Alouette Project Water Use Plan

Substrate Quality

Implementation Year 6

Reference: ALUMON-3

Study Period: 2013

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South Alouette River Substrate Monitoring
2013 Data Report

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Executive Summary

The purpose of this project was to document the substrate condition at 23 sample sites on the South Alouette River by way of Wolman pebble count, in order to identify trends that would help to determine the need for a directed flushing flow. This project is a component of the 2005 Alouette Water Use Plan initiated by BC Hydro and approved by the Comptroller of Water Rights in April 2009 to confirm operational requirements for the Alouette hydroelectric system. Water Use Plan implementation oversight is provided by the Alouette Management Committee, which consists of representatives from the public, Department of Fisheries and Oceans, Ministry of Environment, B.C. Hydro, Katzie First Nation, and the District of Maple Ridge.

The 2013 sampling showed an overall decrease in fine particles less than 2mm diameter of 3.0% since 2012. Regression analyses showed that the levels of fines in the river declined sharply during the 1995 high water event, and then have remained relatively stable since that time.

The 2013 sampling showed that the amount of gravel sized 16-128mm diameter increased overall (38-42%), with the largest increases (37-51%) occurring in the lower sections. Upper sites decreased from 45-44%, while middle sections remained unchanged at 31%. Overall, riffle sites recorded an increase in 6 of 10 sites, while run sites experienced an increase in 6 of 11 sites.
Regressions of Wolman data show an increase in the percentage of gravels for all sites and sections following the 2000 Bridge Coastal Restoration Program gravel placement project at Mud Creek and Alouette Dam.

Analyses of streamflow for the period 1995 to 2013 show that the largest effects on substrate composition were produced by the high flow events of November / December 1995 and October 2003. Although it is likely that the event of March 2007 produced similar results, the lack of sampling data for 2006 and 2007 means that these impacts were not documented.

Although the substrate condition is an important indicator of overall habitat performance, there is no conclusive correlation in the data between substrate condition and chum fry abundance.

Acknowlegements

The author gratefully thanks Darin Nishi of B.C. Hydro and Scott Cope of Westslope Fisheries for providing data that was incorporated into this report.

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1.0 Introduction

The purpose of this project was to document the substrate condition at 23 sample sites on the South Alouette River in 2013, in order to identify trends that would help to determine the need for a directed flushing flow. This project is a component of the 2005 Alouette Water Use Plan initiated by BC Hydro and approved by the Comptroller of Water Rights in April 2009 to confirm operational requirements for the Alouette hydroelectric system. Water Use Plan implementation oversight is provided by the Alouette Management Committee, which consists of representatives from the public, Department of Fisheries and Oceans, Ministry of Environment, B.C. Hydro, Katzie First Nation, the District of Maple Ridge, and the Alouette River Management Society.

1.1 Objectives

The primary goals of the project were:

- To determine substrate composition at 23 sites by way of the Wolman pebble count method.
- To examine trends both short term (2012-2013) as well as long term (1995-2013).
- To examine the relationships, if any, between substrate composition and streamflow as well as fry abundance as a reflection of egg-to-fry survival.
- To address the following Management Questions as identified in the Terms of Reference:

(1) Do the results of the Toe-Pebble count procedure reflect the general composition of bed materials within the channel downstream of Alouette Dam?
(2) Is the <20% fines threshold adequate to distinguish a state in substrate quality that would require a prescribed flushing event?
(3) Is an alternative methodology required to qualify / calibrate the results of the Toe-Pebble count procedure?
(4) For each year of the monitor, is a prescribed flushing flow necessary given the current state of substrate quality?

1.2 Study Area / background

The South Alouette River originates at the southwest end of Alouette Lake, at Alouette Dam. From there, the river flows roughly 25 kilometers westward to reach its confluence with the Pitt River (Figure 1.)

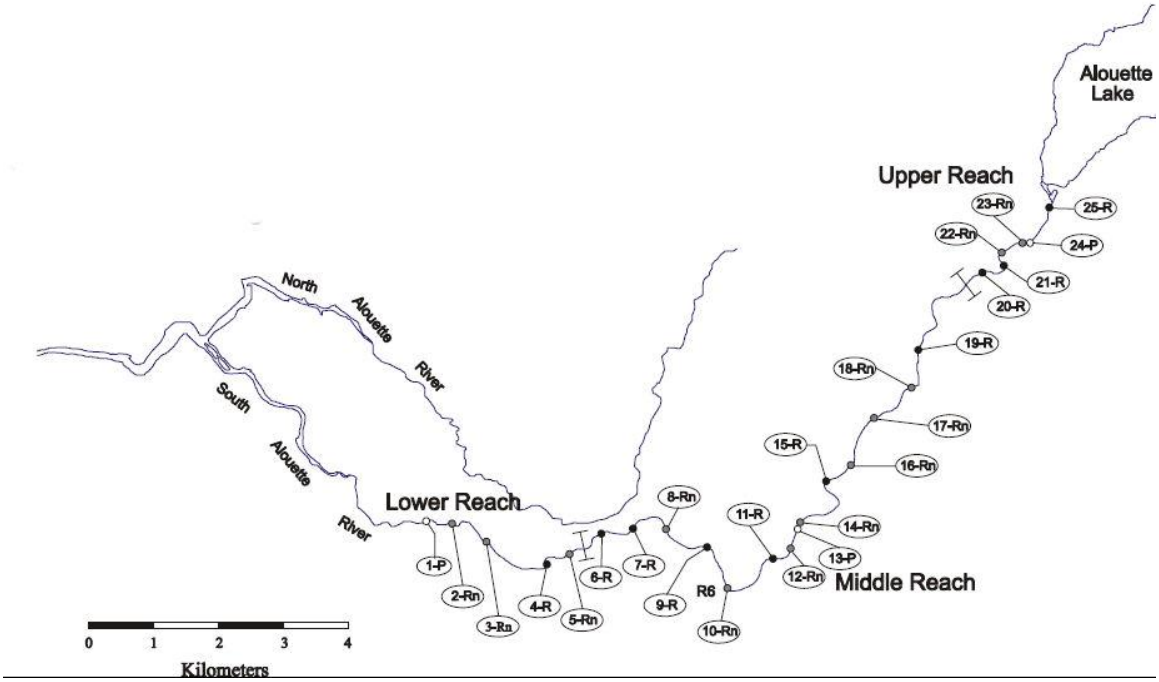


Figure 1. Study area on South Alouette.

