Slocan River
Preliminary Side Channel Assessment: 2010

Prepared By:

Peter J. Corbett, RPBio
Mirkwood Ecological Consultants Ltd.
P.O. Box 138
Winlaw, B.C. V0G 2J0

(250) 226-7249 or pcorbett@columbiawireless.ca

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Abstract

Side channels are a critical component to rainbow trout (*Oncorhynchus mykiss*) ecology and have become increasing rare in human-modified flood plains An initial inventory identified over 80 side channels throughout the Slocan River. Some of these were relatively minor in nature; small channels created by gravel bars. Many were historic. Only 11 identified as fully functioning, meaning that they provided trout habitat for all 3 seasonal habitat uses: spawning, spring refugea and summer/fall habitat. There were a total of 45 significant channels identified throughout the river. From these 10 were selected for further field investigations; 3 fully functioning channels to act as benchmarks and 7 that have potential for restoration.

Biophysical data was collected throughout the year. Trout use was highest in the functioning side channels and was also proportionally higher than in their adjacent mainstem reaches. The 7 potential sites all shared similar biophysical characteristics with the benchmark sites with the exception that stream discharge was much lower. The potential to increase rainbow trout production through side channel restoration on the Slocan River is evident and technical challenges should be explored to realize this goal.

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Slocan River Preliminary Side Channel Assessment: 2010

1.0 Introduction

There are very few large free flowing rivers in the West Kootenay region of SE British Columbia as hydro and flood control developments have impounded most of the major rivers (eg. Columbia, Kootenay, Duncan). The Slocan River is one of the few remaining free flowing rivers in the region; however, it has been heavily impacted over the years through human development especially, rail, road and highway corridors, agriculture and human settlements. Off-channel habitats, a critical component in the life history of pacific salmonids (*Oncorhynchus spp.)*, have become increasingly rare in human-modified flood plains (Morley et al, 2005). Side channels in particular provide a variety of functions for rainbow trout (*O. mykiss*), especially in larger order rivers like the Slocan River, including:

- spawning
- juvenile rearing
- high water refuge
- water temperature moderation
- increased habitat complexity, and
- flood control

Spawning in side channels of the Slocan River has been previously documented (Baxter and Rhome, 1996) but other life history utilization has not been explored nor has the changes to the Slocan River flood plain been assessed as a result of human development. In order to develop effective restoration plans for the Slocan River, it is critical to obtain a basic understanding of the specific ecological functions of the river and monitor these changes over time.

This project undertakes an investigation of present use of existing side channels, historic distribution of past side channel and an inventory of opportunities for fish habitat rehabilitation. Reestablishing water flows into closed off channels not only creates preferred trout habitat but also increases the biological productivity of the river by increasing invertebrate biomass, the primary food source for trout. Funding and support for this project has come from a variety of groups, including, Slocan River Stream Keepers, Columbia Basin Trust and the Columbia Power Corporation.

2.0 Methods

There are 4 main components to this project. Each will be discussed separately in the methods and results section but will all be combined as a component of the discussion.

2.1 Initial Inventory

An initial inventory was undertaken using air photos (1998 and 2003 flights) as well as 1:20,000 TRIM mapping. All side channels, both existing and historical, were identified and then ground checked in the field. Biophysical data was obtained at that time, along with photo records and a brief description of the side channel head (intake). A database was created from these results. Based on this inventory, 10 side channels were identified for further investigation; 3 fully functioning side channels that would act as benchmark sites and 7 channels with potential fish habitat productivity (i.e. all of the elements of good fish habitat, especially spawning, with the exception of adequate water flows).

2.2 Fish Utilization of the Selected Side channels

To determine trout utilization of the selected side channels, snorkel swim counts were conducted for each of the 10 sites. They were assessed during pre runoff (end of April), spring high water (June) and during summer flows (August). This was to determine spawning use, spring refugea and summer productivity respectively.

Swim counts were conducted by 2 swimmers; dividing the channel into 2 observation lanes. Trout and mountain whitefish (*Prosopium williamsoni*) were enumerated by fork length in increments of 10 cm.

Any other relevant observations were also recorded at this time (e.g. significant habitat features, access issues etc)

2.3 Reach Level Population Monitoring

Essential to any restoration efforts, monitoring trout production is central to determine the effectiveness of the program and help guide future projects on the river through adaptive management strategies. Population monitoring has been undertaken sporadically over the last several decades and with an attempt to complete stock assessments annually more recently. Traditionally these assessments were performed using 5 swimmers (observers) with 2 passes per reach. This can be very cost prohibitive. Finding the requited financial resources each year can be difficult and has prevented continuous data collection from year to year. In recent years, a 2-swimmer method has been employed. On a number of instances, both methods were used so that a detection factor could be developed between the two methods thereby standardizing the data and making the results interchangeable. Differences were measured between the 2 methods by fork length and a factor determined for each size class. These were then applied to the entire data set to standardize all of the results since 1996.

2.4 Cursory Restoration Prescriptions for Selected Side Channels

Once the trout utilization assessments were completed and the channels observed at a variety of water levels (environmental conditions), biophysical data was obtained and brief cursory prescriptions for restoration were developed. Prescriptions focused on the potential to re-establish relevant water flows to the candidate side channels thereby increasing habitat availability.

3.0 Results

3.1 Initial Inventory

The initial inventory identified over 80 side channels. Some of these were relatively minor in nature; small side channels created by gravel bars. Most were historic with only 11 identified as actually fully functioning, meaning that they provided trout habitat for all 3 seasonal uses; spawning, spring refugea and summer/fall habitat. There were a total of 45 channels identified throughout the river with the potential to provide fully functioning trout habitat if remedial actions are undertaken (see Figures 1 through 4).

