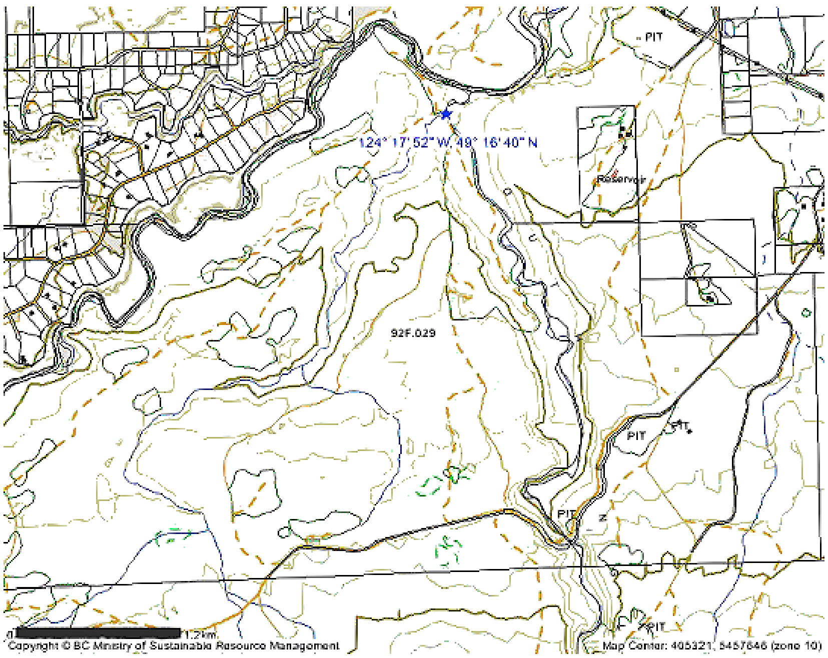
Restoration Plan:

Detailed Salmon Habitat and Riparian Overview with Level II Prescriptions

Center Creek Sub-Basin

Englishman River Watershed



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PREFACE

Restoration Plans are developed to aid in the recovery of both terrestrial and aquatic habitats. In order for a restoration plan to be effective all relevant factors must be considered.

There are many factors associated with declines of anadromous salmonids such as stream habitat loss and degradation[1], over-exploitation in sport and commercial fisheries, as well as ocean survival[2]. This report measures the impacts on the ecosystem of the freshwater habitat through the components of upslope, roads, riparian areas and streams. It does not address fish harvest management, global warming, or variable ocean conditions.

We recommend that salmon recovery efforts be based on restoring and conserving ecosystems, rather than simply restoring the instream habitat attributes. Stream recovery should be planned and managed at a watershed scale. It should be considered in the development of recovery plans [3/4] as relationships between habitat condition and individual salmonid response have been well established within the habitat unit[5/6], stream reach[7], and to the watershed unit [8]. Consideration, and restoration, of upslope and fluvial processes that create and maintain habitats must be integral components of any recovery program[9]. Manage the entire watershed for recovery.

EXECUTIVE SUMMARY

This Restoration Plan addresses not only the root causes directly responsible for the immediate loss of habitat quantity and quality, but also the ecosystem processes that create and maintain habitats through time[10].

The roads within the Center Creek Watershed were generally found to be in good, well maintained condition with limited exceptions that could not be easily addressed. However, the road density was found to be of concern at 3.41 km/km², creating a high risk of cumulative impacts due to sediment.

The riparian zones assessed on lower anadromous Center Creek were found to be in a moderate state of recovery but there was significant opportunity for treatment of the RVT 2 (over stocked conifer) and to utilize the excess conifers for LWD stream structures. Patches of laminated Root Rot (*Phellinus weirii*) infection were noted throughout the riparian zone, which may also provide the forest CWD, and instream LWD. Some of the polygons within the RVT 3 and RVT 4 areas were dominated by Maple, not Alder, indicating a diversity beneficial to forest and stream regeneration. The average age of the second growth co-dominant riparian stands was 41 years, ranging from 36 to 49 years.

The fish habitat in the anadromous reaches of Center Creek was found to be shallow or dry at low flow periods. There was a lack of LWD in the river to create scour pools and cover habitat. The recommendations are to replace the immediate lack of wetted habitat through off channel construction and restore LWD functions through instream positioning and riparian restoration.

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[1] Nehlsen et al. 1991; Frissell 1993
[2] Nehlsen et al. 1991
[3] Report 5, CSSP 1995
[4] Williams et al. 1989
[5] Nickelson et al. 1992
[6] Bisson et al. 1982
[7] Murphy et al. 1989
[8] Schlosser, 1991
[9] Thomas et al. 1993
[10] Report 5 (CSSP), 1995

ACKNOWLEDGMENTS

The authors would like to express sincere thanks for the effort of the following volunteers: Faye Smith of the Qualicum Beach Streamkeepers, Carol Cornish of the Parksville Streamkeepers, and Clay Young of CFDC.   Without their perseverance, this report would not have been possible.

The authors would also like to thank Faye Smith, Carol Cornish, Clay Young, and Dave Davies (DFO) for their volunteer field assistance and behind the scene support.

This, of course, would not have been possible without the permission and assistance of the staff of Timber West (Dave Lindsay and Al Chatterton) and Weyerhaeuser (John Eden), and especially the original insight and direction from the late Bob Willington.

Given the impressive amount of volunteer involvement that has occurred on Center Creek, we apologize in advance if we inadvertently missed someone.

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1.0 INTRODUCTION

The Englishman River Watershed is located on the central East Coast of Vancouver Island (Figure 1) flowing northeast from its headwaters near Mount Arrowsmith into Georgia Straight near Parksville, BC[11]. Due to significant declines in Salmon and Trout populations, and relative possibility for restoration success, it was selected by the Pacific Salmon Endowment Fund (PSEF) Society in 2001as the first watershed for the Georgia Basin salmon recovery process. Historically Chum (*Oncorhynchus keta*) and Coho (*O. kisutch*) salmon have been the two most dominant species. The Englishman River watershed is also inhabited by Chinook (*O. tshawytscha*), Pink (*O. gorbuscha*) and Sockeye (*O. nerka*) salmon. Steelhead Trout, Resident Rainbow (*O. mykiss*), sea run and resident Cutthroat (*O. clarki clarki*) are also present[12]. Steelhead populations are currently at severely reduced levels[13]. The provincial government has classified the Englishman River as a sensitive stream.

The Englishman River (with a total area of 324 km²) consists of five sub-basins[14] (or contributing smaller watersheds) that include the Englishman River mainstem (179 km²), South Englishman River (83 km²), Center Creek (21 km²), Morison Creek (36 km²), and Shelly Creek (5.0 km²)[15]. See Appendix 2, Watershed Ortho-photo, and Appendix 3, Englishman River Sub-Basin Map for more detail.

The Englishman River Watershed is located within the South Island Forest District. The primary Biogeoclimatic zones of the Englishman River watershed include Coastal Douglas Fir (CDF), variant "Moist Maritime" (mm) roughly ranging from sea level to 150m elevation, and Coastal Western Hemlock (CWH) ranging approximately from 150m to 1100m elevation (Figure 2). Primary CWH variants include xm1 and xm2 (very dry maritime), and mm2 (moist maritime)[16]. The drier CDF zone is said to be lying in the rainshadow of the Vancouver Island and Olympic Mountains. The CWH zone is characterized as having the highest precipitation of any zone in British Columbia, with cool summers and mild winters[17]. Annual precipitation within the Englishman River Watershed ranges from 964mm (3.1 feet) at the mouth, to an estimated 2,200mm (7.2 feet) at the higher elevations[18].

Center Creek enters the South Englishman River (124° 17' 52" W, 49° 16' 40" N) approximately 250m upstream from the South Englishman confluence with the mainstem Englishman River. It has 5.2 km of anadromous mainstem length and an estimated 1,100 square meters of spawning habitat[19]. Its overall fish bearing length including headwater trout in tributaries is estimated to be 16.5 km. Center Creek is an important contributor to Coho and Steelhead populations within the Englishman River Watershed. The 2002 Overview of Fish and Fish Habitat in the Englishman River Watershed by Lough and Morley found the highest abundance of juveniles in the Englishman River watershed to be in the Center Creek sub-basin[20]. The primary land-use and effect on stream health in the Center Creek watershed is forestry activities. Other uses include harvest of non-timber resources (e.g. salal and mushroom harvesting) and recreational activities (hiking, mountain biking, horseback riding, all terrain vehicles, etc.).

The Center Creek watershed has had a lengthy history of timber harvesting (early 1900's)[21]. The watershed is comprised entirely of private forest land (Figure 1), with sections owned by Weyerhaeuser (upper Center Creek) and Timber West (lower Center Creek). The Center Creek watershed has a total forest road length of 71.69 km, which translates to a relatively high density of 3.41km per km squared.

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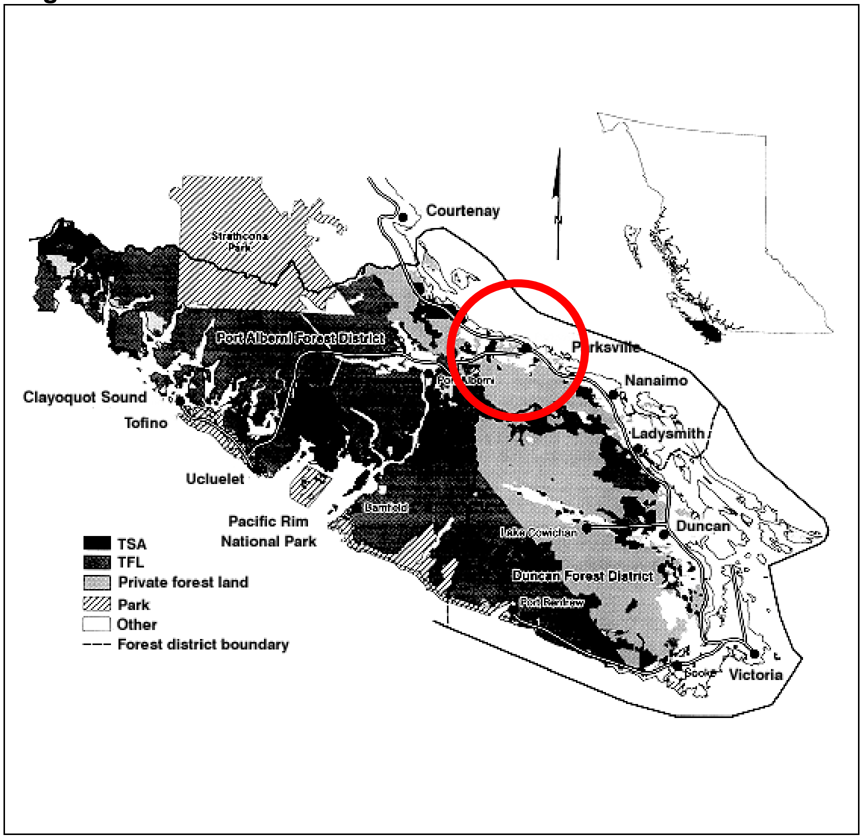
[11] Lough and Morley, 2002
[12] Bocking, Gaboury 2001
[13] Wightman et al. 1998
[14] Bocking, Gaboury 2001
[15] Watershed areas from: Rood, K. 2002
[16] Green, Klinka. 1994
[17] Arrowsmith Timber Supply Analysis. 2001
[18] Higman, et al. 2003
[19] Bocking, Gaboury 2001
[20] Lough and Morley, 2002
[21] Bocking, Gaboury 2001

Streamkeepers and enhancement organizations have had a history of volunteer stewardship activities within the Englishman River Watershed. The watershed is a key management area for both federal and provincial fisheries agencies.

Figure 1. Center Creek watershed location on Vancouver Island and land status[22].

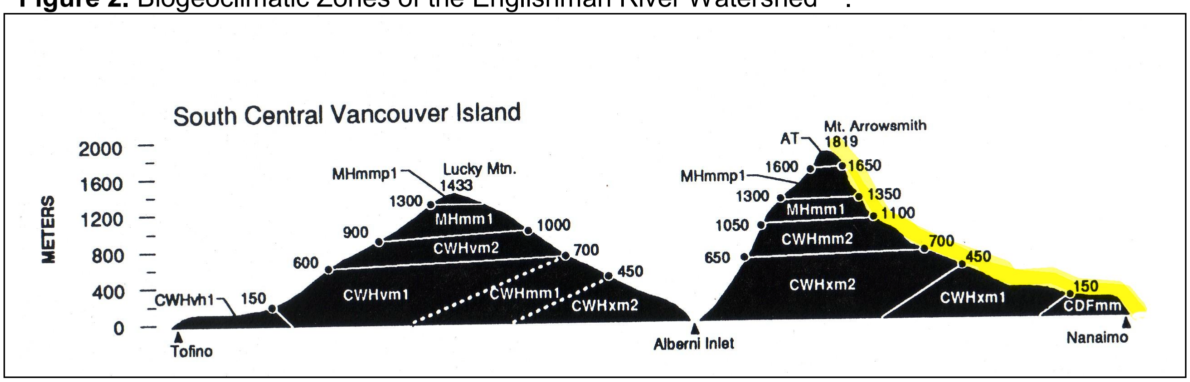


The primary focus to date for PSEF (2001) restoration has been in-stream projects on the Englishman River mainstem. Given the high-energy characteristics and risks associated with these mainstem in-stream structures, there has been relatively little opportunity for the Streamkeepers organizations to develop significant restoration projects.

Center Creek was chosen as a candidate for detailed assessment because of its relatively small size (21 km²) and potential for manageable restoration projects by local stewardship organizations.

Center Creek was also recommended in the 2001 Englishman River Recovery Plan for a more comprehensive assessment of channel and fish habitat to properly determine condition, as well as detailed riparian assessments. The 2002 Overview Assessment of Fish and Fish Habitat in the Englishman River Watershed, by Lough and Morley also recommended Center Creek (Reaches C1 to C3) as the highest priority areas for restoration.

Figure 2. Biogeoclimatic Zones of the Englishman River Watershed [23].



All areas assessed are within private land; restoration cannot proceed without first seeking permission by the private landowner/s and specific agencies that have jurisdiction over areas "in and about a stream". Recommendations for treatments must therefore be reviewed and be deemed acceptable by relevant parties and the private landowner/s.

[22] Arrowsmith Timber Supply Analysis. 2001
[23] Green, Klinka. 1994

2.0 RESTORATION OBJECTIVES AND STRATEGIES

2.1 ROADS

- Assess and prioritize the watershed road condition.
- Identify ways to reduce the residual risk of a road related slope failure to low, where low is defined as the residual risk associated with a similar area without roads[24].
- Improve water quality by restoring surface and subsurface hydrology.
- Improve site productivity.
- Remove fish passage impediments.
- Enhance fish habitat at fish bearing road crossings.
- Remove or substantially reduce hydrological impact.

2.2 STREAMS

- Assess fish habitat using provincial standards comparative with other stream surveys on Vancouver Island.
- Establish a monitoring program of habitat over time.
- Determine current habitat status.
- Prioritize habitat deficiencies.
- Develop Level II prescriptions of priority areas incorporated with other restoration components.
- Build partnerships with landowners and Stewardship groups through ongoing planning, restoration and monitoring activities.

2.3 RIPARIAN

- Speed up the natural recovery process by re-establishing a more natural frequency of conifer species, age distribution, and promoting the conifer species growth for natural LWD recruitment.

2.31 Riparian Vegetation Type 1 Restoration

- Re-establish conifers, through planting or release of existing trees within the riparian zone to stabilize the channel, reduce bank erosion, and provide a long term recruitment of LWD.
- Reduce brush competition through brushing.

2.32 Riparian Vegetation Type 2 Restoration

- Reduce conifer densities to create increased growth on remaining trees to establish as future recruitment source of LWD.
- Enhance old growth attributes.
- Create habitat attributes for birds, mammals and amphibians, particularly identified species where possible.

2.33 Riparian Vegetation Type 3 Restoration

- Lower long-term deciduous density to reduce conifer competition.

2.34 Riparian Vegetation Type 4 Restoration

- Re-establish conifers, through planting or release of existing conifers to stabilize the channel, reduce bank erosion, and provide a long term recruitment source of LWD.
- Lower long-term deciduous density to reduce conifer competition.

