Kalama, Washougal and Lewis River Habitat Assessments

Chapter 5: The Salmon Creek Basin

Prepared for:

Lower Columbia Fish Recovery Board
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Longview, Washington 98637

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In association with:

Mobrand Biometrics, Inc.

December 2004

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CONTENTS

TABLES

MAPS

5. CHAPTER 5 – SALMON CREEK BASIN

5.1 BASIN SPECIFIC METHODOLOGY

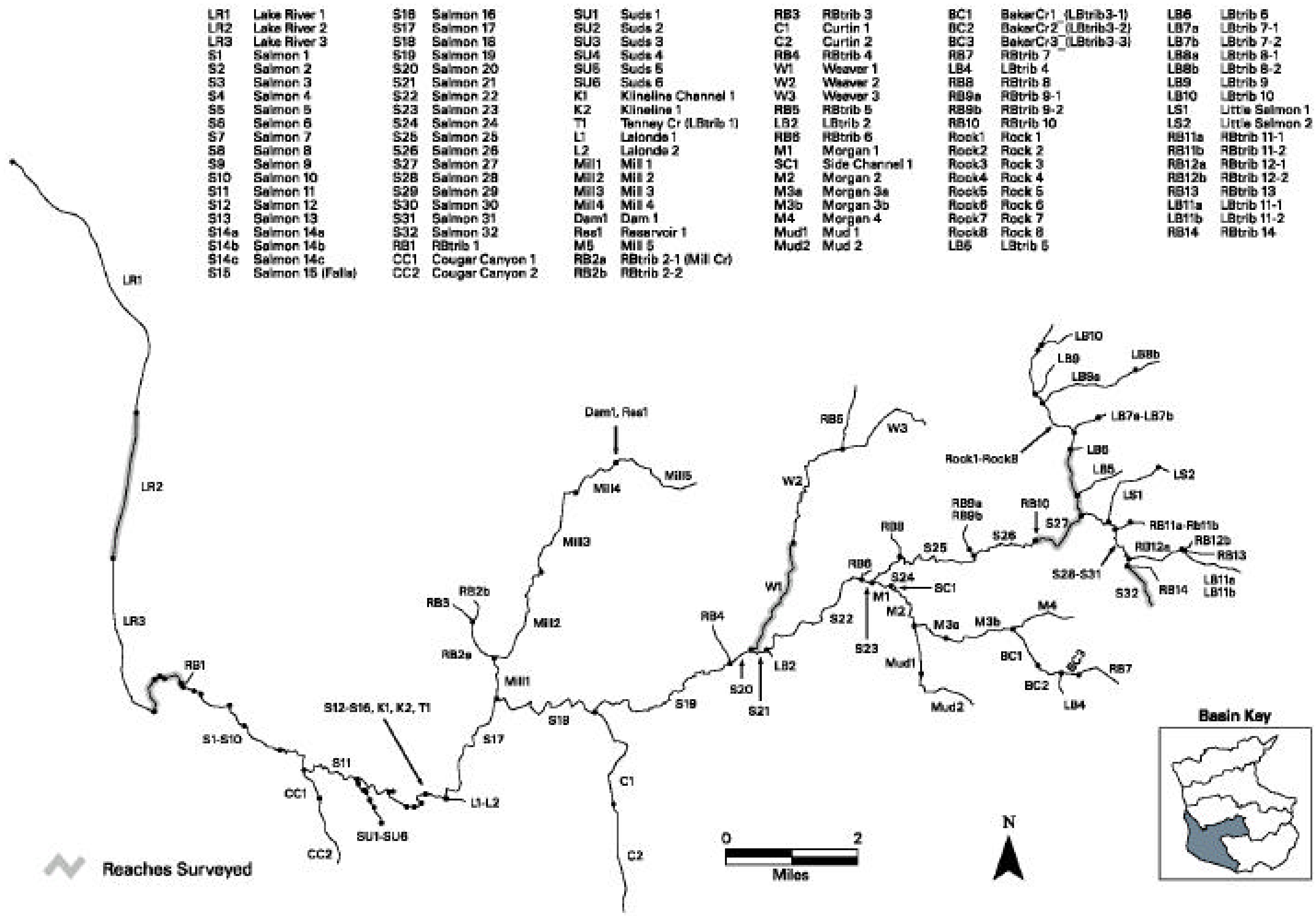
The available information to complete the watershed assessments varied among the targeted river basins, as did the current conditions assessed through field and remote techniques. As such, the methods used were adjusted to match the conditions for each river basin. Consistent with the LCFRB objectives, the assessment for the Salmon Creek basin was limited to riparian and stream habitat. This section describes all necessary deviations, additions, or deletions to the general methods described in Chapter 1.

5.1.2 Riparian Habitat Conditions

The riparian habitat condition assessment was conducted from aerial photo interpretation of 1m digital color infrared orthophotos dated 2002 and provided by Clark County. The aerial photographs at an approximate scale of 1:12,000 were digitally reviewed to assess riparian cover conditions along 117 previously delineated Ecosystem Diagnosis and Treatment (EDT) model reaches (Map 5-1). This assessment represented approximately 129 km (80 miles) of anadromous fish-bearing streams in the Salmon Creek basin. The methods for delineating riparian conditions and assessing the large wood (LW) recruitment potential and current shade levels were in accordance with WFPB guidelines for conducting watershed analysis methodology (Ver. 4.0; WFPB 1997).

Each riparian condition unit was identified using personal computer and ArcInfo computer software to project delineated reaches onto digital aerial photograph images. The riparian stand species composition, relative size, density and percent of stream surface and stream banks visible was estimated from the onscreen image along both banks of the stream reaches as described in Volume I, Methods. These estimates were converted to LW recruitment potential and incremental shade levels, based on criteria in the Standard Methodology for Conducting Watershed Analysis (WFPB 1997).

Shade levels were determined in the photographic assessment in accordance with shade intervals based on the degree of the channel visible on the photo. The existing shade categories were compared to target shade levels based on elevation in accordance with the western Washington temperature/elevation screen (WFPB 1997) that was designed to offer sufficient shade to comply with state water temperature standards. This approach is a top down assessment looking through the riparian canopy closure to the channel. It can be compared on a relative basis to the bottom-



Map 5-1. EDT reaches in Salmon Creek basin

up approach (stream channel looking skyward) in the View-to-the-Sky assessment discussed in the subsequent section, Chapter 1, Section 2.3.2 Stream Surveys.

At the time of this assessment no Integrated Watershed Assessment (IWA) for the Salmon Creek could be located. Thus, no IWA verification was completed for this river basin.

5.1.3 Stream Surveys

Stream surveys in the Salmon Creek basin were completed from October 20-25, 2004. Habitat condition data were collected in 10 EDT reaches representing approximately 6.5 miles per the United States Forest Service (USFS) Level II Stream Reach Inventory methods described in Chapter 1: Introduction and Methods. The locations of the ten surveyed reaches are shown on Map 5-1 and itemized as follows:

Salmon River Tributaries

EDT Reach	Location (RM)
Salmon Creek Tributary Reaches	**--**
Lake River 2	4.7 – 7.0
Salmon 1, 2, 3, 4	0.0 – 1.1
Salmon 27	21.3 – 22.3
Salmon 32	23.8 – 24.6
Rock 1	0.0 – 0.3
Rock 2	0.3 – 1.1
Weaver 1	0.0 – 2.0

5.2 RESULTS

5.2.1 Riparian Habitat Conditions

The intent of the Phase II remote sensing assessment of riparian habitat conditions was to: (1) provide sufficient detail to judge the current level of riparian function related to potential LW recruitment and shade, (2) confirm the Phase I Integrated Watershed Assessment (IWA) results, as well as (3) provide input for refining EDT riparian input factors and for assessing potential restoration opportunities. The results of these assessments are summarized below.

Existing Riparian Function

***Large Wood (LW) Assessment*:** The location and current LW recruitment condition of 117 EDT reaches are shown in Map 5-2. The condition rating for each of the reaches is included in Appendix A.

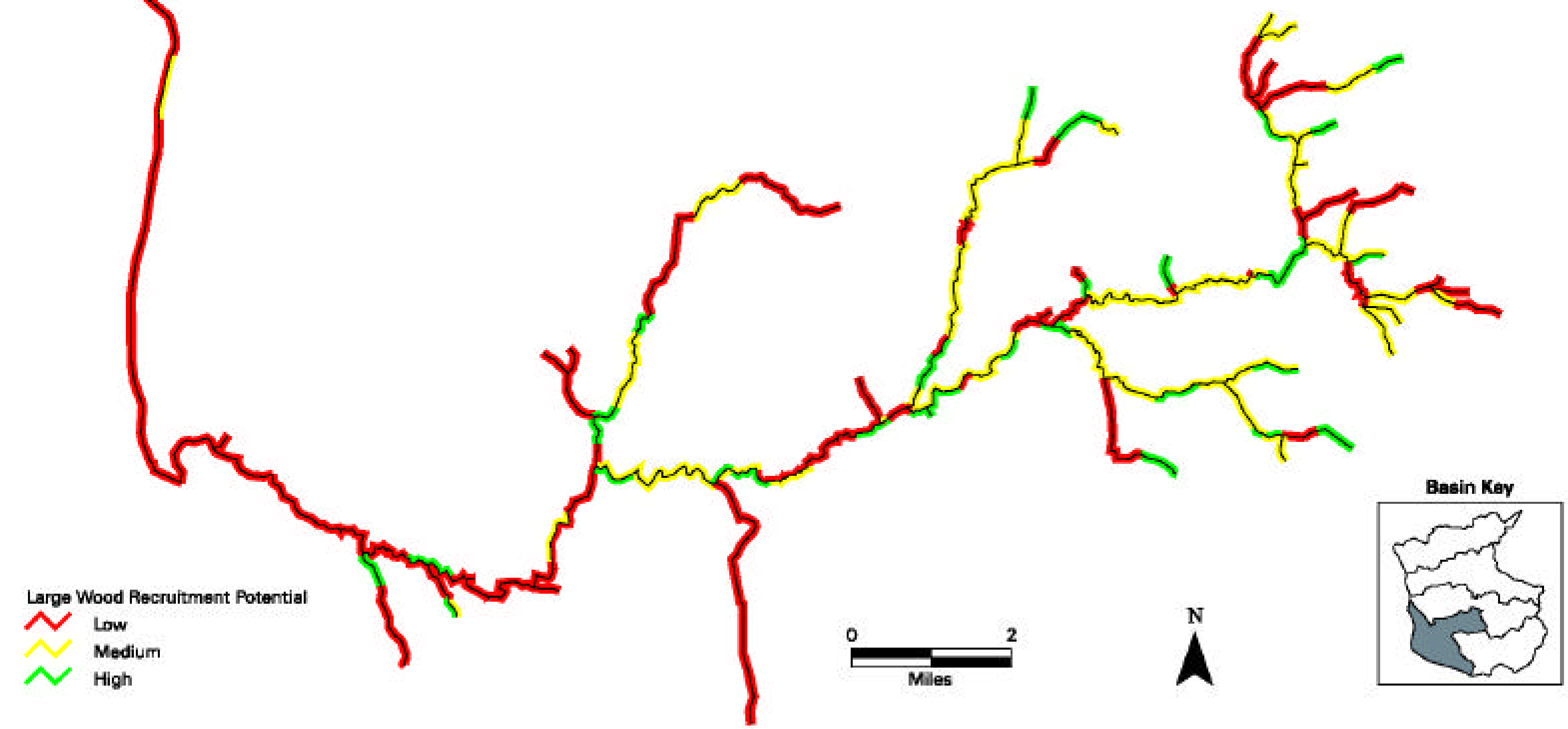
Aerial photo assessment, along both shorelines of nearly 129 km (80 miles) of anadromous fish streams, indicated the overall LW recruitment potential of riparian stands in the Salmon basin was relatively poor. The riparian recruitment potential from the aerial photo assessment suggested more than half of the reaches contained poor conditions.

Large Wood Recruitment Potential

Condition	Frequency
Good	14%
Fair	33%
Poor	53%

The riparian recruitment potential of 117 reaches can be divided approximately into 1/2 poor, 1/3rd fair and a 1/7th representing good conditions. Portions of Salmon Creek 18, 19, and 27, Weaver 1 and 3, Mill 1 and 2, Morgan, Mud 2, and RB Trib 5, 7, 8 and 9 offered good current LW recruitment conditions [low recruitment hazard] on both sides of the stream (Map 5-2; Appendix A). Riparian vegetation in these situations consisted of dense stands of either large or medium-sized conifer or mixed species. The existing fair stand conditions were predominately sparse conifer or mixed stands or dense hardwood stands. A second cohort of conifer stand growth will be needed in these areas to support “functional” LW recruitment potential in the future.

The poor existing stand situation appeared to be related to species composition, sparse density and riparian tree sizes. Based on photographic interpretation, approximately 1/3rd of the stands appeared to be dominated by deciduous species, whereas 1/2 of the stands were dominated by mixed (conifer:hardwood) species. Conifer-dominated stands were low in number (17 percent).



Map 5-2. Large wood condition ratings for EDT reaches in the Salmon Creek basin.

Riparian Species Composition

Type	Frequency
Conifer	17%
Mixed	48%
Hardwood	35%

Stand density data indicated there were greater than 3 times more sparse stands than dense stands along the Salmon Creek EDT reaches.

Riparian Stand Density

Condition	Frequency
Sparse	76%
Dense	24%

The relative size of the trees in incremental size classes was on the small side. Only 2 percent of the stands were categorized in the large (> 8 cm; 20” dbh) size class. This result indicates a number of decades of growth (20 to 40 years) would be needed for the development of a large size class of trees to contribute to future LW recruitment conditions for these streams.

Riparian Stand Size Class

Condition	Size Class	Frequency
	(dbh)	(%)
Small	< 12”	47%
Medium	12 – 20”	51%
Large	> 20”	2%

As described in the Section 4.2.3; *Stream Surveys*, urbanization (including all forms of land use development), roads, railroads, and clearcut timber harvesting along the shorelines have encroached within 30m (100 ft) riparian zones at several places along fish-bearing channels. These activities have adversely influenced the riparian LW recruitment potential.

Riparian Shade Assessment: The location and current shade condition of the 117 EDT reaches is shown in Map 5-2. The condition rating for each of the reaches is included in Appendix A.

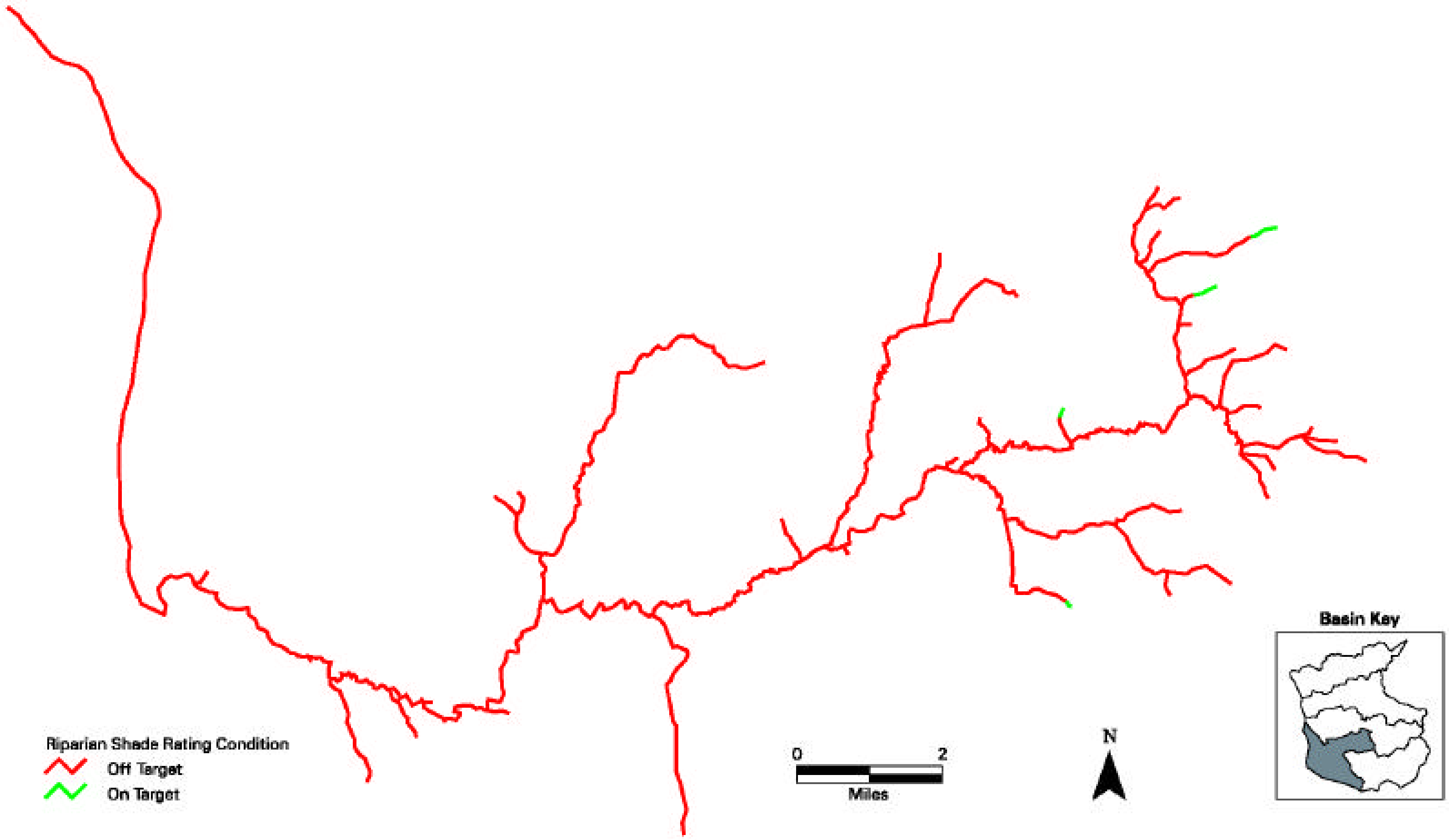
Aerial photo assessment indicated, on average, the current condition of riparian stands was providing little effective shade. Existing shade levels ranged between 0 and 80 percent shade while the mean level was approximately 27 percent shade. According to the State Forest Practices shade/elevation screen, the average shade level would be insufficient to maintain water temperature standards anywhere in the basin since the watershed lies entirely below 2,275 ft msl in elevation.