Three distinct reaches within 25 sample sites were identified in 1995 for the purpose of the ongoing Wolman pebble count studies. Sites 1-5 are contained within the lower section, 6-19 are in the middle section, and 20-25 are in the upper section. Two of the sites, Site 13 and 14, were abandoned after 1995 due to chronic private property access issues. The presence of Alouette Dam provides the river with a much more stable flow regime than a typical coastal B.C. stream, with tributary effects increasing with distance downstream from the dam. The river is characterized by low gradients throughout its length.

2.0 Methods

Each of the 23 sites were sampled using the Wolman pebble count technique as described by Kondolf (1997). At each site, the sampler walked heel to toe perpendicular to the channel. After each step, the pebble touching a mark on the front of the samplerôs boot was picked up and measured. This procedure was repeated until a minimum of approximately 100 particles were sampled and recorded into Wentworth size classes (Table 1). The determination of which size class to record was determined by whether the

particle would be able to pass through a sieve of the size range diameter. To help reduce observer bias, the same sampler was used for the duration of the project, and the samplerôs eyes were averted while picking up the pebble, in order to eliminate visual selection. If the site was too deep to wade, an underwater viewer was used and the particle sizes were visually estimated.

Table 1: Wentworth particle size classes

Particle size (mm)
<2
2-4
4-8
8-16
16-32
32-64
64-128
128-256
256-512
512-1024
1024-2048
2048-4096

One change implemented in 2008 is that the sampling is now conducted on an annual basis, and at the same time of the year. This will improve the documentation of the effects of flow events on the condition of the substrate, as well as avoiding seasonal variations caused by factors such as the actions of spawning chum salmon.

Informal observations were made at all sites concerning the level of substrate compaction as well as the presence / absence of various indicator aquatic invertebrates.

The percentages of fines <2mm diameter as well as gravels of 16-128mm were analyzed, since it is generally accepted that the conditions of these two substrate categories have the largest effect on salmonids and / or their food items, with <2mm diameter size range impairing fish production and 16-128mm size class providing suitable habitat for spawning (Burner, 1951). Statistical analyses applied to the data in order to better identify trends. Specifically, a square root transformation was used to normalize the data in cases where the proportional values were either 0 or 1. Next, the following arcsine transformation was used:

$$Angle(S) = (360/2\pi) * (\arcsin(\sqrt{S}))$$

Where S = raw proportion data

The data was then back transformed by the formula:

*(sin((2π/360)*Angle(s))^2*

3.0 Results and Discussion

3.1 2012 vs. 2013 trends

The 2013 sampling showed an overall decrease in fine particles less than 2mm diameter of 3.0% (Table 2). Sampling sites in the lower sections experienced a decrease from 43% fines in 2012 to 32% in 2013. Middle sections decreased from 6% to 4% while upper sections decreased from 15% to 14%.

Table 2. Percent fines, 2012 vs. 2013

Sections	% fines 2012	% fines 2013	Change 2012-2013
Lower	43	32	-11
Middle	6	4	-2
Upper	15	14	-1
Overall	18	15	-3

It should be noted that instream changes at a localized level sometimes affect certain sites. For example, at Site 1 a large tree fell into the channel along the right bank in 2009, changing the hydrology and subsequent substrate characteristics of the site, by increasing the velocity on the left bank and causing a temporary reduction in fine sediments on the left bank. However, this effect was minimal in 2012 and 2013 as the tree was gradually de-limbed by the current. A similar situation exists at Site 12 (Figure 2), where a considerable debris jam has accumulated on the left bank, resulting of a re-distribution of particles at that site, with an increase of fine sediments on the left bank and reductions on the right bank. In both cases, these effects were confined to the specific sites.

Another event of note is a significant slide that occurred in January 2013 on a tributary upstream of Mud Creek. This has caused several periods of higher than normal sediment loads in the river since that time. Appendix 5.1 (Page 18) explains observations of this slide and sample sites in its vicinity that were made August 22, 2013.

Figure 2: Site 12; site characteristics changed in 2009 based on debris accumulation

There was an increase in the amount of gravel sized 16-128mm diameter overall (38-42%). Riffle sites recorded an increase in 6 of 10 sites, while run sites experienced an increase at 6 of 11 sites. The 4 decreases in gravel for riffle sites were at Sites 11, 15, 19 and 20, while all decreases in gravels in run sites occurred in middle and upper section sites.

Table 3. Percent gravels 16-128mm diameter, 2012 vs. 2013

Sections	% gravels 2012	% gravels 2013	Change 2012-2013
Lower	37	51	+14
Middle	31	31	0
Upper	45	44	-1
Overall	38	42	+4

Figure 3: Chum salmon between Sites 20 and 21, October 2010.

The 2013 sampling run was the third consecutive year that the sampling was not preceded by at least one controlled flow release from Alouette Dam.

In summary, the 2013 sampling showed a decrease in percent fines since 2012, after two straight annual increases. This means that the percent fines has not exceeded the 20% threshold since the 31% that was recorded in 1995 prior to the Minimum Flow Agreement. Analyses of the data in light of river flow conditions and events during the sampling runs is in support of Management Question 1.

3.2 1995 to 2013 trends

Regression analyses for all habitat types and sections for the period 1995 to 2013 show that the substantial high water event of November 1995 (96.6-121.0 cms for a period of approximately 48 hours) resulted in a 31%-16% decrease of fine particles from most sites, with some deposition occurring in the lower river at certain low velocity sites. The overall percentage of fine sediments has remained relatively stable since that time. One fluctuation of note occurred between 2003 and 2004, when the overall percentages of fines dropped from 20% to 10%. This is likely due to the significant high water event of October 2003 (31.0-33.0 cms for a period of approximately 48 hours) and particularly the 6-day period in January 2004 that saw Alouette Dam discharges of 21.5-32.7 cms.

Analyses of gravels sized 16-128mm show some interesting trends. In 2000, 460 tons of spawning gravel was placed at two locations in the upper Alouette River; at Mud Creek, and downstream of the free spill crest as part of a Bridge Coastal Restoration Program initiative. Regressions of Wolman data show an increase in the percentage of gravels for all sites and sections following the 2000 project. A portion of this gravel was marked with environmentally friendly orange paint at the time of this placement. Marked pebbles of 32-64mm diameter have subsequently been found as far as 10km downstream on several different occasions.

Figures 4 to 11 show regression analyses of percentages of fine sediments as well as gravels along with lower and upper confidence intervals.

