Fish Habitat Assessment and Restoration Prescriptions for the Channelized Section on the Mainstem Salmo River from Erie Creek to Hell Roaring Creek

For the
Salmo Watershed Streamkeepers Society
Salmo, B.C.

By
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Statement of Limitations

These habitat assessments and prescriptions are based on training and experience gained in the field and through study. The success and stability of implemented prescriptions is dependant upon adherence to established best management practices. Cabled streambank attachments of large wood to stable large tree bases and/or buried ballast boulders are essential. The Erie Creek to Hell Roaring Creek reach of the Salmo is seen as a 'discharge' reach for the Village of Salmo especially 'section or reach 3' of this area. As such any implementation of fish habitat prescriptions should be preceded by an education/awareness effort in the community to ensure folks that minimal risks are involved. A public meeting may be in order to give the community a venue to ask questions. As well all hydraulic backwater effects of implemented habitat restoration prescriptions should be checked and calculated by a qualified hydraulic engineer to ensure channel capacity is not significantly affected by the prescribed streambank-attached groins or instream boulder structures.

Letters of agreements for habitat restoration should be written between riparian landowners and any organization that implement structural components suggested in this report. This approach should insure full disclosure of the risks and benefits involved in bringing this area closure to nature.

Acknowledgements

This fish habitat/prescription project was funded by The Department of Fisheries and Oceans, Nelson Office and coordinated by Salmo Watershed Streamkeepers Society (SWSS). We thank DFO for their guidance. SWSS, in carrying out this FHAP/Prescription is following the suggestions forwarded by the Salmo Watershed Planning Team. That team came together to develop a Watershed-based Fish Sustainability Plan (WFSP) for this area. Participants involved in the WFSP are listed on the following page. This list is by no means exhaustive, participation in the WFSP constantly evolves and often is shaped by information and ideas gained through 'coffee conversations' that get back to the WPT. The 'Plan' is designed to change; it is a 'living plan' that will adapt as parts of the plan are completed and as new information comes available. SWSS wants to thank all those in our community that contribute to a healthy aquatic ecosystem here, we know there are many of you, your importance to aquatic ecosystem health efforts are profound.

It's a pleasure to thank Pat Slaney of the BC Conservation Foundation for his constant availability to answer questions and provide assistance. Pat provided the format and introductory and other material for this report. Pat's interest in this watershed is inspirational to the SWSS and can only help make the 'Place Where We Live' better.

Last but not least we need to thank Alice Nellestijn she is always there for projects that make the Salmo Watershed a better Place. Her constant computer and/or field contributions always make our projects easier, better and more fun!

Cover Photo: ***Featureless fish habitat conditions of the Salmo River in Reach 3 just down stream of the Salmo-township during low late-summer flows of 2006 -GN.***

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Executive Summary

In the summer base flows of September 2006, the condition of salmonid habitat was assessed for 3.25 km. of the Salmo River main stem from Erie Creek to Hell Roaring Creek using the Fish Habitat Assessment Procedure (FHAP) applied in BC's Watershed Restoration Program (1994-2002). Fish Habitat restoration prescriptions were also completed in featureless habitat units or where streambank erosion was evident. The area covered by this FHAP is commonly known, by those who have worked in the Salmo from a fisheries perspective as the 'Biological Deadzone'. This area lies within Reach 2 – South Salmo River to Erie Cr., as determined by the Salmo Watershed Planning Team (WPT) and was specifically identified by them for FHAP/Prescription work as one of the many channelized areas in the system.

Three sections were determined: Section 1, 989 m's. from Hell Roaring Creek to just downstream of the Carney Mill Rd. river access. Section 2, 580 m's just down stream of the Carney Mill Rd. access to approximately 450 meters up stream of the Carney Mill Rd. access (see map 1). Section 3 is 1676 m's to the confluence of the Salmo River and Erie Creek.

The entire channel – with the exception of approximately 100 meters river left in section 2 in the Hell Roaring Cr. (HRC) to Erie Cr. (EC) area of the Salmo River is in an unnatural vegetative state. The riparian forests of both sides of the river were historically logged or cleared to the riverbanks. Ninety percent of the river left bank and forty percent of the river right bank in section 1, Hell Roaring Cr. to downstream of Carney Mill Road access was channelized in the 1960's. Although section 2, upstream and downstream of Carney Mill Road has relatively little channelization it is greatly braided and sandwiched between the heavily channelized section 1 and the completely channelized section 3. Section 3 has both the left and right banks dyked for its entire length greatly affecting channel geomorphology. A cursory examination of pre and post dyking air photos (figures 1&2) will show existing habitat is perhaps 5% of what it was before channelization. With the exception of section 2 the long-term supply of larger LWD to the channel has been greatly reduced or completely nullified thereby impacting the quality of salmonid habitats, especially salmonid cover. Without stream restoration this area is destined to remain the 'biological deadzone' as it is described now. Natural habitat recovery is unlikely in this stretch of river. However there are opportunities within this area to enhance fish habitat and maintain the flood control values that the area holds to now.

The lower HRC to Carney (R1) Section of the Salmo River consists of simple riffles and flat glides. Pools, as primary and pocket pools equated to only 2.4%, which is extremely low. The Carney Section (R2) was also deficient at .5%, although this reach exhibited the best habitat rating by far of all 3 sections it ratings come in low because of the exceptional braided make up of this area. Bank full widths exceeded 124 m's, four times greater than the other sections.

R3 also came in way below a 'fair' rating (20-30%-Watershed Restoration Technical Circular #8 pg.27, based on streams <15 wide) at 2.4 % pool habitat.

Frequency of functional large woody debris (LWD), a key habitat and cover feature were almost non-existent with the exception of R2 which had functional LWD numbers at 25 was rated as good quality (>2 TC#8). R2 the lowest length area by far displayed the best habitat complexity.

A total of seventeen structures were prescribed in R1, 5 boulder clusters, 9 triangular wood structures (8 - 2 root wad structures c/w ramp logs and 1 - 2 root wad structure no ramp logs) as well as 3 J-hook vanes. There were 3 – 2 root wad c/w ramp log structures prescribed on the river left eroded section of R2. These structures were prescribed to facilitate erosion control more than fish enhancement; habitat in this section was rated good in fact annual snorkel swims (personal observation GN) confirm healthy fish populations in R2. Structures were prescribed as ‘proposed’ should the landowner request them for bank stabilization. Structures in R2 may be at risk because of the braidedness here. In R3 the longest section and the section that seems to carry the most landowner/community concern around bank stabilization issues wood structures, for the most part were restricted and rock structure prevailed. R3 holds 15 structures over more than a kilometer and a half, very lightly prescribed. Six rock groynes c/w root wads, 5 boulder clusters, 1 j-hook vane and 3 apposing rock deflectors were prescribed. Some areas were also suggested for revegetation. Phasing of works over 2 to 3 years is recommended and should include an initial 1 km demonstration project in Reach 1. Estimated restoration costs are $70,000 per km, and can be reduced by use of donated local materials.

Measures need to be taken to respect landowner concerns and to minimize any effects on channel flow capacity, thus requiring hydraulic engineering input within the confined/channelized 1700 m of Reach 1. Furthermore, because some stream paddlers utilize this section of the Salmo River measures to minimize any paddler risk need to be accommodated during construction and maintenance.

Where streambank and channel-attached triangular wood structures are prescribed it should be emphasized, when hydraulically designed, they have had very high physical and biological success rates, as documented in Wilson et al. (2002, with a prime example at the West Kettle River 16 km south of Beavedell). Boulder ballasting acts as a secure replacement for the large root masses that anchor old growth large wood in unlogged natural old-growth channels. In contrast to conventional riprap armouring and dyking, these habitat structures generate a substantial net gain in fish habitat.

Fish habitat rehabilitation of this section of the Salmo River should be beneficial to Salmo River fish production. This rehabilitation could significantly increase the abundance of rainbow trout and bull trout char within a regionally significant sport fishery.

1. Introduction

Fish habitat assessment procedures (FHAP) and habitat restoration prescriptions were conducted on September 29th and 30th, 2006, on the Salmo River main stem between Erie Creek and Hell Roaring Creek by the Salmo Watershed Streamkeepers Society (SWSS). A total of 3.25 km of river was assessed and restoration techniques prescribed throughout a highly anthropogenically modified section of the Salmo River.

Historically, in the 1960's the Provincial Emergency Preparedness Program (PEPP) funded a program to channelize sections of the Salmo River. PEPP and other programs were responsible for channelizing the entire area between Erie and Hell Roaring Creeks with the exception of section 2 of our study area. The work in this area was completed with the idea to discharge or 'move water out' of critical downstream areas of human habitation. The 'Dyke and Drain' approach employed 40 + years ago was thought to provide flood control regardless of loss of fish and wildlife habitat. In many cases this type of flood control has proven to be hazardous because large volumes of fast moving water are too much for dyking systems causing breech and aggressive damage. Today it is thought that a combination of slowing water down, meander and overflow (wetland) within a setback dyke regime provide more safety and a much more diverse fish and wildlife opportunity. Trying to mimic nature in the way it dissipates the force of extreme flows has proven to be the safest technique available to us.

This area is by no means the only channelized area in the Salmo River Watershed. In August 2004 a GPS survey (Nellestijn & Heinbuch) was undertaken from Upper Porto Rico Bridge to the 'old Burnt out Bridge' just down stream of the Canex Tailings. A total of 32.3 kilometers of river were surveyed (64+km's of shoreline). The survey found that 13.9 km's or 24% of these shorelines were channelized. Channelization was mostly rip rap and berms developed by the Ministry of Transport, Railroad construction and some flood protection.

Also there has been extensive mining activity, land clearing and forest harvesting since the late 1800s in the Salmo River watershed. From the late 1800s to the mid-1950s, mining activities were the primary economic activity in the Salmo watershed (Heinbuch and Nellestijn 2000). Coinciding with decreases in mine ore and in precious metal prices by 1950, mining in the watershed declined. Past mining activity in the Salmo River watershed is most evident from remnant mine tailings deposits located near the Salmo River and some of its tributaries. One of the larger deposits is located adjacent to the highway and river about 10 km south of the town of Salmo, where Canadian Exploration Limited's lead-zinc mining and milling operations were active from 1949 to 1970 (and small mining and milling operations since 1917). Another large tailings deposit is located alongside the Salmo River at the town Ymir, located between the township of Salmo and the City of Nelson. Larger primary tributary watersheds have had significant historical mining exploration and mining activity, especially the Sheep Creek and Erie Creek watersheds (Heinbuch and Nellestijn 2000).

Meander-bends of rivers and streams are subject to natural bank erosion. Mature riparian forests with large trees and root masses provide substantial erosion resistance at river banks compared to young trees, as does woody debris including log jams (Slaney et al. 1997). Thus, it is important that riparian zones along the Salmo River and its tributaries are preserved, or at sites historically disturbed or denuded, restored to reduce flood damage as well as to maintain viable fish habitat.

The Salmo River system supports regionally significant populations of rainbow trout and bull trout char. Westslope cutthroat trout, brook trout and mountain whitefish are also reported (from the provincial data warehouse) in some of the waters of the Salmo watershed. Several other non-salmonid species also inhabit the river, including longnose sucker, large scale sucker, redside shiner, slimy sculpin, and northern pike minnow.

In British Columbia, the typical life-history pattern for inland river trout and char is spawning in tributaries and rearing there for 1-3 years prior to further rearing to the adult stage in the main stem. Recent radio tracking studies at the Salmo River have indicated that large trout spawning can occur in the main stem river (G. Nellestijn personal communication 2004), but the general life–history pattern is that most trout and char are reliant on tributary nursery areas for spawning and rearing. Thus, quality of habitat in the key nursery tributaries is ultimately important for viability of these salmonid populations (Slaney et al. 1984). Because piscivourous fish species (as well as fish eating birds, mammals and other predators) inhabit or utilize the Salmo system, woody and boulder refuges within the Salmo River are of vital importance in the annual production of juvenile salmonids which migrate to the mainstem at a size of 8 to 20 cm (Slaney et al. 1986).