Almost all of the EDT reaches in the basin are currently off-target with respect to the State shade/ elevation screen, representing high shade hazards for compliance with water temperature standards. Only the tips of a few reaches in the headwater areas support on-target shade levels (Map 5-3). Due to the low elevation of lands along the EDT reaches accessible to anadromous fish species, a high level of shade is required to comply with aquatic use temperature criteria. The wide mainstem reaches along the lower Salmon Creek and Lake River likely offered naturally open riparian canopies and historic warm stream temperature regimes due to frequent Columbia River floodplain disturbances.

Riparian Shade Condition

Shade Increment	Tally	Frequency
0	1	0.6%
0 – 20%	78	44%
20 – 40%	67	37%
40 – 70%	24	13%
70 – 90%	9	5%
90 – 100%	0	0%

Although variable, concentrations of high LW hazard areas can be found in the lower Lake River, Salmon Creek downstream of the confluence with Mill Creek, and throughout Curtin Creek. Lake River and lower Salmon Creek may have experienced natural high hazards to LW riparian function as a result of the Columbia River floodplain.



Map 5-3. Shade condition ratings for EDT reaches in the Salmon Creek basin.

5.2.2 Stream Surveys

Habitat inventory data are summarized in this section of the Salmon Creek Basin document per individual EDT reach (see Tables 5-1 and 5-2). Habitat conditions for each of the surveyed reaches shown in Map 5-1 are presented in detail in Appendix B.

Channel Morphology

The channel morphologies for the EDT reaches surveyed in the Salmon Creek basin varied between unconfined floodplain backwater sloughs (Lake River) and wide, low gradient (<0.5%), palustrine channels (Salmon 1 - 4) with dune-ripple bedform to moderately confined streams with mixed control features and step-pool bedform up to 4.5 percent gradient (Salmon 32). The tributaries surveyed consisted mostly of low gradient (1%) moderately confined, mixed control channels with forced pool-riffle to plane-bedded bedforms (Rock and Weaver creeks). These channel types offer pool:riffle bedform where channel structure is abundant. However, in the absence of large structure (woody debris, boulder clusters, or bedform controls) some sections would likely consist of plane-bedded channels.

Table 5-1. Channel Gradient, Confinement and Morphology in the Salmon Basin.

Reach	Map Gradient (%)	Confinement	Paustian Process Group	Montgomery Buffington bedform	Comments
Lake River 2	<0.5	Unconfined	Floodplain backwater slough	Dune-ripple	Columbia River side channel – now possibly dredged. Substrate of fines.
Salmon 1-4	<0.5%	Unconfined	Palustrine to large floodplain	Dune-ripple	Salmon Creek valley is ~500-1000 ft wide, and incised through Lake Missoula flood deposits. Many sloughs along channel. Substrate of fines. Pool riffle morphology dominates in steeper or gravel bed sections. LW forms cover and would cause channel avulsions but does not likely force pools or store sediment Habitat type consistently of glides. Sediment naturally deposits.
Salmon 27	1.4% upper end; 0.5% lower end	Confined	Large, contained	Pool-riffle	Bedrock controls lateral migration and likely pool formation. Adjacent terrace appears to be above current flood levels.
Salmon 32	4.5%	Moderate to highly confined	Incised footslope channel	step-pool	Downstream end has short section over alluvial fan, but otherwise channel is steep and confined. Small enough to be responsive to LW for both pool formation and sediment storage
Rock Creek 1	1%	Moderate to Confined	Moderate gradient mixed control	forced pool-riffle to plane bed	Narrow valley but stream small enough to move around in response to blockages. LW important for pools and sediment. Plane bed in absence of LW
Rock Creek 2	1.1%	Moderate to low confinement	Moderate gradient mixed control	forced pool-riffle to plane bed	See above. Valley somewhat wider, but still controls lateral migration
Weaver 1	1%	Moderate to highly Confined	Moderate gradient mixed control to moderate gradient contained	forced pool-riffle to plane bed	First 1,000 ft unconfined across low alluvial fan. Upstream flows through canyon, but channel likely only moderately confined due to small size. LW important for pools and sediment. Plane bed in absence of LW

Table 5-2. Mean Habitat Inventory data in the Salmon Basin.

	Lake River 2	Salmon 1-4	Weaver 1	Salmon 27	Salmon 32	Rock 1	Rock 2
Channel Morphology							
Pool %	0	0	42	49	31	59	74
Pool Tailout	0	0	30	18	32	19	28
Large Riffle	0	0	0	0	22	18	0
Small Riffle	0	0	36	40	31	22	17
Glide	100	100	22	12	16	0	9
Other	0	0	0	0	0	0	0
Gradient	1.0	<1.0	1.0	1.0	1	1.5	1.5
Channel Type							
Bedform							
Wetted channel width	89	27	4.2	9.9	5.6	6.4	6.2
Active channel width			3.6	10.9	5.6	6.4	7.1
Max. Riffle Depth	-	-	0.4	0.5	0.4	0.5	0.4
Res. Pool Depth	-	-	0.5	0.7	0.4	0.6	0.6
Max Pool Depth (m)	3.7	1.5	0.7	1.0	0.6	0.9	1.0
Pools/km	0.0	0.0	15.9	10.0	20.2	19.6	33.5
Primary Pools/km	0.0	0.0	0.9	8.5	0.0	8.2	15.8
% side channels							
LW							
Small Pieces/km	9.3	1.3	16.9	14.2	79	18	26
Medium Pieces/km	4.4	4.5	15	10	126	26	26
Large Pieces/km	3.9	4.9	0.9	2.8	89	8.2	8.4
Jams/km	0	0	0	0	0	0	0
Root Wads/km	0.5	0.9	2.8	0	8	0	7.4
Total LW/km	18.1	11.7	35.6	27	303	52	68
Substrate							
Sand	-	-	33	20	38	29	34
Gravel	-	-	49	49	47	54	56
Cobble	-	-	16	24	11	5	10
Boulder	-	-	1	9	3	5	0
Bedrock	-	-	2	0	1	6	0
Embeddedness	-	-	51	32	57	31	47
0 - 24	-	-	3	33	0	37	4
25 - 49	-	-	34	53	17	53	39
50 - 74	-	-	58	13	65	5	53
>75	-	-	5	0	17	5	4

Table 5-2. Mean Habitat Inventory data in the Salmon Basin.

	Lake River 2	Salmon 1-4	Weaver 1	Salmon 27	Salmon 32	Rock 1	Rock 2
Cover							
LW	0	1	5	3	18	3	4
Undercut Banks	0	0	1	0	0	0	0
Overhanging Cover	0	1	39	22	17	25	31
Depth > 1m	90	62	4	7	0	4	8
Substrate (velocity)	0	0	0	1	0	0	0
Riparian							
Distance to Left Bank (ft)	478	65	76	47	54	65	137
Angle	16	67	67	72	64	72	62
Distance to Rt. Bank (ft)	296	230	194	48	32	81	33
Angle	21	52	48	64	81	66	72
VTS %	79%	34%	36%	24%	20%	23%	25%
Active channel width (m)	89	27	3.7	4.0	4.9	6.3	7.1
Elevation (msl')	5	10	230	275	440	355	385
Reference Temp ^{o}C	19.5	17.2	15.7	15.3	15.4	15.6	15.6
Current Est. Temp ^{o}C	21.8	18.4	18.2	16.9	16.6	17.1	17.1
Vegetation Community (%)							
LB Hardwood	0%	100%	17%	14%	75%	33%	25%
Mixed	0%	0%	67%	43%	0%	33%	25%
Conifer	0%	0%	17%	43%	25%	33%	50%
RB Hardwood	100%	100%	38%	67%	0%	0%	33%
Mixed	0%	0%	50%	33%	100%	50%	67%
Conifer	0%	0%	13%	0%	0%	50%	0%
Bank Stability							
LB Unstable %	-	-	1	0	-	-	2
Disturbance %	0	1	5	0	37	1	20
Disturbance Type	-	UB	RD	-	CC	UB	CC,UB
RB Unstable %	-	-	1	3	-	-	4
Disturbance %	4	29	5	8	39	5	15
Disturbance Type	RR	UB	RD	UB	CC	CC	UB

Channel Codes
Pal = Palustrine; Est = Estuarine; FP = Flood Plain; LC = Large, Contained; MGMC = Moderate Gradient, Mixed Control
Bedform Codes
DR = Dune-ripple; PR = Pool-riffle; FPR = Forced pool-riffle; PB = Plain bed; SP = Step Pool
Riparian Disturbance Code
U = Urbanization; R = Road; RR = Railroad; C = Clearcut; T = Thinning; H = Hydromodification

Habitat Types

The large lowland reaches of Lake River 2 and Salmon 1-4 consisted entirely of glide habitat. The glides were relatively deep with the maximum depths averaging 3.7m (12 ft) in Lake River 2 and 1.5m (5 ft) in Salmon 1-4. Substrate data were not collected in the large lowland reaches. It is likely that Lake River, serves as a transport reach for anadromous fish species.

Pools dominated the channel habitat types in the balance of the surveyed reaches, while gravel-cobble riffles were subdominant. The pools were relatively shallow, with few primary pools, greater than 1.0m (3.3 ft) in depth, measured. Salmon 27 and Rock 2 offered the most prevalent holding pool frequency with 57 and 47 percent of the pools exceeding 1m in depth, respectively. The balance of the surveyed reaches offered infrequent and shallow pool habitat.

Large Wood Structure

On a relative basis, individual instream LW pieces were common in the small tributary reaches of Weaver 1, Salmon 27, Rock 1 and they were abundant in Salmon 32 and Rock 2. Few LW pieces were observed in the wide unconstrained lowland reaches of Lake River 2 and Salmon 1-4. The instream wood loading was primarily of the small size category except for Salmon 32 and Rock 1 and 2 where medium and large size classes were also represented. The presence of wood jams and pieces with attached root wads was very low throughout the survey, except in Rock 2 where we suspected that channel restoration projects have been implemented.

The instream data indicated that either the large wood recruitment to the lowland reaches of the Salmon basin has been low, or the depletion rate has been high. As discussed in the previous section, long-term riparian growth on the order of two to four decades will be needed to offer a high degree of LW recruitment potentials to these channels in the future.

Substrate

There was a high frequency of sand particle sizes and high embeddedness ratings in all of the surveyed reaches. The highly erosive nature of the parent geologic materials in the basin and the predominance of sandy Missoula flood deposits in the areas below approximately 350-ft elevation likely explains the observed high fine sediment signal.

Cover

Water depth provided the primary cover type for fish species in the lowland reaches of the Salmon Basin. The upland tributaries offered more diverse cover types. The most frequent cover type in the tributaries was overhanging vegetation, but LW offered the predominant cover type in Salmon 32 where an abundance of instream LW existed.

Riparian Condition

According to the stream survey information, deciduous species dominated the riparian species stand composition along the lowland reaches of Lake River 2 and Salmon 1-4. Riparian zones of the tributary reaches of Salmon 27, Salmon 32, Weaver 1 and Rock 1 and 2, were composed mostly of mixed stands. Direct comparison with the riparian conditions collected during the photographic assessment was difficult, since riparian stand composition information was collected during the stream inventory on an occasional (Nth unit) basis and summarized over the length of the reach, whereas the photo interpretation was performed continuously along long homogeneous reaches. Nevertheless, the field inventory matched the photo assessment at all sites with the exception of Salmon 32, where a greater presence of hardwood species along the left bank was noted in the field compared to the remote assessment (Table 5-2).

Encroachment into the 30m (100 ft) riparian zone along the surveyed reaches in the Salmon basin resulted in disturbance ratings between 0 and 39 percent of the riparian area on either bank. The greatest frequency of disturbance types included urbanization (all forms of development) and clearcut timber harvesting (Table 5-3). Timber harvesting in riparian zones was a legacy effect prior to recent changes in the forest practices rules. Salmon 32 and Rock 2 exhibited the highest frequency of prior harvesting adjacent to stream channels. Overall, Rock 2 supported the highest level of riparian zone encroachment from both urbanization and prior timber harvests.

Table 5-3. Number of habitat units reporting riparian zone disturbance on either shore.

Disturb Type	Lake River	Salmon 1 - 4	Weaver 1	Salmon 27	Salmon 32	Rock 1	Rock 2
Urbanization		6	1	2		1	12
Roads			7				
Railroads	2						
Clearcut					11	2	8
Thinning							
Hydro-modifications							
Total	2/42	6/26	8/42	2/24	11/14	3/36	20/60

Estimates of the average distance of trees beyond the bank full stage of the channel along the lowland Salmon Creek reaches ranged between 20 and 146 m (65 - 478 ft) on either side of the streams. This zone was wide along the floodplain reaches, especially along Lake River. The resulting mean view to sky angle from mid-channel ranged between 34 percent at Salmon 1-4 and 79 percent along Lake River 2 (Table 5-2).

These reaches were estimated to remain open to solar radiation even under the unlikely assumption of mature forest stands growing immediately adjacent to the channel, (e.g., VTS 88^{o}; 49% along Lake River). As such, these reaches represented areas with naturally low shade levels and they likely offered historically warm surface water temperatures. Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference surface water temperatures were projected to approach 17.2^{o}C and 19.5^{o}C at Salmon 1-4 and Lake River 2, respectively. The reference temperatures at Lake River 2 would not be expected to comply with aquatic use criteria for anadromous salmonid fishes or interior resident trout under mature riparian stands simply due to the expanse of the channel width and the relatively low elevation of the river channel. Similarly, the reference temperature at Salmon 1-4 would not have been conducive to core anadromous salmon spawning and rearing temperatures in the Salmon basin as delineated in the state water temperature regulations (WAC 173-201A).

The current channel conditions were predicted to increase the 7-DADmax on a relative basis between 1.2^{o}C at Salmon 1-4 and 2.3^{o}C at Lake River 2 compared to reference conditions. As a consequence, the anticipated summer 7-DADmax surface water temperatures were estimated to range between 18.4 and 21.8^{o}C at the lowland reaches under normal summer weather (air temperatures and stream flows) patterns.

Tree distances from the center of smaller upland tributary channels ranged between 10-59m (32-194 ft) with solar radiation blocking angles that allowed 24 to 36 percent VTS. Although the channel widths were narrower than the lowland channels, the overhead canopy remained open and the existing riparian conditions fell short of reference conditions in all surveyed reaches. It is anticipated the reference conditions in these tributary reaches likely complied historically with state water temperature standards under normal weather conditions. The projected increases in 7-DADmax surface water temperatures as a result of current conditions ranged between 1.2^{o}C and 2.5^{o}C (Table 5-4). As a consequence, the anticipated summer 7-DADmax surface water temperatures were estimated to range between 16.6.4 and 18.2^{o}C at the upland tributary reaches under normal summer weather (air temperatures and stream flows) patterns. The degree of open channel under the current conditions placed the reaches at moderate or high levels of risk to comply with water temperature standards. As shown in Table 5-4, the riparian condition along Weaver 1 is the farthest away from its reference condition of any of the surveyed reaches.

Table 5-4. Anticipated Stream Temperature Conditions along EDT Reaches based on Channel View-to-the-Sky (VTS).

(Estimated Hot Spots in the LCFRB basins in sequential order)

		Current Change from Reference Temperature[1/]			
Salmon Creek Basin	**EDT Reach**	**- (%)**	**+ T°C**	**Hazard[2/]**	**Comment**
Tributaries	Weaver 1	34%	2.5	High	Beaver dams
	Lake River 2	31%	2.3	High	
	Salmon 27	22%	1.6	Moderate	
	Rock 2	20%	1.5	Moderate	
	Rock 1	19%	1.4	Moderate	
	Salmon 32	16%	1.2	Moderate	
	Salmon 1-4	16%	1.2	Moderate	

1) Reference Temperature Condition occurring under the assumption of mature trees (46m; 150 ft high) growing at edge of active channel width.

