-45 para 1	"Summer flows have remained unchanged."	This statement is in conflict with statements in WTS 2 (p. WTS2-33) which say that the projects "augment summer flows," and with a statement on p AQU 3-16 at the end of the second full paragraph: "This increase in summer flows… provides enhanced benefits…" The document should be revised for consistency and accuracy.	The text will be revised.	
J. Sampson, Technical Advisor to the Conservation Groups	2	TER 09-45 para 4	"Riparian habitats…. Are ….created and retained by flow regimes that build and maintain substrate for various types of plant communities."	The meaning of this sentence is not clear. How do flow regimes build substrate? The sentence should be rewritten or deleted.	The text will be revised.	
J. Sampson, Technical Advisor to the Conservation Groups	2	TER 09-46 para 6	"In river systems as large as the Lewis River, the adjacent riparian habitat has relatively little influence."	There are several problems with this statement. Because it does not specify "on what" the riparian zone has little influence, it is not informative, and too general to be accurate. In fact, riparian zones in large rivers can have huge influences on rivers, particularly during annual high flow events, by providing fish and invertebrate spawning and rearing habitat, providing large wood and substantial exchanges of dissolved nutrients and other	The text will be revised.	

Commenter	Volume	Page/ Paragraph	Statement	Comment	Response	Response to Responses
				materials, and stabilizing soils against forces of erosion. More importantly, its not relevant to the rest of the passage, because the discussion is about the "Effects [of the projects] on Riparian Function" (not the other way around). The functional sentence in this passage is the sentence which follows this one. The statement should be deleted because it is inaccurate and irrelevant, and the last statement in this paragraph should be moved to be the second sentence in the passage to clarify the statistics presented in the rest of the passage.		
WDFW – CURT LEIGH	2	TER 09-50	Aquatic Food Web.	There is no mention of downstream drift as energy (food) source impacted by dams.	This section focuses on the effects of the project on riparian habitat. While the dams do block the downstream drift of allochthonous material, this probably has a greater effect on aquatic habitat and fish than it does on riparian habitat.	
J. Sampson, Technical Advisor to the Conservation Groups	2	TER 09-50 para 2	"…the influence of [large woody debris] on structural diversity and function is likewise less	This statement and much of the 4 sentences that follow it, are inaccurate and do not reflect recent scientific information. These first two sentences are inconsistent with statements in the next paragraph, which describe how wood generates channel complexity.	The text will be revised.	

Commenter	Volume	Page/ Paragraph	Statement	Comment	Response	Response to Responses
			(Bilby 1988). In addition, very large pieces are required to be retained and to form stable accumulations in large rivers (Bilby 1988)."	To make this passage consistent with current scientific information, and to remove conflicts from within the passage, the sentences referenced here and the 4 sentences following them should be deleted, and the following updated information should be inserted: "Abbe and Montgomery (1996) have established that in large rivers of the Pacific Northwest, just one large piece of wood, with a root wad attached and lying nearly parallel to the flow, can provide a focal point for the accumulation of additional wood pieces, both large and small. Subsequent accumulation of wood results in the development of islands, bars and side channels, as well as the formation of pools and in-channel habitat features. Riparian forests develop below these accumulations as flows decelerate, sediments are deposited, and organic matter builds on the surface. It is this process to which development of old growth of up to 300 years old within active channel migration zones have been attributed. Abbe and Montgomery's (1996) work is supported by Sedell and Froggat (1984)."		

Commenter	Volume	Page/ Paragraph	Statement	Comment	Response	Response to Responses
				This insert will connect well to the existing discussion of Sedell and Froggat's (1984) work, eliminating conflicts currently within the passage.		
J. Sampson, Technical Advisor to the Conservation Groups	2	TER 09-50 para 2	"…very large pieces are required to be retained and to form stable accumulations in large rivers (Bilby 1988)."	Very large pieces of wood would be plentiful here if the projects were not blocking the transport of material from upstream areas. The volumes of wood that would be transported to the reach downstream of Merwin in the absence of the projects should be quantified to inform this discussion (please see the letter from the Conservation Groups to the Licensees dated March 6, 2002). In addition, the picture of the Swift forebay which shows tons of wood floating on the water surface (circulated at an ARG meeting in March of 2002) should be included in this report to illustrate the amount of wood that is transported out of the upper watershed each year.	The text will be revised.	
J. Sampson, Technical Advisor to the Conservation Groups	2	TER 09-51 para 4	Conclusion	This section needs to address the likely affect of the projects on the future development of riparian habitats within the reaches discussed. For example, given the evidence that the reach below Merwin is incising, and that there is no wood or sediment from above Merwin reaching that part of the river, what is the	This section will be expanded.	

Commenter	Volume	Page/ Paragraph	Statement	Comment	Response	Response to Responses
				likelihood of new riparian habitat formation, and the likelihood that riparian and aquatic habitat will become more diverse over the term of the next license? What processes will dominate channel and riparian habitat formation in this lower reach if current management (i.e., no habitat augmentation) continues? Please address these questions in the conclusion.		