In the Pacific Northwest, historical practices of riparian logging or clearing have resulted in losses of woody accumulations along riverbanks and at apexes of side-channels (Koski 1992). Removal of riparian functions can accelerate stream bank erosion (Murphy 1995). At Section 1 and 3 within this reach, fear of flooding has resulted in streambank dyking and channelization as attempts to moderate higher flood waters. Large woody debris (LWD) accumulations have also been removed selectively in the past as a channel management activity. Such activities, if not undertaken as “best management practices” via habitat guidance, can greatly affect natural geomorphology to the degree that there are significant losses of fish habitat, including salmonid spawning gravels, flood shelters and cover features (Slaney and Zaldokas 1997). Habitat restoration is required to replace lost large wood and other natural shelter structures (Slaney et al. 1997, Ward 1997, Roni et al. 2002). Drought flows of 0.15-0.2 m^3/sec can be expected periodically in the Salmo River, and thereby, complex woody habitat shelters and other habitat structures are required for fish survival in this part of the stream, a function confirmed from a decade of monitoring at the West Kettle River during the existing global warming regime.

The purpose of this report is to summarize fish habitat assessments (FHAP) and habitat restoration prescriptions that were undertaken on September 29th and

30th, 2006, between Erie Creek and Hell Roaring Creek on the Salmo River main stem. The Salmo Streamkeepers Society (SWSS) initiated this survey after this area was identified by the Watershed Planning Team (WPT) as a priority area for restoration work.

Study Site

The Salmo River rises from the Selkirk Mountains 12 km southeast of Nelson, BC. The river progresses in a southerly direction for approximately 60 km from its origin to the confluence with the Pend d'Oreille River (Seven Mile Reservoir). Geographic information is summarized in Table. 1. The system is a 5th order stream, and has a total drainage basin or roughly 123,000 ha. Stream magnitude is relatively large (367) because there are 29 significant tributaries with high elevations throughout the river's length.

Elevation in the basin ranges from 564 metres at its confluence to 2,343 metres at the height of land. Within this elevation range, the system comprises two biogeoclimatic zones (Braumandl and Curran 1992). At lower elevations, the valley lies within the Interior Cedar-Hemlock (ICH) zone, while areas in the higher elevations are found within the Englemann Spruce-Subalpine Fire (ESSF) zone. The Salmo River has a total of eight 2nd and 3rd order tributaries (including Apex Creek, Clearwater Creek, Hall Creek, Barrett Creek, Ymir Creek, Porcupine Creek, Erie Creek, and Hidden Creek) and two 4th order tributaries (Sheep Creek and the South Salmo River) (Figure 1). The Water Survey of Canada maintains a gauging station on the Salmo River down stream of the town of Salmo. Mean annual discharge in the Salmo River (1949-1988) was 32.5 $m^3 \cdot sec^{-1}$, with mean monthly minimum and maximum values of 7,5 and 128.6 $m^3 \cdot sec^{-1}$, respectively, extreme peak flows can be much greater up to 200 m^3/sec. Runoff reaches a peak in May, with the highest flows between April and July each year.

<table>
<tr><th>Gazetted Name</th><th colspan="2">Stream Length (km)</th><th>Area (ha)</th></tr>
<tr><td>Salmo River</td><td colspan="2">60</td><td>123,000</td></tr>
<tr><th colspan="4">Geographic Information</th></tr>
<tr><td colspan="2">Approximate distance and direction to the nearest town, city or landmark</td><td colspan="2">12 km southeast of Nelson, BC</td></tr>
<tr><td colspan="2">MELP Region</td><td colspan="2">4</td></tr>
<tr><td colspan="2">MELP Management Unit</td><td colspan="2">4-8</td></tr>
<tr><td colspan="2">DFO District</td><td colspan="2">Interior South East (#30)</td></tr>
<tr><td colspan="2">Ministry of Forests Regions</td><td colspan="2">Nelson</td></tr>
<tr><td colspan="2">Ministry of Forests District</td><td colspan="2">Kootenay Lake</td></tr>
<tr><td colspan="2">NTS Base Map Reference</td><td colspan="2">82 F/3 and 82 F/6</td></tr>
</table>

2. Methods

2.1 Fish Habitat Assessments

On Sept 29 and 30th, 2006, the Fish Habitat Assessment Procedure (FHAP) of the Watershed Restoration Program (WRP) (Johnston and Slaney 1996) was conducted for a 3.25 kilometer section of the Salmo River mainstem from the confluence of Erie Creek to the confluence of Hell Roaring Cr. Three Reaches were delineated, in an upstream direction commencing from the Hell Roaring Cr. confluence (Figure 1):

Reach 1: 0 Km to 0.99 km: Hell Roaring Cr. to .2 km downstream of the Carney Rd. access. Channelized (rip rap) river left and river right at the upper end. River left some mature cottonwood riparian with sporadic young riparian growth river right. Low gradient glide infrequent riffle low pool habitat. Gravel to cobble substrate with some boulder at the downstream end.

Reach 2: 0.99 km to 1.57 km: a largely braided area with young to early mature riparian 'Kootenay mix' river right and young cottonwood river right. This is the only section of the study area with good pool structure and lwd. Gravel to cobble substrate.

Reach 3: 1.57 km to 3.25 km: a wide reach almost completely channelized both sides. Young cottonwood forest on river right and clear-cut to young cottonwood forest and other young riparian growth river left. Gravel to cobble substrate, long glide runs with infrequent riffle and few pocket pools and almost no wood. Some residential on upper left bank.

The Fish Habitat Assessment Procedure (FHAP) originated in the Pacific Northwest for quantitatively assessing the effects of past logging activities on forested streams (Schuett-Hames et al. 1994). The procedure was adapted for use in British Columbia (Johnston and Slaney 1996), and ideally it should be applied using diagnostic data collected from old-growth forested watersheds similar to the targeted watershed. Where local diagnostic data is unavailable, which is typical, generic diagnostics are utilized, as Table 5 in Johnston and Slaney (1996). During the Watershed Restoration Program (WRP) of 1994-2002, an unpublished evaluation of the technique by the Ministry of Environment provided support for its use, particularly for the large wood and cover diagnostics, although "pool" quality ratings are usually overly conservative. However this can be resolved by including glides with primary and pocket pools as a combined rating, as considered at this reach of the Salmo River.

The procedure was developed mainly for small to medium sized streams in the order of 15 m channel widths, but past experience in BC's Watershed

Restoration Program indicated that it applies well to large alluvial channels in the range of 50 m channel width. The procedure is also designed to identify opportunities for restoration or for offsetting impaired conditions and lost habitats.

Hydraulic units at base summer flows in the study reach were separated into riffles, glides and pools. Glides were subdivided further into glide flats and glide flat-runs, and pools into pools and runs, to improve designation of prime turbulent trout habitats versus more marginal non-turbulent or “flat” waters. Several physical characteristics were measured with a meter rod and a laser range finder, the latter accurate to + or - 1.0 m. Measurements included lengths of hydraulic units (riffle, glide pool), bankfull width, wetted width, bankfull depth, mean wetted depth, maximum pool depth, and residual pool depth. Channel type was also classified, which was “riffle-bar-pool” throughout R1 and R3.

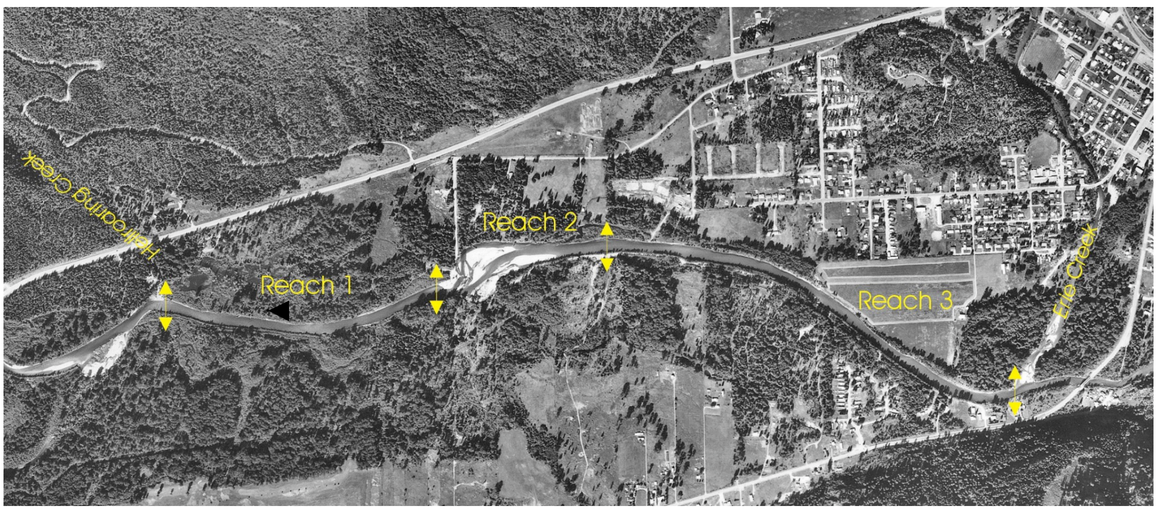


Figure 1. Air-photo (2000) of the Salmo River from the Erie Creek confluence (at the right) to the Hell Roaring Creek confluence (at the left). Flow direction is north to south (right to left) of the air photo.

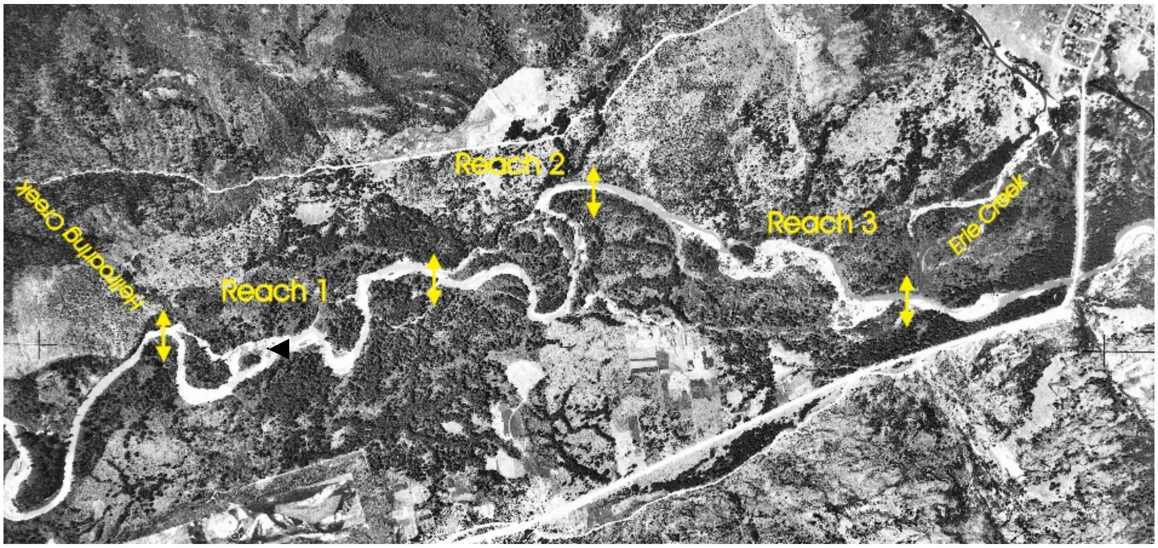


Figure 2. Historic air-photo (1940) of the Salmo River from the Erie Creek confluence to the Hell Roaring Creek confluence illustrating loss of lateral channel migration across floodplain from channelization observed in figure 1.

