

Coquitlam-Buntzen Water Use Plan

Monitoring Program Terms of Reference

- **COQMON#3 – Lower Coquitlam River Fish Habitat Requirements Study**

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| Monitoring Program | 1 st Submission | Revision 1 | Rescinded | Approval |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.

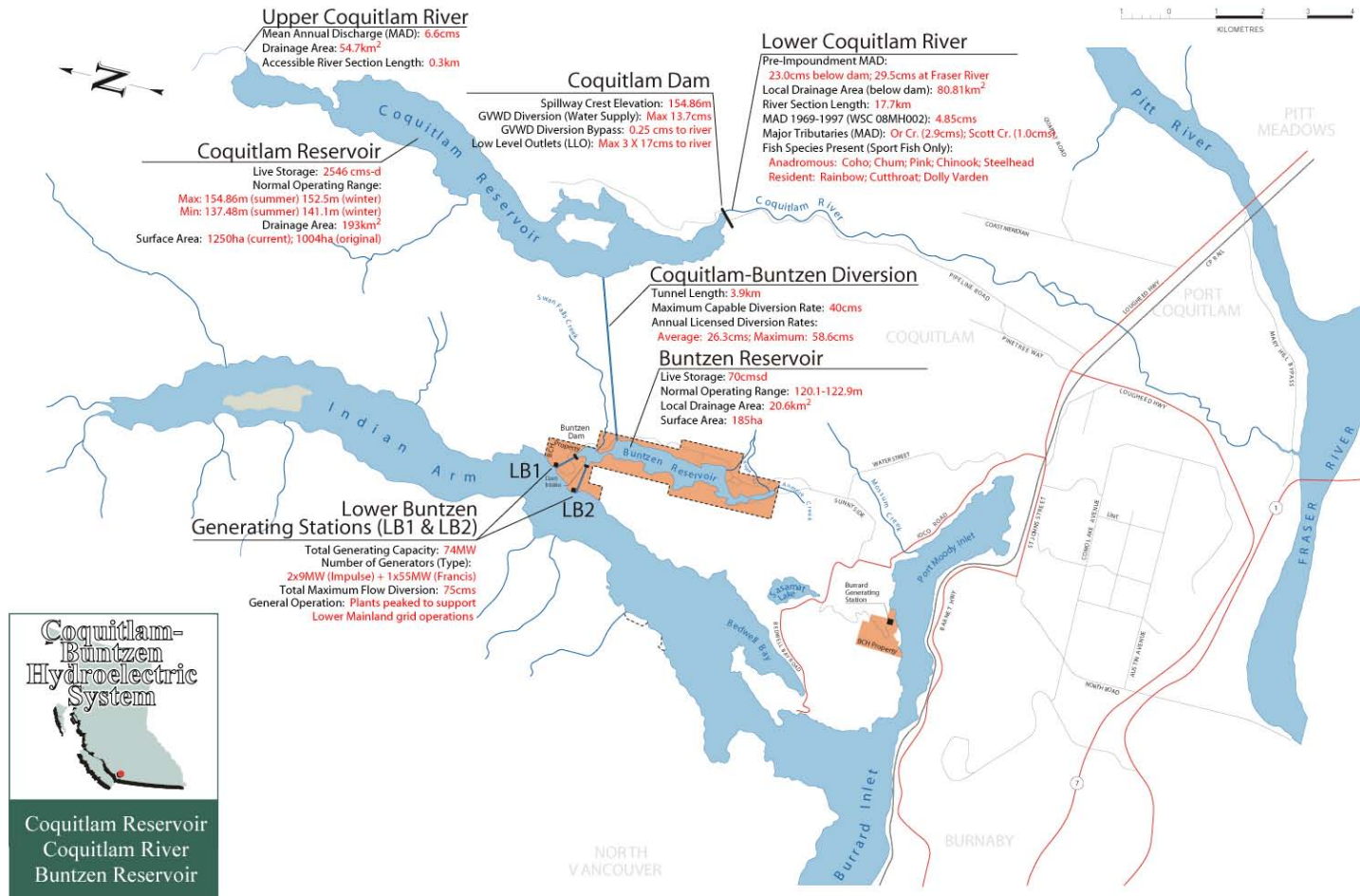


Figure 1-2: Coquitlam-Buntzen System components and attributes

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#3 – Lower Coquitlam River Fish Habitat Requirements Study