2.35 Riparian Vegetation Type 5 Restoration

- Utilize to develop a template for restoration of degraded riparian areas.

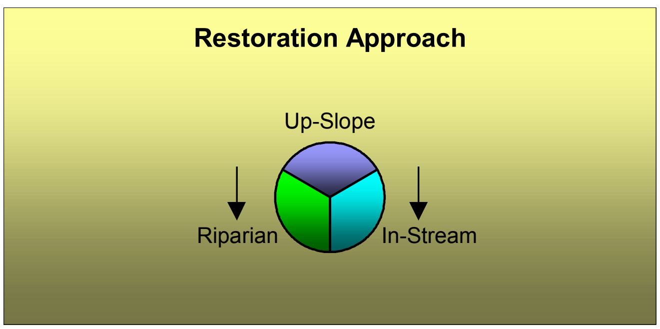
[24] Leslie et al. 1997

3.0 RESTORATION APPROACH

Many of the pre 1995 logging practices have resulted in significant negative impacts on salmon and trout species habitat throughout BC. Due to sub-standard road building methods, particularly in the steep coastal settings and sensitive flood plains, there was often an increase in sediment. Harvesting LWD from watercourses or removal of riparian vegetation resulted in a decrease of large woody debris delivery into stream systems. Collapsing log culverts, misplaced culverts, and poorly located roads on the floodplain or unstable areas resulted in water interception, partial or full fish barriers, and diverted stream segments. Sources of sediment include road surfaces, poor water management, and land slides.

For restoration of impacted coastal streams, a top-down approach is recommended (Figure 3). Without addressing sediment sources (and especially upslope liabilities), in-stream restoration efforts can be ineffective[25]. The ultimate goal for the up-slope restoration programs is to address unstable logging roads and/or sediment sources (through deactivation or upgrade) before any slides occur or have (or are estimated to potentially have) adverse impacts on aquatic resources. Eliminating chronic or severe pulse sediment sources is also of important consideration. Priority of up-slope deactivation (or upgrade) is determined by where it would be most beneficial in preventing or reducing excessive (above natural sediment budget levels) sediment influx.

Figure 3. Restoration Approach



Deactivation or upgrade of the highest risk roads is completed first, working consecutively towards (but not necessarily including) the lower risk roads. The approach is to fully restore the hill slope at the old road location then aggressively revegetate the exposed soil.

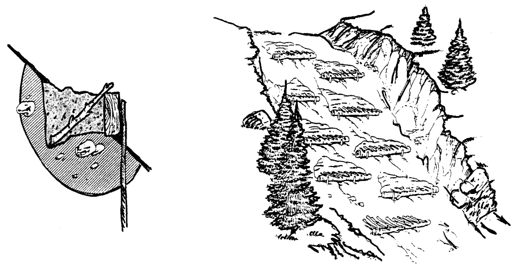
The goal for roads is to re-establish natural steam flow patterns, coordinating deactivation with access requirements for in-stream and riparian restoration. Where deactivation (or upgrade) of roads occur at fish bearing crossings, a biological prescription that enhances fish habitat should be implemented along with the deactivation prescriptions.

In up-slope areas where there has been slide activity, open slope failures are hydro-seeded with a mixture of grass seed (native seed when available), slow release fertilizer, and mulch. Grass seeding is effective in reducing fine sediment leeching from the slide (it is also effective in reducing fine sediment from exposed ditchlines and old road surfaces).

Grass establishes well on areas of a slide that are relatively stable. Zones of instability are identified the following year by observation of areas of poor grass establishment. Following the deactivation of the roads there is a focus on restoring the unstable portions of the landslides. To stabilize and revegetate the slides an approach called soil bioengineering is utilized (Figures 4, 5, 6). Basically this is the use of live willow cuttings to construct living, self-maintaining, retaining walls.

25 Williams et al. 1989

Figure 4. Modified Brush Layer (MBL).



Dormant willow cuttings are used to build living, self-maintaining, retaining walls on landslides. Willow is used because the cuttings grow roots where exposed to soil, and shoots where exposed to air

Figure 5. Live Gully Breaks (LGB).

These bioengineering structures are used to reduce the energy of incised areas of a landslide.

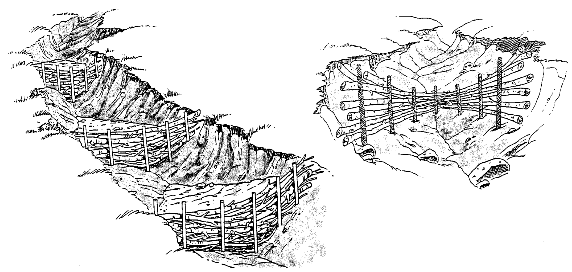
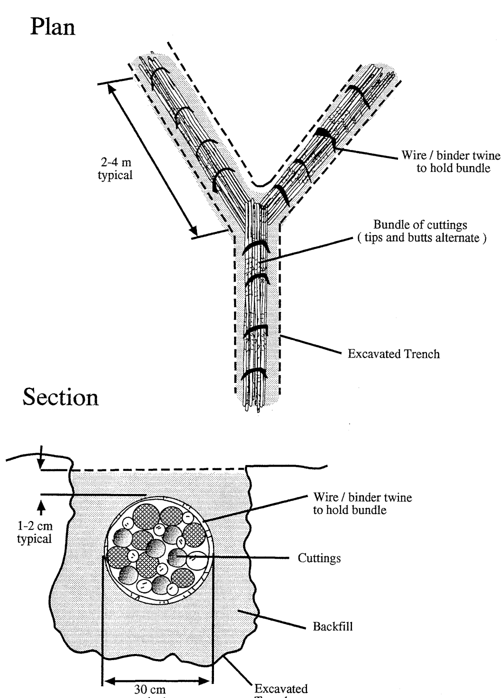
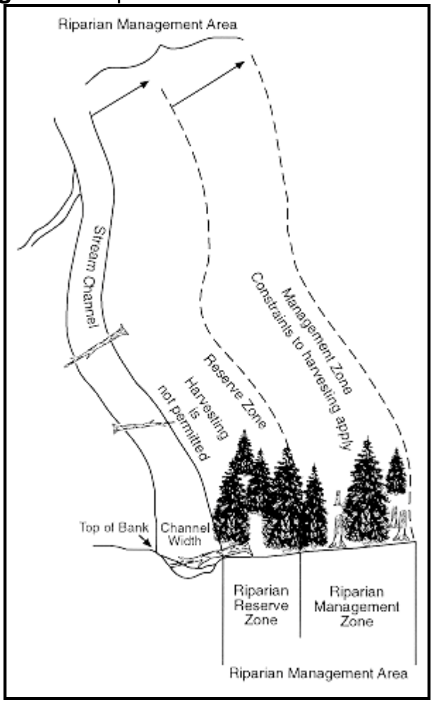


Figure 6. Live Pole Drain (LPD)



These bioengineering structures are used to create a living self-maintaining pipe in incised areas with relatively consistent water flow or seepage.

Figure 7. Riparian Zone



In the past, cut blocks were logged right to the stream banks, which virtually eliminated any chance of larger trees dying and falling into the stream (LWD recruitment). In many cases Alder, Maple, and brush have taken over the riparian areas of the streams and rivers. While Alder and Maple can supply good cover, when they die and fall in the stream they break down quickly (compared to conifers). Maple is superior to Alder as its root strength is substantially higher. Stream rehabilitation projects should have a strong focus on riparian restoration that focuses on developing uneven aged coniferous riparian zone with a mixture of deciduous.

A common result in high relief (steep) areas of some pre-1995 logging practices, is that debris torrents have swept away many of the natural LWD structures rendering the stream system relatively featureless (low pool, riffle, and glide frequency). The bedload fills in the pools and thalweg (the deepest section of a stream) causing in the energy of the stream to be re-distributed towards the stream banks (Figure 9)[26].

Only when the high-risk up-slope areas have been addressed should the in-stream restoration work proceed. In-stream work is generally divided into two components: riparian (Figure 7) the vegetative buffer strip along a stream, and actual in-stream work. Generally, the wider the stream, the greater the riparian reserve that should be established for protection of the important terrestrial and aquatic habitats (Figure 8)[27].

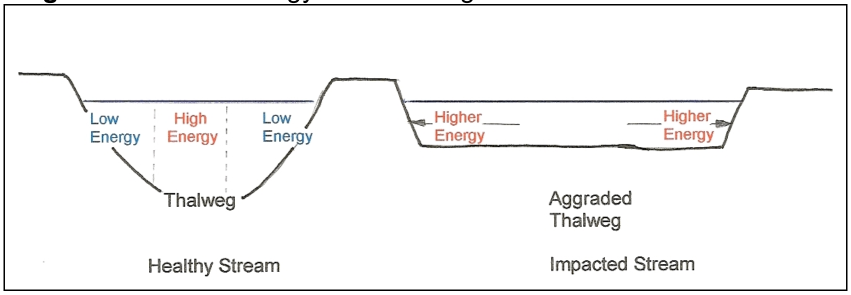
Figure 8. Forest Practices Code Recommended Riparian Management Zones

Riparian class	Average channel width (m)	Reserve zone width (m)	Management zone width (m)	Total RMA width (m)
S1 large rivers	≥100	0	100	100
S1 (except large rivers)	>20	50	20	70
S2	>5≤20	30	20	50
S3	1.5≤5	20	20	40
S4	<1.5	0	30	30
S5	>3	0	30	30
S6	≤3	0	20	20

(shaded) Fish stream or community watershed
(unshaded) Not fish stream and not in community watershed

[26] Warttig et al. 2002
[27] Riparian Management Area Guidebook. 1995

Figure 9. Stream Energy and Thalweg



As this energy erodes the banks (made even less stable with the lack of large conifer roots), the bedload problem is compounded.

An aggraded thalweg is the legacy of combined upslope and riparian impacts. This is visually apparent in the anadromous reaches of Center Creek. Restoration of upslope, roads and riparian zones attenuate the flood effects, cut off the sediment loads and strengthen stream banks. This leads to opportunities for recovery of instream LWD function.

A common interpretation of bedload-laden streams is that flows need augmenting because the streambeds go dry during summer months. This is an incomplete assumption as water flow may still exist, but because of the bedload, is sub-surface. Additionally, the pool-riffle complexity is lost and much of the surface water is transported as shallow glides through the impacted reach. Thus recovery strategies should address the bed load problem by re-contouring the streambed. In this situation, instream restoration of LWD is the most critical component. Efforts are needed to restore;

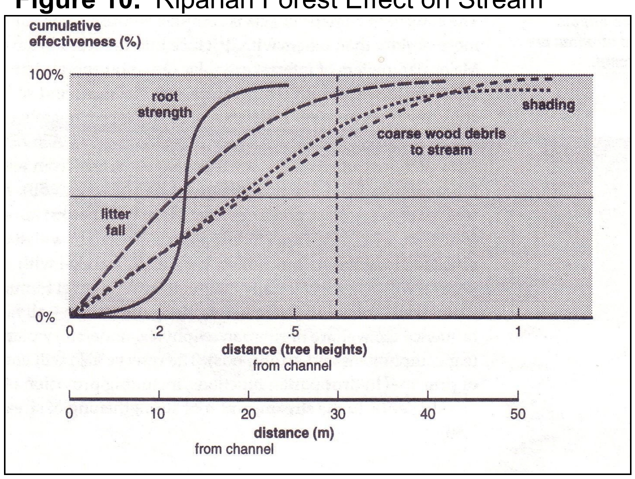
- Natural LWD frequency
- Natural pool-riffle-glide frequency
- Natural off channel rearing habitat

Generally, in-stream restoration work involves the creation of pools, riffles and glides by installing structures in-stream made of LWD and/or rock. By securing LWD in place (with cables or boulders) biologists and engineers hope to temporarily (up to 50 years) mimic nature in its creation of pools, riffles and glides. Much of the designed function of LWD structures involves the manipulation of water currents within the stream. As water is diverted and compressed around the LWD structures, the bedload is scoured away to create the desired pools, riffles, glides, and thalweg.

LWD is a keystone element in coastal low gradient streams, not only for hydraulic processes but also as habitat for fish, mammals, birds, amphibians and invertebrates. It offers cover, feeding, and access in the riparian zone.

Riparian restoration is necessary for ensuring a future source of LWD recruitment, as well as ensuring bank integrity, litter fall input, and shading (Figure 10). The riparian area is an important source of LWD[29] and is also has very high value for wildlife habitat. The zones with the highest mammal species diversity are found in the CWH and IDF zones.

Figure 10. Riparian Forest Effect on Stream[28]



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[28] Riparian Areas, Functions and Strategies for Management. 2003
[29] Reeves, Burnett, and McGarry. 2003

3.1 ROAD RESTORATION PLANNING

3.11 Road Assessment Methodology

The forest road risk assessment procedures listed in this section[30] are expected to increase the benefits of the road deactivation and upgrade and maintenance programs. This method is used to objectively rank and compare potential risk on individual logging roads.

In 1998, a risk model was developed by the Ministry of Forests (MOF) to help prioritize which watershed should be addressed next, but the criteria used could not accurately assess landslide hazard and risk on an individual road.

In early partnerships through MOF, there was recognition that there was a need for a better planning system. Based on the 1998 risk model, Mike Wise, P.Eng. (GeoWise Engineering Ltd.), Mike Leslie (Mike Leslie Consulting Ltd.) and Warren Warttig, RPBio (International Forest Products Ltd.) developed a new planning methodology and designed and field tested field cards to document a road's condition. This new methodology provided an objective risk assessment of each individual road, allowing for a comparison of roads throughout operating areas (Table 1).

In order to document road conditions, the field card was broken into sections to give a numerical rating to indicate the relative risk for each road where: *Environmental Risk = Hazard x Consequence*.

Hazard is a ranking of instability based out of a maximum score of 9. The higher the instability of the road (i.e. the likelihood of a road-related landslide initiating within the next five years) the higher ranking it receives. The card is designed to record hazard indicators of road instability and their location such as tension cracks, displacement, incising, water control problems, etc.

When looking at the stability of an existing road, how the roads in the watershed are performing is usually a good indication of comparable stability. If there are no landslides elsewhere in the watershed, that watershed may be inherently stable. How the road was constructed is also important as roads have different kinds of stability concerns based on what kind of equipment was used to build them. A road built by a bulldozer will have different stability concerns than a road built by an excavator.

Consequence is also based on of a maximum score of 9, and is a ranking of what a slide would impact if it were to initiate. The greater the potential damage, the higher the consequence ranking the road receives. A section of the field card was designed to record a list of consequences such as impact on a salmon bearing stream, loss of human life, property damage, visual aesthetics, etc.

Once the roads have been rated for *Environmental Risk*, then there is assessment of the feasibility of a proposed deactivation program. This *Feasibility* Rating also has a maximum score of 9, and includes factors such as access, technical feasibility and level of funding.

The *Environmental Risk* score is then multiplied by the *Feasibility* Score to give a maximum score of 729, indicating *Overall Risk* (Table 2).

The scores of all roads are summarized so they can be objectively compared. Decisions can then be made that ensure that a given level of funding will provide the greatest reduction of risk, thus allowing for a "best investment" planning process. Road deactivation planning must be carefully coordinated with the stream and riparian restoration in order not to eliminate important access to work sites.

[30] Warttig et al. 2001 Kennedy Flats Restoration Plan

Table 1. Road Risk Template Definitions: Up-slope WRP Risk Assessment Rating.

