

## **Coquitlam-Buntzen Project Water Use Plan**

### **Coquitlam River Rampdown Fisheries Impact Summary**

**Implementation Year 7**

**Reference: COQMON-2**

**Study Period: April 1, 2011 – March 31, 2012**

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**April 22, 2013**

## **Executive Summary**

This report summarizes rampdown events occurring on the Lower Coquitlam River for the water year April 1, 2011 to March 31, 2012. A total of 8 rampdown events were monitored during the annual survey period: 5 scheduled rampdowns; May 31, September 1 November 1, January 16 and March 30, 2012 and 3 unscheduled rampdowns May 4, May 18, and October 6, 2012.

The 2011-2012 water year was the third complete year under the treatment 2 flow regime (only half the year in 2008-2009 was under treatment 2). Under treatment 2, rampdowns are more frequent, but of a much smaller scale in terms of total discharge reduction. Additionally, they are predictable due to their scheduled flow reduction dates. The increase in the maximum allowable reservoir stage elevation (from 149m to 155m) was also intended to reduce the need for large scale flow releases and subsequent full river rampdown fisheries impact surveys. In spite of a hoped for reduction in unscheduled spill events, three occurred in the 2011-2012 water year (2008-2009 is the only year since surveys were initiated that an unscheduled spill did not occur).

Areas previously identified as susceptible to de-watering and fish stranding were visually inspected by survey crews during each rampdown event. Stranded fish were captured and relocated to the river mainstem by dip netting, seine netting or gee-type minnow traps. The five scheduled rampdowns stranded a total of 1480 fish 1044 of which were salvaged alive. The three unscheduled rampdown events produced a total of 444 stranded fish, 391 of which were salvaged live and relocated to the river mainstem. The total number of fish stranded for all rampdowns (1924) was the largest observed since surveys were initiated in 2001. The majority of stranded fish (92.5%) observed during fish salvage operations were juvenile coho.

## **Acknowledgements**

This project was supported by BC Hydro Water Licence Requirements. Jeffery Walker, Ian Dodd and Brent Wilson (BCHydro) kindly provided data, maps and information on all gate closures. Thank you to field technicians Matt Townsend, Stu Barker, Dmitri Koltsov, Thibault Doix and Robertta.

BC Hydro operations staff for access to the gate house and updates

## Table of Contents

1.0 Introduction and Site Description .....	5
2.0 Methods .....	9
3.0 Results .....	11
3.1 Scheduled Rampdown Summaries .....	11
3.2 Unscheduled Rampdowns .....	14
4.0 Results and Discussion .....	15
4.1 Stranding Risk.....	15
4.2 Rampdowns and Flow Release Targets .....	19
4.3 Fish Productivity Impacts .....	21
5.0 Conclusions and Recommendations .....	23
Appendix 1 Total daily and hourly river stage reductions by staff gauge scheduled Rampdowns .....	27
Appendix 2 Total daily and hourly river stage reductions by staff gauge with number of fish stranded and site, unscheduled rampdowns. Flow release target table .....	28
Appendix 3 Total number of fish stranded by sub-section and species for both scheduled and unscheduled rampdowns. ....	30
Appendix 4 Site descriptions and photographs .....	31
Appendix 5 Coquitlam River Rampdown Site Maps .....	36

## List of Tables

Table 1 Coquitlam River flow release schedule under Treatment 1 and 2 .....	8
Table 2 Revised gate adjustment schedule for Coquitlam Dam Low level outlets gates during release reductions .....	10
Table 3 Fish stranding by species, age class and Reach during scheduled rampdowns 2011-2012 .....	13
Table 4 Total of salvaged fish and mortalities by Reach for unscheduled rampdown event s April 2011-March 2012. ....	15
Table 5 Species and age class stranding composition by Reach and Site 2011-2012 .....	18
Table 6 Yearly site by site comparison of stranded fish during all rampdown events, 2004-2011. ....	19
Table 7 Number of rampdown per year 2001-2012.....	20
Table 8 Showing the relationship between seasonal timing and stranding risk all rampdowns, 2004-2012 and 2011-2012. Totals represent stranded salmonids only. ....	22

## List of Figures

Figure 1 Coquitlam-Buntzen Reservoir, Diversion and Generating System .....	7
Figure 2 Comparison of Reach 4 with Reach 1 river stage change. Total river stage change during all rampdowns 2011-2012. ....	17
Figure 3 Fish salvaged and mortalities for all rampdowns 2004-2012.....	18
Figure 4 Stranding distribution by Reach, 2004-2012, highlighting the difference between scheduled and unscheduled rampdowns. ....	20
Figure 5 Stranding distribution by species and age class, 2004-2012, all rampdowns. ....	22
Figure 6 Site A1 showing gravel bar separating river mainstem (left) with isolated pool (right), following rampdown June 1 2009.....	31
Figure 7 Showing trench dug to allow water from river mainstem to flow into isolated pool. ....	31
Figure 8 Site A1 showing gravel area on fluvial island where fish are regularly stranded	32
Figure 9 Site B2, showing isolated pool formed during flow reduction, this site strands juveniles, adults and redds. Substrate is primarily mud and soil. ....	33
Figure 10 View of site C1 side channel that is wetted during single gate openings. This site typically has the highest incidence of stranding on Coquitlam River. ....	34
Figure 11 Stranded Redd, (outlined) along recently dewatered river margin, Site D2. ..	34

## 1.0 Introduction and Site Description

The Coquitlam River watershed located in the Greater Vancouver area in southwestern British Columbia is a typical southwest pacific coastal watershed. Natural river flows are dominated by snowmelt during the spring months, with lower flows through dry summer months prior to elevated precipitation driven flows October through March. The Coquitlam Lake Reservoir portion of the watershed is utilized by two facilities. One facility, with origins dating back to 1892, provides an intake for domestic water supply by the Greater Vancouver Regional District (GVRD) for the Greater Vancouver area. The other facility, BC Hydro's, Coquitlam-Buntzen generation project dates to 1903 and diverts water out of Coquitlam Lake Reservoir via a 3.9 km tunnel to Buntzen Lake Reservoir, where dual penstocks lead to powerhouses, for electricity generation, located in Indian Arm, Burrard Inlet.

The Lower Coquitlam River watershed covers an area of approximately 60 km<sup>2</sup> and has its source at the Coquitlam Dam located within the GVRD watershed boundary. The Lower Coquitlam River flows through the municipality of Port Coquitlam before becoming confluent with the Fraser River. At present the lower watershed is impacted by gravel extraction, urbanization and the variable controlled discharges from the dam.

Controlled flow releases from the Coquitlam River Dam have potential impacts on downstream aquatic communities. Fish can be affected by the ramping rate (rate at which flow is released or decreased from the dam outlets) at all life-history stages. Impacts can include stranding of redds, fry, juveniles or adults depending on the time of year. Rampdown monitoring serves to minimize the potential impacts by identifying areas known to be susceptible to stranding during rampdown events.

Investigations into the impact of rampdowns on fish in Lower Coquitlam River have been ongoing since 2001. Field methods have been developed and refined over the past six years and surveys have been opportunistic. Rampdown assessments undertaken since 2001 have focused on developing survey methods that will enable BC Hydro to evaluate the performance of the interim ramping rate (Table 2), and its influence on mitigating fish stranding on the Coquitlam River. With respect to this, the management questions outlined by the WUP Consultative Committee (CC) and addressed during monitoring in 2003-2005 (BC Hydro CQD WUP TOR 2006) are:

*a) What is the most appropriate ramping rate protocol that should be developed for the Coquitlam Dam that best reduces fish stranding risk while being operationally feasible?*

*b) What are the ongoing fish stranding risks and/or impacts of the revised ramping rate protocol?*

The result of management question (a) being addressed, was the implementation of the interim ramping rate protocol in 2005. The following hypothesis will be tested over the remainder of the review period to continue to evaluate the performance of the interim ramp rate protocol:

*H1: The LB1 WUP interim ramping rate protocol does not strand fish at index sites in the lower Coquitlam River.*

The ramping rate established under Treatment 1 had the goal of minimizing the impact of stranding during rampdowns, while maintaining operational feasibility (BC Hydro 2005). Following completion of the seismic upgrade on Coquitlam Dam in October 2008, a new flow release schedule (Treatment 2) was also initiated. Under this new flow regime a series of scheduled rampdowns will occur at pre-determined times throughout the year. These rampdowns amount to small scale reductions (between 3.00m<sup>3</sup>s and 0.60m<sup>3</sup>s) in the flow release from Coquitlam Dam (Table 1), but can represent a sizeable decrease in the total volume of flow entering Coquitlam River. For example, rampdowns scheduled for the dates January 15 and May 31 constitute a drop in the total flow release of 51% and 62% respectively (Table 1).

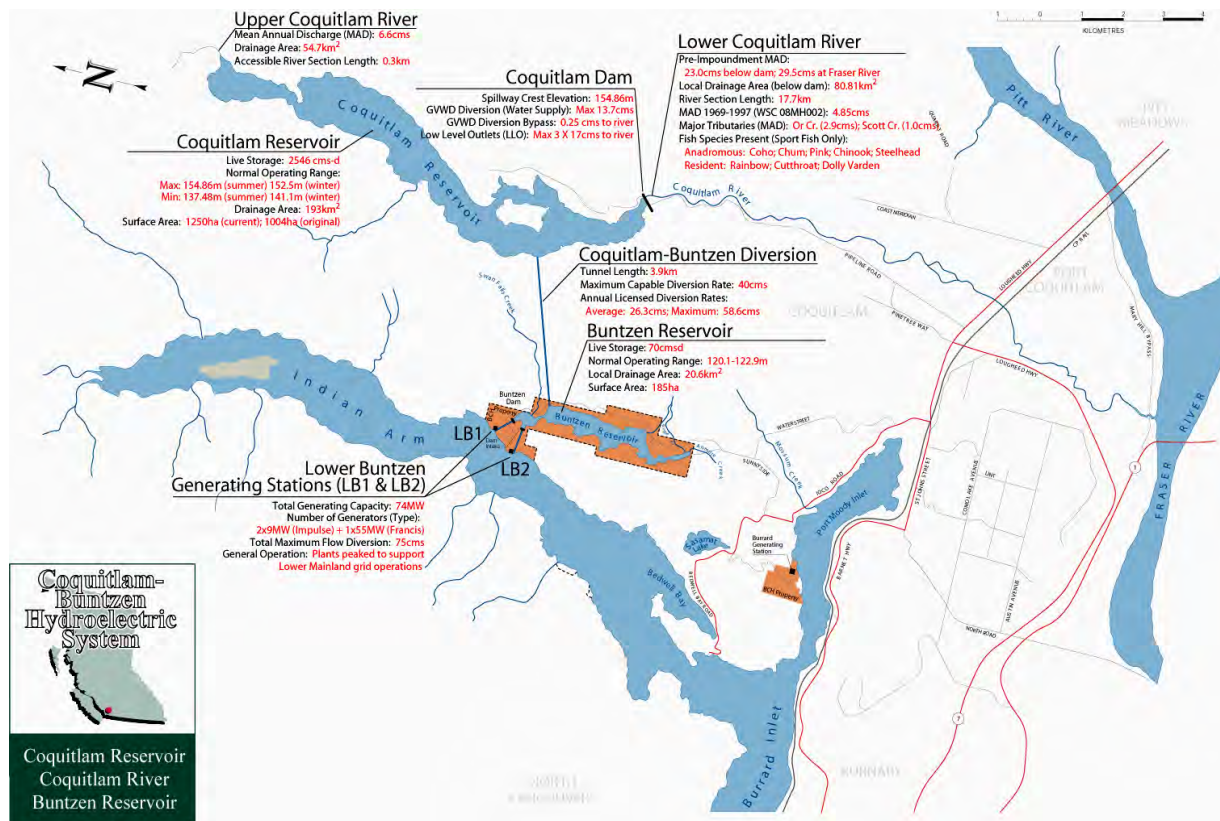
The introduction of the new flow regime is tied to Coquitlam River Fish Productivity as part of the Coquitlam River Water Use Plan. (LB1 WUP). It is central to a long-term adaptive management study being conducted in Coquitlam River to compare anadromous fish production under two experimental flow regimes. Fish population monitoring under the first flow regime (Treatment 1) occurred from 2000 until the completion of the Coquitlam Dam seismic upgrade in October 2008. Fish production under Treatment 2 will be monitored for up to 9 years; 2009 was the first year of monitoring during Treatment 2.