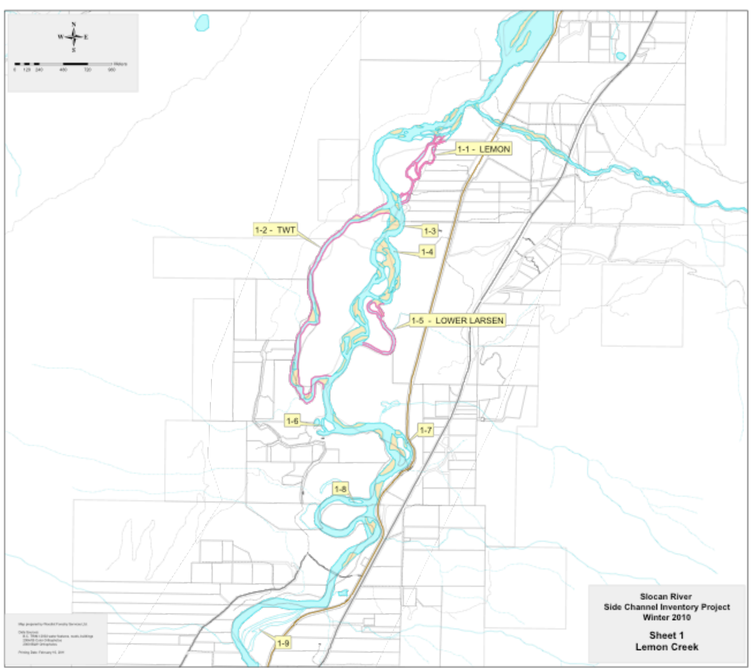

Figure 1. Side channel locations in the Upper Slocan River (Lemon). Red highlighted channels indicate the selected sites for further investigation.

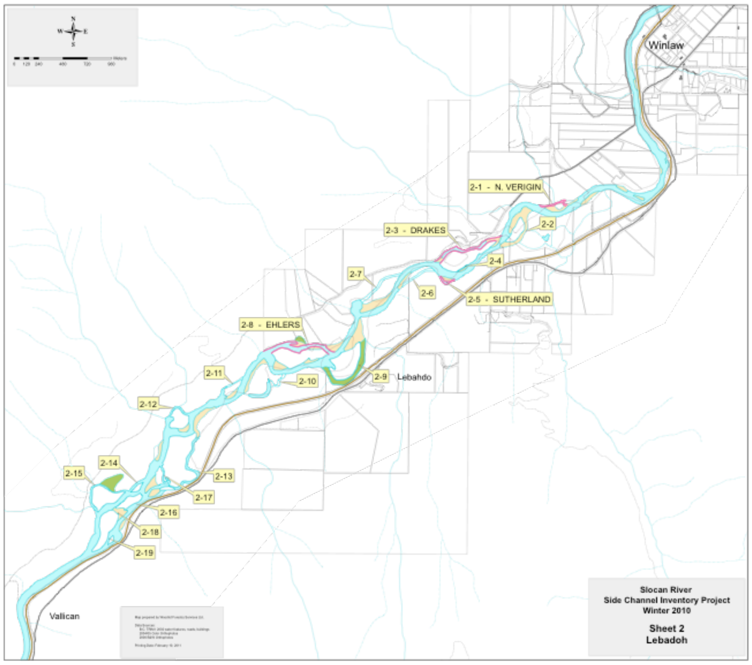

Figure 2. Side channel locations in the mid section (Lebadoh) of the Slocan River. Red highlighted sites indicate channels selected for further investigation.

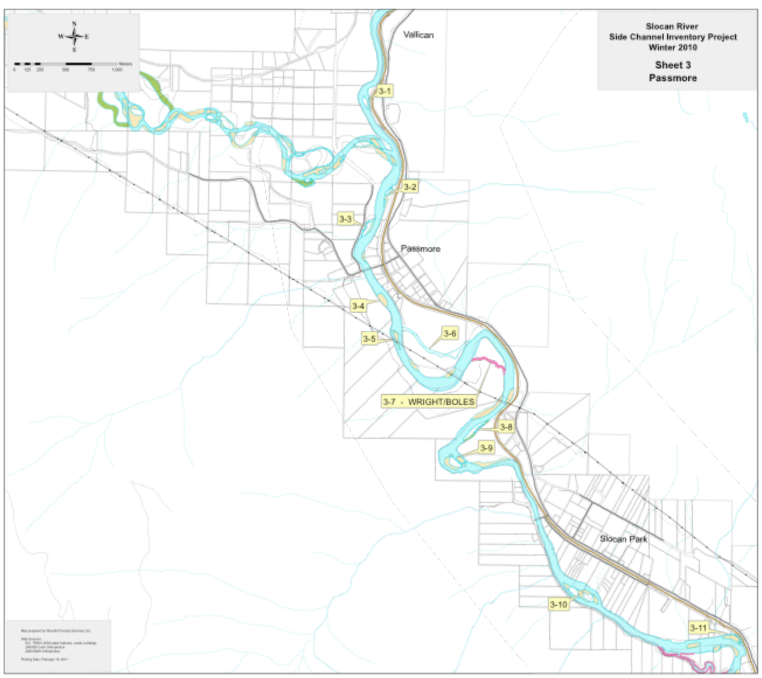

Figure 3. Side channel locations in the mid section (Passmore) of the Slocan River. Red highlighted channels indicates sites selected for further investigation.

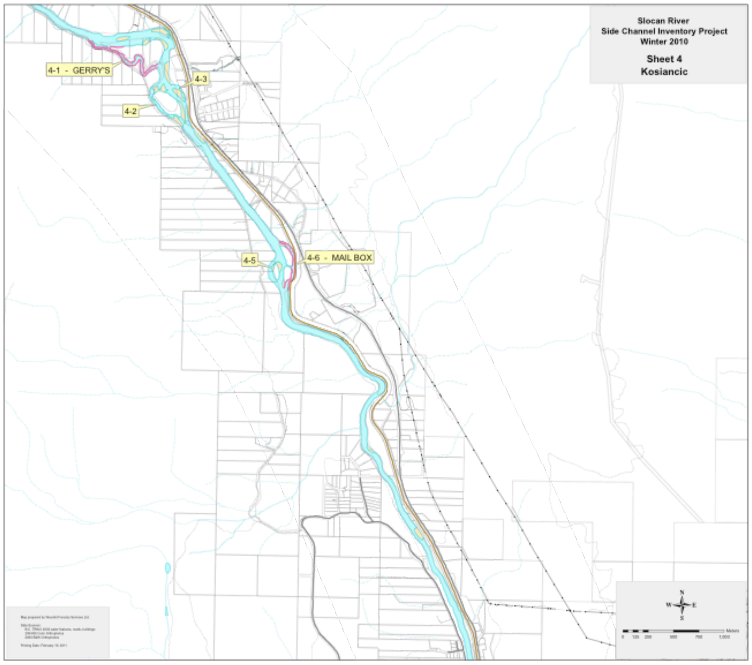

Figure 4. Side channel location in the lower section (Kosiancics) of the Slocan River. Red highlighted channels indicate sites selected for further investigation.

