

**Alouette Water Use Plan**

**Substrate Quality**

**ALUMON#3**

**Study Period: Summer 2008**

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# **South Alouette River Substrate Monitoring 2008 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 an outcome of the 2006 Alouette Water Use Plan as recommended by the Consultative Committee to assess environmental effects of the proposed operational regime.

The 2008 sampling showed an overall increase in fine particles less than 2mm diameter of 3.0% since 2005. 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.

Although the 2008 sampling showed that the amount of gravel sized 16-128mm diameter remained relatively unchanged overall (41-43%) between 2005 and 2008, there did appear to be a redistribution of these particles during this period. Riffle sites recorded an increase in gravels in all sections, while run sites experienced a concurrent decrease in gravels. Most of the increases in gravel for riffle sites took place in the middle and upper sections, while gravels in run sites decreased primarily in the middle section. There was a significant increase of 41% to 56% for these particles for all sites in the lower sections.

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 2008 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.

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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 order to identify trends that would help to determine the need for a directed flushing flow. This project is an outcome of the 2006 Alouette Water Use Plan as recommended by the Consultative Committee to assess environmental effects of the proposed operational regime. The Committee consisted 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 (2005-2008) as well as long term (1995-2008).
- To examine the relationships, if any, between substrate composition and streamflow as well as fry abundance.
- To research documented substrate other than the Wolman method.

## 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.)

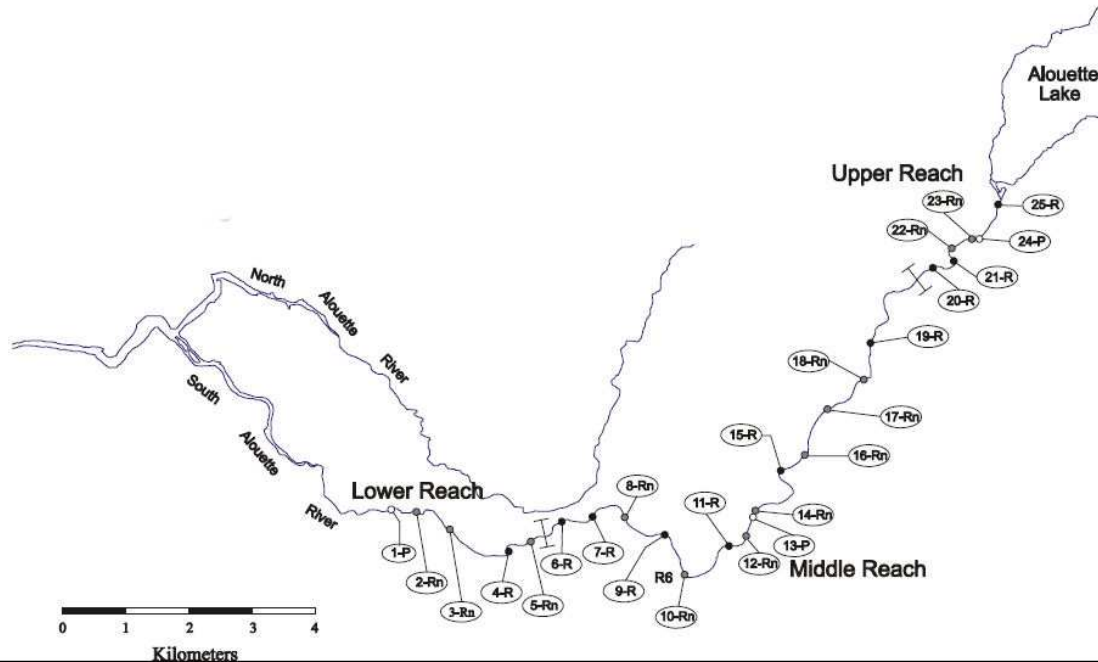


Figure 1. Study area on South Alouette.

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. The presence of Alouette Dam means that the river has a much more stable flow regime than a typical coastal B.C. stream, with tributary effects increasing with distance downstream from the dam. Two of the sites, Site 13 and 14, were abandoned after 1995 due to chronic private property access issues. 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 for 2008 is that the sampling will now be 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.

At Site 7, a comparison test was done between the traditional Wolman sampling method versus a modified "triangulation" method where set transects were walked between pre-determined points on the streambank. While the data derived from the two methods was virtually identical (Table 2) it was found that undertaking the triangulation method was extremely difficult and time consuming, due to the sheer width and velocity of the Alouette. It appears that this triangulation method would be best suited to smaller streams.

Table 2: Wolman vs Triangulation Methods for Site 7(raw pebble count data)

Particle Size Class	Tradition Wolman Method	Triangulation Method
<2	5	5
2-4	2	4
4-8	6	4
8-16	4	5
16-32	6	8
32-64	45	40
64-128	45	46
128-256	26	26
256-512	26	22
512-1024	6	9
1024-2048	0	0
2048-4096	0	0
Total Count	171	169

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. Since distributions of proportion data are skewed because they are between 0 and 1 and thus have no tails, arcsine transformation was used to stretch out the tails on both ends for a more bell-shaped, normal distribution. First, 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:

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

### 3.0 Results

Table 3 shows the raw data as collected from the 23 sample sites during the 2008 sampling period. Sites 13 and 14 were not sampled; these two sites were abandoned in 1995 due to chronic private property issues.