2) Water Temperature hazard is the relative degree of risk to complying with aquatic use categories compared to reference condition per reach.

These estimates predicted freshwater surface temperatures only based on elevation, channel width and canopy coverage. They did not consider the cool water influence of groundwater influx or conversely, additional heating due to runoff from wetlands or ponds or the effect of shallow channel cross-sections. Actual water temperatures will vary with Salmon Creek discharge, groundwater flux, the relative volume of ponded water runoff and local weather patterns.

Clark County Public Utilities (CPU) and Clark County Public Works (Water Resources) collected continuous surface water temperature recordings of 15 stations in the basin during 2003 and 2004. Three of those sites overlapped EDT reaches surveyed during this effort including Salmon 27, Weaver 1 and Rock 1. Comparison with VTS modeled results with 2004 temperature data measured by Clark County in the basin indicates actual surface water temperatures are warmer than predicted by the VTS model (Appendix B). The data imply site-specific factors other than elevation and the relative degree of open riparian canopy are likely influencing local water temperatures. Both Weaver 1 and Rock 1 have a high frequency of beaver ponds, a general lack of deep pools and shallow cross-sectional gradients in free-flowing sections of the creeks. These factors have the potential to increase the surface water thermal regimes in these creeks. Riparian stand conditions in Rock 1 consisted of small sparse stands of mixed species composition. Weaver 1 supported a mixture of sparse and dense riparian stand conditions. The VTS model has a optional routine to address sparse riparian stand conditions by adjusting the height of radiation blocking elements to account for various levels of stand opacity. Based on the comparison of measured and predicted temperature levels, the next generation of the VTS model for the Salmon Creek basin should consider an adjustment for stand opacity.

Enhancement of Existing EDT Model

The Salmon Creek Basin stream survey data were compared to existing attribute values in the EDT Stream Reach Editor (SRE) in an effort to enhance the current EDT modeling effort with site-specific data. In general, categorical ratings for wood, sediment and embeddedness were relatively consistent between the data in the SRE and the recent field observations. However, measurement data, primarily width and habitat types, occasionally differed between the SRE and the recent field observations. Caution is advised when interpreting wetted or minimum stream width comparisons since the low flow widths are a function of stream flow levels during the surveys and vary between wet and dry years.

Specific comparisons between the SRE and the current stream surveys are itemized in Appendix 2B. In general, the following major items were noted in the Salmon Creek basin:

1. Width: Minimum stream widths differed appreciably between the two data sets.

    a. An appreciable difference occurred in Lake River. The SRE has maximum and minimum width at 76 feet whereas the recent field observations describe the reach at Lake River 2 as having an average width of 276 feet. If this result is extrapolated to the full 15.4 km (9.6 miles) of Lake River, a significant increase in juvenile rearing habitat would occur along the glide habitat.

2. Beaver Ponds: The field surveys indicated greater frequency of beaver ponds in many of the reaches compared to the registered SRE dataset.

    a. Increases in beaver pond frequencies were recorded in Salmon 27, Weaver 1, Rock 1 and 2 with the greatest differences noted in Weaver 1 and Rock 1.

The extent of differences between the recent observations and the data in SRE may result in substantial differences in estimated fish performance measures in EDT, depending upon the extent changes permeate through the model. Because the differences appear to be related to habitat quantity (capacity) rather than quality (productivity), the EDT is likely to be improved in terms of estimating population capacity. The increased beaver pond frequency will likely show improvement for juvenile fish rearing production, especially for coho salmon and steelhead trout, but this enhancement may be offset by increased temperature regimes resulting from runoff from warm standing water. Based on the findings of the Clark County Public Works Water Resources study of stream temperatures in Salmon Creek (Schnabel 2003), the next version of the SRE should offset added rearing production from beaver ponds due to the apparent influence of ponds on sub-lethal thermal regimes in the reaches.

5.3 SYSTEM WEAKNESS, STRENGTHS AND OPPORTUNITIES

The primary goal of the enhancement strategy for the Lower Columbia Watershed Assessment was to identify system strengths and weaknesses and where appropriate identify restoration opportunities. Restoration was focused on re-establishing natural watershed processes that formed and maintained fish habitat prior to changes resulting from historic and current land-use practices. Restoration, therefore, includes three main components: (1) restoration of habitat connectivity; (2) restoration of upslope and riparian geomorphic processes; and (3) rehabilitation of degraded habitats. This restoration approach is consistent with that outlined by NMFS scientists in their NWFSC Watershed Program (Roni et al. 2002).

Identification of System Weaknesses

Habitat weaknesses identified during the watershed assessment process are summarized below:

- More than half of the riparian reaches assessed had poor conditions for LW recruitment potential. This poor potential was related to a high proportion of deciduous trees, sparse stand densities, and small tree sizes.

- Riparian encroachment associated with urbanization and clearcut timber harvest has impacted LW potential.

- There were very few deep holding pools found in surveyed reaches.

- Embeddedness was high in all streams surveyed.

- Throughout the basin current riparian conditions are not providing sufficient shade and are predicted to result in exceedances of state water temperature standards.

Identification of System Strengths

Habitat strengths identified during the assessment process are summarized below.

- Except for lower river reaches, in-channel LW was common to abundant in surveyed reaches.
- Large amounts of lands in the lower reaches (below I-5) are under public ownership.

Protection/Restoration Opportunities

The habitat conditions for the Salmon Creek basin were reviewed and data from stream surveys and riparian analysis were synthesized into appropriate opportunities for preservation and/or protection throughout the basin. Potential restoration opportunities were prioritized by (1)emphasizing preservation and protection of areas that currently function normally, (2) considering actions that help to restore overall system function and (3) considering the distribution of and likely habitat use by anadromous salmonids fishes.

Recommended categories of management actions for the improvement of riparian conditions in the Salmon Creek Basin, include protecting existing riparian vegetation and promoting recovery were possible. Efforts to preclude future human-induced encroachment into the riparian zone or reversal of prior encroachment should be considered. Riparian improvements are limited in lower Salmon Creek mainstem since these reaches likely offered a naturally low levels of shade and wood recruitment potential. The reaches lying in the existing and historic floodplain likely experienced a frequent disturbance history in the riparian zone. Lake River appears to lie in a historic side channel of the Columbia River.

With respect to in-channel habitat restoration opportunities, the large floodplain reaches have a good level of stream power. Wood placement opportunities may be restricted to massive engineered log-jams in the unconstrained portions of the lower Salmon Creek and Lake River. Wood placement is occurring in the tributary reaches and should be encouraged at sites where the structures have a good likelihood of remaining during storm events.

The following prioritized list of conceptual opportunities, based on the data and field observations, offer the greatest potential for success and benefits to salmon production (Table

5-5). However, it is strongly recommended additional, detailed studies be conducted to determine feasibility of the potential opportunities.

1. Riparian Preservation. Preservation strategies would be worthwhile to preclude future riparian degradation in Salmon 32 (NSO #10), Rock 1 (NSO #s 1, and 3), and Rock 2 (NSO #s 16 and 18).

2. Riparian LW Enhancement. Riparian condition and LW recruitment potential can be enhanced by either: (1) hardwood conversion where soil conditions are conducive to conifer growth or (2) releasing conifers in mixed stands for enhance conifer growth rates at appropriate sites to increase the size (diameter) of standing timber. Weaver 1 (NSO #s 1, 21, 28 and 29), Salmon 27 (NSO #27), and Rock 1(NSO #s 15, 16 and 17) have specific opportunities for riparian plantings or other techniques to narrow the current VTS or to increase the LW recruitment potential.

3. The low gradient portions of all tributary reaches offer good opportunities for further wood placement. Wood should remain stable in all of the upland tributary reaches.

4. Riparian Plantings. The left bank along Lake River is devoid of tree species and focused plantings with native species appropriate for the soil conditions and site characteristics would be of value. Similarly, the riparian zones along Salmon 1-10 consist of sparse stands of small hardwood species. These areas should be evaluated for potential conifer plantings or hardwood conversions if the soil type and disturbance frequency allow establishment and long-term growth of conifer species.

Table 5-5. Prioritized protection/enhancement opportunities for the Salmon Creek basin by geographic area. Detailed project descriptions are found in section 5.3 of the report. NA indicates no corresponding EDT reach.

Location	EDT Reach/ RM	Opportunity	Short Description	Priority
Lake River	Lake River 2/ RM 4.7 to 7.0	Riparian Plantings.	Left band is devoid of trees and plantings with native species would improve riparian habitat.	4
Salmon River	Salmon 27/ RM 21.4 to 22.3	Riparian Large Wood Enhancement.	Improve riparian condition and large wood potential by hardwood conversion, conifer release, or riparian plantings	2
Salmon River	Salmon 32/ RM 23.8 to 24.6	Riparian Preservation	Employ strategies to prevent riparian degradation.	1
Salmon River	All Tributaries	Large Wood Enhancement.	Place wood in low gradient portions of all tributaries.	3
Weaver and Rock Creek	Weaver 1/ RM 0.0 to 2.0 Rock 1/ RM 0.0 to 1.1	Riparian Large Wood Enhancement.	Improve riparian condition and large wood potential by hardwood conversion, conifer release, or riparian plantings	2
Rock Creek	Rock 1 and 2/ RM 0.0 to 1.1	Riparian Preservation	Employ strategies to prevent riparian degradation.	1

5.4 REFERENCES

Roni, P., T. Beechie, G. Pess, M. Pollock, F. Leonetti, and B. Bilby. 2002. A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds. Paper presented at NWFSC Watershed Program Open House, Museum of History and Industry, Seattle, WA, March 19, 2002.

Schnabel, J. 2003. Salmon Creek Watershed: Summer 2003 stream temperature. Report prepared by Jeff Schnabel, Clark County Public Works, Water Resources Section. September 2004, 23p.

Washington Forest Practices Board. 1997. Standard methodology for conducting watershed analysis, Version 4.0. Washington Department of Natural Resources, Olympia, WA. November 1997.

APPENDIX 5A

Large Wood Recruitment Potential and Shade Ratings for each EDT Reach in Salmon Basin

Based on Aerial Photograph Assessment Data (2002/2003 Photo Data Sets)

SALMON RIVER BASIN

		RIPARIAN							LW Recruitment Potential					
		lb		rb		Shade		Length						
Case	EDT Reach Name	Code	Hazard	Code	Hazard	Code	(%)	(ft)	Good		Fair		Poor	
1	BakerCr1_(LBtrib3-1)	MMS	Fair	MMS	Fair	2	30	3661			3661	3661		
2	BakerCr2_(LBtrib3-2)	CMS	Fair	CMD	Good	3	55	1325		1325	1325			
3	BakerCr2_(LBtrib3-2)	MMD	Good	MMS	Fair	2	30	963	963			963		
4	BakerCr3_(LBtrib3-3)	MSS	Poor	MSD	Poor	3	55	1444					1444	1444
5	CougarCanyon1	MMD	Good	MMD	Good	3	55	2755	2755	2755				
6	CougarCanyon2	MSD	Poor	MSD	Poor	3	55	5849					5849	5849
7	Curtin1	HSS	Poor	HSS	Poor	1	10	6287					6287	6287
8	Curtin1	HSS	Poor	HSS	Poor	2	30	3213					3213	3213
9	Curtin2	HSS	Poor	HSS	Poor	1	10	8935					8935	8935
10	CurtinCulv							5					5	5
11	Dam1							5						
12	Fishway1							5						
13	Klineline1	HSS	Poor	HSS	Poor	2	30	257					257	257
14	KlinelineChannel1 (SCPC1)	HSS	Poor	HSS	Poor	2	30	348					348	348
15	LBtrib10	CMS	Fair	CMS	Fair	1	10	2933			2933	2933		
16	LBtrib11-1	CSS	Poor	CSS	Poor	1	10	202					202	202
17	LBtrib11-2	CMS	Fair	CMS	Fair	2	30	1920			1920	1920		
18	LBtrib11-2	CSS	Poor	CSS	Poor	1	10	3240					3240	3240
19	LBtrib2	CLD	Good	CLD	Good	4	80	782	782	782				
20	LBtrib4	CMS	Fair	CMS	Fair	2	30	1802			1802	1802		
21	LBtrib5	HSS	Poor	HSS	Poor	1	10	4305					4305	4305
22	LBtrib6	CMS	Fair	CMS	Fair	1	10	979			979	979		

SALMON RIVER BASIN

Case	EDT Reach Name	RIPARIAN							LW Recruitment Potential					
		lb		rb		Shade		Length						
		Code	Hazard	Code	Hazard	Code	(%)	(ft)	Good		Fair		Poor	
23	LBtrib7-1							1270						
24	LBtrib7-1	CMS	Fair	CMS	Fair	2	30	1239			1239	1239		
25	LBtrib7-2	CMD	Good	CMD	Good	4	80	588	588	588				
26	LBtrib8-1	CSD	Poor	CSD	Poor	3	55	2588					2588	2588
27	LBtrib8-1	HMD	Fair	HMD	Fair	3	55	3607			3607	3607		
28	LBtrib8-1	HMS	Poor	HMS	Poor	2	30	2372					2372	2372
29	LBtrib8-2	MMD	Good	MMD	Good	4	80	2130	2130	2130				
30	LBtrib9	HSS	Poor	HSS	Poor	1	10	3034					3034	3034
31	LakeRiver1	HMS	Poor	HMD	Poor	1	10	7924					7924	7924
32	LakeRiver1	HSS	Poor	HMD	Fair	1	10	4544				4544	4544	
33	LakeRiver1	HSS	Poor	HMS	Poor	1	10	12377					12377	12377
34	LakeRiver2	HSS	Poor	HSS	Poor	1	10	11955					11955	11955
35	LakeRiver3	HSS	Poor	HSS	Poor	1	10	13761					13761	13761
36	Lalonde1	HSS	Poor	HSS	Poor	1	10	62					62	62
37	Lalonde2	HSS	Poor	HSS	Poor	1	10	1584					1584	1584
38	LalondeCulv1							5						
39	LittleSalmon1	CMS	Fair	CMS	Fair	2	30	2877			2877	2877		
40	LittleSalmon1	MSD	Poor	MSD	Poor	3	55	4025					4025	4025
41	LittleSalmon2	MSD	Poor	MSD	Poor	3	55	932					932	932
42	LittleSalmonCulv1	MSD	Poor	MSD	Poor	3	55	5					5	5
43	Mill1	HSS	Poor	HSS	Poor	2	30	1454					1454	1454
44	Mill1	MMD	Good	MMD	Good	4	80	2078	2078	2078				
45	Mill2							9						

SALMON RIVER BASIN

Case	EDT Reach Name	RIPARIAN lb Code	lb Hazard	rb Code	rb Hazard	Shade Code	Shade (%)	Length (ft)	LW Recruitment Potential Good		Fair		Poor	
46	Mill2	CMD	Good	CMD	Good	2	30	2044	2044	2044				
47	Mill2	CMD	Good	CMD	Good	4	80	1908	1908	1908				
48	Mill2	MMS	Fair	MMS	Fair	1	10	2501			2501	2501		
49	Mill2	MMS	Fair	MMS	Fair	3	55	3147			3147	3147		
50	Mill3	MSS	Poor	MSS	Poor	1	10	8123					8123	8123
51	Mill4	CMS	Fair	CMS	Fair	2	30	4715			4715	4715		
52	Mill5							19						
53	Mill5	HSS	Poor	HSS	Poor	1	10	4710					4710	4710
54	Mill5	MSS	Poor	MSS	Poor	2	30	2579					2579	2579
55	Morgan1	CLD	Good	CLD	Good	3	55	1448	1448	1448				
56	Morgan1	MMS	Fair	MMS	Fair	2	30	343			343	343		
57	Morgan2	MMS	Fair	MMS	Fair	1	10	4717			4717	4717		
58	Morgan3_A	MMS	Fair	MMS	Fair	1	10	3210			3210	3210		
59	Morgan3_B	MMD	Good	MMS	Fair	3	55	3549	3549			3549		
60	Morgan3_B	MMS	Fair	MMS	Fair	2	30	1574			1574	1574		
61	Morgan3_B	MMS	Fair	MMS	Fair	3	55	885			885	885		
62	Morgan4	MMD	Good	MMS	Fair	3	55	3309	3309			3309		
63	Morgan4	MMS	Fair	MMS	Fair	2	30	2385			2385	2385		
64	Mud1	HSS	Poor	HSS	Poor	1	10	3964					3964	3964
65	Mud2	HSS	Poor	HSS	Poor	1	10	3478					3478	3478
66	Mud2	MMD	Good	MMD	Good	4	80	2805	2805	2805				
67	NW119thCulv	HSS	Poor	HSS	Poor	2	30	5					5	5
68	RBtrib1	HSS	Poor	HSS	Poor	2	30	1438					1438	1438

