

Coquitlam-Buntzen Water Use Plan

Monitoring Program Terms of Reference

- **COQMON#2 – Coquitlam Dam Flow Release Interim Ramping Rate Monitoring**

Initial submission: October 24, 2005
Revision 1: December 14, 2006

December 14, 2006

Terms of Reference for the Coquitlam-Buntzen Water Use Plan Monitoring Programs

Introduction

This document outlines the Coquitlam-Buntzen Water Use Plan (WUP) Terms of Reference for the monitoring programs as per the Coquitlam-Buntzen Order under the Water Act, dated 21 April 2005

This Revision 1 document contains the detailed Terms of Reference for the eight monitoring programs for the Coquitlam-Buntzen WUP approved based on the below schedule Table 1.

Monitoring Program	1 st Submission	Revision 1	Rescinded	Approval
COQMON#1	24 Oct 2005			3 Jan 2006
COQMON#2	24 Oct 2005			3 Jan 2006
COQMON#3	24 Oct 2005	8 Feb 2006	8 Mar 2006	
COQMON#4	24 Oct 2005			3 Jan 2006
COQMON#5	24 Oct 2005			3 Jan 2006
COQMON#6	24 Oct 2005			3 Jan 2006
COQMON#7	24 Oct 2005	8 Feb 2006		8 Mar 2006
COQMON#8	24 Oct 2005			3 Jan 2006

Table 1. Coquitlam-Buntzen monitoring program Terms of Reference submission and approval schedule.

The attached Terms of Reference includes the revised Lower Coquitlam River Habitat Suitability Criteria Development entitled Lower Coquitlam River Habitat Requirements Study (COQMON#3) and increased implementation costs for COQMON#5 – Coquitlam River Periphyton and Benthic Invertebrate Monitoring, COQMON#7 – Lower Coquitlam River Fish Productivity Index, and COQMON#8 – Lower Coquitlam River Substrate Quality Assessment based an extended WUP review period resulting from the delayed implementation of the Treatment 2 flow release.

- 1) COQMON#1: Assessment of Fisheries Access to Streams Tributary to Coquitlam Reservoir. The objective of this study is to identify fish use and/or fish habitat potential in each of the three streams identified with potential fish access issues (BC Hydro 2000) and to recommend physical works and/or operational constraints to restore fish access for all operations.
- 2) COQMON#2: Coquitlam Dam Flow Release Interim Ramping Rate Monitoring. The objective of this monitoring program is to report on the fish stranding impacts in the lower Coquitlam River associated with the implementation of the interim ramping rate protocol for the Coquitlam Dam.
- 3) COQMON#3: Lower Coquitlam River Fish Habitat Requirements Study. The objective of this study is to identify any changes to the habitat suitability criteria used

in the Coquitlam-Buntzen Water Use Plan calculations of weighted useable area of habitat, and refine the habitat-flow relationships and flow release targets developed in the WUP.

- 4) COQMON#4: Assessment of Pink Salmon Passage in Lower Coquitlam River. The objective of this study is to monitor the migration of returning pink salmon in odd years to determine if there are any flow-related partial or complete migration barriers in the lower Coquitlam River corridor.
- 5) COQMON#5: Coquitlam River Periphyton and Benthic Invertebrate Monitoring. The objective of this study program is to develop a predictive model for evaluating periphyton and invertebrate benefits associated with Lower Coquitlam River flow alternatives.
- 6) COQMON#6: Lower Coquitlam River Temperature Monitoring. The objective of this monitoring program is to identify if and how temperature in the lower Coquitlam River is influenced by reservoir operations.
- 7) COQMON#7: Lower Coquitlam River Fish Productivity Index. The objective of this monitoring program is to determine the fisheries benefits of two test flows and to enable a better understanding of trade-offs between fisheries, domestic water and power generation for the benefit of future water planning processes.
- 8) COQMON#8: Lower Coquitlam River Substrate Quality Assessment. The objective of this monitoring program is to evaluate the effectiveness of the flushing flow provisions outlined in the LB1 WUP to increase fish productivity through improved substrate quality in the lower Coquitlam River.

Physical works terms of reference will be delivered in a separate package.