One site that is of particular interest is Site 20, due to its close downstream proximity to the Mud Creek settling pond. This site has been problematic from time to time during the duration of the years of Wolman sampling. However, neither the levels of fine particles or the levels of substrate compaction have ever been observed to be in excess of what constitutes good salmonid spawning and rearing habitat. This has been true for Site 20 as well as the two next closest sample sites downstream. It is likely that the clay based nature of the runoff from Mud Creek means that the particles remain in suspension for an extremely long period, possibly long enough to completely exit the Alouette system. In 2009, the primary source of fine sediments was originating at a debris slide located upstream of Mud Creek, 5.1 kilometers by road from the Alouette Dam road access gate (Figure 3). In 2010, at least two significant sediment releases originated from Mud Creek following the 2010 sampling run, and there was also a short term sediment event associated with sanitary sewer construction.

In summary, the sampling exercises that have taken place since the 1996 Minimum Flow Agreement have shown that the levels of fine sediments do tend to fluctuate across the sites and / or river sections from year to year, but there has not been any evidence of steadily increasing sedimentation or substrate compaction. The standardized seasonal sampling that is part of this Monitor should help to verify this trend over time, by minimizing seasonal confounding factors such as the activities of chum salmon.

Observations described in this report indicated that a directed flush flow could benefit middle and upriver sites such as Sites 17 and 23 by removing accumulated fines from certain sections of the side habitat. These sites, due to their relatively upriver locations, did not benefit from high flow tributary origin events between the 2010 and 2013 sampling runs. It is also is theoretically possible to restore pool habitat downstream of Site 21 via a directed flushing flow. However, none of these localized affects appear to be having a negative effect on area salmonids and / or their food sources, when one considers the river channel as a whole. In addition, negative sedimentation impacts such as spawning prevented by compaction were not encountered at any site. Other assessments that were made during the study, such as examining the abundance and variety of macro invertebrates, as well as examinations of several sites following the approximately 48-hour controlled flow release of 40-42 cubic meters per second in November 2009, strongly suggest that sedimentation is not a limiting factor on salmonid habitat at this time (Figure 16). All observations made during the duration of the Alouette studies have supported Terms of Reference Management Question #2, which asks if the < 20% fines threshold is adequate to distinguish a state in substrate quality that would require a prescribed flushing event. In addition, background research supports this as well. For example, Kondolf (2000) compared 4 studies that determined that a fry emergence of 50% would be achieved by a percentage of particles less than 2mm diameter of 14% or lower, while Cover and Resh (2006) determined that fines in excess of 10-30% inversely affected fry emergence.