SALMON RIVER BASIN

		RIPARIAN							LW Recruitment Potential					
		lb		rb		Shade		Length						
Case	EDT Reach Name	Code	Hazard	Code	Hazard	Code	(%)	(ft)	Good		Fair		Poor	
69	RBtrib10	HMS	Poor	HMS	Poor	2	30	344					344	344
70	RBtrib11-1	MMD	Good	MMS	Fair	3	55	1400	1400			1400		
71	RBtrib11-2	MMD	Good	MMS	Fair	0	0	1241	1241			1241		
72	RBtrib11Culv1	MMD	Good	MMS	Fair	3	55	5	5			5		
73	RBtrib12-1	CMS	Fair	CMS	Fair	2	30	3724			3724	3724		
74	RBtrib12-1	CSS	Poor	CSS	Poor	1	10	929					929	929
75	RBtrib12-2	CSS	Poor	CSS	Poor	1	10	1088					1088	1088
76	RBtrib13	CSS	Poor	CSS	Poor	1	10	2502					2502	2502
77	RBtrib14	MMS	Fair	MMS	Fair	2	30	3032			3032	3032		
78	RBtrib2-1 (MillCr)	MSS	Poor	MSS	Poor	4	80	3881					3881	3881
79	RBtrib2-2	MSS	Poor	MSS	Poor	2	30	1996					1996	1996
80	RBtrib3	CSS	Poor	CSS	Poor	3	55	2160					2160	2160
81	RBtrib4	MSS	Poor	MSS	Poor	1	10	3485					3485	3485
82	RBtrib5	MMD	Good	MMD	Good	2	30	2267	2267	2267				
83	RBtrib5	MMS	Fair	MMS	Fair	1	10	3102			3102	3102		
84	RBtrib6	HSS	Poor	HMS	Poor	1	10	1314					1314	1314
85	RBtrib7	CLD	Good	CLD	Good	3	55	2820	2820	2820				
86	RBtrib7	MSS	Poor	MSS	Poor	2	30	960					960	960
87	RBtrib8	CMD	Good	CMD	Good	4	80	1168	1168	1168				
88	RBtrib8	HSS	Poor	HSS	Poor	1	10	1085					1085	1085
89	RBtrib9-1	HSS	Poor	HSS	Poor	1	10	640					640	640
90	RBtrib9-2	MMD	Good	MMD	Good	4	80	2149	2149	2149				
91	RBtrib9Dam							5						

SALMON RIVER BASIN

Case	EDT Reach Name	RIPARIAN							LW Recruitment Potential					
		lb		rb		Shade		Length						
		Code	Hazard	Code	Hazard	Code	(%)	(ft)	Good		Fair		Poor	
92	Reservoir1	MSS	Poor	MSS	Poor	2	30	712					712	712
93	Rock1	MSS	Poor	MMD	Good	3	55	756		756			756	
94	Rock1	MSS	Poor	MSS	Poor	2	30	991					991	991
95	Rock2	MMS	Fair	MMD	Good	2	30	1		1	1			
96	Rock2	MMS	Fair	MMS	Fair	2	30	3155			3155	3155		
97	Rock2	MSS	Poor	MSS	Poor	1	10	931					931	931
98	Rock3	CMS	Fair	MMS	Fair	1	10	767			767	767		
99	Rock3	MMS	Fair	MMS	Fair	2	30	683			683	683		
100	Rock4	MMS	Fair	MMD	Good	2	30	62		62	62			
101	Rock4	MMS	Fair	MMD	Good	3	55	3274		3274	3274			
102	Rock4	MMS	Fair	MMS	Fair	2	30	671			671	671		
103	Rock5	MSS	Poor	MSS	Poor	2	30	1034					1034	1034
104	Rock6	HSS	Poor	HSS	Poor	1	10	3944					3944	3944
105	Rock7	HSS	Poor	HSS	Poor	1	10	531					531	531
106	Rock8	CMS	Fair	CMS	Fair	2	30	1958			1958	1958		
107	RockCulv1							5						
108	Salmon1	HSS	Poor	HSS	Poor	1	10	2932					2932	2932
109	Salmon10	HSS	Poor	HSS	Poor	1	10	3780					3780	3780
110	Salmon11	HSD	Poor	MMD	Good	2	30	1057		1057			1057	
111	Salmon11	HSS	Poor	HSS	Poor	1	10	4352					4352	4352
112	Salmon11	HSS	Poor	MMD	Good	2	30	814		814			814	
113	Salmon12	HSD	Poor	MMD	Good	2	30	2349		2349			2349	
114	Salmon12	HSS	Poor	HSD	Poor	1	10	1488					1488	1488

SALMON RIVER BASIN

Case	EDT Reach Name	RIPARIAN							LW Recruitment Potential					
		lb		rb		Shade		Length						
		Code	Hazard	Code	Hazard	Code	(%)	(ft)	Good		Fair		Poor	
115	Salmon13	HSS	Poor	HSD	Poor	1	10	646					646	646
116	Salmon13	HSS	Poor	HSS	Poor	1	10	1377					1377	1377
117	Salmon14_A	HSS	Poor	HSS	Poor	1	10	610					610	610
118	Salmon14_B	HSS	Poor	MSS	Poor	1	10	800					800	800
119	Salmon14_C	MSS	Poor	MSS	Poor	1	10	1649					1649	1649
120	Salmon15(falls)							5						
121	Salmon16	MSS	Poor	MSS	Poor	1	10	1764					1764	1764
122	Salmon17	HSS	Poor	MSS	Poor	1	10	3445					3445	3445
123	Salmon17	MMD	Good	MSS	Poor	2	30	632	632					632
124	Salmon17	MSS	Poor	MMS	Fair	2	30	4293				4293	4293	
125	Salmon17	MSS	Poor	MSS	Poor	1	10	2853					2853	2853
126	Salmon18	MMD	Good	MMS	Fair	2	30	3237	3237			3237		
127	Salmon18	MMS	Fair	MMD	Good	2	30	576		576	576			
128	Salmon18	MMS	Fair	MMS	Fair	2	30	8087			8087	8087		
129	Salmon19	HMD	Fair	HMS	Poor	1	10	3511			3511			3511
130	Salmon19	HMS	Poor	HMS	Poor	1	10	5236					5236	5236
131	Salmon19	MMD	Good	HMS	Poor	2	30	3567	3567					3567
132	Salmon19	MMD	Good	MMS	Fair	2	30	2234	2234			2234		
133	Salmon19	MMS	Fair	MMD	Good	2	30	1564		1564	1564			
134	Salmon2	HSS	Poor	HSS	Poor	1	10	462					462	462
135	Salmon20	HSS	Poor	HSS	Poor	1	10	1355					1355	1355
136	Salmon20	MMD	Good	MMS	Fair	2	30	710	710			710		
137	Salmon21	HSS	Poor	HSS	Poor	1	10	380					380	380

SALMON RIVER BASIN

Case	EDT Reach Name	RIPARIAN lb Code	lb Hazard	rb Code	rb Hazard	Shade Code	Shade (%)	Length (ft)	LW Recruitment Potential Good		Fair		Poor	
138	Salmon21	MMD	Good	MMS	Fair	2	30	1114	1114			1114		
139	Salmon22	CMD	Good	MMS	Fair	2	30	1864	1864			1864		
140	Salmon22	CMS	Fair	MMS	Fair	2	30	481			481	481		
141	Salmon22	HMS	Poor	HMS	Poor	1	10	2091					2091	2091
142	Salmon22	HMS	Poor	MMS	Fair	1	10	1481				1481	1481	
143	Salmon22	MMD	Good	MMS	Fair	2	30	3432	3432			3432		
144	Salmon22	MMS	Fair	MMS	Fair	1	10	1583			1583	1583		
145	Salmon22	MMS	Fair	MMS	Fair	2	30	1183			1183	1183		
146	Salmon23	CLD	Good	HMS	Poor	2	30	903	903					903
147	Salmon24	HSS	Poor	CLD	Good	2	30	504		504			504	
148	Salmon24	HSS	Poor	HSS	Poor	1	10	2284					2284	2284
149	Salmon24	MMD	Good	HMS	Poor	2	30	947	947					947
150	Salmon25	MMS	Fair	MMS	Fair	1	10	3776			3776	3776		
151	Salmon25	MMS	Fair	MMS	Fair	2	30	5164			5164	5164		
152	Salmon26	MMS	Fair	MMS	Fair	1	10	6700			6700	6700		
153	Salmon27	MMD	Good	MMD	Good	3	55	4434	4434	4434				
154	Salmon27	MMD	Good	MMS	Fair	2	30	1166	1166			1166		
155	Salmon28	MMS	Fair	MMS	Fair	2	30	2750			2750	2750		
156	Salmon29	MMS	Fair	MMS	Fair	2	30	950			950	950		
157	Salmon3	HSS	Poor	HSS	Poor	1	10	426					426	426
158	Salmon30	MSS	Poor	MSS	Poor	1	10	3600					3600	3600
159	Salmon31	MSS	Poor	MSS	Poor	2	30	600					600	600
160	Salmon32	CMS	Fair	CMS	Fair	2	30	4050			4050	4050		

SALMON RIVER BASIN

		RIPARIAN							LW Recruitment Potential					
		lb		rb		Shade		Length						
Case	EDT Reach Name	Code	Hazard	Code	Hazard	Code	(%)	(ft)	Good		Fair		Poor	
161	Salmon4	HSS	Poor	HSS	Poor	1	10	2148					2148	2148
162	Salmon5	HSS	Poor	HSS	Poor	1	10	919					919	919
163	Salmon6	HSS	Poor	HSS	Poor	2	30	723					723	723
164	Salmon7	HSS	Poor	HSS	Poor	1	10	2894					2894	2894
165	Salmon8	HSS	Poor	HSS	Poor	1	10	2245					2245	2245
166	Salmon9	HSS	Poor	HSS	Poor	1	10	3744					3744	3744
167	SideChannel1	MMS	Fair	MMS	Fair	1	10	689			689	689		
168	Suds1	HSS	Poor	HSS	Poor	3	55	377					377	377
169	Suds2	HSS	Poor	HSS	Poor	1	10	722					722	722
170	Suds3	HSS	Poor	HSS	Poor	1	10	206					206	206
171	Suds4	MSS	Poor	MSS	Poor	1	10	732					732	732
172	Suds5	MSS	Poor	MSS	Poor	1	10	708					708	708
173	Suds6	MMD	Good	MMS	Fair	3	55	1483	1483			1483		
174	SudsCulv1							5						
175	SudsCulv2							5						
176	SudsCulv3	HSS	Poor	HSS	Poor	1	10	5					5	5
177	SudsCulv4							5						
178	SudsCulv5	MSS	Poor	MSS	Poor	3	55	5					5	5
179	SudsCulv6							5						
180	TenneyCr(LBtrib1)	MSS	Poor	MSS	Poor	1	10	256					256	256
181	Weaver1	MMD	Good	MMD	Good	2	30	2600	2600	2600				
182	Weaver1	MMD	Good	MSS	Poor	1	10	1620	1620					1620
183	Weaver1	MMS	Fair	MMS	Fair	1	10	3191			3191	3191		

SALMON RIVER BASIN

		RIPARIAN							LW Recruitment Potential					
		lb		rb		Shade		Length						
Case	**EDT Reach Name**	**Code**	**Hazard**	**Code**	**Hazard**	**Code**	**(%)**	**(ft)**	**Good**		**Fair**		**Poor**	
184	Weaver1	MMS	Fair	MMS	Fair	2	30	2986			2986	2986		
185	Weaver2	HMD	Fair	HMD	Fair	2	30	1041			1041	1041		
186	Weaver2	MMS	Fair	MMS	Fair	1	10	6109			6109	6109		
187	Weaver2	MMS	Fair	MMS	Fair	2	30	2670			2670	2670		
188	Weaver2	MSS	Poor	MSS	Poor	1	10	1904					1904	1904
189	Weaver3	CMD	Good	CMD	Good	2	30	3692	3692	3692				
190	Weaver3	CMS	Fair	CMS	Fair	1	10	1683			1683	1683		
191	Weaver3	HMD	Fair	HMD	Fair	2	30	1181			1181	1181		
192	Weaver3	HMS	Poor	HMS	Poor	1	10	2366					2366	2366
193	WeaverCulv1						178	5						
						1.79	27							
SALMON RIVER BASIN							Ft	421430	69044	47951	124173	149883	226864	222247
	SUMMARY						Mi	80	13	9	24	28	43	42
							Km	128	21	15	38	46	69	68
	117 Reaches													
							miles			22		52		85
			LB	RB	Total	%								
	Conifer	C	31	28	59	17%				14%		33%		53%
	Mixed	M	81	89	170	48%								
	Hardwood	H	64	60	124	35%								
			176	177	353	100%			**Good**		**Fair**		**Poor**	

SALMON RIVER BASIN

		RIPARIAN												
		lb		rb		Shade		Length	LW Recruitment Potential					
Case	EDT Reach Name	Code	Hazard	Code	Hazard	Code	(%)	(ft)	Good		Fair		Poor	
	Small													
	Med								LW Recruitment Potential					
	Large													
		S	87	79	166	47%								
		M	86	94	180	51%								
		L	4	4	8	2%								
	Sparse													
	Dense		177	177	354	100%								
		S	131	137	268	76%								
		D	46	40	86	24%								
			177	177	354	100%								
		CLD	CMD	MLD	MMD	CLS	CMS	MLS	MMS	HLD	HMD	CSD	CSS	MSD
		8	12	0	40	0	24	0	75	0	7	2	12	9

APPENDIX 5B

Stream Inventory
Reach Summaries
for Salmon Creek Basin

LAKE RIVER 2

INTRODUCTION

Lake River is a former side channel of the Columbia River. As such is has a very low gradient and is located wholly within the Columbia River floodplain. Lake River currently receives inflow from the Columbia River as well as Salmon Creek and several smaller tributaries. However, given the low gradient and extensive floodplain it likely has a lower stream power than other mainstem river segments. The entire length of Lake River 2 was surveyed as highlighted in yellow in Map B-1.

Map B-1. Portion of Lake River 2 surveyed.

CHANNEL MORPHOLOGY

Lake River was classified as a floodplain backwater slough. The map gradient is < 0.5 percent. Substrate is primarily fines, with dune-riffle bedforms. The entire length of Lake Creel is located within a depositional area, thus LW would not play an important role for sediment storage. Habitat would naturally be expected to consist primarily of glides. However, LW would play an important roles in off-channel habitat formation and would provide cover for salmonid fishes.

The wetted width of Lake Creek during the survey averaged 89 m (292 ft). Habitat consisted of glide throughout the survey reach (Figure B-1). No pools were observed (Table B-1).

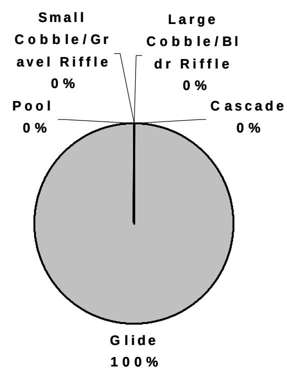


Figure B-1. Unit composition by percent surface area of the surveyed section of Lake River.

Table B-1. Average channel morphology characteristics of surveyed sections of Lake River.

Parameter	Reach Value
Mean gradient	<0.5%
Mean wetted width (m)	89 m
Mean active channel width (m)	NA
Mean of the maximum riffle depths (m)	NA
Mean residual Pool depth (m)	NA
Mean of the maximum glide depths (m)	3.7
Pools per kilometer (p/km)	0.0
Primary pools (>1.0m deep) per kilometer	0.0

WOOD

There were 18.1 pieces of large woody debris per kilometer (LW/km) recorded in Lake River during the summer of 2004. The majority of LW observed consisted of small and medium size pieces (Table B-2). No debris jams, and few rootwads were also observed during the survey.

Table B-2. Size and density of wood, jams and root wads in surveyed section of Lake River

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	9.3
Medium Pieces	20-50 cm diameter; > 2 m long	4.9
Large Pieces	> 50 cm diameter; > 2 m long	3.9
Jams	> 10 pieces in accumulation	0.0
Root wads	> 2 m long	0.5

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant substrate class was sand and silt. The predominance of fine sediments in this channel is not unusual given its location and morphology.

Embeddedness and substrate grain size composition were not rated in Lake River because the substrate consisted primarily of fine sediments. No pebble count was performed in Lake River.

COVER

Cover was classified using the five different cover forms recognized by the protocol including: LW, undercut banks, overhanging cover, depth and substrate velocity breaks. Lake River was a wide channel with limited riparian vegetation. Cover was provided only by depth (Table B-3)

Table B-3. Presence of cover within the surveyed portion of Lake River. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	0%
Undercut Banks	0%
Overhanging Vegetation	0%
Water Depth > 1 m	90%
Substrate (Velocity Cover)	0%

RIPARIAN

Lake River is a wide channel that was open to the sky for most of its length at the time of the survey in 2004. Riparian vegetation was absent on the left bank, and consisted entirely of hardwoods on the right bank (Figure B-2). The open channel width to the sky averages 89 m (292 ft) of channel width plus an additional 147 m (482 ft) of open bank or a total of 236 m (774 ft)-wide zone without vegetative cover. The mean view to sky is 79 percent open (Table B-4).