Relevant portions of the cursory side channel database are found in Table 1 below. The 10 selected side channels for further investigation are highlighted.

Table 1. Slocan River side channel database. (blue = selected channels, * = fully functioning channel, status refers to the dynamic stage the channel is in: decreasing = depositional or flow reduction, increasing = scouring or flow increasing)

Number	Reach	Status	Rearing	Spawning	Spring	Summer	Opening	Length
1-1 (Lemon)	Lemon	decreasing	yes	?	yes	marginal	open	900
1-2 (TNT)	Lemon	decreasing	yes	no	yes	marginal	log jam	2900
1-3 (Larsen)*	Lemon	decreasing	yes	yes	yes	yes	open	300
1-4 *	Goat	stable	yes	yes	yes	yes	open	600
1-5 (Lower L)*	Goat	decreasing	yes	likely	yes	yes	log jam	900
1-6 (Ferguson)*	Goat	increasing	yes	?	yes	yes	open	250
1-7	Goat	decreasing	yes	no	yes	yes	open	300
1-8 (Oxbow)	Goat	stable	yes	no	marginal	marginal	open	1000
2-1 (N Verigin)	Cougar	decreasing	no	no	no	no	log jam	200
2-2 (Verigin)	Cougar	decreasing	yes	no	yes	no	gravel	300
2-3 (Drakes)*	Cougar	decreasing	yes	yes	yes	yes	log jam open	600
2-4	Cougar	decreasing	yes	?	yes	no	log jam	200
2-5 (Sutherland)	Cougar	stable	yes	no	yes	no	open	200
2-6	Ehlers	historic						
2-7	Ehlers	historic						
2-8 (Ehlers)	Ehlers	decreasing	yes	no	yes	no	log jam	
2-9	Ehlers	historic						
2-10 (Frank's)	Lumberyard	historic					oxbow	
2-11 (Taberti)	Lumberyard	decreasing	yes	?	yes	no	log jam	300
2-12 (Slootweg)*	Lumberyard	decreasing	yes	yes	yes	yes	log jam	300
2-13 (Williamson)	Lumberyard	decreasing	yes	no	yes	no	open	900
2-14	Lumberyard	increasing	yes	yes	yes	yes	open	300
2-15 (Havelcheck)	Lumberyard	decreasing	yes	no	yes	marginal	log jam	600
2-16	Lumberyard	decreasing	yes	?	yes	yes	open	900
2-17*	Lumberyard	increasing	yes	?	yes	yes	open	300
2-18	Lumberyard	decreasing	?	?	?	?	?	200
2-19	Lumberyard	decreasing					gravel bar	
3-1*	Passmore	stable	yes	yes	yes	yes	open	200
3-2	Passmore	decreasing	?				log jam	200
3-3*	Passmore	decreasing	yes	yes	yes	yes	gravel bar	400
3-4	Passmore	decreasing	?				gravel bar	
3-5	Passmore	increasing	yes	yes	yes	yes	open	100
3-6 (Pass Slide)	Passmore	decreasing	?					
3-7 (Wright)	Passmore	decreasing	yes	no	yes	no	log jam	500
3-8	Passmore	decreasing	yes	no	yes	no	open	300
3-9 (Horseshoe)	Passmore	changing						
3-10 (Island)	Slocan Park	stable	yes	yes	yes	yes	open	300
3-11	Slocan Park	decreasing	yes	no	no	no	open	800
4-1 (Gerry's)*	Kosiancic	stable	yes	yes	yes	yes	open	1200
4-2 *	Kosiancic	stable	yes	?	yes	yes	open	700
4-3	Kosiancic	increasing	yes	yes	yes	yes	gravel bar	200
4-4	Kosiancic	decreasing	no	no	yes	no	open	200
4-5	Kosiancic	stable	yes	yes	yes	yes	open	200
4-6 Mail Box	Kosiancic	decreasing	yes	?	yes	marginal	log jam	400
4-7 (Nesbitt)	Kosiancic	historic						1000

3.2 Fish Utilization of the Selected Side Channels

The timing of the spawning swims coincided with the peak of the spawning window as seen from the Gravel Pit Bridge in Slocan City where we have established a redd count index site for the last 7 years. Unfortunately, the window is short and the discharge and associated turbidity quickly increases on the main Slocan River. Of the 10 selected channels only Drakes and Gerry's where confirmed to have spawning fish present. Lower Larsen's is expected to have spawning fish but the sample window closed prior to assessment, therefore requires further investigation. All other sites were confirmed to have no spawning trout.

During the spring freshet trout were observed in all of the side channels except North Verigin's (see table 2 below). During this same period whitefish were also observed in all but Verigins and Wright/Boles (see Appendices).

Table 2. Rainbow Trout Utilization of Selected Slocan River Side Channels During Spring Freshet, 2010

Site	Fork Length (cm)					
	<20	20+	30+	40+	50+	Total Trout
Drakes	3	8	5	2	0	18
Ehlers	11	2	1	0	0	14
Mail Box	2	4	7	1	0	14
Gerry's	26	20	6	3	0	55
N Verigins	0	0	0	0	0	0
Lower Lemon	0	4	3	1	0	8
TNT	13	9	6	3	0	31
Lower Larsen	2	4	2	1	0	9
Wright Boles	1	2	0	0	0	3
Sutherlands	1	4	1	0	0	6

During the summer sample period trout were observed in all but Ehlers, Verigins and Wright/Boles (see table 3) while whitefish were absent from all channels but Drakes, Gerry's and Mail Box (see Appendices).