2.1 Monitoring Program Rationale

2.1.1 Background

During the Coquitlam-Buntzen Water Use Plan project (LB1 WUP), an empirically-derived habitat-flow model was developed to predict the effects of different flow regimes on fisheries habitat in the Lower Coquitlam River (see BC Hydro 2003a). The weighted-usable-area (WUA) model incorporated physical measurements of depth, velocity and substrate size with known habitat suitability index (HSI) criteria from other BC rivers for fish species of interest. HSI criteria were not derived from Coquitlam River observations, although there was an effort during the project to develop watershed-specific criteria for application to the watershed. A study was carried out as part of the habitat model development that saw habitat criteria developed for juveniles in the Coquitlam system; however, these results were not incorporated into the habitat model development for two reasons:

- a) the sample sizes of many of the fish species observed were not large enough to develop strong habitat suitability relationships; and
- b) the fish habitat available while assessing use was limiting for juveniles in some situations, resulting in relationships that were biased towards available, sub-optimal habitat types. Streamflows during these surveys were not sufficiently large enough to create diverse hydraulic conditions to support habitat preference research.

Provincial HSI criteria (MWLAP 2001) were used to develop the habitat flow relationships used in the LB1 WUP project based on validation of criteria using existing stock assessment and meso-habitat conditions. For example, high steelhead parr counts were aligned with fast-water habitats; the criteria predicted the same outcome. The consultative committee used the habitat modeling results to help develop a WUP and monitoring program for the Coquitlam-Buntzen system, which will see two flow treatments being released from Coquitlam Dam and evaluated in terms of productivity benefits. The CC recommended that the monitoring program include funding to develop watershed specific HSI relationships for fish species that consider habitat use for fish species of interest under both flow treatments, and that the habitat-flow relationships be revised according to the updated criteria. In order to meet requirements from the Comptroller of Water Rights (pers. comm. 2006), the recommended study was revised to supplement the Lower Coquitlam River Fish Productivity Index Study (COQMON#7 in the LB1 WUP monitoring program).

These study terms of reference outline an annual program consisting of:

- Analysis of habitat requirements of fish sampled in various components of the Lower Coquitlam River Fish Productivity Index study;
- A review of study requirements after three-years; and

- A review of habitat requirements integrated into the Coquitlam River habitat-flow model with recommendations for further changes.

2.1.2 Management Questions

The CC wished to understand how benefits in habitat predicted using habitat models translates to benefits in aquatic productivity in the Lower Coquitlam River. The information in this study will specifically address the following important question:

Do habitat requirements for fish species of interest observed during the monitoring program differ from those integrated into the habitat modeling conducted during the LB1 WUP?

Annual data collection will be conducted during rearing and spawning periods for the species and life histories of interest starting in Spring 2007 (concurrent with the initiation of Treatment 2).

2.1.3 Summary of Alternative Hypotheses

This study will test two hypotheses posed by the FTC:

H₁: Habitat requirements monitored during Treatment 2 differ significantly from those used in LB1 WUP habitat modeling.

H₂: Habitat targets are achieved by flows different than those defined in the Coquitlam-Buntzen Water Use Plan.

It is not anticipated that significant differences will be detected between observed and modeled data. However, should differences be detected, the existing habitat model will be revised, and the results will comprise one component of the information for monitoring committee consideration at the end of the monitoring program.