Total large wood, defined as all wood >2 m in length and >10 cm in diameter, was enumerated within the bankfull channel. Total large wood included that in the wetted channel as well as on bars. Functional large wood was that which influenced the nature of the hydraulic units in terms of scour and salmonid cover. LWD was counted by size category according to basal diameters of 10-20, 20-30, 30-40, 40-50 and >50 cm. The authors made estimates of several other features. Parameters included dominant substrate size, sub-dominant substrate size, gradient, surface velocity, percent total cover, percent boulder cover, percent large woody debris (LWD) in pools, and cover types per habitat unit.

Furthermore, within each hydraulic unit, percent useable parr to sub-adult habitat was assessed by visually estimating useable depths, velocities and cover criteria from previous experience. Visual estimates approximated measured useable salmonid parr habitat, based on velocities and depths recorded at a sample of riffle transects in the Lardeau River in 2005 and 2006.

In the riparian zone on each bank, dominant trees were classified as shrub, pole sapling, young forest, and mature forest. The zone was also classified as deciduous, conifer or mixed structure, and the percent canopy closure over the stream was visually estimated.

Other features recorded were numbers of side-channels, substrate quality in terms of infilling with sediments, frequency of salmonid spawner holding pools, frequency of spawning gravels and its quality, and periphyton development on riffle substrates.

Values of the various parameters were converted to those required for FHAP diagnostics as percent pool, pool frequency or spacing per channel width, functional large wood per channel width, percent woody debris in pools, percent boulder cover in riffles, percent total cover and substrate quality.

2.2. Fish Habitat Prescriptions

Fish habitat rehabilitation techniques were prescribed based on an identified need in the Salmo Watershed-based Fish Sustainability Plan (WFSP) to restore habitat complexity in channelized reaches of the Salmo River. Recommendations outlined in the "Salmo River Watershed Profile" were also considered during the prescriptive phase as this document provided an overview fish habitat assessment and recommendations for restoration activities that should be considered in the Salmo River Watershed including:

- natural restoration techniques that accent channel morphometric features rather than creating additional structures,
- incorporation of log jams and root wads in flood control measures
- bank stabilization and riparian restoration,
- habitat complexing and,
- side-channel flow augmentation.

Results from the level 2 assessment were then used to clarify the objectives and scope of restoration activities at specific locations. Objectives for fish habitat rehabilitation prescriptions were different for each reach based on existing habitat and channel morphology and are outlined below.

Reach 3: To restore channel roughness and increase habitat complexity in a channelized section of the Salmo River without the use of wood structures due to local landowner concerns. Therefore, in consideration for local landowners rock structures were prescribed to provide complex habitat for rearing salmonids and staging areas for salmonid migration, incorporating minimal amounts of large woody debris (LWD) for cover where applicable.

Reach 2: Due to the natural complexity and good fish habitat found in this location a vehicle barrier and bank stabilization are the main restoration objectives within this reach.

Reach 1: To restore channel roughness and increase habitat complexity for rearing salmonids in a channelized section of the Salmo River by incorporating LWD into flood control measures and accenting existing channel morphometric features.

Specific techniques selected to meet the above outlined objectives were taken from Slaney and Zaldokas (1997) Technical Circular No. 9 (Fish Habitat Rehabilitation Prescriptions) and Saldi-Caromile, K. et. al. (2004) Stream Habitat

Restoration Guidelines: Final Draft and Rosgen (2001). These techniques included:

- rock groyne enhancement with rootwad incorporated for cover,
- boulder clusters to restore rearing habitat,
- opposing deflectors to restore rearing habitat and holding areas for salmonid migration,
- j-hook vanes to reduce bank erosion and provide holding areas for salmonids and,
- rootwad triangle w/ ramp logs to accelerate the recovery of log jam habitat and provide cover for fish.

Design details and conceptual drawings are provided in section 3.1.2 “Habitat Rehabilitation Prescriptions” and section 3.1.3 “Standard Habitat Structure Conceptual Designs” within the Results section.

3. Results and Discussion

3.1. Fish Habitat Assessments

A distance of 3.25 km was assessed and prescriptions completed, including 989 m in Reach 1, 580 m in Reach 2 and 1676 m in Reach 3 (Figure 1). Overall, 30 habitat units were assessed, including 7 in Reach 1, 10 in Reach 2 and 13 in Reach 3. R1 was channelized for its’ entire length river left and approximately 40% of the upper section of R1 is channelized as well. The rest is in a natural state that has off channel wetland just upstream of Hell Roaring Cr. R2 is largely braided with approximately 70% of the flow following the river right bank and 30% flow in a secondary channel at the time of the FHAP. These 2 channels merge about 100 m upstream of the reach boundary and two additional dry flood channels were easily identified at this time as well. R1 is completely channelized along both banks and has an unprecedented uniformity anywhere in the Salmo River.

Overall, average main stem channel width and wetted width were 65.4 m (range 29-200 m) and 22.72 m (range 10.9-39.1 m), respectively (Appendix 2). The reaches varied greatly in channel width as a result of braiding (Reach 2), channelization and or dyking (Reach 2&3). R 2&3 are very similar in width due to dyking that occurred in this area in the 1960’s. Mean channel widths in Reach 1, 2 and 3 were 35, 124 and 36 m, respectively. Respective average wetted widths in late September were 27.7, 15.4, and 25.7 m.

3.1.1. Fish Habitat Ratings

Overall, glides were dominant in the study area. Glides, riffles and pools comprised 62.8%, 34.8% and 2.4%, respectively (Appendix 2). Habitat depths were low with an estimated mean depth of 0.29 m. Mean maximum depth was

0.73 m. Mean bank-full depth (at a peak 3-year freshet level) of all habitat units was 1.6 m.

Substrates were dominated by cobbles throughout the 3.25 km, with boulders mainly where banks had been dyked. Mean estimated dominant substrate size in all habitat units was 0.14 m and ranged from 0.1 to 0.25 m. Mean sub-dominant size was 0.06 m and ranged from 0.02 m to 0.15 m (Appendix 2).

Average estimated gradients varied highly from 0.01 % (pool) to .8 % (riffle), with an average gradient of 0.46 % because of the dominance of glides (Appendix 2). Estimated average velocity was 0.17 m/sec during late-summer flows.

Overall, percent primary pool (including runs) by area was only 2.4 %, but if all glides were included as equivalent to shallow pools, "pools" were 64% by area. Inclusion of eight pocket pools in riffles increased pool area to 68%. Therefore, percent pool plus glide rated as *good*. However the quality of glides in these sections would probably negate their inclusion as 'pool' habitat because of their low depths .29m's. As such the authors would recommend against glide inclusion in the pool count.

Pool frequency rated *poor*, as 1.99 channel widths per pool plus pocket pools. *Thus, overall, pool ratings, excluding glides and including pocket pools rated poor (Table 1).*

As primary habitat and cover features, large wood in the channel was mixed in abundance. Total pieces of large wood in the 3.25 km length of channel assessed equated to 3.57 per channel width. Functional large wood, affecting the channel geomorphology or providing fish habitat cover, was 3.57 pieces per channel width. Thus, functional large wood rated as *poor* quality, and approached fair quality. Unfortunately, size of large wood was small, only 17.5 % was >30 cm basal diameter, with only 6 % >40 cm because most habitat units were associated with a young forest or pole sapling riparian areas. *Thus, functional LWD frequency (Table 1), reflected limited large wood recruitment from the young riparian forest, resulting in a quality rating as poor quality.*

The other variable that it is imperative to keep in mind is that R2 representing only 17.9% of the overall length of the total habitat unit contains 66% of the LWD including 90% of LWD >30cm. basal. Indeed R2 skews pool data for the study area in a likewise manner.

Overall, fish habitat cover was sparse in the 3.25 km reach, and total cover averaged 7.6 %. Of this, boulder cover averaged only 1.4 % (range, 0 to 5 %), and as a diagnostic, riffles boulders averaged only 1.5 %, and *thus, boulder cover rated as poor* (<10 %). Overall, mean percent woody cover was only 6.6 %, and woody cover in primary pools as a diagnostic was .3 % which rated as *poor quality (<5 %) (Table 1).* With glides included with pools, percent woody debris in "pools" at .3 % also rated *poor quality*. Only in the Reach 2 were there any significant large pieces of LWD. Overstream vegetative cover was virtually non-existent within the _poor quality_ category of <10 %*. Thus, cover was _poor quality_ in the three reaches combined, and well below the poor-fair rating boundary.*

As well as poor habitat cover, side-channel development was not abundant, at the lower end of R3 there was a backchannel that could be partially watered at high water and in R2 there was a stretch with 2 watered channels and an additional 2 dry channels that would be watered in freshet. Thus, side-channel quality was rated as _poor quality_, without restorative measures.

Interstices of stream substrates were only moderately in-filled with fine sediments from some of the eroding banks, and not to the degree that existing spawning and rearing habitats were not viable.

Table 1. Fish habitat characteristics (pools, large wood and cover), and habitat quality ratings of the Salmo River from Erie Creek to Hell Roaring Cr. in late Sept. 2006. Targets for quality from Table 5 of Johnston and Slaney (1996).

Habitat Parameter	Reach Amount	Rating	Target (good Quality)
Percent Primary Pool	2.4	Poor	>55
Pool plus pocket pool Frequency	1.99	Poor	<2
Pieces of Functional LWD/ Channel Width:	3.57	Good	>2
Percent Woody Cover in Pools & Glides+Pools	6.6-0.3	Poor	>20

Indicators of fish habitat disturbance were common, either as extensive dyking of R1 and 3 where there are limited habitat features. Some streambank erosion has occurred river right in R2. Past logging/clearing of riparian areas and removal of instream woody debris were other indicators of disturbance. None of the 30 habitat units had a mature riparian forest with perhaps the exception of 1 small area river left R2. The most degraded riparian area was the right (west) bank of Reach 3 just down stream of Springboard Park (at the Erie Cr. confluence) for approximately.3km. There, farm fields merge directly with riprap bank stabilization efforts.

Few areas of spawning gravels have developed throughout the study reach. Cobbles are prevalent because of low gradients combined with sparse large wood, the latter causing a lack of sorting of transported gravel sediments. Thus, spawning gravel deposition was infrequent, although sporadic gravels detected were of adequate quality where naturally deposited.

Mean estimated trout parr (to sub-adult) rearing habitat was only 7.2 %, and ranged from 0 % to 15 % in the three reaches (Appendix 2). Only 10% of the 30 habitat units had >10 % parr habitat. This estimate confirms the marginal quality of salmonid rearing habitat in the study area. Regardless of a fair frequency of pools plus glides, the highly sporadic distribution of large wood and other cover provided sparse habitat overall for age 1+ salmonids. Average estimated fry habitat was even less than parr habitat, or 1.8 % (Appendix 2). However, if overall habitat diversity including side-channels were more frequent, increases can be expected.

From a stream productivity perspective, periphyton seemed adequately developed on stream substrates, which can support a diverse community of aquatic insects. Yet, an overly "thin" riparian canopy limits most leaf litter input throughout the study area. The immature and degraded riparian area also can be predicted to overly increase water temperatures for salmonids fishes during an increased frequency of summer droughts from global warming.

In summary, salmonid habitat in the study area was poor quality (with the exception of R2) because of past disturbances including channelization and riparian removal or alteration, resulting in low supply of riparian large woody debris within a simplified channel. Channel maintenance to reduce flood risks appears to have overly simplified the channel, greatly reducing viable fish habitat. Thus, selective habitat restoration would be beneficial to recovery nursery habitat for the Salmo River, which supports an important recreational sport fishery.