A new low level outlet (LLO) knife-gate installed at Coquitlam Dam in 2008 will control the flow adjustments at the same rate as the previous rampdown schedule (Table 2 for revised gate adjustment schedule). With the seismic upgrade to Coquitlam Dam complete, BC Hydro dam safety constraints no longer stipulate a maximum reservoir elevation of 149 metres, beyond which spill releases must be initiated to ensure dam integrity. The new maximum reservoir operating level is 155 metres. It is hoped that the increased reservoir capacity will reduce the need for unscheduled spills from Coquitlam Dam.

Since 2001, stranding risk has been assessed on the Coquitlam River at several locations from the face of the dam to the confluence with Maple Creek (Macnair et.al 2004-2009). The total survey area incorporates approximately 14 river kilometers. Maps of the area in Appendix 4 identify all stranding index sites. New areas of potential stranding risk under Treatment 2 have been identified by survey crews during rampdown surveys (Macnair 2010). These new sites were identified by their stranding risk characteristics: River margins with; shallow sloped banks and benches, numerous potholes and



depressions, ephemeral channels, porous substrate, and observations of redds, adults or juveniles in habitat.



**Figure 1 Coquitlam-Buntzen Reservoir, Diversion and Generating System**

Due to the size of the study area, some sections of the river have received little investigation. Areas that are not highlighted on the maps in Appendix 5 are generally free of any characteristics that would indicate susceptibility to stranding. All areas not highlighted have been surveyed at least once over the past 10 years and have been determined by survey crews to have minimal or no stranding risk due to the complete absence of any observed stranding and the stream morphology characteristics of the area therefore, therefore, they are not included in any rampdown assessments.

Stranding is identified by three categories:

1. Adult stranding of spawning salmon, which is confined to the active spawning period (Oct.- Jan. depending on species), or other resident adult species.
2. Redd stranding during active spawning period (Sept.-May).
3. Juvenile stranding (fry, parr and smolt), potential risk exists year round.

These categories are used to distinguish stranding by the life stage of salmonids using the Coquitlam River. A single adult female stranded or redd stranded may represent the possible loss of thousands of eggs and the resulting loss of fry, whereas the loss of one fry among potential millions (chum and pink for example) would not have the same impact on fish productivity. Redd and adult stranding, however, is much less frequent than stranding of juvenile fish.

Mortalities of adults and juveniles during rampdown events can result from fish being caught in pools or ephemeral channels which dewater during release reductions. This leaves fish isolated in pools that eventually completely drain. In addition, fry are vulnerable to increased predation risk and oxygen depletion when trapped in highly visible, shallow pools (Bradford, 1997). Elevated dam releases during the fall or spring may temporarily give access to spawning areas which dewater during subsequent flow reduction. This can impact redds by leaving them stranded, and rendering incubated eggs or alevins unviable.

**Table 1 Coquitlam River flow release schedule under Treatment 1 and 2. \*Estimated flow is based on monthly flow transects performed to confirm flow target compliance.**

Reservoir Diversion Schedule (m <sup>3</sup> /sec)						
Domestic Water			Coquitlam Dam Releases			
Period	Target	Min	Treatment 1	Treatment 2		
				Target	Estimated*	Min
Jan 1-15	11.9	10.7	1.0	5.9	5.9	3.6
Jan 15-31	11.9	10.7	1.0	2.9	2.8	2.9
February	11.9	10.7	1.0	2.9	2.8	1.8
March	11.9	10.7	0.8	4.3	4.1	1.1
April	12.0	10.8	0.8	3.5	3.3	1.1
May	12.0	11	1.0	2.9	2.7	1.1
June	12.0	10.9	1.4	1.1	1.2	1.1
July	18.0	15.8	1.4	1.2	1.3	1.1
August	23.0	20.2	1.1	2.7	2.6	1.1
September	23.0	20.9	0.8	2.2	2.1	1.1
October	12.0	10.8	0.8	6.1	6.1	3.6
November	12.0	10.8	1.1	4.0	4.0	1.5
December	11.9	10.7	1.1	5.0	5.0	2.5

## 2.0 Methods

During spill reductions, locations susceptible to stranding risk are assessed during daylight hours by crews of between two and four people. Crew size varies depending on the stranding risk associated with a particular rampdown. Due to the short duration of most rampdown events and the large amount of habitat potentially affected, only locations that are most susceptible or have been previously identified as high risk are assessed. Therefore, fish stranding numbers presented in this report represent only what is observed in the index sites, not the entire Coquitlam River area. Areas susceptible to stranding are generally directly adjacent to the river mainstem and have a flat, un-sloped topography containing numerous potholes and depressions where isolated pools can form (Figure 8). Ephemeral side channels that fill during flow releases and drain completely following gate closures are also highly susceptible to stranding (Figure 9). Areas judged to have no stranding risk are usually steeply sloped river banks that drain rapidly and do not retain any standing water, or areas that have been surveyed repeatedly with no stranding having ever been observed.

Susceptible areas are visually surveyed several times over the course of the rampdown event to assess at what point stranding becomes evident. All isolated pools are assessed for fish and initial attempts at salvaging are conducted with dip nets or seine nets. Fish that are observed to be in danger of stranding, but are not yet stranded can be “pushed” or “chased” out of risk areas by survey crews. Another technique employed is the use of shovels to dig out escape channels that open access to the river mainstem, allowing fish a safe passage out of stranding areas. Areas that are difficult to net by hand or are known to strand large numbers of fish are fished overnight with baited minnow traps if warranted.

Rampdown site assessments are also linked to dam operations through the three LLO gates and their release stages (Table 2). Timing of site assessments can be correlated with the specific LLO gate flow release stage. For example, during the closure of the second LLO gate, survey crews know to respond to specific index sites which dewater during this stage of the rampdown. LLO gates are classed; LLO1 starting gate = first gate to close, LLO2 second gate = second gate to close, LLO3 = third and last gate to close (Table 2). LLO gate flow reductions can be influenced by rainfall and tributary inputs to varying degrees. For example, the stranding risk at rampdown sites located downstream of Or Creek, (Coquitlam Rivers main tributary Appendix B) is sometimes minimized due to high flows from this tributary which moderates or even eliminates the stage reduction below the confluence. Survey crews keep in constant contact with BC Hydro gate operators during rampdown events to ensure proper survey timing during dewatering. Prior to initiation of gate changes the rampdown survey crew rendezvous with BC Hydro operating staff to determine rampdown start and finish time. Contact is maintained throughout the gate changes via cel phone and through direct contact at the LLO gatehouse.

**Table 2 Revised gate adjustment schedule for Coquitlam Dam Low level outlets gates during release reductions**

Gate	Step	Gate Change		Action
		From	To	
Starting Gate	1	60"	0"	Continuous gate change until closed
Second Gate	2	60"	46"	0.5hr change
Second Gate	3	46"	36"	0.5hr change
Second Gate	4	36"	24"	0.5hr change
Second Gate	5	24"	16"	0.5hr change
Second Gate	6	16"	9"	0.5hr change
Second Gate	7	9"	3"	0.5hr change
Second Gate	8	3"	0	0.25hr change
LLO3 (Knife Gate Valve)	9	100%	85%	0.5hr change
LLO3 (Knife Gate Valve)	10	85%	83%	0.5hr change
LLO3 (Knife Gate Valve)	11	83%	81%	0.5hr change
LLO3 (Knife Gate Valve)	12	81%	79%	0.5hr change
LLO3 (Knife Gate Valve)	13	79%	76%	0.5hr change
LLO3 (Knife Gate Valve)	14	76%	71%	0.5hr change
LLO3 (Knife Gate Valve)	15	71%	66%	0.5hr change
LLO3 (Knife Gate Valve)	16	66%	62%	0.5hr change
LLO3 (Knife Gate Valve)	17	62%	60%	0.5hr change
LLO3 (Knife Gate Valve)	18	60%	56%	0.5hr change
LLO3 (Knife Gate Valve)	19	56%	53%	0.5hr change
LLO3 (Knife Gate Valve)	20	53%	48%	0.5hr change
LLO3 (Knife Gate Valve)	21	48%	45%	0.5hr change
LLO3 (Knife Gate Valve)	22	45%	41%	0.5hr change
LLO3 (Knife Gate Valve)	23	41%	34%	0.5hr change
LLO3 (Knife Gate Valve)	24	34%	31%	0.25hr change
LLO3 (Knife Gate Valve)	25	31%	28%	0.25hr change For special

Dewatered areas are classified according to index sites lettered A-E, including two to three specific rampdown sub-areas in each index site (Appendix 3 & 5). Rampdown survey areas within each index site are not always contiguous, and may represent a large area of discontinuous but comparable fluvial and river edge characteristics (see Appendix 4 & 5 for site maps and descriptions). All sites surveyed typically contain many small depressions and areas where fish and spawning habitat are susceptible to stranding. Isolated pools are examined and their location recorded using a GPS so that they can be located during future rampdown assessments if they are determined to pose a stranding risk. All salvaged fish, both live and dead are enumerated, identified to species and live fish are returned to areas of the river mainstem not affected by the flow reduction.

When evaluating whether fish are stranded or not, a distinction is made between fish stranded in an area that will eventually become effectively dry (resulting in mortalities), and fish that are in temporarily isolated areas. Isolated areas will remain continually wetted and capable of supporting fish until higher flows return whether by an increase in flow from the dam, seasonal rainfall or freshet conditions. These isolated areas may be supported by a number of sources, such as: interstitial flows, bank seepage, tributaries or ground water which help to ensure a supply of oxygen and a degree of temperature regulation. Fish in these areas are not considered "stranded" and are therefore not included in stranding data

River stage elevation changes are monitored at several staff gauge sites during the course of rampdown events (Appendix 5). Stage reductions are determined by survey crews at approximately hourly visual inspections of staff gauges located in reach 1, reach 4 and reach 2b (Appendix 1 & 2). These gauges are monitored from the onset of flow reductions to the end of daily salvage operations. Target flow release from Coquitlam Dam is monitored during each rampdown at a transect established in Reach 4 (Appendix 5, Figure A). River stage elevation is also monitored using hourly flow data from the Water Survey of Canada (WSC) gauge located in Port Coquitlam (08MH002).

