Alouette Project Water Use Plan

Substrate Quality

Implementation Year 4

Reference: ALUMON-3

Study Period: 2011

Ross Davies
2392 Fern Crescent
Maple Ridge, BC V4R 2S3

May 2012

South Alouette River Substrate Monitoring
2011 Data Report

Prepared by:

Ross Davies
23924 Fern Crescent
Maple Ridge, B.C.
V4R-2S3

Prepared for:

Alouette Management Committee
B.C. Hydro Generation
6911 Southpoint Drive
Burnaby, B.C. V3N-4X8

May 2012

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 2011 sampling showed an overall increase in fine particles less than 2mm diameter of 4.0% since 2010. 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 2011 sampling showed that the amount of gravel sized 16-128mm diameter decreased overall (45-43%), with the largest decreases (34-29%) occurring in the middle sections. Upper sites decreased from 51-50%, while lower sections remained unchanged at 46%. Overall, riffle sites recorded a decrease in 6 of 10 sites, while run sites experienced a decrease 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 2011 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 Ian Dodd of B.C. Hydro, Scott Cope of Westslope Fisheries, and Lynn Campu of Environment Canada for providing data that was incorporated into this report.

Table of Contents

List of Tables

List of Figures

1.0 Introduction

The purpose of this project was to document the substrate condition at 23 sample sites on the South Alouette River in 2011, 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.

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 (2010-2011) as well as long term (1995-2011).
- To examine the relationships, if any, between substrate composition and streamflow as well as fry abundance.

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.)

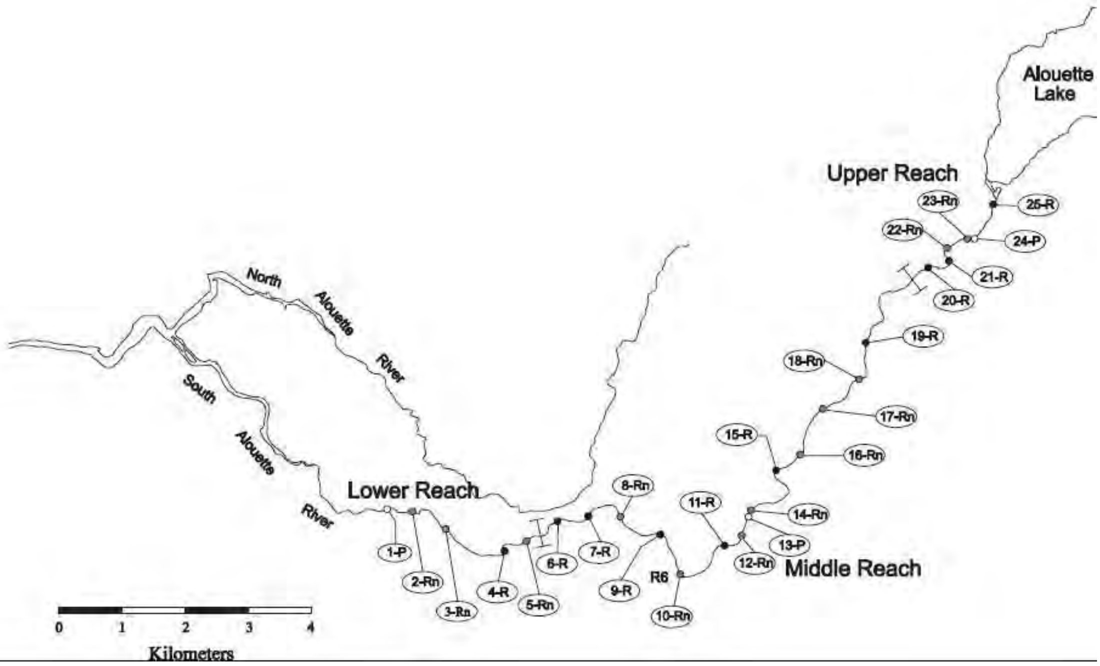


Figure 1. Study area on South Alouette.

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 sampler's 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 sampler's 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. 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:

$(sin((2\pi/360)*Angle(s))\wedge 2$

3.0 Discussion

3.1 2010 vs. 2011 trends

The 2011 sampling showed an overall increase in fine particles less than 2mm diameter of 4.0% (Table 2). Sampling sites in the lower sections experienced an increase from 26% fines in 2010 to 33% in 2011. Middle sections increased from 3% to 5% while upper sections increased from 9% to 11%.

Table 2. Percent fines, 2010 vs. 2011

Sections	% fines 2010	% fines 2011	Change 2010-2011
Lower	26	33	+7
Middle	3	5	+2
Upper	9	11	+2
Overall	10	14	+4

It should be noted that instream changes 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 2011 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 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.