*Table 3: Raw sampling data, 1998*

RAW DATA - SUBSTRATE MONITORING IN SOUTH ALOUETTE:													Aug - Oct 2008		
PARTICLE SIZE	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12	Site 13		
mm															
<2	50	80	35	18	6	10	5	3	14	34	10	27			
2-4	0	0	2	2	8	2	2	0	4	12	5	1			
4-8	0	0	6	6	9	0	6	2	4	9	2	3			
8-16	0	0	8	4	7	2	4	6	12	7	3	6			
16-32	25	0	24	8	8	8	6	5	17	13	7	15			
32-64	25	10	56	70	30	50	45	43	42	31	9	30			
64-128	0	10	0	35	15	32	45	18	38	13	17	8			
128-256	0	0	0	14	17	8	26	25	12	8	17	3			
256-512	0	0	0	0	5	2	26	0	12	13	26	0			
512-1024	0	0	0	0	0	0	6	0	10	0	11	9			
1024-2048	0	0	0	0	0	0	0	0	4	0	3	4			
2048-4096	0	0	0	0	0	0	0	0	0	0	6	0			
Total counted	100	100	131	157	105	114	171	102	169	140	116	106	0		

PARTICLE SIZE	Site 14	Site 15	Site 16	Site 17	Site 18	Site 19	Site 20	Site 21	Site 22	Site 23	Site 24	Site 25
mm												
<2		26	12	27	34	20	12	0	16	22	5	0
2-4		4	6	0	6	12	0	2	8	2	0	0
4-8		4	0	4	3	6	2	0	2	8	30	4
8-16		12	2	4	1	4	4	4	4	2	25	2
16-32		14	4	4	5	8	8	2	6	20	0	10
32-64		103	51	26	37	36	28	20	30	78	0	24
64-128		11	10	16	11	34	28	54	12	6	0	22
128-256		2	4	6	3	14	15	22	18	4	0	8
256-512		2	24	12	5	24	4	8	14	4	0	14
512-1024		0	12	4	4	12	0	0	18	3	20	6
1024-2048		0	0	6	0	0	0	14	20	10	10	12
2048-4096		0	9	0	2	0	0	0	0	0	10	0
Total counted	0	178	134	109	111	170	101	126	148	159	100	102

## 4.0 Discussion

### 4.1 2005 vs. 2008 trends

The 2008 sampling showed an overall increase in fine particles less than 2mm diameter of 3.0% (Table 3). Sampling sites in the lower sections experienced a decrease from 30% fines in 2005 to 23% in 2008. Middle sections increased from 4% to 7% while upper sections increased from 3% to 10%.

*Table 4. Percent fines, 2005 vs 2008*

Sections	% fines 2005	% fines 2008	Change 2005-2008
Lower	30	23	-7
Middle	4	7	+3
Upper	3	10	+7
Overall	9	12	+3

It should be noted that instream changes have significantly affected two sites. For example, at Site 1 a large tree has fallen into the channel along the right bank, changing the hydrology and subsequent substrate characteristics of the site. The result has been an increase in stream velocity on the left bank, which has reduced and increased the percentages of fines and gravels on the left bank respectively. A similar situation exists at Site 12 (Figure 2), where a considerable debris jam has accumulated on the left bank, increasing fines on that side of the channel while increasing percent gravels on the opposite right bank.

*Figure 2: Site 12.*



Although the 2008 sampling showed that the amount of gravel sized 16-128mm diameter remained relatively unchanged overall (41-43%), there did appear to be a redistribution of these particles during the period 2005-2008. Riffle sites recorded an increase in all sections, while run sites experienced a concurrent decrease. Most of the increases in gravel for riffle sites took place in the middle and upper sections, while gravels in run sites decreased primarily in the middle section. There was a significant increase of 41% to 56% for these particles for all sites in the lower sections.

*Figure 3: Typical run habitat, between Sites 18 and 19.*



*Table 5. Percent gravels 16-128mm diameter, 2005 vs 2008*

Sections	% gravels 2005	% gravels 2008	Change 2005-2008
Lower	41	56	+15
Middle	31	27	-4
Upper	48	46	-2
Overall	41	43	+2

The relatively quiet winter of 2007-2008 that preceded the 2008 sampling run means that the sampling took place during what can be defined as a pre-flush flow period. By contrast, the winter of 2006-2007 was characterized by a number of high flow events,

including an extremely unusual “pineapple express” storm on March 11, 2007. It is the opinion of the author that many of the changes in particle distribution recorded between 2005 and 2008 could be attributed to this event. Unfortunately, substrate sampling was not conducted in 2006 or 2007.

In summary, the sampling carried out in 2005 and again in 2008 shows that there have been no significant increases in fine particles and / or site substrate compaction.