Hazard: (the likelihood a slide will initiate) rating scale:

Value	Description
7-9 (high)	There is a significant probability that the hazard will worsen within the next 5 years
4-6 (mod)	Addressing the hazard will be required, but it is not expected to worsen significantly over the next 5 years
1-3 (low)	Low likelihood of a slide initiating now or over the next 5 years

Consequence: (what a slide would impact if it were to initiate) rating scale:

Value	Description
7-9 (high)	Major fish streams, human health, infrastructures
4-6 (mod)	Minor fish streams (resident fish only), productive forest land, significant wildlife Habitat, high visual quality
1-3 (low)	Lower visual quality, informal recreational values

Feasibility:

- Access (is access by road possible) rating scale:

Value	Description
3 (high)	Road intact / machine access possible
2 (mod)	Road intact but overgrown / Reactivation required to install drainage structures (road presently cross-ditched/Road previously deactivated to inadequate standard)
1 (low)	No access possible (road removed by slide)/reactivation not required to reduce hazard

- Technical (will work completed using proven road deactivation techniques reduce risk) rating scale:

Value	Description
3 (high)	A reasonable level of intervention is likely to reduce the over-all hazard rating to low
2 (mod)	A reasonable level of intervention is likely to reduce the over-all hazard rating to an acceptable level
1 (low)	A reasonable level of intervention is **not** likely to reduce the over-all hazard rating to an acceptable level/No hazard exists

- Fiscal (can road be deactivated given the current funding level) rating scale:

Value	Description
3 (high)	Hazard will be reduced to low given the allotted budget
2 (mod)	Hazard will be significantly reduced with allotted budget
1 (low)	Hazard will **not** be significantly reduced with allotted budget

Table 2. Breakdown of environmental and overall road risk ratings. Maximum environmental risk = 81(9x9), maximum overall risk = 729 (9x9x9).

Environmental Risk Breakdown (Hazard x Consequence)	
Critical	**64 or greater**
High	**55-63**
Medium	**28-54**
Low	**1-27**

Overall Risk Breakdown (Hazard x Consequence x Feasibility)	
Critical	**567 or greater**
High	**486 to 566**
Medium	**243 to 485**
Low	**Less than 243**

3.12 Road Assessment Results

Table 3 below describes the overall risk to the road in the Center Creek area.

Table 3. Summary of Center Creek Roads and Their Risks.

Center Ck. Roads	Length (m)	Current Status	Reactivation Length (m)	Deactivation/ Maintenance Length (m)	Overall Risk
BR.155 M/L	3896	Intact Mainline	0	3896	H
BR.155E	600	Intact, 2wd accessible	0	600	L
BR.155E4	994	Intact, 4wd accessible	0	934	L
BR.155E4A	110	Overgrown/stable	0	0	L
BR.155E9	879	Overgrown/no access	879	879	L
BR.155E10	300	Overgrown/stable	0	0	L
BR.155F	3346	Intact, 2wd accessible	0	2236	M
BR.155F1.5	1480	Intact, 2wd accessible	0	1480	L
BR.155F1.6	140	Intact, 2wd accessible	0	140	H
BR.155F1.7	280	Overgrown/stable	0	0	L
BR.155F1A	330	Overgrown/no access	68	68	M
BR.155F1B	1277	Deactivated	0	0	L
BR.155F1B3	255	Overgrown/no access	173	173	L
BR.155F1B5	266	Overgrown/no access	147	147	L
BR.155F1B7	307	Overgrown/stable	0	0	L
BR.155F1	1130	Overgrown/no access	312	312	L
BR.155F2	655	Overgrown/no access	230	230	L
BR.155F3	508	Overgrown/no access	211	211	M
BR.155F3A	88	Overgrown/stable	0	0	L
BR.155F4	2185	Intact/no access	0	0	L
BR.155F4A	165	Overgrown/stable	0	0	L
BR.155F4B	285	Overgrown/stable	0	0	L
BR.155F5	220	Intact, 4wd accessible	0	0	L
BR.155F6	110	Intact, 4wd accessible	0	0	L
BR.155F8	938	Intact, ATV accessible	0	0	L
BR.155F7	1708	Intact Mainline	0	100	L
BR.155F7A	180	Intact, 4wd accessible	0	35	L
BR.155F70-1	285	Intact, 2wd accessible	0	285	M
BR.155F-15	255	Intact, 4wd accessible	0	0	L
BR.155F-16	157	Intact, 4wd accessible	0	0	L
BR.155G	3630	Overgrown/no access	876	643	M
BR.155G.6	894	Intact/partial access	754	754	H
BR.155GA	1384	Overgrown/stable	0	0	L
BR.155GA1	40	Overgrown/stable	0	0	L
BR.155GA2	413	Overgrown/stable	0	0	L
BR.155G1	357	Overgrown/stable	0	0	L
BR.155G2	668	Overgrown/stable	0	0	L
BR.155G3	285	Overgrown/stable	0	0	L
BR.155G-10	345	Overgrown/stable	0	0	L
BR.155K	1846	Intact, 2wd accessible	0	726	L
BR.155K1	265	Intact, 2wd accessible	0	0	L
BR.155K2	1558	Intact, 2wd accessible	0	1135	H
BR.155H	1826	Overgrown/ATV accessible	476	476	L
BR.155H1	410	Overgrown/no access	165	165	L
BR.155H2	233	Overgrown/stable	0	0	L

Table 3 (Continued). Summary of Center Creek Roads and Their Risks.

Center Ck. Roads	Length (m)	Current Status	Reactivation Length (m)	Deactivation/ Maintenance Length (m)	Overall Risk
BR.155H3	177	Overgrown/stable	0	0	L
BR.155I	982	Intact, 4wd accessible	0	982	M
BR.155I1	183	Intact, 4wd accessible	0	0	L
BR.155J	4339	Intact/partial deactivation	4339	4339	H
BR.155J9	886	Overgrown/stable	0	0	L
BR.155J-20	3711	Deactivated	0	0	L
BR.155J21	116	Overgrown/stable	0	0	L
BR.155J21.5	219	Overgrown/stable	0	0	L
BR.155J22	40	Overgrown/stable	0	0	L
BR.155J23	436	Overgrown/ATV accessible	75	75	L
BR.155J24	294	Intact/overgrown	0	0	L
BR.155J26	569	Overgrown/stable	0	0	L
BR.155J26A	161	Overgrown/stable	0	0	L
BR.155L	275	Intact, 4wd accessible	0	0	L
BR.155J27	785	Intact, 4wd accessible	0	0	L
BR.155J28	1335	Intact, 4wd accessible	0	1335	L
BR.155J29	726	Overgrown/stable	0	0	L
BR.155J29A	471	Overgrown/stable	0	0	L
BR.155J30	982	Intact, 4wd accessible	0	0	L
BR.155J31	1021	Intact, 4wd accessible	0	0	L
BR.155J35	460	Overgrown/stable	0	0	L
BR.155J1	953	Overgrown/stable	0	0	L
BR.155J1A	124	Overgrown/stable	0	0	L
BR.155J2	398	Overgrown/stable	0	0	L
BR.155J3	600	Overgrown/stable	0	0	L
BR.155J4	675	Overgrown/no access	675	675	L
BR.155J4A	156	Overgrown/stable	0	0	L
BR.155J5/5A	660	Intact, 4wd accessible	0	660	L
BR.155J5.5	383	Overgrown/no access	383	383	L
E4900	115	Intact, 2wd accessible	0	0	L
E4800	260	Intact, 2wd accessible	0	0	L
E4600	425	Intact, 2wd accessible	0	0	L
E4500	790	Deactivated	0	0	L
E4510	300	Overgrown/stable	0	0	L
E4520	100	Deactivated	0	0	L
E502	569	Deactivated	0	0	L
E503	186	Intact, 4wd accessible	0	186	L
E500	1218	Intact/partial deactivation	0	50	L
E1500	1495	Deactivated	0	195	M
E1510	525	Intact, 2wd accessible	0	20	M
E1510A	145	Intact, 2wd accessible	0	0	L
E3000	1795	Deactivated	0	1145	L
E3300	210	Intact, 2wd accessible	0	0	L
E3400	1827	Intact, 2wd accessible	0	1681	L
E3410	30	Deactivated	0	0	L
E3420	281	Deactivated	0	0	L
E3500	202	Intact, 4wd accessible	0	202	L
E3600	1063	Deactivated	0	0	L
E3700	440	Intact, 2wd accessible	0	0	L
E3710	118	Intact, 2wd accessible	0	0	L
TOTAL:	**71,694**		**9,763**	**27,553**	

3.2 STREAM RESTORATION PLANNING

3.21 Stream Assessment Methodology

Stream habitat was assessed using the Urban Salmon Habitat Program Assessment Procedures for Vancouver Island [31]. This methodology has been adopted by Stewardship groups and is their standard for habitat comparison on Vancouver Island.

Dave Clough RP Bio, Warren Warttig RP Bio, Carol Cornish (Fisheries Technician), Faye Smith (Streamkeeper) and Dave Davies (FOC Community Advisor) conducted the survey. Access to the site is off Highway 1A south of Parksville at the Weyerhaeuser Northwest Bay gate. The Northwest Bay Mainline was then taken approximately 5.0 km crossing over the South Englishman River and then the first road right at the Timberwest gate. The Timberwest road leads approximately 3.0 km to the mouth of Center Creek.

Center Creek enters the South Englishman River on the left bank. The South Englishman enters the mainstem Englishman River approximately 250 m downstream. There is anadromous salmon and trout access 8.0 km from the ocean up the mainstem river and 5.2 km upstream to a 4.5 m height bedrock falls on Center Creek. The BR155 mainline crossing is at approximately 7.0 km upstream. Primarily Coho and Rainbow Trout occupy the anadromous habitat. Some Chum and Cutthroat Trout are noted to be in the system. Resident Cutthroat can be assumed to be present in the headwater mainstem and tributaries anywhere that is accessible from year round pools.

Previous habitat survey work had been done on Center Creek, in June 2000. A Salmon Habitat Inventory and Mapping (SHIM) survey was conducted by the Community Fisheries Development Center (M. Leighton, J. Thomas). The survey mapped the mainstem of Center Creek upstream to the logging road using a Trimble GPS unit. They also collected habitat data that covered widths, slope, substrate and riparian information. It lacked USHP information on discrete habitat units (pools/riffles) or instream cover characteristics and functional LWD counts. The SHIM survey also provided a photo log of the entire length.

John Ebell and Dave Clough conducted an overview assessment on May 27, 2002 along the mainstem of Center Creek and Tributary C-3. Notes and photos were taken in regard to general habitat features as well as fish observed, flow and temperature.

The author (D. Clough) also used information from files on Center Creek, as it was part of the Coho Colonization Program (DFO)[32] from 1987 to 1994.

Center Creek is currently under biological assessment of its smolt and adult runs. Direction of the program is by DFO (M. Sheng & K. Simpson) with the Community Fisheries Development Center (CFDC) doing the assessments lead by Clay Young, project supervisor. There is a counting fence at the mouth of the creek, it operates in spring and fall but was deactivated at the time of survey. There were older flagging stations along the river where the salmon counters and SHIM surveyors had marked survey locations. A trail had been roughed in and followed the left bank for most of its length.

[31] T. A. Michalski, G.E. Reid and G.E. Stewart, 1998
[32] R. Hurst, D. Clough, G. Stewart & B. Blackman, 1987-94, DFO South Coast unpublished data.

3.22 Stream Assessment Results and Observations

The USHP habitat survey conducted by the authors and Streamkeepers was done over two days on Sep 21 and 25th, 2003. The stream discharge was at seasonal low flow, with a discharge estimated at 100 lpm where visible. We completed 2,953 m of habitat survey, (Appendices 4, 5, 6 – USHP Summary Data and Reaches C1 & C2) but fell short of completing reach C3 to the end of anadromous mainstem habitat due to time limitations. Flagging was hung and trees marked with paint for traverse stations and distance from the confluence for future reference. We walked upstream to the falls (chained to 5+200m) and out the mainline (approx. 7+000m) inspecting the habitat as we went. Table 4 shows the summary of characteristics and their rating according to Fish Habitat Assessment Procedures [33]. A score of 5 is poor, 3 may be a concern and 1 meets the criteria.

Table 4. Center Creek Habitat Assessment Summary and Ratings Table.

Habitat Parameter	Reach C1		Reach C2	
	Value	Rating	Value	Rating
Length (m)	1042	N/a	1809	N/a
Gradient (%)	1.75	N/a	1.57	N/a
LWD Frequency (lwd/cw)	0.3	5	0.4	5
% Cover in Pools	1	5	6	5
% Boulder Cover	1	5	1	5
% Pool Area	30	5	24	5
% Wetted Area	50	5	27	5
% Reach Eroded	6	3	4	1
Substrate - % Fines	14	3	6	1
Substrate - % Gravel	19	N/a	24	N/a
% Reach Altered	6	3	4	1
No. Obstructions	2	1	1	1

REACH C1 – Habitat Condition

Reach C1 is the lowest reach in Center Creek, it has salmon and trout access throughout its 1,042m length. Table 4 above indicates some very poor habitat conditions. The are described in more detail below. The mouth of Center Creek enters at the South Englishman River upstream from the mainstem Englishman approximately 200 m. The creek confluence area appears to be significantly impacted by loss of riparian vegetation from flooding and erosion. A logging road crosses through the Creek 20 m upstream from the mouth. The smolt and adult counting fence is located at 64 m upstream. The logging road (and traffic) travels across and up the creek bed. Hikers, mountain bikers, trail bikes and horses also cross in this area. There is a large deposition of gravel just downstream of Center Creek in the South Englishman. The gravel bar backs up water at high flow creating eddy scour from the mouth of Center Creek upstream 15 m to the roadbed.

All along Reach C1 it is apparent there is a lack of functional LWD. Table 4 shows a LWD frequency of 0.3 pieces per channel width. This lack of LWD structure contributes to the lack of Pool Area (30% in Table 4). LWD structure creates scour and dam pools, which would result in a larger wetted area and increased wetted depth. The USHP results showed a mean depth of 0.37 m in the remaining pools, which is very poor in relation to the 8.45 m mean bank full width. In the strict definition of a pool being at least 1/10th as deep as its width, most of these sites fail to qualify[29]. At stream stations 2 (0+109m) and 4 (0+150m), there are sites where pieces of LWD are alongside the bank. These sites offer habitat improvement opportunities through re-positioning, which are described in Section 4.24.

Walking upstream on the channel it is evident that its bed profile is very similar to the example in Figure 9 of an aggraded channel. The areas of aggradation (at almost every riffle site) result in the floodwaters inundating the riparian with increased severity and frequency. This is compounded by the fact the young mixed forest does not have the root strength of mature conifers. Many alders were falling into the channel, as their small root boles were incapable of resisting the flood pressure.

[33] N.T. Johnston & P.A. Slaney, 1996, Fish Habitat Assessment Procedures, WRP Tech. Circ. No. 8.

There were opportunistic sites such as Station 6 (0+257m) where placement of a mid-channel V-weir was visualized as the site had anchors, LWD nearby and a good location (Sec. 4.24).

Reach C1 is a good candidate for restoration among reaches as it is the lowest section, and the most fish accessible reach. At Station 7 (0+282m) to Station 8 (0+340m) is an 85 m long side channel off the right bank (see Appendix 17 for more detail). This site was an off channel separated by 5 to 15 m of vegetated land that was inundated likely every year on high flood events. The site is identified as a potential off channel refuge for summer drought and winter flooding. Off channel habitat was found to be lacking in the survey results, this was perhaps best site in the lower river. It has a potential access route for machinery 270m from the road (east side of the Center Creek watershed) on an old skid trail. The restoration proposal is described in Sec. 4.24.

Reach C1 continues upstream relatively barren of features with the exception of two obstructions in the form of large debris jams at Station 13 (0+551m) and Station 21 (0+992m). The jams appear to have resulted from the few large remaining LWD in the channel collect the small woody debris (SWD) generated by the thinning second growth. The SWD collects and plugs the LWD preventing water flow to the historic channel route. The slower velocities create sediment deposition and further braiding. The channel is poorly suited to protect itself with a young riparian zone with poor root strength and few conifer species. These jams may impede fish access during lower flow periods and create spawning and rearing conditions that result in drying redds and trapped fish. These sites are identified for restoration in Sec. 4.24 for removal of SWD to prevent erosion and anchoring and repositioning of the few LWD pieces remaining.

REACH C2 - Habitat Condition

This second reach of Center Creek extends 1,809 m from 1+042m to 2+971m. It has salmon and trout access to the end. The Habitat Assessment (Table 4) characteristics are similar to reach C1 with the exception of wetted area changing from 50 % to 27%. Pool area also was reduced slightly from 30 % in C1 to 24% in C2. The average pool depth was less than half of C1 at only 0.16m. The other significant characteristics of the reach are (again) related to very poor LWD frequency, cover and pool area.