Coquitlam-Buntzen Water Use Plan

Monitoring Program Terms of Reference Summary

1.0 Background

In 2003, the Coquitlam-Buntzen Water Use Plan (LB1 WUP) consultative committee (CC) agreed on a set of operating conditions for the review period ending in 2016. The recommended operations include the release of two flow regimes from Coquitlam Dam (see Figure 1-1): Treatment #1 will continue the release schedule of two fish valves fully open (this flow agreement has been in place since 1999, releasing between 0.8-1.7m³s⁻¹). Upon dam seismic upgrade completion in 2007, Treatment #2 will take effect, releasing 1.1-5.9m³s⁻¹ depending on the time of year (see Table 1-1).

Treatment Schedule 3 - 3 Yrs Base (2FVC); 9 Years STP6																		
Activity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Treatment #1 - 2FVC baseline smolt monitoring	1	2	3	4	5	6												
Dam Modifications				1	2	3												
Treatment #2 - STP6							1	2	3	4	5	6	7	8	9			

Figure 1-1: Treatment schedule recommended by the Consultative Committee for LB1 WUP review period to 2015¹.

¹ Note that recommendations from the Monitoring Committee in 2006 will result in extending Treatment 1 to September 2007, and Treatment 2 to September 2016.

Table 1-1: Annual schedule for release amounts as agreed by the Consultative Committee. Note that 2FV dam release amounts are average and affected by reservoir elevations, resulting in variation similar to, but not equal to those summarized.

	<i>Reservoir Diversion Schedules (cms)</i>					Species Driver and Priority for Coquitlam River Releases
	Domestic Water		Coquitlam Dam Releases			
	Target	Min	2 Fish Valves (Current)	"Share the Pain 6"		
				Target	Min	
<i>01-Jan</i>	11.9	10.7	1.0	5.9	3.6	Chinook Spawning
<i>15-Jan</i>	11.9	10.7	1.0	2.9	2.9	Chinook Incubation
<i>Feb</i>	11.9	10.7	1.0	2.9	1.8	Chinook Incubation
<i>Mar</i>	11.9	10.7	0.8	4.3	1.1	Steelhead Spawning
<i>Apr</i>	12.0	10.8	0.8	3.5	1.1	Steelhead Spawning
<i>May</i>	12.0	11.0	1.1	2.9	1.1	Steelhead Spawning
<i>Jun</i>	12.0	10.9	1.4	1.1	1.1	Steelhead Parr
<i>Jul</i>	18.0	15.8	1.4	1.2	1.1	Steelhead Parr
<i>Aug</i>	23.0	20.2	1.1	2.7	1.1	Steelhead Parr
<i>Sep</i>	23.0	20.9	0.8	2.2	1.1	Steelhead Parr
<i>Oct</i>	12.0	10.8	0.8	6.1	3.6	Chinook Spawning
<i>Nov</i>	12.0	10.8	1.1	4.0	1.5	Chinook Spawning
<i>Dec</i>	11.9	10.7	1.1	5.0	2.5	Chinook Spawning

In addition to Coquitlam Dam flow releases for fish interests, the CC also agreed to increased water diversion from Coquitlam Reservoir for Greater Vancouver Regional District (GVRD) for drinking water.

The CC also made provisions in the LB1 WUP to address uncertainties through long-term monitoring, and to facilitate Treatment #2 flow releases through Coquitlam Dam gate improvements.