#### **4.2 1995 to 2008 trends**

Regression analyses for all habitat types and sections for the period 1995 to 2008 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 back transformed 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 due to occasional silt releases from the Mud Creek settling pond. However, neither the levels of fine particles or the levels of substrate inbeddedness have ever been observed to be in excess of 10% or 25% respectively, which are the levels that are usually accepted to constitute 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 summary, the sampling exercises that have taken place since the 1996 Water Use Plan 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 indicate that a directed flush flow could benefit upriver lower velocity sites such as Sites 17 and 18 by removing accumulated fines from certain sections of the lower velocity side habitats. 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 compaction at a level that would hinder or prevent spawning were not encountered at any site. Other assessments that were made during the study, such as examining the abundance and variety of macro invertebrates, strongly suggest that sedimentation is not a limiting factor on salmonid habitat at this time.

Figure 4: Percent fines, all sites, all years

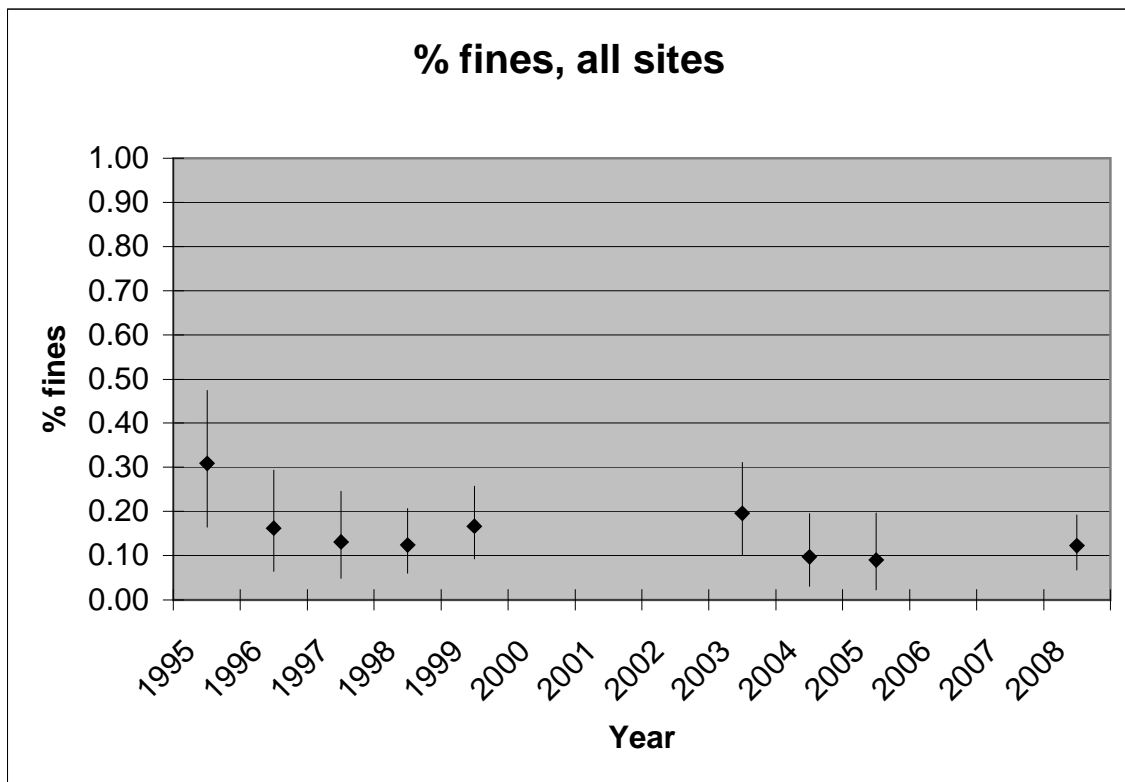


Figure 5: Percent fines, lower sites, all years

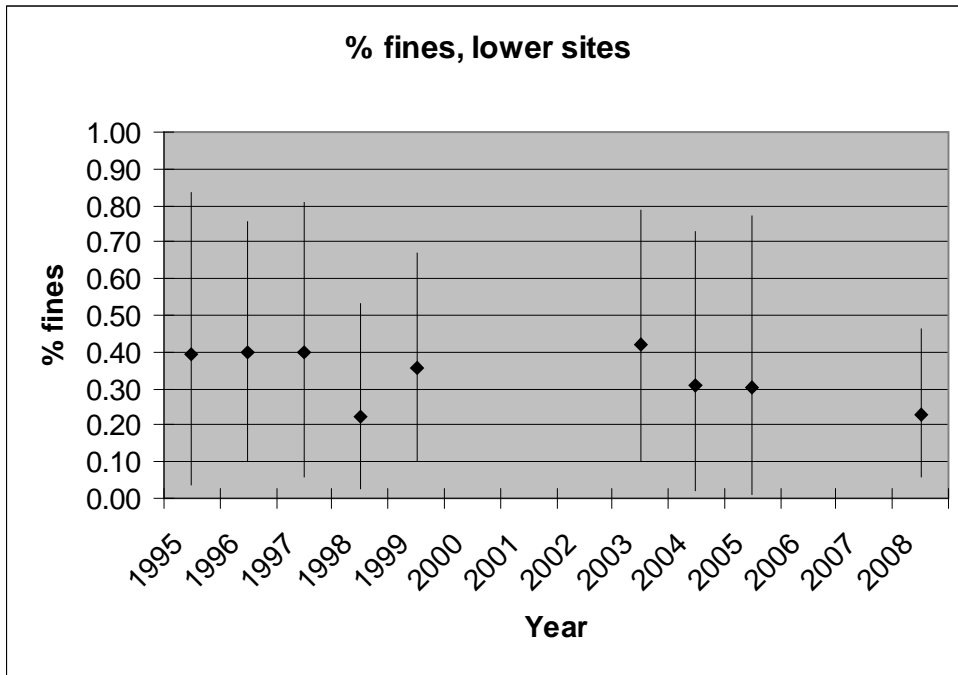


Figure 6: Percent fines, middle sites, all years

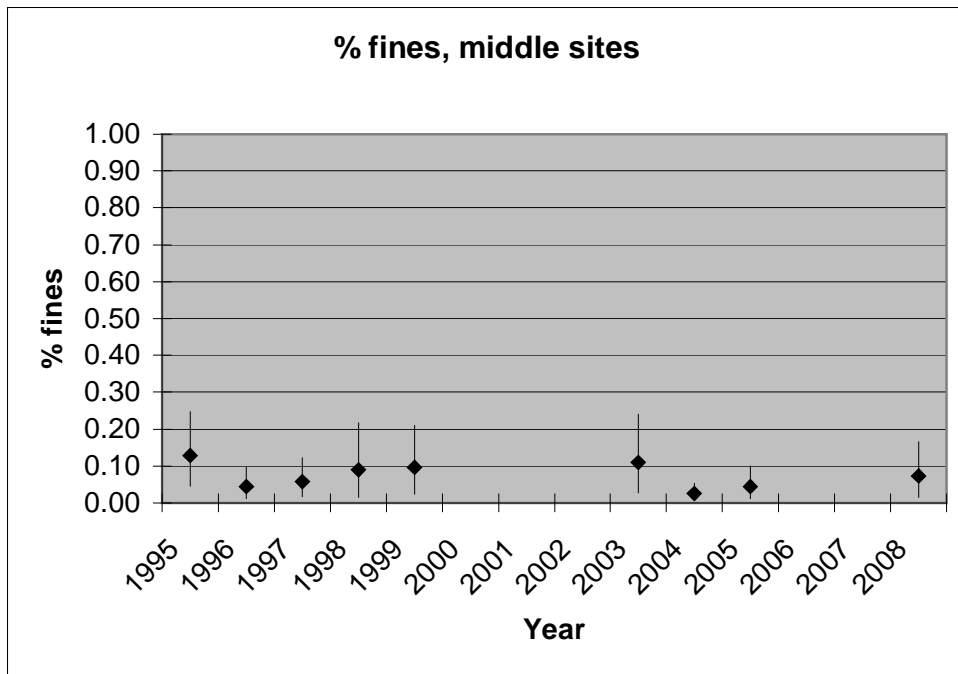


Figure 7: Percent fines, upper sites, all years

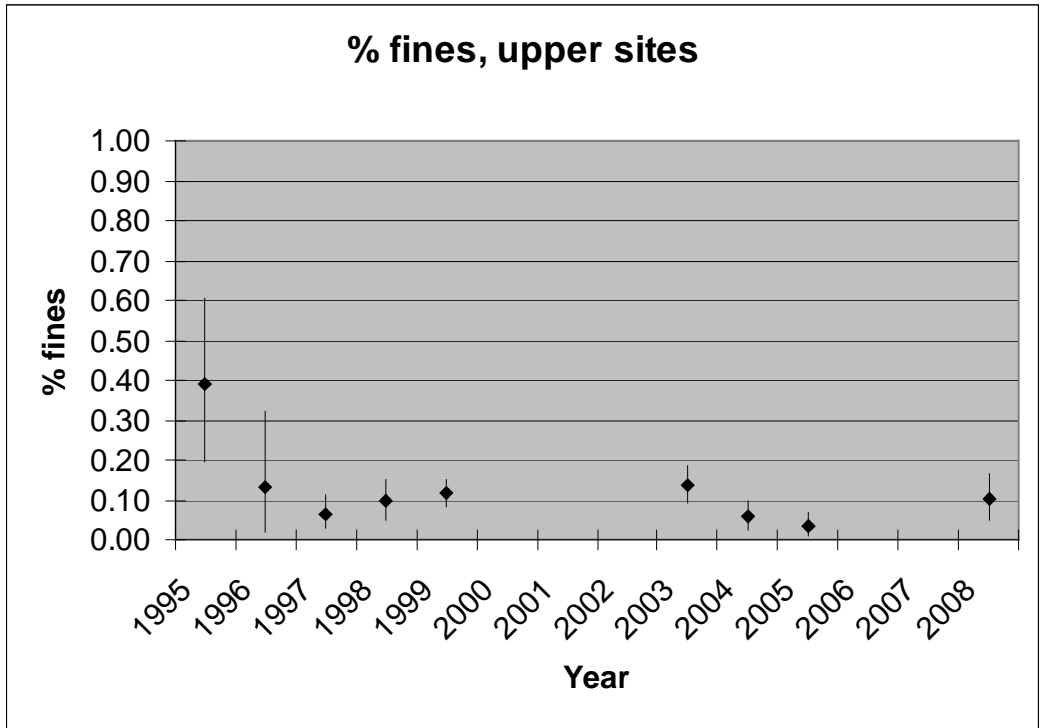


Figure 8: Percent gravels, all sites, all years

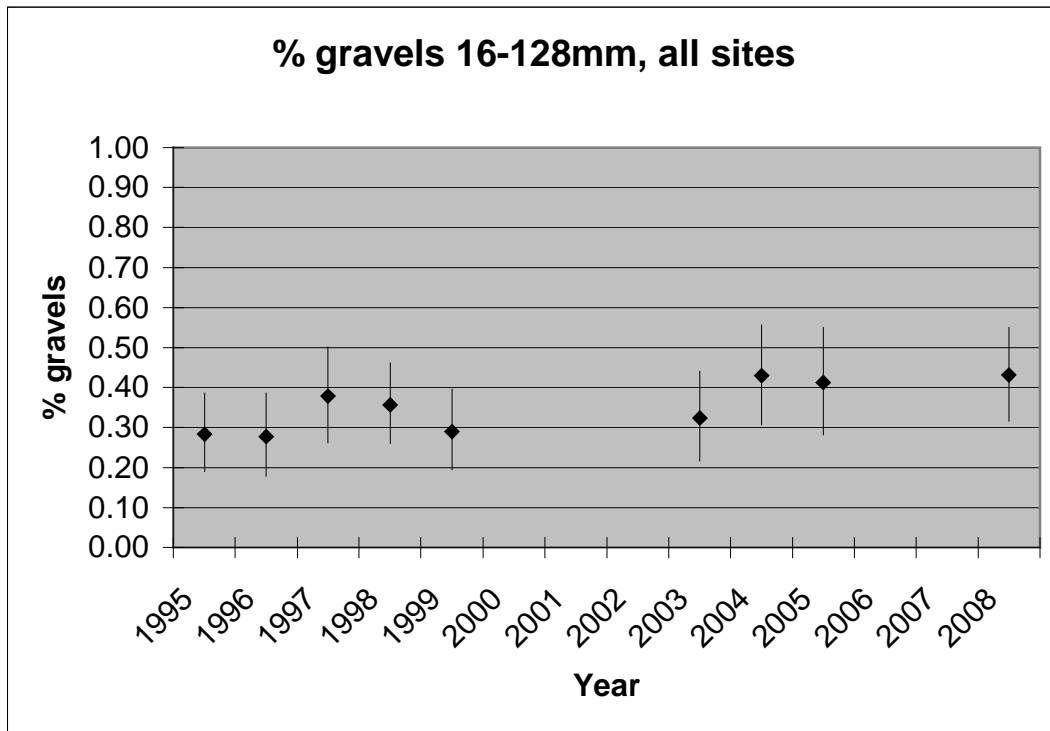