3.1.2. Habitat Rehabilitation Prescriptions

Habitat rehabilitation prescriptions were focused on boulder and large wood structures in riffles, glides and shallow pools throughout channelized sections of the Salmo River which lacked adequate depth and cover for sustaining rearing salmonids in both summer and winter. Specific prescriptions are listed in Appendix 2, by station with fish habitat assessment data. Representative photos of habitat prescription sites are provided in Appendix 3.

Reach 3 consists of a long, homogenous, highly modified stream reach due to flood control levees and private properties resulting in a loss of riparian vegetation. Structures prescribed in this reach to increase habitat complexity in place of appropriate LWD techniques include: boulder clusters, rock groynes, opposing rock deflectors and a j-hook vane. The schematic layout of these structures is illustrated in figure 3 and conceptual drawings are provided in figures 5, 6, 7, 8. It should be noted that LWD prescriptions in this reach would be beneficial to restoring natural stream ecological functions because porous woody structures provide more habitat for salmonids than rock groynes.

Reach 2 consists of a short braided section of the Salmo River where good fish habitat is present due to natural habitat complexity. Rehabilitation prescriptions in this reach are focused on stabilizing the river access point at the end of Carney Mill Rd. and blocking access to motorized vehicles which have caused increased bank erosion. Bank erosion is also present on the right bank upstream of Carney Mill Rd. and the landowner has expressed interest in structure installation to reduce the rate of erosion. Three rootwad triangles have been prescribed for the eroding banks in this area but it should be noted that structure installation in this section of river is considered to be ‘high risk’ due to the dynamic nature of the channel and the potential for installed structures to be become dry when the channel shifts. The schematic layout of these structures is illustrated in figure 4.

Reach 1 has also been highly modified due to flood control levees. Structures prescribed in this reach to increase habitat complexity include: rootwad triangles, boulder clusters and j-hook vanes. The schematic layout of these structures is illustrated in figure 4 and conceptual drawings are provided in figures 5, 8 and 9.

Boulder clusters are prescribed to restore structural complexity and hydraulic diversity in homogenous sections of the Salmo River. They function to provide cover, turbulence and water velocity gradients where slow water velocities occur in close proximity to faster ones. Water velocity gradients are desirable for many fish species including juvenile and adult salmonids because it allows them to maintain a position near faster, food-delivering current without expending too much energy (Saldi-Caromile, K et. al., 2004 and Ward, B. R., 1997). Boulder clusters also provide microhabitats utilized by many invertebrate species.

Opposing deflectors are prescribed to restore salmonid holding and rearing habitat by increasing the availability of deep pools and runs. Paired deflectors constructed of durable materials such as large rock have been used successfully in streams and medium/large sized rivers up to 60 m in width, subject to other criteria such as slope and channel stability (Allan, J. H., and Lowe, S, 1997).

Rock groyne enhancements with rootwads are prescribed to enhance existing channel morphometric features along flood control levees where subtle existing riprap protrusions were observed to have caused the formation of pocket pools by producing a downstream re-circulation eddy. The intent of these prescriptions is to add additional rock to existing riprap features to promote scour and increased pool depths on the downstream side of the groyne. This technique is only prescribed where landowners are opposed to the use of large wood structures. LWD in the form of rootwads should be integrated, where approved, into the structure to provide cover in the downstream pool. Interstitial spaces between the boulders will also provide cover for fish.

J-hook vanes are prescribed to reduce bank erosion and provide holding areas for fish. The structure comprises 1/3 of the bankfull channel width creating a scour pool in the centre 1/3 of the channel that provides energy dissipation and holding cover for fish. The center of the channel associated with the hook is efficient at transporting sediment, debris and improving channel capacity and sediment competence. The “shooting flow” associated with the hook portion of the structure provides for recreational boating in moderate to larger sized rivers. Width/depth ratios are maintained by decreasing the bank erosion rate and increasing bankfull channel depth, even following major floods (Rosgen, D.L. 2001).

Rootwad triangles are prescribed to increase habitat complexity by increasing LWD abundance in the channel. LWD structures will restore fish habitat by accumulating driftwood, small woody debris and small organic debris that will improve productivity of the fish food chain in the river while simultaneously providing cover for fish.

The habitat rehabilitation plan proposed in this document will require review and input by a qualified engineer, regulatory agencies, private property owners and the Village of Salmo. Approvals from the Ministry of Environment, the Department of Fisheries and Oceans and Navigable Waters will also be required to implement these prescriptions.

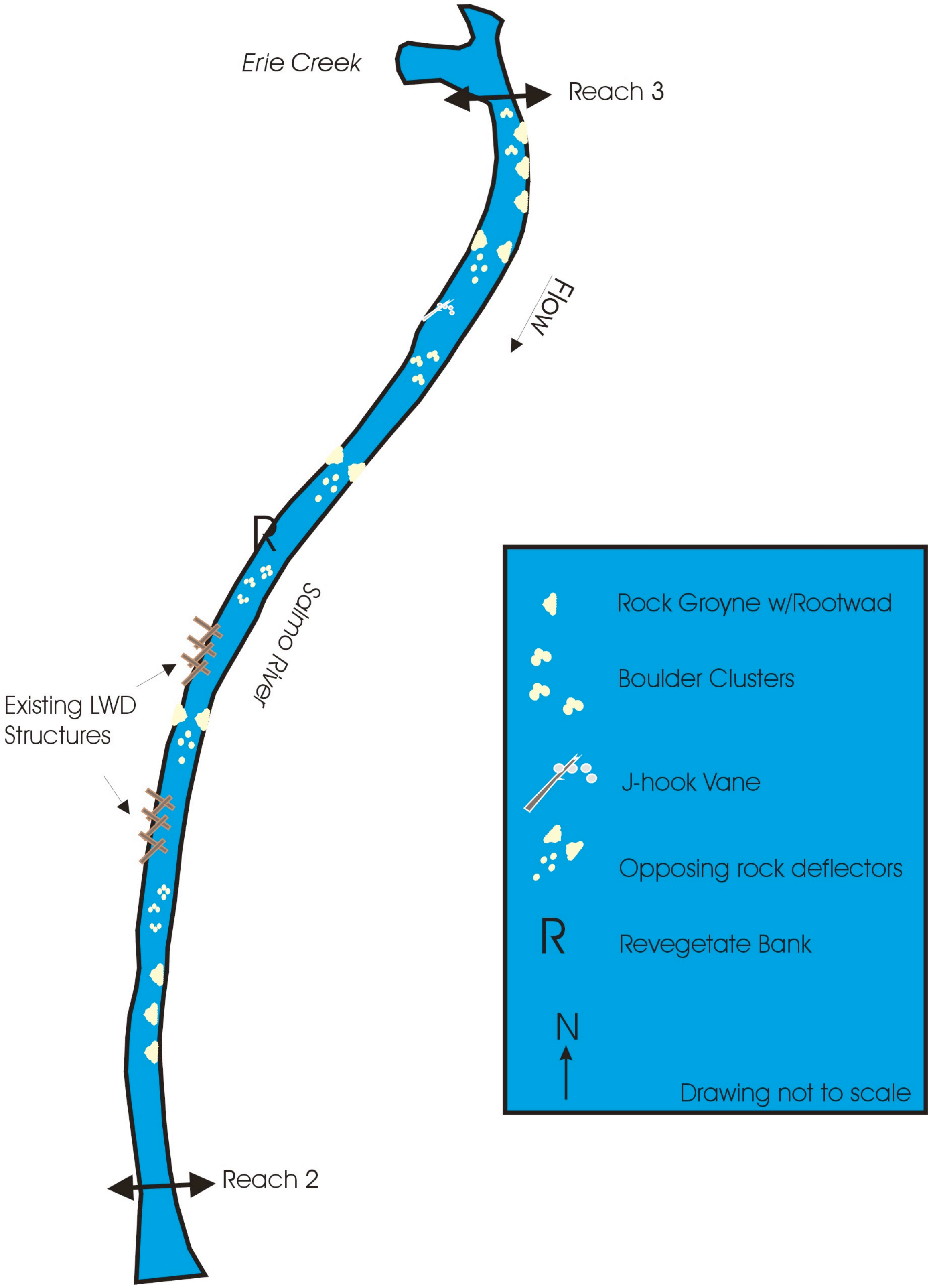


Figure 3. Schematic layout of habitat structures prescribed for the Salmo River Reach 3 from the Erie Creek confluence to the braided section of river in Reach 2. Note that no wood structures were prescribed in this reach due to concerns expressed by local landowners.