The difference in wetted area in summer in C2 versus C1 shows the impacts of the aggraded channel are worse upstream. The most likely explanations are that the reach is closer to the biggest sediment sources, and/or the sediment is currently working its way down stream. At Station 36 (1+769m) upstream to Station 40 (1+908m) is an area where the channel is split into a braid. The braid originates at a wide aggraded and dry gravel bar with a channel spanning debris jam. The debris jam at Station 40 is comprised of 7 LWD and approximately 300 SWD and would benefit from some hand cleaning of small material and relocating the bigger material to encourage one channel to recover (Sec 4.24).

A second larger debris jam occurs at Station 65 to 67 (2+837m to 2+865m). A large sediment avulsion and debris jam of 27 LWD is spread across 30 m of channel. The high-water flows over the site but the low water flow follows a newly cut channel through the forest floodplain on the river right bank that re-enters downstream at Station 56 (2+654m). There are smaller overflow channels in the forest as well. Two tributaries enter on the right bank in this reach area (both were dry with short fish accessible reaches). There may be some off channel opportunities in the future, as the river stabilizes around the upper avulsion site. Hand cleaning and re-positioning of the LWD at the Station 65-67 jams may restore the channel with low risk and investment. The current sediment load and potential upslope recruitment of more material make any large scale investments unlikely until more assessment and observations are done.

REACH C3 - Habitat Condition

Reach C3 was inspected but not inventoried with a USHP survey due to time constraints. An overview walk of the entire reach (2003) and a review of the habitat data from the Salmon Habitat Inventory Mapping (SHIM) project (M. Leighton & J. Thomas, 2000) was completed. Reach C3 extends 1,229 m from Station 69 at 2+971 m upstream to the barrier falls at 5+200 m. It is confined in a 15 to 20 m deep gully with steep sides. The river meanders in its valley with alternating sides of active floodplain. Bedrock outcroppings on the banks and along the channel occur more frequently than the lower reaches. There was a lack of LWD and deep, wetted pools throughout. The channel riparian was historically logged and the second growth mixed canopy is small and inadequate for functional LWD contribution.

There are erosion sites of concern along the C3 reach. The biggest erosion site is a slope failure approximately 50m (river right) upstream in Reach C3. It is in a confined canyon area with steep slopes of layers of marine gravel and clay to creek edge. The river right bank slope is 60 to 90% immediately below an old logging road heading. The slide tracks are treeless but old enough to have regenerated shrubbery. They were likely caused by slippage of different compositions of bank material saturated by water. The Englishman Watershed has similar examples of slope failure along a glacial/marine escarpment running north-south at this elevation. This site may have been aggravated by surface runoff or blowdown associated with a logging spur above. The sediment in the jam at the top of Reach C-2 is likely sourced from this site. An assessment of the bank stability and restoration plan is described in Sec. 4.24.

The Reach ends at the end of the gully as it rises over the escarpment at a bedrock falls. The falls is a 5.5m slope over a 3.0m drop and 2.5m chute. This forms a barrier to upstream fish migration. The barrier does have a plunge pool at the base and offers fish holding with depth for cover and spawning gravel at the outlet. There are coho fry to this site. Tributary C3-1 enters the left bank just below the falls.

TRIBUTARY C3 –1

A reconnaissance inspection was done of the reach from the logging road culvert downstream to Center Creek in May 2002 (J. Ebell & D. Clough). Beginning at the bottom end at the Reach C3 falls pool; the tributary rises 20 m elevation over approximately 600 m distance to the bench above. This section of channel is confined and approximately 2.5m wide on a 4% gradient. The channel has small wood debris jams laden with sediment but has small fish accessible steps where coho fry were observed confirming access.

At the top edge of the gully there is a gravel bottom pool 1.0m deep. The pool appears to be spring fed as there was more water coming out than going in. Also, the pool was 7ºC while other surface flow drainage was 9ºC, indicating a ground water source. At this point, three forks feed the channel; they each flow over a low gradient bench from the Br 155 to the south. The center and east fork drainages were walked and both were approximately 600m to the Br 155 mainline. They had intermittent flow in spring and may dry with a few solitary pools remaining in summer. No fish were seen but access appears possible, although there are impediments in the form of braids over historic sediment bars. The channels appear to be recovering but both had a dry disconnected braid of approximately 50m before a channel was found with flow again. The east fork (C3-1-1) had a 1x2m wood culvert at the Br 155 mainline and had the largest channel (3.0m). The upper east fork of Trib. C3-1 appears to be confined and may offer some wetted pools in summer upstream in an older second growth forest. The center fork, Tributary C3-1-2, is adjacent a more recently logged slash and had a dry section before it crossed a Timberwest Spur road and then another 50m to the Br 155 mainline. The channel also had small flow at the road crossings and older riparian areas upstream that may offer some small summer refuges. The western fork (Trib.C3-1-3) was not walked but riparian and gradients were similar. A USHP survey should be completed on Tributary C3 –1. Our overview assessment identified impacts such as channel sediment, drying and lack of LWD.

REACH C4

The C4 reach was walked in September 2003 and surveyed with SHIM in June 2000. It begins at the barrier falls at 5+200m and ends approximately 1,800m upstream below the logging mainline, 7.0km from the mouth. Resident trout were observed in the reach (D. Clough, 2003). Based on the information collected, the headwater reach is similar to the lower areas with lack of wetted area and LWD. The channel rises out of the entrenched gully in this reach but remains semi-confined in an alluvial channel. There were bedrock outcroppings forming the substrate in a few lower sites. The riparian zone is younger with more recent logging and disturbances. This reach splits 100 m before the Br 155 mainline, with the upper mainstem (C5) draining due south joining a large tributary (C5-F) draining the Branch F road network to the east. The road assessment (Table 3) findings indicate there are some concerns along the Branch F area. The restoration recommendations cannot be completed until a habitat USHP survey is done.

3.3 RIPARIAN RESTORATION PLANNING

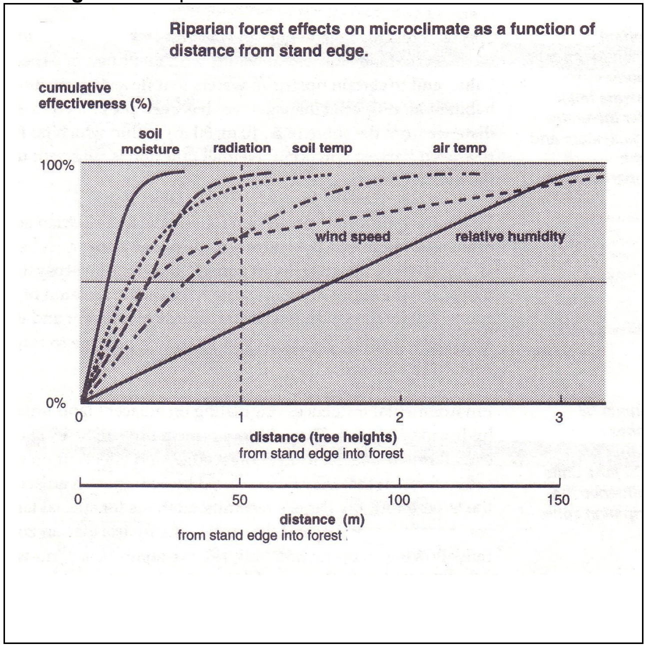
3.31 Riparian Assessment Methodology

Riparian areas are an essential component of healthy forest and stream ecosystems, and (especially in more arid regions) support the vast majority of wildlife species. Functioning riparian ecosystems provide many of the essential attributes required by fish and other aquatic organisms, including shade, bank stability, protection from flood events, a recruitment source of large woody debris and coarse woody debris and fine leaf and branch material (allochthonous input)[34]. Approximately 72 percent of terrestrial vertebrates highly utilize riparian areas[35]. Because riparian areas perform a disproportional amount of biological and physical functions on a unit area basis, their restoration can have a major influence on achieving watershed restoration goals[36].

Non-functioning (or impaired) riparian ecosystems supply poor bank protection and are a poor recruitment supply of large woody debris. This type of impaired ecosystem will eventually recover, but over an extended period of time[37]. The goal of riparian restoration is to accelerate the recovery of the riparian ecosystem.

While "Riparian" and "Stream" have been separated for the purposes of this report, it should be noted that "*this separation disregards the ecological reality that waterbodies and the immediately adjacent environment are ultimately linked by the exchange of water, material, and organisms*" [38]. This "hydro/riparian microclimate affect " is predominant in first 30m along each edge of a larger stream, and falls off dramatically in the next 20m (Figure 11).

Figure 11. Riparian Forest Effects on Microclimate



Riparian Vegetation Types (RVT's) are broken into 5 basic classifications[39] (Appendix 6):

- **RVT 1**: Brush dominated, with poor regenerated conifer component
- **RVT 2**: Over stocked conifer
- **RVT 3**: Deciduous forest over top of a good conifer understory
- **RVT 4**: Deciduous forest with a poor conifer understory
- **RVT 5**: Old growth or very old second growth forest

Each sub-basin requires stratification of the different RVT types. There can then be a focus of treatments of the highest priority RVT's. RVT 1 and RVT 4 are the highest priority for treatment to have maximum immediate benefit for fisheries habitat RVT 2 and RVT 3 are the highest priority for immediate benefit to terrestrial species. RVT 2, in particular, can be treated to enhance habitat attributes for Vaux's Swift, Pileated and Hairy Woodpeckers, Northwest and Clouded Salamander, Rough Skinned Newt, Black Bear, Martin, Mink, Otter, Bald Eagle[40] as well as the identified wildlife species (Table 5) for the Englishman River area. "Identified Wildlife" are red and blue listed species believed to be vulnerable to forest management activities. Lower Center Creek falls within Ecosection NAL (Nanaimo Lowlands) and upper Center Creek within Ecosection LIM (Leeward Island Mountains)[41] (Figure 12).

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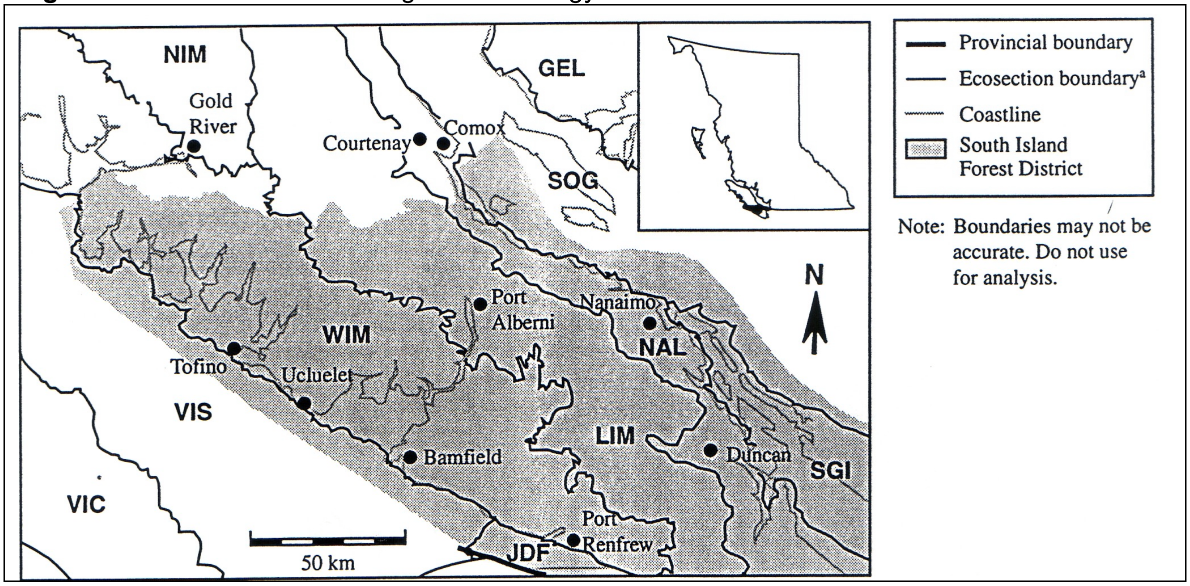
[34] Riparian Areas, Functions and Strategies for Management. 2003
[35] Report 5 (CSSP). 1994
[36] Riparian Areas, Functions and Strategies for Management. 2003
[37] Prichard, 1993
[38] Report 5 (CSSP). 1994
[39] Poulin et al. 2000
[40] Brown, T. 1995
[41] Identified Wildlife Management Strategy, Volume 1. 1995

Figure 12. Interim Wildlife Management Strategy Zones



The class of species that are the most vulnerable to development activities are "cavity dwellers". RVT 2 is especially suited for construction of cavity type habitat to supply habitat for cavity dwellers[42]. Techniques for constructing cavities for insects, amphibians, fir bearing mammals, birds, and bats can be seen in Appendix 8. Birdhouse construction and installation is also a good method of providing habitat for a number of bird species (Appendix 9), and bat house's are easily constructed and installed as well (Appendix 10).

Table 5. Identified Wildlife Species for the Englishman River Watershed

Identified Species	Preferred Habitat
Birds:	
American Bittern (Blue-listed)	Nesting wetlands less than 5ha in size. Usually protected and adequately managed through the Riparian Management Area Guidebook. Recommended maintaining nesting wetlands not protected by Riparian Reserve and Riparian Management Zones. Also recommended retaining as many understory trees, shrubs and herbaceous plants as is practical. Vulnerable habitat attribute – nest sites.
Northern Goshawk (Red-listed)	Succession forest stages, interspersed patches. Forests exhibiting old growth characteristics. Riparian areas
Marbled Murrelet (Red-listed)	Riparian areas. Forests exhibiting old growth characteristics. Old seral retention required (age class 9 and 8, structural stage 7). Vulnerable habitat attribute – nest sites.
Mammals:	
Vancouver Island Marmot (Red-listed)	Maintain nesting habitat with interior forest conditions. Vulnerable habitat attribute – den(s)
Keen's Long-eared Myotis (Red-listed)	Rock or talus slopes. Coarse Woody Debris (logs on the forest floor), snags, cracks and crevices, holes, and hollow interior in standing trees. Vulnerable habitat attribute – hibernaculum.

Alder, Maple and most brush species are shade intolerant, colonizers of disturbed sites. Although Alder and brush may be good nitrogen fixers, they lack adequate root strength for stream bank stability. Alder is an extremely fast growing tree that puts most of its energy into canopy and stem growth in an effort to maximize its exposure to the sun. As an Alder approaches the end of its life span, the supporting root structure becomes insufficient to bear the weight of the tree, and if it isn't blown over, it will eventually fall over. Alder growing close to a riverbank will often grow towards the centre of the

[42] Brown. 1995

river to capitalize on the sunlight. As the trees grow older and fall over into the river, the upturned root ball creates a divot along the riverbank resulting in an “erosion nick point”.

Once Alder has fallen into a stream system, it will degrade quickly. While it is beneficial for invertebrate populations (and hence food sources for rearing fry and smolts), its rapid degradation makes it a poor species for in-stream LWD structures. It is these characteristics of Alder that make it a poor dominant riparian species. Alder is an important component of a healthy riparian system, but not as a dominant tree species.

Maple is longer lived, and has greater root integrity and greater resilience in-stream than Alder does. But is not as long-lived and resilient as most conifer species. Maple is also an important component of a healthy riparian system, but not as a dominant tree species.

Conifers are generally more shade tolerant than deciduous species. Conifers are slower growing but longer lived, so will eventually out-compete a deciduous forest. They have a more developed root system, and are therefor more likely to provide stream bank stability. They are also far slower to degrade once in the water, making them superior for LWD structures. As a result of these differing characteristics RVT 1 and RVT 4 represent the highest opportunity and priority for recommended treatment[43].