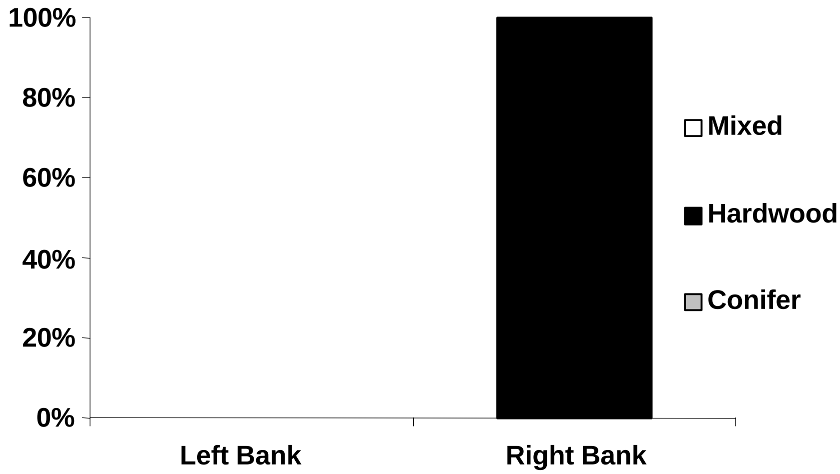


Figure B-2. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Table B-4. Riparian shading characteristics in survey section of Lake River. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	89 m
Mean distance to blocking vegetation – left bank (m)	146 m
Mean left bank canopy angle (degrees)	16 ^{o}
Mean distance to blocking vegetation – right bank (m)	90 m
Mean right bank canopy angle (degrees)	21 ^{o}
Mean view to sky (percent)	79%
Elevation (msl)	10’
Reference Temperature ($T^{o}C$) 7-DADmax	19.5^{o}C
Estimated Current Temperature ($T^{o}C$) 7-DADmax	21.8^{o}C

INSTABILITY AND DISTURBANCE

Only minor bank instability was recorded in the surveyed section of Lake River (Table B-5). If well vegetated, erosion would naturally be expected to be low in this channel type. However, undercut banks with exposed floodplain deposits could be revealed at low flows. Unvegetated banks would be highly susceptible to erosion.

Approximately 4 percent of the of the 35m (100 ft) riparian zone on the left bank was disturbed by the presence of a railroad. No riparian vegetation was noted on the left bank, because the riparian zone naturally supported only low vegetation.

Table B-5. Bank instability and disturbance of surveyed section of Lake River. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	0
Right bank instability (%)	0
Left bank disturbance (%)	0
Right bank disturbance (%)	4

COMPARISON TO EDT VALUES

EDT patient scores were generally similar to scores assigned based on the 2004 survey results. Important differences include a minimum width substantially greater than the EDT patient score, and less in-channel LW than anticipated under the EDT patient score (Tables B-6 – B-8).

Table B-6. Comparison of EDT Level 2 attribute ratings assigned to Lake River 2 and EDT ratings based on 2004 stream survey and hydromodification analysis results for habitat quantity attributes.

Attribute	SRE Rating	Rating from Survey	% Change in Habitat Quantity
Channel width – minimum (ft)	76	292	NA
Channel width – maximum (ft)	76	NO DATA	
Habitat Type – off-channel habitat factor (patient)	1.0%	NA	NA
Habitat Type – off-channel habitat factor (template)	50.0%	NA	NA

Table B-7. Comparison of EDT Level 2 attribute ratings assigned to Lake River 2 and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	0.0%	0.0%	
Habitat Type – backwater pools	0.0%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	0.0%	0.0%	
Habitat Type – glides	100.0%	100.0%	
Habitat Type – small cobble/gravel riffles	0.0%	0.0%	
Habitat Type – large cobble/boulder riffles	0.0%	0.0%	

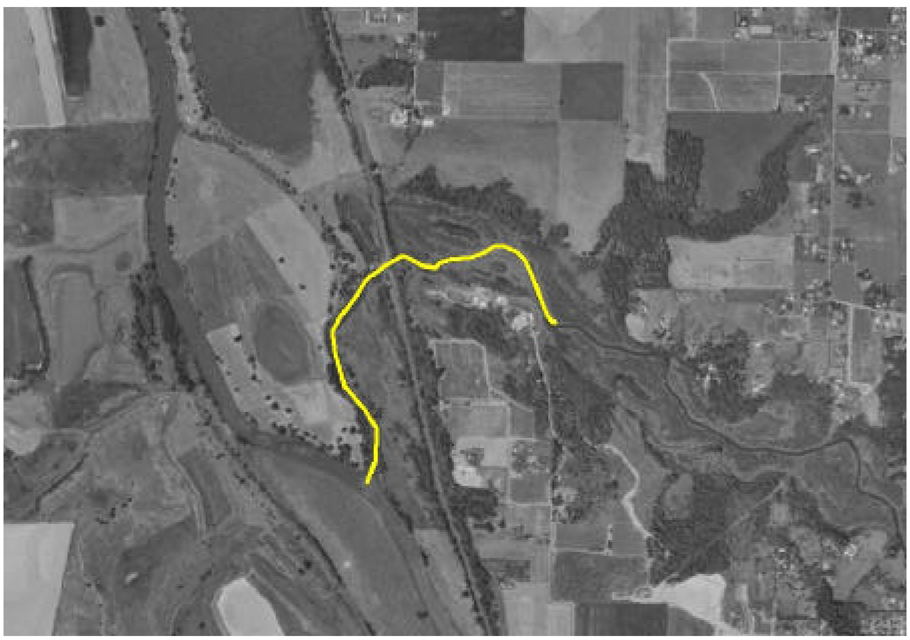
Table B-8. Comparison of EDT Level 2 attribute ratings assigned to Lake River 2 and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	0.0%	<0.5%	
Confinement – natural	0	0	
Confinement – hydromodifications	4	NO DATA	
In-channel wood	3	3.8	
Embeddedness	4.0	NA - no riffles	
Fine sediment	4.0	NA - no riffles	

SALMON CREEK 1 - 4

INTRODUCTION

Salmon Creek is a tributary of the Columbia River that flows into Lake River, a side channel of the Columbia River. The lower 16 miles of Salmon Creek flow through an approximately 450 m (1,500 ft) wide valley that is carved through extensive Lake Missoula flood deposits. The channel gradient is very low, and the channel meanders back and forth across the valley bottom. Topographic maps reveal numerous sloughs in the lower 4 miles of river. Several ponds that may represent former gravel extraction operations are present near RM 6.0. Reaches 1 - 4 are short channel segments located in the first 1-mile of Salmon Creek that exhibit the same general morphology and habitat conditions. These reaches were surveyed and analyzed as a single unit. The lower section of these reaches, downstream of the railroad bridge, flows across the current Columbia River floodplain. The entire length of Salmon 1 - 4 was surveyed as highlighted in yellow in Map B-2.



Map B-2. Portion of Salmon 1-4 surveyed.

CHANNEL MORPHOLOGY

Salmon 1 - 4 were classified as palustrine to wide, large floodplain channel types. The map gradient is < 0.5 percent. Substrate is primarily fines, with predominantly dune-riffle bedforms and glide habitat. LW does not typically play an important role for pool formation or sediment storage in Palustrine habitat types. However, wood may be important for off-channel habitat formation and provides cover for salmonid fishes.

The wetted width of Salmon 1 - 4 during the survey averaged 27 m (89 ft). Habitat consisted was glide throughout the survey reach (Figure B-3). No pools were observed (Table B-9).

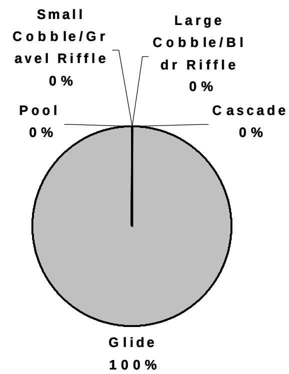


Figure B-3. Unit composition by percent surface area of the surveyed section of Salmon 1 - 4.

Table B-9. Average channel morphology characteristics of surveyed sections of Salmon 1 - 4

Parameter	Reach Value
Mean gradient	<0.5%
Mean wetted width (m)	27 m
Mean active channel width (m)	NA
Mean of the maximum riffle depths (m)	NA
Mean residual pool depth (m)	NA
Mean of the maximum glide depths (m)	1.5
Pools per kilometer (p/km)	0.0
Primary pools (>1.0m deep) per kilometer	0.0

WOOD

There were 11.7 pieces of large woody debris per kilometer (LW/km) recorded in Salmon 1 - 4 during the summer of 2004. The majority of LW observed consisted of medium and large size pieces (Table B-10). No debris jams, and few rootwads were also observed during the survey.

Table B-10. Size and density of wood, jams and root wads in surveyed section of Salmon 1 - 4

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	1.3
Medium Pieces	20-50 cm diameter; > 2 m long	4.5
Large Pieces	> 50 cm diameter; > 2 m long	4.9
Jams	> 10 pieces in accumulation	0.0
Root wads	> 2 m long	0.9

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant substrate class was sand and silt. Embeddedness and substrate grain size composition were not rated in Salmon 1 - 4 because the substrate consisted primarily of fine sediments. No pebble count was performed in Salmon 1 - 4.

COVER

Cover was classified using the five different cover forms recognized by the protocol including: LW, undercut banks, overhanging cover, depth and substrate velocity breaks. Salmon 1 - 4 had wide channels with overhead cover. In-stream cover was provided primarily by depth (Table B-11). Overhanging vegetation ad LW provided some cover along channel margins.

Table B-11. Presence of cover within the surveyed portion of Salmon 1 - 4. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	1%
Undercut Banks	0%
Overhanging Vegetation	1%
Water Depth > 1 m	62%
Substrate (Velocity Cover)	0%

RIPARIAN

Lower Salmon Creek has a wide channel that was open to the sky for most of its length at the time of the survey in 2004. Riparian vegetation consisted exclusively of hardwoods (Figure B-4). The open channel width to the sky averages 27 m (89 ft) of channel width plus an additional 63 m (207 ft) of open bank or a total of 90 m (296 ft) wide zone without vegetative cover. The mean view to sky is 34 percent open (Table B-12).

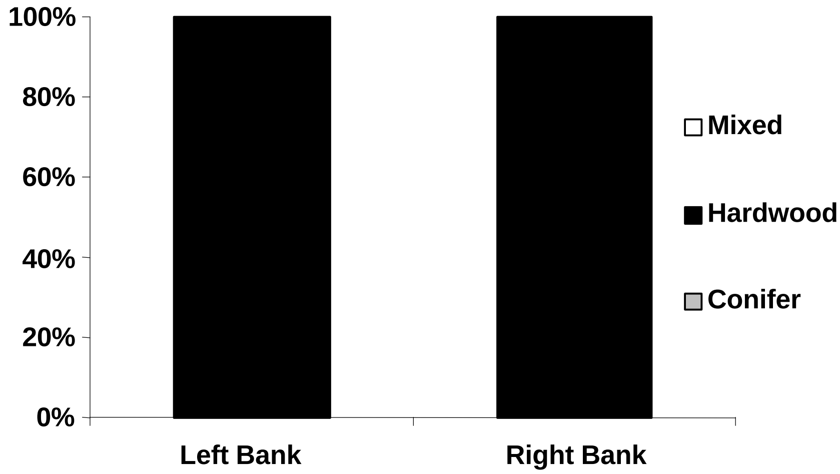


Figure B-4. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Table B-12. Riparian shading characteristics in survey section of Salmon 1 - 4. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	27 m
Mean distance to blocking vegetation – left bank (m)	20 m
Mean left bank canopy angle (degrees)	67 ^{o}
Mean distance to blocking vegetation – right bank (m)	70 m
Mean right bank canopy angle (degrees)	52 ^{o}
Mean view to sky (percent)	34%
Elevation (msl)	10’
Reference Temperature ($T^{o}C$) 7-DADmax	17.2^{o}C
Estimated Current Temperature ($T^{o}C$) 7-DADmax	18.4^{o}C

INSTABILITY AND DISTURBANCE

Only minor bank instability was recorded in the surveyed section of Salmon 1 - 4 (Table B-13). If well vegetated, erosion would naturally be expected to be low in this channel type. However, undercut banks with exposed floodplain deposits could be revealed at low flows.

The riparian zone on the left bank was generally undisturbed. Approximately 29 percent of the of the 35m (100 ft) riparian zone on the right bank was disturbed by development.

Table B-13. Bank instability and disturbance of surveyed section of Salmon 1 - 4 . Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	0
Right bank instability (%)	0
Left bank disturbance (%)	1
Right bank disturbance (%)	29

COMPARISON TO EDT VALUES

EDT patient scores were generally similar to scores assigned based on the 2004 survey results. Important differences include a minimum width substantially greater than the EDT patient score, and less in-channel LW than anticipated under the EDT patient score (Tables B-14 to B-16).

Table B-14. Comparison of EDT Level 2 attribute ratings assigned to Salmon 4, and EDT ratings based on 2004 stream survey and hydromodification analysis results for habitat quantity attributes.

Attribute	SRE Rating	Rating from Survey	% Change in Habitat Quantity
Channel width – minimum (ft)	52	89	NA
Channel width – maximum (ft)	61	NO DATA	
Habitat Type – off-channel habitat factor (patient)	3.0%	NO DATA	NA
Habitat Type – off-channel habitat factor (template)	50.0%	NO DATA	NA

Table B-15. Comparison of EDT Level 2 attribute ratings assigned to Salmon 4, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	0.0%	0.0%	
Habitat Type – backwater pools	0.0%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	0.0%	0.0%	
Habitat Type – glides	100.0%	100.0%	
Habitat Type – small cobble/gravel riffles	0.0%	0.0%	
Habitat Type – large cobble/boulder riffles	0.0%	0.0%	

Table B-16. Comparison of EDT Level 2 attribute ratings assigned to Salmon 4, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	0.1%	<0.5%	
Confinement – natural	2	0-1	
Confinement – hydromodifications	2	NO DATA	
In-channel wood	3	3.5	
Embeddedness	4.0	NA - no riffles	
Fine sediment	4.0	NA - no riffles	

SALMON CREEK 27

INTRODUCTION

Salmon Creek Reach 27 is located in the upstream part of the Salmon Creek basin. Salmon 27 is a 2.0-mile long reach beginning at the Rock Creek confluence. At the confluence with Rock Creek, Salmon Creek occupies a narrow gorge. The downstream end of Salmon 27 flows into a wide valley. The survey segment was located in the less confined portion of Salmon 27, and thus, it may not be representative of the reach as a whole (Map B-3).

Map B-3. Portion of Salmon 27 surveyed.

CHANNEL MORPHOLOGY

Salmon 27 was classified as a large, contained channel type with a map gradient of 1.4%. In the canyon section, the channel is strongly controlled by bedrock. The lower section likely becomes semi-alluvial to alluvial, and has a lower gradient (0.5%) than the upstream section. LW does not typically play an important role for pool formation in large contained channels, as pools are primarily formed by bedrock. Salmon 27 is relatively narrow for this channel type. It is possible channel-spanning log jams could play some role in sediment storage. However, since the high confinement and relatively high gradient result in a high stream power, such features would not be expected to persist within the channel for long periods of time. This reach would function primarily as a sediment transport reach. Gravel deposits would be expected to be limited.

The wetted width of Salmon 27 during the survey averaged 3 m (10 ft). Habitat consisted primarily of pools, which represented 49 percent of the habitat within the reach (Figure B-5 and Table B-17). The remainder of the habitat consisted of small riffles or glide.

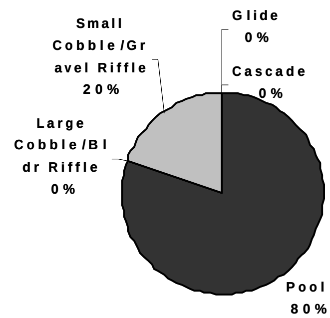


Figure B-5. Unit composition by percent surface area of the surveyed section of Salmon 27.

Table B-17. Average channel morphology characteristics of surveyed sections of Salmon 27.

Parameter	Reach Value
Mean gradient	1%
Mean wetted width (m)	3 m
Mean active channel width (m)	10.9 m
Mean of the maximum riffle depths (m)	0.5
Mean residual pool depth (m)	0.7
Mean of the maximum pool depths (m)	1.0
Pools per kilometer (p/km)	10.0
Primary pools (>1.0m deep) per kilometer	8.5

WOOD

There were 27 pieces of large woody debris per kilometer (LW/km) recorded in Salmon 27 during the summer of 2004. The majority of LW observed consisted of small and medium (Table B-18). No debris jams or rootwads were also observed during the survey.

Table B-18. Size and density of wood, jams and root wads in surveyed section of Salmon 27.

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	14.2
Medium Pieces	20-50 cm diameter; > 2 m long	10.0
Large Pieces	> 50 cm diameter; > 2 m long	2.8
Jams	> 10 pieces in accumulation	0.0
Root wads	> 2 m long	0.0

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes were gravel and cobble, respectively (Table B-19). The survey segment was located in the less confined section of Salmon 27, thus substrate may not be representative of the higher gradient confined section.

Table B-19. Substrate grain size composition in surveyed section of Salmon 27.

Category	Mean Frequency
Sand	20
Gravel	49
Cobble	24
Boulder	9
Bedrock	0

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). The overall mean embeddedness level was 32 percent.