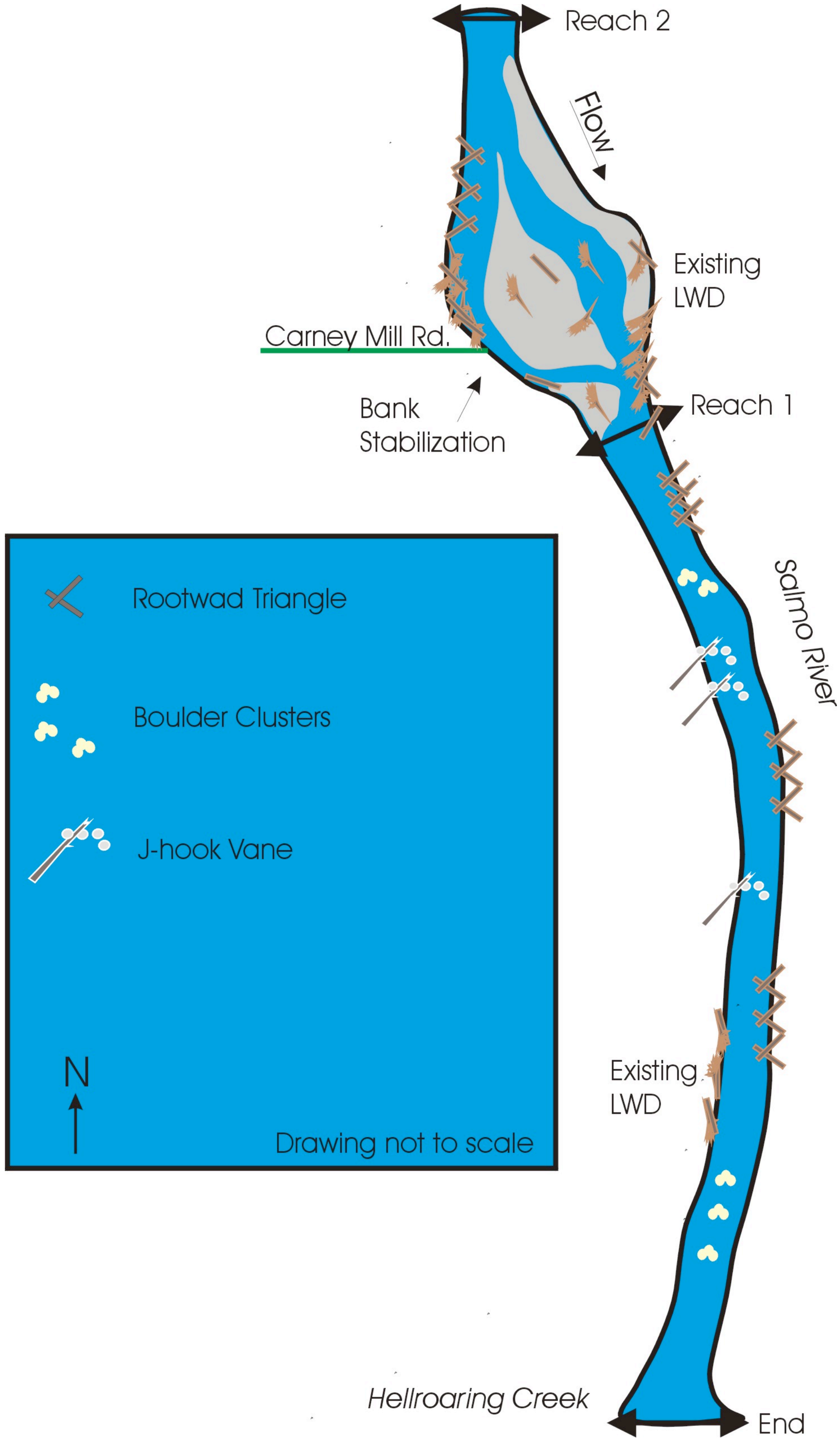
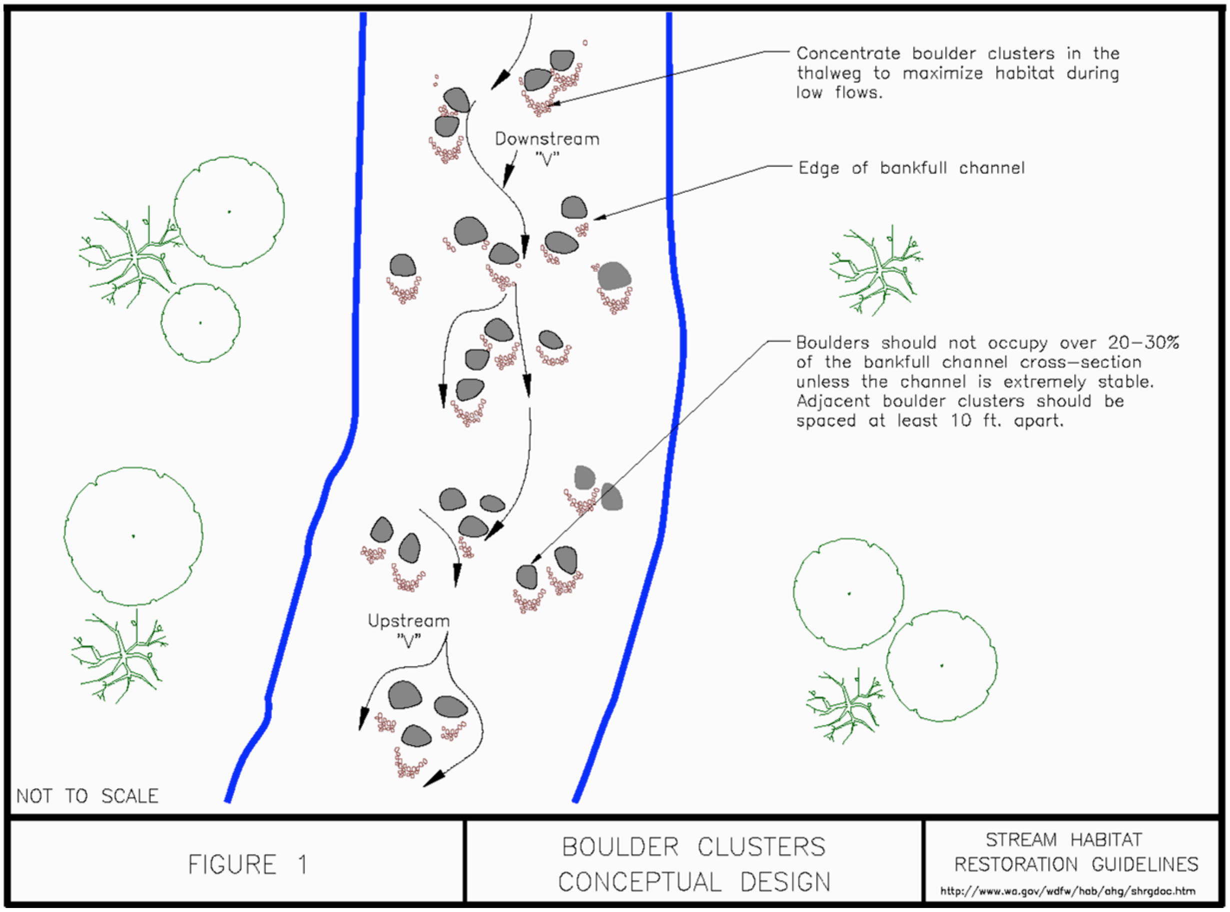


Figure 4. Schematic layout of habitat structures prescribed for the Salmo River in Reach 2 and Reach 1 to the Hell roaring Creek confluence. Note that few structures were prescribed in Reach 2 due to the dynamic nature of the channel in this area and the good quality existing fish habitat.

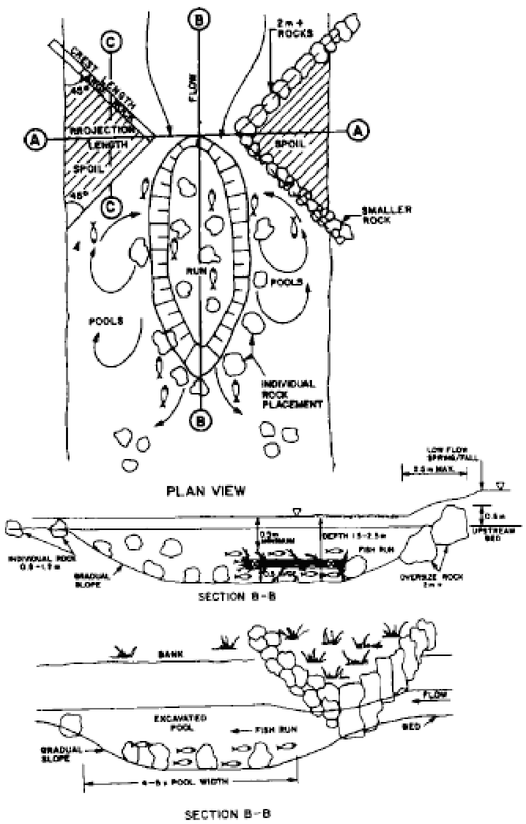
3.1.3. Standard Habitat Structure Conceptual Designs

Conceptual designs are provided for all prescribed structures including rock groyne with rootwad, boulder clusters, opposing deflectors, j-hook vane, rootwad triangle w/ ramp logs and debris groyne.



Source: Saldi-Caromile, K et. al. 2004. Stream Habitat Restoration Guidelines: Final Draft. Co-published by the Washington Departments of Fish and Wildlife and Ecology and the U.S. Fish and Wildlife Service. Olympia, Washington.

Figure 5. Boulder clusters conceptual design to provide cover, holding and rearing habitat for fish while providing a mechanism for substrate scour and sorting. Boulder clusters should be placed in straight, stable, moderately to well-confined, low gradient riffles (0.5 to 1%) (Saldi-Caromile, K et. al., 2004). They should be placed in the lower section of the riffle to stabilize the riffle crest and transfer scouring forces to the downstream pool. Placing boulders at the riffle crest can cause backwater affects such as channel aggradation (Ward, B. R. 1997).



CONSTRUCTION NOTES

1 - **All rocks** (Class I, II, III, 2 M+) must slope **DOWN** to the middle of the stream to the point of the deflector.
2 - The upstream face **must contain the LARGEST rocks** so that the pressure of the flow may be resisted. Smaller rocks may be placed on the downstream face. Each rock is to be placed in the **shadow** of the previous rock from the point to the bank. All rock **must fit tightly together** and jammed together by machinery.
3 - **Place** the upstream rock face in a trench, then place the downstream rock face in a similar trench, taking care that the rocks slope upwards to the side of the stream such that the point of the deflector is about 0.3 m above the water level and the root is at least 1 to 1.5 m above current water level.
4 - Excavate the downstream run, placing much of the spoil material within the confines of the two rock faces. The top surface of the spoil **must be below** the level of the adjacent rock faces. All **remaining spoil** must be deposited 10 m outside the stream banks and preferably 1.5 m above the water level.
5 - In **very large rivers**, a double row of rocks will be required for both the upstream and downstream faces of the deflectors.
6 - The open area in the middle of the stream must be about ¼ of the stream width or less, so that a section of rapid flow conditions exists to funnel the water into the downstream run. On occasion the opening must be constricted even more to provide higher flow velocities when necessary.
7 - The instream point of the deflectors shall be 0.6 m above the stream bed. The root of the deflectors shall be 1.0 to 1.5 m above current water levels and firmly imbedded in the stream bank.
8 - All elevations relate to low stream flow in the spring or fall.
9 - All individually placed rocks in and around the pool are to be 0.8 – 1.2 m in size or less, depending of the size of the river or stream.

Source: Slaney, P.A. and D. Zaldokas. 1997. Fish habitat Rehabilitation Procedures Province of BC Watershed restoration Technical Circular 9. Pg. 11-3.

Figure 6. Opposing deflectors conceptual design to rehabilitate salmonid holding and rearing habitat. Structures are prescribed to be placed in low gradient glides, 3 channel widths downstream of the upstream boundary of the glide, and are spaced at least 10 channel widths apart, separated by a riffle as recommended by Allan, J. H., and Lowe, S., 1997. The structures should be constructed out of large rock leaving ¼ to 1/3 of the stream width open in the centre to create a section of rapid flow conditions that funnel water into the downstream run. The pool or run downstream of the deflectors should be excavated to a designed depth to create the initial deep water (Allan, J. H., and Lowe, S. 1997). Boulders can then be placed in the run or pool downstream for cover.