Figure 4: Percent fines, all sites, all years

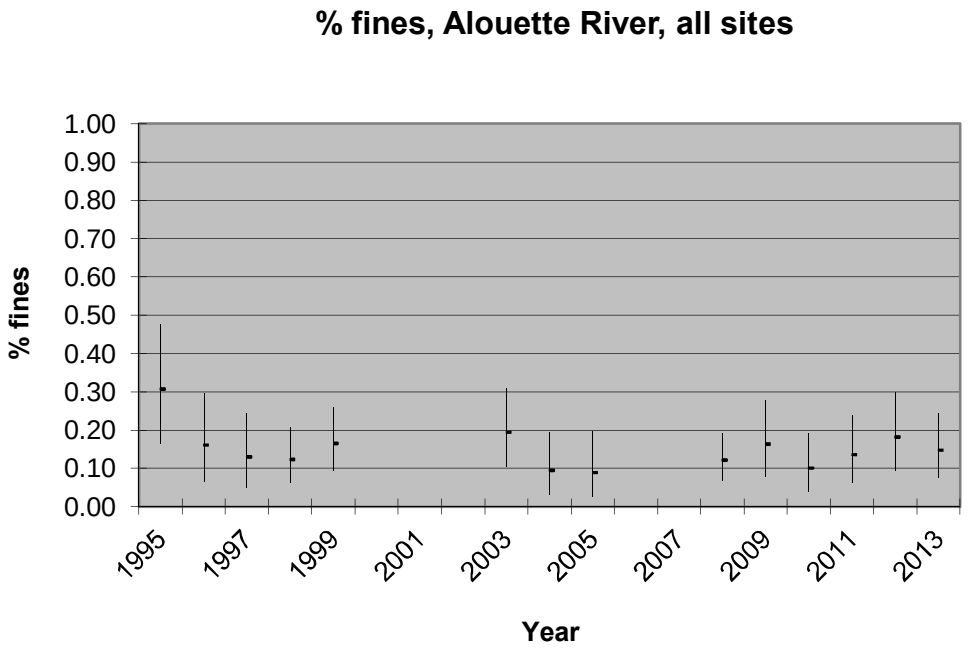


Figure 5: Percent fines, lower sites, all years

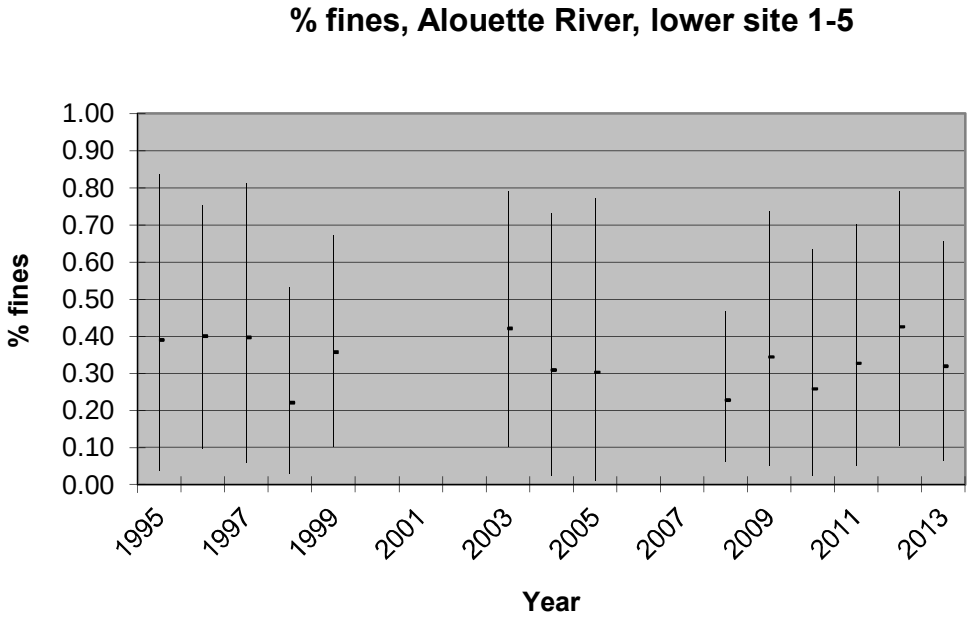


Figure 6: Percent fines, middle sites, all years

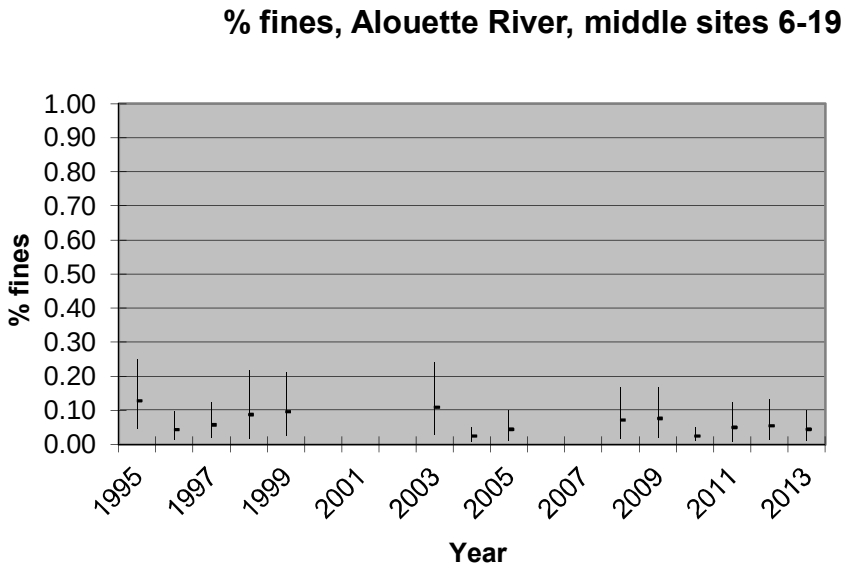


Figure 7: Percent fines, upper sites, all years

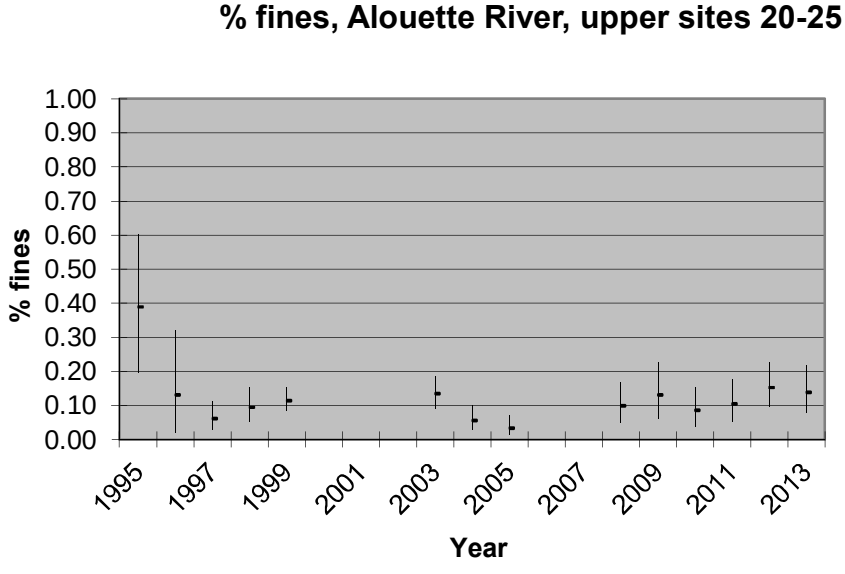


Figure 8: Percent gravels, all sites, all years

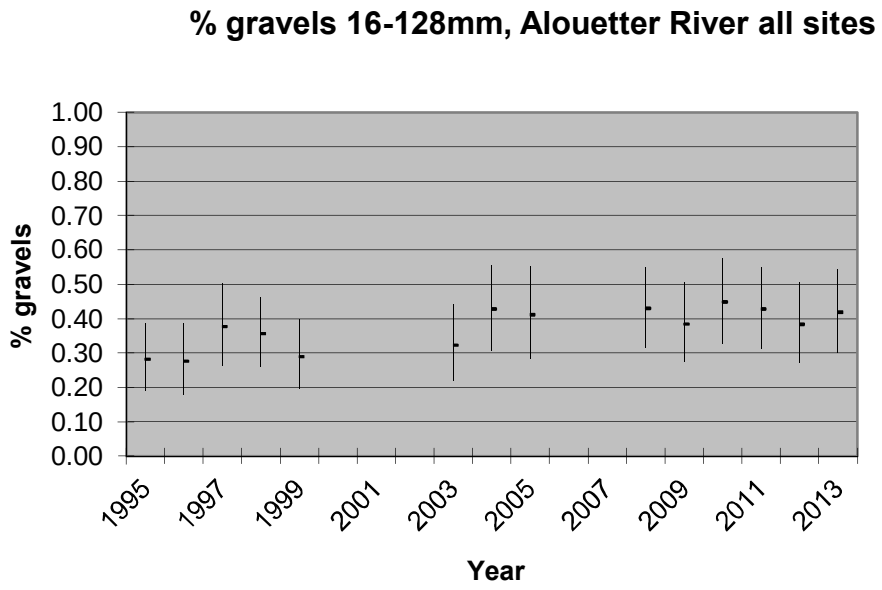


Figure 9: Percent gravels, lower sites, all years

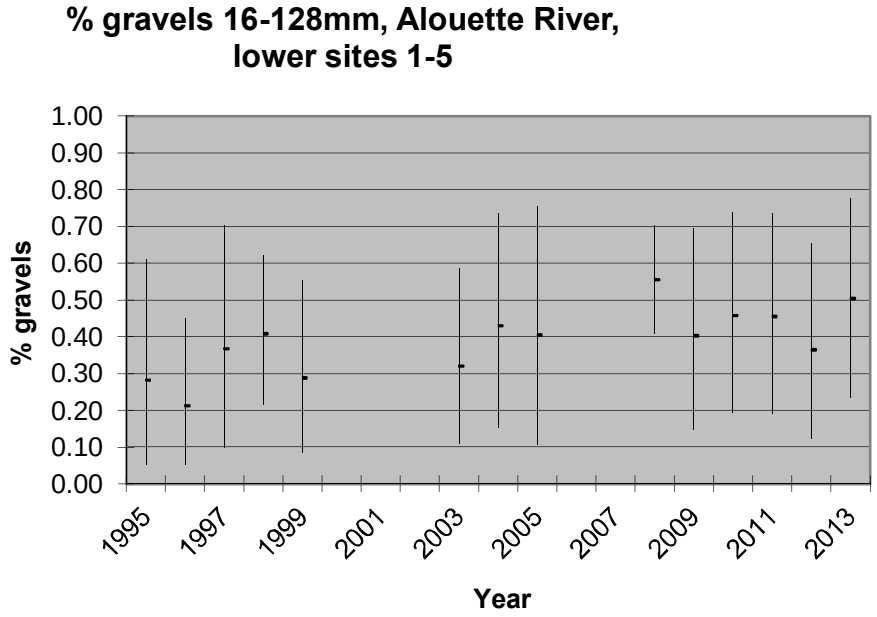


Figure 10: Percent gravels, middle sites, all years

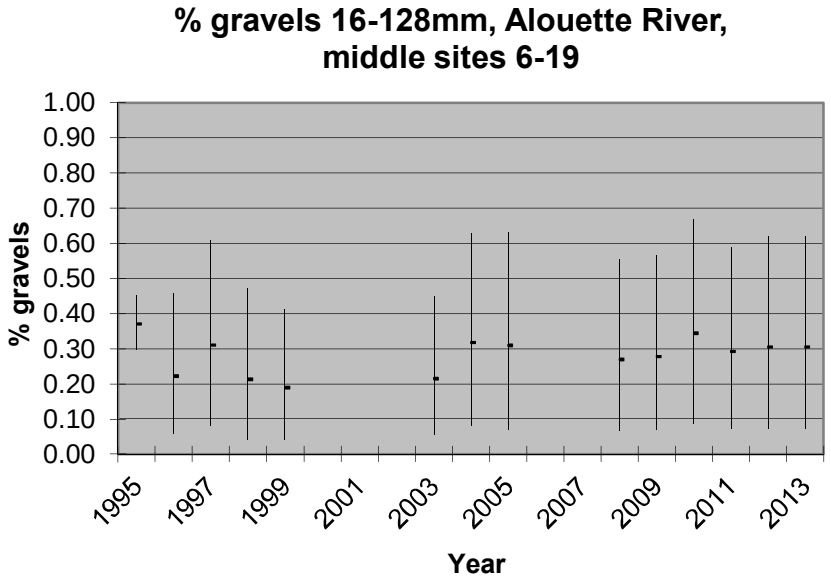
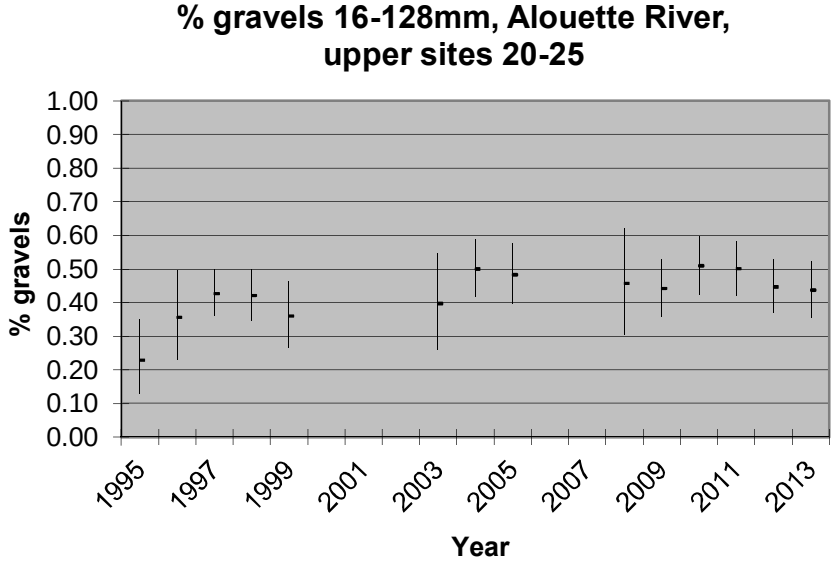