COVER

Cover was classified using the five different cover forms recognized by the protocol including: LW, undercut banks, overhanging cover, depth and substrate velocity breaks. Salmon 27 had a moderately wide channel with dense overhead cover. In-stream cover was provided primarily overhanging vegetation (Table B-20). Depth, LW and substrate also provided some cover.

Table B-20. Presence of cover within the surveyed portion of Salmon 27. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	3%
Undercut Banks	0%
Overhanging Vegetation	22%
Water Depth > 1 m	7%
Substrate (Velocity Cover)	1%

RIPARIAN

Upper Salmon Creek has moderate width channel that could be shaded by streamside trees if they are present. Salmon 27 was shaded for most of its length at the time of the survey in 2004. Riparian vegetation consisted primarily of conifer and mixed hardwood conifer on the left bank, and of hardwoods on the right bank (Figure B-6). The open channel width to the sky averages 3 m (10 ft) of channel width plus an additional 26 m (85 ft) of open bank or a total of 29 m (95 ft) wide zone without vegetative cover. The mean view to sky is 24 percent open (Table B-21).

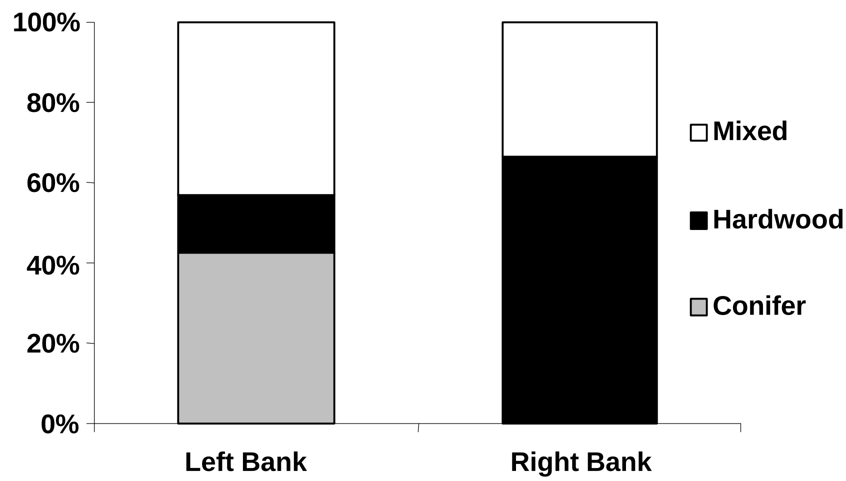


Figure B-6. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Table B-21. Riparian shading characteristics in survey section of Salmon 27. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	3 m
Mean distance to blocking vegetation – left bank (m)	14 m
Mean left bank canopy angle (degrees)	72 ^{o}
Mean distance to blocking vegetation – right bank (m)	15 m
Mean right bank canopy angle (degrees)	64 ^{o}
Mean view to sky (percent)	24%
Elevation (msl)	275’
Reference Temperature ($T^{o}C$) 7-DADmax	15.3
Estimated Current Temperature ($T^{o}C$) 7-DADmax	16.9
Measured Temperature ($T^{o}C$) 7-DADmax (estimated)	20.7

With mature forest stands growing immediately adjacent to the channel, this reach is estimated receive considerable shade. As such, it represents an area that is vulnerable to temperature increases resulting from vegetation removal. Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to approach 15.3^{o}C. The current channel condition (VTS 24%) is anticipated to increase the reference condition 7-DADmax on a relative basis approximately 1.6^{o}C or peak at 16.9^{o}C. An estimate of the current 7-DADmax from surface water measurements collected by Clark County Public Utilities (CPU) during the summer of 2003 (Schnabel 2004) was 20.7^{o}C; higher than the predicted VTS temperature.

The VTS estimates predict surface water temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of cool groundwater influx or warm wetland runoff. Actual water temperatures will vary with stream discharge, local weather patterns and the relative volume of groundwater, ponded water or tributary contribution to the channel.

INSTABILITY AND DISTURBANCE

Only minor bank instability was recorded in the surveyed section of Salmon 27 (Table B-22). The riparian zone on the left bank was generally undisturbed. Approximately 8 percent of the 35m (100 ft) riparian zone on the right bank was disturbed by development.

Table B-22. Bank instability and disturbance of surveyed section of Salmon 27. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	0
Right bank instability (%)	3
Left bank disturbance (%)	0
Right bank disturbance (%)	8

COMPARISON TO EDT VALUES

EDT patient scores were generally similar to scores assigned based on the 2004 survey results. Important differences include: (1) channel morphology adjustments based on less minimum channel widths and glide habitats and more small cobble/gravel riffle habitat and; (2) lower fine sediment levels recorded during the 2004 stream surveys than previously estimated in the SRE database (Tables B-23 to B-25).

Table B-23. Comparison of EDT Level 2 attribute ratings assigned to Salmon 27, and EDT ratings based on 2004 stream survey and hydromodification analysis results for habitat quantity attributes.

Attribute	SRE Rating	Rating from Survey	% Change in Habitat Quantity
Channel width – minimum (ft)	22	10	-16.5%
Channel width – maximum (ft)	35	39	
Habitat Type – off-channel habitat factor (patient)	0.0%	NO DATA	NA
Habitat Type – off-channel habitat factor (template)	0.0%	NO DATA	NA

Table B-24. Comparison of EDT Level 2 attribute ratings assigned to Salmon 27, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	41.7%	33.7%	
Habitat Type – backwater pools	2.6%	0.0%	
Habitat Type – beaver ponds	0.0%	4.0%	
Habitat Type – pool tailouts	7.9%	9.3%	
Habitat Type – glides	32.2%	9.8%	
Habitat Type – small cobble/gravel riffles	13.6%	43.2%	
Habitat Type – large cobble/boulder riffles	2.1%	0.0%	

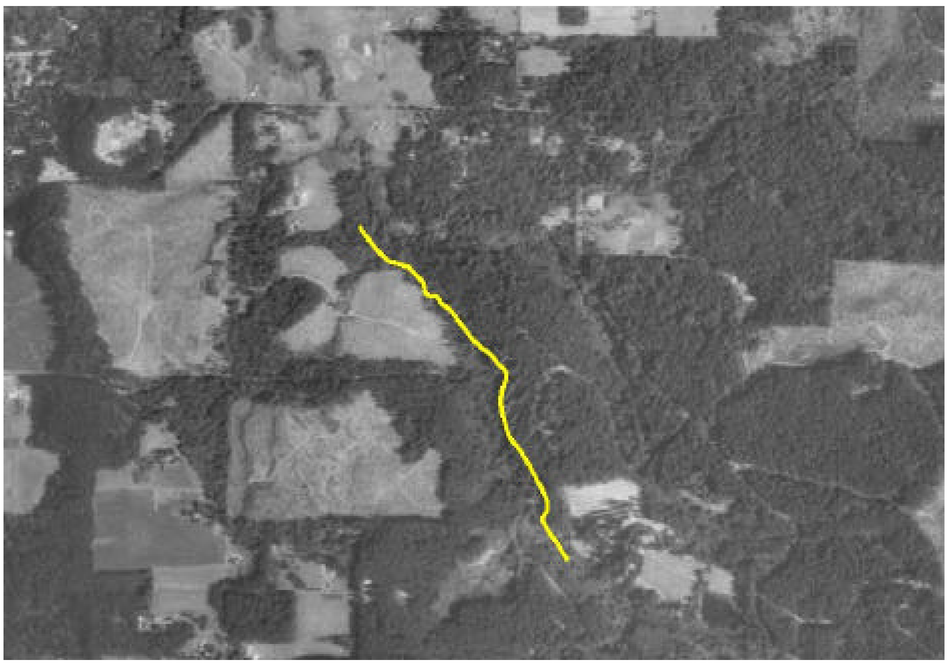
Table B-25. Comparison of EDT Level 2 attribute ratings assigned to Salmon 27, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	0.9%	1.0%	
Confinement – natural	3	3	
Confinement – hydromodifications	2	NO DATA	
In-channel wood	3	3.5	
Embeddedness	0.9	1.3	
Fine sediment	2.3	0.7	

SALMON CREEK 32

INTRODUCTION

Salmon Creek Reach 32 is located in the upper Salmon Creek basin and it is the most upstream reach of the river accessible to anadromous fishes. Salmon 32 is a 2.5 mile long reach that ends at Salmon Falls. For most of its length, Salmon 32 occupies a narrow v-shaped valley. The downstream end of Salmon 32 flows into a wide valley. The entire segment was surveyed (Map B-4).



Map B-4. Portion of Salmon 32 surveyed.

CHANNEL MORPHOLOGY

Salmon 32 was classified as an incised footslope channel. The reach had a map gradient of 4.5 percent. The channel is strongly controlled by bedrock. Because of the small channel size, large pieces of LW or jams could deposit and play an important role in sediment storage. However, due to the high confinement and gradient, stream power is high, thus LW features would not be expected to persist within the channel for long periods of time. This reach would function primarily as a sediment transport reach. Gravel deposits would be expected to be limited except in the presence of wood or other obstructions.

The wetted width of Salmon 32 during the survey averaged 3 m (10 ft). Habitat consisted primarily of riffles (Figure B-7). Pools represented 31 percent of the habitat by length. The maximum depth of pools averaged greater than 0.4 m (1.3 ft). See Table B-26.

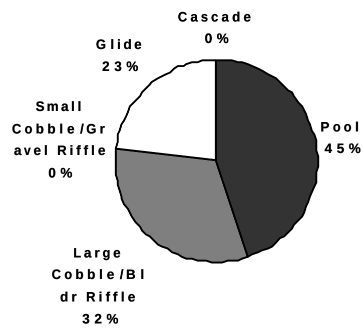


Figure B-7. Unit composition by percent surface area of the surveyed section of Salmon 32.

Table B-26. Average channel morphology characteristics of surveyed sections of Salmon 32.

Parameter	Reach Value
Mean gradient	1%
Mean wetted width (m)	1.7 m
Mean active channel width (m)	5.6 m
Mean of the maximum riffle depths (m)	0.4
Mean residual pool depth (m)	0.4
Mean of the maximum pool depths (m)	0.6
Pools per kilometer (p/km)	20.2
Primary pools (>1.0m deep) per kilometer	0.0

WOOD

There were 303 pieces of large woody debris per kilometer (LW/km) recorded in Salmon 32 during the summer of 2004. The majority of LW was in the medium size class, but pieces of all sized were observed (Table B-27). Some rootwads, but no debris jams were observed during the survey.

Table B-27. Size and density of wood, jams and root wads in surveyed section of Salmon 32.

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	79
Medium Pieces	20-50 cm diameter; > 2 m long	126
Large Pieces	> 50 cm diameter; > 2 m long	89
Jams	> 10 pieces in accumulation	0.0
Root wads	> 2 m long	8.0

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes were gravel and sand, respectively (Table B-28). The predominance of fine substrates and high LW load demonstrate the importance of wood for sediment storage in this channel type.

Table B-28. Substrate grain size composition in surveyed section of Salmon 32.

Category	Mean Frequency
Sand	38
Gravel	47
Cobble	11
Boulder	3
Bedrock	1

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). The overall mean embeddedness level was 57 percent.

COVER

Cover was classified using the five different cover forms recognized by the protocol including: LW, undercut banks, overhanging cover, depth and substrate velocity breaks. Salmon 32 had a moderately wide channel with overhead cover. In-stream cover was provided by LW and overhanging vegetation (Table B-29).

Table B-29. Presence of cover within the surveyed portion of Salmon 32. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	18%
Undercut Banks	0%
Overhanging Vegetation	17%
Water Depth > 1 m	0%
Substrate (Velocity Cover)	0%

RIPARIAN

Upper Salmon Creek has moderately wide channel that could be shaded by streamside trees. Salmon 32 was partially shaded for most of its length at the time of the survey in 2004. Riparian vegetation consisted primarily of hardwood or mixed hardwood conifer forest (Figure B-8). The open channel width to the sky averages 5.6 m (18 ft) of channel width plus an additional 21 m (64 ft) of open bank or a total of 27 m (82 ft)-wide zone without vegetative cover. The mean view to sky is 20 percent open (Table B-30).

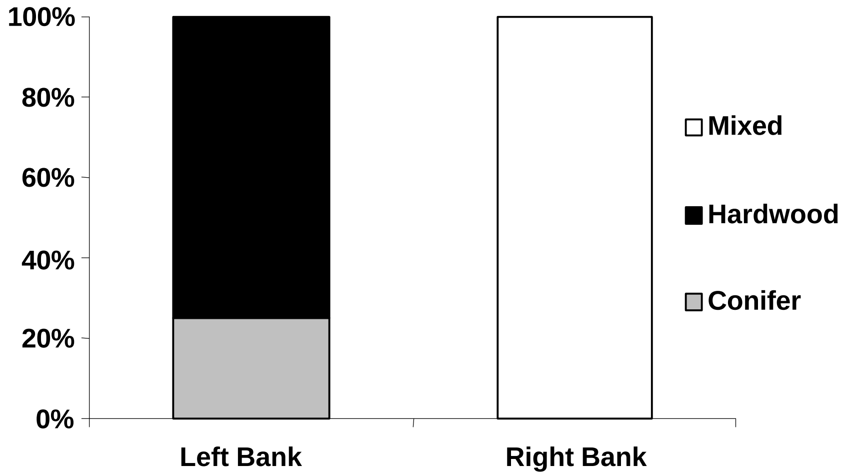


Figure B-8. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Table B-30. Riparian shading characteristics in survey section of Salmon 32. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	5.6 m
Mean distance to blocking vegetation – left bank (m)	17 m
Mean left bank canopy angle (degrees)	64 ^{o}
Mean distance to blocking vegetation – right bank (m)	10 m
Mean right bank canopy angle (degrees)	81 ^{o}
Mean view to sky (percent)	20%
Elevation (msl)	440’
Reference Temperature ($T^{o}C$) 7-DADmax	15.4
Estimated Current Temperature ($T^{o}C$) 7-DADmax	16.6

With mature forest stands growing immediately adjacent to the channel, this reach would receive considerable shade. As such, it represents a vulnerable area to temperature increases resulting from vegetation removal. Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to approach 15.4^{o}C. The current channel condition (VTS 20%) is anticipated to increase the reference condition 7-DADmax on a relative basis approximately 1.2^{o}C or peak at 16.6^{o}C.

These estimates predict surface water temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of cool groundwater influx or warm wetland runoff. Actual water temperatures will vary with stream discharge, local weather patterns and the relative volume of groundwater, ponded water or tributary contribution.

INSTABILITY AND DISTURBANCE

No bank instability was recorded in the surveyed section of Salmon 32 (Table B-31). Banks are expected to be naturally stable due to the predominance of bedrock control in the narrow valley. Almost 40 percent of the 35m (100 ft) riparian zone on the right bank was disturbed by development.

Table B-31. Bank instability and disturbance of surveyed section of Salmon 32. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	0
Right bank instability (%)	0
Left bank disturbance (%)	37
Right bank disturbance (%)	39

COMPARISON TO EDT VALUES

EDT patient scores were generally similar to scores assigned based on the 2004 survey results. Important differences include: (1) channel morphology adjustments based on less minimum channel widths and less pool and glide habitats and steeper channel gradient with more riffle habitat and; (2) lower fine sediment levels but more embeddedness and more in-channel LW recorded during the 2004 stream surveys than previously estimated in the SRE database (Tables B-32 to B-34).

Table B-32. Comparison of EDT Level 2 attribute ratings assigned to Salmon 32, and EDT ratings based on 2004 stream survey and hydromodification analysis results for habitat quantity attributes.

Attribute	SRE Rating	Rating from Survey	% Change in Habitat Quantity
Channel width – minimum (ft)	12	6	-25.0%
Channel width – maximum (ft)	16	16	
Habitat Type – off-channel habitat factor (patient)	0.0%	NA	NA
Habitat Type – off-channel habitat factor (template)	0.0%	NA	NA

Table B-33. Comparison of EDT Level 2 attribute ratings assigned to Salmon 32, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	36.1%	21.3%	
Habitat Type – backwater pools	0.6%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	3.8%	8.7%	
Habitat Type – glides	25.4%	0.0%	
Habitat Type – small cobble/gravel riffles	23.0%	33.2%	
Habitat Type – large cobble/boulder riffles	11.1%	36.9%	

Table B-34. Comparison of EDT Level 2 attribute ratings assigned to Salmon 32, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	3.0%	4.5%	
Confinement – natural	4	4	
Confinement – hydromodifications	0	NO DATA	
In-channel wood	3	1.9	
Embeddedness	0.9	2.5	
Fine sediment	2.3	1.9	

WEAVER CREEK 1

INTRODUCTION

Weaver Creek 1 is a tributary to Salmon Creek that enters from the north at RM 14.6 Reach 1 of Weaver Creek extends from it's confluence with Salmon Creek to the culvert where NE 199th Street crosses the stream. For most of the 2 mile section of Reach 1, Weaver Creek flows through a narrow v-shaped valley. The lowermost 305m (1,000 feet) of Weaver 1 flows across a small alluvial fan formed where Weaver Creek enters the Salmon Creek Valley. A total length of 1.1 km (0.7 mile) in two segments of this reach was surveyed as highlighted in yellow in Map B-5.