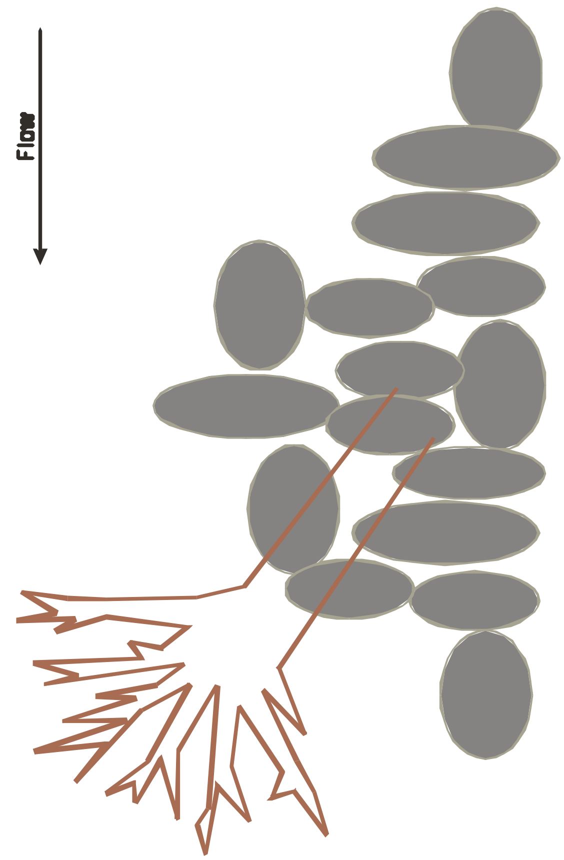
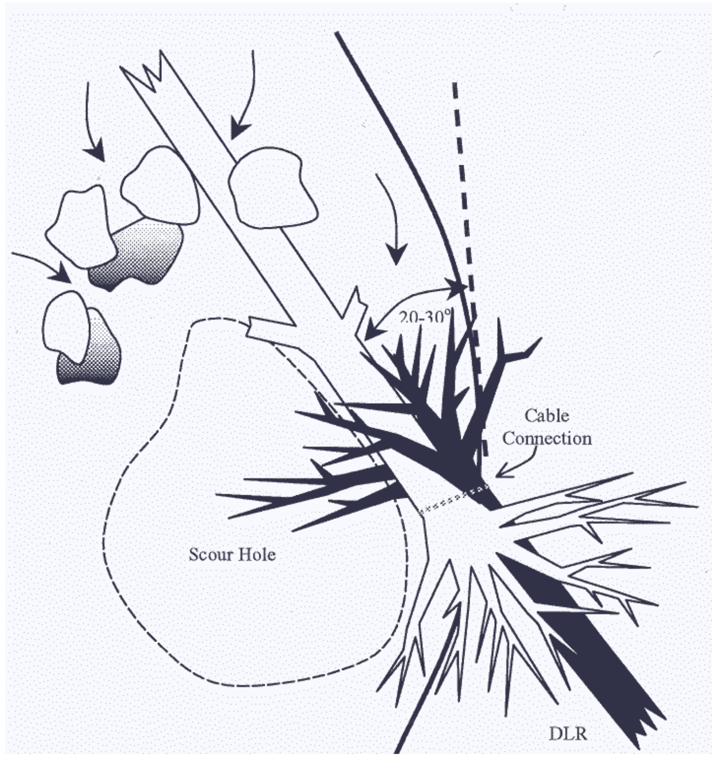
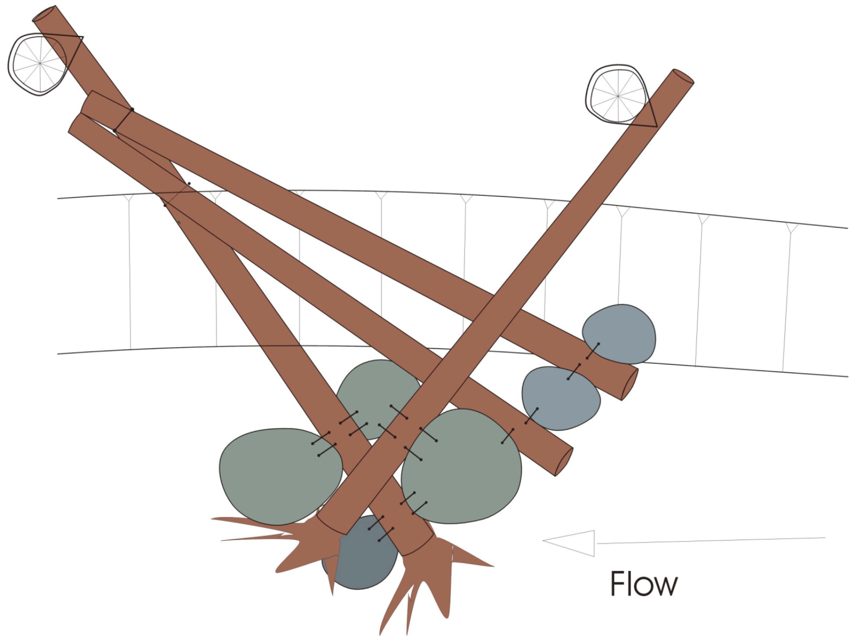


Figure 7. Rock groyne enhancement with rootwad conceptual design to promote pool formation and cover for rearing salmonids. Additional rock added to existing riprap features will promote scour of small pools on the downstream side of the structure. The structures size is to remain small in overall projection into the channel (less than 1/4 of the bankfull channel width) and LWD in the form of rootwads should be incorporated to provide cover. This technique should only be utilized where riprap bank protection is in place immediately upstream and downstream of the proposed structure to prevent bank erosion from backeddy re-circulation. Impacts to the opposing bank must also be considered in the detailed design phase.



Source: Rosgen, D.L. 2001. The cross-vane, w-weir and J-hook vane structure: their description, design and application for stream stabilization and river restoration. Wildland Hydrology, Pagosa Springs, Colorado.

Figure 8. J-hook vane with 2 rootwads and ballast-scour boulders conceptual design to reduce bank erosion and promote holding areas for fish. The vane portion occupies 1/3 of the bankfull channel width while the “hook” occupies the centre 1/3. Ballast boulders are used to secure the rootwad of the vane on-shore (ballast not shown) while the J-hook rounded boulders provide the in-water ballast. The LWD is set at 25 degrees off the stream bank (range 20-30^0, preferably at a bank curve) and sloped at 5 % (range 2-7 %) upwards into the bank. On the bank side of the LWD, boulders infilled with cobbles and gravels are used to seal the vane to ensure it dos not erode under the LWD. (In paddler-used waters, the 2nd rootwad is either not used, or all upper root projections are cut off.).



Source: Slaney, P.A. 2006. Habitat Assessments and Restoration Prescriptions for the Lower Reach of Erie Creek within the Salmo River Watershed.

Figure 9. 2-rootwad triangular ramp-log structure concept designed to restore fish habitat, trap driftwood and protect/stabilize streambanks. Large buried ballast boulders are required at the top of the bank where riparian trees are small, or <30 cm in basal diameter. Two ramp logs are placed under the upstream rootwad and over the downstream rootwad or log. Elevation of the ramp logs to peak flood level is achieved by reducing the height of the upstream LWD and increasing the height of the downstream LWD. The ramp logs are thereby “ramped up towards the top of the bank to collect drift wood and minimize bank erosion; the upper ramp log ends are cable-secured to the upper portion of the downstream rootwad. Note that structures should be small in overall size/projection into the channel, or targeted on scouring small pools/runs. Boulder ballasting may be applied at the stream margin to generate more scour under the rootwads

3.1.4. Project Phasing and Materials Required Per LWD Structure

A phased project could be most efficiently accomplished over one to three years and should include a community demonstration element to gain public support for sustainable fish habitat and fisheries in the Salmo watershed. An initial public meeting is advised in support of habitat restoration and to address any public concerns with the fish habitat restoration project.

- Year 1: Reach 3 as a community demonstration project
- Year 2: Reach 1
- Year 3: Reach 2 If requested

Materials

Boulder Clusters

Total number of boulders required based on prescriptions found in Appendix 2 are as follows:

Reach 1:	144
Reach 2:	0
Reach 3:	170

Boulder sizing should be conducted by a qualified engineer during the detailed design phase. Boulders should be sized to withstand the shear stress or tractive force generated during the 50-year flow at a minimum, and ideally for the 100-year flow. Any debris caught on the boulders magnifies the total shear stress imposed on the boulders substantially during large floods. If these torques and additional forces are not estimated directly and accounted for, the 100-year design flow provides some degree of protection against these additional forces during lesser (20 to 50 year) storm events (Saldi-Caromile, K et. al., 2004).

Angular and irregular shaped boulders (e.g., quarried rock) typically provide greater hydraulic complexity and cover than rounded boulders. Angular rock is also less likely to roll and, therefore, offers greater resistance to shear. Most rock-sizing equations and methods are based on angular, durable rock. The diameter of rounded rock, if used, will have to be greater than the mean dimension of angular rock to provide the same resistance to entrainment. While angular rock may offer some advantages for stability and habitat, the use of angular boulders can have significant aesthetic impact, particularly in systems that are dominated by rounded rock (Saldi-Caromile, K et. al., 2004).

Opposing Deflectors

The size of the rock materials utilized for tie-ins and bank armouring in the opposing groynes must be based on the 1:50-year flood velocity. The next highest class of rock must be used for the portion of the structure within the channel. Rock should be competent and angular rather than rounded to avoid shifting and rolling. Further specifications for rock materials will be determined during the detailed design phase and rock sizing should be conducted by a qualified engineer.

Rock Groyne

Quantification and sizing of materials will be conducted during the detailed design phase; a qualified engineer should conduct boulder sizing at that time.

J-hook Vane

The J-hook vane can be constructed with boulders, logs and a combination of both. A geotextile fabric is required to prevent scour under the structure when logs are used or when rocks are used in sand or silt/clay bed channels. Large flat rocks can be substituted for the duckbill anchor and cable to keep the logs in place (Rosgen, D.L. 2001). Quantification and sizing of materials will be conducted during the detailed design phase; boulder sizing should be conducted by a qualified engineer at that time.

Large Wood Structures

LWD 2-rootwad triangular ramp-log structures prescribed in Reaches 2 and 3 require 2 rootwads and 2 ramp logs each. The rootwads should be at least 50 cm in diameter and the ramp logs 30 to 50 cm in diameter. All LWD should have in-tact stems greater than 12 m in length when transported to site. The total amount of LWD required, based on prescriptions found in Appendix 1 are as follows:

Reach 1:	0
Reach 2:	6 rootwads and 6 logs
Reach 3:	18 rootwads and 14 logs

The ends of each of the 2 rootwads utilized in the structure should be fixed to trees or stumps on the bank in addition to being ballasted together instream by a common anchor boulder. If trees > 30 cm diameter are unavailable than boulders or buried deadheads must be used. The instream ballast requirement is approximately 1 m^3 of boulder ballast per log or rootwad or two 0.5 m^3 boulders (one on each side) per rootwad (or log) in the channel, in addition to the fixed bank attachments. The boulders must be placed in pairs along rootwads to facilitate cabling, with the largest boulder placed upstream (Slaney, P.A. 2006). Ballasting of LWD structures is set by guidelines provided in Slaney et al 1997, using a *minimum safety factor of 1.25* which can be increased to 1.5-2.

Note: It should be noted that in some navigable (paddler) waters, the upstream facing rootwad in the triangle may not be approved by the Canada Navigable Waters Protection Division (Canadian Coast Guard). Also, the top of the lower rootwad may need to be cut off. Alternatively, this rootwad may be placed inside the structure to provide additional habitat**.** Fully submerging the well-ballasted root ends of the rootwads at base summer flows will minimize navigation concerns, and in the past Coast Guard has used an instream structure guideline maximum of 30 % of the wetted navigable channel width per structure (Slaney, P.A. 2006).

3.1.5. Estimated Restoration Costs

Restoration costs vary greatly depending on site accessibility, availability and distance to materials and local site conditions. Estimated costs per restoration structure based on information provided in Slaney, P.A. and D. Zaldokas, 1997:

- 100-150 per 3 boulder cluster
- 10,000 to 15,000 for each opposing deflector
- 2,500 to 3,000 for each j-hook vane
- 2,000-2,500 for each rock groyne
- 3,000 per LWD rootwad triangle

The total restoration budget based on these estimated costs would be approximately $124,000 where access to site is readily available and materials do not require helicopter transport. This estimate includes construction costs only and does not include additional consulting, engineer fees and approval fees.

A more conservative approach to estimating restoration costs outlined in Slaney, P.A. and D. Zaldokas, 1997, would be to apply a geometric mean cost of $70,000 per km based on implemented instream and off-channel fish habitat rehabilitation projects. The total budget to restore 3.2 km on the Salmo River based on the geometric mean cost would therefore be approximately $224,000.

3.1.6. Estimated Benefits of Restoration

The proposed instream fish habitat rehabilitation prescriptions will provide habitat complexity by implementing boulder and large wood structures in riffles, glides and shallow pools throughout channelized sections of the Salmo River which lacked adequate depth and cover for sustaining rearing salmonids in both summer and winter. Boulder cluster placements are intended to provide habitat benefits on a small (relative to channel size) localized scale. They will increase the food availability in velocity-homogenous sections of river that tend to be food poor. Rock groynes prescribed in Reach 3 are intended to increase the number and size of pocket pools by enhancing existing channel morphometric features along the flood control levees. The prescribed opposing deflectors are estimated to create between 300 to 800 m^2 of holding/rearing habitat each, thus an overall estimated habitat creation of 900 to 2400 m^2. J-hook vanes will stabilize banks while providing large holding cover pools for fish in addition to creating downwelling and upwelling currents that are habitat features utilized by trout. Prescribed LWD structures in Reach 1 will increase the amount of functional LWD instream thus improving habitat quality and also increasing aquatic insect abundance. Monitoring of parr to adult rainbow trout at the West Kettle River found a substantial increase (3-fold) in trout (and char) abundance of fish >10 cm in rehabilitated reaches where LWD structures were installed (Slaney, P.A. 2006).

