Wahleach Project Water Use Plan

Lower Jones Creek Channel Stability Assessment
Year 7 Reporting

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FINAL REPORT

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NOTIFICATION

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NHC. August 31, 2012. *Lower Jones Creek Channel Stability Assessment, WAHMON-2 Year 7*. Prepared for BC Hydro. 2012.

EXECUTIVE SUMMARY

The channel stability assessment on lower Jones Creek was established by BC Hydro as part of the Wahleach Water Use Plan monitoring program to investigate the extent to which channel stability and substrate quality limit fish productivity. Channel stability and substrate quality are evaluated at five (5) previously established cross sections through repeat topographic surveys and photogrammetric substrate photographs of the wetted channel.

The assessment and field program extends from mid-October to mid-March to coincide with peak spawning, mid-incubation and end of incubation dates for pink and chum salmon during odd (pink spawning) years. This report presents summary results of the Year 7 field program and provides a comparison with data collection efforts in previous years.

There were major changes in channel stability and substrate quality in early years of the program when a large wedge of sediment was deposited in lower Jones Creek between April 2006 and November 2007(estimated to be as much as 7500 m^3; NHC, 2008). Despite the magnitude of sediment deposition, there were no large changes in upstream sections (where most of the deposit came to be located) due to a lack of large flows capable of mobilizing much bed and bank material.

Despite the lack of large floods, changes were much more significant downstream, especially in the widened sedimentation zone upstream of section 6. In the past, there were no survey transects located in this section of channel, but a new section has since been established (February 2012) to better gauge the magnitude of changes here in the future. Channel stability was not a major concern during Year 7 except at the downstream monitoring section (XS 4) where a large bar developed during freshet flows on Fraser River. It was subsequently eroded by Jones Creek, with extensive degradation during the Year 7 incubation period. This erosion would not have had a potential negative impact on chum salmon productivity, despite being a favored spawning habitat, as peak spawning occurred after the instability. Pink salmon favour upstream habitats and would have been proportionately less impacted.

Instream flows were below the minimum target threshold for all but a single day near the start of spawning, but were at or above target by the date of peak pink salmon escapement and thereafter during the entire incubation period. Flows did not appear to have any significant impact on early returning pinks. Chum salmon numbers peak nearly a month later and would not have been affected as typical seasonal flows increase.

A main physical characteristic related to substrate quality and fish productivity is the fraction of fine sediment (<10 mm) on the surface, representative of the proportion of fines within the gravel matrix. Higher percentages infer less interflow through the redd, poor incubation conditions and reduced egg-fry survival. At most sampling sections, this proportion has commonly remained above the upper limit (30%) and very nearly always above the lower limit (10%).

The habitat quality as measured by this metric was improved in Year 7 relative to Year 5 (and to most previous reporting periods) except at XS 8 where the total fine fraction (59%) was much higher than at any other section. The findings suggest that egg-fry survival rates may be improved relative to most years. This is supported by preliminary results from Greenbank and Macnair (2012b) who calculated egg-fry survival of 2.24% for pinks (equal to the long term average) and 1.98% for chum (above the long term average).

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1 INTRODUCTION

Jones Creek (also Wahleach Creek) flows northward into the Fraser River about 16 km west of Hope, BC (**Figure 1**). The channel drains an area of 115 km^2 in the rugged terrain of the Cascade Mountains. The channel is confined until it emerges from the mountains where gradient declines from 4% to 1.2% (Newbury Hydraulics, 2004) and sediments transported from upstream are deposited on a broad alluvial fan. An alluvial fan is a conical deposit of river transported sand and gravel that commonly occurs at mountain fronts where the reduced slope limits the ability of the channel to convey the material further. The creek continues across the fan for approximately 900 m before joining the Fraser River. This fan reach of the creek is commonly referred to as Lower Jones Creek.

BC Hydro owns and operates the 64 MW Wahleach Hydroelectric Project which consists of a dam on Wahleach Lake about 8 km upstream from the mouth of Jones Creek and a diversion tunnel from the lake to a generating station near Herrling Island on the Fraser River. Approximately 88 km^2 (78%) of the total watershed area drains into Wahleach Lake. Operation of the Wahleach project began in 1952, significantly altering the flow regime downstream of the dam site. Peak flows have been reduced by as much as 65% and average annual flow has been reduced by over 80% (MMAL, 1997). Contemporary flows are mainly from tributaries below the dam, though BC Hydro can augment these to meet the Water Use Plan minimum flow target.

Compensation measures to reduce fisheries impacts associated with the hydroelectric project began soon after completion of the dam. An artificial spawning and rearing channel was constructed in 1954 adjacent to Lower Jones Creek (Hartman and Miles, 1997) but the channel was plagued by sedimentation problems and has since been abandoned. More recently, BC Hydro has attempted to improve natural channel functions by replacing concrete and sheet pile weirs with constructed rock riffles (in 2004) and through placement of an engineered log jam at a side channel entrance (in 2005) to prevent its enlargement (Streamworks Unlimited, 2006). In 2006, several new enhancement projects were completed near the downstream end of Jones Creek, the most significant of which was construction of a new right bank side channel (Streamworks Unlimited, 2006 – Figure 1). Additional recent enhancement projects include flow augmentation of a backwater rearing habitat and revegetation of adjacent banks near Lorenzetta Creek confluence.

BC Hydro's Wahleach Water Use Plan (2005) currently addresses seasonal instream flow targets for pink salmon in Lower Jones Creek. However, the effectiveness of these flows for maintaining pink salmon productivity is not known due to the potentially more significant effects of channel instability and sedimentation in the creek channel.

The Lower Jones Creek Channel Stability Assessment was initiated in 2005 under the Wahleach WUP Monitoring Program to evaluate the effects of channel instability and sedimentation on pink salmon productivity during the spawning and incubation phases of their life cycle. This report presents the results of data collection efforts during Year 7 of the monitoring program (2011/2012) and provides a comparison with data collected during Years 1 (2005/2006), 3 (2007/2008) and 5 (2009/10). Results to date reveal that program objectives appear to be met, but additional monitoring has been recommended for Year 9 to better capture the spatial variability of channel change that has previously been observed.

1.1 BACKGROUND

The Lower Jones Creek study reach extends 900 m from the Laidlaw Road Bridge near the apex of the fan to the Highway 1 Bridge near the mouth of the creek (**Figure 1**). Lorenzetta Creek enters Lower Jones Creek approximately 80 m upstream from the mouth. BC Hydro operates a streamflow gauging station (BCH_LJC) immediately downstream of the Laidlaw Road Bridge. A buried pipeline crosses beneath the creek channel approximately 200 m downstream of the Laidlaw Road Bridge.

The creek channel is incised on the upper part of the alluvial fan, from the apex near Laidlaw Road Bridge to a point shortly downstream of the pipeline crossing. In this section, the channel is approximately 10 m in bottom width and is confined within banks 3 to 4 m in height. Exposed tree roots in the banks provide evidence of significant channel downcutting through fan deposits in recent years and there is some recession and ravelling along the steep left bank. There were very large floods in both 1989 and in 1990 (the flood of record; Newbury Hydraulics, 2004) that introduced large volumes of sediment from upstream through which the channel has since incised.

Large rainstorm generated floods in 1993 and 1995 also introduced large volumes of sediment to the fan (Hartman and miles, 1997) depositing material up to 3 m thick near the Laidlaw Bridge (Interfor, 1996). The channel bed is comprised mainly of coarse, infrequently mobile material, with pockets of finer material in protected areas between the boulders. Active sediment sources related to logging activities were a primary source of sediment in the past (cf. Hartman and Miles, 1997) while large natural landslides provide the primary source of sediment to the fan at present.

Below the pipeline crossing, the channel widens dramatically (to 40 - 50 m in width) and is bounded by lower banks (1 to 2 m in height, occasionally less). The meandering channel is characterized by frequent point, lateral and mid-channel gravel bars which are inundated during high runoff events. The wetted low-flow channel occupies only a small (less than one-third) portion of the active flood channel. This part of the fan channel is subject to active sediment deposition and lateral channel activity. Near the downstream end of the fan is a recently constructed (2004) rock weir that constricts the channel (**Figure 1** – Photo point #2). The weir replaces older concrete and sheet pile weirs that were lowered because they were creating a sediment wedge that raised the bed (Newbury Hydraulics, 2004)

Near the mouth of the creek, Fraser River exerts a seasonal backwater influence on Jones Creek water levels. The Fraser River hydrograph is dominated by snowmelt with maximum water levels occurring between May and July. During this period, the lowermost 200 m of Jones Creek is affected by Fraser River backwater and there can be significant accumulations of sediment on a right bank bar (**Photo 1**). Jones Creek also experiences a modest spring freshet resulting from snowmelt in the watershed below Wahleach Lake. However, the largest flows typically occur during rainfall and rain-on-snow events in the autumn and winter, typical of small basins in coastal British Columbia.

1.2 OBJECTIVES AND APPROACH

BC Hydro completed a Water Use Plan (WUP) for the Wahleach Project which was submitted to the Comptroller of Water Rights in 2004 and implemented in January, 2005. The Consultative Committee (CC) formed under the WUP, recommended several operational changes as part of the WUP, including the provision of minimum flow targets. A minimum discharge of 1.1 m^3/s is currently targeted during the spawning period (15 September through 30 November), and a minimum discharge of 0.6 m^3/s is targeted during the remainder of the year.

These instream flow targets can be met pending available Wahleach Dam siphon available at reservoir elevations >636 m and Boulder Diversion augmentation available for flows > 0.14 m^3/s. The CC could not address whether instream flows or channel instability was limiting spawning success and fish productivity in Lower Jones Creek. Therefore, a comprehensive monitoring program was approved to assess the effectiveness of the minimum flow regime on fish productivity, and to assess channel conditions in Lower Jones Creek as a possible limiting condition for fish productivity.

The channel stability assessment commenced in 2005-2006 and is scheduled to be conducted in alternate years though 2013 corresponding to pink salmon runs. The overall purpose of the lower Jones Creek channel stability assessment is to address two management questions:

1) Is channel stability in Lower Jones Creek limiting fish productivity; and
2) Is substrate quality in Lower Jones Creek limiting fish productivity?

In order to address the first question, the following hypotheses are to be tested:

- H_1: In consideration of improvements to spawning habitat through increased spawning and incubation flows, fish productivity is not correlated to habitat instability in the anadromous reach of lower Jones Creek.
- H_{1a}: Fish productivity is not correlated to channel instability as measured by cross-sectional areas of scour and fill in the anadromous reach.
- H_{1b}: Fish productivity is not correlated to channel instability as measured by lateral channel migration involving abandonment of spawning habitat in the anadromous reach.

In order to address the second question, the following hypothesis will also be addressed:

- H_2: In consideration of improvements to spawning habitat through increased spawning and incubation flows, fish productivity is not correlated to substrate quality as measured by substrate particle size in the anadromous reach of lower Jones Creek.

The approach to addressing these hypotheses was outlined in the original Terms of Reference, but has been subsequently modified to reflect problems encountered with data collection and methodology. Data and analysis presented in this annual data report for Year 7 of the monitoring program is based on a proposal originally submitted by NHC in August, 2007 and subsequently agreed to by BC Hydro.

These changes include showing topographic changes over time at discrete x-sections location only rather than attempting to integrate volumetric changes throughout the study reach, and a consistent approach for substrate monitoring using photo sampling. More recently, NHC (2010) suggested adding a new section between XS 6 and XS 8 to better reflect the spatial extent of spawning habitat.

For the seventh year of the monitor, topographic surveys, site photography and photographic substrate sampling was completed at five previously established transect locations along Lower Jones Creek (**Figure 1**) and an additional section (XS 7) was added between XS 6 and XS 8. Target survey dates were established to coincide with peak spawning (15 October), mid-incubation (1 January), and end of incubation periods (15 March). Repeat topographic surveys and site photos are used to monitor habitat stability, while the repeat photographic substrate samples are used to monitor changes in substrate quality.

Habitat stability is further evaluated over the entire period of the monitor by comparing morphologic channel features mapped from periodic orthophoto coverage. Comparison of these results with data collected by the fish productivity monitor permits the testing of study hypotheses. This analysis is also based on the assumption that the WUP flow regime is being adhered to, which is verified by comparing streamflow data from the Lower Jones Creek gauging station to the minimum flow targets during spawning, incubation and rearing periods.

This report outlines the methodology and results for the seventh year of the monitoring program. The results of this report are compared to the morphologic data collected during previous years, and to fish productivity indices and trends, to evaluate whether management objectives are being met. There have been no substantive changes to this monitor following an interim review in 2010.

2 DATA COLLECTION

2.1 HABITAT STABILITY MONITORING

Habitat stability monitoring quantifies the magnitude of channel changes during the post-spawning period. Habitat monitoring surveys have been scheduled to correspond with various points in the spawning and incubation life cycle phases for pink salmon. In practice, the actual dates of channel survey and site photography deviate from the target dates due to poor weather or high flow conditions, and because of scheduling constraints (**Table 1**). This combination of factors led to the long delay in completing the Jan 1 target survey. The March survey was not therefore completed as it was decided that the channel would have experienced little or no change during a few weeks time. The lag between the survey target date and the actual survey date is not critical provided there have been no large or sustained peak flows, as these can cause significant changes in channel shape.