The area of each rampdown site was calculated by estimating the extent of inundation during a full 3 LLO gate release. This is done on a yearly basis by survey crews in all areas, regardless of whether stranding has occurred at a site. The full extent of each site is included in the area calculation, therefore, areas within the ramp site that do not pose a stranding risk are represented in the area calculation. The total extent of each stranding site is represented as dewatered area in square metres (see Appendix 4 for ramp site descriptions). Survey crews perform area measurements using hip chain and tape measure, measuring the length and width of each site to determine its areal extent. For scheduled rampdown events, the area of inundation is not quantified due to the fact that these are base flows and do not inundate areas of the river which are not normally wetted.

## **3.0 Results**

### **3.1 Scheduled Rampdown Summaries**

#### ***Coquitlam Rampdown May 31, 2011***

On May 31, 2011 the Low Level Outlet release from Coquitlam Dam was scheduled to be reduced from 2.9cms to 1.1cms. The scheduled rampdown began at approximately 0830hr and was completed by 1030hr. Due to rainfall and freshet conditions at the time of the rampdown, potential stranding areas downstream of Reach 4 did not experience any significant river stage reduction. Coquitlam River stage in Reach 1 dropped as much as 0.06 metres initially, but flow increased over the course of the day and river stage actually rose downstream of Reach 4 (Appendix 1) by evening.

The area above Or Creek (Reach 4) was not influenced by the rainfall and freshet conditions and did experience a significant reduction in river stage during the gate closure. The staff gauge installed in Reach 4 showed a total decrease of 0.16 metres over the course of the rampdown survey (Figure 2). The majority of this decrease in river elevation occurred during the final gate adjustments when the river stage dropped 0.08 metres in one hour. This rapid decline in river stage led directly to a large amount of coho fry stranding and mortality. A total of 1376 coho fry were observed to be

stranded in Reach 4 (Site E), 331 of which were mortalities (Table 3). This total represents the most stranding ever witnessed during a rampdown on Coquitlam River. The 1376 stranded represents over half the observed stranded fish for the entire 7 year monitoring program to date. The 331 mortalities found is greater than the total of all mortalities combined for the past 7 years (Table 3 & Figure 3). The true number is likely to be greater within Reach 4, as some isolated areas could not be salvaged or surveyed properly due to the nature of local stream bank morphology (ie. boulder and cobble substrate that prevents access to stranded fish)

### ***Coquitlam Rampdown September 1, 2011***

On September 1, 2011 the Low Level Outlet release from Coquitlam Dam was scheduled to be reduced from 2.7cms to 2.2cms. The scheduled rampdown began at approximately 1000hr and was completed by 1200hr. River stage reduction throughout Coquitlam River was minimal; 0.05 metres in Reach 4 and approximately 0.03 metres in Reaches 3-1. A complete survey of stranding sites in Reach 4 yielded no stranded fry or isolated pools. However, a total of 70 stranded coho and 28 steelhead fry were observed at three separate locations in Reach 2b and Reach 3 despite the minimal decrease in river stage (Table 3).

### ***Coquitlam Rampdown November 1, 2011***

On November 1, 2011 the Low Level Outlet release from Coquitlam Dam was scheduled to be reduced from 6.1 m<sup>3</sup>s to 4.0 m<sup>3</sup>s. The scheduled rampdown began at approximately 0945hr and was completed by 1145hr. River stage elevation downstream of Or Creek (Figure 2) dropped approximately 0.03-0.05 metres following completion of the flow reduction. Upstream of Or Creek river stage elevation dropped a total of 0.06 metres over the course of the rampdown with an average decrease of 0.03m/hr. No stranding was observed and no stranding risk was evident as the detectable decrease in river stage elevation was too small.

### ***Coquitlam Rampdown January 16, 2012***

On January 16, 2011 the Low Level Outlet release from Coquitlam Dam was scheduled to be reduced from 5.9 m<sup>3</sup>s to 2.9 m<sup>3</sup>s. The scheduled rampdown began at approximately 0930hr and was completed by 1230hr. Upstream of Or Creek (Reach 4), river stage dropped a total of 0.10 metres following completion of the flow reduction and had an average decrease of 0.025 m/hr (Figure 2). Downstream of Reach 4 the river stage dropped approximately 0.06-0.07 metres. Stranding was observed in three locations in Reach 4 (Table 3). Two steelhead trout parr were salvaged alive and two steelhead trout parr mortalities were recovered, one adult coho was also salvaged alive (Table 3). No other stranded fish or mortalities were observed in any other stranding sites.

### ***Coquitlam Rampdown March 30, 2012***

On March 30, 2012 Low Level Outlet (LLO) releases from Coquitlam Dam were scheduled to be reduced from 4.3 m<sup>3</sup>s to 3.5 m<sup>3</sup>s. The scheduled rampdown began at approximately 1030hr and was completed by 1230hr. River stage elevation dropped 0.04 metres in Reach 4 and 0.02 metres in Reach 1 following completion of the flow reduction (Figure 2). A single pink salmon fry was observed to be stranded during the course of the fish salvage monitoring.

**Table 3 Fish stranding by species, age class and Reach during scheduled rampdowns 2011-2012**

Date	Species	Salv/Mort	Reach					Total	Stage Reduction (m)		
			R1	R2a	R2b	R3	R4		R4	R2b	R1
31-May-11	Co 0	s					1021	1021	0.16	0.08	0.06
31-May-11	Ko 1+	s					1	1			
31-May-11	Crayfish	s					2	2			
31-May-11	TSS	s					21	21			
31-May-11	Co 0	m					329	329			
31-May-11	St 1+	m					1	1			
31-May-11	Crayfish	m					1	1			
1-Sep-11	Co 0	s			3	10		13	0.05	0.04	0.03
1-Sep-11	St 0	s				3		3			
1-Sep-11	Co 0	m			4	53		57			
1-Sep-11	St 0	m			7	18		25			
1-Nov-11	n/a	n/a							0.06	0.03	0.05
16-Jan-12	Co Adult	s					1	1	0.10	0.07	0.06
16-Jan-12	St 1+	s					2	2			
16-Jan-12	St 1+	m					2	2			
30-Mar-12	Pk 0	s					1	1	0.04	0.02	0.02
			0	0	14	84	1382	1480			

## 3.2 Unscheduled Rampdowns

Three unscheduled rampdowns occurred on Coquitlam River during the 2011-2012 monitoring program. One of the three events was a large rampdowns from a full three LLO gate spill (October 5, 6, 2011), the other two were related to kokanee smolt out-migration, and involved only a small flow increase prior to flow reduction.

### ***Coquitlam Rampdown May 4 and 18, 2011***

In order to facilitate kokanee smolt outmigration from Coquitlam Reservoir, two experimental flow releases from Low Level Outlet Gate 1, (LLOG1), at Coquitlam Dam were scheduled to run from April 27 to May 4, 2011 and from May 11-18, 2011. The releases increased flow from the LLOG from approximately  $2.9 \text{ m}^3\text{s}$  to  $6.0 \text{ m}^3\text{s}$ . The rationale for the flow increase was based on the hypotheses that Kokanee smolt outmigration may be encouraged with a stronger “attraction flow” through the LLO gates. The timing of the flow increase occurred at a very sensitive time on Coquitlam River, as the peak of coho and steelhead smolt migration and coho fry emergence was occurring. The Rampdowns were scheduled for May 4, 2011, and May 18, 2011 commencing at 0700hr, and were complete by 1130hr.

A total of 419 stranded fish were observed over the course of both rampdown surveys. Of this total, 380 were salvaged alive and 39 were mortalities, the majority of stranded fish were coho fry (Table 4). The number of stranded fish was high – the third largest amount of stranding recorded to date - and stranded fry were recovered from several sites (Table 4).

The flow in Coquitlam River was dropping prior to the start of the rampdown in response to natural fluctuation in river stage brought on by freshet conditions. Therefore the river stage elevation decrease should be seen as a combination of natural and rampdown induced flow reduction. River stage reduction was highest in Reach 4 where the river dropped by 0.20 metres over a five hour period during both rampdowns (Figure 2). Downstream of Reach 4, river stage decreased by approximately 0.06-0.10 metres depending on location, despite the smaller decrease, stranding was more severe in the downstream sites (Table 4).

### ***Coquitlam Rampdown October 5,6, 2011***

On October 5,6 2011 a flow reduction from Coquitlam Dam was scheduled. A flow release (initiated to reduce reservoir elevation for dam safety) from all three LLO gates had been ongoing since September 25 and was scheduled to be reduced to the October flow target of  $6.1 \text{ m}^3\text{s}$ . Commencing at 0930hr on October 5, two gates were ramped down at the prescribed ramping rate from a flow of approximately  $41 \text{ m}^3\text{s}$  to  $12 \text{ m}^3\text{s}$ . The flow reduction was complete at approximately 1600hr on the same day. The third and



final gate was ramped down on the following day, October 6, at the prescribed rate. A total of 18 stranded fish were observed over the two day rampdown monitoring period. Of this total, 4 were salvaged and returned to the river mainstem and 14 were mortalities (Table 4).

**Table 4 Total of salvaged fish and mortalities by Reach for unscheduled rampdown event s April 2011-March 2012.**

Date	Species	Salv/Mort	Reach					Total	Stage Reduction (m)		
			R1	R2a	R2b	R3	R4		R4	R2b	R1
4-May-11	Co 0	s	89	53		27	2	171	0.20	0.06	0.09
4-May-11	Ch 0	s	9	21		11		41			
4-May-11	Cm 0	s	13	3				16			
4-May-11	Dace	s	2					2			
4-May-11	Co 0	m	2	7		2		11			
4-May-11	Ch 0	m		1		1		2			
4-May-11	Cm 0	m	1	2				3			
18-May-11	Co 0	s	36	84		13	20	153	0.20	0.08	0.07
18-May-11	Ch 0	s	4					4			
18-May-11	Co 0	m	6			14	3	23			
5-Oct-11	NPM	m	1					1	0.58	0.47	0.55
6-Oct-11	PK adult	s				1		1	0.05	0.04	0.04
6-Oct-11	Cottidae	s		2				2			
6-Oct-11	Lamprey	s		1				1			
6-Oct-11	Co 0	m		2				2			
6-Oct-11	St 0	m		11				11			
			<b>163</b>	<b>187</b>	<b>0</b>	<b>69</b>	<b>25</b>	<b>444</b>			

## 4.0 Results and Discussion

### 4.1 Stranding Risk

In this, the third full year of rampdown monitoring under Treatment 2 (2011-2012), stranded fish were observed in greater numbers than any previous monitoring year. The total of 1924 stranded fish observed is nearly equivalent to the total of all previous rampdowns combined from 2004-March 2011 (2130 total stranded) and the number of mortalities (467) exceeds the total (303) of the past 7 years (Table 6). Virtually all of this increase in stranding was the result of the three fish salvages in the month of May 2011 which were responsible for 94% of stranding observed in the 2011-2012 monitoring year. The May 31 rampdown alone was responsible for 72% of all stranding during the 2011-2012 monitoring year. The section of Coquitlam River where most of the stranding occurred was heavily concentrated in Reach 4, where 73% of all stranding was observed.