Table 3. Rainbow Trout Utilization of Selected Slocan River Side Channels During the Summer Season, 2010

Site	Fork Length (cm)					
	<20	20+	30+	40+	50+	Total Trout
Drakes	10	12	5	4	1	32
Ehlers	0	0	0	0	0	0
Mail Box	1	2	0	0	0	3
Gerry's	22	27	19	3	1	72
N Verigins	0	0	0	0	0	0
Lower Lemon	4	0	0	0	0	4
TNT	0	0	0	2	0	2
Lower Larsen	6	10	3	1	0	20
Wright Boles	0	0	0	0	0	0
Sutherlands	0	0	1	0	0	1

When comparisons are made between sites and seasons, some interesting trends appear. In Figure 5 the 10 selected channels are shown with target trout utilization by season. A target trout is one with a fork length of 20 cm or greater. Drakes, Gerry's and Lower Larsen's are the 3 benchmark sites and are the only sites with trout utilization higher in the summer season versus the spring. These are also the only sites where spawning was observed. Greater discharge results in a greater number of fish using the side channel during the summer when the river is low and that there is still sufficient discharge in the spring, pre run off, to ensure adequate habitat for spawning.

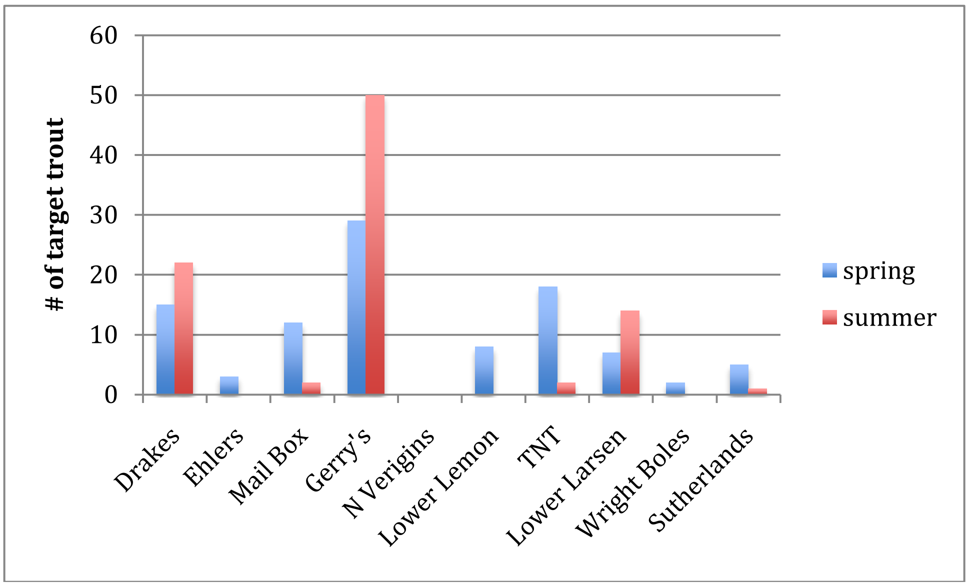

Figure 5. The number of target rainbow trout (fork length >20cm) utilizing selected Slocan River side channels, 2010.

3.3 Reach Level Population Assessments

As previously stated in the Methods section, the original population assessments were conducted using 5 observers over 2 passes looking at 5 index sites over the length of the river. While this method provided statistically defendable data, the coverage was inadequate as too much of the river was not assessed and therefore not accounting for fish movement between years. It was also determined that sampling precision is not significantly increased enough between 5 swimmers versus 2 to justify the cost, especially at the expense of covering less of the river each year. To this end, on 4 separate occasions, both methods were applied concurrently and comparisons of the results are presented in Table 4 below. The average value will be the factor applied to standardize the data by size class. As expected, the smaller size is more difficult to detect where the larger size classes differences there was no difference in detection.

Table 4. The differences in trout detection in the Slocan River between the 5-swimmer method versus the 2-swimmer method buy reach and size class.

		Size Class (cm)				
Year	Reach	<20	20+	20+	40+	50+
2005	lemon	1.491071429	1.54368932	1	0.958333333	1
2007	winlaw	2.074074074	0.971698113	1.541666667	2.181818182	1
2008	winlaw	2.7	2.208333333	1.043478261	1	1
2008	cougar	0.425531915	0.888888889	1.642857143	0.611111111	1
Average		**1.672669354**	**1.403152414**	**1.307000518**	**1.187815657**	**1**

Employing the new standardized data techniques, Figure 6 represents trout population trends in the upper river including the data collected in 2010. To see all of the 2010 raw and standardized data, as well as previous years, please refer to the Appendices.

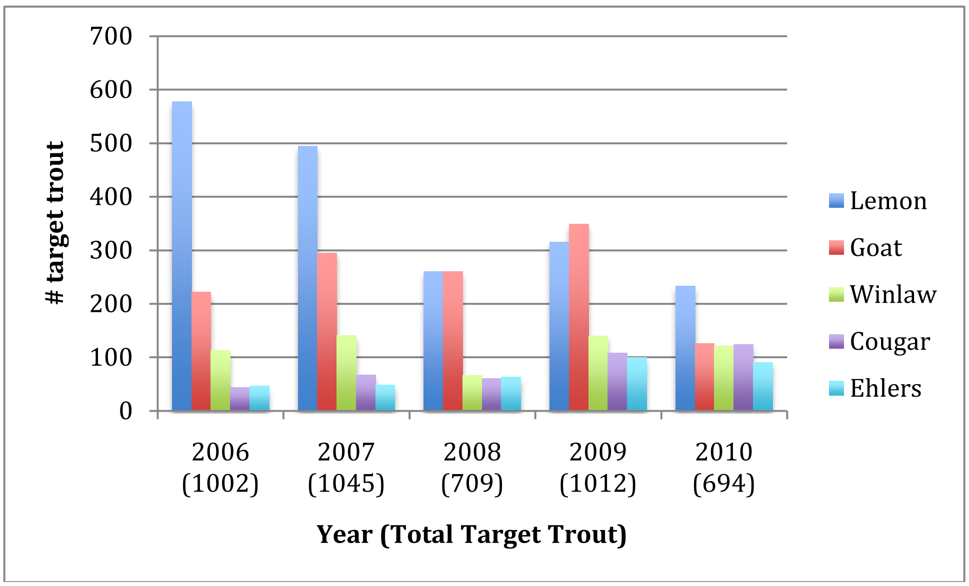

Figure 6. Rainbow trout population trends in the upper Slocan River, 2006-2010. This data has been standardized to reflect detection differences between the two assessment methods.

Trout movement between reaches between years is evident in Figure 6 and demonstrates the necessity to sample all of the reaches to increase accuracy of the population assessment and to complete the assessment each year to gain insightful trends that would otherwise be missed.