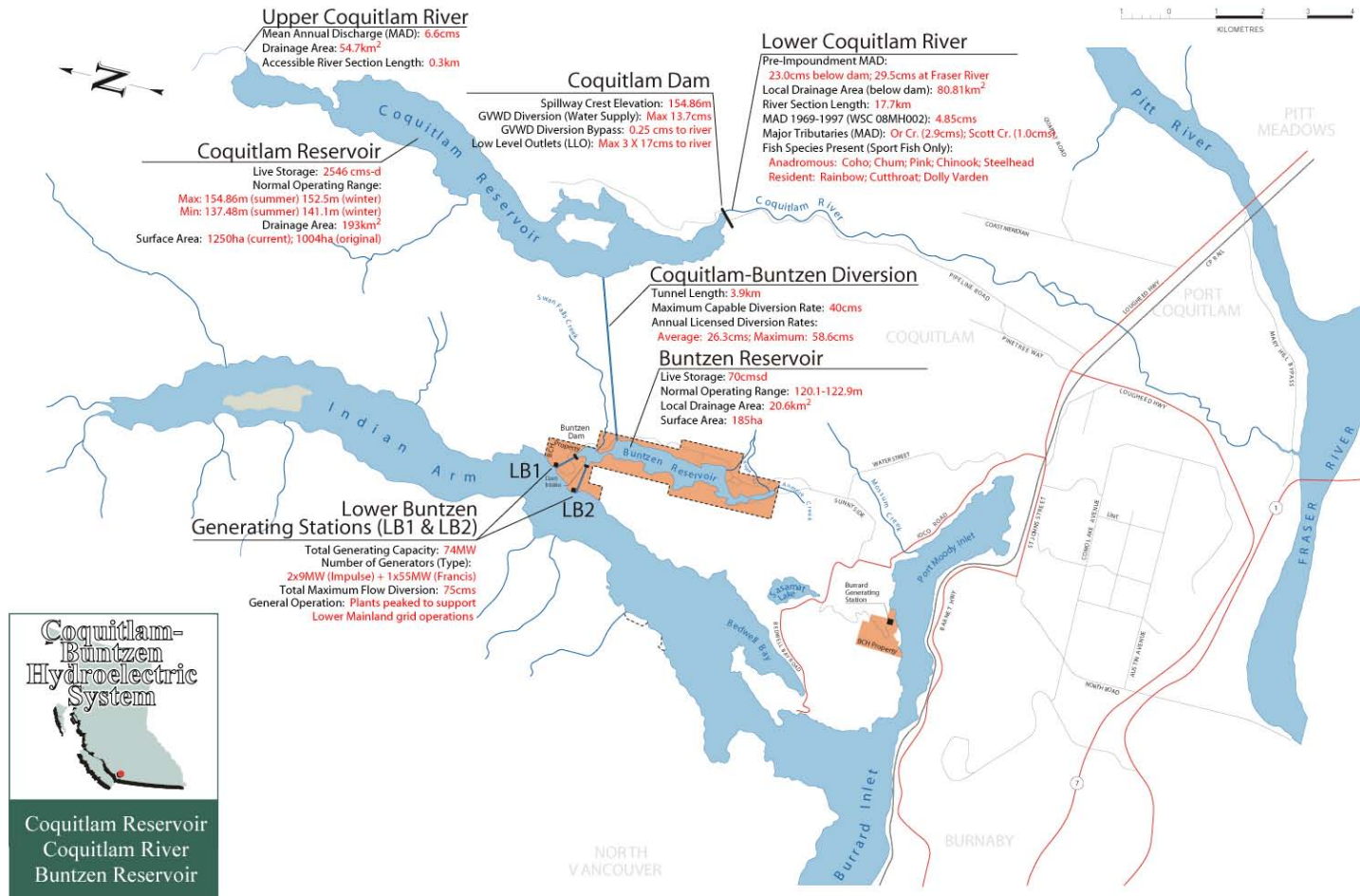


Figure 1-2: Coquitlam-Buntzen System components and attributes

1.1 Monitoring Program Summary

1.1.1 Program Objective

To address uncertainties related to the effectiveness of the LB1 WUP operating constraints, the CC recommended that a monitoring program be implemented for the duration of the review period. The overall objective of the monitoring program is to provide the level of information required for future water planning processes on the Coquitlam-Buntzen system to recommend a Coquitlam Dam release regime that fits within the parameters of the LB1 WUP agreement: between the annual water budgets of Treatment #1 and Treatment #2 (or STP5² whichever is more desirable to fish).

1.1.2 Program Approach

Although the approach varies between study programs, the program in general attempts to address key uncertainties and evaluate the effectiveness of the Water Use Plan operations. The most important indicator of effectiveness will be the productive response of fish species in the Lower Coquitlam River. In lieu of unknown productivity relationships, predictions of habitat response in Reaches 2 and 3 (see BC Hydro 2003a for reach summaries) to flow alternatives were reviewed in WUP deliberations. The validity of these predictions as proxies for fish production will be evaluated at the end of the WUP review period.

To inform the monitoring approach, a power analysis (Higgins et. al. 2002) was conducted that described the ability of a monitoring program to measure a response to a flow change. It concluded that 15 years of monitoring in reaches 2 and 3 would be required to obtain a reliable result. Although lower reaches (i.e. reaches 0 or 1) are extremely productive for fish in the Coquitlam River, the effect size used in the analysis showed that lower sites would not be a reliable indicator of response to dam releases upstream. Therefore, the Consultative Committee agreed that the focus of the monitoring program would be on the upper reaches of the Lower Coquitlam River. There are several other components of the monitoring program (e.g. Interim Ramping Rate Monitoring, Pink Salmon Passage and the Substrate Quality Assessment) that conduct at least some aspects of their monitoring in the lower reaches in recognition that impacts of operations affect the entire Lower Coquitlam River.