Table 1. Topographic survey schedule for Lower Jones Creek, 2011-2012

Target Date	Actual Date	Pink Salmon Periodicity
Oct 15, 2011	Nov 1, 2011	Peak spawning
Jan 1, 2012	Feb 23, 2012	Incubation midpoint
Mar 15, 2012	Feb 23, 2012	Incubation endpoint

NHC visited Lower Jones Creek on November 1, 2011 to locate previously established cross-section markers and complete the cross-sections, substrate photo surveys and collect photo documentation points (PDPs). In past years of the monitor, some cross-section markers have been lost due to vandalism, construction, and erosion or burial and had to be reinstated. Site photographs were taken from each PDP with roughly the same view orientation used in previous years. The site photographs were initially intended to provide supplementary information for interpreting topographic survey results (presented in **Appendix A**). However, orthophotos taken during low water periods in 2008, 2009 and 2010 provide a more robust means of interpreting channel stability because they have identical scaling and orientation, allowing lateral changes to be quantified. Orthophotos are not specifically collected for this monitor and are not available for every study year which limits the temporal coverage of this information.

The layout function in the total station was used to establish the location of the existing sections and search for endpoint benchmarks. New spikes were added to trees closest to each benchmark to aid section relocation during future surveys. All sections were surveyed using a Nikon-Trimble NPL 362 Total Station tied to geodetic control established using a Real-Time Kinetic (RTK) GPS Total Station. The RTK GPS cannot be used to survey the entire area due to limited Can-Net cell coverage because of tree canopy and mountains that narrow the sky view.

The basic survey procedure involves recording the location of breaks in slope, the edge of the wetted channel, and significant changes in bed texture between cross-section endpoints. The site was not visited again until late February, when the field procedures were repeated. During this visit, a new cross section (XS 7) was established and surveyed (**Photo 2**). Analysis of the new cross-section data, and a comparison to the data collected in previous years, is presented in Section 3.

2.2 SUBSTRATE QUALITY MONITORING

An abundance of fine sediment in stream substrates is thought to be a key indicator of poor quality fish habitat. The *Terms of Reference* specifies the use of grain-size limits from 0.85 mm to 9.5 mm as recommended by Tappel and Bjornn (1983). The fraction of sediment within this range was found to be a limiting factor for salmonid embryonic survival. These limits do not correspond to conventional physically based thresholds, but rather are based on an artefact of sieves sizes used in earlier work (Kondolf, 2000) so are rounded to 1 mm and 10 mm.

Photographic substrate samples are also scheduled to correspond with various points in the spawning and incubation life cycle phases for pink salmon, hence used to assess changes in fine sediment content over this period. The actual dates of photographic substrate sampling are identical to the cross section dates, eliminating potential bias in surface sediment changes introduced by a large lag period between photo and topographic sampling. Photo sampling is limited by elevated turbidity levels, so field visits are not completed immediately following rain events or when water levels are too high.

Photographic substrate samples were collected at the same five transects as the topographic surveys (**Figure 1**). Samples were taken on each transect near points coinciding with ¼, ½ and ¾ of the measured width of the entire wetted channel at the time of survey. Two photographs are taken at each site immediately to the left and the right of the distance marker (6 samples in total) to ensure that the truncated sample size (material < 64 mm) is usually greater than 100 making the samples statistically representative of the actual surface distribution (Kellerhals and Bray, 1971). Additional photos are taken from different orientations or with different camera settings in poor light conditions so that only the two sharpest images are retained for analysis.

The autumn sampling was completed during clear water at low to intermediate flows ($Q=1.6\ m^3/s$) and the winter photos were taken during higher water ($Q=2.8\ m^3/s$) when the flow was moderately turbid. Photos are taken through the water column using a 65 cm tall, 36 cm diameter aluminum tube adapted from a device developed for work in Alaskan Streams (Whitman *et al*., 2003). The tube is fitted with a clear Plexiglas bottom, and mounted on 5 cm high legs. A darkened, removable lid with camera mount and viewing hole sits on top of the tube. The tube design blocks all light except that which filters in from the bottom.

By using a digital camera with polarizing filter, sharp, high-resolution images can be acquired in a variety of light conditions. A height-adjustable rod attached to the side allows the device to be used in clear water to depths of roughly 1 meter. The device can be used in moderately turbid water provided flow depth is small as the base can be placed near the bottom, minimizing the thickness of the water column through which the picture is taken. Results of the substrate analysis are provided in Section 3.

3 RESULTS

3.1 HYDROLOGIC ANALYSIS

Daily discharge records were provided by BC Hydro for the period July 1, 2010 to March 31, 2012 to review flows from the end of Year 5 through the extent of the Year 7 monitoring. The record is not continuous, with a gap from mid May to early July, 2011. **Figure 2** presents the hydrograph from the end of Year 5 through the entire Year 7 monitor with the survey and sample dates and required target flows noted. Mean daily discharge for each of the channel surveys and substrate sample collections is presented below:

- 01 November 2011: 1.57 m^3/s; and
- 23 February 2012: 2.76 m^3/s.

The current Water Use Plan indicates that a minimum flow of 1.1 m^3/s is targeted during the spawning cycle (Sept 15 – Nov 30). The data provided by BC Hydro shows that minimum flow targets were met only during a single day during the first 11 days of the spawning cycle, but were consistently met after this period. The final day that flows remained below target (September 24) corresponds to the peak count of pink salmon escapement (Greenbank and Macnair, 2012a).

Low flow conditions are most problematic when spawner escapements are large, as this can lead to potential redd superimposition. With reduced physical spawning habitat area, returning adults spawn on top of previous laid redds. However, since returning pink salmon spend some period of time in the channel before spawning during migration and redd selection, it is unlikely that the low flows in mid to late September would have significant limitation on the availability of spawning habitat for the majority or returning pinks. Chum salmon escapement peaks more than a month later, so they would not have been affected by lower flows at all. However, chum salmon may have spawned on top of previous pink redds causing loss of eggs and potential production. Given the partial overlap in habitat use, this is a potential issue during every pink spawning year.

The occurrence of high flows causes changes in channel morphology and substrate quality. Newbury Hydraulics (2004) estimated bankfull discharge to be roughly 20 m^3/s. The bankfull discharge is able to reshape alluvial channel dimensions by eroding banks and transporting bed material. The available data reveal a peak daily flow of 15.5 m^3/s on January 14, 2011 with peak instantaneous flows reaching 22.6 m^3/s during that same day. Preliminary data provided by BC Hydro reveal even larger flows during a rainstorm on January 16-17th with a peak hourly flow of 47 m^3/s on January 16 and flows above estimated bankfull discharge for a total of 40 consecutive hours. It is therefore expected that there would have been significant local changes in channel morphology since the Y5 surveys.

High flow events that occur during the incubation period are of particular interest since they can scour and disturb existing redds containing eggs and alevins. The mean daily flow reached 8.3 m^3/s on September 27 (with a peak instantaneous flow near 15.5 m^3/s as reported by Greenbank and Macnair, 2012a). The authors note that this flow eroded away existing right bank bar deposits between the rock weir and Lorenzetta Creek, more than doubling active channel width, increasing the wetted area from 484 m^2 to 1172 m^2 and scouring to a depth of 2 metres. These morphologic changes would likely have resulted in the destruction of redds within this section of channel. However, Greenbank and Macnair (2012a) add that the erosion greatly expanded the area available for spawning, and densely coverage of pinks redds were present at the end of September.

Similar flows were recorded in late November, late February and early March additional redds may have either scoured or been buried prior to emergence. Habitat stability is reviewed in the following section of this report.

3.2 HABITAT STABILITY MONITORING

Significant lateral shifts in wetted channel position occurred at the two downstream sections between 2008 and 2010 based on a comparison of available orthophotos (NHC, 2010). There are no current orthophotos to define and describe changes that have since occurred, but it is known that there have been major changes near XS 4.

In recent years, there have been large changes between XS 6 and XS 8 where the channel widens and sand and gravels accumulate as bars. A new section (XS 7) has been established to monitor changes at this location in the future. Upstream sections are laterally stable, but there has been significant vertical bed aggradation and degradation during the period of monitor. The magnitude of these changes is not surprising for an alluvial fan, and significant morphologic changes can occur during flows in the range of 8-10 m^3/s which is much smaller than bankfull discharge on lower Jones Creek.

Cross-sectional areas of net scour and fill are computed by comparing sequential cross-section profiles. Vertical differences in bed elevation of 10 cm or less are considered within the range of survey error due to the irregularity of the channel bed. Minor differences in elevation also occur due to small deviations from the previous survey line during the time of survey. Chainage and elevation values recorded by the total station are exported to a spreadsheet for plotting. Scour and fill polygons are calculated using GIS tools. The points that define each transect are connected by lines, with an additional line added that connects left and right bank tops to ‘close’ each polygon. By overlying closed polygons for consecutive survey dates, scour and fill areas are automatically calculated and stored in the GIS database.

The results of five sets of channel surveys dating back to October, 2009 are shown in **Figure 3** and **Figure 4**. Surveyed profiles have been overlaid for each of the dates using the cross-section benchmarks for vertical and horizontal control and distance is plotted from the left bank marker. Measured changes in cross-sectional area are shown in **Table 2** (scour area) and **Table 3** (fill area). Net values (i.e. scour minus fill) are given in **Table 4**.

Between February and March 2010, there was modest aggradation at all sections downstream of XS 10, with apparently large deposition at XS 6. As previously noted (NHC, 2010) discharge remained less than 1 m^3/s during this reporting period so the change likely reflects survey imprecision or possibly one of the surveys was not on the correct line. By November, 2011 there was scour at all sections, much of which likely occurred during the high flow event on January 14, 2011. A similar pattern was observed between October 2009 and February 2010.

This pattern suggests a period of supply-limited conditions to the fan from upstream sediment sources (i.e. there have been no recent landslides). Changes to February 2012 appear to represent active sediment transport in the main channel during intermediate flows (approx. 8 m^3/s). The most significant change is observed at XS 4 where there was additional erosion of the large right bank point bar deposit. Additional discussion of the magnitude of changes at each cross section is provided below. Site photographs at associated PDPs are presented in **Appendix A**.

Table 2: Measured scour area – Year 5 to Year 7

Study Period	Section 4	Section 6	Section 8	Section 9	Section 10
Feb 10 – Mar 10	1.33 m^2	0.04 m^2	1.47 m^2	0.17 m^2	1.45 m^2
Mar 10 – Nov 11	5.98	9.39	7.24	3.76	5.53
Nov 11 – Feb 12	9.34	1.54	0.07	2.11	0.55

Table 3: Measured fill area – Year 5 to Year 7

Study Period	Section 4	Section 6	Section 8	Section 9	Section 10
Feb 10 – Mar 10	2.90 m^2	5.55 m^2	1.64 m^2	2.87 m^2	0.46 m^2
Mar 10 – Nov 11	0.30	0.36	0.01	0.27	2.13
Nov 11 – Feb 12	0.09	1.14	2.74	0.59	2.23

Table 4: Net scour and fill – Year 5 to Year 7

Study Period	Section 4	Section 6	Section 8	Section 9	Section 10
Feb 10 – Mar 10	+ 1.57 m^2	+ 5.51 m^2	+ 0.17 m^2	+ 2.70 m^2	- 0.99 m^2
Mar 10 – Nov 11	- 5.68	- 9.03	- 7.23	-3.49	- 3.40
Nov 11 – Feb 12	- 9.25	- 0.40	+ 2.67	- 1.52	+ 1.68

3.2.1 SECTION 10

Section 10 (XS 10) is located in the incised portion of channel below the anadromous barrier. From there, it extends a total length of 280 m, ending halfway to XS 9 downstream. It exhibits a simple morphology characterized by a well established lateral bar on the right bank that gently slopes towards the left bank thalweg. There are occasional boulders found within the wetted low flow channel that would only move during exceptional flows. Between March 2010 and November 2011, there was net scour averaging 11 cm but the channel bed was largely unchanged and most of this loss is attributed to recession of the step left bank. The bed remained stable to February 2012 (**Figure 4**) and there was apparent deposition on the right bank that likely reflects a difference in survey detail – the bank is steep and difficult to access.

3.2.2 SECTION 9

Sections 9 (XS 9) is also located in the incised portion of channel on the upper fan (PDPs 8 and 9) and has a total length of 108 m (the shortest representative length of all study sections). The section has a trapezoidal channel shape, characterized by a flat bed that gently slopes downward towards the left bank terrace, exposing a minor right bank lateral bar at lower flows. Between March 2010 and November 2011 there was an average bed lowering of 13 cm which was previously attributed to degradation through existing deposits and supply limited conditions upstream. There was further degradation averaging 6 cm by February 2012 which is within the limits of survey precision but could reflect continued incision.

3.2.3 SECTION 8

Section 8 (XS 8) is located within a length of channel that exhibits similar morphology to that found at XS 6 downstream. The section has a total length of 164 m. The morphology at this section has become more complex since 2008/9 as a minor chute channel has developed and enlarged, bifurcating an existing, extensive point bar deposit, and the main channel thalweg has deepened. From March 2010 to November, 2011 there was a net degradation of 20 cm, but by February 2012, the bed had aggraded by 7 cm, mainly in the thalweg. There was a marked fining of bed material during this period (the D_{50} decreased from roughly 13 mm to 5 mm) which is consistent with a large influx of sand. Large transient deposits of sand have previously been observed at this location.

3.2.4 SECTION 7

Section 7 (XS 7) is a new transect established in the widest (~60 m) and most morphologically complex section of channel. The thalweg is bounded by a large point bar on the left bank and mid channel bar bear the right bank. A smaller, shallow secondary channel is found adjacent to the right bank (**Figure 1**). An engineered log jam(s) in the right bank bend immediately downstream of the section maintains the channel in its present course. There are no previous surveys at this location so it is not known if there are recent bed level changes.