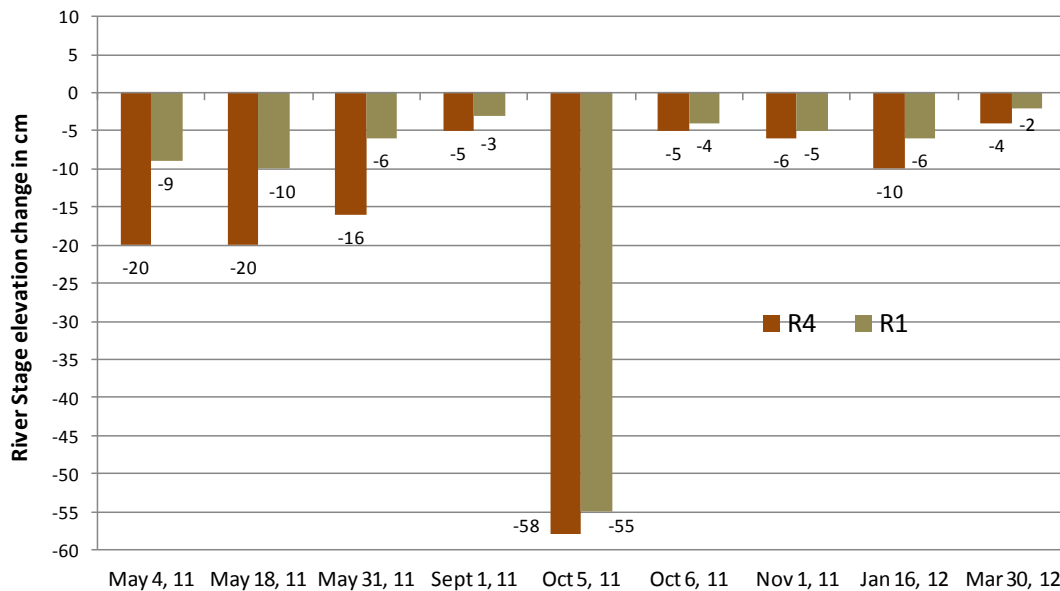
The May 31 scheduled flow reduction from 2.9 m<sup>3</sup>s to 1.1 m<sup>3</sup>s represents a significant decrease in flow for the upper reach of Coquitlam River. While areas downstream of Reach 4 may not be significantly impacted at this time of year from a planned flow reduction, due to freshest conditions; the flow reduction in Reach 4 is equivalent to 62% of the total flow volume in this section of Coquitlam River. In addition, the two, week-long Kokanee smolt attraction releases in May elevated the river stage in Reach 4 between 20 to 25 centimetres above normal for the time of year (each kokanee smolt “attraction release” increased the discharge from 2.9m<sup>3</sup>s to 6.0m<sup>3</sup>s). This would have enabled coho fry to gain access to areas of the river margin that would normally not be accessible which compounded the potential for stranding.

Reach 4 is particularly susceptible to stranding during most rampdowns. This area is above the buffering influence of Or Creek, and has only minimal natural inflow. In addition, its entire length is composed of shallow pools, and small channels that attract juvenile fish. Reach 4 is also narrow and confined by berms and roadways along its length, which causes river stage elevation to drop more rapidly and to a greater degree than areas downstream of Or Creek, (See Figure 2). Scheduled rampdowns typically see only a small decrease (or a river stage increase depending on Or Creek flow) in river stage in the areas below Or Creek (Figure 2).

Adult Coho escapement in Coquitlam River is also concentrated in Reach 4. Typically between 65-75% of all Coho spawning occurs in this Reach (Decker et. al. 2011). This heavy spawning concentration, combined with the fact that May represents peak emergence for Coho fry, adds another level of risk for rampdowns at this time of year. The fall 2011 adult coho escapement was one of the largest on record (est 3850 adult coho compared to 2002-2011 average of 1908, Decker et. al. 2011) which would have lead to greater than average numbers of fry in the system. Adult steelhead spawning also occurs in Reach 4 but in lower concentrations of between 10-25% of total steelhead spawning for the river. Peak fry emergence for Steelhead fry is in late June and July.

All fish stranded during the May 31 rampdown were found in Reach 4. Figure 2 shows the difference in river elevation change between Reach 4 and areas downstream during flow reductions. Of the three rampdowns in May 2011, there was an average river stage decrease of approximately 0.08 metres downstream of Reach 4, while in Reach 4 the average was closer to 0.20 metres (Figure 2).

As the results of the May rampdowns demonstrate, the strongest determiner of stranding risk on Coquitlam River, is the time of year at which a rampdown occurs. Rampdowns that occur in the fall and winter months (December 22 – March 21) are the least likely to strand fish. Data on stranding by season given in Table 7 shows that fall and winter rampdowns strand an average of 22 and 11 fish per rampdown respectively, while the average for spring and summer is 172 and 102 fish per rampdown. This seasonal difference is likely due to the reduction of juvenile fish in the system during the fall and winter (compared to spring and summer when literally millions of fry may be present) and colder water conditions in winter which can minimize fish movement (Bustard 2011).



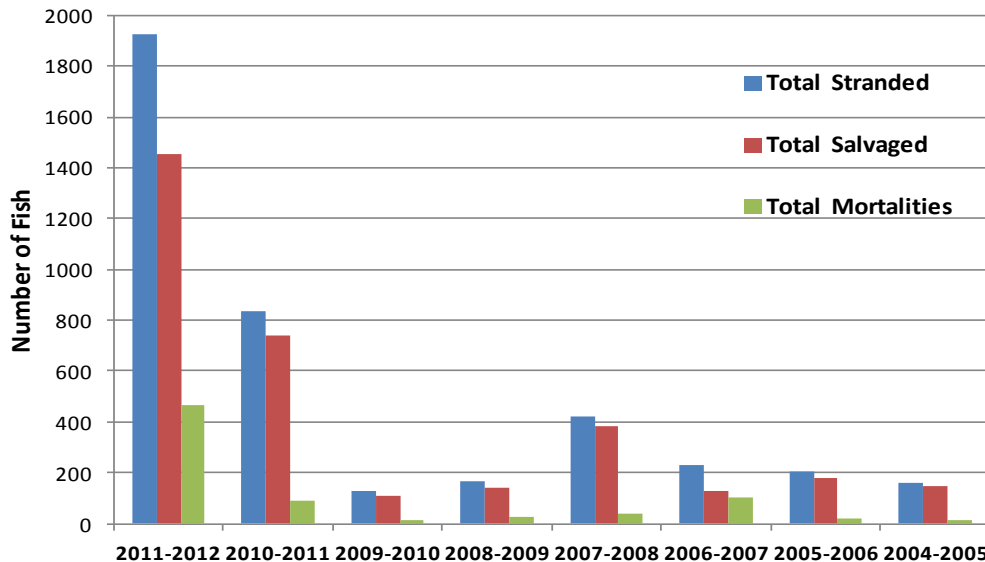
**Figure 2 Comparison of Reach 4 with Reach 1 river stage change. Total river stage change during all rampdowns 2011-2012.**

This seasonal influence is further demonstrated by the fact that the 5 other rampdowns that occurred in 2011-2012 had a minimal impact with respect to stranding, despite the fact that the largest flow reduction was during the October 5, 6, 2011 rampdown, which saw a total river stage decrease of approximately 0.60-0.55 metres over the course of an eight hour period (October 5, 2011) (Figure 2). Final river stage elevation is also an important contributing factor as rampdowns occurring from October 1 -January 15 (under Treatment 2) have a higher final stage elevation than spring and summer rampdowns (with the exception of the month of April, Table 1).

The total decrease in river volume in Reach 4 is high during the January 15, May 31 and November 1 scheduled rampdowns, with a loss of 50%, 63% and 33% of total flow volume respectively (Table 1). These scheduled rampdowns are much more susceptible to stranding compared to the March 31, April 30 and August 31 scheduled rampdowns which have flow volume decreases of 19%, 17% and 19% respectively. However, during periods of low flow in Coquitlam River (mid-late summer) even small reductions in release can have impacts. Witness the Sept 1, 2011 rampdown which had a minimal elevation decrease (0.05-0.03 metres depending on Reach), but stranded 98 fish. Compare this to the October 5 rampdown which had a river stage decrease of between 0.50-0.60m and stranded only 1 fish. This again points to the influence that time of year can have on fish stranding, as well as the fact that flow reductions in spring and summer more frequently reduce the river stage to lower elevations than in the fall and winter.

Coho fry are most likely to be stranded due to their year round residence, abundance at emergence and habit of congregating in shallow river margins, ephemeral channels and shallow pools (Dunn, 2002, Macnair 2008). All of these factors make them heavily susceptible to stranding. This contrasts with chum and pink fry which are the most numerous species when emergence is underway (March-May), but almost immediately

migrate out of the river and are absent from the water column from June to February. Coho salmon juveniles were the most likely fish to be stranded over all years, representing 78.3% of all stranded fish. Overall, salmonids made up 93% of all stranded fish for the 2004-2011 period (Figure 5).



**Figure 3 Fish salvaged and mortalities for all rampdowns 2004-2012.**

As has been shown, stranding was concentrated in the upper reaches of Coquitlam River with the majority (73%) in Reach 4 (Table 5). This trend is the opposite of years prior to Treatment 2, which involved solely unscheduled rampdowns (Figure 4), and reflects the prominence of stranding in Reach 4 during scheduled flow reductions. There has been no stranding to date in Reach 1 and 2a during scheduled rampdowns. Reach 2b and 3 have the smallest amount of stranding risk by area (Appendix 4), in addition to being the areas of river with the steepest banks. These factors all contribute to Reach 3 and 2b having the lowest stranding risk and the least amount of stranding.