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Appendix 1. Definitions of abbreviations of fish habitat assessment parameters

St	station
Rh	reach
Dist.m	cumulative distance in m from starting point in reach or section
Hab.	habitat types: (where abbreviated): Rif = riffle; Gl = glide; Sub-habitat types: po = pool ru = run; fl = flat; fr flat run; g = glide; cs = cascade
HabCl	habitat geomorphological class
Len.m	length in m of habitat unit
MxDm	maximum depth in m
MBDm	Mean bankfull depth: mean depth plus lowest flood plain height: flood plain height used instead of bankfull depth owing to regulated flows
MWDm	mean water depth in m
BFWm	bankfull width in m
WtWm	Wetted width in m
PoT	pool type (scour, dam, falls)
PmxD	pool maximum depth in m
PMnD	pool mean depth in m
PRsD	pool residual depth at tailout
DomSb.m	dominant substrate in m
SdomSb.m	sub-dominant sustrate in m
Est.%Grad.	Estimated or measured gradient in %
Est.Vel.	Estimated velocity in m/sec.
#PkPo	number of pocket pools in habitat unit (mainly riffles)
M2PPo	m^2 of pocket pools in habitat unit
TW	total large woody debris (>2 m in length and 10 cm in diameter)
L1020	large woody debris (LWD) 10-20 cm in average diameter
L2030	large woody debris (LWD) 20-30 cm in average diameter
L3040	large woody debris (LWD) 30-40 cm in average diameter
L4050	large woody debris (LWD) 40-50 cm in average diameter
L>50	large woody debris (LWD) >50 cm in average diameter
CovTy	cover types: LWD, boulders, cutbank, near-surface vegetation, pool or run turbulence
TCv%	percent total estimated cover
B%	percent boulder cover (as protruding boulders providing parr habitat)
OCT	off-channel habitat type (alcove, pond, side-channel)
OfA	off-channel access (yes, no)
Ofm	measured (or estimated) lineal m of off-channel habitat
RipTy	riparian type (conifer, deciduous, shrub)
RipSt	sh = shrub; ps = pole sapling; yf = young forest[1], mf = mature forest
CpyC	percent canopy closure (shading)
Ob?	Obstruction to fish passage (0 = no)
%Ufry	estimated percent useable fry habitat in habitat unit, using weighted useable depth and velocity criteria
%UP	estimated percent useable parr habitat in habitat unit, using weight depths, velocity and cover criteria Note: visual estimates should be derived by concensus of two individuals with experience with measuring and calculating weighted useable widths
Rehab.Presc.	habitat rehabilitation prescription (e.g., 6Bx3 = six boulders in clusters of 3 Bould. Restor. to Thal. = boulder restoration by shifting boulders); Lat Tri+RW-4log = lateral triangle constructed of 2 rootwads and 2 logs;

[1] young forest is <80 years of age of conifer tees in the riparian forest

Appendix 2.				**Habitat/Channel Assessment/Prescriptions**								**Recorders:**		LH / GN		**Project: SalmoR/Erie/Hellroaring-Prescriptions**					
Date:		Sep 29-30, 2006							**Loc:**	Salmo R. - Erie Ck. to Hellroaring Ck.						**Conditions:**		Sunny		low flow	
GpsUTM			11U0480633 5448460						**BF**	**Wt**					**Dom.**	**S-dm**	**Est.%**	**Est.**	**#Pk**	**M2**	
St	**Rh**	**Dist m**	**HabTy**	**HabC**	**Len.m**	**MxDm**	**MBDm**	**MnDm**	**Wm**	**Wm**	**PoT**	**PMxD**	**PMnD**	**PRsD**	**Sb.m**	**Sb.m**	**Grad.**	**Vel.**	**Po**	**PPo**	
																					11U0480633 5448460 Confluence Erie Cr.
1		76.44	Glide	Rbp	76.4	0.3	1.9	0.45	36.4	15.47	—	—	—	—	0.15	0.05	0.5	0.2	—	—	Gps 480641
																					5448410
2		125.6	Riffle	Rbp	49	0.8	1.9	0.4	39.13	20.02	—	—	—	—	0.2	0.07	0.3	0.3	—	—	Gps 480665
																					5448352
3		283	Glide	Rbp	157.4	1.3	2.1	0.35	40.04	20.02	Sc	1.3	1.05	0.6	0.2	0.05	0.01	0.2	—	—	
4		352	Riffle	Rbp	69.2	0.6	1.2	0.22	45.5	36.4	Sv	0.6	0.55	0.22	0.2	0.05	0.4	0.4	2	8	Gps 480628
																					5448237
5		380	Glide	Rbp	28.2	1.15	1.623	0.3	48.23	39.13	Sc	1.15	0.95	0.35	0.25	0.08	0.2	0.25			Gps 480597
											tail-out										5448145
6		520	Riffle	Rbp	140	0.5	1	0.2	38.22	27.3	—	—	—	—	0.25	0.08	1	0.45	—	—	Gps 480595
																					5448146
7		606.5	Glide	Rbp	86.5	0.5	1	0.25	0	0	—	—	—	—	0.3	0.08	1	0.2	—	—	Gps 480515
																					5448070
8		662.9	Riffle	Rbp	56.42	0.25	1.1	0.15	36.4	34.58	—	—	—	—	0.2	0.06	1	0.3			Gps 480465
																					5448016
9		844.9	Glide	Rbp	182				34.58	31.85	—	—	—	—	0.15	0.03	0.2	0.3			Gps 480431
																					5447965
10		952.9	Riffle	Rbp	108.29	0.6	1.5	0.25	35.49	20.93					0.2	0.05	1	0.5	—	—	Gps 480339
																					5447866
11		1398	Glide	Rbp	444.9	0.3	0.7	0.15	30.94	21.84	—	—	—	—	0.15	0.03	0.1	0.5	3	6	Gps 480272
																					5447776
12		1474	Riffle	Rbp	76.44	0.25	0.8	0.15	41.86	36.4	—	—	—	—	0.18	0.05	1	0.5	—	—	Gps 480134
																					5447327
13		**1676**	Glide	Rbp	201.11	0.4	1	0.2	41.86	30.03	—	—	—	—	0.15	0.03	0.05	0.1	—	—	Gps 480095
																					5447269
																					start reach 3
14		1734	Riffle	Rbp	59.15	0.6	2.2	0.3	60.97	12.74	Sc	0.9	0.75	0.55	0.15	0.05	0.8	0.4	—	—	Gps 480084
											tail-out										5446889
15		1848	Glide	Rbp	113.75	0.85	2.1	0.45	62.79	17.29	Sc	1.1	0.8	0.6	0.18	0.05		0.2	2	10	Gps 480065
																					5446845
16		1954	Riffle	Rbp	106.47	0.65	2	0.35	118.3	10.92	—	—	—	—	0.15	0.05	0.4	0.3	2	8	Gps 480082
																					5446758
17		1992	Pool	Rbp	38.22	1.1	2.2	0.5	200.2	19.11	Sc	1.1	0.5	0.35	0.1	0.02	0.1	0.1	0	0	Gps 480054
																					5446654
18		2022	Riffle	Rbp	30.03	0.65	2	0.3	186.55	16.38	—	—	—	—	0.1	0.15	0.5	0.2	2	6	Gps 480069
																					5446628
19		2045	Glide	Rbp	22.75	0.8	1.8	0.4	191.1	17.29	Sc	0.85	0.6	0.4	0.05	0.1	0.2	0.1	1	4	Gps 480078
											tail-out										5446599
20		2191	Riffle	Rbp	145.6	1.8	1.5	0.2	170.17	17.29	Sc	1.8	0.85	0.4	0.1	0.03	1	0.3	4	16	Gps 480116
																					5446544
21		2209	Pool	Rbp	17.29	1.5	2	0.5	86.45	13.65	Sc	1.5	0.5	0.3	0.03	0.1	1	0.1			Gps 480241
																					5446503

22		2232	Glide	Rbp	23.66	0.9	2.2	0.4	86.45	12.74	—	—	—	—	0.03	0.1	0.3	0.1	1	4	Gps 480255
																					5446505
23		**2255**	Pool	Rbp	22.75	1.3	2.2	0.65	81.9	16.38	Sc	1.3	0.65	0.5	0.03	0.02	0.2	0.1	—	—	Gps 480241
																					5446496
24		2441	Glide	Rbp	185.64	1	1.8	0.3	38.22	31.85	—	—	—	—	0.1	0.03	0.1	0.2	3	20	Gps 480235
																					5446465
																					start reach 2
25		2507	Riffle	Rbp	65.52	0.45	1.5	0.2	38.22	30.94	—	—	—	—	0.1	0.03	0.5	0.3	1	3	Gps 480315
																					5446307
26		2637	Glide	Rbp	130.13	0.8	1.5	0.3	38.22	28.21	—	—	—	—	0.15	0.05	0.2	0.2	3	12	Gps 480306
																					5446219
27		2768	Riffle	Rbp	131.04	0.7	1.5	0.15	40.95	34.58	—	—	—	—	0.2	0.05	1	0.3	2	4	Gps 480330
																					5446105
28		3023	Glide	Rbp	254.8	0.9	2	0.25	29.12	24.57	—	—	—	—	0.05	0.13	0.2	0.1	3	10	Gps 480333
																					5445974
29		3114	Riffle	Rbp	91	0.55	1.5	0.25	30.94	17.29	—	—	—	—		0.05	0.5	0.2			Gps 480299
																					5445725
30		3245	Glide	Rbp	131.04	0.35	1.5	0.15	32.76	26.39	—	—	—	—	0.05	0.1	0.2	0.1			Gps 480250
																					5445644
																					start reach 1
																					Number Channel Widths
Overall means/tot.					**3244.7**	**0.73**	**1.58**	**0.29**	**65.40**	**22.72**	—	**1.16**	**0.72**	**0.43**	**0.14**	**0.06**	**0.47**	**0.17**	**29**	**111**	49.61
Reach 3					1675.86	0.53	1.22	0.24	36.05	25.69	—	0.23	0.20	0.09	0.20	0.05	0.52	0.32	5	14	46.49
Reach 2					579.67	1.02	2.02	0.41	124.49	15.38	—	0.86	0.47	0.31	0.09	0.07	0.45	0.19	12	48	4.66
Reach 1					989.17	0.68	1.61	0.23	35.49	27.69	—	0.00	0.00	0.00	0.09	0.06	0.39	0.20	12	49	27.87

St	**TW**	**L1020**	**L2030**	**L3040**	**L4050**	**L>50**	**CovTy**	**TCv%**	**PoW%**	**OhC%**	**B%**	**OffCm**	**RipTyp**	**RipSt**	**CpyC**	**Ob?**	**%Ufry**	**%UP**	**Rehabilitation Prescriptions**
																			End Reach 3. NOTE: Asses/Prescriptions Start at Erie Cr
																			Conf. End Hell Roaring Cr. Confluence
1	3	0	2	0	1	0	c/ov	1	0	0	0	—	mix	yf	2	—		5	3Bx1
																			Gps 480665 5448352
2	0	—	—	—	—	—	b	3	0	0	3	—	mix	yf	1	—		15	Rock groyne w/rootwad LB
																			3Bx6 at lower half of riffle
3	2	2	—	—	—	—	p/b/ov	10	0	0	5	—	mix	yf	5	—	5	15	Rock groyne w/rootwad LB
																			Gps 480668 5448332
																			Rock groyne w/rootwad LB
																			Gps 480618 5448269
																			Opposing Deflector Gps 48630 5448235
																			1Bx10 placed D/S of Opp. Deflector
4	0	—	—	—	—	—	b/ov	3	0	—	2	—	M	yf	5	—	5	15	3Bx8 at lower half of riffle
5	1	—	1	—	—	—	dp	20	1	—	2	—	mix	yf	3	—	5	10	
6	1	1		—	—	—	ov/swd	4	0	—	1	—	dec	ps	5				1 J-hook vane Gps480523 5448061
																			3Bx12 at lower half of riffle
7	0	—	—	—	—	—	ov/b	1	0	—	1	—	dec	ps	1	—	5	10	
8	1	1	—	—	—	—	ov/b	1	0	—	1	—	mix	ps	3	—	5	5	Existing riprap RB, private property
																			3Bx6 at lower half of riffle
9	0	—	—	—	—	—	ov	1	0	—	0	—	dec	ps	3	—		10	Opposing Deflector placed
																			3 chnl w D/S of Sta 9 boundary
																			1Bx10 placed DS of Opp. Deflector
10	0	—	—	—	—	—	ov/b	8	0	—	3	—	dec	ps	3		5	0	3Bx12 at lower half of riffle