Figure 9: Percent gravels, lower sites, all years

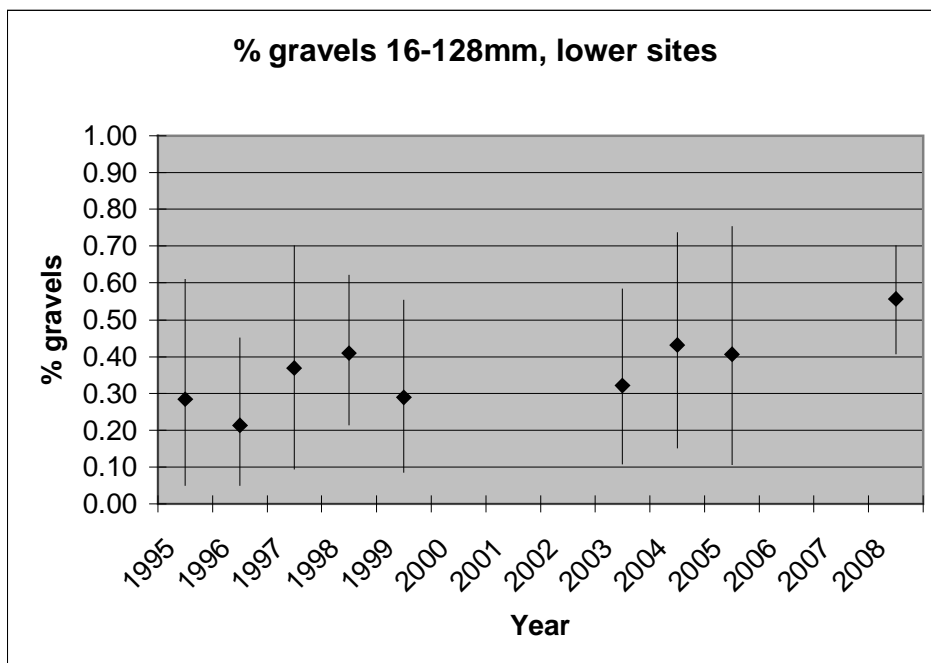


Figure 10: Percent gravels, middle sites, all years

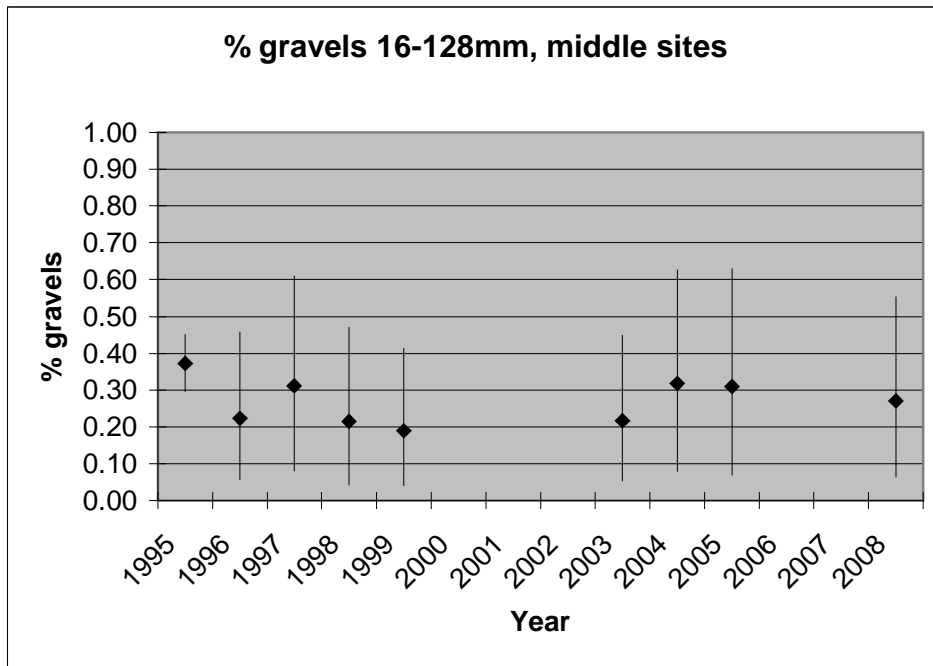
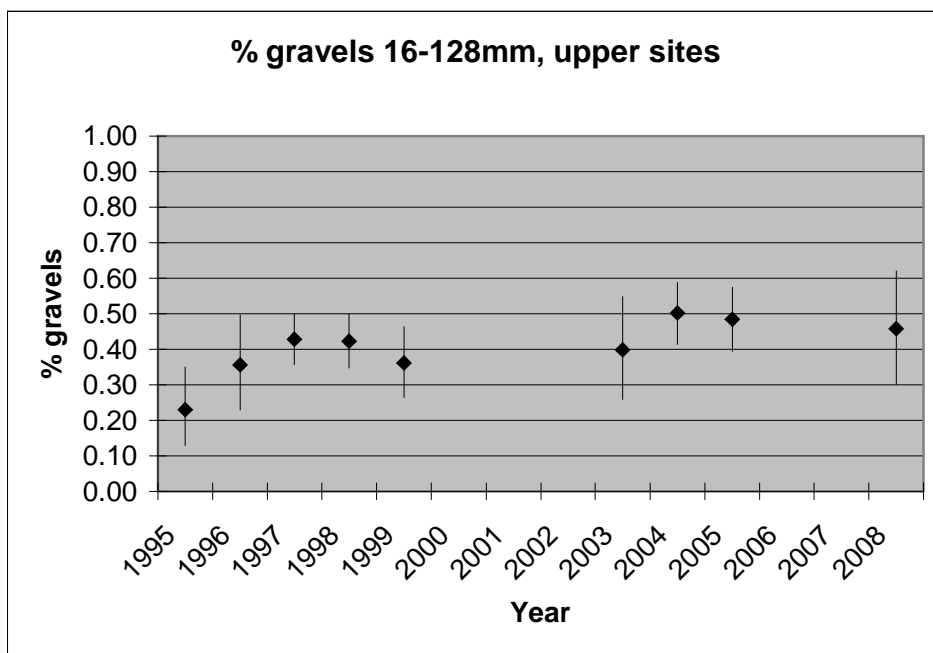


Figure 11: Percent gravels, upper sites, all years



### 4.3 Substrate condition versus chum fry abundance

Data from Alouette River fry enumeration activities (Cope 2008) 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 Allo 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 1995-2008, 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