**Table 5 Species and age class stranding composition by Reach and Site 2011-2012**

Index Site Code and Reach	R1			R2a		R2b		R3			R4			Total	% Comp
Species Stranded	A1	A2	A3	B1	B2	C1	C2	D1	D2	D3	E1	E2	E3		
Coho Salmon (age 0)	126	7	0	5	139	0	7	56	21	42	221	760	396	1780	92.5%
Steelhead (age 0)	0	0	0	0	11	0	7	0	6	15	0	0	0	39	2.0%
Steelhead (age 1+)	0	0	0	0	0	0	0	0	0	0	2	3	0	5	0.3%
Chinook Salmon (age 0)	13	0	0	0	22	0	0	12	0	0	0	0	0	47	2.4%
Pink Salmon (age 0)													1	1	0.1%
Chum Salmon (Age 0)	14			1	4									19	1.0%
Coho Adult											1			1	0.1%
Threespine Stickleback													21	21	1.1%
Kokanee 1+											1			1	0.1%
Longnose Dace	2													2	0.1%
Crayfish												1	2	3	0.2%
Northern Pike Minnow		1												1	0.1%
Pink Adult										1				1	0.1%
Cottidae					2									2	0.1%
Lamprey					1									1	0.1%
	155	8	0	6	179	0	14	68	27	58	225	764	420	1924	100%
Percentage stranded by reach	8.5%			9.6%		0.7%		8.0%			73.2%				

**Table 6 Yearly site by site comparison of stranded fish during all rampdown events, 2004-2011.**

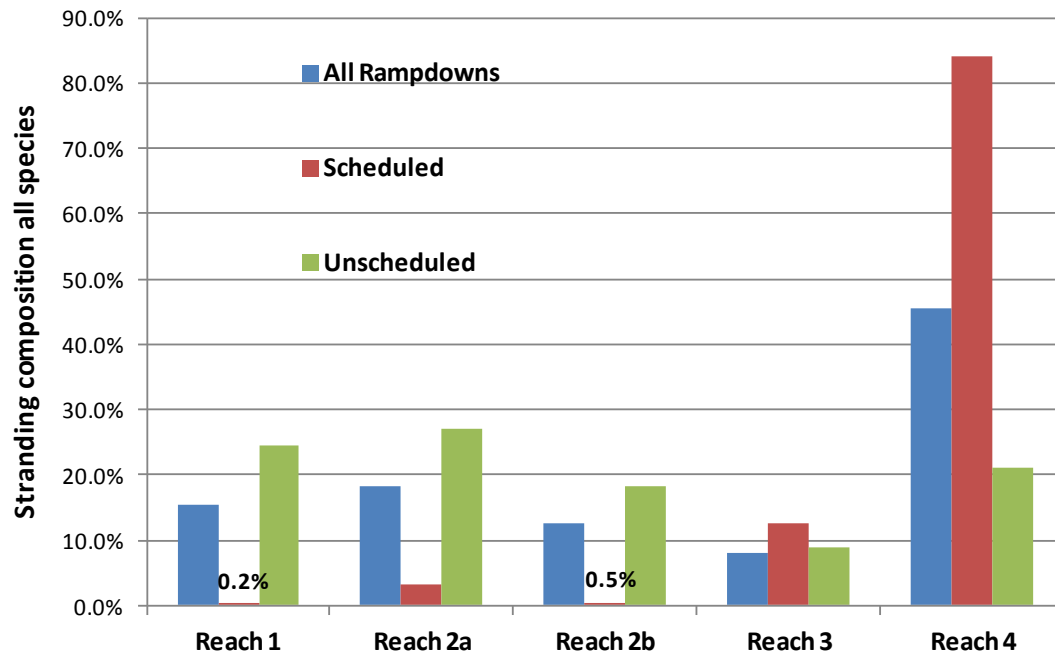
Year	Site A		Site B		Site C		Site D		Site E		Total Stranded	Total Salvaged	Total Morts	Ramp Events	% Morts
	Salv	Mort	Salv	Mort	Salv	Mort	Salv	Mort	Salv	Mort					
2011-2012	154	9	164	21	3	11	65	88	1071	338	1924	1457	467	8	24.3%
2010-2011	103	6	389	21	39	25	78	13	134	26	834	743	91	11	10.9%
2009-2010	21	0	40	2	0	0	5	0	45	13	126	111	15	10	11.9%
2008-2009	31	5	33	9	49	12	12	0	13	0	164	138	26	4	15.9%
2007-2008	67	6	32	11	199	17	20	1	65	1	419	383	36	5	8.6%
2006-2007	39	14	3	4	47	80	36	4	0	0	227	125	102	4	44.9%
2005-2006	95	0	0	0	1	9	0	7	85	6	203	181	22	6	10.8%
2004-2005	75	2	10	0	13	9	0	0	48	0	157	146	11	3	7.0%
<b>Total</b>	<b>585</b>	<b>42</b>	<b>671</b>	<b>68</b>	<b>351</b>	<b>163</b>	<b>216</b>	<b>113</b>	<b>1461</b>	<b>384</b>	<b>4054</b>	<b>3284</b>	<b>770</b>	<b>51</b>	<b>19.0%</b>

## 4.2 Rampdowns and Flow Release Targets

Since the introduction of Treatment 2 there has been no reduction in the total number of unscheduled rampdowns (Table 8). It was anticipated that a return to a reservoir maximum operating level of 155m from 149m (in place during Treatment 1 2001-2009) would reduce the number of unscheduled spill events. However, the opposite has been evident in the past three years of monitoring. Of the 13 unscheduled rampdowns since the initiation of Treatment 2, four have been full three LLO gate release rampdowns, the remainder have been due to dam maintenance and for experimental flows designed to attract Kokanee smolt migration.

Flow transects performed throughout the monitoring year indicate that flow releases from Coquitlam Dam have been consistently within the targeted range throughout the monitoring year; with the exception of a two day period at the end of May (May 31-June 1, 2011) and a five day period at the end of July (July 27-August 1, 2011) (Appendix 2). It is worth noting that both of these below target periods, though brief, coincided with scheduled flow reductions that stranded fish. This fact (both scheduled flow reductions below target), may have contributed to the severity of the stranding. If the river stage decreased more than planned, the stranding risk would naturally be increased.

Figure 3 shows the increase in the past two monitoring years in the amount of fish stranded on Coquitlam River under Treatment 2. This increase was influenced by a number of factors, including: the number of rampdown events, seasonal timing of rampdown events, below target flow releases, in addition to survey crews finding more stranding areas and increased efficiency in fish salvage. In the first year under Treatment 2 fish stranding was reduced, but the results have swung far in the other direction the past two monitoring years (Figure 3).



**Figure 4 Stranding distribution by Reach, 2004-2012, highlighting the difference between scheduled and unscheduled rampdowns.**

**Table 7 Number of rampdown per year 2001-2012**

Monitoring Year	Unscheduled	Scheduled
2001-2002	1	n/a
2002-2003	1	n/a
2003-2004	3	n/a
2004-2005	3	n/a
2005-2006	6	n/a
2006-2007	4	n/a
2007-2008	5	n/a
2008-2009	1	3
2009-2010	5	5
2010-2011	5	6
2011-2012	3	5
	<b>37</b>	<b>19</b>

### ***4.3 Fish Productivity Impacts***

Stranding influence on fish production in Coquitlam River is likely to be minimal for all species with the exception of coho and possibly steelhead juveniles. For pink and chum fry the impact is negligible. Decker et. al. 2011 reports the estimated average annual outmigrating population for chum and pink fry for the 2003-2011 period is 2,816,900 and 340,000 respectively. Contrast this with a total of 66 chum mortalities and zero pink mortalities observed during rampdowns for the same period. Coho and steelhead smolt population estimates for the same period average 14,972 and 6,867 per year respectively (Decker et. al. 2009). The estimated average number of coho and steelhead smolt/parr mortalities per year due to rampdowns is 3 and 7 respectively, or less than 0.1% of the estimated population. However, in light of the impacts on coho fry, and to a lesser extent, steelhead fry in the past two monitoring years, there may be cause for concern.

Coho fry populations are typically the hardest hit with respect to stranding, estimates of total fry productivity (based on fall standing stock estimates 2006-2011) range from 21,000 to 105,000 with a mean of approximately 53,000 (Decker 2011). Using available data it is possible to give a rough idea of the impact of stranding on the coho fry population in Coquitlam River. For example: If the total number of coho fry observed stranded in the 2011-2012 monitoring year, (1780) was compared to the 2011 standing stock estimate (105,200), this would represent approximately 1.7% of the population. This level of loss could have the potential to have an impact on the coho fry population. The impact on Steelhead fry is not quite as dramatic; using the total number observed stranded (39) in the 2011-2012 monitoring year and comparing it to the 2011 standing stock estimate (40,921), gives a potential loss of 0.10% of the population due to stranding.

One steelhead redd was observed stranded in Reach 2b following flow reduction on May 31, this is the second year this has occurred for steelhead redds on Coquitlam River. Elevated dam releases during the spring spawning period gave continuous access to steelhead spawning areas which then dewatered during flow reduction in June (Appendix 4). This can impact redds by leaving them stranded, and rendering incubated eggs or alevins unviable.

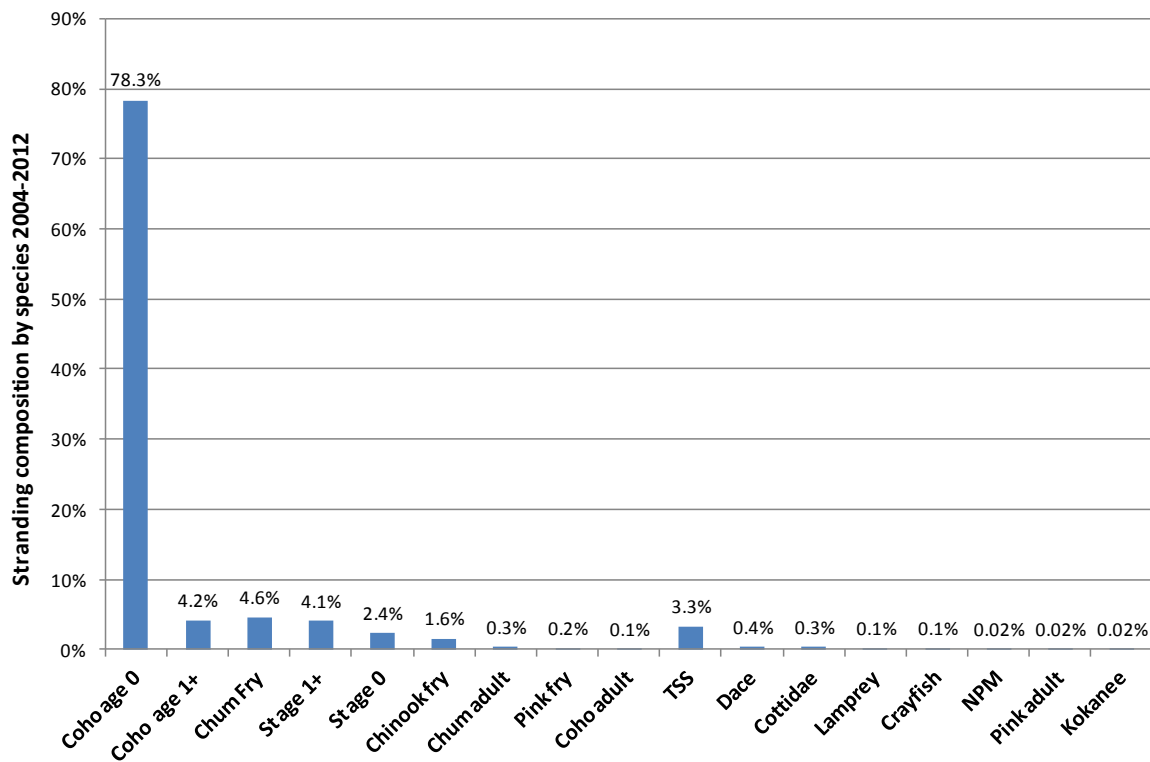


Figure 5 Stranding distribution by species and age class, 2004-2012, all rampdowns.

Table 8 Showing the relationship between seasonal timing and stranding risk all rampdowns, 2004-2012 and 2011-2012. Totals represent stranded salmonids only.