3.2.5 SECTION 6

The 171 m long XS 6 is located roughly 100 m upstream of the rock weir in a generally widened section of channel characterized by frequent bar deposits. The thalweg is located near the left bank and has remained nearly fixed in position since 2009 (**Figure 3**) while there have been significant changes to the large left bank lateral bar and smaller min channel bar. By March, 2010 the bed had aggraded by an average of 14 cm, and there was subsequent degradation averaging 22 cm by November, 2011 which is the largest measured at any section. The bed remained nearly stable to the next survey period in February, 2012. In general, repeating cycles of aggradation and subsequent erosion at this location may affect egg-fry survival, although the effect was minimal for 2011 spawners.

3.2.6 SECTION 4

Section 4 (XS 4) is located immediately downstream from a recently lowered weir and extends downstream past the Lorenzetta Creek confluence to Fraser River and halfway upstream to XS 6, a total length of 265 metres. The creek channel below the weir is subject to seasonal backwater from the Fraser River during the late spring freshet when bed filling of up to a metre or more can occur (see **Photo 1**).

It was previously suggested (NHC, 2006) that this section is less likely to experience sediment deposition than XS 6 and XS 8 upstream because the channel at XS 4 is narrower and faster-flowing – i.e. bed material is transported through this section, not deposited. Repeat surveys, however, indicate that this is also an active section of channel with aggradation occurring during the summer when high water on Fraser River creates a backwater effect, and this material is removed during high creek flows in the autumn and winter. The rock weir actually creates a steep channel gradient downstream that is conducive to sediment transport.

There was 13 cm average bed degradation between March 2010 and November 2011 as previously deposited bar material on left and right channel banks was scoured to increase flow conveyance. There were additional large changes to February 2012 with a mean bed lowering of 21 cm that extended across the entire channel width (**Figure 3**). The large amount of scour at this section is also likely to negatively impact fish productivity.

3.3 HABITAT STABILITY WEIGHTED BY FISH UTILIZATION

In order to relate importance of substrate stability to fish habitat and productivity, proportional fish use within each cross-section was estimated. The fish productivity monitoring studies (Greenback and Macnair, various dates) divide lower Jones Creek into four transects of measured length, extending from the Fraser River confluence upstream past Laidlaw Road to the anadromous fish barrier, a total distance of 935 metres. Cross-sections boundaries extend mid-way up and downstream to the next section, and were extended to match the endpoints defined by the fish monitor to facilitate direct comparison.

The total channel length represented by the cross sections is 988 m. This discrepancy was previously noted (NHC, 2008) and was explained as an under-reporting of distance between Lorenzetta confluence and Fraser River in the fish monitoring study. In order to make the two study lengths match, the representative length of XS 4 (the downstream transect) was reduced to 132 metres (the half distance to XS 6) plus 80 metres, for a total length of 212 metres.

The percentage of each fish sampling section represented by each surveyed cross-section was calculated by determining the common overlapping length, as summarized in **Table 5**. These fractions are multiplied by the total escapement figures for 2011 (i.e. XS 4 represents 100% of the fish in S1 and S2, and 4% of the fish in S3) to determine the proportion of the total escapement represented by each substrate cross-section with corresponding escapement values in **Table 6**.

Proportional escapement figures are also provided for the years 2007 and 2009 for comparison. Total escapement figures for 2011 are 92 Chum salmon and 7,569 pink salmon (Greenbank and Macnair, 2012a). The chum escapement figures are below average, while pink escapement is the second highest value since reporting commenced in 1999 (only 3% smaller than the highest value reported in 2009).

Table 5: Proportionate fish escapement (2011) by substrate XS

XS	Length	% of fish section within each substrate XS				% of escapement	
		S1	S2	S3	S4	Chum	Pink
4	212 m	100 %	100 %	4 %	0 %	26%	13%
6	171 m	0 %	0 %	30 %	0 %	18%	25%
8	164 m	0 %	0 %	29 %	0 %	17%	24%
9	108 m	0 %	0 %	19 %	0 %	11%	15%
10	280 m	0 %	0 %	18 %	100 %	28%	23%

Table 6: Pink and chum salmon escapement over time by XS

XS Year	Chum 2007	Pink 2007	Chum 2009	Pink 2009	Chum 2011	Pink 2011
4	29	226	48	655	24	1,005
6	26	749	88	2,011	16	1,862
8	25	718	85	1,928	16	1,786
9	17	473	56	1,270	10	1,176
10	35	999	140	1,957	26	1,740
Total	132	3,167	417	7,820	92	7,569

The proportion of pink salmon in each representative cross section was very similar in 2009 (NHC, 2010) while the proportion of chum in XS 4 is much higher in 2011 (26% vs. 12% in 2009) and decreased a few percentage points in all upstream sections. In 2007, 22% of chum were found in Section 4 so the result does not appear anomalous. While the proportion of Chum in XS 10 declined from 34% in 2009, it remains the highest used habitat. In 2005, both chum and pink salmon showed a strong preference for XS 4 and XS 10, which accounted for nearly 80% of total escapement. While these locations continue to be preferential habitat for chum salmon, pink distribution is more widely spread out. The large increase in pink escapement since 2009 (relative to previous years) may have forced a change in habitat utilization due to competition for space.

The proportional fish use can be used to weight the cross-sectional area changes between November 2011 and February 2012, the period during which redds would be subject to negative impacts from channel change. Scour and fill values during this period are summed; absolute values are used for the calculations since both scour and fill have the same negative impact. The total areal change at each cross-section is normalized by the escapement values. These scaled values are then multiplied by the original area to adjust the weighting at each cross section (**Table 7**).

In effect, cross-sections that have above average use by fish are given an adjusted (expanded) area of change, while sections that have lower than average use have a reduced area, but the total remains the same. The rationale behind this approach is that a cross-section may show a large areal change over time (i.e. high values of scour and fill) but this change is less important relative to other sections if it has a lower relative enumeration. Similarly, a section with no spawners would have no weight, and its effective area of net change would be reduced to zero. The results of this weighted area change analysis are summarized below.

Section 4 closely corresponds to fish sampling sections S1 and S2 (Greenbank and Macnair, 2012a). In 2011 (as in 2009), it had a lower total pink salmon escapement than upstream monitoring sections. However, the weighted area change at this section is 7.03 m^2 – higher than at all other sections (the average change across all sections is 4 m^2). Despite the large amount of degradation at XS 4, it is not likely to have had a major impact on the overall spawning success of pink salmon. The erosion also occurred in late September, before most chum entered the channel, so would not have impacted their spawning success.

Section 6 corresponds to the downstream limit of fish sampling section S3 (Greenbank and Macnair, 2012a). In 2011, it had the highest total pink salmon escapement, the same as in 2009. The weighted area change is near the average for all sections. Section 8 has similar numbers for pink escapement, and the weighted area change is nearly identical to that of XS 6. Egg-fry survival rates in these sections should be higher than in XS 4 downstream.

Section 9 encompasses 19% of the total length of S3 and correspondingly had the lowest pink escapement total upstream of section 4, the same result as in 2007 and 2009. Adjusted cross-section area changes are 2.3 m^2 for pink, the smallest value for all sections. Therefore, erosion and deposition should have a reduced impact on spawning success relative to other sections of channel. Section 10 extends upstream to the impassable fish barrier, and roughly corresponds to the upstream 18% of S3 and the entire length of S4. This section had similar escapement values to XS 6 and XS 8. Adjusted cross-section area changes are 3.6 m^2 for pink, which is somewhat below average. In general, these results indicate that it is unlikely that morphologic changes would have had a significant impact on egg-fry success for chum or pink salmon in 2011. Preliminary results from Greenback and Macnair (2012b) support this assertion with reported egg-fry survival rates of 2.24% for pinks (equal to the long term post-WUP average) and 1.98% for chum (above average). Redd superimposition was likely a problem in 2011 due to high spawner density for pinks and may have suppressed spawning success in 2011 (Greenbank and Macnair, 2012b).

Table 7: Cross-section changes weighted by fish escapement, Nov 2011 - Feb 2012

XS	Total area change	% of escapement		Weighted area	
		Chum	Pink	Chum	Pink
4	9.43 m^2	26.2	13.3	11.17 m^2	7.03 m^2
6	2.68 m^2	17.8	24.6	2.12 m^2	3.70 m^2
8	2.81 m^2	17.0	23.6	2.22 m^2	3.72 m^2
9	2.70 m^2	11.2	15.5	1.33 m^2	2.36 m^2
10	2.78 m^2	27.8	23.0	3.57 m^2	3.59 m^2
Sum	20.4 m^2	100	100	20.4 m^2	20.4 m^2

3.4 SUBSTRATE QUALITY MONITORING

Substrate photographs were analysed by measuring the b-axis of each particle underlying a grid node from the digital photographs using GIS software. A metal bar of known dimensions that is placed on the bed when the photos are taken is used to scale each image. A 64 mm x 64 mm ‘digital’ sampling grid was created in the GIS and superimposed on the digital images. The 64 mm grid size coincides with the grain-size break between gravel and cobbles, and is used as the truncation limit for the grain size analysis.

The dimensions of each measured particle are measured to the nearest tenth-millimetre and stored in a database. All clasts smaller than 1 mm (the upper limit for coarse sand) were assigned an arbitrary value of 0.5 mm. The b-axis dimension of particles smaller than 1 mm cannot be reliably measured from the substrate photographs. Size fractions are based on particle counts for different size classes, so it is not necessary to have an accurate measurement of grains less than 1 mm diameter.

The actual number of samples that can be obtained from each photo depends upon the bed material texture, with fewer counts recorded where there are clasts larger than 64 mm. By taking 6 total photos along each transect, the pooled samples generally provide truncated samples in excess of 100 stones which has statistical significance. Counts only exceeded the 100 criteria at XS 8 in November and XS 4 in February as the supply limited conditions upstream appears to have resulted in a winnowing of finer material in Lower Jones Creek resulting in greater exposure of larger clasts on the surface.

The fraction of measured grains falling within the three indicative size ranges – very fine (less than 1mm), fine (greater than 1 mm and less than 10 mm) and coarse (greater than 10 mm and less than 64 mm) fractions – are presented in **Table 8** to **Table 12** for each cross-section transect, extending back to the Year 3 surveys. The Year 3 report (NHC, 2008) provides results that extend back to Year 1 of the monitor.

Grain size distributions, along with example site and substrate photographs from each transect are also provided in **Appendix B**. Changes in grain-size distributions at each section between sample dates are also given. The values are differences in the percentage values between consecutive dates. Grain-size distributions for each of the cross-sections and sample dates are presented in **Figure 5** to **Figure 9**. For clarity, only data from Year 5 and Year 7 are shown on the graphs. A discussion of changes at each cross-section is given below.

3.4.1 SECTION 4

There has been a general increase in very fine sediment at the downstream cross section since the monitoring program began to March, 2010 but more recent monitoring shows no sand at all that has resulted in a significant coarsening of the bed (**Figure 5**,**Table 8**). The significance of change is determined by comparing cumulative frequency distributions for any two sampling dates using the Kolmogorov-Smirnov (KS) test for two independent samples. The test compares the maximum difference at different points along the distribution (chosen at half-phi size intervals, i.e. at 5.6 mm, 8 mm, 11.3 mm, etc.).

Between March 2010 and November 2011, the largest deviation (difference in cumulative percentages) was found at the 1 mm break (0.3). This value is much larger than the critical value of 0.21 (2-tail) at the 5% significance level, so it is concluded that the two samples are drawn from populations with different particle size distributions. This difference can be attributed to an overall coarsening of the bed as fine sediments were removed. There is no significant change in the grain size distribution by February 2012.

Table 8: Substrate grain size and grain size changes, XS 4

Date	D < 1 (mm)	1 < D < 10 (mm)	10 < D < 64 (mm)
Nov 5, 2007	7%	11%	82%
Jan 25, 2008	10%	27%	63%
Mar 19, 2008	15%	28%	57%
Oct 28, 2009	10%	32%	58%
Feb 03, 2010	12%	14%	74%
Mar 18, 2010	30%	21%	49%
Nov 1, 2011	0%	31%	69%
Feb 23, 2012	0%	24%	76%
% Change	**D < 1**	**1 < D < 10**	**10 < D < 64**
Nov – Jan	+ 3	+ 16	- 19
Jan – Mar	+ 5	+ 1	- 6
Mar – Oct	- 5	+ 4	+ 1
Oct – Feb	+ 2	- 18	+ 16
Feb – Mar	+ 18	+ 7	- 25
Mar – Nov	- 30	+ 10	+ 20
Nov – Feb	0	- 7	+ 7

3.4.2 SECTION 6

There were major changes in all size fractions between October 2009 and February 2010 resulting in a significant change in the overall grain size distribution (**Figure 6, Table 9**) as the amount of fine sands increased from only 2% to 51%, significantly altering the overall distribution. The very fine fraction increased to 63% by March 2010. By November 2011, this fine material had been removed, resulting in a significant coarsening of the bed. The November 2011 grain size distribution is nearly identical to that measured in October 2009. There was no significant change in the grain size distribution to February 2012.

The transport and deposition of sands, which can be mobilized by modest flows, creates these large changes. These deposits are generally transient, but may be harmful if they persist for extended periods during incubation. The lack of sand on the bed in Sections 4 and 6 during the Year 7 spawning and incubation period may be beneficial to fish productivity, though this is countered by the effects of degradation at XS 4.