Figure 11: Percent gravels, upper sites, all years



3.3 Substrate condition versus chum fry abundance

Data from Alouette River fry enumeration activities (Cope 2013) was plotted against the percentages of fines as well as gravel in order to determine if a correlation exists between the data sets. The fry data were used for this exercise since the trapping locations are located downstream of the majority of the chum spawning areas, while the adult fence counts at Allco Hatchery are upstream of much of the spawning areas.

Figures 12 and 13 show the comparisons between percent fines and gravels versus chum fry abundance respectively. There was generally a steady increase in chum populations during the Wolman studies of 1995-2009, and then a drop during 2010-2012. It is not possible to solely attribute these changes to substrate conditions. While high quality substrate is a critical component of productive salmonid habitat, there is a complex relationship with other factors including flow regimes and the increase of available habitat produced by the Minimum Flow Agreement. The substrate condition could therefore be looked at as a benefactor and important indicator of overall habitat performance.

Figure 12: Percent fines vs chum fry migration

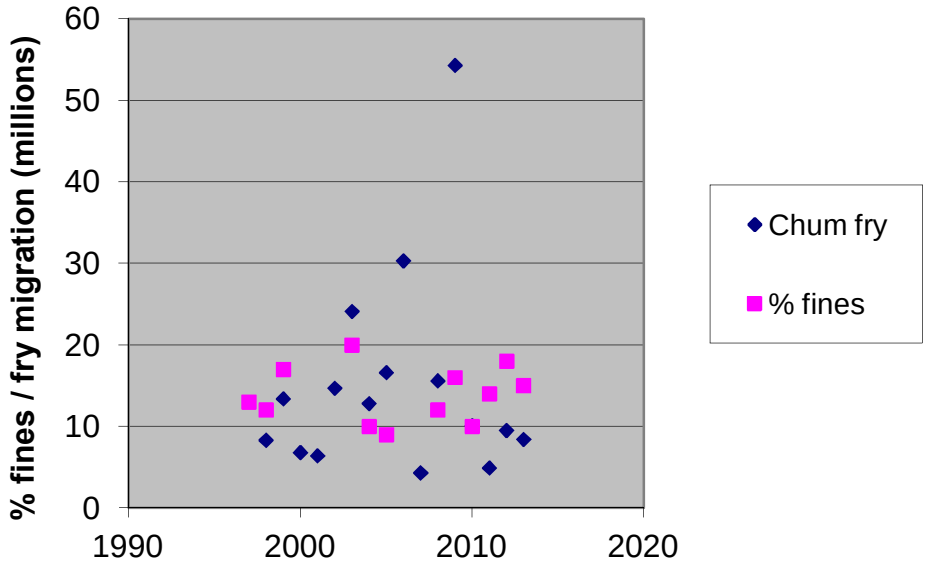
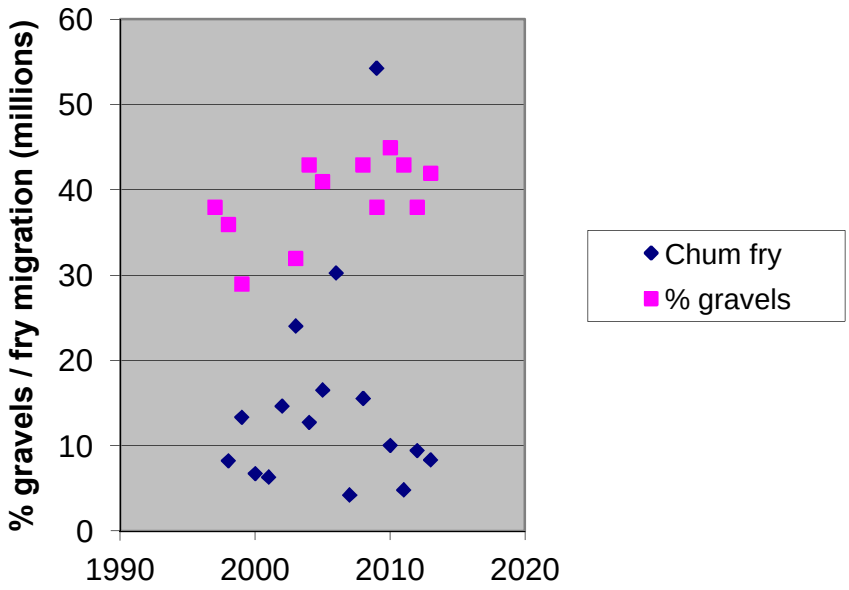