2004-March 2012		Life Stage When Stranded				
Season	Rampdown	Adult	Fry	Smolt/Parr	Total	Average
Spring (Mar 23-June 22)	15	0	2516	64	2580	172
Summer (June 23-Sept 22)	8	0	751	64	815	102
Fall (Sept 23 - Dec 22)	15	12	176	137	325	22
Winter (Dec 23 - Mar 22)	11	1	40	85	126	11
2011-2012		Life Stage When Stranded				
Season	Rampdown	Adult	Fry	Smolt/Parr	Total	Average
Spring (Mar 23-June 22)	4	0	1773	2	1775	444
Summer (June 23-Sept 22)	1	0	98	0	98	98
Fall (Sept 23 - Dec 22)	2	1	13	0	14	7
Winter (Dec 23 - Mar 22)	1	1	0	4	5	5



## 5.0 Conclusions and Recommendations

Due to the fact that the scheduled releases under Treatment 2 do not inundate large areas of habitat, that flow releases are maintained at a relatively constant rate throughout the year, and flow reductions are generally small in proportion to the amount of flow in the entire river, the risk of stranding appears to be minimal during most scheduled rampdowns downstream of Or Creek. The fact that in the first three years under Treatment 2 only 5.4% of stranded fish have been observed during scheduled rampdowns downstream of Or Creek supports this conclusion at the present time.

Though only minimal stranding has yet to be observed under the January 15, August 31, March 31, and April 30 scheduled rampdowns, it is recommended that they continue to be monitored by survey crews during the upcoming monitoring year. The potential for stranding definitely exists, particularly in the section of Coquitlam River above Or Creek. As described, this section is minimally influenced by natural inflows and therefore has the potential to be impacted by the scheduled flow reductions. Furthermore, areas downstream of Or Creek cannot always be expected to receive buffering flows from rainfall and freshet conditions, in their absence, the risk of stranding during scheduled rampdowns is amplified.

The increase in the number of unscheduled rampdown events due to climatic conditions (Heavy rainfall resulting in LLO spilling) dam maintenance and experimental flows was again an issue during the 2011-12 monitoring year. Following the increase in the minimum operating level from 149m to 155m it was hoped that the number of unscheduled ramp events would decrease (as it did in year 1 of Treatment 2).

Stranding sites examined under the previous flow regime have been reevaluated under the new Treatment 2 conditions. The results of the third year under Treatment 2 demonstrate that some formerly susceptible areas may now be considered low risk for stranding. Additionally, new areas have been identified during scheduled rampdowns and those new areas have been categorized and included in all rampdown fish salvage surveys. The fluvial morphological structure of Coquitlam River will continue to transform as it adapts to the increased annual flow, therefore areas of stranding will shift.

The ramping rate established under Treatment 2 appears to be effective at minimizing stranding during both scheduled and unscheduled rampdowns with the exception of The May 31 rampdown. The May scheduled rampdown, and possibly rampdowns that occur at the critical time period (Spring- Summer) may need to have their ramp rates reexamined. Certainly the results indicate that the May 31 rampdown could benefit from a more gradual flow reduction. In addition, this particular rampdown should undergo a reassessment of its minimum target flow. The May 31 reduction does not fit the natural hydrograph for the watershed (according to WSC Gauge 08MH141 Coquitlam River above Coquitlam Lake). Flows are normally high and rising during the

Month of May and June, but this is not reflected in Reach 4, where instead flows drop significantly. A higher minimum flow target for June would have the potential to prevent a significant amount of stranding.

Comparison of rampdown mortalities to fish productivity clearly shows the negligible impact that rampdowns appear to have on fish productivity in Coquitlam River. However, results from this year of greatly elevated coho fry stranding during scheduled and unscheduled rampdowns at critical time periods is cause for concern. Rampdowns that occur in spring and summer should potentially require larger rampdown crews, and a modified ramp rate to ensure that high numbers of juvenile mortalities do not occur.

With respect to the management questions outlined in the introduction, results to date indicate that fish continue to be stranded under the revised ramping rate protocol. In addition, the risk of fish stranding has increased since the introduction of Treatment 2 flow regime despite careful adherence to the ramping protocol. Although fish will continue to be stranded regardless of ramp rate, survey crews are well adapted to the conditions of the ramp rate and are able to salvage the majority of fish that become stranded. Minimizing impacts with careful adherence to rampdown rates, minimum flow targets and consistent monitoring of potential stranding sites will continue to be the most appropriate means to reduce the fish stranding risk while being operationally feasible.

### **Summary of Recommendations**

- It is recommended that future trash rack maintenance and experimental flow releases (to accommodate Kokanee smolt out-migration) be scheduled outside of the fry and smolt migration period, as this would greatly reduce any risk of juvenile stranding. Realistically, this is likely not possible with respect to the kokanee releases due to life stage overlap; at a minimum ensure that rampdowns during this time period have a full stranding crew on site (minimum 4 people).
- Results to date for Treatment 2, indicate that some scheduled rampdowns may eventually be done without survey crews on site. The scheduled flow reductions on, January 15, March 31 and April 30 have stranded only 6 fish to date, and the river stage elevation reduction does not appear to pose a risk of stranding.
- Develop reach specific flow transects to estimate the influence of tributary inflow on rampdown fisheries impact surveys. Install a staff gauge in Or Creek and begin to monitor discharge there in order to establish the influence of this tributary on stranding.
- The ramp rate for the May 31 flow reduction should be modified to be more gradual.

- The possibility of increasing the minimum flow target for June should be considered, this may prevent large scale stranding of coho fry as a result of the May 31 rampdown.
- During scheduled rampdowns fish salvage crews should focus efforts in Reach 4, due to the elevated risk of stranding in this area.

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## Appendix 1 Total daily and hourly river stage reductions by staff gauge scheduled rampdowns

### May 31, 2011

Reach 4 Staff Gauge		WSC Staff Gauge	
Time	Stage (m)	Time	Stage (m)
0800	0.21	0800	7.88
0900	0.16	1000	7.88
1000	0.06	1100	7.86
1100	0.05	1200	7.83
1200	0.05	1400	7.82
1400	0.05	2200	7.86
3.0hr		4.0hr	
0.16		0.06	
5.33		1.5	
		Total time (hr)	
		Total Stage Change (m)	
		Stage Change (cm)/hr	

### September 1, 2011

Reach 4 Staff Gauge		WSC Staff Gauge	
Time	Stage (m)	Time	Stage (m)
0900	0.21	1100	7.76
1000	0.21	1300	7.76
1100	0.18	1400	7.74
1200	0.16	1500	7.73
1400	0.16	1700	7.73
1500	0.16	1800	7.73
3.0hr		7.0hr	
0.05		0.03	
1.7		1.0	
		Total time (hr)	
		Total Stage Change (m)	
		Stage Change (cm)/hr	

### Nov 1, 2011

R4 Staff Gauge		R2B (at Galette)		WSC Staff Gauge	
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)
0830	0.41	0830	0.72	0800	7.95
1000	0.37	1000	0.71	1000	7.93
1200	0.35	1200	0.69	1100	7.93
1300	0.35	1300	0.69	1200	7.91
1400	0.35	1400	0.69	1400	7.89
1600	0.35	1600	0.69	1600	7.89
1800	0.35	1800	0.69	1800	7.90
5.0hrs		6.0hrs		6.0hrs	
-0.06m		-0.08m		-0.10m	
4.0cm/hr		1.2cm/hr		1.7cm/hr	
				Total time	
				Total Stage Reduction (m)	
				Stage Reduction (cm)/hr	

**Jan 16, 2012**

R4 Staff Gauge		R2B (at Galette)		WSC Staff Gauge	
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)
0900	0.375			1000	7.90
1000	0.375	1000	0.70	1200	7.90
1200	0.35	1100	0.68	1300	7.89
1300	0.275	1300	0.64	1400	7.87
1400	0.275	1400	0.63	1500	7.84
.10m		.07m		.08m	
2.5cm		1.2cm		1.3cm	

**Appendix 2 Total daily and hourly river stage reductions by staff gauge unscheduled rampdowns.**

**May 4, 2011**

R4 Staff Gauge		R2B (at Galette)		WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0700	0.42	0700	0.78	0800	7.96	
0900	0.33	0900	0.76	1000	7.93	
1100	0.27	1100	0.74	1100	7.92	
1200	0.22	1330	0.72	1200	7.91	
1400	0.22	1500	0.72	1400	7.87	
1600	0.22	1700	0.72	1600	7.87	
				1800	7.86	
5.0hrs -0.20m 4.0cm/hr		6.5hrs -0.06m 1.0cm/hr		6.0hrs -0.09m 1.3cm/hr		Total time Total Stage Reduction (m) Stage Reduction (cm)/hr

**May 18, 2011**

R4 Staff Gauge		R2B (at Galette)		WSC Staff Gauge	
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)
0630	0.41	0830	.79	0800	8.00
0830	0.37	1100	.77	1000	7.98
1030	0.30	1230	.71	1100	7.96
1130	0.21	1430	.71	1200	7.93
1400	0.21			1400	7.90
				1600	7.90
				1800	7.90
5.0hrs -0.06m 4.0cm/hr		6.0hrs -0.08m 1.2cm/hr		6.0hrs -0.10m 1.7cm/hr	
				Total time Total Stage Reduction (m) Stage Reduction (cm)/hr	

**Oct 5, 2011**

R4 Staff Gauge		R2B (at Galette)		WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0830	1.05	0830	1.18	0800	8.68	
1000	0.89	1000	1.17	1000	8.45	
1200	0.67	1200	1.02	1100	8.37	
1300	0.49	1300	.84	1200	8.28	
1400	0.48	1400	.80	1400	8.12	
1600	0.47	1600	.80	1600	8.13	
1800	0.47	1800	0.79	1800	8.12	
5.0hrs		6.0hrs		6.0hrs		Total time
-0.58m		-0.39m		-0.55m		Total Stage Reduction (m)
11.5		6.3		9.7		Stage Reduction (cm)/hr

**Oct 6, 2011**

R4 Staff Gauge		R2B (at Galette)		WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0800	0.46	0800	0.78	0800	8.10	
1000	0.45	1000	0.77	1000	8.10	
1200	0.41	1200	0.76	1100	8.08	
1400	0.41	1400	0.75	1200	8.08	
1600	0.41	1600	0.75	1400	8.06	
1700	0.41	1700	0.75	1600	8.06	
1800	0.41	1800	0.75	1800	8.05	
6.0hrs -0.05m 0.8		6.0hrs -0.06m 1		6.0hrs -0.04m 0.7		Total time Total Stage Reduction (m) Stage Reduction (cm)/hr

**Flow release target table**

Date	SG	R4	Tunnel	Target	Difference m3/sec	Difference %	Difference %
April 1, 2011	0.31	4.08		4.3	-0.22	95%	-5.1%
April 1, 2011	0.26	3.31		3.5	-0.19	95%	-5.4%
April 1, 2011	0.30		3.31	3.5	-0.19	95%	-5.4%
May 4, 2011	0.22	2.69		2.9	-0.21	93%	-7.2%
May 31, 2011	0.05	0.95		1.1	-0.15	86%	-13.6%
June 1, 2011	0.05	0.93		1.1	-0.17	85%	-15.5%
June 2, 2011	0.09	1.24		1.1	0.14	113%	13%
July 27, 2011	0.10	1.29		1.1	0.19	117%	17%
July 27, 2011	0.07		0.96	1.1	-0.14	87.3%	-13%
August 2, 2011	0.20		2.55	2.7	-0.15	94.4%	-6%
September 1, 2011	0.16		2.12	2.2	-0.08	96.4%	-4%
October 7, 2011	0.41	6.08		6.1	-0.02	100%	0%
November 1, 2011			4.03	4.0	-4.0	101%	1%
December 1, 2011	0.375	5.2		5.0	0.20	104%	4%
December 1, 2011	0.375		4.84	5.0	-0.2	97%	-3%
January 16, 2012	0.275	2.77		2.9	-2.9	96%	-4%
March 30, 2012	0.29	3.47		3.5	-3.5	99%	-1%