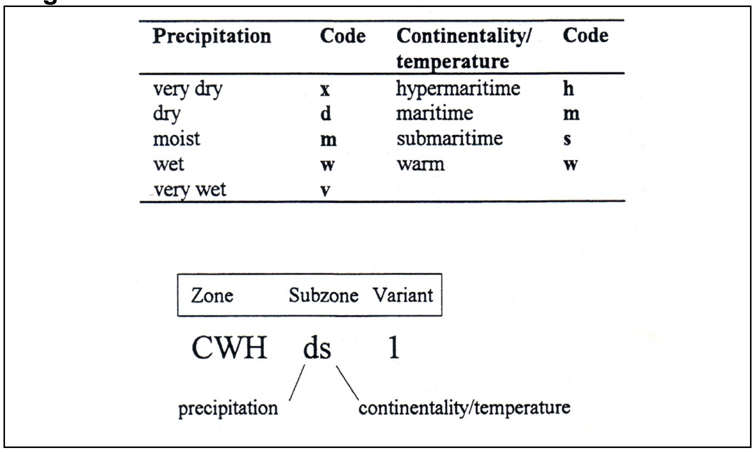
Determining the Biogeoclimatic Ecosystem Classification (BEC) is the first step in developing riparian prescriptions. BEC is a provincial system that groups similar ecosystems into categories of a hierarchical classification system. The process involves three steps: Site assessment, Site description, and Site identification. Site assessment (or site diagnosis) involves describing the forest ecosystem in the field, site description involves the gathering of information, and site identification involves reviewing the gathered information to then identify the biogeoclimatic units and site series. Rough indication of the biogeoclimatic zone is indicated through BEC mapping (Appendix 11). More accurate confirmation is completed by the collection of site level information like vegetation features, elevation ranges, etc. To collect this site level information, representative measurement plots (3.99m radius) are established within each RVT and the following information is collected:

- Tree species, diameter at breast height (DBH)
- Height of representative tree species per height class
- Age of representative tree species per height class
- Little and Fermenting Humous (LFH) layer depth
- Soil A and B horizon Depth
- Soil classification
- Average rooting depth
- Shrub and Herb species

Plot information is summarized in Tables 6 and 7. Climate is one of the most important factors influencing the formation of a forest ecosystem, as is vegetation. Vegetation is highly visible and reflects the environment, biology, and history of the site. Information is combined to help accurately ascertain the correct biogeoclimatic zone, sub zone, and variant to ensure the proper tree species are selected for planting within that particular area[44].

[43] Poulin, Simmons. 2000
[44] Green, Klinka, 1994

Figure 13. Codes used in subzone names



Precipitation	Code	Continentality/ temperature	Code
very dry	x	hypermaritime	h
dry	d	maritime	m
moist	m	submaritime	s
wet	w	warm	w
very wet	v		

Within the BEC system, "zone" codes are designated by the most dominant climax tree species (e.g. CWH is Cedar and Western Hemlock), "subzone" codes are derived from relative precipitation and/or continentality/temperature. "Variants" are named with geographic labels that reflect their general distribution within a particular subzone (Figure 13).

3.32 Riparian Assessment Results

The riparian zones assessed on lower Center Creek (0+000 to2+971m) were found to be in a relative state of recovery. There was significant opportunity for treatment of the RVT 2 (over stocked conifer) and to utilize the excess conifers for LWD stream structures. Patches of laminated Root Rot (Phellinus weirii) infection were noted throughout the riparian zone. Some of the polygons within the RVT 3 and RVT 4 areas were dominated by Maple, which is significantly more preferable than Alder. The average age of the second growth co-dominant riparian stands was 41 years, ranging from 36 to 49 years. Approximately 1.2 ha of original CDFmm zonal forest (RVT5) was found in the assessment area (Table 6). This is significant, as this intact plant community is Red listed (Table 5). For detailed maps of RVT locations see Appendix 12.

Table 6. Center Creek Current Riparian Status

RVT 1 (ha)	RVT 2 (ha)	RVT 3 (ha)	RVT 4 (ha)	RVT 5 (ha)	Total (ha)
0.5	6.2	1.7	8.2	1.2	17.8

Table 7. RVT plot results

	RVT 1	RVT 2	RVT 3	RVT 4
Dominant Species	N/A	Fir	Alder	Maple/Alder
Age co-dominant (years)	N/A	41	0	0
Age Intermediate (years)	N/A	40	N/A	N/A
Height co-dominant (m)	N/A	29	29	32
Height Intermediate (m)	N/A	26	N/A	N/A
Stems/ha co-dominant	N/A	1000	1200	1000
Stems/ha Intermediate	N/A	400	0	0
Stems/ha Understory	N/A	300	0	200
Understory Species	N/A	Fir/Cedar	N/A	Fir
LFH Layer (cm)	N/A	8	6	3
Soil Type	N/A	Silt loam	Silt Loam	Silt Loam
A Horizon (cm)	N/A	15	> 30	> 40

Some ribbons labeled "cutting boundary" were noted well within 30m of Center Creek, and also within the low and medium bench floodplains adjacent to Center Creek. Also observed, were relatively new cutblocks that had been harvested within three to five meters of the stream bank in upper mainstem Center Creek (immediately below the mainline logging road). Given the current bedload problems associated with Center Creek this lack of riparian and stream bank protection is cause for concern.

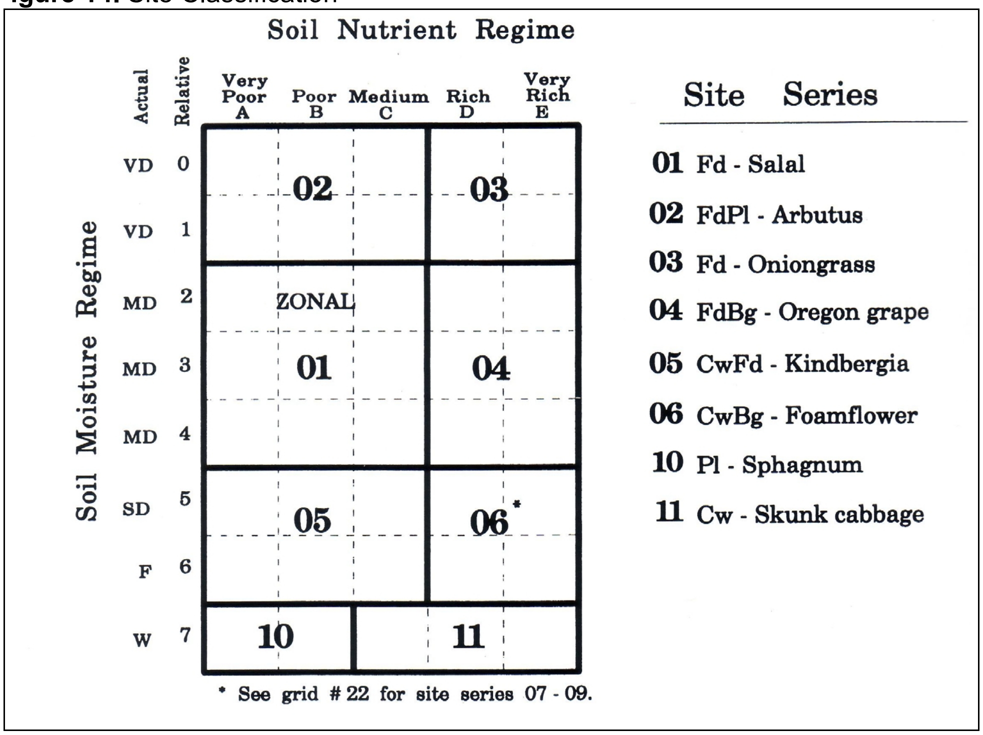
The riparian assessment vegetation analysis found overlaps between the CDFmm and CWHxm1 biogeoclimatic units (Table 8).

Table 8. Biogeoclimatic vegetation analysis

Plants Found in Center Creek RVT Sites[45]			Plants Found in Biogeoclimatic Units	
	Latin	Common	CDFmm	CWHxm1
Tree Layer	Pseudotsuga menziezii	Douglas Fir	Yes	Yes
	Thuja plicata	Western Red Cedar	Yes	Yes
	Acer macrophylum	Bigleaf Maple	Yes	Yes
	Tsuga heterophylla	Western Hemlock	No	Yes
Shrub Layer	Gaultheria shallon	Salal	Yes	Yes
	Mahonia nervosa	Dull Oregon Grape	Yes	Yes
	Vaccinium parvifolium	Red Huckleberry	Yes	Yes
	Rubus ursinsus	Trailing Blackberry	Yes	Yes
	Holodiscus discolor	Ocean Spray	Yes	Yes
Herb Layer	Linnaea borealis	Twinflower	Yes	Yes
	Polystichum munitum	Sword Fern	Yes	Yes
	Pteridium aquilinum	Bracken Fern	Yes	Yes
	Achlys triphylla	Vanilla Leaf	Yes	Yes
	Cornus canadensis	Bunch Berry	No	No

Hemlock is common in the CWHxm1 unit, and only one Western Hemlock was documented within the established plots. As well, CWHxm is characterized by far less Ocean Spray and Salal. Therefor the biogeoclimatic unit is likely closer to the CDFmm classification.

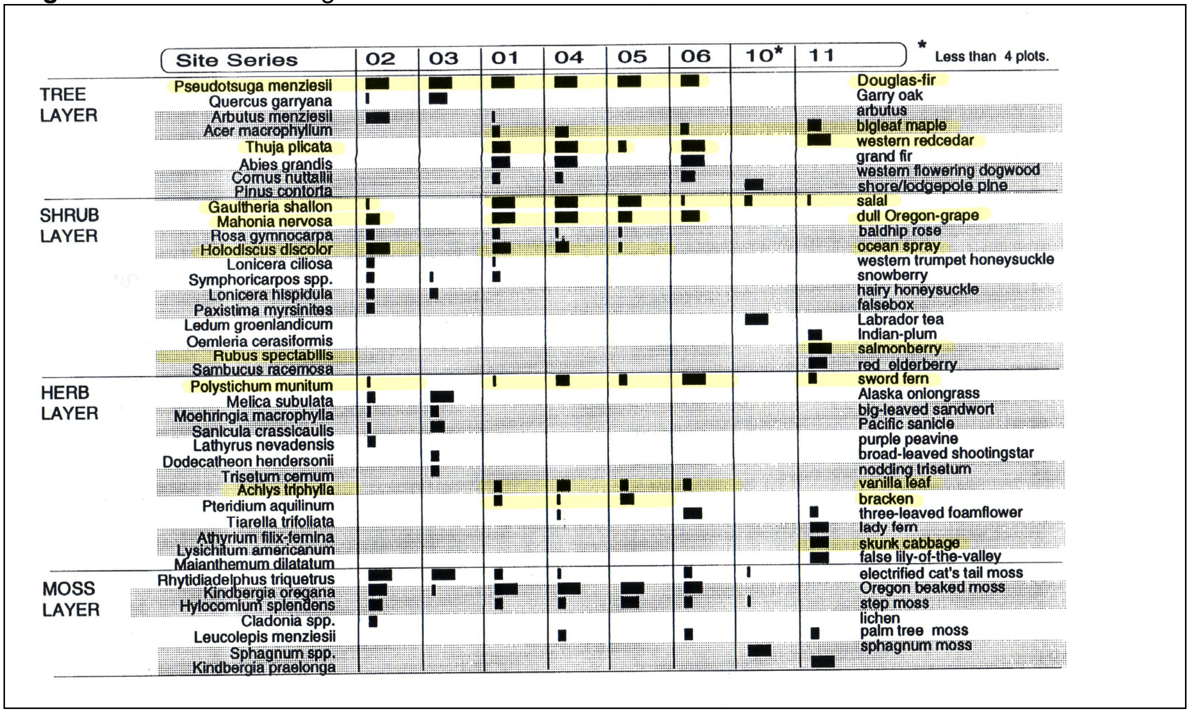
Figure 14. Site Classification[46]



Specific site level classification is further delineated into a "Site Series" designation based upon soil moisture and nutrient regime (Figure 14). Indicator plants are used, along with soil moisture and nutrient regime to help determine site series classification (Figure 15).

[45] Pojar, MacKinnon. 1994
[46] Green, Klinka. 1994

Figure 15. Site Series Vegetation Table[47]



Determinations of site series by RVT based on soil, moisture, and plant indicators are as indicated in Table 9. There was no information gathered in RVT 1 type, but the visually noted predominance of Salmon Berry and Skunk Cabbage would indicate a site series of 05 / 11.

Table 9. RVT Site Series

RVT Type	Plot #	Zone	Subzone	Site Series
1	None	CDF	-mm	• 05 CwFd – Kindbergia / • 11 Cw – Skunk Cabbage
2	1	CDF	-mm	• 05 CwFd – Kindbergia
	4	CDF	-mm	• 03 Fd – Oniongrass / • 04 FdBg – Oregon Grape
3	6	CDF	-mm	• 01 Fd-Salal
4	2	CDF	-mm	• 04 FdBg – Oregon Grape / • 05 CwFd – Kindbergia
	3	CDF	-mm	• 04 FdBg – Oregon Grape / • 05 CwFd – Kindbergia
	5	CDF	-mm	• 05 CwFd – Kindbergia

Expected forest pest risk to CDFmm trees are: persistent (but low) deer browse, low periodic vole damage, persistent (medium frequency) damage by Armillaria root rot, persistent (low frequency) damage by black stain root disease, and persistent and high frequency laminated root rot[48].

[47] Green, Klinka. 1994
[48] Green, Klinka, 1994

3.4 NUTRIENT REPLACEMENT PLANNING

Due to a combination of pre-code logging practices, over harvesting of fish, and climatic conditions, returning runs of Salmon and Steelhead have been reduced significantly. Fish returning to river or stream systems to spawn play an important role in enhancing the nutrients of that stream or river. The nutrients, in turn, have significant impact on the health of aquatic invertebrate populations, which become a primary food source for emerging fry. Research has indicated that spawning salmon contribute up to 40% of the carbon and nitrogen content in juvenile salmonids[49]. Unexpectedly, some research has found timber harvesting to cause higher concentrations of nitrates to leach into streams, possibly mitigating some of the adverse habitat effects.[50]

When runs of returning fish become depleted, the nutrients they bring to that stream or river system are also reduced, potentially affecting the health of the invertebrate population. Nutrient replacement can help augment the required levels for a healthy food source for emerging fry[51].

Healthy levels in a stream of Nitrogen and Phosphorus are as low as two parts per billion (or the equivalent of 2 seconds every 33 years). Water sampling can identify any shortfalls in nutrient levels (Appendix 13, Nutrient Sampling SOP), and a customized blend of slow release fertilizer briquettes (chemical, compressed Pollock) can be designed to bring the level of nutrients up to a healthy level. Alternatively salmon carcasses are commonly applied. If a nutrient program is initiated, as the returning numbers of fish improve, the level of nutrient replacement is reduced.

4.0 RESTORATION WORKPLAN

4.1 ROAD RESTORATION AND UPSLOPE WORK PLAN

Road restoration cannot proceed without first seeking permission from the private landowner/s and specific agencies that have jurisdiction over areas "in and about a stream". Recommendations for treatments must therefor be reviewed and be deemed acceptable by relevant parties and the private landowner/s.

Specific information on road condition is in a separate 2003 report Road Risk Assessment for Center Creek[52]. Overall, specific road condition (per segment) and associated risks were estimated to be low. Generally, only point source liabilities were discovered during the assessment, which can be addressed relatively inexpensively. The results listed in Table 10 are somewhat misleading in that the risk assessment methodology ranks the entire length of the road with the highest risk found along that road length. For example, a 200m road can have only one high-risk section of 5m, and the entire 200m length is ranked as high risk.

However, road density and the associated cumulative adverse impacts are a concern for watershed health due to surface erosion. The Center Creek watershed area is 21 km² and has a total forest road length of 71.69 km, which translates to a road density of 3.41km per km². The "Coastal Watershed Assessment Procedures guidebook" (CWAP) provides the maximum "poor health" score of 1.0 (ranging form 0 to 1.0 where 0 is best) for road densities of ">3.0" (Table 11). This is important as high road density can have an adverse impact on peak stream flows and aquatic habitat in several ways. Ditchlines intercept water and transfer it to streams much more quickly than through the soil. Road surfaces are relatively impervious, so water is shed into ditchlines much more quickly than being absorbed through the forest floor and soil. This interception of water reduces charging of the aquifer, and ultimately results in reduced summer water flows. However there may be a counteracting effect from logging, as removal of vegetation through logging may increase summer flows (see below).