Table 9: Substrate grain size and grain size changes, XS 6

Date	D < 1 (mm)	1 < D < 10 (mm)	10 < D < 64 (mm)
Nov 5, 2007	0%	10%	90%
Jan 25, 2008	0%	8%	92%
Mar 19, 2008	14%	18%	68%
Oct 28, 2009	2%	4%	94%
Feb 03, 2010	51%	9%	40%
Mar 18, 2010	63%	8%	29%
Nov 1, 2011	0%	16%	84%
Feb 23, 2012	0%	14%	86%
% Change	**D < 1**	**1 < D < 10**	**10 < D < 64**
Nov – Jan	0	- 2	+ 2
Jan – Mar	+ 14	+ 10	- 24
Mar – Oct	-12	- 14	+ 26
Oct – Feb	+ 49	+ 5	- 54
Feb – Mar	+ 12	- 1	- 11
Mar – Nov	- 63	+ 8	+55
Nov – Feb	0	- 2	+ 2

3.4.3 SECTION 8

There have also been substantial changes in the substrate grain-size distribution at Section 8 over the monitoring period (**Figure 7**, **Table 10**). Between October 2009 and February 2010, the amount of very fine material increased to 54%, producing a much finer size distribution overall (while the fine and coarse gravel fractions also declined). By March 2010, the very fine and fine fractions declined, while the coarse fraction roughly doubled.

By November, 2011, some of the finer sediments were removed, but the K-S test reveals that the two distributions are not significantly different. By February 2012, there was an increase in the <1 mm and 1-10 mm fractions that caused a significant fining of the bed. This influx of this fine sediment would negatively impact egg-fry survival rates.

Table 10: Substrate grain size and grain size changes, XS 8

Date	D < 1 (mm)	1 < D < 10 (mm)	10 < D < 64 (mm)
Nov 5, 2007	25 %	22 %	53 %
Jan 25, 2008	-	-	-
Mar 19, 2008	24 %	37 %	40 %
Oct 28, 2009	3 %	42 %	55 %
Feb 03, 2010	54 %	22 %	24 %
Mar 18, 2010	38%	11%	51%
Nov 1, 2011	24%	13%	63%
Feb 23, 2012	31%	28%	41%
% Change	**D < 1**	**1 < D < 10**	**10 < D < 64**
Nov – Mar	-1	+ 15	- 13
Mar – Oct	- 21	+ 5	+ 15
Oct – Feb	+ 51	- 20	- 31
Feb – Mar	- 16	- 11	+ 27
Mar – Nov	- 14	+ 2	+ 12
Nov – Feb	+ 7	+ 15	- 22

3.4.4 SECTION 9

Section 9 is steeper, narrower and faster flowing than the downstream cross-sections. As a consequence, the very fine sediment fraction has consistently remained very low (**Figure 8, Table 11**). There have been comparatively larger changes in the fine and coarse fractions, but the full grain size distribution exhibits little variability over time and there have been no significant changes in the distribution since 2007. Egg-to-fry survival rates near XS9 are apt to be higher than at any other location in Lower Jones Creek.

Table 11: Substrate grain size and grain size changes, XS 9

Date	D < 1 (mm)	1 < D < 10 (mm)	10 < D < 64 (mm)
Nov 5, 2007	1 %	16 %	84 %
Jan 25, 2008	1 %	24 %	74 %
Mar 19, 2008	2 %	24 %	74 %
Oct 28, 2009	2 %	14 %	83 %
Feb 03, 2010	1 %	32 %	67 %
Mar 18, 2010	4%	20%	76%
Nov 1, 2011	0%	23%	77%
Feb 23, 2012	4%	24%	72%
% Change	**D < 1**	**1 < D < 10**	**10 < D < 64**
Nov – Jan	0	+ 8	- 10
Jan – Mar	+ 1	0	0
Mar – Oct	0	- 10	+ 9
Oct – Feb	- 1	+ 18	- 16
Feb – Mar	+ 3	- 12	+ 9
Mar – Nov	- 4	+ 3	+ 1
Nov – Feb	+ 4	+ 1	- 5

3.4.5 SECTION 10

Section 10 has a similar morphologic configuration to Section 9 but has experienced considerably greater changes in the grain size fractions (**Figure 9**, **Table 12**). This is likely related to the presence of occasional large rocks and boulders that create sheltered areas where finer sediments can deposit. The very fine fraction was measured at 39% in March 2009 but has since declined as finer material was winnowed away. There was no sand at all on the bed in the November 2011 survey.

There was also a consistent, albeit modest, increase in the fine and coarse fractions over this same period (though the most recent comparative period shows a modest decrease in the coarse fraction). Changes in the grain size distribution since March 2010 are not significant. It is expected that egg-fry survival rates are relatively high in this section of channel.

Table 12: Substrate grain size and grain size changes, XS 10

Date	D < 1 (mm)	1 < D < 10 (mm)	10 < D < 64 (mm)
Nov 5, 2007	0 %	6 %	94 %
Jan 25, 2008	9 %	10 %	81 %
Mar 19, 2008	39 %	12 %	49 %
Oct 28, 2009	31 %	3 %	66 %
Feb 03, 2010	20 %	4 %	76 %
Mar 18, 2010	8%	10%	82%
Nov 1, 2011	0%	16%	84%
Feb 23, 2012	8%	20%	72%
% Change	**D < 1**	**1 < D < 10**	**10 < D < 64**
Nov – Jan	+ 9	+ 4	- 7
Jan – Mar	+ 30	+ 2	- 32
Mar – Oct	- 8	- 9	+ 17
Oct – Feb	-11	+ 1	+ 10
Feb – Mar	- 12	+ 6	+ 6
Mar – Nov	- 8	+ 6	+ 2
Nov – Feb	+ 8	+ 4	- 12

The percentage of fine and very fine sediments reported for each cross-section is assumed to represent the substrate quality for the length that each section represents. This assumption is necessarily tenuous as there can be substantial spatial variability in sediment texture on a single bar or within any section. However, the field effort required to fully describe the spatial heterogeneity of sediment texture is beyond the scope of this project.

As each cross-section has a different proportionate fish use, these figures also need to be appropriately weighted to summarize substrate quality for the entire study area. The proportional fish use can be used for this weighting, as applied to the cross-section area changes, except percentages are substituted for area values. The unadjusted and weighted values for the surveys between November 2011 and February 2012 (the period during which pink redds would be affected) are presented below for pinks (**Table 13**). The fine fraction as previously measured in March 2010 is shown for comparison.

Section 8 exhibits a much higher fine sediment fraction than average and is expected to have limited productivity relative to other sections of channel given the proportionately high fish use and potential burial through net deposition (**Table 2** to **Table 4**). For comparison, the total fine fraction is quite low in the section represented by XS 6 which should have much higher egg-fry survival rates than any other length of channel. For Year 7, this is an important distinction from Year 5 given historically high fish escapement at this location.

The weighted results for pink salmon do not change the results appreciably, but reduce the apparent impacts at Section 4 and Section 9 due to proportionately lower escapement in these sections. Comparative figures for chum salmon are given in **Table 14**. Chum and pink distributions are broadly similar, except at XS 4 which has proportionately much higher chum escapement. This increases the weighted fine fraction to 41% in November and 32% in February but substrate conditions are less of a consideration than channel stability for chum salmon at this location.

The pooled results (total of fine and very fine fractions) show a small increase in the total fine fraction during the Year 7 monitor at Sections 8, 9 and 10. Sections downstream have declining total fine fraction during the year, and show a large decrease since March 2010.

Table 13: Areal fraction (%) of study area covered by fine sediment with weighting for Pinks

XS	Total fine fraction (%) unadjusted				Total fine fraction (%) weighted			
	Mar 10	Nov 11	Feb 12	*Mean*	Mar 10	Nov 11	Feb 12	*Mean*
4	51	31	24	35	21	21	16	19
6	71	16	14	34	90	20	17	42
8	49	37	59	48	60	45	68	58
9	24	23	28	25	19	18	21	19
10	18	16	28	21	22	19	31	24
Mean	43	25	31	33	43	25	31	33

Table 14: Areal fraction (%) of study area covered by fine sediment with weighting for Chum

XS	Total fine fraction (%) unadjusted				Total fine fraction (%) weighted			
	Mar 10	Nov 11	Feb 12	*Mean*	Mar 10	Nov 11	Feb 12	*Mean*
4	51	31	24	35	31	41	32	35
6	71	16	14	34	80	14	13	36
8	49	37	59	48	53	33	53	46
9	24	23	28	25	17	13	16	15
10	18	16	28	21	32	23	41	32
Mean	43	25	31	33	43	25	31	33

Overall, the surface fine fractions are intermediate to high at sampled sections, but conditions are largely improved from Year 5. Ptolemy (pers. comm., as reported in NHC, 2001) indicated that good substrate should have no more than 10% material less than 10 mm, and poor substrate has up to 30% material less than 10 mm. Ptolemy's results were presented for Steelhead on Coquihalla River and do not strictly translate to requirements for different species but have been adopted as the biostandard for Coquitlam River. Kondolf (2000) notes that gravel quality criteria are inconsistent amongst different studies, but suggested that generalized results may be applicable.

For 50% redd emergence (considered as productive) the mean percentage finer than 1 mm was about 14% and the mean percentage finer than 9.5 mm was 28%. Adopting 30% fines as a conservative biostandard value for recruitment success, the mean total fine fraction is below the threshold during the incubation and emergence periods for all of lower Jones Creek in Year 7, except the length of channel represented by XS 8.

Historic productivity rates for lower Jones Creek have been low. McNair (pers. comm.) gives pink egg-smolt survival rates of less than 3% in 2005 and 2007, and only 0.6% in 2009. Comparative values for chum were slightly better than 1% in 2005 and 2007, increasing to 2.8% in 2009. For comparison, lower Fraser River biostandards for egg-fry survival are 9% for chum and 13% for pinks (BC Hydro, 2008). The total fine fraction on Coquitlam River is typically about 20% on average (since 2005) and survival rates have ranged from 8% to 18%. It therefore seems reasonable to suggest that substrate quality is adversely limiting fish productivity in lower Jones Creek, but Year 7 results show a modest improvement over most previous years.

4 SUMMARY

4.1 HABITAT STABILITY

Habitat stability in lower Jones Creek is examined through both repeat cross section surveys and mapping of channel morphologic features from periodic orthophotos. The purpose of this analysis is to address the management question of whether channel stability in lower Jones Creek is limiting fish productivity. In order to address this question, the following hypotheses are to be tested:

- H_1: In consideration of improvements to spawning habitat through increased spawning and incubation flows, fish productivity is not correlated to habitat instability in the anadromous reach of lower Jones Creek.
- H_{1a}: Fish productivity is not correlated to channel instability as measured by cross-sectional areas of scour and fill in the anadromous reach.
- H_{1b}: Fish productivity is not correlated to channel instability as measured by lateral channel migration involving abandonment of spawning habitat in the anadromous reach.

Channel changes observed on Lower Jones Creek in Year 7 were fairly modest compared to previous years. In Year 3, for example, an estimated 7500 m^3 of sand and gravel was deposited on the fan between April 2006 and November 2007. It is believed that this material derived from a large landslide on a small un-named tributary several kilometres upstream. Similar large sediments inputs have been documented in the past (cf. Hartman and Miles, 1997).

There was net scour at all sections between the end of Year 5 and the start of Year 7, suggesting a period of supply limited conditions from upstream sediment sources. There were only modest changes at most sections during the Year 7 incubation period. The exception is at the downstream section (XS 4) where the channel scoured a large right bank bar that was deposited during freshet flows on Fraser River; this creates a backwater effect on the lower 200 m of Jones Creek. This scour destroyed some early redds but also expanded available spawning habitat which was heavily spawned in late September. These findings indicate that channel instability was not likely a limiting factor for fish productivity during the recent year of monitoring, and this is largely confirmed by the preliminary results of Greenbank and Macnair (2012b) who calculated average spawning success for pinks and above average success for chum. However, the large sediment inputs that have occurred in the past are apt to re-occur in the future, reflective of the dynamic nature of the watershed and alluvial fan development.

In years with large floods, it appears that fish productivity is correlated to habitat instability, so H_1 can be rejected. Habitat instability is related to both scour and fill, as measured by repeat cross-section surveys, and to channel shifting. In the period between these events, however, the bed is apt to remain stable or slowly degrade to maintain flow conveyance and re-establish a stable grade. In the absence of new deposits and large floods capable of causing substantive re-mobilization of stored bed and bar sediments, fish productivity is likely only weakly correlated to habitat instability and H1 cannot be rejected for years with no large flood. Egg- fry survival rates from the recent period of monitor will help to support this supposition but additional years of monitoring are required to determine more definitive trends. While evidence to date suggests that stable habitat conditions provide a benefit in terms of improved spawning success and/or egg-fry survival – and conversely, instability is related to reduced productivity – there is insufficient data at present to fully support this statement.

There were no large changes in morphology during Year 7 except as the downstream monitoring section (XS 4). However, as pink escapement is low in this length of channel relative to upstream sections, channel shifting is probably not a limiting factor for pink salmon. Greenbank and Macnair (2012a) note that pink salmon were observed spawning in this location prior to a high flow in late September, 2011 that eroded away part of the existing bar and redds that were constructed there.

However, the authors point out that the potential number of redds destroyed would have been small relative to the total escapement estimate, and that the erosion increased the available area of spawning habitat and was densely spawned after the erosion occurred. Chum salmon escapement was very small in late September, with most of the fish arriving in mid October, so the erosion would had had minimal impact on chum productivity. This finding is important in that the impacts of channel morphology changes on spawning use, egg survival and fry recruitment appear strongly linked to the timing of channel changing flows in relation to key periods in life history.