The flow treatments were developed to address habitat requirements for various key species life histories throughout the year, predominantly steelhead and chinook salmon. However, because chinook are in low abundance, coho, chum and pink salmon will be used as indicators in the monitoring program and chinook will be monitored where possible.

² STP5 or "Share the Pain" 5 was an alternative tentatively approved for implementation by the Consultative Committee in 2002 (BC Hydro 2002), and the agreement by the CC at the time was not amended when the CC refined the alternative to STP6 (Treatment #2).

1.1.3 Program Summary

This package outlines eight monitoring programs being implemented during the review period. The objectives and monitoring indicators to be reported to BC's Comptroller of Water Rights are listed below:

- COQMON#1 – Assessment of Fisheries Access to Streams Tributary to Coquitlam Reservoir: The objective of this study is to identify fish use and/or fish habitat potential in each of the three streams identified with potential fish access issues (BC Hydro 2000) and to recommend physical works and/or operational constraints to restore fish access for all operations.
Monitoring Indicator: Barrier to fish passage identified (yes/no)
- COQMON#2 – Coquitlam Dam Flow Release Interim Ramping Rate Monitoring: The objective of this monitoring program is to report on the fish stranding impacts in the lower Coquitlam River associated with the implementation of the interim ramping rate protocol for the Coquitlam Dam.
Monitoring Indicator: Stranding risk (number of fish stranded per area of dewatered habitat measured).
- COQMON#3 – Lower Coquitlam River Fish Habitat Requirements Study: The objective of this study is to identify any changes to the habitat suitability criteria used in the Coquitlam-Buntzen Water Use Plan calculations of weighted useable area of habitat, and refine the habitat-flow relationships and flow release targets developed in the WUP.
Monitoring Indicator (a): Habitat suitability for species of interest
Monitoring Indicator (b): Flow target (Coquitlam Dam releases) for LB1 WUP
- COQMON#4 – Assessment of Pink Salmon Passage in Lower Coquitlam River: The objective of this study is to monitor the migration of returning pink salmon in odd years to determine if there are any flow-related partial or complete migration barriers in the lower Coquitlam River corridor.
Monitoring Indicator: Number of days of unimpeded access
- COQMON#5 – Coquitlam River Periphyton and Benthic Invertebrate Monitoring: The objective of this study program is to develop a predictive model for evaluating periphyton and invertebrate benefits associated with Lower Coquitlam River flow alternatives.
Monitoring Indicators (short term): seasonal results of benthos monitoring;
Monitoring Indicators (long term): modeled results of benthos abundance and diversity indicators.
- COQMON#6 – Lower Coquitlam River Temperature Monitoring: The objective of this monitoring program is to identify if and how temperature in the lower Coquitlam River is influenced by reservoir operations.
Monitoring Indicator (a): Deviation of temperature regime from natural examples.
Monitoring Indicator (b): Correlation between temperature and reservoir operations
- COQMON#7 – Lower Coquitlam River Fish Productivity Index: The objective of this monitoring program is to determine the fisheries benefits of two test flows and to enable a better understanding of trade-offs between fisheries, domestic water and power generation for the benefit of future water planning processes.

Monitoring Indicator (a): Smolt per spawner (stock productivity) for coho salmon and steelhead.

Monitoring Indicator (b): Fry per spawner for chum and pink salmon.

- COQMON#8 – Lower Coquitlam River Substrate Quality Assessment: The objective of this monitoring program is to evaluate the effectiveness of the flushing flow provisions outlined in the LB1 WUP to increase fish productivity through improved substrate quality in the lower Coquitlam River.

Monitoring Indicator: Substrate quality (areal fraction of fine sand)

Physical works terms of reference will be delivered in a separate package.