[49] Bilby, Fransen, Bisson. 1996
[50] Hudson, Tolland. 2002
[51] Ashley, Slaney. 1998
[52] Leslie, Wise. 2003

Table 10. Center Creek Road Liabilities

Road	Length (m)	Current Status	Reactivation Length (m)	Deactivation/ Maintenance Length (m)	Overall Risk
BR.155 M/L	3896	Intact Mainline	0	3896	H
BR.155F	3346	Intact, 2wd accessible	0	2236	M
BR.155F1.6	140	Intact, 2wd accessible	0	140	H
BR.155F1A	330	Overgrown/no access	68	68	M
BR.155F3	508	Overgrown/no access	211	211	M
BR.155F70-1	285	Intact, 2wd accessible	0	285	M
BR.155G	3630	Overgrown/no access	876	643	M
BR.155G.6	894	Intact/partial access	754	754	H
BR.155K2	1558	Intact, 2wd accessible	0	1135	H
BR.155I	982	Intact, 4wd accessible	0	982	M
BR.155J	4339	Intact/partial deactivation	4339	4339	H
E1500	1495	Deactivated	0	195	M
E1510	525	Intact, 2wd accessible	0	20	M
TOTAL:	21928		**6248**	**14904**	

Table 11. Cumulative Surface Erosion Indicator Scores[53] (Center Creek score 3.41)

Impact Category	Indicator	Good ← Score → Poor										
		0	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**	**1.0**
Surface Erosion	Road Density (km/km²)	0	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	>3.0
	Roads on Erodible Soil (km/km²)	0	0.05	0.10	0.15	0.20	0.25	0.35	0.45	0.55	0.65	>0.75
	Mainline Road Within 100m of Stream (km/km²)	0	0.04	0.08	0.12	0.16	0.20	0.25	0.3	0.35	0.40	>0.45
	Number of Stream Crossings (No./km²)	0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	>2.0

Exposed soil surfaces of roads are prone to erosion and transport of sediment. The greater the exposed surface the higher the potential for sediment production. Most roads (CWAP classification[54]) found within the Center Creek watershed could likely be classed (conservatively) as an average "sediment class 2", resulting in an estimated sediment production of 1.0 m³/km/yr. An industrial mainline gravel logging road is classified as a "sediment class 4", which is estimated to produce up to 70m³/km/yr sediment production. Most of the roads would be listed as a "delivery class 2" (resulting in a relative risk category of Moderate to Low for Center Creek).

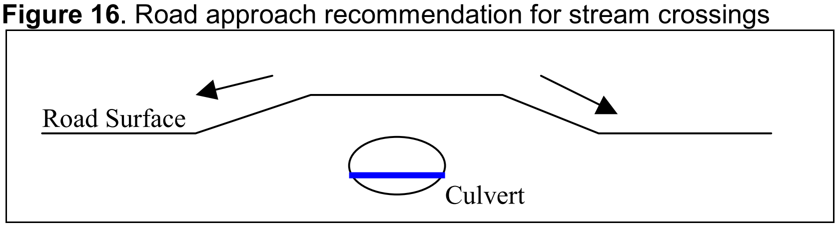
The risk of road sedimentation into Center Creek may be relatively low per kilometer of road, however the high density of roads are still cause for concern due to the cumulative nature of the sediment delivery. To help reduce adverse impacts for roads the following recommendations should be considered:

- Monitor industrial road use during rain events for sediment transport into ditches and streams
- Grass seeding of the lesser-utilized roads. Recommend a seed mixture high in sod forming grasses, if road use is planned in near future.
- Grass seeding of all ditch lines
- Installation of series of sumps on regular intervals in ditch lines. This serves to intercept sediment prior to entering streams, as well as lowering overall road maintenance costs (only the sumps require maintaining instead of the entire ditch line).

[53] Coastal Watershed Assessment Procedure Guidebook (CWAP), 1995. 19p.
[54] Coastal Watershed Assessment Procedure Guidebook (CWAP), 1999. 30p.

- If ditch lines are maintained, make efforts to make the ditches as deep and as wide as possible to extend the required maintenance intervals as long as possible.
- Deactivation and seeding of lesser utilized roads to lower the road density
- Increase culvert frequency to maintain natural drainage patterns.
- Road approaches to bridges or culverts should slope away from water course (Figure 16)
- Avoid grading into ditch lines
- Install buffer logs on roads that cross watercourses to prevent accidental grading into stream.

Figure 16. Road approach recommendation for stream crossings



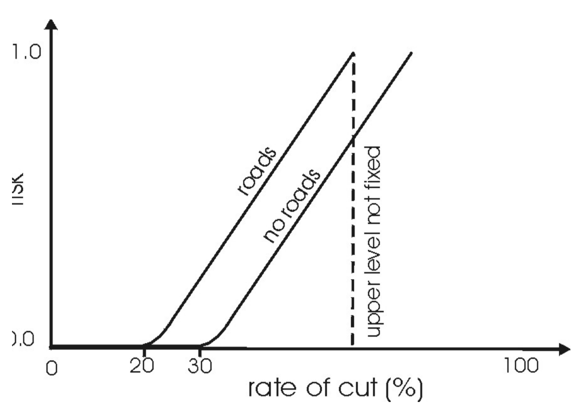
Another significant component of watershed development that can have an effect on timing and delivery of water flow is the area harvested within the watershed. Harvested areas increase the amount of water directly to the forest floor, and given enough area, there is a measurable increase in the streams peak discharge rates. Timber harvesting appears to have a negligible and slightly positive effect on summer low flows[55].

As a harvested area re-grows, its ability to intercept rainfall and retain fine sediment increases with tree height and root strength. The ability of this second growth to function hydrologically like the original forest is measured by percent hydrological recovery (Table 12)[56]. For example, when the second growth has reached a height of 8m, its ability to perform hydrologically is 75% of that of the original forest and now the equivalent clearcut area (ECA) is 25% of the original block size. (i.e. a 100 ha cut block with 8m-second growth, is considered equivalent to a 25ha clearcut).

Table 12. Hydrological Recovery with tree height

Average Height of Second Growth Canopy	Percent Hydrological Recovery Compared to Original Clearcut	Equivalent Clearcut Area Percent
0 - < 3m	0	100
3 - < 5m	25	75
5 - < 7m	50	50
7 - < 9m	75	25
9+ m	90	10

Figure 17. Risk to Stream Integrity[57]



Depending on watershed characteristics, risk to stream integrity may increase significantly if greater than 20 percent ECA (Figure 17) of the watershed has been harvested. It is recommended that this component be monitored and carefully managed by the land owner/s.

[55] Coastal Watershed Assessment Procedure Guidebook (CWAP). 1995 50 p.
[56] Coastal Watershed Assessment Procedure Guidebook (CWAP). 1995 49 p.
[57] Price et al. 2003

Landscape units outside the riparian zone are addresses in this report, as their status may have implications for stream ecosystems[58]. There is recognition for cumulative effects of various components of watershed development as noted in the Coastal Watershed Assessment Procedures (CWAP) Guidelines. The CWAP lists nine specific components that act cumulatively to potentially adversely affect watershed health:

- Percent of watershed harvested, corrected for equivalent clearcut area (ECA) %
- ECA by important elevation bands (% and ha)
- Total road density (km/km²)
- Length of road as high sediment source (km)
- Total number of landslides (total numbers of point sources, road related, etc.) entering streams
- Length of road on unstable slopes
- Number of stream crossings
- Length of stream with non-functional riparian forests (km and %)
- Length of stream with disturbed stream channel (km and %)

CWAP's are not legally required on private forestland, but it is recommended that the nine specific components be monitored by the landowners to ensure cumulative effects of development do not adversely impact the natural recovery process and restoration efforts within the Center Creek Watershed.

Salmon have evolved to adapt to a series of natural impacts. Therefore timber harvesting plans should be encouraged, where possible, to mimic the natural disturbance regimes[59]. Examples of natural disturbance regimes could be: blow down, wildfires, encouraging uneven aged stands to develop from even aged second growth, etc. Research has shown that clearcuts are quite unlike almost any natural disturbance in their intensity of impacts and low levels of biological legacies and uniformity[60].

4.2 STREAM RESTORATION WORK PLAN

Below is an outline for continued Assessment, Monitoring and Instream Restoration of priority areas. It includes estimates for time and expenses to complete. The activity costs are summarized on Table 13 below. Costs are broken down by activity in the sections below.

Table 13. Priority Work Plan Budget.

Activity	Budget
Habitat Assessment	$10,800.00
Water Quality Monitoring	$2,300.00
In-Stream Restoration	$15,700.00
Total:	**$28,800.00**

4.21 Habitat Assessment Work Plan

Center Creek has approximately 16.3 km of fish habitat. The lower, highest fish use reaches of Center Creek were inventoried in 2003 representing 2+851m. The completion of the USHP survey is desirable for the entire watershed upstream with Reach C3, C4 & C5 and headwater reaches. This represents approximately 13.5 km of stream length. A USHP assessment combined with a riparian assessment (as done in 2003) would cover approximately 1.5 km per day and result in the need for 9 days of survey (Table 14). It is important to maintain the reference stations from the traverse. These sites will need placement of permanent metal tags and/or plastic disks as additional flags to maintain their location.

[58] Coastal Watershed Assessment Procedure Guidebook, 1999 and 1995
[59] Report 5 (CSSP), 1995
[60] Kolme, Franklin, Thomas. 1997

Table 14. Center Creek Habitat Assessment Work Plan.

Reach	Length (m)	Days	Estimated Budget $**	Description
C1	1042	1.0	$1,200.00	Completed USHP survey 2003
C2	1809	1.0	$1,200.00	Completed USHP survey 2003
C3	1229	1.0	$1,200.00	Anadromous to falls.
C3-1	600*	0.5	$600.00	Anadromous
C3-1-1	700*	0.5	$600.00	East fork, anadromous?
C3-1-2	700*	0.5	$600.00	Middle fork, anadromous?
C3-1-3	2000	1.5	$1,800.00	West fork to mainline, anadromous?
C4	1800	1.0	$1,200.00	Headwater trout reach
C5	4000*	2.5	$3,000.00	Headwater includes tributaries
C5-F	2500*	1.5	$1,800.00	Headwater includes tributaries
Total:	16,380	11.0	$13,200.00	All potential fish habitat
Total:	**13,529**	**9.0**	**$10,800.00**	**Remaining assessment habitat**

**map based length estimates **Costs based on 2 persons field and 1 for write-up at $400/day incl. all expenses.*

4.22 Monitoring Work Plan

Water quality analysis is important in determining overall productivity, limitations and possibly mortality events for aquatic life (Table 15). Appendix 12 shows the nutrient monitoring guidelines, which include low level sampling of nitrate nitrogen (NO^3N), soluble reactive phosphorus (SRP) and total phosphorus (TP). We suggest that for small additional cost the following also be collected; Total Alkalinity, Ammonia (NH^3), Conductance, Solids, and Ph. Sampling should be done at the mouth of Center Creek and just below the logging mainline (Br155). Additional sites could be located at the exit of every tributary but for practical costs we suggest the two sites unless a concern is determined that needs traced. Field sampling is recommended of common biological parameters; Oxygen (D.O^2. & Sat.), Temperature, PH and turbidity. Additional parameters such as (but not limited to) Alkalinity and Conductance are encouraged where equipment costs are reasonable. The timing of the lab water sampling should be in the growing season in July/August. A more frequent routine of field sampling should be scheduled on the four seasons during site visits. The most critical field-sampling period appears to be during summer low flow conditions. Data collected then will be very useful in identifying habitat limitations. Placement of an electronic water quality data logger could also be considered. The long-term water temperature profile would be an indicator of riparian performance. More sophisticated devices are used by government agencies that take in temperature, water level and oxygen. Sampling may be done in conjunction with other groups in the Englishman Watershed (Parksville, DFO, and MWLAP) to save cost and be comparative. A staff gauge for flow monitoring should be installed and calibrated with a flow meter near the mouth. This will involve a day to set up and assumes that an agency meter can be borrowed for calibration. Photo point monitoring is recommended during water quality sampling at benchmark photo sites.

Table 15. Center Creek Water Sampling Work Plan.

Sample Sites	Sample Method	Estimated Budget $*	Description
Mouth	Lab Sample Field Sample Data Logger Flow Photo Point	$400.00 $200.00 $200.00 $800.00 $200.00	2 Sample bottles collected D.O./PH/Temp/Conductance meters needed Data logger (Temp) site Includes annual calibration 2 benchmarks, 4 sites
C2	Field	$100.00	Sample at lowest part of reach
C3	Field	$100.00	Sample at lowest part of reach
C3-1	Field	$100.00	Sample at lowest part of reach
C4	Field	$100.00	Sample at lowest part of reach
C5	Lab Sample Field Sample Data Logger Flow Photo Point	$400.00 $100.00 $200.00 $800.00 $200.00	2 Sample bottles collected D.O./PH/Temp/Conductance meters needed Data logger (Temp) site Includes calibration 2 benchmarks, 4 sites
C5-F	Field	$100.00	Sample at lowest part of reach
	Reporting	1000.00	
Total:		**5000.00**	**Annual Budget**

**Costs per bottle with shipping or labour & mtls with other activities $400/day/person*

4.23 Level II In-Stream Prescription Work Plan

Site-specific, detailed prescriptions (Level II prescriptions) are to be developed for the identified restoration objectives. This may require the combined efforts of biologists, engineers, geomorphologists, and hydrologists. Some of this work has been done during the surveys, the C1 reach opportunistic LWD positioning and side channel development. Site cards for LWD placement and repositioning were completed at distances 0+109m, 0+150m and 0+257m (Appendix 14, 15 & 16). These areas of the creek were traversed and measured more intensively for plan and cross section views. A traverse of the station 7 (0+282m) side channel was completed as well as a level traverse of the access route from the existing logging road (Appendix 17). Once the Level II prescriptions are approved by MWALP, a permit (Section 9) to work in and about a stream is applied for annually and in-stream restoration work proceeds within the established “fish window”.

4.24 In-Stream Restoration Work Plan

Stream restoration cannot proceed without first seeking permission by the private landowner/s and specific agencies that have jurisdiction over areas “in and about a stream”. Recommendations for treatments must therefore be reviewed and be deemed acceptable by relevant parties and the private landowner/s.

The work plan has been established from the results of the USHP survey (Table 4) which evaluated each habitat parameter. Table 16 describes each parameter deficiency and includes action items to address the problems for the following year. During the habitat survey, the team made notes on restoration opportunities that address the deficiencies. The work plan for year 1 is described. The work plan should continue until action is no longer required for the watershed to attain acceptable levels of restoration.

Table 16. Center Creek Instream Work Plan – Year 1

Habitat Parameter	Description	Site Activity
LWD Frequency (lwd/cw)	Anchor existing LWD	Sites 0+109, 0+150, 0+257, 0+580, 0+970, 1+798 & 2+899. LWD anchoring.
% Cover in Pools	See LWD	
% Boulder Cover	Boulder Placement	Add in select areas (0+064) where flow allows function.
% Pool Area	See LWD & build off-channel	Dig test pits at machine accessible site at 0+282 – 85m long site.
% Wetted Area	Build base flow.	See Riparian Restoration, examine storage areas in headwaters.
% Reach Eroded	Erosion from scour at jams & slide source at 3+020.	Pull SWD at Jams and position LWD for spurs. Bank/bar recovery with plants & staking. Inspect slide with landowner to determine recovery.
Substrate - % Fines	Reduce sources and increase channel scour	Assess slides, at jams remove SWD and form spurs with LWD.
Substrate - % Gravel	Ample supply, needs to be clean and stable.	Keep clean with scour (LWD/Boulders) and anchor with Boulders.
% Reach Altered	Road Crossings	Deactivate or upgrade, discuss with landowner.
Obstructions	Instream debris jams	Pull SWD and reposition LWD at distances 0+580, 0+970, 2+899m.