A comparison between the reach level assessments with 2 of the benchmark side channels provides insight into the productivity of the side channels and their potential to increase the trout population in the river.

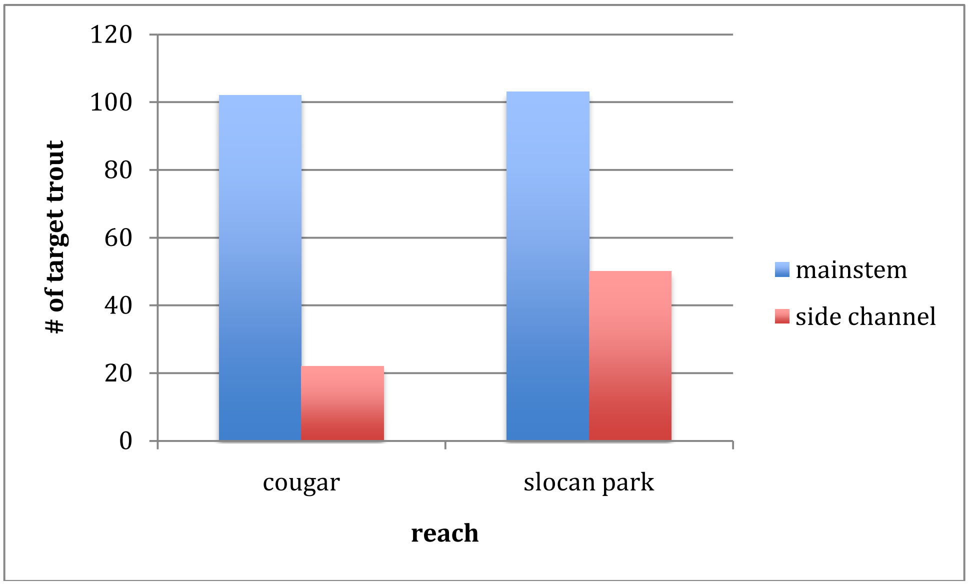

Figure 7. A comparison between target trout use of 2 mainstem reaches versus the side channels within the reaches, summer 2010. Drake's side channel is found in the Cougar reach, Gerry's in the Slocan Park reach.

In the summer, Drakes and Gerry's side channels contribute 22% and 49% respectively to the population of their associated reaches; Cougar and Slocan Park respectively. The Cougar reach has 2 restoration projects within its boundaries contributing to an additional 22 target trout in the mainstem (Corbett, 2011a; Corbett, 2011b). If this increase is taken into consideration, then the proportion Drakes contributes to the population level of the Cougar reach would be 28%. The productivity of the side channels within their respective reaches is significant especially when considering the proportion of stream discharge that the side channels represent compared to the mainstem. Drakes represent 0.68% of summer discharge in the river while Gerry's is 1.83% (complete discharge data can be found in the Appendices). A very small proportion of the river contributes significantly to the overall trout population. The implication of these findings is that side channel restoration has the potential to make significant contributions to trout productivity in the Slocan River by essentially increasing the wetted area of preferred trout habitat.

3.4 Cursory Restoration Prescriptions for Selected Side Channels

The following is a brief biophysical description of each of the 10 selected side channels followed by a cursory prescription that would address the potential to restore adequate stream discharge into the channel to enhance rainbow trout productivity.

Lower Lemon 1-1

The Lower Lemon side channels begins as a single cobble opening and then braids into several channels before merging as a single channel again at its terminus. It is approximately 900 m long. There appears to be a cold-water spring entering the channel 300 m up from the downstream end ensuring that there is always water in its lower reaches. There are potentially 10+ good pools with good stream cover throughout. Unlike many of the other side channels on the Slocan River, this channel does not lose stream gradient for the bottom half of its length but remains steep enough to provide trout habitat along its entire length. There are portions of the channel dominated by gravel and would likely provide spawning opportunity.

The channel opening is within approximately 300 m from the small road leading to the Lemon Pool. Removal of cobbles would be required. This could be facilitated by hand removal or machine.

Figure 8. Lower Lemon channel (1-1) looking downstream.

The Nature Trust (TNT) 1-2

This is the longest side channel on the river and is separated from the mainstem by Nixon's Island that The Nature Trust has just recently purchased. In the 90's this was the mainstem of the river. The bottom half of the channel loses gradient and provides little trout habitat. The upper half provides excellent trout habitat but will require a significant amount of discharge to once gain provide habitat. There are approximately 7 pools with potential to provide good habitat for trout. There are also a significant number of gravel sites that could provide for spawning opportunities.

There is a large volume of cobbles and boulders that would require removal to establish this channel once again. A machine would likely be need. Access would best be from the other side of the river through the Larsen property and would require crossing the river during low water.

Figure 9. TNT channel (1-2) looking up stream towards channel mouth.

Lower Larsen 1-5

This is one of the 3 benchmark sites and is fully functioning but on the decline as depositional material is building at the channel mouth. Its opening is a braided long jam that comes in from another side channel 1-4. There are only 4 pools at the top of the side channel that function adequately for trout. The lower two thirds of the channel does not provide adequate trout habitat due to the reduced stream velocity created from a low stream gradient.

It is not practical to restore this channel at this time.

North Verigins (2-1)

This is a small side channel that has too little water in it to function for trout at all seasons. The opening is a logjam and gravel bar. There are 2 potential pools below the opening and then the gradient backs off. There is a small cool water tributary entering the side channel in the lower half.

There is good access to the mouth of this channel from a flat cleared field. This channel could be opened using either hand tools or a machine.

Drakes (2-3)

This is one of the 3 benchmarks. The head of the channel is braided with only one channel clear. The remaining channels are restricted by logjams. The braided section joins into one channel half way down its length. There is excellent habitat for the full length of the channel. There are 6 good pools that support trout. Cover is excellent. There is a variety of substrate size from very large pieces of bedrock to smaller spawning gravel. This channel is in decline as depositional materials are building at the channel mouth thereby decreasing water flows, especially during the summer/fall season.

This channel should be considered for restoration at some point in the future. At present, the mouth of the channel could be cleared by hand. It would be difficult to access the mouth of the channel with machines as it is protected by sensitive wetlands.