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

There was a slight decrease in the amount of gravel sized 16-128mm diameter overall (45-43%), with the largest decrease occurring in the middle sections (34-29%) (Table 3). Riffle sites recorded a decrease in 6 of 10 sites, while run sites experienced a decrease at 6 of 11 sites. The 4 increases in gravel for riffle sites were divided evenly between the middle and upper sections, while gravels in run sites decreased mainly in the middle sections (Sites 10, 12, 17 and 18).

Table 3. Percent gravels 16-128mm diameter, 2010 vs. 2011

Sections	% gravels 2010	% gravels 2011	Change 2010-2011
Lower	46	46	+0
Middle	34	29	-5
Upper	51	50	-1
Overall	45	43	-2

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

The 2011 sampling run was unprecented since this monitoring began, since it was the first ever sampling run that was not preceded by at least one controlled flow release from Alouette Dam.

In summary, the 2011 sampling showed the second largest annual increase in percent fines since the sampling commenced in 1995 (tied with the 2008 vs. 2009 data).

3.2 1995 to 2011 trends

Regression analyses for all habitat types and sections for the period 1995 to 2011 show that the substantial high water event of November 1995 resulted in a significant 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.

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 12, 17, 18 and 25 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 2011 sampling runs. However, these did not 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 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

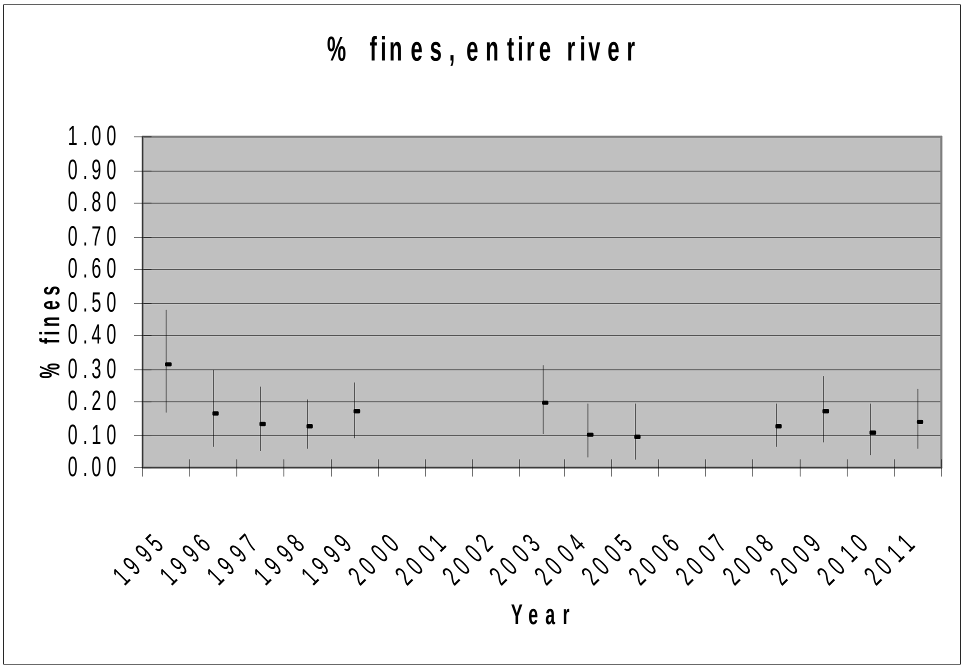


Figure 5: Percent fines, lower sites, all years

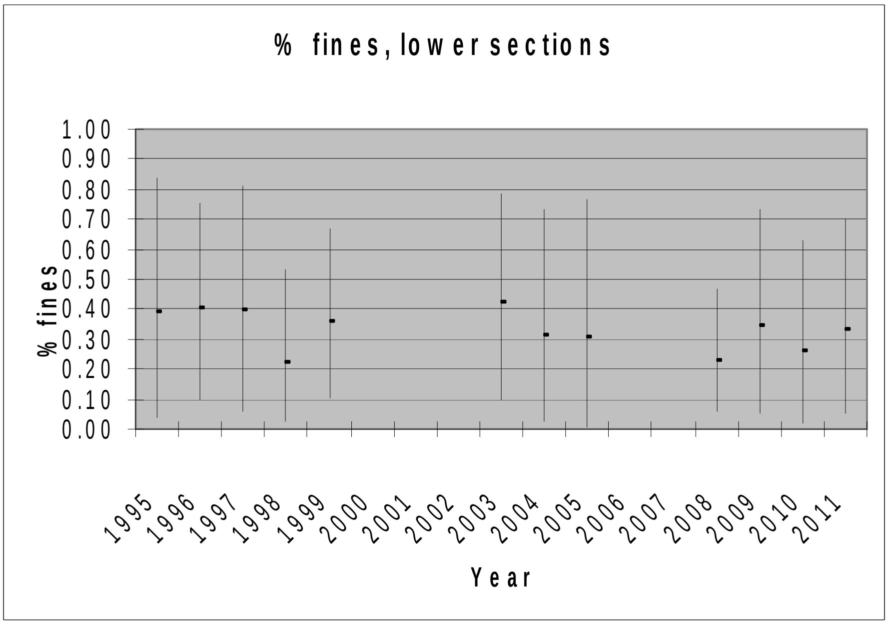


Figure 6: Percent fines, middle sites, all years

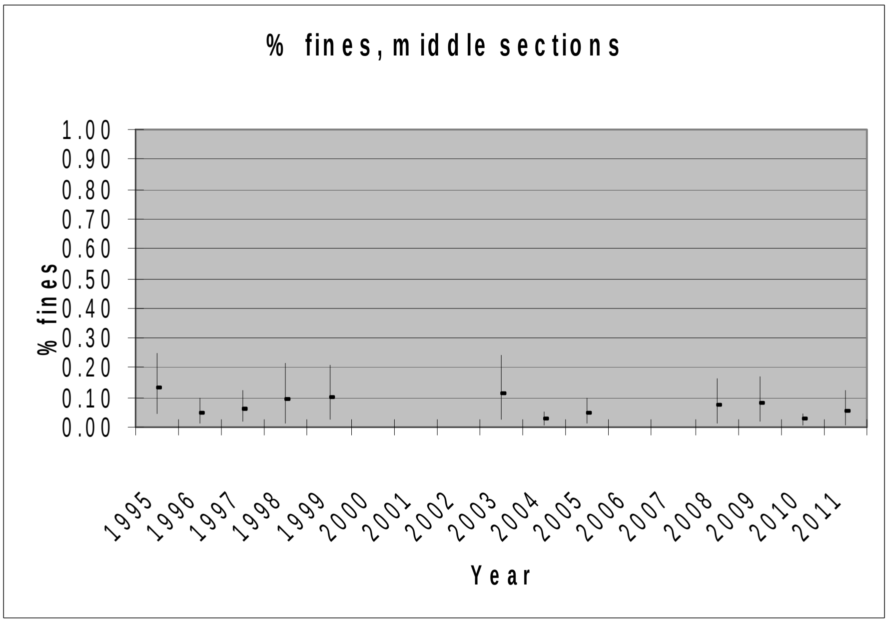


Figure 7: Percent fines, upper sites, all years

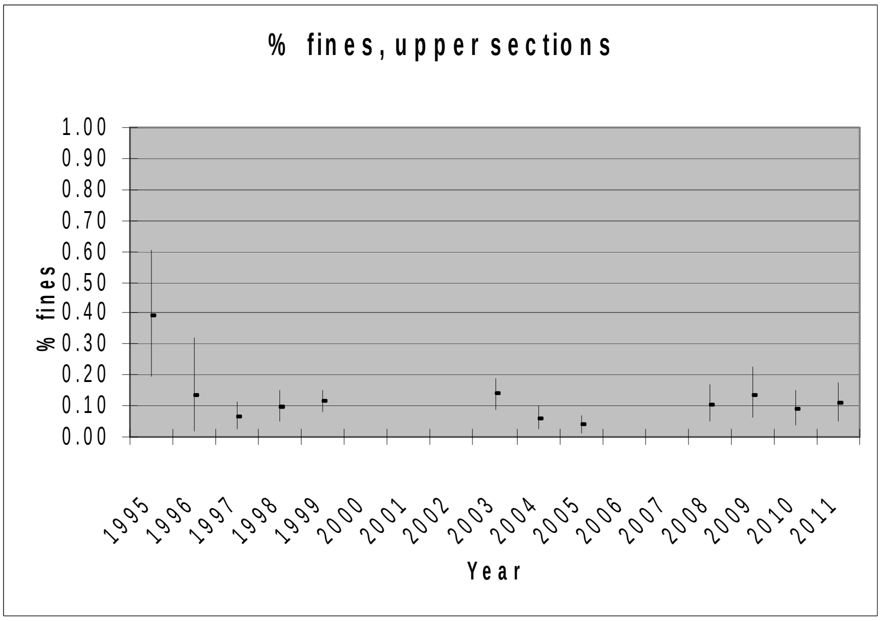


Figure 8: Percent gravels, all sites, all years