Table 17 shows the instream restoration activities budget projected in year 1. Actual components will depend on actual budget and time of personnel. Further permits and details will be required as mentioned above. Streamkeeper volunteers may initiate some of these undertakings (such as the monitoring, inventory and SWD removal). They can be undertaken one task at a time. The highest priorities are the debris jams. The structural components of the jams are in need of saving before the jams blow out and all the material is lost. Tossing the small woody debris out of the thalweg areas of the jams to make them permeable to winter water flow would help considerably. It is estimated to take 1 day to remove SWD and another to reposition and anchor LWD in the smaller jams at 0+580m and 0+970m. The large jam at 2+899 will take approximately 5 days for an experienced crew of 3 to restore. All of the activities with the exception of the side channel test pits and boulder placements are possible without machinery allowing opportunity for streamkeeper crews to undertake.

Table 17. Instream Work Plan Budget.

Site	Action	Estimated Budget for Labour & Materials
Reach C1: Station 1 (0+064m)	Boulder placement – 2 clusters of 3 at 0.5m diameter. ½ day plus materials & delivery.	$ 400.00
Station 2 (0+109m)	Reposition 3 LWD in glide for scour/bank protection and anchor. ½ day 3 persons, hand tools and hardware. (Appendix 14)	$ 700.00
Station 4 (0+150m)	Reposition 3 LWD in corner as cover and anchor. (Appendix 15)	$ 700.00
Station 6 (0+257m)	Reposition 2 LWD in V-weir and anchor (Appendix 16)	$ 700.00
Station 7 (0+282m)	Excavate 2 test pits for investigation of off channel pool site. ½ day machine (Appendix 17)	$ 800.00
Station 13 (0+580m)	Jam - reposition 9 LWD and remove 100 SWD. 2 days for 3 persons & equipment.	$2,400.00
Station 21 (0+970m)	Jam -reposition/anchor 7 LWD and remove 150 SWD. 1.5 days for 3 persons & gear.	$2,000.00
Reach C2: Station 40 (1+908m)	Jam - reposition 7 LWD remove 300 SWD.	$2,000.00
Station 65 – 68 (2+899m).	Jam/Avulsion– reposition/anchor 12 LWD & remove 500 SWD. 5 days 3 people & gear.	$6,000.00
Reach C3: Station 70 (3+020m)	Stability assessment of stream banks at old slide site and action if needed (diversion of upland drainage's, planting, staking)	To be determined after on-site visit. after on-site visit.
	Total:	**$15,700.00**

4.3 RIPARIAN RESTORATION WORK PLAN

4.31 Riparian Prescription Work Plan

During the 2003, 2004 field season the bottom three kilometers of Center Creek, which are considered to be the most important areas of the Creek, were assessed in detail for riparian restoration. It is recommended that further detailed riparian assessment and restoration prescriptions continue further up stream in the future. Detailed assessment and prescriptions should continue from the termination point of each consecutive assessment (Table 18). This level of detailed assessment should likely cover all significant reaches of Center Creek both in relation to direct influence, as well as upslope influence on fish habitat.

Table 18. Riparian Prescription Work Plan

Year	Assessment Type	Output	Estimated Cost
2004	Detailed overview and Level II prescriptions	20 ha / 3km	$6,500
2005	Detailed overview and Level II prescriptions	20 ha / 3km	$6,500
2006	Detailed overview and Level II prescriptions	20 ha / 3km	$6,500
2007	Detailed overview and Level II prescriptions	20 ha / 3km	$6,500
2008	Detailed overview and Level II prescriptions	20 ha / 3km	$6,500
2009	Detailed overview and Level II prescriptions	20 ha / 3km	$6,500
	TOTAL:	**120 ha / 18 km**	**$39,000**

4.32 Riparian Treatment Work Plan

Riparian restoration cannot proceed without first seeking permission by the private landowner/s and specific agencies that have jurisdiction over areas "in and about a stream". Recommendations for treatments must therefor be reviewed and be deemed acceptable by relevant parties and the private landowner/s.

Some riparian treatment units have intermittent sites with steep slopes that are not safe to work in. Avoidance of work within these areas is mandatory. In particular, the “river right” section from 0+450m to 0+574m (approximately, station 10 to station 14), and the “river left” section 0+775m to 0+825m (approximately, station 17 to 18) appears to be high-risk areas for riparian restoration worker safety.

Several patches of what appears to be Laminated Root Rot (*Phellinus weirii*) were noted through out the assessment area (i.e. 0+100m, 1+160m, 1+769, and 2+187). The root rot was indicated by chlorotic thinning foliage, crisscross patterns of windthrow infection centres, absence of large windthrow root mats, and indications of white mycelia on overturned root surfaces. When planting understory trees, care must be taken to select the appropriate species for the site that is resistant to Laminated Root Rot (Table 19) in order to grow a wind-firm forest. The suitable root rot resistant tree for under planting in the RVT treatment areas is Western Red Cedar.

Table 19. Root Rot Susceptibility Tree Species

Highly Susceptible	Susceptible		Tolerant	Resistant
Douglas Fir	California Red Fir	Noble Fir	Lodgepole Pine	Yellow Cedar
Grand Fir	Engelmann Spruce	Sitka Spruce	Ponderosa Pine	Incense-Cedar
Mt. Hemlock	Giant Sequoia	Subalpine Fir	Sugar Pine	Redwood
Pacific Silver Fir	Pacific Yew	Western Hemlock	Western White Pine	**Western Redcedar**
White Fir	Western Larch			

What is interesting is that some literature predicts that Western Red Cedar will actually outperform the growth of Douglas Fir in certain Site Series (Appendix 18).

The riparian reserve zone and riparian management is assumed (and recommended) in this report to follow (at minimum) the Forest Practices Code Guidelines for recommended riparian width (Figures 7 and 8). Within the area covered by this report, Center Creek falls within the S2 stream classification (>5m ≤ 20m bank full width) which requires a minimum of a 30m riparian reserve zone (RRZ), and an additional 20m management zone.

Given the sensitive nature of Center Creek the following forest harvest management practices for riparian management are recommended:

- At a minimum, follow the Riparian Management Area Guidebook
- Minimum 30m Riparian Reserve Zones on all S2 and S3 streams
- Low and medium bench flood plains should not be considered for harvest even if they are outside the 30m RRZ
- Assume fish bearing status on all streams (i.e. all streams > 1.5m should have an RRZ)
- Careful consideration should be made for possible sediment sources on headwater streams when planning Riparian Reserve Zones.

The treatment units within the Center Creek riparian zone are first divided into RVT’s 1 to 4 (RVT 5 requires no treatment). RVT’s 3 and 4 are further divided into treatment “polygons” as there are different treatment requirements for Alder dominated RVT’s versus Maple dominated RVT’s. (Appendix 7)

Priority order of riparian treatments for stream health is:

1. RVT 1, Brush Dominated
2. RVT 4, Deciduous forest over top poor conifer understory
3. RVT 3, Deciduous forest over top good conifer understory
4. RVT 2, Overstocked Conifer

Priority order of treatment will however, also depend on coordination with in-stream restoration activities (e.g. excess LWD could be utilized from the RVT 2 restoration treatments for in-stream LWD structures).

RVT 1, Brush Dominated:

Restoration Prescription:

Increase conifer stocking by brushing, planting and releasing suppressed conifer

Brushing:

- Brush out 5.0m diameter areas to create openings devoid of brush (use a chain saw or brush saw). After removing the above ground vegetation, manually screef away all brush root mat within a 1.5m diameter area around each proposed planting spot within the opening. A polaski could be used, or possibly a "Hawk power scarifier" could be used to power screef the entire root mat. Note: all Maple or Alder pole saplings should be retained within 5m of the stream bank.
- These 5.0m openings should be on approximately 10m centers (or ±100 openings/ha)
- The openings should, where possible, be "anchored" on existing suppressed conifer regeneration. At a minimum, all suppressed conifers should be "released" by brushing back vegetation to open a 3.0m diameter area around the conifer.

Planting:

- Species – Western Red Cedar (Cw)
- Size – 1015 size planting stock is recommended, but if not available a minimum of a 615 panting stock can be used
- Planting density - Plant clusters of 5-6 Western Red Cedar (Cw) within each of the 5.0m diameter brushed openings utilizing the best microsites (if existing suppressed conifers are present, they would count in the seedling density). This will produce an estimated target density of 600 conifer trees per hectare.
- Planting spacing – 1.5m minimum, 2.5m maximum.
- Plant 1015 Cw within 1.5m of the stream bank where possible.
- Apply a water soluble, agricultural grade pellet fertilizer, high in nitrogen and phosphate to each tree (20 grams per tree). Make a slit 10 to 15 cm from each of the seedlings (or suppressed conifer) with a planting shovel and drop the required amount of fertilizer into each slit and close the hole.

Browse Protection:

- As deer browse is estimated to be persistent[61], and Cw is a preferred tree species by deer for browsing, all planted seedlings should be protected with some form of caging. Wire mesh or Synocast caging is the two most recommended cages, with the latter being preferable. Synocast caging is cheaper, easier to install, and easier to remove.
- Deer caging should be removed once the top of the tree is above deer browse height, or 2m.

Brush Mats:

- Where brush competition is extreme, and where flooding is not a problem (i.e. mid or high bench floodplains), brush mats around the planted or released conifers may be an option to minimize competition.

Maintenance:

- Follow up manual brushing of these planted clusters and released suppressed conifer should be undertaken in the late summer, and in subsequent years, once in the spring and once in the summer until the seedlings have overtopped the brush by at least one meter.
- Not all of the planted trees will survive. If the density falls below 4 trees per opening, an assessment should occur to determine whether additional replacement trees need planting.

Opportunities for wildlife/biodiversity treatments:

- See Appendices 8, 9 and 10

[61] Green, Klinka. 1994

RVT 2, Overstocked Conifer:

Restoration Prescription:

Thin to 400-600 stems per hectare, increase biodiversity through wildlife treatments

Felling/Thinning:

- Thin dominant tree layer to clumps (clusters and gaps are a target condition) 500 stems/ha by either felling or girdling.
- 20 to 30% of the thinned conifers should be girdled to create snags for biodiversity values. Avoid creating snags near high use trails.
- Thin out ½ to ¾ tree length patches to create openings around areas of poor understory density, and Thin out ½ to ¾ tree length patches to create openings around root rot centers. The openings should be roughly on 40 to 55m centers (Figure 17).
- Favour retaining largest diameter, windfirm trees while preserving species diversity within the stand while thinning
- Thin understory conifer trees to 300-500 stems/ha (clusters and gaps are a target condition)
- 20 to 30% of thinned understory conifer should be girdled for biodiversity values, as well as limiting the immediate slash load from treatments
- Overstocked clusters, where the densities are very high, can be thinned
- Retain 10 to 15 stems/ha of the largest best form Dr (or those that show signs of wildlife use), dispersed throughout the polygon.
- Felled trees can be utilized for a source of in-stream LWD, or for the construction of biodiversity features within the riparian reserve zone
- High stumps are acceptable sources of coarse woody debris and may be left high to lock debris on floodplain.

Brushing:

- Brush out the root rot/under-stocked openings to create openings devoid of brush (use a chain saw or brush saw). After removing the above ground vegetation, manually screef away all brush root mat within a 1.5m diameter area around each proposed planting spot within the opening. A polaski could be used, or possibly a "Hawk power scarifier" could be used to power screef the entire root mat. Note: all Maple or Alder pole saplings should be retained within 5m of the stream bank.
- The openings should, where possible, be "anchored" on existing suppressed conifer regeneration. At a minimum, all suppressed conifers should be "released" by brushing back vegetation to open a 3.0m diameter area around the conifer.

Fill Planting:

- Species – Western Red Cedar (Cw)
- Size – 1015 size planting stock is recommended, but if not available a minimum of a 615 panting stock can be used
- Planting density – Spot plant uniformly through polygon approximately 200 stems/ha utilizing the best microsites. Space at least 1.5m from any existing suppressed conifer. This will produce understory diversity that is root rot resistant.
- Plant 1015 Cw within 1.5m of the stream bank where possible.
- Apply a water soluble, agricultural grade pellet fertilizer, high in nitrogen and phosphate to each planted tree (20 grams per tree). Make a slit 10 to 15 cm from each of the seedlings (or suppressed conifer) with a planting shovel and drop the required amount of fertilizer into each slit and close the hole.

Browse Protection:

- As deer browse is estimated to be persistent[62], and Cw is a preferred tree species by deer for browsing, all planted seedlings should be protected with some form of caging. Wire mesh or Synocast caging is the two most recommended cages, with the latter being preferable. Synocast caging is cheaper, easier to install, and easier to remove.
- Deer caging should be removed once the top of the tree is above deer browse height, or 2m.

Brush Mats:

- Where brush competition is extreme, and where flooding is not a problem (i.e. mid or high bench floodplains), brush mats around the planted or released conifers may be an option to minimize competition.

Maintenance:

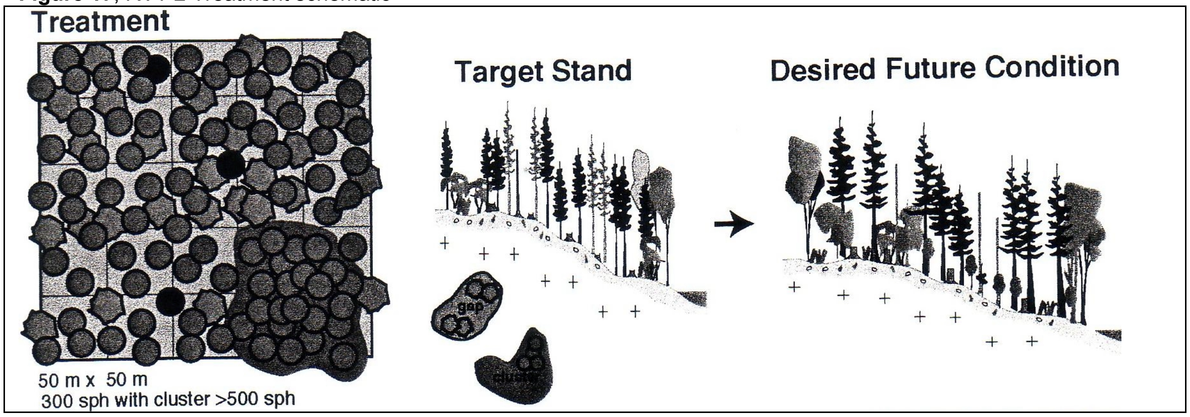
- Follow up manual brushing of these planted clusters and released suppressed conifer should be undertaken in the late summer, and in subsequent years, once in the spring and once in the summer until the seedlings have overtopped the brush by at least one meter.
- Not all of the planted trees will survive. If the density falls below 4 trees per opening, an assessment should occur to determine whether additional replacement trees need planting.

[62] Green, Klinka. 1994

RVT 2 cont'd ….Opportunities for wildlife/biodiversity treatments:

- (See Appendices 8, 9 and 10 for detailed treatment descriptions)
- Creation of standing dead trees – provide critical nesting habitat for birds that nest in cavities excavated from wood
- Creation of stressed trees – second growth stands are usually too healthy and supply little opportunity for insect colonization. Scarring or partially girdling will reduce the vigor of the tree.

Figure 17, RVT 2 Treatment schematic[63]



RVT 3, Polygon 1 – Deciduous Alder forest over top good conifer understory

Restoration Prescription:

Release suppressed conifer seedlings through competition removal and/or spot fertilizing and planting.

Falling Alder Patches:

- Objective is 60% removal (felling, girdle, or distress) of Alder (Dr) canopy (Figure 18), required to attain 40% diffuse light.
- Retain all dominant Maple trees
- Any Dr that is felled should be greater than 3m from the stream bank.
- If Dr competition is required to be removed within 3m from the bank, double girdle only if a lower live limb is present to allow coppicing and retention of live roots.
- Retain the 40% Dr that is the largest and best form, particularly if wildlife use/nesting is apparent.
- Fall Dr away from any suppressed conifer (outside the 3m-stream buffer). If directional falling is not possible, double girdle below a live limb. Buck and remove any tree or branches causing conifer press. Upright any tree disturbed by felling.
- Try to "criss-cross" the felled Dr to create a barrier for deer browse, but maintain at least one trail that parallels the stream for safety exits and wildlife use.
- To the extent possible, fell trees at right angle to the floodplain to maximize sediment storage capability of downed slash and debris.
- Do not buck felled Dr
- High stumps are acceptable sources of coarse woody debris and may be left high to lock debris on floodplain.