Sutherlands (2-5)

This is a small side channel that was restored in the fall of 2010. It is a component of a larger restoration project down stream. The original channel had 1 pool at its head. The stream bank along the channel has been supported with large rock and logs. An additional plunge pool was also constructed half way down its length. This side channel will continue to be monitored and will act as a learning guide for future projects.

Ehlers (2-8)

This was a fairly significant channel at one time and may have once been the mainstem. The start of the channel has an old log jam that is now backed up by a gravel/cobble bar. There are 4 or 5 potential pools below the mouth. There is a cold ground water source in the channel. The lower half of the channel becomes quite slack and does not have trout restoration potential. There is good cover in place in the upper pool section as well as a smaller channel above the original opening that still functions adequately and is currently providing trout habitat.

This channel has good access through a developed property. The current landowners would be willing to participate in a restoration project at the channel mouth. Machine or hand tools could be employed to open this channel.

Figure 10. Ehlers side channel (2-8) looking downstream from the mouth.

Wright/Boles (3-7)

This channel is approximately 500 m long but is fairly narrow, never exceeding 3 m in width. There are 4 potential pools. Substrate consists of gravel and cobbles in the upper reaches but as the gradient lessens, the stream bottom is dominated by smaller and finer substrate. The opening is a combination of logs and gravel.

There is machine access to this site and a very willing landowner.

Gerry's (4-1)

This is one of the benchmark sites and is also one of the larger side channels on the Slocan River. It has twice the discharge volume as Drakes. There were 8-10 spawning fish observed in the channel in 2010. There are over 10 pools in this channel with much functioning cover and large woody debris (LWD). There is excellent trout habitat for the full length (1200 m) of the channel.

Mail Box

This is a short but relatively wide old channel with 2 openings. The upper opening is the most restricted with both logs and a gravel bar reducing stream flow to the channel. The lower opening has a log jam at its mouth but is still functioning adequately. There are 5 potential pools in this channel. The gradient of the lower half does lessen but in high water, there were numerous adult trout holding in this section. The near shoreline is substantially rip-wrapped as part of the old rail bed. The far shore island is crown land.

A machine would be required to open this channel along with extensive cutting into the logjam. Access would be from along the rails to trails.

Figure 11. Mail Box side channel (4-6) looking up stream towards the mouth.

4.0 Conclusion

There are numerous restoration opportunities on the Slocan River. Technical challenges, along with the sensitive nature of private property issues must be at the forefront of consideration at the earliest possible stages of restoration development. Continued monitoring is required to better understand the function of the channels and to improve upon the prescriptions developed for restoration to ensure that benefits to trout are optimized. In addition other areas of degraded fish habitat should also be assessed and considered for restoration, using a multidimensional approach to restoring and improving the Slocan River. The opportunity to substantially increase the rainbow trout population is evident and may provide a cost effective method to restore ecological function on the Slocan River.

A cursory engineering plan for each of the potential side channels identified for restoration should be developed with associated costs so that a cost benefit analysis can be completed. Potential effected property owners need to be consulted along with all responsible regulatory agencies. In this manner an appropriate project can be selected for a trial treatment. Biophysical monitoring must continue so that changes to the river can be determined and effectiveness of the treatments can be measured.

5.0 References

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6.0 Appendices

Appendix A. Mountain whitefish use of selected side channels in the Slocan River

Species	MWF					
Year	2010					
Season	Spring High Water					
	Fork Length					
Site	<20	20+	30+	40+	50+	Total
Drakes	2	15	11	0	0	28
Ehlers	0	2	5	0	0	7
Mail Box	0	5	3	0	0	8
Gerry's	11	19	12	0	0	42
N Verigins	0	0	0	0	0	0
Lower Lemon	2	2	0	0	0	4
TNT	1	5	5	0	0	11
Lower Larsen	0	4	6	0	0	10
Wright Boles	0	0	0	0	0	0
Sutherlands	1	2	0	0	0	3

Species	MWF					
Year	2010					
Season	Summer					
	Fork Length					
Site	<20	20+	30+	40+	50+	Total
Drakes	7	2	2	0	0	11
Ehlers	0	0	0	0	0	0
Mail Box	0	5	3	0	0	8
Gerry's	27	34	20	0	0	81
N Verigins	0	0	0	0	0	0
Lower Lemon	0	0	0	0	0	0
TNT	0	0	0	0	0	0
Lower Larsen	0	0	0	0	0	0
Wright Boles	0	0	0	0	0	0
Sutherlands	0	0	0	0	0	0

Appendix B. Reach Level Rainbow Trout Data (raw and standardized)

Raw Data

Year	Reach	Pass #	<20	20+	30+	40+	50+	# swimmers
1996	Winlaw	1	126	26	6	0	0	5
1996	Winlaw	2	71	27	5	0	0	5
1996	Passmore	1	63	36	12	2	0	5
1996	Passmore	2	95	38	8	0	0	5
1996	Cresent	1	12	26	15	0	0	5

	Valley							
1996	Slocan Park	1	40	35	3	5	0	5
1998	Lemon	1	236	145	103	22	0	6
1998	Lemon	2	357	161	70	20	0	6
1998	Winlaw	1	344	63	15	8	0	6
1998	Winlaw	2	390	58	21	1	0	6
1998	Passmore	1	91	76	37	8	0	6
1998	Passmore	2	95	58	50	11	0	5
1998	Slocan Park	1	122	44	23	1	0	5
1998	Slocan Park	2	115	35	22	6	0	5
1998	Cresent Valley	1	137	88	34	8	0	6
1998	Cresent Valley	2	141	66	38	1	0	5
2000	Lemon	1	346	127	65	44	0	5
2000	Lemon	2	429	133	99	27	0	5
2000	Winlaw	1	378	59	17	3	0	5
2000	Winlaw	2	288	36	8	3	0	5
2000	Passmore	1	169	27	20	1	0	5
2000	Passmore	2	268	27	25	5	0	5
2000	Slocan Park	1	340	17	4	2	0	5
2000	Slocan Park	2	477	18	4	2	0	5
2000	Cresent Valley	1	103	25	15	2	0	5
2000	Cresent Valley	2	86	25	14	0	0	5
2005	Lemon	1	223	150	70	19	3	5
2005	Lemon	2	112	168	77	27	1	5
2005	Lemon	1	101	99	69	24	2	2
2005	Lemon	2	122	106	78	24	2	2
2005	Winlaw	1	84	53	33	7	1	5
2005	Winlaw	2	96	64	37	6	1	5
2005	Passmore	1	30	41	29	11	0	5
2005	Passmore	2	93	42	31	2	0	5
2005	Slocan Park	1	25	37	23	2	0	5
2005	Slocan Park	2	0	8	18	6	0	5
2005	Cresent Valley	1	5	17	6	4	0	5
2005	Cresent Valley	2	5	19	11	2	0	5
2006	Lemon	1	67	196	181	53	4	3
2006	Goat	1	16	60	81	21	7	3
2006	Winlaw	1	11	37	30	17	2	2
2006	Cougar	1	3	10	18	5	1	2
2006	Ehlers	1	1	11	18	5	1	2
2006	Lumberyard	1	15	33	38	25	5	2