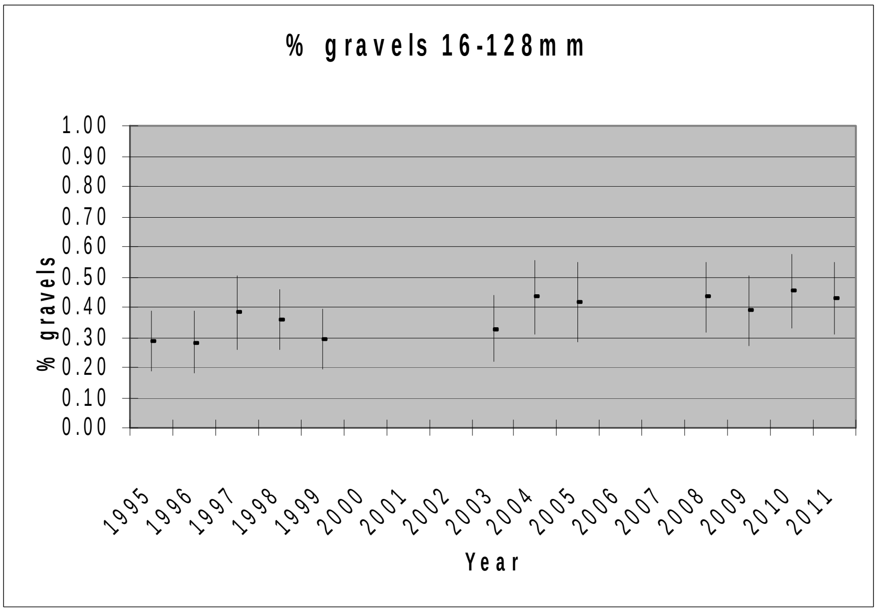


Figure 9: Percent gravels, lower sites, all years

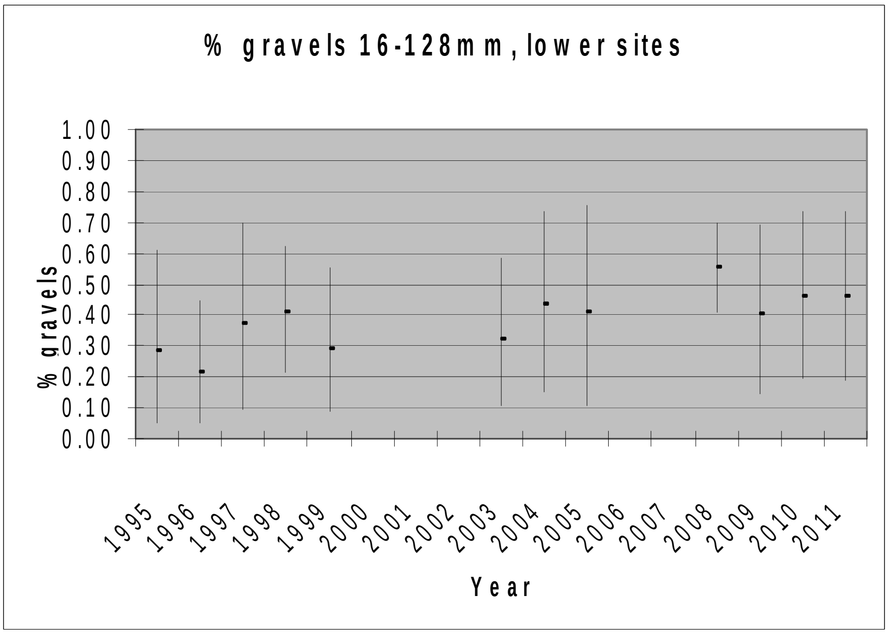


Figure 10: Percent gravels, middle sites, all years

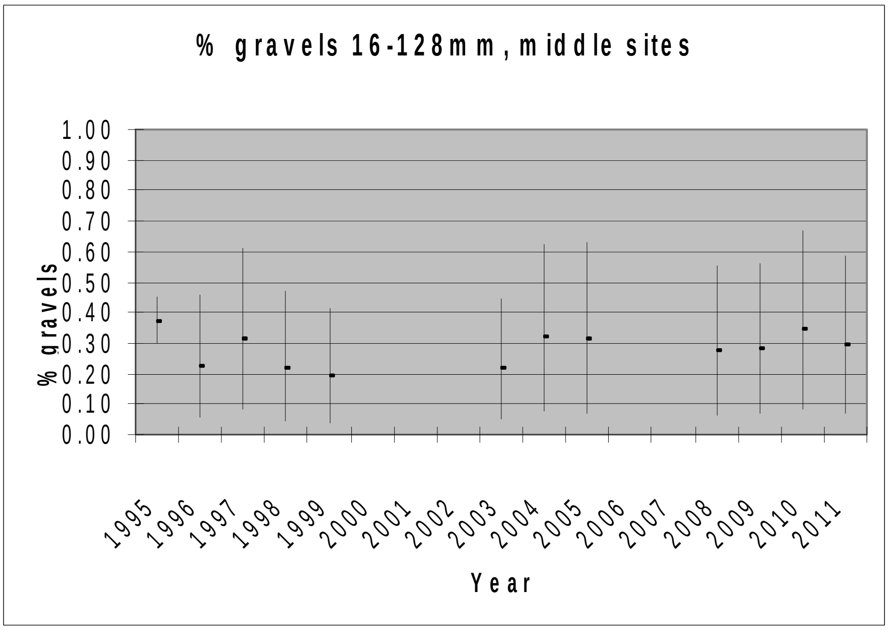
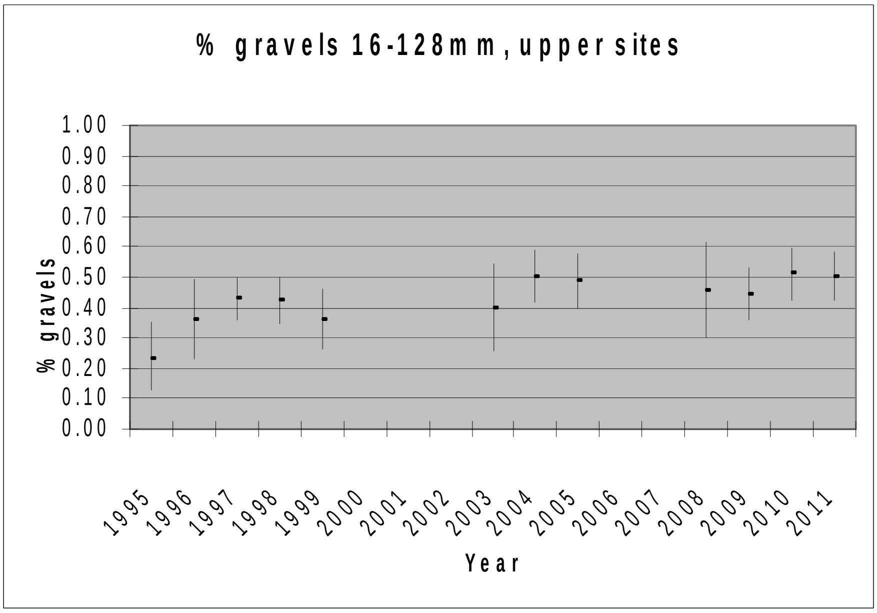


Figure 11: Percent gravels, upper sites, all years



3.3 Substrate condition versus chum fry abundance

Data from Alouette River fry enumeration activities (Cope 2011) 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. While there has generally been a steady increase in chum populations during the Wolman studies of 1995-2011, 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