4.2 SUBSTRATE QUALITY

Substrate quality in lower Jones Creek is examined through a comparison of substrate photos taken across each cross section line. The purpose of this analysis is to address the management question of whether substrate quality in lower Jones Creek is limiting fish productivity. In order to address this question, the following additional hypothesis is tested:

- H_2: In consideration of improvements to spawning habitat through increased spawning and incubation flows, fish productivity is not correlated to substrate quality as measured by substrate particle size in the anadromous reach of Lower Jones Creek.

The proportion of fine sediment (<10 mm) on the bed was generally lower during Year 7 relative to previous reporting periods. At XS 4, there was a statistically significant coarsening of the bed between March 2010 and November 2011, and no significant change to February 2012. During the Year 7 incubation period, the total fine fraction remained near the upper biostandard value of 30% fines less than 9.5 mm. A similar pattern was observed at XS 6, though the total fine fraction was much less than at all other sections, and this length of channel likely had the highest egg-fry survival rate.

There was a significant fining of the bed at XS 8 during Year 7 and the total fine fraction was much greater than the upper biostandard value. Given the high escapement in the length of channel, fish productivity was likely lowest in the section. There were no significant changes in the fine fraction at XS 9 and XS 10 and the total fine fraction remained below the upper biostandard threshold during Year 7, so fish productivity was likely not affected by changes in substrate quality.

Since monitoring began in 2005, egg- fry survival rate have been very low for both chum and pink salmon. This appears to be directly correlated to the high fraction of fines (<10 mm) sediment found on the bed. Fine sediment affects substrate quality by filling the interstices within the substrate, reducing oxygen and interflow through the redds, hence limiting egg survival because of poor incubation conditions. Over the course of the annual monitor during a given pink spawning year, roughly half the sections have a total fine fraction in excess of 30%, which is above the biostandard limit for fish productivity.

In addition, the average for the entire channel is at or above this threshold in most years. During Year 7, the average for the entire channel was below the upper threshold during spawning and just slightly above this threshold during incubation, the result of high fine content at a single section (XS 8). It is therefore expected that productivity – as measured by egg-fry survival – for the recent period of monitor may be higher than in previous years. While spawning success was higher than average for chum (1.98% compare to the post WUP mean of 1.59%, it was only average for pink salmon (Greenbank and Macnair, 2012b). There were very high spawning densities for pinks in 2011 and it is thought that red superimposition may have resulted in a suppressed egg-fry survival rate. Nevertheless, the total fine fraction is still high and likely explains why the freshwater survivals (egg-fry survival) and overall fish productivity (spawner escapements) is low on Jones Creek relative to other nearby systems.

While study results to date appear to demonstrate that H_2 can be rejected, additional monitoring is required to confirm these results. Final results from the Year 7 fish productivity studies will prove valuable in supporting this preliminary conclusion. Additional data will also be collected in Year 9, the last year of fish productivity monitoring prior to a program review, which will give five years of post-WUP egg-fry survival estimates for pink salmon (and 9 years for chum) which should be sufficient for definitively addressing the management questions.

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Northwest Hydraulic Consultants (2006). Wahleach Water Use Plan monitoring program: Lower Jones Creek channel stability assessment. Final Report Prepared for BC Hydro and Power Authority, Burnaby, BC. February 2006. 26 pp + appendices.

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FIGURES

WAHLEACH WATER USE PLAN MONITORING

Lower Jones Creek
Monitoring Sites

Scale - 1:2,500

50 25 0 50 100 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
northwest hydraulic consultants	project no. 300102	September 2012

Reference Map

Legend

⌖ Photo Documentation Point (PDP)

∧ Cross Section Alignment

NOTES:

1) CROSS SECTION LOCATIONS ESTABLISHED OCTOBER, 2005.
2) REFER TO FIGURE 3 FOR PLOTTED CROSS SECTIONS.
3) NINE (9) PHOTO DOCUMENTATION POINTS (PDP) ARE SHOWN ON THE MAP.
4) LOCATION OF SPAWNING REARING CHANNEL FEATURES AFTER 1973, (MMAL, 1997).
5) BACKGROUND ORTHOPHOTO CAPTURED APRIL 2010, PROVIDED BY BC HYDRO

MSN, \\192.168.100.12\projects\300102 WAHMON-2\GIS\300102_MSN_Fig_MonitoringSites1.mxd

Figure 1: Jones Creek monitoring sites

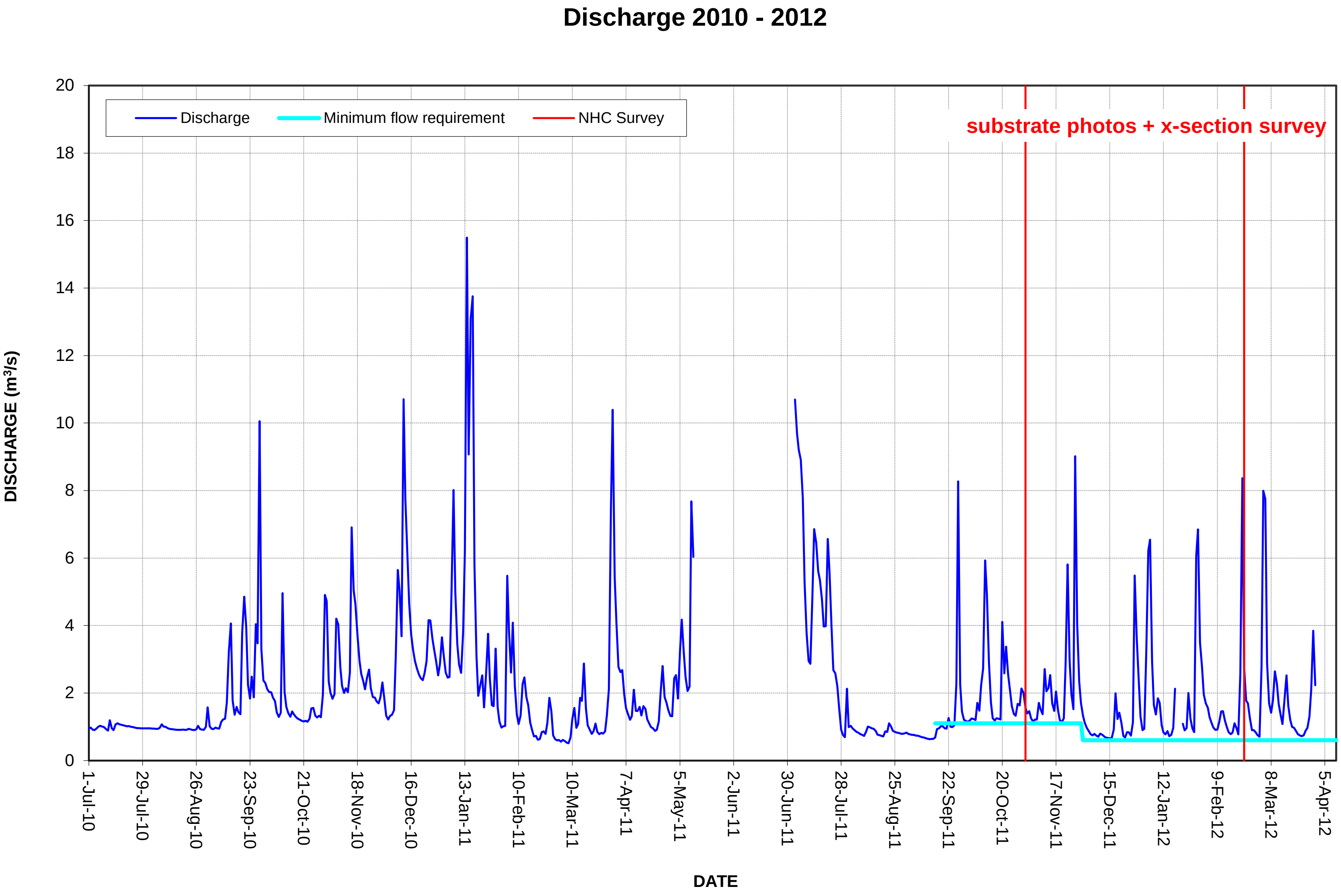
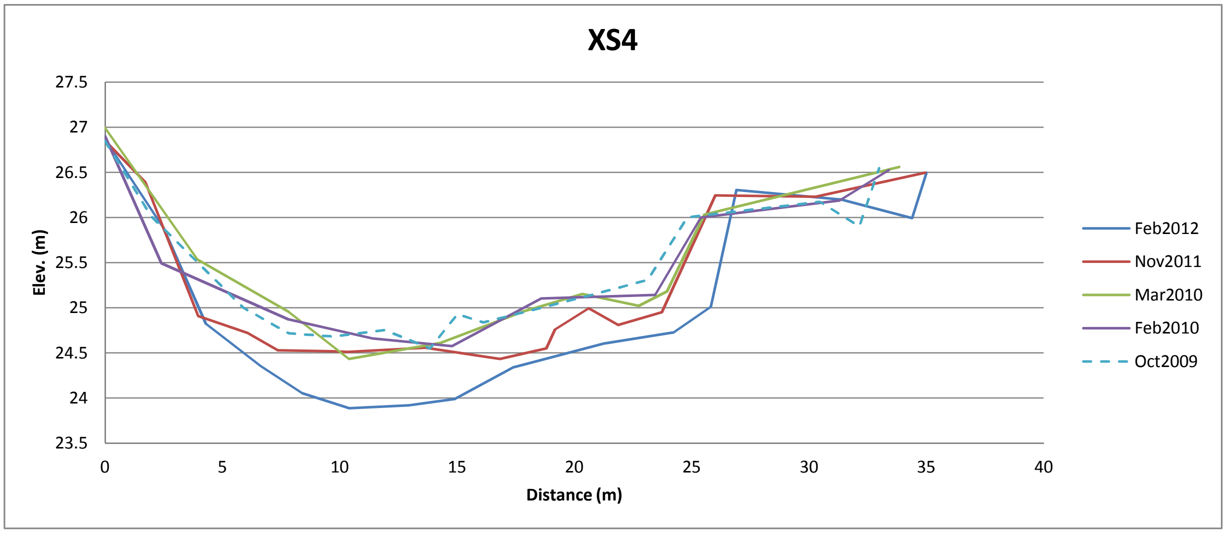
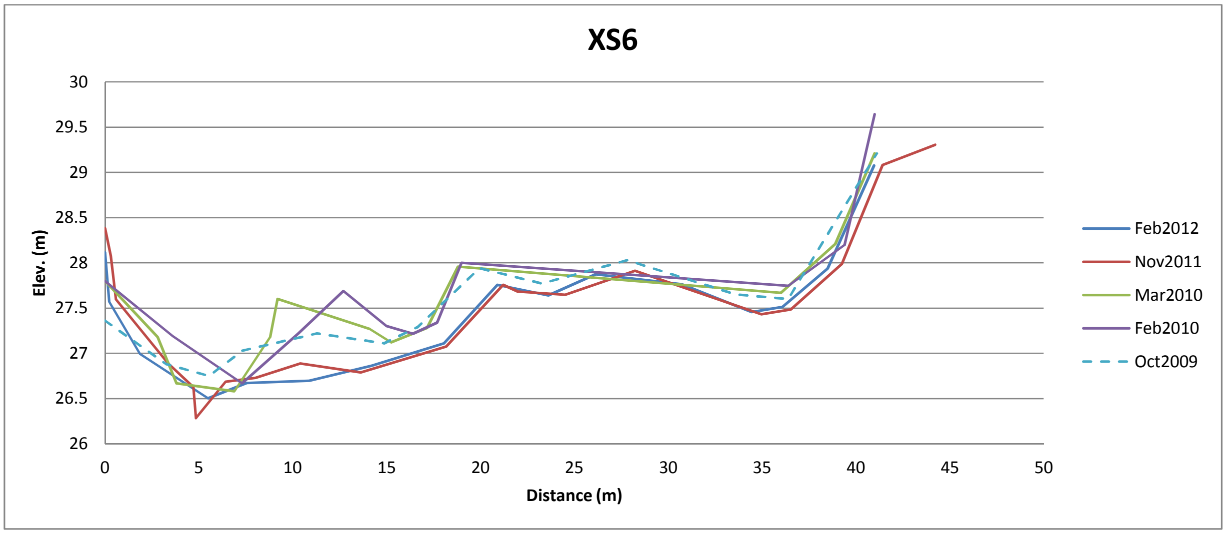