2006	Passmore	1	13	24	18	13	0	2
2006	Horseshoe	1	25	98	65	35	4	2
2006	Slocan Park	1	15	27	20	7	1	2
2006	Cookie Jar	1	9	56	51	16	0	2
2006	Kosiancics	1	1	2	4	0	0	2
2006	Cresent Valley	1	5	29	32	8	0	2
2007	Lemon	1	34	185	134	48	3	2
2007	Goat	1	13	67	103	51	6	2
2007	Winlaw	1	54	106	48	11	1	6
2007	Winlaw	1	20	48	46	11	1	2
2007	Cougar	1	6	19	21	11	0	2
2007	Ehlers	1	2	16	16	4	0	2
2008	Lemon	1	104	92	91	11	0	2
2008	Goat	1	45	82	78	36	1	2
2008	Winlaw	1	58	61	26	21	0	5
2008	Winlaw	2	36	47	30	14	0	5
2008	Winlaw	1	11	18	20	12	0	2
2008	Cougar	1	56	44	38	13	0	5
2008	Cougar	2	48	38	35	10	1	5
2008	Cougar	1	17	14	23	9	0	2
2008	Ehlers	1	11	21	19	7	0	2
2008	Lumberyard	1	18	45	42	12	0	2
2008	Passmore	1	28	37	39	5	0	2
2009	Lemon	1	92	196	88	24	1	5
2009	Lemon	2	79	204	94	23	0	5
2009	Goat	1	64	137	98	25	0	2
2009	Winlaw	1	61	85	37	9	0	5
2009	Winlaw	2	61	97	50	2	0	5
2009	Cougar	1	63	61	41	9	2	5
2009	Cougar	2	51	45	45	12	0	5
2009	Ehlers	1	17	38	32	4	0	2
2009	Lumberyard	1	37	78	58	19	0	2
2009	Passmore	1	61	102	69	17	2	5
2009	Passmore	2	53	91	66	23	2	5
2009	Slocan Park	1	5	6	14	8	0	5
2009	Cresent Valley	1	63	122	54	8	1	5
2009	Cresent Valley	2	75	124	54	10	1	5
2010	Winlaw	1	26	44	38	8	0	2
2010	Cougar	1	23	42	38	13	0	2
2010	Ehlers	1	11	31	29	7	0	2
2010	Lumberyard	1	20	39	49	10	0	2
2010	Little Slocan 1	1	47	86	28	8	1	2

2010	Lemon	1	33	68	89	17	2	2
2010	Goat	1	13	31	47	13	6	2
2010	Crescent Valley	1	24	35	31	5	1	2
2010	Passmore	1	4	25	56	17	2	2
2010	Horseshoe	1	43	75	72	15	5	2
2010	Slocan Park	1	6	38	31	8	0	2

Standardized (target and catchable)

target	catchable	Year	Reach
		Year	Reach
32	6	1996	Winlaw
32	5	1996	Winlaw
50	14	1996	Passmore
46	8	1996	Passmore
41	15	1996	Cresent Valley
43	8	1996	Slocan Park
270	125	1998	Lemon
251	90	1998	Lemon
86	23	1998	Winlaw
80	22	1998	Winlaw
121	45	1998	Passmore
119	61	1998	Passmore
68	24	1998	Slocan Park
63	28	1998	Slocan Park
130	42	1998	Cresent Valley
105	39	1998	Cresent Valley
236	109	2000	Lemon
259	126	2000	Lemon
79	20	2000	Winlaw
47	11	2000	Winlaw
48	21	2000	Passmore
57	30	2000	Passmore
23	6	2000	Slocan Park
24	6	2000	Slocan Park
42	17	2000	Cresent Valley
39	14	2000	Cresent Valley
242	92	2005	Lemon
273	105	2005	Lemon
259	121	2005	Lemon
281	132	2005	Lemon
94	41	2005	Winlaw
108	44	2005	Winlaw
81	40	2005	Passmore

75	33	2005	Passmore
62	25	2005	Slocan Park
32	24	2005	Slocan Park
27	10	2005	Cresent Valley
32	13	2005	Cresent Valley
577	303	2006	Lemon
222	138	2006	Goat
113	61	2006	Winlaw
44	30	2006	Cougar
46	30	2006	Ehlers
131	84	2006	Lumberyard
73	39	2006	Passmore
268	131	2006	Horseshoe
73	35	2006	Slocan Park
164	86	2006	Cookie Jar
8	5	2006	Kosiancics
92	51	2006	Cresent Valley
494	235	2007	Lemon
295	201	2007	Goat
166	60	2007	Winlaw
141	74	2007	Winlaw
67	41	2007	Cougar
48	26	2007	Ehlers
260	132	2008	Lemon
260	146	2008	Goat
108	47	2008	Winlaw
91	44	2008	Winlaw
66	40	2008	Winlaw
95	51	2008	Cougar
84	46	2008	Cougar
60	41	2008	Cougar
63	33	2008	Ehlers
132	69	2008	Lumberyard
109	57	2008	Passmore
309	113	2009	Lemon
321	117	2009	Lemon
349	157	2009	Goat
131	46	2009	Winlaw
149	52	2009	Winlaw
113	52	2009	Cougar
102	57	2009	Cougar
100	46	2009	Ehlers
207	98	2009	Lumberyard
190	88	2009	Passmore
182	91	2009	Passmore