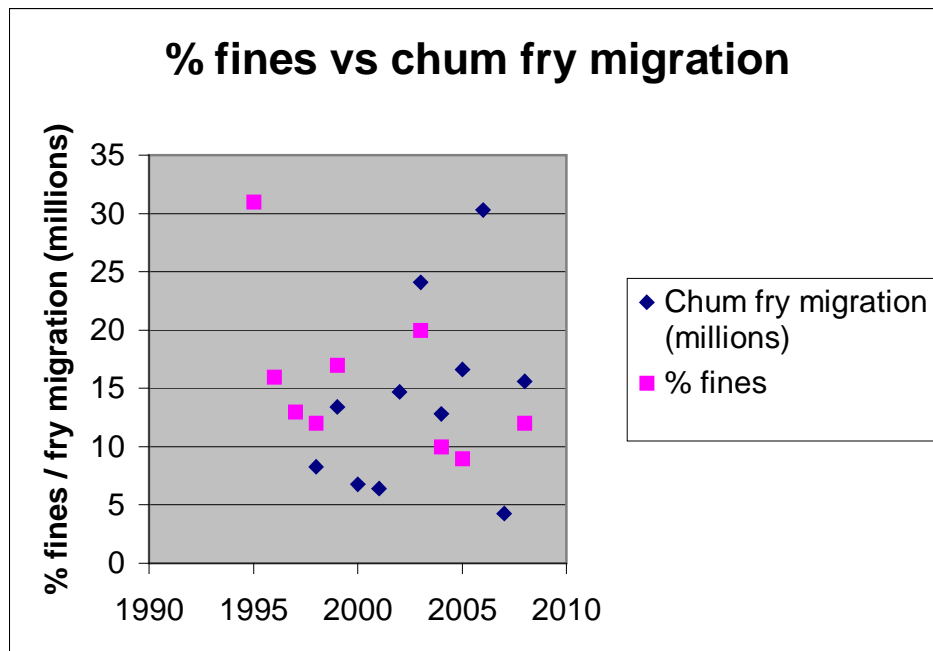
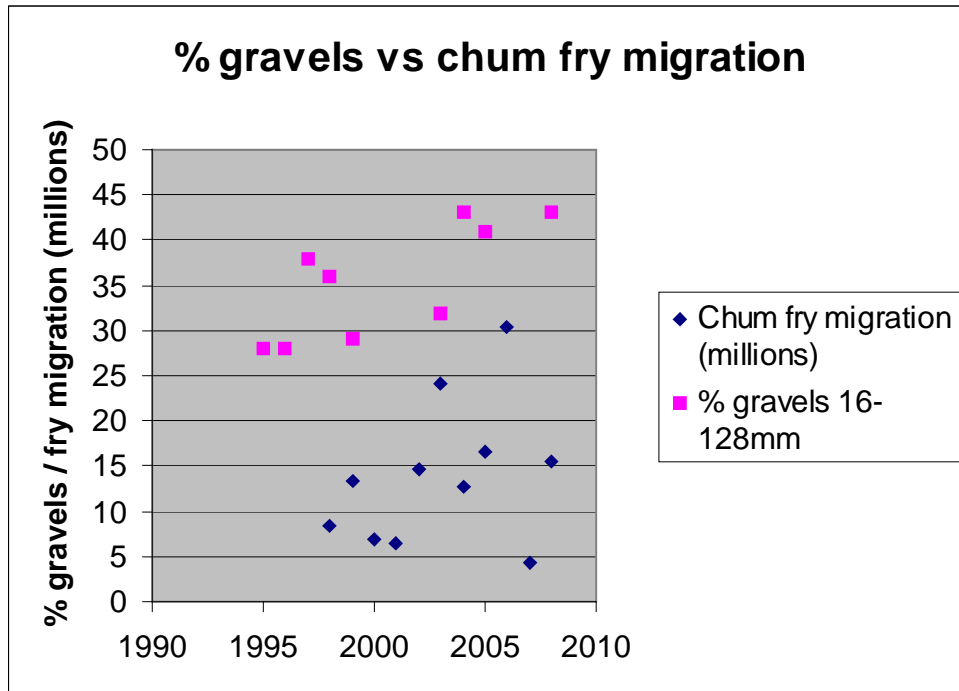


Figure 13: Percent gravels vs chum fry migration



#### 4.4 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 – 2008 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.