Figure 2: Jones Creek discharge with survey dates





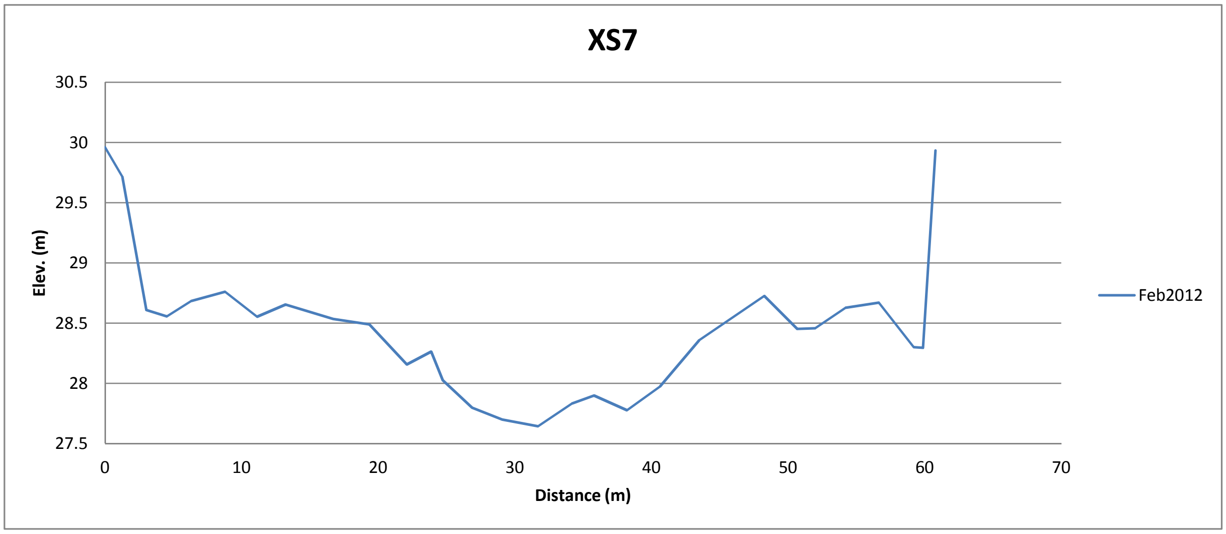
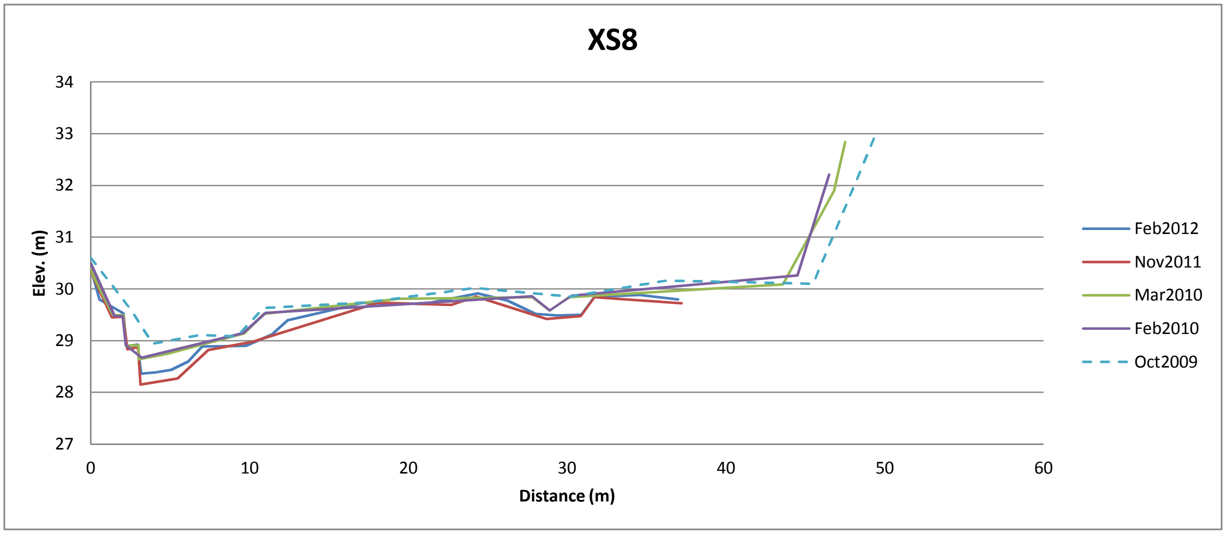
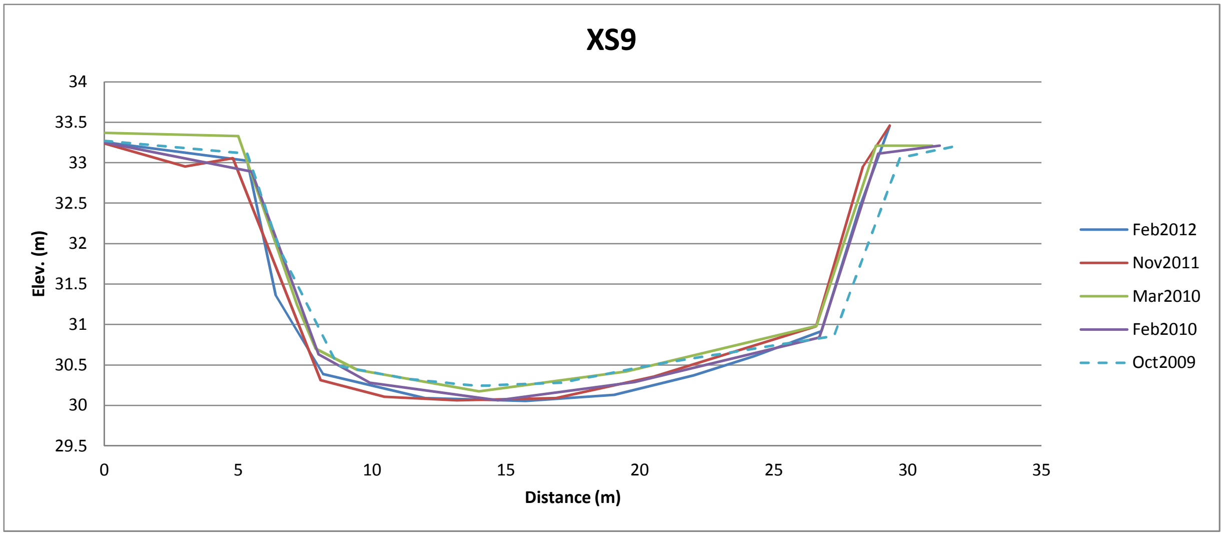