																			Revegetate RB
11	0	—	—	—	—	—	ov/b	5			1	—	dec	ps	5				Opposing Deflector placed
																			3 chnl w D/S of Sta 11 boundary
																			Existing Terasen Gas LWD Structures
12	1	—	1	—	—	—	ov	1	0	—	0	—	dec	ps	0		5	10	3Bx5 at lower half of riffle
13	1	—	1	—	—	—	b/ov	5	0	—	1	—	mix	ps	5	—	5	10	Rock groyne w/rootwad LB x 3
																			to maintain flow in sidechannel RB
																			End Reach 2
14	5	2	2	1	—	—	lwd/ov	8	80	—	0	—	mix	mf	3	—			
15	15	8	4	1	1	2	lwd/dp	15	30	—	0	SC	mix	mf	10	—			1 2rw /tri (w/ramp) RB
																			Gps 480062 5446780
16	5	2	3	—	—	—	lwd	5	10	—	0	—	mix	mf	5	—		10	2 2rw Tri (w/ramp) RB
																			Gps 480054 5446696
17	19	13	3	2	—	1	lwd/dp	8	5	—	0		mix	mf	5	—		5	
18	17	10	5	1	1	—	lwd	15	5	—	0	—	mix	mf	3			10	None - Island natural re-vegetation occurring
19	9	4	2	1	1	1	ov/lwd	8	1	—	0	—	mix	mf	5		5	10	Good riparian vegetation cover
20	25	18	5	1	1	—	lwd	5	3	—	2		mix	mf	1	—		5	Bank Stabilization End of Carney Mill Road
																			Fence to block vehicle access
21	8	4	2			2	lwd	50	40	—	0	—	dec	yf/mf	3	—		10	none
22	4		1	1	1	—	lwd	5	3	—	0	—	dec	yf	3	—		10	none
23	9	3	3		2	1	lwd	15	10	—	0	—	dec	yf	3	—			
24	9	3	3	2	1	0	lwd/ov	5	2	—	3	—	mix	yf	0	—	5		**End Reach 1** 3 2rw Tri (w/ramp) LB
																			Gps 480281 5446323
25	5	2	2	1	—	—	lwd/b	3	1	—	3	—	mix	yf	0	—		15	60m RB eroding bank
																			Gps 480298 5446297 Plant Live Cuttings
																			3Bx6 lower half of riffle
26	3	2	1	—	—	—	ov	1	0	—	0	—	mix	yf/mf	3			5	J-hook vane x2 RB
27	3	2	1	—	—	—	ov/b	3	0	—	5	—	mix	yf	8	—		10	3 2rw Tri (w/ramp) LB
																			Gps 480323 5446085
																			3Bx18 at lower portion of riffle
28	17	10	5	1	1	0	ov/lwd	8	3	—	5	—	mix	yf	0	—	5	10	J-hook vane RB
																			1 2rw Tri (w/ramp) LB
																			2rw Tri (no ramp) lft bk
29	11	6	4	—	1	—	ov/lwd	8	3	—	0	—	dec	ps	1	—		10	3Bx24 at lower half of riffle
30	3	2		1	—	—	ov/b	3	1	—	3	wl	dec	ps	0				none due to eroding bank on outside bend of sharp
																			meandor DS of Hellroaring confluence
T	**177**	**95**	**51**	**13**	**11**	**7**		**7.6**	**6.6**	**0.0**	**1.4**	**1.4**			**3.1**		**1.8**	**7.2**	**LWD functional=3.57**
R3	**9**	**4**	**4**	**0**	**1**	**0**		**4.833**	**0.08333**	**0**	**1.583**	**0**	**0**	**0**	**3**	**0**	**2.917**	**7.917**	**LWD functional=0.19**
R2	**117**	**64**	**31**	**8**	**7**	**7**		**12.64**	**17**	**0**	**0.273**	**0**	**0**	**0**	**4.182**	**0**	**0.909**	**6.364**	**LWD functional=25**
R1	**51**	**27**	**16**	**5**	**3**	**0**		**4.429**	**1.42857**	**0**	**2.714**	**0**	**0**	**0**	**1.714**	**0**	**1.429**	**7.143**	**LWD functional=1.83**

Photo 1. Sta. 1-2 upstream view towards Erie Creek Confluence.

Photo 2. Sta. 2 Rock Groin enhancement 1.

Photo 3. Sta. 3 looking downstream.

Photo 4. Sta. 3 Rock Groin enhancement 2.

Photo 5. Sta. 3 Rock Groin enhancement 3.

Photo 6. View upstream of proposed Rock Groins.

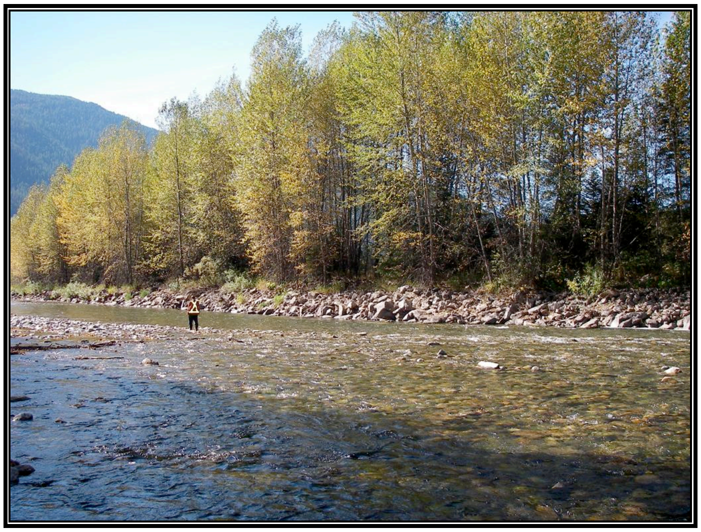

Photo 7. Sta. 3-4 upstream view. Note extensive flood control dykes on bank.

Photo 8. Sta. 6 proposed J-hook Vane.

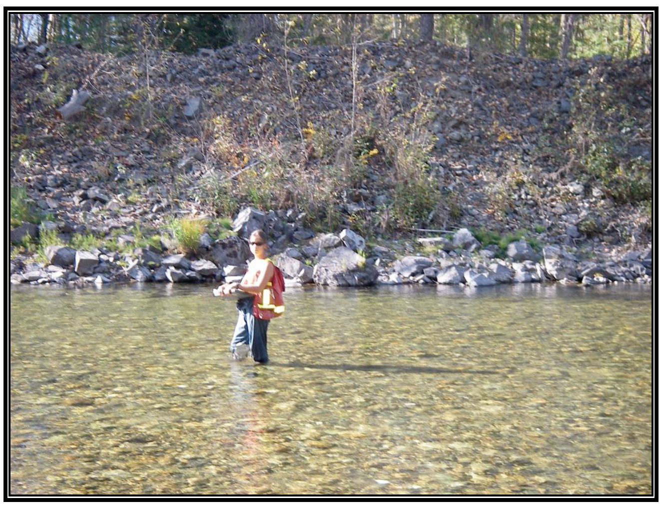

Photo 9. Sta. 11 proposed location of V-weir.

Photo 10. Downstream view of Reach 2.

Photo 11. Sta. 15 eroding bank. Proposed Debris Groin.

Photo 12. Sta. 16 downstream view eroding bank.

Photo 13. Sta. 20 eroding bank at end of Carney Mill Rd. Proposed bank stabilization.

Photo 14. River access end of Carney Mill Rd. eroded by ATV's.

Photo 15. ATV tracks and cut logs on gravel bar in Reach 2.

Photo 16. Braided section of channel downstream of Sta. 20.

Photo 17. Downstream view Sta. 24-25. Existing riprap on both banks. Prescribed Rootwad triangles and J-hook vane.

Photo 18. Sta. 24 looking downstream. Proposed Rootwad triangles (3).

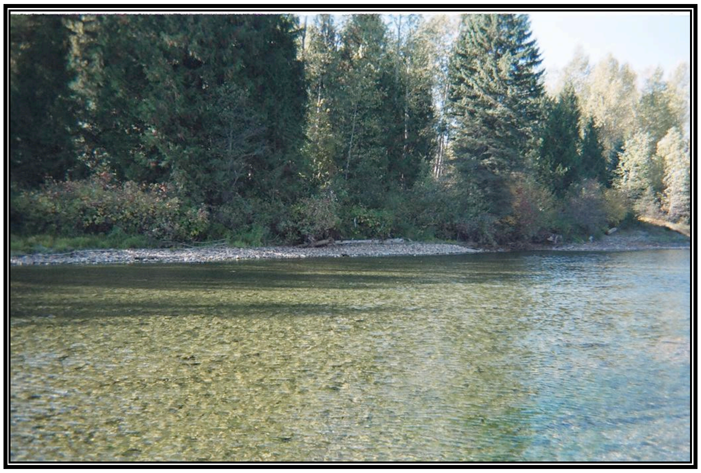

Photo 19. Sta. 26 proposed J-hook vane.

Photo 20. Sta 27 proposed Boulder Clusters in downstream portion of riffle.

Photo 21. Sta. 28 proposed Rootwad triangles (3) left bank. Natural LWD on right bank.

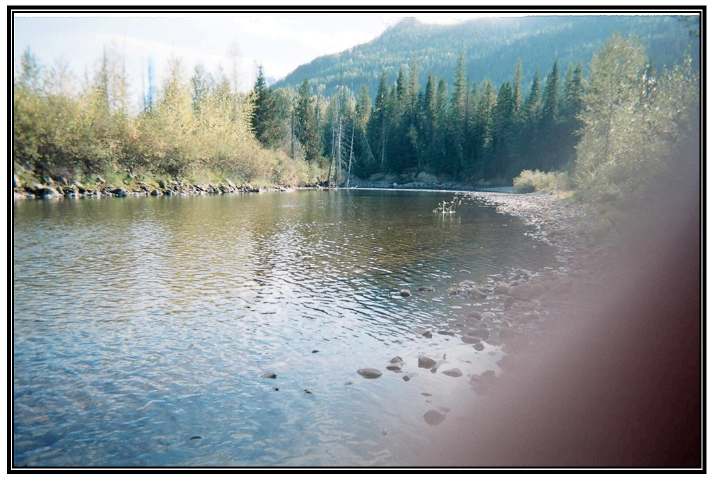

Photo 22. Sta. 30 view downstream toward Hellroaring confluence. No restoration prescriptions due to eroding banks on outside bend of meander downstream.

Photo 23. ATV access created at the end of Carney Mill Rd. through the Salmo River.

Photo 24. ATV access created at the end of Carney Mill Rd. through the Salmo River.
Note trail over braided area to remove LWD from center braid.