Brushing:

- At a minimum, all suppressed conifers should be "released" by brushing back vegetation to open a 3.0m diameter area around the conifer.

Thinning:

- Thin overstocked patches of conifer understory if present, to 660-800 stems/ha unless the patch is to be retained untreated for wildlife or biodiversity reasons. Do not thin overstocked conifer patches where over-story is girdled (girdling can cause upwards to 40% mortality to understory seedlings).

Fill Planting:

- Species – Western Red Cedar (Cw)
- Size – 1015 size planting stock is recommended, but if not available a minimum of a 615 panting stock can be used
- Planting density – Spot plant uniformly through polygon approximately 200 stems/ha utilizing the best

[63] Poulin. 2000

microsites. Space at least 1.5m from any existing suppressed conifer. This will produce understory diversity that is root rot resistant.

- Plant 1015 Cw within 1.5m of the stream bank where possible.
- Apply a water soluble, agricultural grade pellet fertilizer, high in nitrogen and phosphate to each planted tree (20 grams per tree). Make a slit 10 to 15 cm from each of the seedlings (or suppressed conifer) with a planting shovel and drop the required amount of fertilizer into each slit and close the hole.

Browse Protection:

- As deer browse is estimated to be persistent[64], and Cw is a preferred tree species by deer for browsing, all planted seedlings should be protected with some form of caging. Wire mesh or Synocast caging is the two most recommended cages, with the latter being preferable. Synocast caging is cheaper, easier to install, and easier to remove.
- Deer caging should be removed once the top of the tree is above deer browse height, or 2m.

Brush Mats:

- Where brush competition is extreme, and where flooding is not a problem (i.e. mid or high bench floodplains), brush mats around the planted or released conifers may be an option to minimize competition.

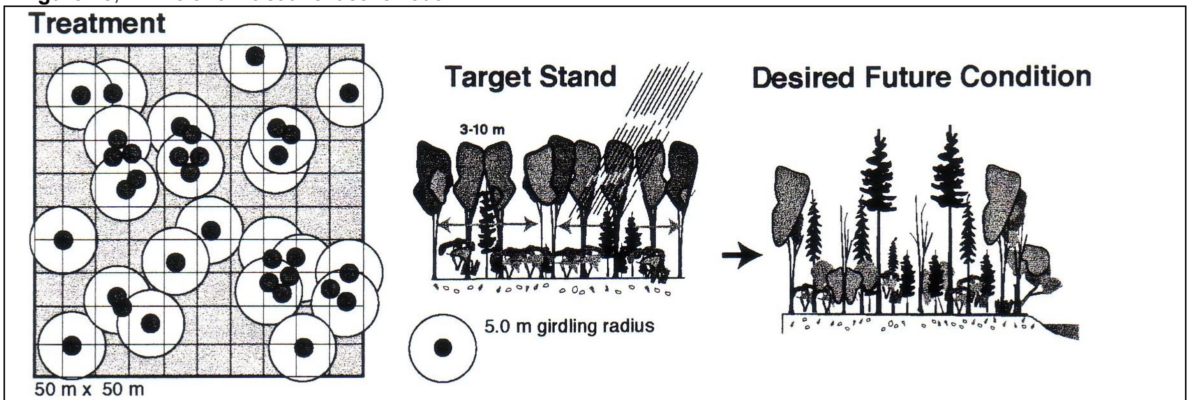
Maintenance:

- Follow up manual brushing of these planted clusters and released suppressed conifer should be undertaken in the late summer, and in subsequent years, once in the spring and once in the summer until the seedlings have overtopped the brush by at least one meter.
- Not all of the planted trees will survive. If the density falls below 4 trees per opening, an assessment should occur to determine whether additional replacement trees need planting.

Opportunities for wildlife/biodiversity treatments:

- See Appendices 8, 9 and 10

Figure 18, RVT 3 and 4 treatment schematic[65]



[64] Green, Klinka. 1994
[65] Poulin. 2000

RVT 3, Polygon 2 - Deciduous Maple forest over top good conifer understory:

Restoration Prescription:

Improve conifer viability through underbrush competition removal and/or spot fertilizing and planting.

Falling Alder Patches:

- Objective is removal (felling, girdle, or distress) of Alder (Dr) canopy to try to attain 40% diffuse light (Figure 18). Retain all dominant Maple trees
- Any Dr that is felled should be greater than 3m from the stream bank.
- If Dr competition is required to be removed within 3m from the bank, double girdle only if a lower live limb is present to allow coppicing and retention of live roots.
- If any Dr is retained, it should be Dr that shows signs of wildlife use/nesting.
- Fall Dr away from any suppressed conifer (outside the 3m-stream buffer). If directional falling is not possible, double girdle below a live limb. Buck and remove any tree or branches causing conifer press. Upright any tree disturbed by felling.
- Try to "criss-cross" the felled Dr to create a barrier for deer browse, but maintain at least one trail that parallels the stream for safety exits and wildlife use.
- To the extent possible, fell trees at right angle to the floodplain to maximize sediment storage capability of downed slash and debris.
- Do not buck felled Dr, High stumps are acceptable sources of coarse woody debris.

Brushing:

- At a minimum, all suppressed conifers should be "released" by brushing back vegetation to open a 3.0m diameter area around the conifer.

Thinning:

- Thin overstocked patches of conifer understory if present, to 660-800 stems/ha unless the patch is to be retained untreated for wildlife or biodiversity reasons. Do not thin overstocked conifer patches where over-story is girdled (girdling can cause upwards to 40% mortality to understory seedlings).

Fill Planting:

- Species – Western Red Cedar (Cw). Size – 1015 size planting stock is recommended, but if not available a minimum of a 615 panting stock can be used
- Planting density – Spot plant uniformly through polygon approximately 200 stems/ha utilizing the best microsites. Space at least 1.5m from any existing suppressed conifer. This will produce understory diversity that is root rot resistant. Plant 1015 Cw within 1.5m of the stream bank where possible.
- Apply a water soluble, agricultural grade pellet fertilizer, high in nitrogen and phosphate to each planted tree (20 grams per tree). Make a slit 10 to 15 cm from each of the seedlings (or suppressed conifer) with a planting shovel and drop the required amount of fertilizer into each slit and close the hole.

Browse Protection:

- As deer browse is estimated to be persistent[66], and Cw is a preferred tree species by deer for browsing, all planted seedlings should be protected with some form of caging. Wire mesh or Synocast caging is the two most recommended cages, with the latter being preferable. Synocast caging is cheaper, easier to install, and easier to remove.
- Deer caging should be removed once the top of the tree is above deer browse height, or 2m.

Brush Mats:

- Where brush competition is extreme, and where flooding is not a problem (i.e. mid or high bench floodplains), brush mats around the planted or released conifers may be an option to minimize competition.

Maintenance:

- Follow up manual brushing of these planted clusters and released suppressed conifer should be undertaken in the late summer, and in subsequent years, once in the spring and once in the summer until the seedlings have overtopped the brush by at least one meter.
- Not all of the planted trees will survive. If the density falls below 4 trees per opening, an assessment should occur to determine whether additional replacement trees need planting.

Opportunities for wildlife/biodiversity treatments:

- See Appendices 8, 9 and 10

[66] Green, Klinka. 1994

RVT 4, Polygon 1 – Deciduous Alder forest over top poor conifer understory:

Restoration Prescription:

Improve conifer stocking by planting, and through competition removal and/or spot fertilizing.

Falling Alder Patches:

- Objective is 60% removal (felling, girdle, or distress) of Alder (Dr) canopy (Figure 18). Retain any dominant Maple
- Any Dr that is felled should be greater than 3m from the stream bank.
- If Dr competition is required to be removed within 3m from the bank, double girdle only if a lower live limb is present to allow coppicing and retention of live roots.
- Retain the 40% Dr that is the largest and best form, particularly if wildlife use/nesting is apparent.
- Fall Dr away from any suppressed conifer (outside the 3m-stream buffer). If directional falling is not possible, double girdle below a live limb
- Try to "criss-cross" the felled Dr to create a barrier for deer browse, but maintain at least one trail that parallels the stream for safety exits and wildlife use. Do not buck felled Dr
- High stumps are acceptable sources of coarse woody debris.

Brushing:

- Brush out 5.0m diameter areas to create openings devoid of brush (use a chain saw or brush saw). After removing the above ground vegetation, manually screef away all brush root mat within a 1.5m diameter area around each proposed planting spot within the opening. A polaski could be used, or possibly a "Hawk power scarifier" could be used to power screef the entire root mat. Note: all Maple or Alder pole saplings should be retained within 5m of the stream bank.
- These 5.0m openings should be on approximately 10m centers (or ±100 openings/ha)
- The openings should, where possible, be "anchored" on existing suppressed conifer regeneration. At a minimum, all suppressed conifers should be "released" by brushing back vegetation to open a 3.0m diameter area around the conifer.

Planting:

- Species – Western Red Cedar (Cw)
- Size – 1015 size planting stock is recommended, minimum of a 615 panting stock can be used
- Planting density - Plant clusters of 5-6 Western Red Cedar (Cw) within each of the 5.0m diameter brushed openings utilizing the best microsites (if existing suppressed conifers are present, they would count in the seedling density). This will produce an estimated target density of 600 conifer trees/ha.
- Planting spacing – 1.5m minimum, 2.5m maximum. Plant 1015 Cw within 1.5m of the stream bank where possible.
- Apply a water soluble, agricultural grade pellet fertilizer, high in nitrogen and phosphate to each tree (20 grams per tree). Make a slit 10 to 15 cm from each of the seedlings (or suppressed conifer) with a planting shovel and drop the required amount of fertilizer into each slit and close the hole.

Browse Protection:

- As deer browse is estimated to be persistent[67], and Cw is a preferred tree species by deer for browsing, all planted seedlings should be protected with some form of caging. Wire mesh or Synocast caging is the two most recommended cages, with the latter being preferable. Synocast caging is cheaper, easier to install, and easier to remove.
- Deer caging should be removed once the top of the tree is above deer browse height, or 2m.

Brush Mats:

- Where brush competition is extreme, and where flooding is not likely to be a problem (i.e. mid or high bench floodplains), brush mats around the planted or released conifers may be an option to minimize competition.

Maintenance:

- Follow up manual brushing of these planted clusters and released suppressed conifer should be undertaken in the late summer, and in subsequent years, once in the spring and once in the summer until the seedlings have overtopped the brush by at least one meter.
- Not all of the planted trees will survive. If the density falls below 4 trees per opening, an assessment should occur to determine whether additional replacement trees need planting.

Opportunities for wildlife/biodiversity treatments:

- See Appendices 8, 9 and 10

[67] Green, Klinka.1994

RVT 4, Polygon 2 – Deciduous Maple forest over top poor conifer understory:

Restoration Prescription:

Improve conifer stocking by planting, and through underbrush competition removal and/or spot fertilizing.

Falling Alder Patches:

- Objective is removal (felling, girdle, or distress) of Alder (Dr) canopy to try to attain 40% diffuse light (Figure 18). Retain all dominant Maple trees
- Any Dr that is felled should be greater than 3m from the stream bank.
- If Dr competition is required to be removed within 3m from the bank, double girdle only if a lower live limb is present to allow coppicing and retention of live roots.
- If any Dr is retained, it should be Dr that shows signs of wildlife use/nesting.
- Fall Dr away from any suppressed conifer (outside the 3m-stream buffer). If directional falling is not possible, double girdle below a live limb. Buck and remove any tree or branches causing conifer press. Upright any tree disturbed by felling.
- Try to "criss-cross" the felled Dr to create a barrier for deer browse, but maintain at least one trail that parallels the stream for safety exits and wildlife use.
- To the extent possible, fell trees at right angle to the floodplain to maximize sediment storage capability of downed slash and debris. Do not buck felled Dr
- High stumps are acceptable sources of coarse woody debris and may be left high to lock debris on floodplain.

Brushing:

- At a minimum, all suppressed conifers should be "released" by brushing back vegetation to open a 3.0m diameter area around the conifer.

Planting:

- Species – Western Red Cedar (Cw)
- Size – 1015 size planting stock is recommended, a minimum of a 615 panting stock can be used
- Planting density - Plant clusters of 5-6 Western Red Cedar (Cw) within each of the 5.0m diameter brushed openings utilizing the best microsites (if existing suppressed conifers are present, they would count in the seedling density). This will produce an estimated target density of 600 conifer trees/ha.
- Planting spacing – 1.5m minimum, 2.5m maximum.
- Plant 1015 Cw within 1.5m of the stream bank where possible.
- Apply a water soluble, agricultural grade pellet fertilizer, high in nitrogen and phosphate to each tree (20 grams per tree). Make a slit 10 to 15 cm from each of the seedlings (or suppressed conifer) with a planting shovel and drop the required amount of fertilizer into each slit and close the hole.

Browse Protection:

- As deer browse is estimated to be persistent[68], and Cw is a preferred tree species by deer for browsing, all planted seedlings should be protected with some form of caging. Wire mesh or Synocast caging is the two most recommended cages, with the latter being preferable. Synocast caging is cheaper, easier to install, and easier to remove.
- Deer caging should be removed once the top of the tree is above deer browse height, or 2m.

Brush Mats:

- Where brush competition is extreme, and where flooding is not likely to be a problem (i.e. mid or high bench floodplains), brush mats around the planted or released conifers may be an option to minimize competition.

Maintenance:

- Follow up manual brushing of these planted clusters and released suppressed conifer should be undertaken in the late summer, and in subsequent years, once in the spring and once in the summer until the seedlings have overtopped the brush by at least one meter.
- Not all of the planted trees will survive. If the density falls below 4 trees per opening, an assessment should occur to determine whether additional replacement trees need planting.

Opportunities for wildlife/biodiversity treatments:

- See Appendices 8, 9 and 10

[68] Green, Klinka. 1994

Costs associated with the various Riparian Restoration treatments can be seen in Table 20.

Table 20. Riparian treatment costs (maintenance costs extra)

RVT Type	Treatment Area	Cost/ha	Total $
RVT 1, Brush Dominated	0.5 ha	$3,800	$1,900
RVT 2, Overstocked Conifer	6.2 ha	$4,500	$27,900
RVT 3, Deciduous forest over top good conifer understory	1.7 ha	$2,500	$4,250
RVT 4, Deciduous forest over top poor conifer understory	8.2 ha	$3,200	$26,240
Total Treatment Area:	**16.6 ha**		**$60,290**

4.4 MONITORING WORK PLAN

Roads: Routine Monitoring will occur each year for the first three years following completion of a deactivated or upgraded road system, then every five years after that until it is deemed no longer necessary to continue.

Streams: Routine Monitoring will occur each year for the first three years following completion of an in-stream project, then every five years after that until it is deemed no longer necessary to continue.

Riparian: Routine Monitoring will occur every five years after completion of a riparian project until it is deemed no longer necessary to continue.

Nutrient Replacement: When a nutrient replacement program is initiated, water sampling is usually taken annually until the Nutrient Replacement program is no longer deemed necessary.

Monitoring costs over a ten year period can be seen in Table 21.

Table 21. Ten Year Monitoring Plan

Title	10 Year Cost
Road Monitoring Program	$ 15,000
Stream Monitoring/Maintenance Program	$ 50,000
Riparian Monitoring/Maintenance Program	$ 20,000
Nutrient Monitoring Program	$ 5,000
TOTAL	**$90,000**

5.0 SUMMARY

The potential for successful fish and forest ecosystem restoration, combined with the high productivity potential of the Center Creek watershed unit, make it an extremely good candidate for restoration investment. This report starts the process but there is still much to do. There are partnerships to establish or maintain, plans to develop and funds to apply for. Who will do this is a concern. The Centre Creek watershed has no one stewardship group under its wing and this perhaps is its greatest weakness. The existing organizations – government, first nations, industry and streamkeepers are spread thin on current activities. What may be needed is a poll of individuals from each organization to determine whom would like to follow up on these recommendations by establishing a sub-committee or organization for this. One additional group that may be interested is Malaspina University where they have been undertaking assessment and restoration projects on local streams in their resource programs. It is important that the non-land owner partners maintain a close relationship with the landowners. Most of the watershed is private land and that has to be respected. For the long term; watershed recovery will only be sustainable if the partnerships are sustainable.

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