Figure 3: Changes at XS 4, 6 and 7





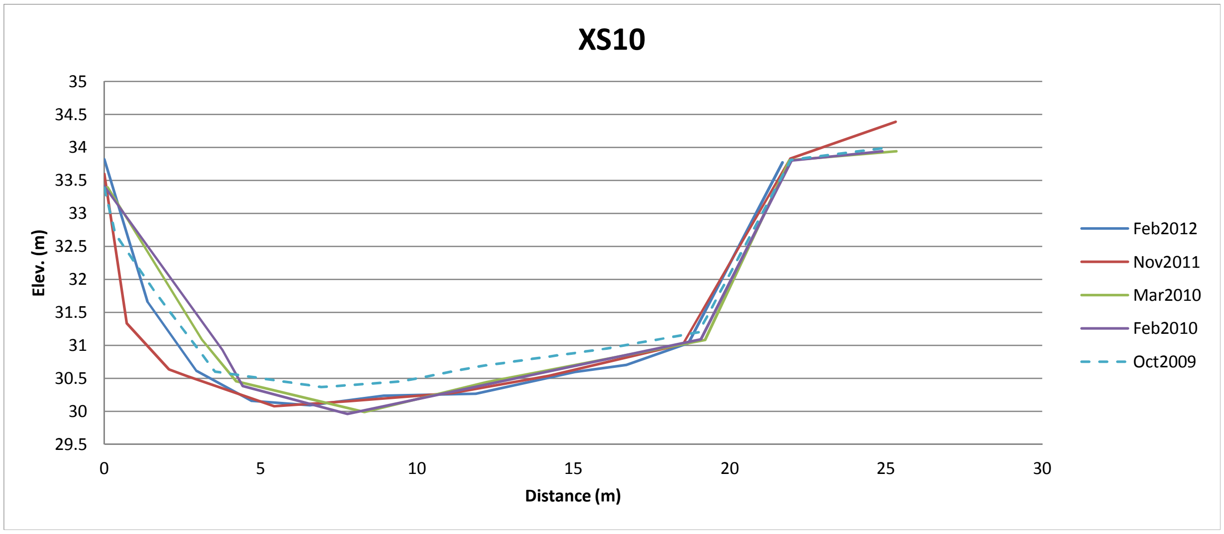


Figure 4: Changes at XS 8, 9 and 10

Figure 5: Section 4 grain size distribution

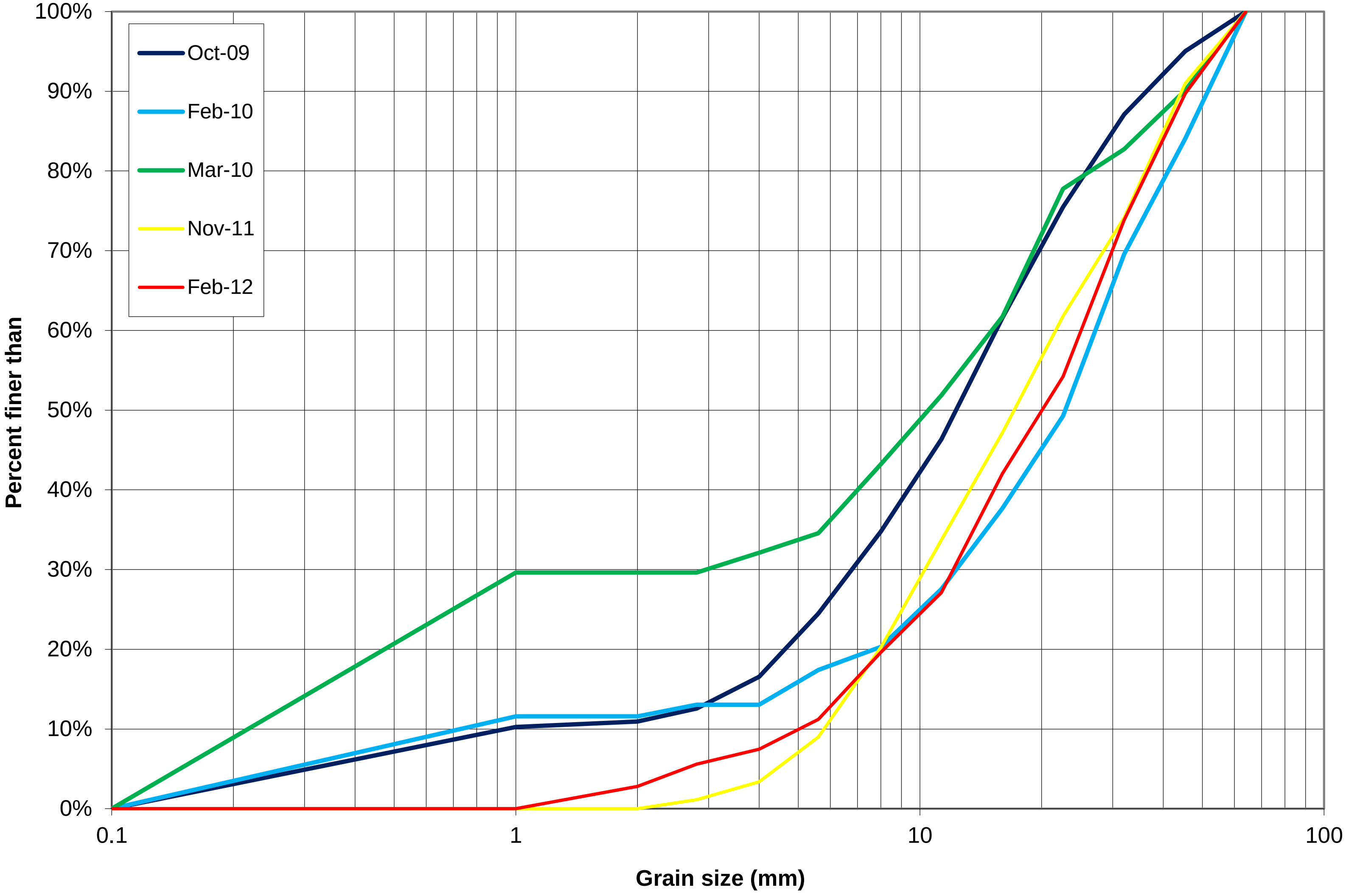


Figure 6: Section 6 grain size distribution

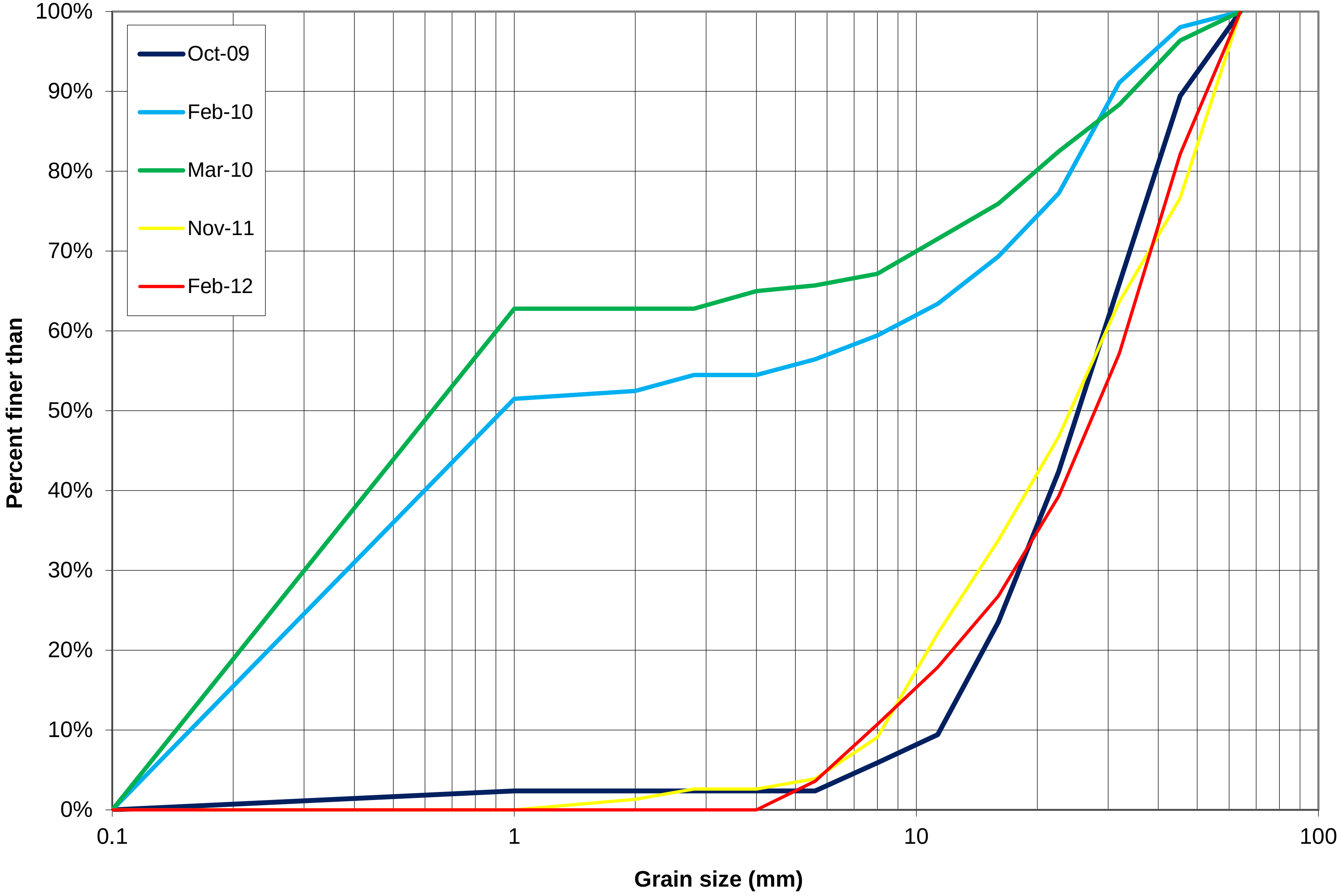


Figure 7: Section 8 grain size distribution

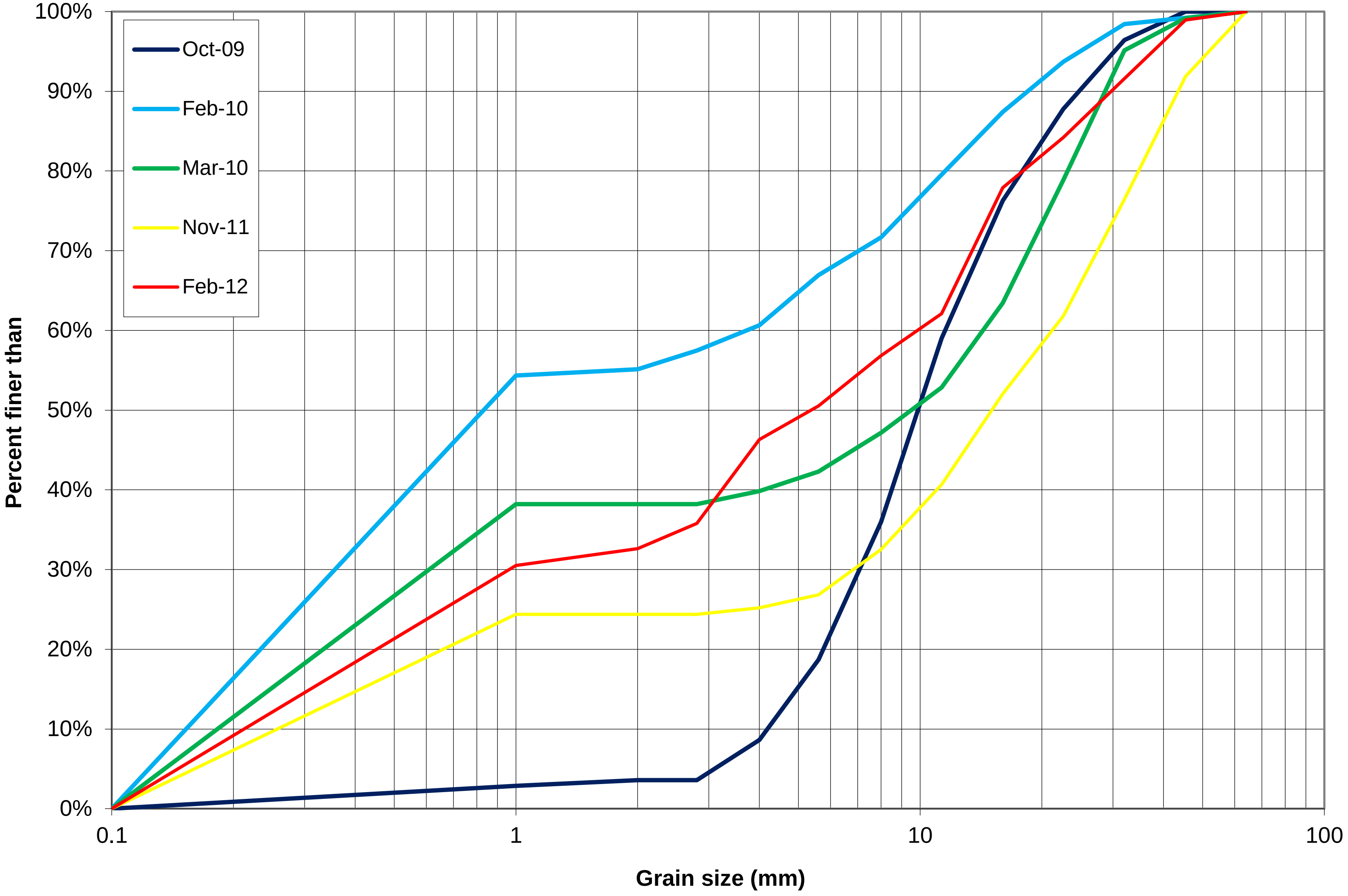


Figure 8: Section 9 grain size distribution

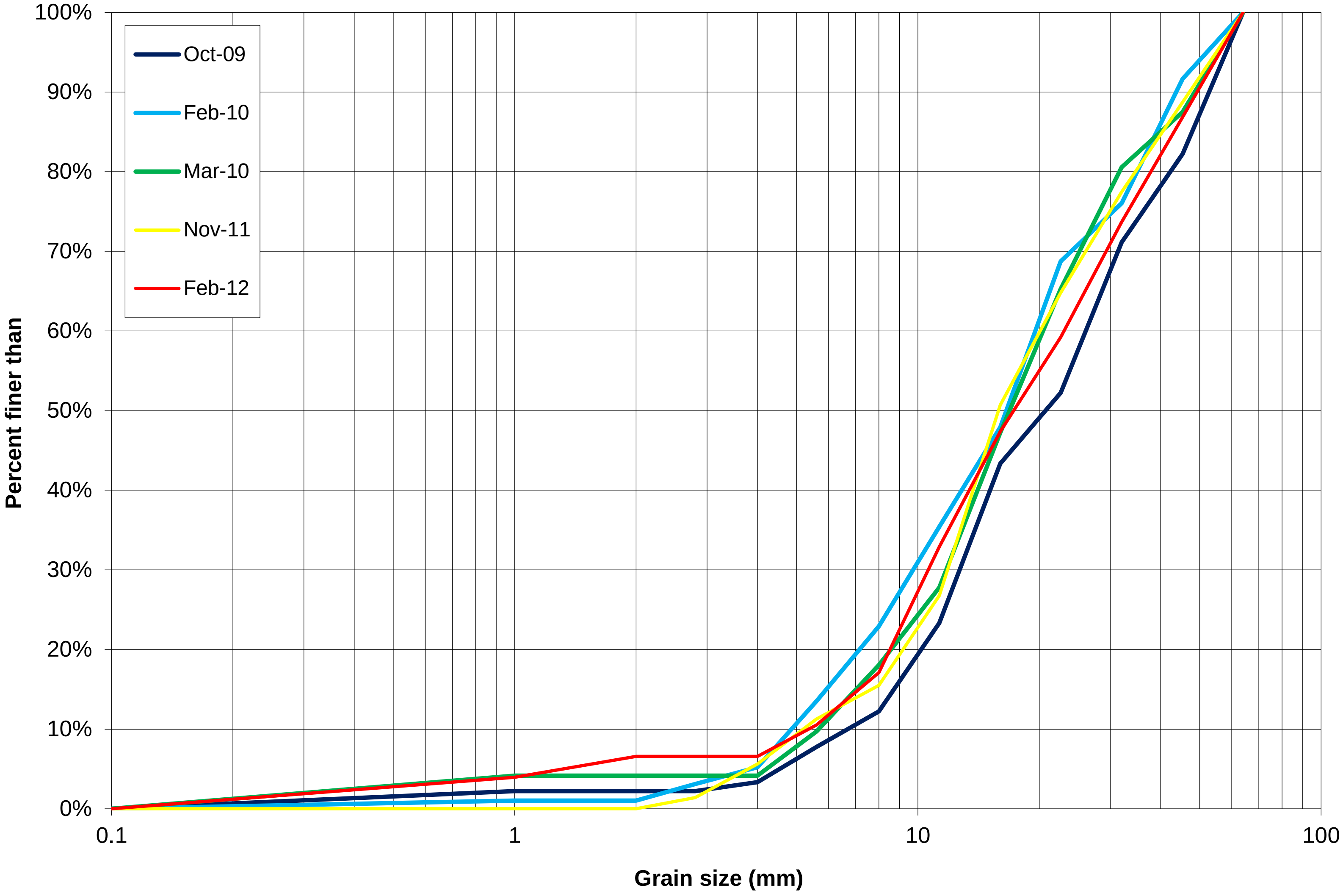
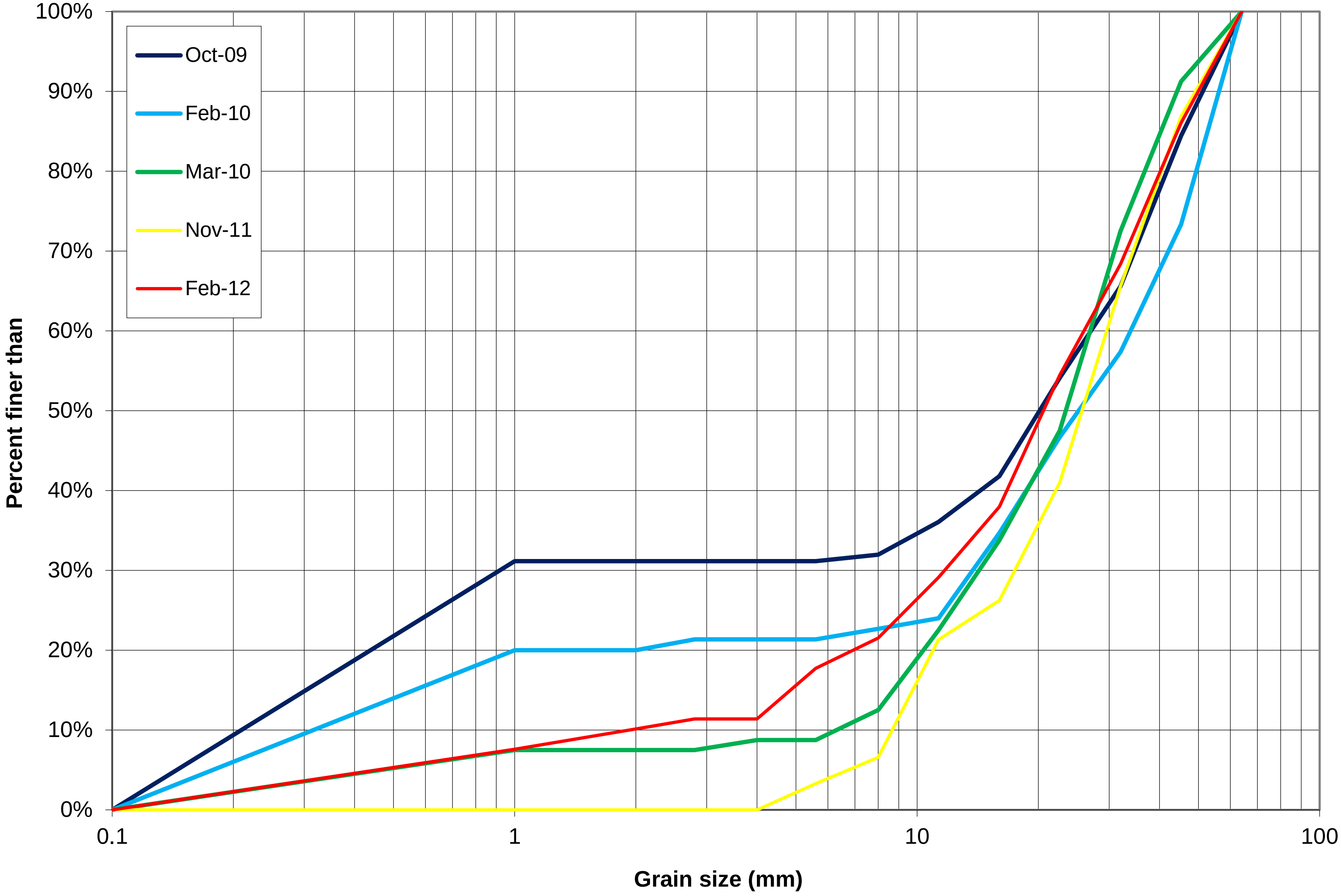


Figure 9: Section 10 grain size distribution



PHOTOGRAPHS

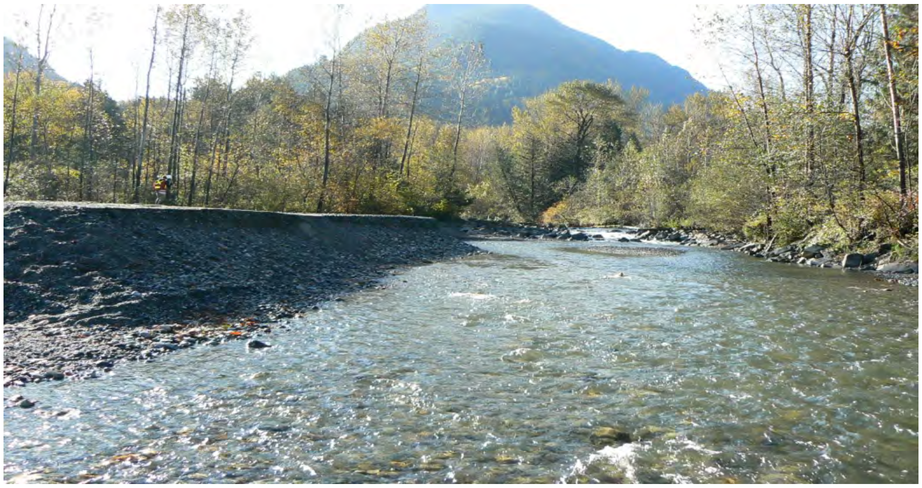
Photo 1: Large bar deposit near XS4 at confluence of Jones Creek and Lorenzetta Creek (left centre of image). Bar is roughly 2 m in height.