Figure 13: Percent gravels vs chum fry migration



3.4 Substrate condition versus flow

Alouette River discharge data was plotted against the percentages of fines as well as gravel in order to determine if a correlation exists between the data sets. Figures 14 and 15 show that the largest changes of percent fines and gravels during the period of 1995 ï 2013 occurred following the peak flow events of 54.5 cms in 1995 and 31.2 cms in 2003. Another large event occurred in March of 2007, when flows exceeded 45cms for several days. Although this likely caused significant changes to the substrate composition, these changes were not documented due to the fact that Wolman sampling was not carried out in 2006 or 2007 due to an absence of directed funds for this purpose. The 48 hour, 40-42cms event of November 2009 is thought to have contributed to the 6% drop in fine sediments between 2009 and 2010. Although the fine sediment proportion approached the 20% threshold in 2012, the 2013 sampling showed a decrease despite the absence of controlled flow releases from Alouette Dam between the 2010 and 2013 sampling runs.

Figure 14: Percent fines vs ALU flow

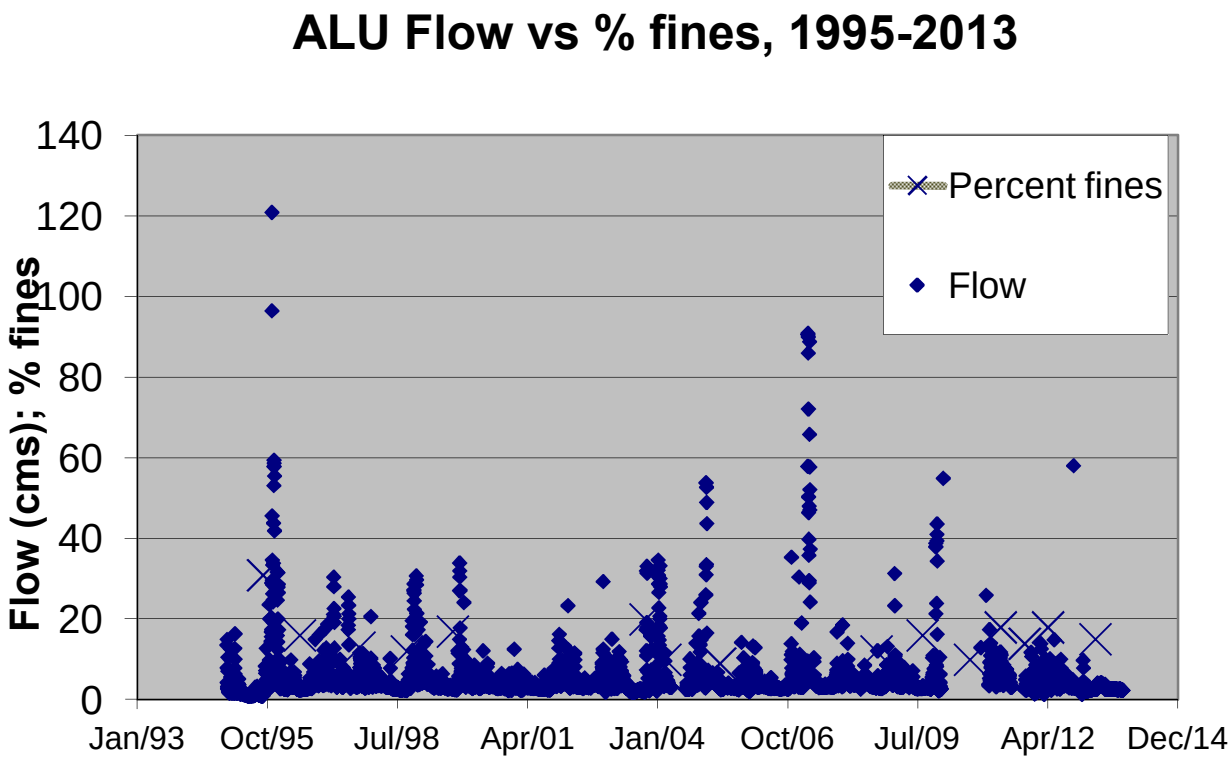


Figure 15: Percent gravels vs ALU flow

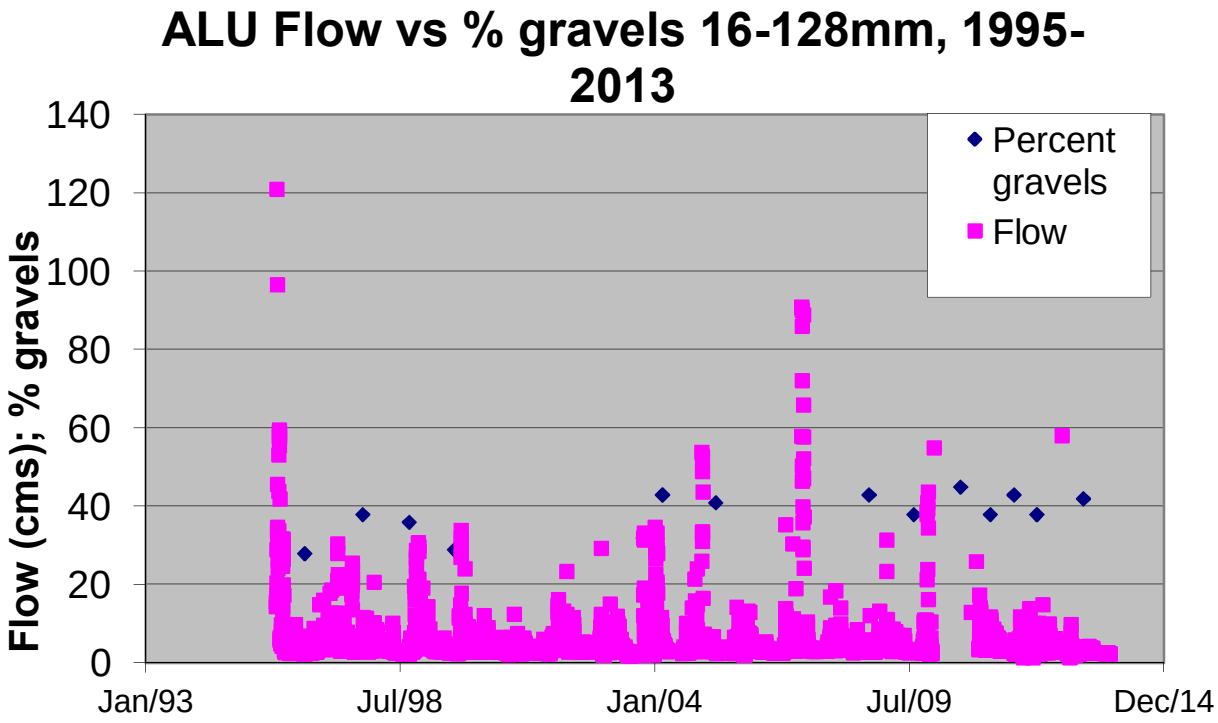


Figure 16. Upper river, upstream of Site 25 near Alouette Dam, September 2011.

3.5 Results related to Management Questions

One of the purposes of this monitor is to attempt to address the following Management Questions as identified in the Terms of Reference:

(1) Do the results of the Toe-Pebble count procedure reflect the general composition of bed materials within the channel downstream of Alouette Dam?

The completion of the 2013 sampling concluded the 14th year of pebble count sampling on the Alouette. The sampling results during this time have been consistent with other observations of substrate condition.

(2) Is the <20% fines threshold adequate to distinguish a state in substrate quality that would require a prescribed flushing event?

The 20% level is still uncertain on Alouette, since this level has only been recorded once (31% in 1995). It should be noted that this preceded the Minimum Flow Agreement.

(3) Is an alternative methodology required to qualify / calibrate the results of the Toe-Pebble count procedure?

The toe-pebble procedure has been proven over time to be the most suitable method for assessing the substrate condition on this system. During the 2009 sampling run, a triangulation method was attempted in order to provide a comparison to the toe-pebble method, but the sheer size and velocity of the sample sites on the Alouette rendered the triangulation method impossible.

(4) For each year of the monitor, is a prescribed flushing flow necessary given the current state of substrate quality?

The 2013 data suggests that that a directed flushing flow could benefit certain sections of the river, but only on a very localized basis.

4.0 Conclusions

Information contained within this report suggests that:

- The levels of fine particles in the Alouette substrate have remained relatively stable since the significant drop that occurred with the 1995 flood.

- The 2013 sampling run recorded an 18-15% decrease in fine sediments, despite the absence of controlled flow releases during the past 3 years.
- The Wolman sampling exercises have recorded a percentage increase of gravels sized 16-128mm following the gravel placement conducted via a Bridge Coastal Restoration Project in 2000.
- Regression analyses for the period 1995 to 2013 show that the largest effects on substrate composition were produced by the high flow events of November / December 1995 and October 2003 / January 2004. Although it is likely that the event of March 2007 produced similar results, the lack of sampling data for 2006 and 2007 means that these impacts were not documented.
- Although the substrate condition is an important indicator of overall habitat performance, there is no conclusive correlation in the data between substrate condition and chum fry abundance.
- Informal observations made during the fieldwork showed that compaction levels were seldom in excess of levels that would begin to affect salmonid spawning, rearing, or food production.
- The 2013 sampling run followed a prolonged period of relatively quiet flow conditions, and the decrease in fine sediments occurred despite this.

Information contained in this report suggests that a directed flushing flow could benefit certain sections of the river, but only on a very localized basis.

5.0 Appendices

5.1 Appendix 1: Alouette River Observations, August 22, 2013

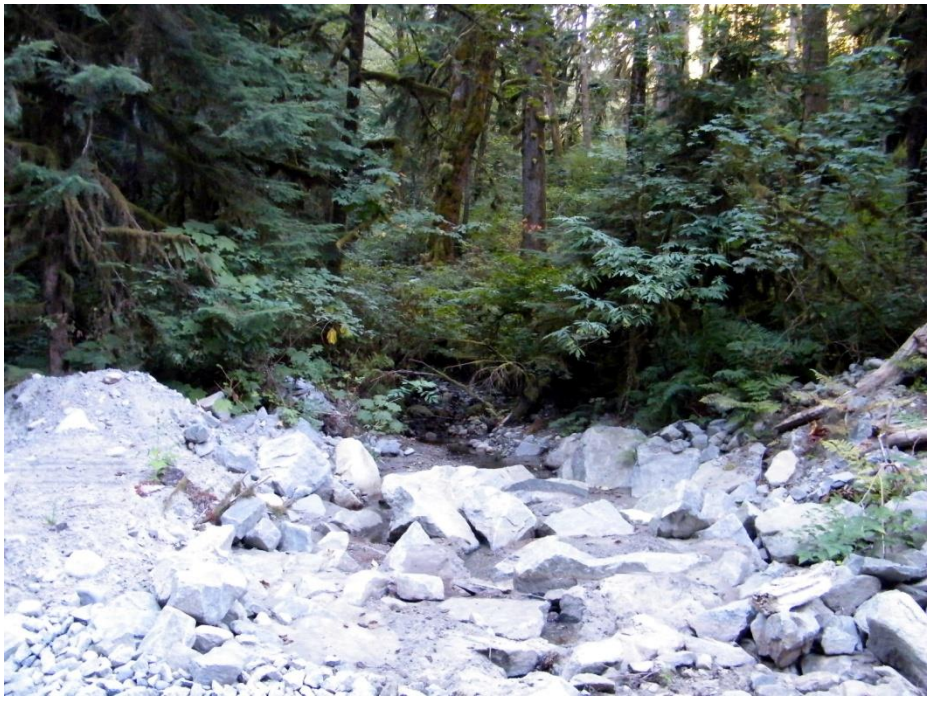
Alouette River observations, August 22, 2013

In January 2013, a significant tributary event took place in the Alouette River, approximately 200 meters upstream of Mud Creek. In light of the substrate monitoring program that I oversee, I visited the site today, and I am passing along todayôs observations as well as sampling data I have obtained to date this year that could reflect

on the effects of this event. Following are photos of the area, and my observations of the situation.