Map B-5. Portion of Weaver 1 surveyed.

CHANNEL MORPHOLOGY

Weaver 1 was classified as a moderate gradient mixed control to moderate gradient contained channel type. The reach had a map gradient of 1 percent. The channel is strongly controlled by bedrock. Because of the small stream size, channel confinement is expected to range from high to moderate, depending on the valley width. Because of the small channel size and low gradient, LW is expected to play an important role in sediment storage and pool formation. In the presence of abundant LW, channel bedforms would be expected to consist of forced pool-riffle sequences, with gravel stored in associated with wood features. If LW is scarce, plane-bed morphology would be expected to develop.

The wetted width of Weaver 1 during the survey averaged 3.4 m (11 ft). Habitat consisted primarily of pools, which represented 42 percent of the habitat by length (Figure B-9). Riffles and glides comprised the remainder of the habitat. The maximum depth of pools averaged greater than 0.5 m (1.6 ft). See Table B-35.

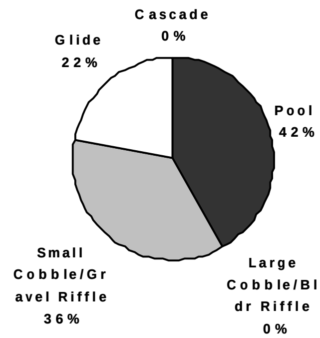


Figure B-9. Unit composition by percent surface area of the surveyed section of Weaver 1.

Table B-35. Average channel morphology characteristics of surveyed sections of Weaver 1

Parameter	Reach Value
Mean gradient	1%
Mean wetted width (m)	3.4 m
Mean active channel width (m)	3.6 m
Mean of the maximum riffle depths (m)	0.4
Mean residual pool depth (m)	0.5
Mean of the maximum pool depths (m)	0.7
Pools per kilometer (p/km)	15.9
Primary pools (>1.0m deep) per kilometer	0.9

WOOD

There were 35.6 pieces of large woody debris per kilometer (LW/km) recorded in Weaver 1 during the summer of 2004. The majority of LW was in the small and medium size classes (Table B-36). Some rootwads, but no debris jams were observed during the survey.

Table B-36. Size and density of wood, jams and root wads in surveyed section of Weaver 1.

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	16.9
Medium Pieces	20-50 cm diameter; > 2 m long	15
Large Pieces	> 50 cm diameter; > 2 m long	0.9
Jams	> 10 pieces in accumulation	0.0
Root wads	> 2 m long	2.8

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes were gravel and sand, respectively (Table B-37). The survey segment was located on the alluvial fan section of Weaver 1, thus substrate may not be representative of the higher gradient confined section.

Table B-37. Substrate grain size composition in surveyed section of Weaver 1.

Category	Mean Frequency
Sand	33
Gravel	49
Cobble	16
Boulder	1
Bedrock	2

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). The overall mean embeddedness level was 51 percent.

COVER

Cover was classified using the five different cover forms recognized by the protocol including: LW, undercut banks, overhanging cover, depth and substrate velocity breaks. Weaver 1 had a moderately wide channel with some overhead cover. In-stream cover was provided primarily by overhanging vegetation (Table B-38). Wood, undercut banks and water depth also provided some cover.

Table B-38. Presence of cover within the surveyed portion of Weaver 1. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	5%
Undercut Banks	1%
Overhanging Vegetation	39%
Water Depth > 1 m	4%
Substrate (Velocity Cover)	0%

RIPARIAN

Weaver Creek has a narrow channel that could be almost completely shaded by streamside trees. Weaver 1 was only partially shaded at the time of the survey in 2004. Riparian vegetation consisted primarily of mixed hardwood/conifer or hardwood forest (Figure B-10). The open channel width to the sky averages 3.6 m (12 ft) of channel width plus an additional 78 m (257 ft) of open bank or a total of 81 m (269 ft)-wide zone without vegetative cover. The mean view to sky is 36 percent open (Table B-39).

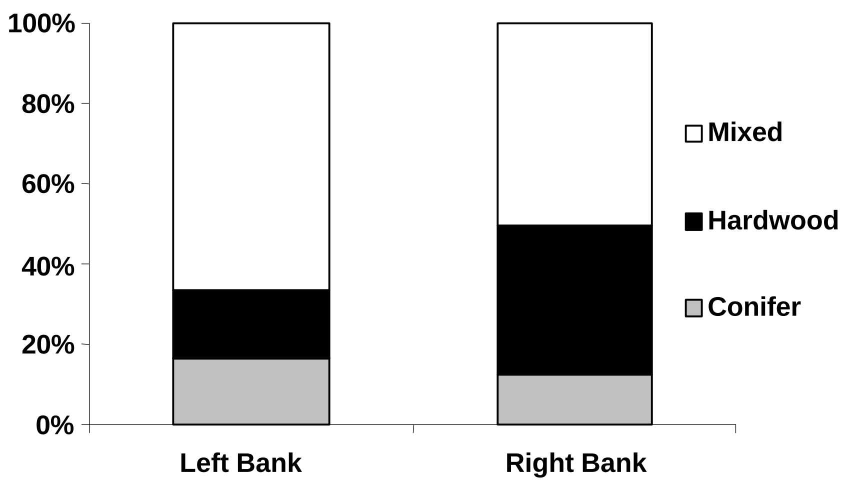


Figure B-10. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Table B-39. Riparian shading characteristics in survey section of Weaver 1. Data oriented in downstream direction.

Parameter	**Result**
Active Channel Width (m)	3.6 m
Mean distance to blocking vegetation – left bank (m)	23 m
Mean left bank canopy angle (degrees)	67 ^{o}
Mean distance to blocking vegetation – right bank (m)	59 m
Mean right bank canopy angle (degrees)	48 ^{o}
Mean view to sky (percent)	36%
Elevation (msl)	230’
Reference Temperature ($T^{o}C$) 7-DADmax	15.7
Estimated Current Temperature ($T^{o}C$) 7-DADmax	18.2
Measured Temperature ($T^{o}C$) 7-DADmax	21.8

With mature forest stands growing immediately adjacent to the channel, this reach would receive considerable shade. As such, it represents an area that is vulnerable to temperature increases resulting from vegetation removal. Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to approach 15.7°C. The current channel condition (VTS 20%) is anticipated to increase the reference condition 7-DADmax on a relative basis approximately 2.5°C or peak at 18.2°C. The predicted temperature is greater than aquatic use criteria for salmon and trout spawning and rearing. An estimate of the current 7-DADmax from surface water measurements collected by Clark County Public Utilities (CPU) during the summer of 2003 (Schnabel 2004) was 21.8 °C; higher than the predicted VTS temperature.

These estimates predict surface water temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of cool groundwater influx or warm wetland runoff. Actual water temperatures will vary with stream discharge, local weather patterns and the relative volume of groundwater, ponded water or tributary contribution.

INSTABILITY AND DISTURBANCE

Only minor bank instability was recorded in the surveyed section of Weaver 1 (Table B-40). Banks are expected to be naturally stable due to the predominance of bedrock control in the narrow valley. Approximately 5 percent of the 35m (100 ft) riparian zone on each bank was disturbed by roads.

Table B-40. Bank instability and disturbance of surveyed section of Weaver 1. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	1
Right bank instability (%)	1
Left bank disturbance (%)	5
Right bank disturbance (%)	5

COMPARISON TO EDT VALUES

EDT patient scores were generally similar to scores assigned based on the 2004 survey results. Important differences include: (1) channel morphology adjustments based on less minimum and maximum channel widths and less small cobble riffle and glide habitats with more pool habitats, especially beaver ponds and; (2) lower fine sediment levels but more embeddedness and less in-channel LW recorded during the 2004 stream surveys than previously estimated in the SRE database (Tables B-41 to B-43). The preponderance of beaver ponds may be one of the explanations for the warm surface water temperature regime in Weaver 1.

Table B-41. Comparison of EDT Level 2 attribute ratings assigned to Weaver 1, and EDT ratings based on 2004 stream survey and hydromodification analysis results for habitat quantity attributes.

Attribute	SRE Rating	Rating from Survey	% Change in Habitat Quantity
Channel width – minimum (ft)	14	11	-35.4%
Channel width – maximum (ft)	22	12	
Habitat Type – off-channel habitat factor (patient)	0.0%	NA	NA
Habitat Type – off-channel habitat factor (template)	1.0%	NA	NA

Table B-42. Comparison of EDT Level 2 attribute ratings assigned to Weaver 1, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	22.5%	24.5%	
Habitat Type – backwater pools	0.0%	0.0%	
Habitat Type – beaver ponds	0.0%	18.5%	
Habitat Type – pool tailouts	2.4%	11.3%	
Habitat Type – glides	30.6%	18.9%	
Habitat Type – small cobble/gravel riffles	44.4%	26.8%	
Habitat Type – large cobble/boulder riffles	0.0%	0.0%	

Table B-43. Comparison of EDT Level 2 attribute ratings assigned to Weaver 1, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	0.5%	1.0%	
Confinement – natural	2	2	
Confinement – hydromodifications	1	NO DATA	
In-channel wood	3	3.8	
Embeddedness	1.6	2.5	
Fine sediment	3.3	2.0	

ROCK CREEK 1

INTRODUCTION

Rock Creek is a tributary to Salmon Creek that enters from the north near RM 22. Reach 1 of Rock Creek extends from the confluence with Salmon Creek to a left bank tributary that enters near RM 0.3. Rock 1 occupies a narrow v-shaped valley. The entire reach was surveyed in 2004 (Map B-6).

Map B-6. Portion of Rock 1 surveyed.

CHANNEL MORPHOLOGY

Rock 1 was classified as a moderate gradient mixed control channel type. The reach had a map gradient of 1 percent. The channel is strongly controlled by bedrock; however, because of the small stream size, confinement is moderate. LW plays an important role in sediment storage and pool formation in this channel type. In the presence of abundant LW, channel bedforms would be expected to consist of forced pool-riffle sequences, with gravel stored in associated with wood features. If LW is scarce, plane-bed morphology would be expected to develop.

The wetted width of Rock 1 during the survey averaged 2.0 m (6.5 ft). Habitat consisted primarily of pools, which represented 59 percent of the habitat by length (Figure B-11). Riffles comprised the remainder of the habitat. The maximum depth of pools averaged greater than 0.9 m (3.0 ft). See Table B-44.

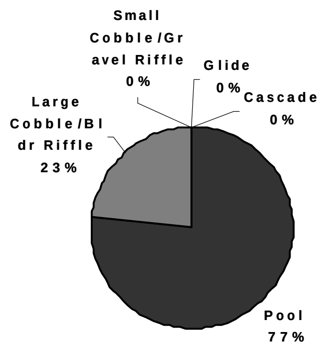


Figure B-11. Unit composition by percent surface area of the surveyed section of Rock 1.

Table B-44. Average channel morphology characteristics of surveyed sections of Rock 1.

Parameter	Reach Value
Mean gradient	1%
Mean wetted width (m)	2.0 m
Mean active channel width (m)	7.1 m
Mean of the maximum riffle depths (m)	0.5
Mean residual pool depth (m)	0.6
Mean of the maximum pool depths (m)	0.9
Pools per kilometer (p/km)	19.6
Primary pools (>1.0m deep) per kilometer	8.2

WOOD

There were 52.2 pieces of large woody debris per kilometer (LW/km) recorded in Rock 1 during the summer of 2004. The majority of LW was in the small and medium size classes (Table B-45). No rootwads or debris jams were observed during the survey.

Table B-45. Size and density of wood, jams and root wads in surveyed section of Rock 1.

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	18.0
Medium Pieces	20-50 cm diameter; > 2 m long	26.0
Large Pieces	> 50 cm diameter; > 2 m long	8.2
Jams	> 10 pieces in accumulation	0.0
Root wads	> 2 m long	0.0

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes were gravel and sand, respectively (Table B-46).

Table B-46. Substrate grain size composition in surveyed section of Rock 1.

Category	Mean Frequency
Sand	29
Gravel	54
Cobble	5
Boulder	5
Bedrock	6

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). The overall mean embeddedness level was 31 percent.

COVER

Cover was classified using the five different cover forms recognized by the protocol including: LW, undercut banks, overhanging cover, depth and substrate velocity breaks. Rock 1 has a narrow channel with some overhead cover. Instream cover was provided primarily by overhanging vegetation (Table B-47). Wood and water depth also provided some cover.

Table B-47. Presence of cover within the surveyed portion of Rock 1. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	4%
Undercut Banks	0%
Overhanging Vegetation	31%
Water Depth > 1 m	8%
Substrate (Velocity Cover)	0%

RIPARIAN

Rock Creek has a narrow channel that could be almost completely shaded by streamside trees. Rock 1 was partially shaded at the time of the survey in 2004. Riparian vegetation consisted of a mixture of hardwood conifer and mixed stands on the left bank, and was border by conifer or mixed hardwood conifer stands on the right bank (Figure B-12). The open channel width to the sky averages 7.1 m (23 ft) of channel width plus an additional 45 m (147 ft) of open bank or a total of 52 m (170 ft) wide zone without vegetative cover. The mean view to sky is 25 percent open (Table B-48).

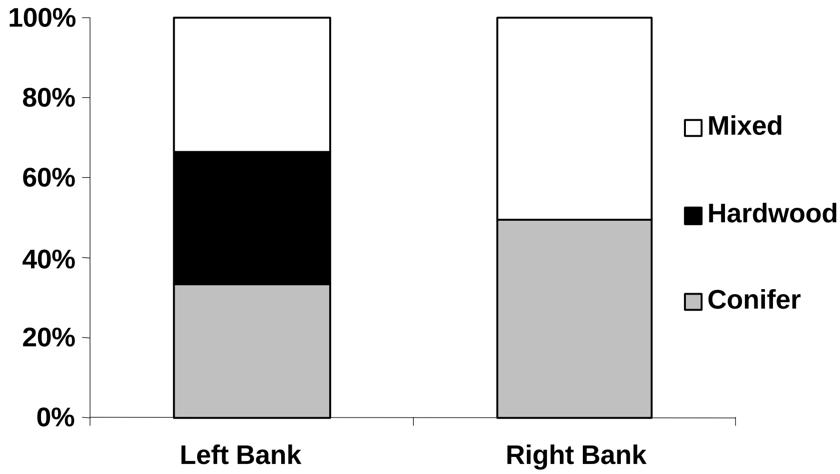


Figure B-12. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Table B-48. Riparian shading characteristics in survey section of Rock 1. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	7.1 m
Mean distance to blocking vegetation – left bank (m)	42 m
Mean left bank canopy angle (degrees)	62^{o}
Mean distance to blocking vegetation – right bank (m)	10 m
Mean right bank canopy angle (degrees)	72^{o}
Mean view to sky (percent)	25%
Elevation (msl)	355’
Reference Temperature ($T^{o}C$) 7-DADmax	15.6
Estimated Current Temperature ($T^{o}C$) 7-DADmax	17.1
Measured Temperature ($T^{o}C$) 7-DADmax – 2003	21.4
Measured Temperature ($T^{o}C$) 7-DADmax – 2004	23.6

With mature forest stands growing immediately adjacent to the channel, this reach would receive considerable shade. As such, it represents an area that is vulnerable to temperature increases resulting from vegetation removal. Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to approach 15.6^{o}C. The current channel condition (VTS 25%) is anticipated to increase the 7-DADmax on a relative basis approximately 1.5^{o}C compared to reference conditions or peak at 17.1^{o}C. The predicted temperature is greater than aquatic use criteria for salmon and trout spawning and rearing. Estimates of the current 7-DADmax from surface water measurements collected by Clark County Public Works, Water Resources during the summers of 2003 (Schnabel 2004) and 2004 were 21.4^{o}C and 23.6^{o}C, respectively. Both of these measurements were substantially higher than the predicted VTS temperature.

These estimates predict surface water temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of cool groundwater influx or warm wetland runoff. Actual water temperatures will vary with stream discharge, local weather patterns and the relative volume of groundwater, ponded water and tributary contribution

INSTABILITY AND DISTURBANCE

Only minor bank instability was recorded in the surveyed section of Rock 1 (Table B-49). Banks are expected to be naturally stable due to the predominance of colluvium or bedrock control in the narrow valley. Approximately 15 to 20 percent of the 35m (100 ft) riparian zone on each bank was disturbed by residential development or forest harvest.

Table B-49. Bank instability and disturbance of surveyed section of Rock 1. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	0
Right bank instability (%)	0
Left bank disturbance (%)	20
Right bank disturbance (%)	15

COMPARISON TO EDT VALUES

EDT patient scores were generally similar to scores assigned based on the 2004 survey results. Important differences include: (1) channel morphology adjustments based on less minimum and maximum channel widths and less small cobble riffle and glide habitats with more pool habitats, especially beaver ponds and; (2) lower fine sediment levels recorded during the 2004 stream surveys than previously estimated in the SRE database (Tables B-50 to B-52). The preponderance of beaver ponds may be one of the explanations for the warm surface water temperature regime and lower in-channel loading of fine sediments in Rock 1.