Photo 2: Looking upstream at new XS7. Tape across centre of image shows the location of the survey transect.

APPENDIX A

PHOTO POINT 1
LOOKING
UPSTREAM
TOWARD
SECTION 4

MAR 2010



NOV 2011

FEB 2012

PHOTO POINT 2
LOOKING
DOWNSTREAM
TOWARD
SECTION 4

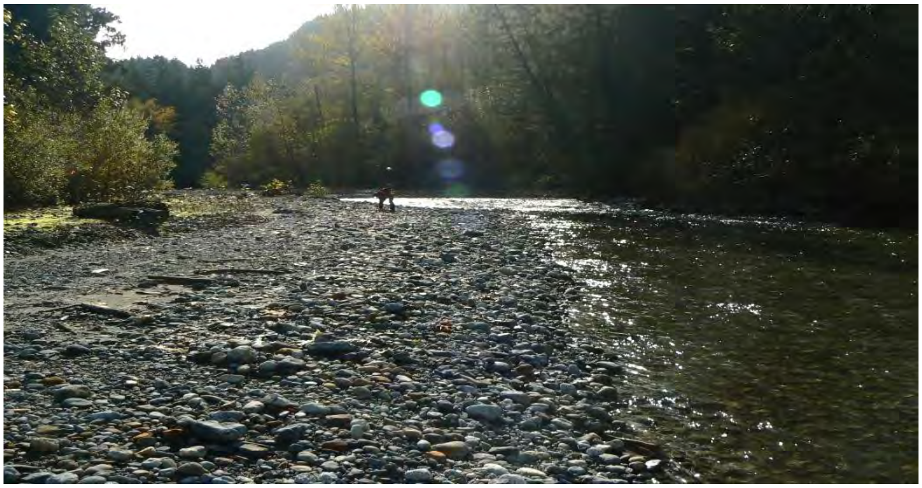
MAR 2010

NOV 2011

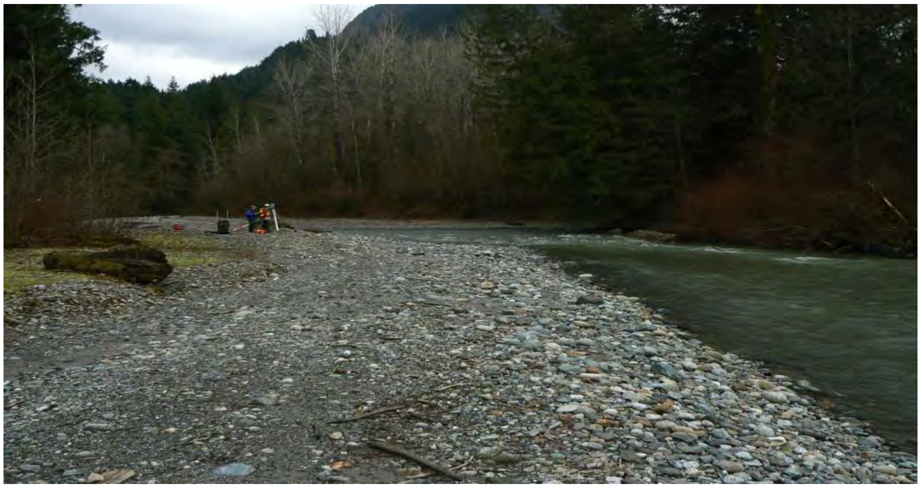
FEB 2012

PHOTO POINT 3
LOOKING
UPSTREAM
TOWARD
SECTION 6

MAR 2010



NOV 2011



FEB 2012

MAR 2012

PHOTO POINT 4
LOOKING
DOWNSTREAM
TOWARD
SECTION 6

NOV 2011

FEB 2012

PHOTO POINT 5
LOOKING
UPSTREAM
FROM SECTION 8

MAR 2010

NOV 2011

FEB 2012

PHOTO POINT 6

LOOKING DOWNSTREAM FROM SECTION 8

MAR 2010

NOV 2011

FEB 2012

MAR 2010

NOV 2011

FEB 2012

PHOTO POINT 7
LOOKING
DOWNSTREAM
TOWARD
SECTION 8

PHOTO POINT 8
LOOKING
UPSTREAM
FROM SECTION 9
TOWARD 10

MAR 2010

NOV 2011

FEB 2012

PHOTO POINT 9
LOOKING
DOWNSTREAM
TOWARD
SECTION 9

MAR 2010

NOV 2011

FEB 2012

APPENDIX B

XS 4

LOOKING UPSTREAM OF XS 4
(01 NOV 2011)

LOOKING DOWNSTREAM OF XS 4
(01 NOV 2011)

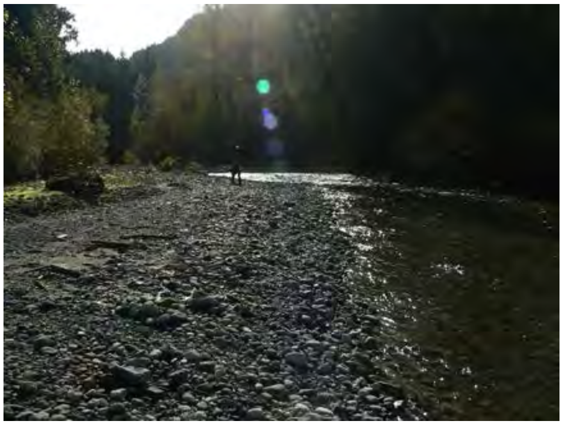
XS 4 – L2 (01 NOV 2011)

XS 4 – R1 (01 NOV 2011)

DATE	FLOW (m^3/s)	WATER CLARITY	TRUNCATED D < 64 mm			N_T	D > 64
			D ≤ 1	1 < D < 9.5	9.5 ≤ D < 64		
Feb 03, 2010	0.79	Moderate	12%	14%	74%	69	28
Mar 18, 2010	1.31	Clear	30%	21%	49%	83	31
Nov 1, 2011	1.57	Clear	0%	31%	69%	89	14
Feb 23, 2012	2.76	Moderate	0%	24%	76%	107	8

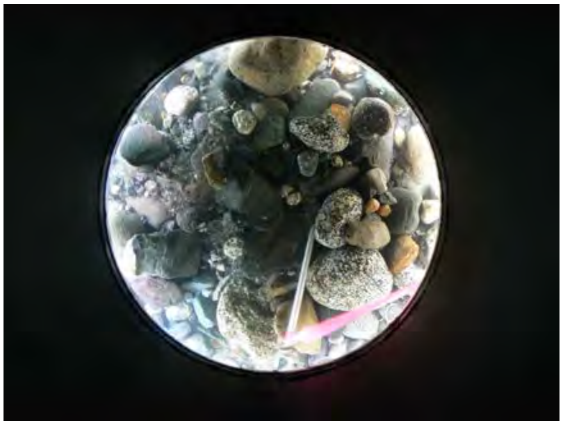
where; N_T = TRUNCATED SAMPLE SIZE (D < 64 mm); D = NUMBER > 64 mm

XS 6



LOOKING UPSTREAM OF XS 6
(01 NOV 2011)

LOOKING DOWNSTREAM OF XS 6
(01 NOV 2011)



XS 6 – L1 (01 NOV 2011)

XS 6 – R1 (01 NOV 2011)

DATE	FLOW (m^3/s)	WATER CLARITY	TRUNCATED D < 64 mm			N_T	D > 64
			D ≤ 1	1 < D < 9.5	9.5 ≤ D < 64		
Feb 03, 2010	0.79	Moderate	51%	9%	40%	101	5
Mar 18, 2010	1.31	Clear	63%	8%	29%	137	1
Nov 1, 2011	1.57	Clear	0%	16%	84%	77	25
Feb23, 2012	2.76	Moderate	0%	14%	86%	56	31

where; N_T = TRUNCATED SAMPLE SIZE (D < 64 mm); D = NUMBER > 64 mm

XS 8

LOOKING UPSTREAM OF XS 8
(01 NOV 2011)

LOOKING DOWNSTREAM OF XS 8
(01 NOV 2011)

XS 8 – M2 (01 NOV 2011)

XS 8 – R2 (01 NOV 2011)

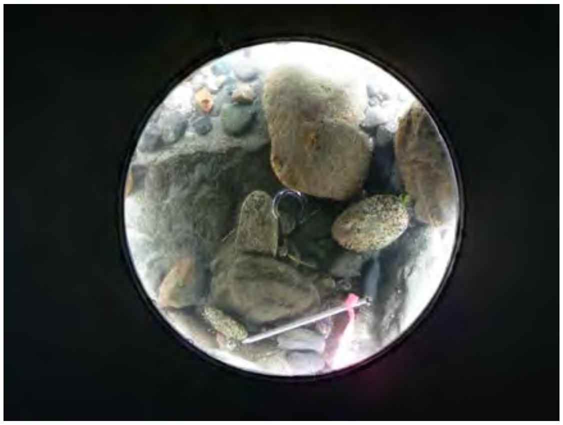
DATE	FLOW (m^3/s)	WATER CLARITY	TRUNCATED D < 64 mm			N_T	D > 64
			D ≤ 1	1 < D < 9.5	9.5 ≤ D < 64		
Feb 03, 2010	0.79	Moderate	54%	22%	24%	127	0
Mar 18, 2010	1.31	Clear	38%	11%	51%	123	1
Nov 1, 2011	1.57	Clear	24%	13%	63%	123	5
Feb 23, 2012	2.76	Moderate	31%	28%	41%	95	5

where; N_T = TRUNCATED SAMPLE SIZE (D < 64 mm), D = NUMBER > 64 mm

XS 9

LOOKING UPSTREAM OF XS 9
(01 NOV 2011)

LOOKING DOWNSTREAM OF XS 9
(01 NOV 2011)



XS 9 – L2 (01 NOV 2011)

XS 9 – R1 (01 NOV 2011)

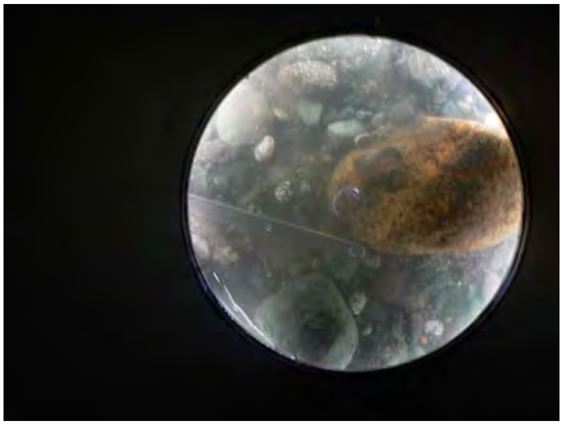
DATE	FLOW (m^3/s)	WATER CLARITY	TRUNCATED D < 64 mm			N_T	D > 64
			D ≤ 1	1 < D < 9.5	9.5 ≤ D < 64		
Feb 03, 2010	0.79	Moderate	1%	32%	67%	96	17
Mar 18, 2010	1.31	Clear	4%	20%	76%	104	32
Nov 1, 2011	1.57	Clear	0%	23%	77%	71	38
Feb 23, 2012	2.76	Moderate	4%	24%	72%	76	19

where; N_T = TRUNCATED SAMPLE SIZE (D < 64 mm); D = NUMBER > 64 mm

XS 10

LOOKING UPSTREAM OF XS 10
(03 FEB 2010) *2011-12 unavailable due to low light

LOOKING DOWNSTREAM OF XS 10
(23 FEB 2012)



XS 10 – L1 (23 FEB 2012)

XS 10 – R2 (23 FEB 2012)

DATE	FLOW (m^3/s)	WATER CLARITY	TRUNCATED D < 64 mm			N_T	D > 64
			D ≤ 1	1 < D < 9.5	9.5 ≤ D < 64		
Feb 03, 2010	0.79	Moderate	20%	4%	76%	75	34
Mar 18, 2010	1.31	Clear	8%	10%	82%	80	26
Nov 1, 2011	1.57	Clear	0%	16%	84%	61	38
Feb 23, 2012	2.76	Moderate	8%	20%	72%	79	25

where; N_T = TRUNCATED SAMPLE SIZE (D < 64 mm); D = NUMBER > 64 mm