### Appendix 3 Total number of fish stranded by sub-section and species for both scheduled and unscheduled rampdowns.

#### Scheduled Rampdowns

Index Site Code														
Fish Salvaged	A1	A2	A3	B1	B2	C 1	C2	D1	D2	D3	E1	E2	E3	Total
Coho Fry							3		4	6	95	573	353	1034
Coho parr														0
Chinook Fry														0
Steelhead Parr												2		2
TSS													21	21
St Fry									2	1				3
Kokanee 1+											1			1
Coho adult											1			1
Pink Fry													1	1
Crayfish													2	2
Lamprey														0
Total	0	0	0	0	0	0	3	0	6	7	97	575	377	1065
Total Site	0			0		3		13			1049			

Index Site Code														
Mortalities	A1	A2	A3	B1	B2	C 1	C2	D1	D2	D3	E1	E2	E3	Total
Coho Fry							4		17	36	116	170	43	386
St Fry							7		4	14				25
Crayfish												1		1
St Parr											2	1		3
Total	0	0	0	0	0	0	11	0	21	50	118	172	43	415
Total Site	0			0		11		71			333			

#### Unscheduled Rampdowns

Index Site Code														
Fish Salvaged	A1	A2	A3	B1	B2	C 1	C2	D1	D2	D3	E1	E2	E3	Total
Coho Fry	118	7		2	135			40			7	15		324
Chinook Fry	13				21			11						45
Chum Fry	13				3									16
Dace	2													2
Adult pink										1				1
cottidae					2									2
Lamprey					1									1
Total	146	7	0	2	162	0	0	51	0	1	7	15	0	391
Total Site	153			164		0		52			22			

Index Site Code														
Mortalities	A1	A2	A3	B1	B2	C 1	C2	D1	D2	D3	E1	E2	E3	Total
Coho Fry	8			3	4			16			3	2		36
Chinook Fry					1			1						2
Chum Fry	1			1	1									3
St Fry					11									11
NPM		1												1
Total	9	1	0	4	17	0	0	17	0	0	3	2	0	53
Total Site	10			21		0		17			5			



## Appendix 4 Site descriptions and photographs

**Site A1:** This area is characterized by densely treed and shrubby river margins that contain many depressions that form isolated pools. The substrate is mainly soil and vegetated cover, along with some areas of exposed gravel and cobble.

**Total Area: 3800m<sup>2</sup>**



**Figure 6 Site A1 showing gravel bar separating river mainstem (left) with isolated pool (right), following rampdown June 1 2009.**



**Figure 7 Showing trench dug to allow water from river mainstem to flow into isolated pool.**





**Figure 8** Site A1 showing gravel area on fluvial island where fish are regularly stranded

**Site A2:** These areas are characterized by large expanses of exposed gravel and cobble suitable for spawning adjacent to the river, accompanied by moderately treed areas with numerous depressions that form isolated pools when dewatering. These areas represent a hazard for stranding of both adults, juveniles and redds due to the combination of off channel habitat and spawning gravel that is wetted during flow releases.

**Total Area: 19000m<sup>2</sup>**

**Site A3:** This area is primarily a large gravel and cobble fan with gently sloping topography. There are several areas where large isolated pools form during rampdowns.

**Total Area: 4800m<sup>2</sup>**

**Site B1:** This area is a side channel that is normally wetted except at very low flows (below 3.00cms WSC gauge Port Coquitlam). It is a gravel and cobble substrate, that drains quickly and leaves behind many isolated pools. It rarely completely dewateres, so is only a stranding risks when flow in the river is very low.

**Total Area: 270m<sup>2</sup>**

**Site B2:** This area is a long narrow partially treed platform with a combined soil, gravel and vegetated substrate. It strands adults, juveniles and redds. This site only becomes inundated during a full three LLO release, and is one of the earliest sites to begin dewatering.



**Total Area: 3000m<sup>2</sup>**



**Figure 9 Site B2, showing isolated pool formed during flow reduction, this site strands juveniles, adults and redds. Substrate is primarily mud and soil.**

**Site C1:** This site is a long side channel composed of gravel and cobble substrate. It drains rapidly and forms many isolated pools that do not retain water well. This site experienced the highest number of stranding during the past two years

**Total Area: 690m<sup>2</sup>**





**Figure 10** View of site C1 side channel that is wetted during single gate openings. This site typically has the highest incidence of stranding on Coquitlam River.

**Site C2:** The area is densely covered in shrubs. The substrate is very muddy with vegetated ground cover. Juveniles were regularly stranded in this area until the 2007/2008 rampdown period, which often requires the use of minnow traps for salvage. Morphological changes may have reduced the risk of stranding at this site.

**Total Area: 550m<sup>2</sup>**

**Site D1:** This area is densely vegetated with trees and shrubs. It is primarily a narrow river margin, with mud and soil substrate.

**Total Area: 1000m<sup>2</sup>**

**Site D2:** This area is densely vegetated with trees and shrubs. It is primarily a narrow river margin with cobble and boulder substrate and relatively steep banks.

**Total Area: 600m<sup>2</sup>**



**Figure 11** Stranded Redd, (outlined) along recently dewatered river margin, Site D2.

**Site D3:** This area is a short, narrow platform densely grown in with trees and shrubs, it has a combined soil, gravel and vegetated substrate. Isolated pools form during flow reductions, stranding juveniles which are best removed using minnow traps due to the dense concentration of roots within the pools.

**Total Area: 665m<sup>2</sup>**

**Site E1:** This area is adjacent to a rearing pond that overflows during dam releases. Juveniles spill over the pond and can become stranded. Substrate is mainly cobble and gravel intermixed with moderately treed areas.

**Total Area: 1900m<sup>2</sup>**

**Site E2:** This area consists of narrow river margins that are densely treed and shrub covered. Many isolated pools form close to the river mainstem during gate closure. Observations over the past 3 years indicate that many of these pools remain wetted year round due to their proximity to the river channel.

**Total Area: 1800m<sup>2</sup>**

**Site E3:** This area, situated near the dam face, is densely covered in trees and shrubs. Isolated pools are minimal, but juveniles are often caught in the area of dense vegetation during dewatering.

**Total Area: 6000m<sup>2</sup>**

## Appendix 5 Coquitlam River Rampdown Site Maps

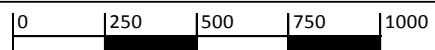


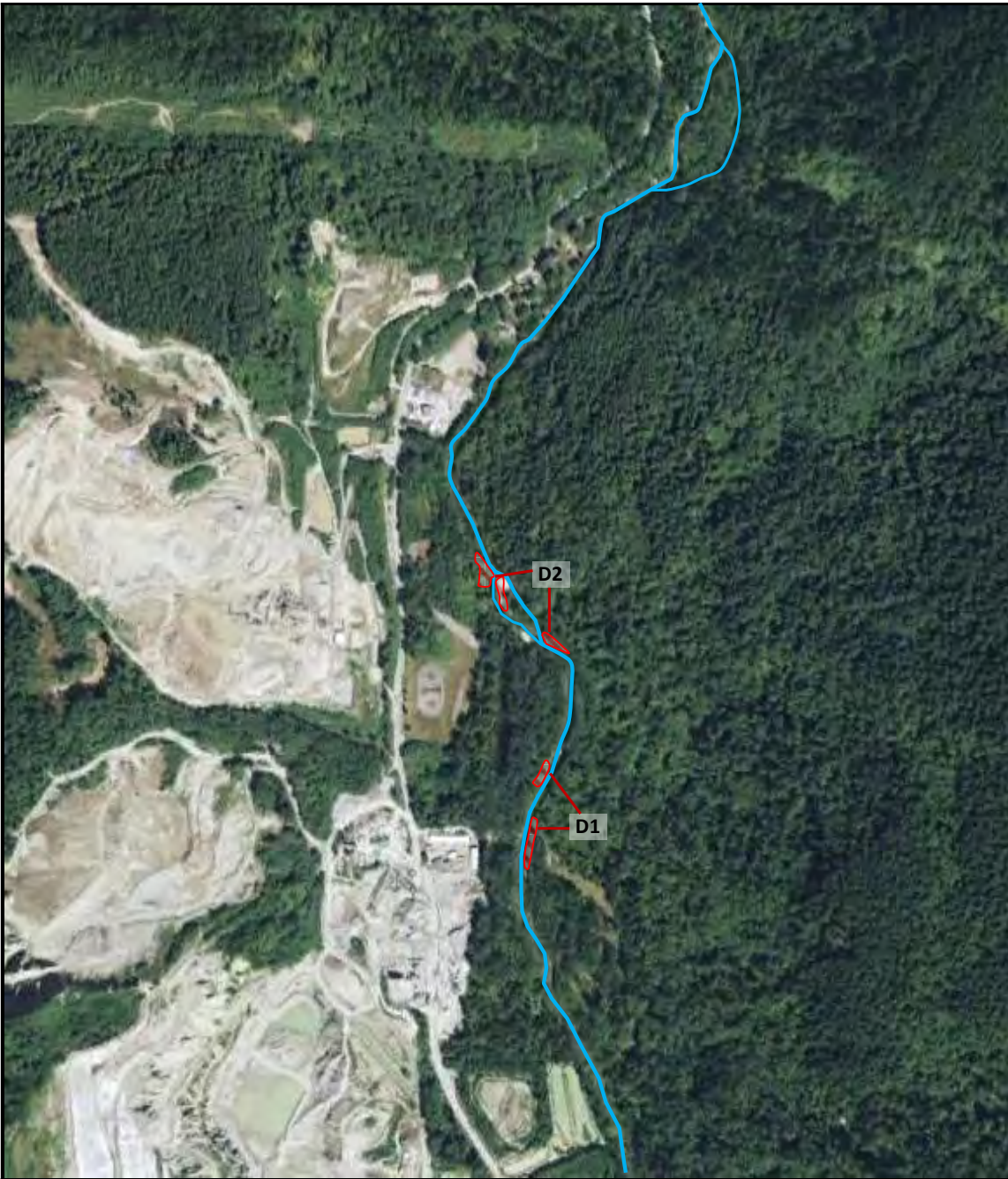




Figure A

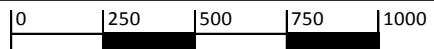
Coquitlam River Stranding, Sites D & E, Reach 4 and 3.