28	22	2009	Slocan Park
185	63	2009	Cresent Valley
189	65	2009	Cresent Valley
121	59	2010	Winlaw
124	65	2010	Cougar
90	46	2010	Ehlers
130	76	2010	Lumberyard
123	37	2010	Little Slocan 1
233	138	2010	Lemon
126	83	2010	Goat
96	47	2010	Crescent Valley
130	95	2010	Passmore
222	117	2010	Horseshoe
103	50	2010	Slocan Park

Appendix C. Discharge Data

Discharge Table		Q=discharge				
		V=velocity				
		h= velocity head				
1	h	V	start depth	finish depth	width	Q
2	0.5	31.32	0	5	100	7829.03
3	1	44.29	5	11	100	35430.16
4	2	62.63	11	16	100	84553.55
5	2	62.63	16	24	100	125264.52
6	3	76.71	24	29	100	203277.63
7	3	76.71	29	30	100	226290.19
8	3	76.71	30	35	100	249302.75
9	4	88.58	35	42	100	341015.26
10	3	76.71	42	42	100	322175.87
11	3	76.71	42	25	100	256973.61
12	1	44.29	25	10	100	77503.47
13	0.5	31.32	10	2	100	18789.68
14	0.1	14.00	2	0	30	420.15
15						
16						
17						
18						
					cm3/s	113774.18
	August 30th, 2010				m3/3	0.11
	Drakes	0.11				
	Slocan	38.20				
	%	0.30				

Discharge Table		Q=discharge				
		V=velocity				
		h= velocity head				
	h	V	start depth	finish depth	width	Q
1	1	44.28769581	0	7	100	15500.69353
2	2	62.63226006	7	12	100	59500.64706
3	2	62.63226006	12	18	100	93948.39009
4	2	62.63226006	18	24	100	131527.7461
5	3	76.70853929	24	26	100	191771.3482
6	2	62.63226006	26	23	100	153449.0371
7	3	76.70853929	23	24	100	180265.0673
8	3	76.70853929	24	28	100	199442.2022
9	4	88.57539162	28	37	100	287870.0228
10	3	76.70853929	37	43	100	306834.1572
11	4	88.57539162	43	41	100	372016.6448
12	3	76.70853929	41	28	100	264644.4606
13	1	44.28769581	28	0	50	31001.38707
14		#VALUE!			100	#VALUE!
15		#VALUE!			100	#VALUE!
					cm3/s	175982.4465
	October 12th, 2010				m3/3	0.175982446
	Drakes	0.18				
	Slocan	49.40				
	%	0.36				

Discharge Table		Q=discharge				
		V=velocity				
		h= velocity head				
1	h	V	start depth	finish depth	width	Q
2	1	44.28769581	0	20	100	44287.69581
3	3	76.70853929	20	38	100	222454.7639
4	3	76.70853929	38	46	100	322175.865
5	4	88.57539162	46	54	100	442876.9581
6	4	88.57539162	54	59	100	500450.9626
7	4	88.57539162	59	61	100	531452.3497
8	4	88.57539162	61	57	100	522594.8105
9	4	88.57539162	57	66	100	544738.6584
10	6	108.4822566	66	63	100	699710.5552
11	8	125.2645201	63	76	100	870588.4148
12	6	108.4822566	76	82	100	857009.8272
13	8	125.2645201	82	91	100	1083538.099
14	7	117.1742292	91	102	100	1130731.312

15	6	108.4822566	102	113	100	1166184.259
16	6	108.4822566	113	121	100	1269242.402
17	6	108.4822566	121	131	100	1366876.433
18	6	108.4822566	131	117	100	1345179.982
19	5	99.03029839	117	71	100	930884.8049
20	5	99.03029839	71	43	100	564472.7008
21	3	76.70853929	43	21	100	245467.3257
22	0.5	31.31613003	21	0	100	32881.93653
					cm3/s	699704.7675
	02-Sep-10				m3/3	0.699704767
	Gerry	0.70				
	Slocan	38.20				
	%	1.83				

Discharge Table		Q=discharge				
		V=velocity				
		h= velocity head				
	h	V	start depth	finish depth	width	Q
1	1	44.28769581	0	10	100	22143.8479
2	1	44.28769581	10	23	100	73074.69808
3	2	62.63226006	23	39	100	194160.0062
4	2	62.63226006	39	41	100	250529.0402
5	3	76.70853929	41	49	100	345188.4268
6	3	76.70853929	49	58	100	410390.6852
7	2	62.63226006	58	51	100	341345.8173
8	2	62.63226006	51	36	100	272450.3313
9	1	44.28769581	36	30	100	146149.3962
10	1	44.28769581	30	33	100	139506.2418
11	1	44.28769581	33	33	100	146149.3962
12	1	44.28769581	33	32	100	143935.0114
13	1	44.28769581	32	29	100	135077.4722
14	1	44.28769581	29	22	100	112933.6243
15	1	44.28769581	22	16	100	84146.62204
16	1	44.28769581	16	9	100	55359.61976
17	1	44.28769581	9	4	100	28787.00228
18	0.5	31.31613003	4	4	100	12526.45201
19	0.5	31.31613003	4	3	100	10960.64551
20	0.5	31.31613003	3	3	100	9394.839009
21	0.5	31.31613003	3	3	100	9394.839009
22	0.5	31.31613003	3	3	100	9394.839009
23	0.5	31.31613003	3	3	100	9394.839009
24	0.5	31.31613003	3	4	100	10960.64551

25	0.5	31.31613003	4	4	100	12526.45201
26	0.5	31.31613003	4	3	100	10960.64551
27	0.5	31.31613003	3	5	100	12526.45201
28	0.5	31.31613003	5	5	100	15658.06501
29	0.5	31.31613003	5	5	100	15658.06501
30	0.1	14.00499911	5	3	100	5601.999643
31	0.1	14.00499911	3	3	100	4201.499732
32	0.1	14.00499911	3	2	100	3501.249777
33	0.1	14.00499911	2	2	100	2800.999821
34	0.1	14.00499911	2	2	100	2800.999821
35	0.1	14.00499911	2	2	100	2800.999821
36	0.1	14.00499911	2	0	100	1400.499911
					cm3/s	85105.34073
	October 5th, 2010				m3/3	0.085105341
	TNT	0.09				
	Slocan	49.10				
	%	0.17				