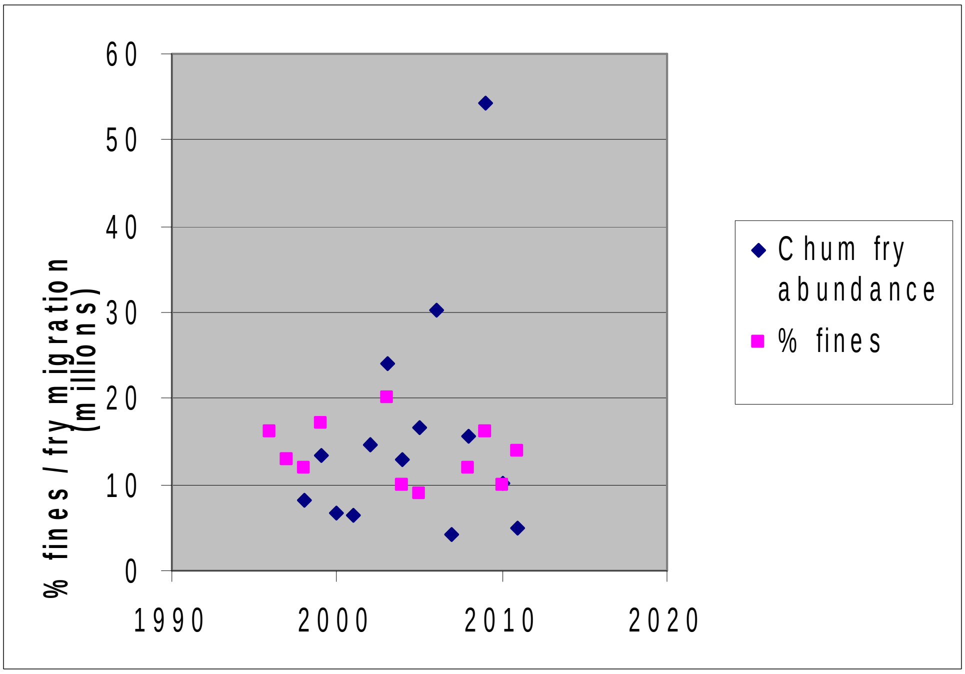
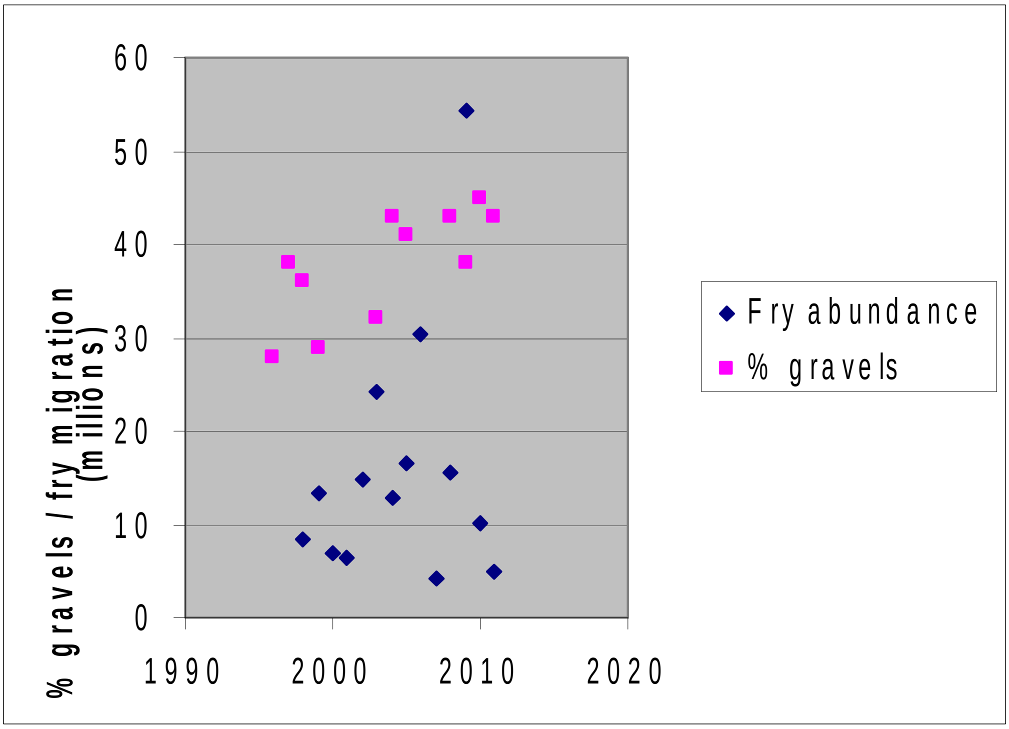


Figure 13: Percent gravels vs chum fry migration



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 – 2011 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. As commented previously, the absence of controlled flow releases from Alouette Dam between the 2010 and 2011 sampling runs could have contributed to the increase of fine sediment proportions in 2011.