1.2 Monitoring Cost Summary

The following table describes the costs associated with the monitoring program proposals in this document. It is assumed that the funding for this program will be initiated in 2006. Note that resources not spent in 2005 will be carried forward to the next year where warranted. Based on revised terms of references (COQMON#3) and revised implementation schedules resulting from physical works delays, the budgets and the review period have increased for this program beyond those originally approved. The revised average annual cost is \$212K, with an expected inflated total program cost of \$2,542K over the 12-year (2005-2016 inclusive) review period. This is 43% higher than what was approved in the LB1 WUP (total inflated approved costs were \$1,781K), although only 12% of this is due to the recent program changes. The remainder of the cost variance is due in-part to an unanticipated shortfall in partnership funding associated with the smolt enumeration program, a sub-component of the Lower Coquitlam River Fish Productivity Index study program. In addition to the shortfall, several items identified during the Terms of Reference review were added to the program to improve the power and consistency of monitoring the effectiveness of the operational changes. These included an annual standing stock assessment, an expansion of the periphyton and benthic invertebrate monitoring program, and an annual survey of substrate quality, as requested by agency representatives.

Table 1-2: Summary of LB1 WUP monitoring program costs and variance from budgets approved during the WUP (inflated values)

Study Ref#	Terms of Reference Proposals	Program Costs
1	Assessment of Fisheries Access to Streams Tributary to Coquitlam Reservoir	\$10,260
2	Coquitlam Dam Flow Release Interim Ramping Rate Monitoring	\$87,235
3	Lower Coquitlam River Fish Habitat Requirements Monitoring Program	\$82,992
4	Assessment of Pink Salmon Passage in Lower Coquitlam River	\$37,241
5	Coquitlam River Periphyton and Benthic Invertebrate Monitoring	\$168,739
6	Lower Coquitlam River Temperature Monitoring	\$22,791
7	Lower Coquitlam River Fish Productivity Index	\$1,925,301
8	Lower Coquitlam River Substrate Quality Assessment	\$208,346
Total – All Components		\$2,542,905
WUP Approved Budget		\$1,772,666
% Variance from Approved		43%

1.3 Monitoring Program Delivery

The LB1 WUP was ratified in 2003 and was ordered by the BC Comptroller of Water Rights (CWR) in April 2005. Current implementation of Treatment 1 flows are in effect until 2007 when gate modifications and dam seismic upgrades will be complete and Treatment 2 flows will be instated and monitored.

After 9 years of Treatment 2 monitoring, the review period will conclude and the results of the monitoring program will be deliberated. A recommendation on the basis of the monitoring results pertaining to the flow release regime needed to meet the objectives laid out in the LB1 WUP will be provided to the CWR by BC Hydro on behalf of the monitoring committee. The recommendation will be constrained between the annual water budgets of Treatment 1 and Treatment 2 per the agreement made by the Consultative Committee as outlined in the consultative committee report (BC Hydro 2003).

2.0 COQMON#2 – Coquitlam Dam Flow Release Interim Ramping Rate Monitoring

2.1 Monitoring Program Rationale

2.1.1 Background

During the development of the Coquitlam-Buntzen Water Use Plan (LB1 WUP), the consultative committee (CC) outlined several issues with dam operations that could possibly impact fisheries values in the lower Coquitlam River. Coquitlam Dam release flow reductions following pre-spill operations are known to cause fish stranding (Macnair et. al. *in prep.*) particularly in relation to the rate of flow reduction (herein referred to ramping rates) and the magnitude of flow. Due to time constraints, the issue of fish stranding related to ramping rates was not fully addressed and therefore a monitoring study to be implemented immediately was recommended. Rates of change related to flow increases from the dam (up-ramping rates) were identified as an issue, but were not formally explored due to their perceived low impact.

Ramping rates for dam were not formally developed for Coquitlam Dam operations prior to WUP implementation, and were generally set to the maximum rate possible. There are three low level outlets that can release a cumulative amount of 50 cms from the dam, and are typically only opened to mitigate spilling from the dam for flood control purposes. Other less frequent releases from low level outlets have been conducted for gate testing and fisheries requirements. As part of the Coquitlam Dam release regime recommended for fisheries values in the LB1 WUP, increased low level outlet releases will also increase the need for a comprehensive ramping rate strategy for implementation.

At the end of the WUP, the CC recommended that the monitoring study relating to ramping rates be implemented immediately, whereby ramping rates be adaptively developed preceding the formal implementation of the WUP. A study was initiated in 2003, and an interim ramping rate protocol was developed for implementation and monitoring over the review period (see Macnair et. al. *in prep.*). This document outlines the monitoring approach to be taken during dam release reductions over the review period.

2.1.2 Management Questions

The CC monitoring recommendations were driven by two important questions:

- 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?*

Management question (a) was addressed during the “pre-spill seasons” of 2003/04, 2004/05 and 2005/06 when, typically between November and January each year,