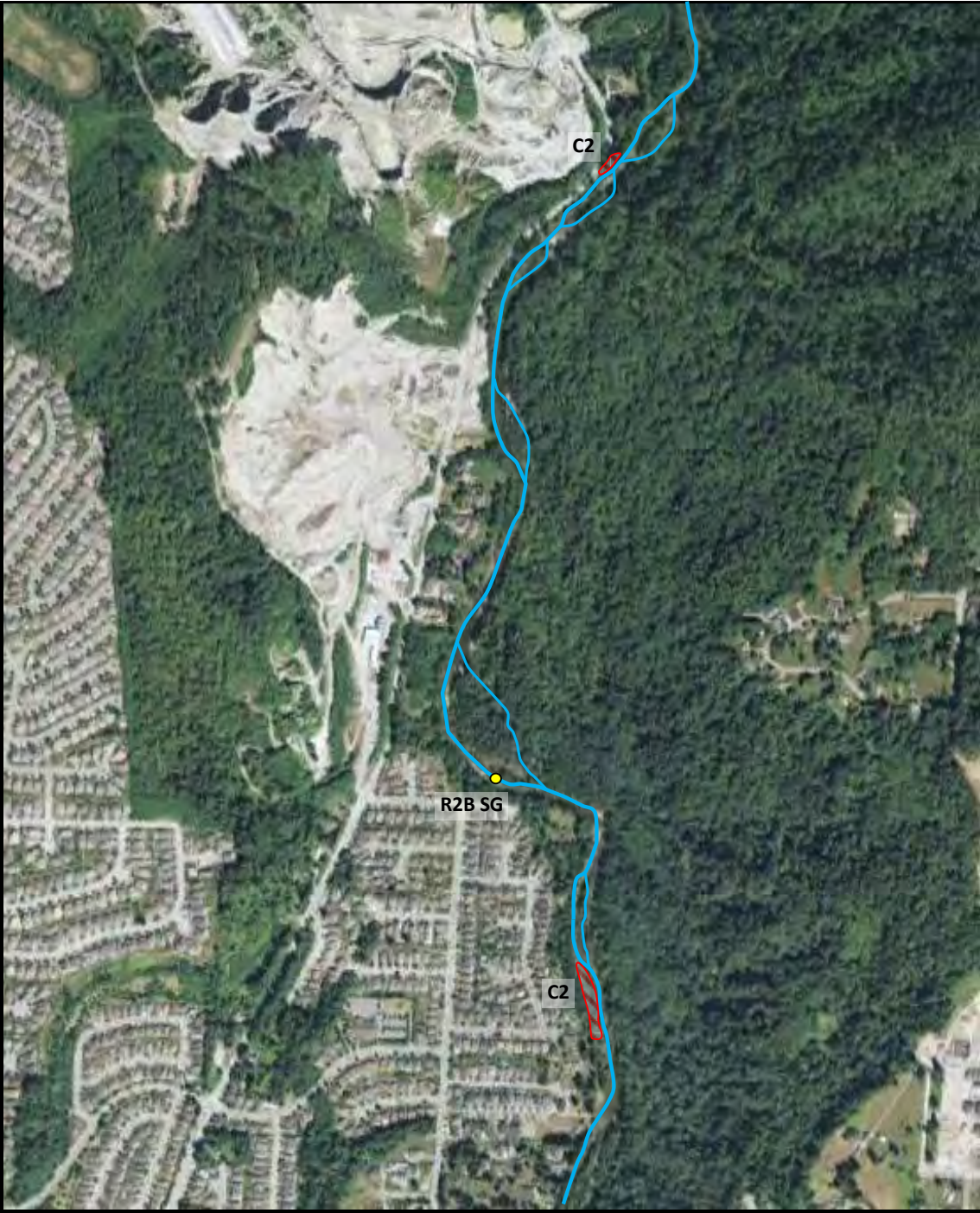


**Figure B**

**Coquitlam River Stranding, Site D, Reach 2a & 3.**

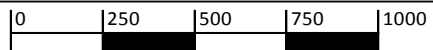






**Figure C**

**Coquitlam River Stranding, Site C, Reach 2a & 2b.**





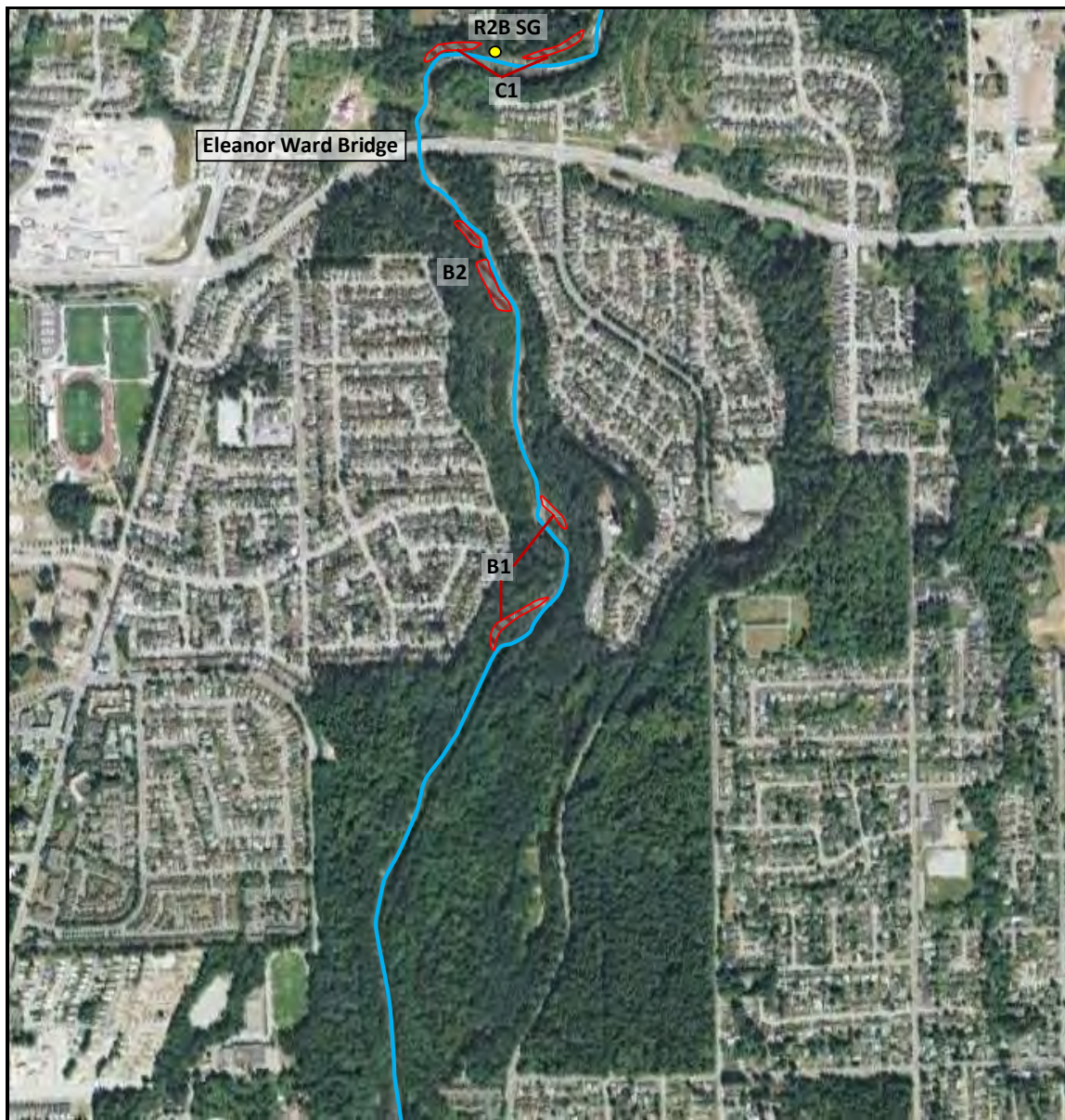
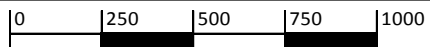


Figure D



Coquitlam River Stranding, Site B & C, Reach 2a.



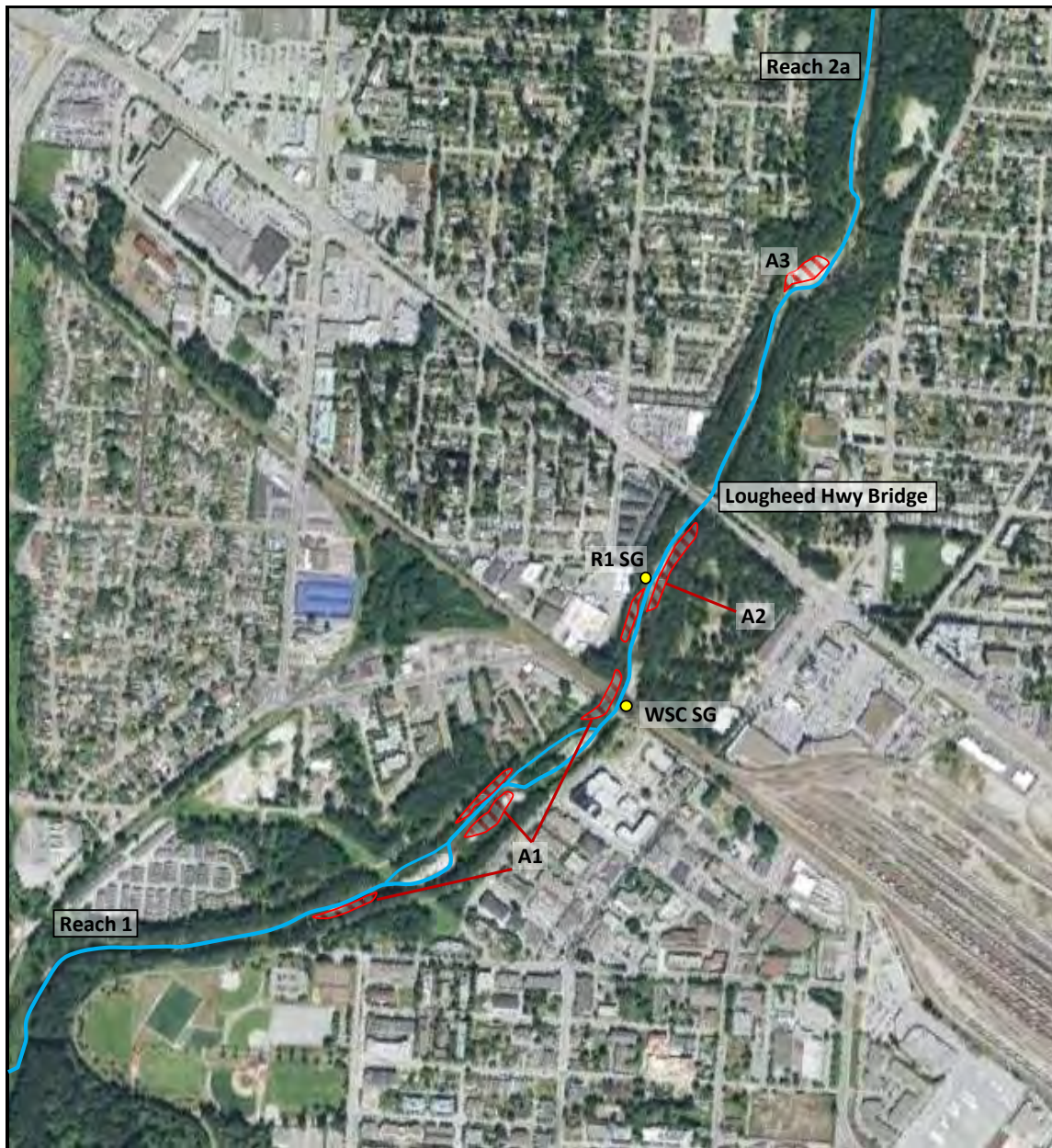
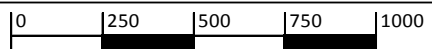


Figure E



Coquitlam River Stranding, Site A, Reach 1.