Figure 14: Percent fines vs stream flow, ALU

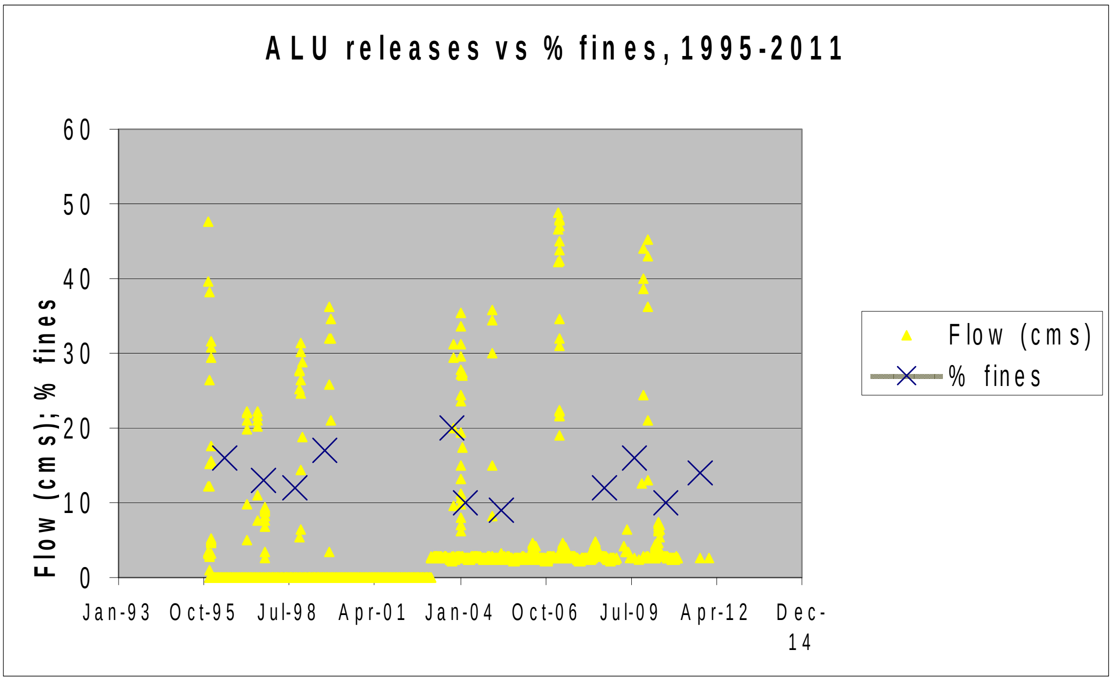


Figure 15: Percent gravels vs stream flow, ALU

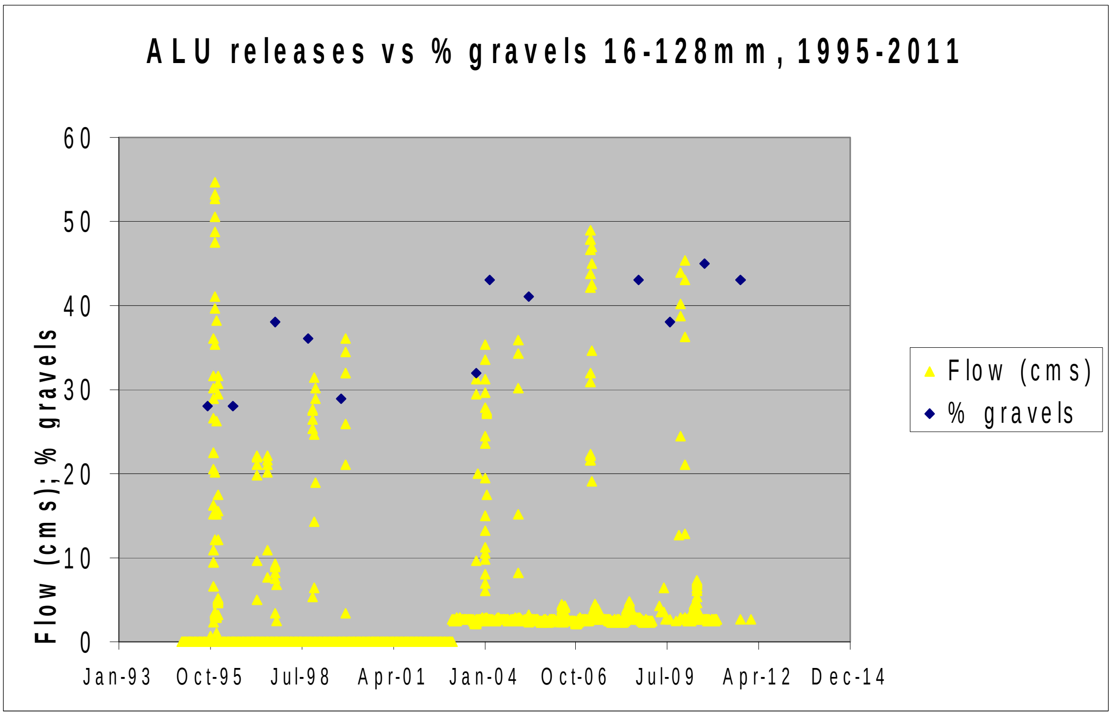


Figure 16: Percent fines vs WSC flow

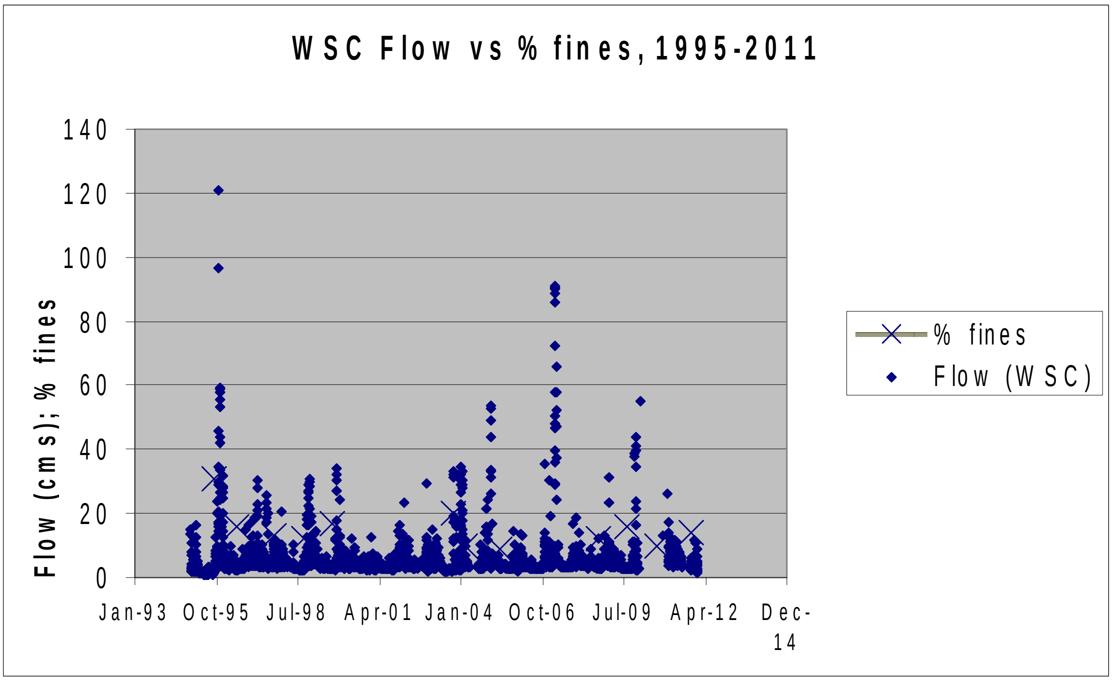


Figure 17: Percent gravels vs WSC flow

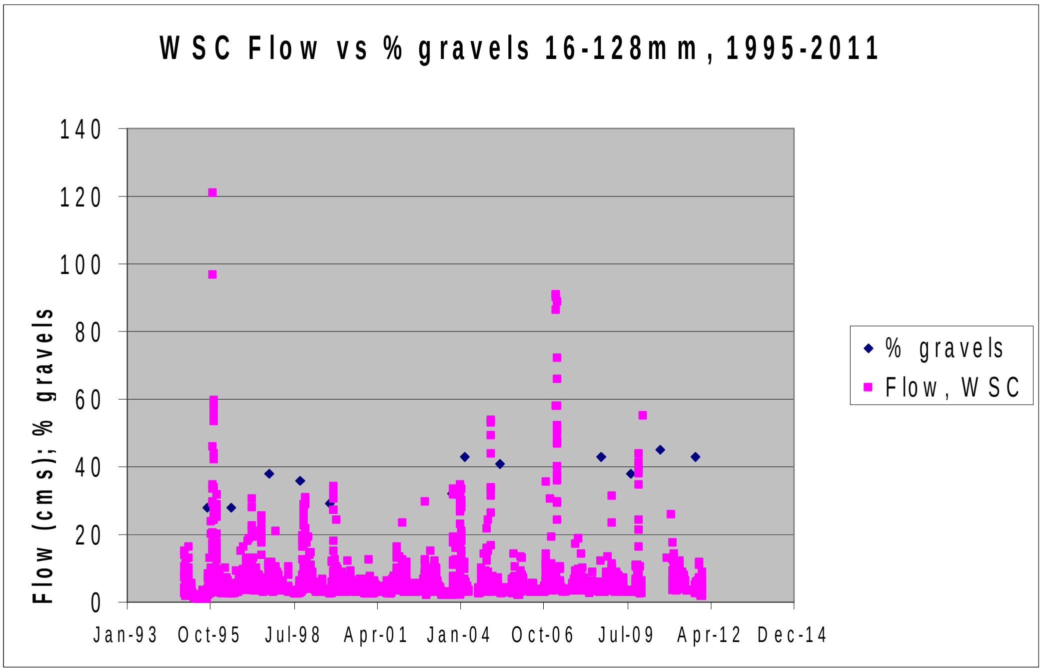


Figure 18. Upper river, upstream of Site 25 near Alouette Dam, September 2011.

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 2011 sampling run recorded a 10-14% increase in fine sediments, with the absence of controlled flow releases being possible contributor.
- 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 2011 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.
- 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 2011 sampling run followed a prolonged period of relatively quiet flow conditions, and this could have led to the increase in percent fine particles.

It is the opinion of the author of this report that a directed flushing flow could benefit certain sections of the river.

5.0 References

1. Kondolf, G.M. 1997. Application of the pebble count: Reflections on purpose, method, and variants. *Journal of the American Water Resources Association* (formerly Water Resources Bulletin) 33(1):79-87.

2. 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

3. 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 129:262–281, 2000