Table B-50. Comparison of EDT Level 2 attribute ratings assigned to Rock 1, and EDT ratings based on 2004 stream survey and hydromodification analysis results for habitat quantity attributes.

Attribute	SRE Rating	Rating from Survey	% Change in Habitat Quantity
Channel width – minimum (ft)	17	6	-45.5%
Channel width – maximum (ft)	34	22	
Habitat Type – off-channel habitat factor (patient)	0.0%	NA	NA
Habitat Type – off-channel habitat factor (template)	1.0%	NA	NA

Table B-51. Comparison of EDT Level 2 attribute ratings assigned to Rock 1, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	25.6%	20.5%	
Habitat Type – backwater pools	11.9%	0.0%	
Habitat Type – beaver ponds	10.7%	40.2%	
Habitat Type – pool tailouts	6.1%	5.1%	
Habitat Type – glides	2.9%	0.0%	
Habitat Type – small cobble/gravel riffles	42.8%	18.2%	
Habitat Type – large cobble/boulder riffles	0.0%	16.0%	

Table B-52. Comparison of EDT Level 2 attribute ratings assigned to Rock 1, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	0.7%	1.0%	
Confinement – natural	3	3	
Confinement – hydromodifications	1	NO DATA	
In-channel wood	3	3.4	
Embeddedness	1.3	1.7	
Fine sediment	2.8	1.3	

ROCK CREEK 2

INTRODUCTION

Rock Creek is a tributary to Salmon Creek that enters from the north near RM 22. Reach 2 of Rock Creek extends from RM 0.3 to RM 1.1. Rock 2 occupies a narrow v-shaped valley, although there are some wider areas than were present in Rock 1. The entire reach was surveyed in 2004 (Map B-7).

Map B-7. Portion of Rock 2 surveyed.

CHANNEL MORPHOLOGY

Rock 2 was classified as a moderate gradient, mixed control channel type. The reach had a map gradient of 1.1 percent. The valley appears to be controlled by bedrock; however, because of the small stream size, confinement is moderate, and there may be areas of low confinement in wider sections of the valley. LW plays an important role in sediment storage and pool formation in this channel type. In the presence of abundant LW, channel bedforms would be expected to consist of forced pool-riffle sequences, with gravel stored in associated with wood features. If LW is scarce, plane-bed morphology would be expected to develop.

The wetted width of Rock 2 during the survey averaged 1.9 m (6.0 ft). Habitat consisted primarily of pools, which represented 74 percent of the habitat by length (Figure B-13).

Riffles and glides comprised the remainder of the habitat. The maximum depth of pools averaged greater than 1.0 m (3.3 ft). See Table B-53.

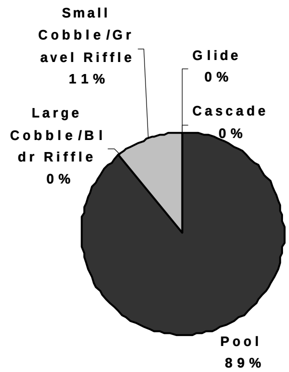


Figure B-13. Unit composition by percent surface area of the surveyed section of Rock 2.

Table B-53. Average channel morphology characteristics of surveyed sections of Rock 2.

Parameter	Reach Value
Mean gradient	1.5%
Mean wetted width (m)	1.9 m
Mean active channel width (m)	6.3 m
Mean of the maximum riffle depths (m)	0.4
Mean residual pool depth (m)	0.6
Mean of the maximum pool depths (m)	1.0
Pools per kilometer (p/km)	33.5
Primary pools (>1.0m deep) per kilometer	14.9

WOOD

There were 68 pieces of large woody debris per kilometer (LW/km) recorded in Rock 2 during the summer of 2004. The majority of LW was in the small and medium size classes (Table B-54). No debris jams were observed during the survey, although some rootwads were present.

Table B-54. Size and density of wood, jams and root wads in surveyed section of Rock 2.

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	26.0
Medium Pieces	20-50 cm diameter; > 2 m long	26.0
Large Pieces	> 50 cm diameter; > 2 m long	8.4
Jams	> 10 pieces in accumulation	0.0
Root wads	> 2 m long	7.4

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes were gravel and sand, respectively (Table B-55).

Table B-55. Substrate grain size composition in surveyed section of Rock 2.

Category	Mean Frequency
Sand	34
Gravel	56
Cobble	10
Boulder	0
Bedrock	0

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). The overall mean embeddedness level was 47 percent.

COVER

Cover was classified using the five different cover forms recognized by the protocol including: LW, undercut banks, overhanging cover, depth and substrate velocity breaks. Rock 2 has a narrow channel with some overhead cover. In-stream cover was provided primarily by overhanging vegetation (Table B-56). Wood and water depth also provided some cover.

Table B-56. Presence of cover within the surveyed portion of Rock 2. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	3%
Undercut Banks	0%
Overhanging Vegetation	25%
Water Depth > 1 m	4%
Substrate (Velocity Cover)	0%

RIPARIAN

Rock Creek has a narrow channel that could be almost completely shaded by streamside trees. Rock 2 was partially shaded at the time of the survey in 2004. Riparian vegetation consisted primarily of hardwood and mixed stands, although some conifer stands were present on the right bank (Figure B-14). The open channel width to the sky averages 6.3 m (21 ft) of channel width plus an additional 39 m (128 ft) of open bank or a total of 45 m (149 ft)-wide zone without vegetative cover. The mean view to sky is 23 percent open (Table B-57).

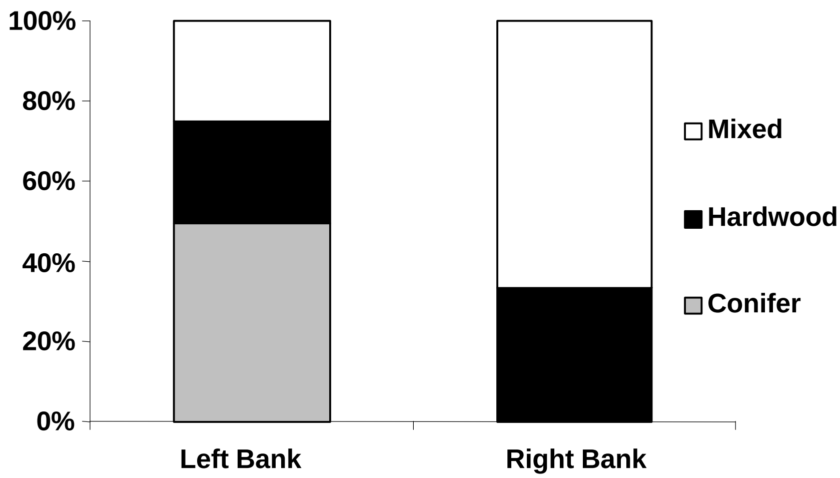


Figure B-14. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Table B-57. Riparian shading characteristics in survey section of Rock 2. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	6.3 m
Mean distance to blocking vegetation – left bank (m)	20 m
Mean left bank canopy angle (degrees)	72 ^{o}
Mean distance to blocking vegetation – right bank (m)	25 m
Mean right bank canopy angle (degrees)	66 ^{o}
Mean view to sky (percent)	23%
Elevation (msl)	385’
Reference Temperature ($T^{o}C$) 7-DADmax	15.6
Estimated Current Temperature ($T^{o}C$)- 7-DADmax	17.1

With mature forest stands growing immediately adjacent to the channel, this reach would receive considerable shade. As such, it represents an area that is vulnerable to temperature increases resulting from vegetation removal. Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to approach 15.6^{o}C. The current channel condition (VTS 23%) is anticipated to increase the 7-DADmax on a relative basis approximately 1.5^{o}C compared to reference conditions or peak at 17.1^{o}C. The predicted temperature is greater than aquatic use criteria for salmon and trout spawning and rearing.

These estimates predict surface water temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of cool groundwater influx or warm wetland runoff. Actual water temperatures will vary with stream discharge, local weather patterns and the relative volume of groundwater, ponded water and tributary contribution.

INSTABILITY AND DISTURBANCE

Only minor bank instability was recorded in the surveyed section of Rock 2 (Table B-58). Banks are expected to be naturally stable due to the predominance of colluvium or bedrock control in the narrow valley. Less than 5 percent of the 35m (100 ft) riparian zone on each bank was disturbed.

Table B-58. Bank instability and disturbance of surveyed section of Rock 2. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	2
Right bank instability (%)	4
Left bank disturbance (%)	1
Right bank disturbance (%)	5

COMPARISON TO EDT VALUES

EDT patient scores were generally similar to scores assigned based on the 2004 survey results. Important differences include: (1) channel morphology adjustments based on less minimum channel widths and less small cobble riffle and glide habitats with more beaver ponds and pool tailouts; (2) lower fine sediment levels with slightly more embeddedness levels recorded during the 2004 stream surveys than previously estimated in the SRE database (Tables B-59 to B-61). The preponderance of beaver ponds may be one of the explanations for the lower in-channel loading of fine sediments in Rock 2 and it may indicate a warmer thermal regime than predicted based on elevation and current riparian canopy closure levels.

Table B-59. Comparison of EDT Level 2 attribute ratings assigned to Rock 2, and EDT ratings based on 2004 stream survey and hydromodification analysis results for habitat quantity attributes.

Attribute	SRE Rating	Rating from Survey	% Change in Habitat Quantity
Channel width – minimum (ft)	11	6	-15.0%
Channel width – maximum (ft)	22	23	
Habitat Type – off-channel habitat factor (patient)	0.0%	NA	NA
Habitat Type – off-channel habitat factor (template)	1.0%	NA	NA

Table B-60. Comparison of EDT Level 2 attribute ratings assigned to Rock 2, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	45.0%	49.5%	
Habitat Type – backwater pools	2.2%	0.0%	
Habitat Type – beaver ponds	0.0%	5.8%	
Habitat Type – pool tailouts	8.1%	20.1%	
Habitat Type – glides	21.8%	8.2%	
Habitat Type – small cobble/gravel riffles	22.9%	16.4%	
Habitat Type – large cobble/boulder riffles	0.0%	0.0%	

Table B-61. Comparison of EDT Level 2 attribute ratings assigned to Rock 2, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	0.9%	1.5%	
Confinement – natural	2	2	
Confinement – hydromodifications	0	NO DATA	
In-channel wood	3	3.4	
Embeddedness	1.3	2	
Fine sediment	2.8	1.5	

APPENDIX 5C

Geologic Map Units

Table C-1. Definition of geologic map units found in Kalama, lower North Fork Lewis, and Washougal basins (edited from Walsh et al. 1987).

Database Symbol	Unit Name	Description
Qa	Alluvium	Silt, sand, and gravel deposited in streambeds and fans; surface relatively undissected
Qls	Landslide debris	Clay, silt, sand, gravel, and larger blocks; unstratified and poorly sorted; surface commonly hummocky. Includes the 1980 debris avalanche of Mt St Helens, talus, and all other mass wasting deposits
Qt	Terraced sediments	Silt, sand, and gravel of diverse compositions and origins, such as proglacial outwash, glacial outburst deposits, older alluvium, lahars, and uplifted coastal marine and estuarine deposits.
Qfs	Flood sand and silt (Glacial Lake Missoula Outburst deposits)	Silt, sand, and clay, commonly grading into unit Qfg; contains slackwater deposits and cross-bedded fine grained surge deposits, and some interbedded gravels
Qfg	Flood gravel (Glacial Lake Missoula Outburst deposits)	Boulder to cobble gravel with sandy matrix and minor silt interbeds
Qap	Undifferentiated drift	Glacial till and outwash sand and gravel.
QPlc	Continental sediments	Gravel, sand, silt and clay; deposits of ancestral Columbia River contain distinctive orange quartzite clasts thought to be derived from northeast Washington
Qvb	Quaternary basalt flows	Light gray to black, microphyric to coarsely phyric olivine basalt and olivine-clinopyroxene basalt
Qvc	Quaternary volcaniclastic deposits, undivided	Ash- to block-sized lithic and pumice-rich pyroclastic deposits, debris flows, laharic deposits, pumice lapilli, and ash tephra, and fluvial gravels, sand, and silt; deposited by pyroclastic flows, lahars, and debris avalanches; at Mt St Helens, lithic clasts consist of gray to pink hornblende-hypersthene dacite and andesite and lesser black andesite and basalt, locally interbedded with glacial till
Qvl	Quaternary lahars	Unsorted to poorly sorted, generally unstratified mixtures of cobbles and boulders supported by a matrix of sand or mud; also contains lesser stratified fluvial deposits
Qplva	Pleistocene-Pliocene andesite flows	Gray olivine-hypersthene, pyroxene, hornblende, and hypersthene-hornblende andesite flows and associated breccias; erupted from vents
QPlvb	Pleistocene-Pliocene basalt flows	Gray to gray-black, aphyric and plagioclase-olivine-phyric and pyroxene-olivine-phyric basalt; commonly trachytic; platy, blocky, and columnar jointed; commonly scoriaceous; erupted from multiple vents distinguished by cinder cones
@va	Oligocene andesite flows	Aphyric to porphyritic andesite flows and flow breccia; in southwest Skamania County, thick flows of clinopyroxene basaltic andesite.
@vc	Oligocene volcaniclastic rocks	Greenish to brown and maroon, andesitic to basaltic lithic breccia, tuff, and tuff breccia, and volcanic siltstone, sandstone, and conglomerate; interbedded with basalt and andesite flows and rare dacite to rhyolite flows and tuffs; breccias typically unstratified, crudely graded, or very thickly bedded, poorly sorted, with clasts of pyroclastic rock, porphyritic basaltic andesite to dacite, aphyric to glassy lava, in a matrix of altered plagioclase, devitrified glass ahards and clay; sandstone and ash to lapilli tuff commonly form well-bedded, graded, parallel laminated, poorly to well sorted sequences

Table C-1. Definition of geologic map units found in Kalama, lower North Fork Lewis, and Washougal basins (edited from Walsh et al. 1987).

Database Symbol	Unit Name	Description
@vt	Oligocene tuff	Crystal-lithic and pumice-lithic tuff and tuff-breccia; in the Mt St Helens area, dominantly pyroxene- and plagioclase-phyric with lesser quartz-phyric, block to lapilli tuffs, commonly unstratified and poorly sorted; interbedded with volcanic sedimentary rocks and dacitic to andesitic flows or plugs
@Eva	Lower Oligocene to upper Eocene andesitic flows	Platy to massive, vesicular to dense, porphyritic basaltic andesite flows and flow breccia, with lesser andesite, basalt, and dacite; flows commonly have oxidized, wavy bases and thin interbeds of shale, tuff, or volcanic sandstone and conglomerate; forms complexes of numerous thin, irregularly shaped flows of limited areal extent; most flows are plagioclase-clinopyroxene phyric; two-pyroxene or olivine-phyric flows also present; zeolites and calcite common in amygdules and fractures
#igd	Miocene granodiorite	Porphyritic to equigranular, Fine- to medium-grained, hornblende-biotie or pyroxene granodiorite and lesser quartz monzonite and quartz diorite
#iq	Miocene quartz diorite	Equigranular to porphyritic quartz diorite
#ian / #@ian	Miocene / Miocene-Oligocene intrusive andesite	Aphanitic to porphyritic pyroxene and hornblende andesite and basaltic andesite / aphyric to porphyritic hornblende-, pyroxene-, and hornblende-pyroxene andesite; forms dikes, dike swarms, sills, small plugs, and stocks
#id / #@id	Miocene / Miocene-Oligocene diorite	Fine- to medium-grained and commonly porphryitic pyroxene diorite, pyroxene-hornblende diorite, and hornblende diorite; occurs as sills, dikes, small stocks, and cupulas of major plutons; contains lesser quartz diorite
#vt / #@vt	Miocene / Miocene-Oligocene tuff	Welded to non-welded, vitric to crystalline, lithic and pumiceous dacite and rhyolite tuffs and tuff breccias; commonly quartz phyric; contains pyroclastci flows and airfall tuff with minor silic lava flows and volcaniclastic sedimentary rocks,
#va	Miocene andesite flows	Pyroxene andesite and two-pyroxene andesite and balsatic andesite flows and flow breccia; also contains minor hornblende-pyroxene andesite and clinopyroxene basalt flows interbedded with volcaniclastic breccia, tuff, and volcanic sandstone; lavas commonly porphryitic
#vc	Miocene volcaniclastic rocks	Massive to well-bedded volcaniclastic breccias and conglomerates, tuffs, tuff breccias, and volcanic sandstones and siltstones
#vg	Middle Miocene Grande Ronde basalt	Fine grained, aphyric to very sparsely phyric flood-basalt with basaltic andesite chemistry, forms broad sheet flows with sedimentary interbeds of tuffaceous sandstone, siltstone, and conglomerate
#vw	Middle Miocene Wanapum basalt	Fine- to coarse-grained, sparsely phyric to abundantly phyric theoleiitic basalts, forming sheet flows that have thin sedimentary interbed and a few intracanyon flows
#cg	Miocene continental sedimentary rocks, conglomerate	Conglomerate with abundant dark-colored porphyritic andesite clasts, debris flow breccia, pebbly volcaniclastic sandstone, siltstone, and minor airfall tuff; commonly thick bedded