Tributary observations

The tributary crossing of Alouette Dam access road



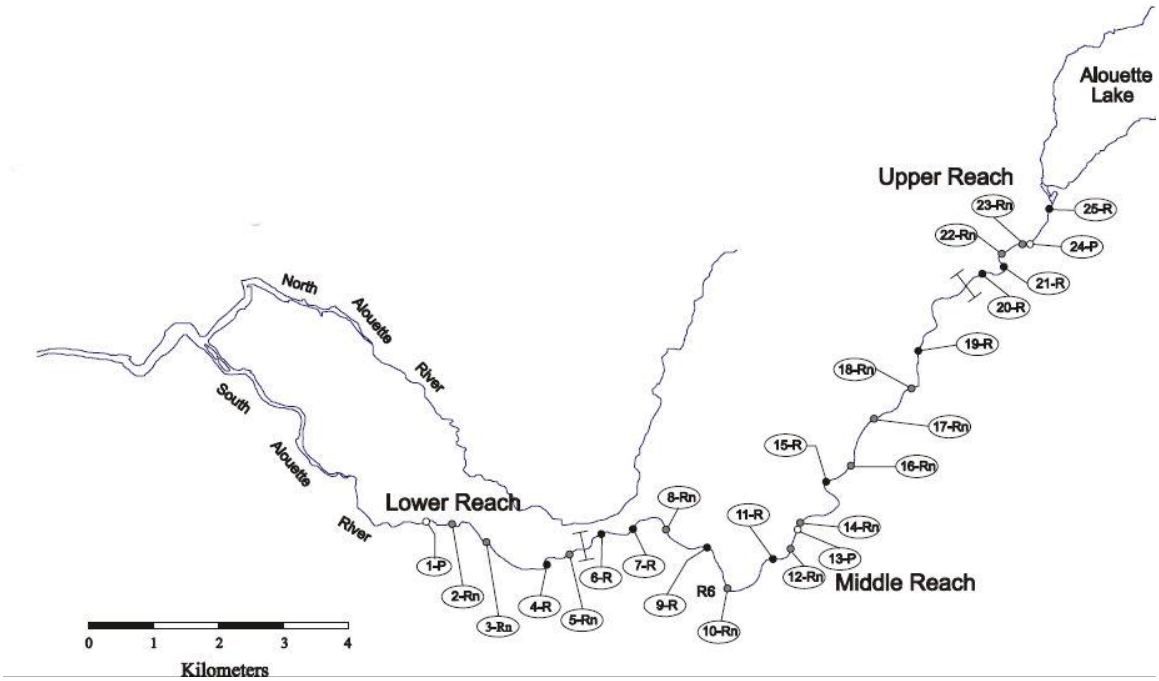
Looking downstream from Alouette Dam access road

This is midway between Alouette Road access road and the tributaryõs Alouette River confluence.

New gravel in the Alouette

Pool on left hand bank at Mud Creek eliminated.

Looking downstream from Mud Creek



Substrate sample site locations

Substrate data

Wolman pebble count data collected to date in 2013 strongly suggests a very localized effect of the January 2013 tributary event. The tributary enters the Alouette River at sampling site number 21 (see map). On August 22, 2013, Sites 21, 20, and 19 were sampled using the Wolman technique, consistent with previous yearôs sampling. Sites 15 and 16, both near Allco Park, were sampled in July 2013. Although data is preliminary, sites sampled during 2013 between Allco Park and 216th Street do not indicate a widespread effect of the January 2013 event. Percent fines are defined as particles that are less than 2mm in diameter. The results for sites closest to the event completed to date compare to 2012 as follows:

Site	% fines, 2012	% fines, 2013	Change, 2012-2013
15	13	5	-8
16	9	7	-2
19	7	10	+3
20	5	22	+17
21	10	4	-6

Anecdotal observations

Two enhancement projects have been impacted by this event. First, a handmade fishway that was constructed on the tributary in 1999 was destroyed in the flood event, but

ironically the event has made the tributary fish passable at least to the Alouette Dam access road. Secondly, a large woody debris project carried out by the Alouette River Management Society and B.C. Corrections has been seriously impacted due to the infilling of the stream channel.
This event is different than recent events originating from tributaries in the area in that this event resulted in a considerable amount of sand and gravel being recruited into the stream, rather than fine clay. The Alouette from Site 21 (where the slide entered the river) downstream to Site 20 has an abundance of new gravel. Site 20 had a 17% increase in fine particles as compared to 2012, primarily due to an accumulation of sand on the left hand bank. The overall effect on the river between Sites 21 and 20 is that the channel bed has been raised. The substrate appeared to be of very good quality between Sites 21 and 20, with the gravel very loose, with little or no compaction. A pleasing abundance of benthics were observed in this area. Elsewhere on the river, observations of juvenile salmonid and benthic abundance to date in 2013 are not consistent with any river event that would be of concern.

August 22 Conclusions:

- Localized effect captured in the Wolman sampling at Site 20
- Observations in the Mud Creek area show a significant localized change in channel morphology
- Wolman sampling indicates no significant effect on the river as a whole

5.0 References

Burner, C.J. 1951. Characteristics of spawning nests of Columbia River salmon. U.S. Fish and Wildlife Service, Fish. Bull. 61.52:97-110

Cover, M. and Resh, V. 2006. Quantitative Linkages Between Sediment Supply, Streambed Fine Sediment, and Benthic Macroinvertebrates in Streams of the Klamath National Forest. Department of Environmental Science, Policy, and Management, Division of Insect Biology, University of California at Berkeley

Kondolf, G.M. 1997. Application of the pebble count: Reflections on purpose, method, and variants. *Journal of the American Water Resources Association*

Kondolf, G.M. 2000. Assessing Salmonid Spawning Gravel Quality. Department of Landscape Architecture and Environmental Planning and Department of

Geography, University of California, Berkeley, California 94720, USA Transactions of the American Fisheries Society 129:262ï 281, 2000

Platts, W.S., Shirazi, M.A. and Lewis, D.H. 1979. Sediment particle sizes used by salmon for spawning with methods for revaluation. U.S. EPA-600/3-79-043. 32 pp.