Figure 14: Percent fines vs stream flow

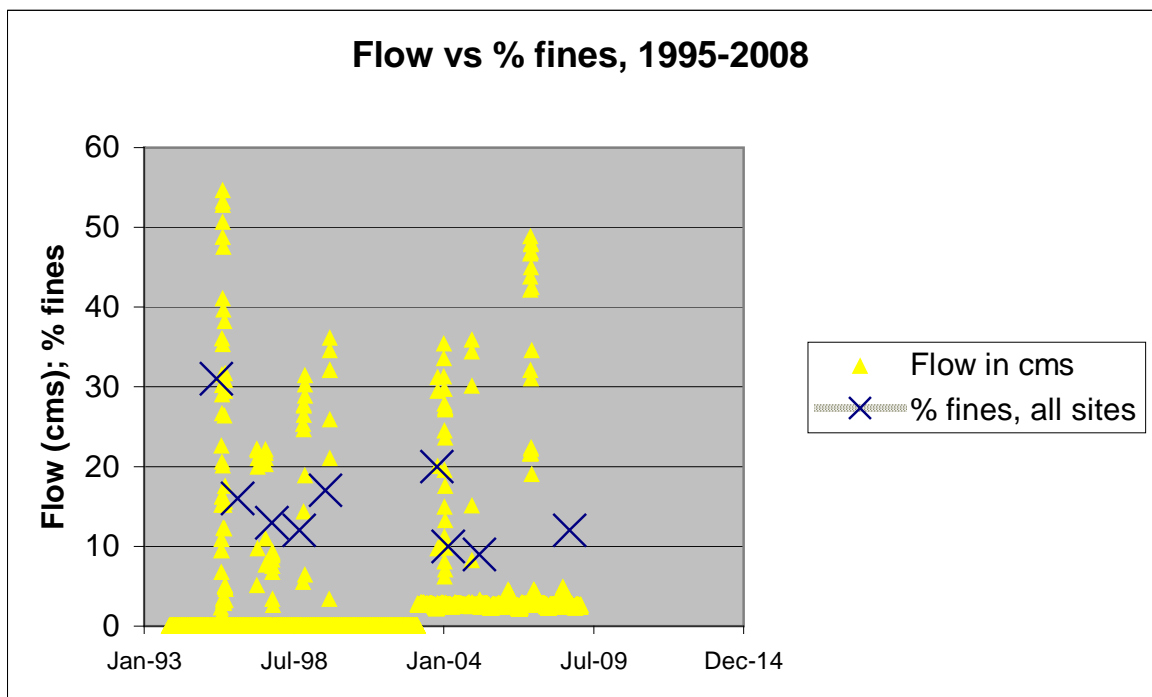


Figure 15: Percent gravels vs stream flow

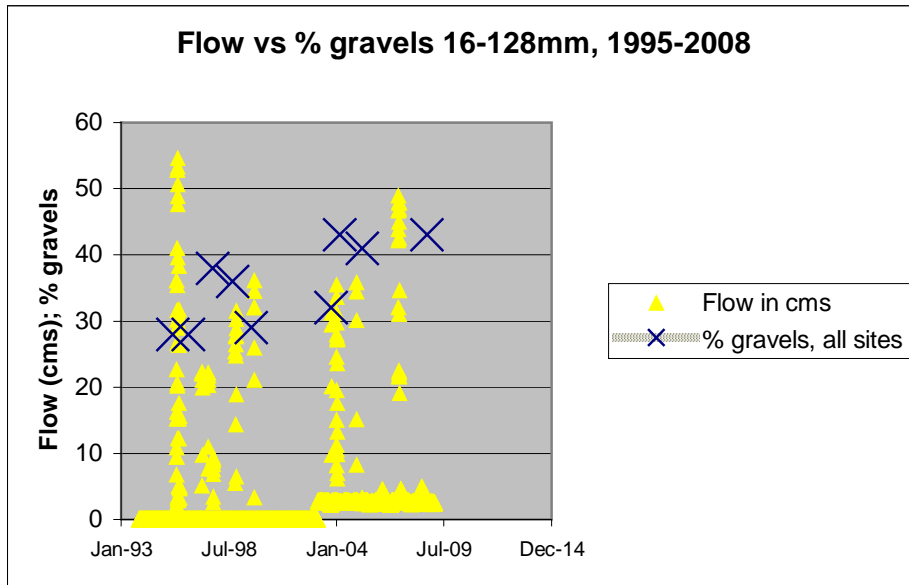


Figure 16. High flow event of March 2007 on South Alouette, 1.5km upstream of 232<sup>nd</sup> Street.



#### 4.5 Comparison of Wolman versus other sampling methods

Several different methods of substrate sampling have been developed and compared to the Wolman method.

Kondolf (2000) examined the “zig-zag” method that was discussed in Bevenger and King (1995), which involves sampling along a diagonal line and drawing data points from many different geomorphic units. Kondolf concluded that this method is not reproducible, probably because it incorporates stones from many different populations, and because an inadequate number of grains is sampled from any given population.

Bunte, K., and S.R. Abt. 2001 examined the various sources of error in the Pebble Count Procedure due to operator bias, as well as modifications to the method to improve accuracy by reducing error due to operator bias. They compared the traditional Pebble Count Procedure to a method where the operator collects rocks at equidistant points along a tape stretched out along the streambed. While the original examination indicated little difference between the two methods, Bunte and Abt determined that “variability due to operator bias in the traditional method is more pronounced than in the tape method when considering data in the context of the bed type (gravel vs cobble vs boulder). They concluded that the tape method is an improvement over the traditional method, but, in submerged beds, the tape needs to be secured in a manner that disturbs the bed and that the water distorts the appearance of the bed relative to the tape.” The tape method would not be feasible for the Alouette monitor due to stream velocities as well as the sheer size of the transects.

Bunte and Abt also proposed “a sampling grid method that employs a sampling frame device that allows for the benefit of the tape method without its drawbacks. The device’s construction and use is detailed, along with results testing its effectiveness which shows that there is less variability in distribution results between operators when using the sampling frame vs the traditional boot toe method.” Once again however, stream velocities and transect sizes would seriously compromise the effectiveness of this method on the Alouette, since it would be nearly impossible to deploy the sampling frame in any kind of consistent manner, if at all, due to Alouette’s stream velocities and transect depths.

Marcus, W.A., Ladd, S.C., and J.A. Stoughton. 1995, examined the contribution of operator bias to sampling error in the pebble count procedure. They found that “bias is indeed significant, especially between operators.”

Hey, R., and C. R. Thorne. 1983 looked at sampling error in relation to sample size and operator bias. Their overall conclusion was that “when sampling in excess of 100

samples, a single operator should be used in order to enable larger samples to be collected without invalidating the analysis.”

To summarize, the Literature Search portion of this project supports the methodology that has been applied, in terms of cost effectiveness, the use of a single operator, and the fact that the Wolman method is the most suitable for relatively large systems such as Alouette.

## **5.0 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 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 2008 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 never in excess of levels that would begin to affect salmonid spawning, rearing, or food production.

It is the opinion of the author of this report that a directed flushing flow is not required at this time.

## 6.0 References

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