2.1.4 Key Water Use Decision Affected

Flow targets in the LB1 WUP were set to meet objectives to maximize fish productivity through the provision of optimal habitats according to flow-habitat modeling (BC Hydro 2003a) for species life histories of interest. Where habitat requirements monitored in the LB1 WUP review period significantly deviate from those used in the LB1 WUP habitat modeling, the habitat-flow relationship will change accordingly, potentially resulting in a change in flow targets required to achieve objectives set out for the WUP.

Any change to habitat-flow targets resulting from this study will not be considered in this review period. However, the data collected here will provide context for habitat calculations in future water planning processes on the lower Coquitlam River.

2.2 Monitoring Program Proposal

2.2.1 Objective and Scope

The objective of this study is to quantify indicator species' juvenile and spawning habitat requirements in the Lower Coquitlam River. The methodology will combine field and analytical tasks to refine the habitat-flow relationships and flow release targets developed in the WUP. Only daytime habitat use will be captured in this study program, as this was the metric used in the LB1 WUP calculations.

Three seasons of data collection - summer rearing, fall spawning and spring spawning assessments – will be conducted annually starting in 2007 (the first year of Treatment 2 operations). Assessments of habitat requirements will be conducted in reaches 2 and 3 of the lower Coquitlam River. Assessments will be conducted as part of existing tasks under the Lower Coquitlam River Fish Productivity Index monitoring program (COQMON#7) according to the following table:

Table 2-1: Species life histories, study components and recommended peak timing of habitat requirement assessments.

| Target Species | Life History | COQMON #7 Study Component | Peak Timing |
|----------------|------------------------------|--|-------------------|
| Chinook salmon | Spawning | Adult salmon escapement assessment | 21 Oct to 07 Nov |
| Chum salmon | Spawning | Adult salmon escapement assessment | 21 Oct to 07 Nov |
| Coho salmon | Juvenile Rearing (1+ and 2+) | Fry and juvenile standing stock assessment | CPSF (Aug to Oct) |
| | Spawning | Adult salmon escapement assessment | 07 Nov to 07 Dec |
| Steelhead | Juvenile rearing (1+ and 2+) | Fry and juvenile standing stock assessment | CPSF (Aug to Oct) |
| | Spawning | Adult steelhead redd surveys | 07 Apr to 31 May |

2.2.2 Approach

Annual data collection for each of the following program components will be conducted as part of the existing study program already in place, starting in 2007:

- a) Habitat requirement assessments: Annual rearing and spawning habitat use assessments will be conducted by documenting the depth, velocity and substrate conditions utilized by a large sample of observed individuals in a variety of meso-habitats of the lower Coquitlam River;
- b) Data summary and analysis: using ANOVA techniques, data for each species life history will be analysed to assess fish habitat requirements for depth velocity and substrate.

- c) Habitat requirement review and assessment: at the three-year and 9-year mark of the review period, all data will be collated and analysed to determine whether the observed habitat requirements differ from those used in Water Use Plan habitat-flow analyses (BC Hydro 2003a). After 3-years, the Monitoring Committee will determine whether further work is required.

2.2.3 Methods

2.2.3.1 Habitat Requirement Assessments

Starting with spring Steelhead spawning assessments April-May 2007, the following assessments will be conducted during respective field programs already underway under the Lower Coquitlam River Fish Productivity Index monitoring program (COQMON#7, see Table 2-1).

Steelhead Spawning

During steelhead redd surveys, snorkel assessments already being conducted will include the measurement of depth/velocity/substrate/cover at each newly formed redd site encountered in each stream survey throughout the assessment period. The snorkeler will identify the redd to be measured with an instream marker, and the on-shore observer will collect the habitat properties of interest. Newly-formed test or partial redds will also be measured.

Because the redd mound can change hydraulic dynamics, and may not represent the habitat requirements that the steelhead female would target pre-redd, measurements should be taken at both the original level upstream of the redd pitt and at the height of the tailspill over the egg pockets (see figure below for descriptions). Substrate class (dominant/subdominant per BC RIC standards 2001) will also be collected at both locations.

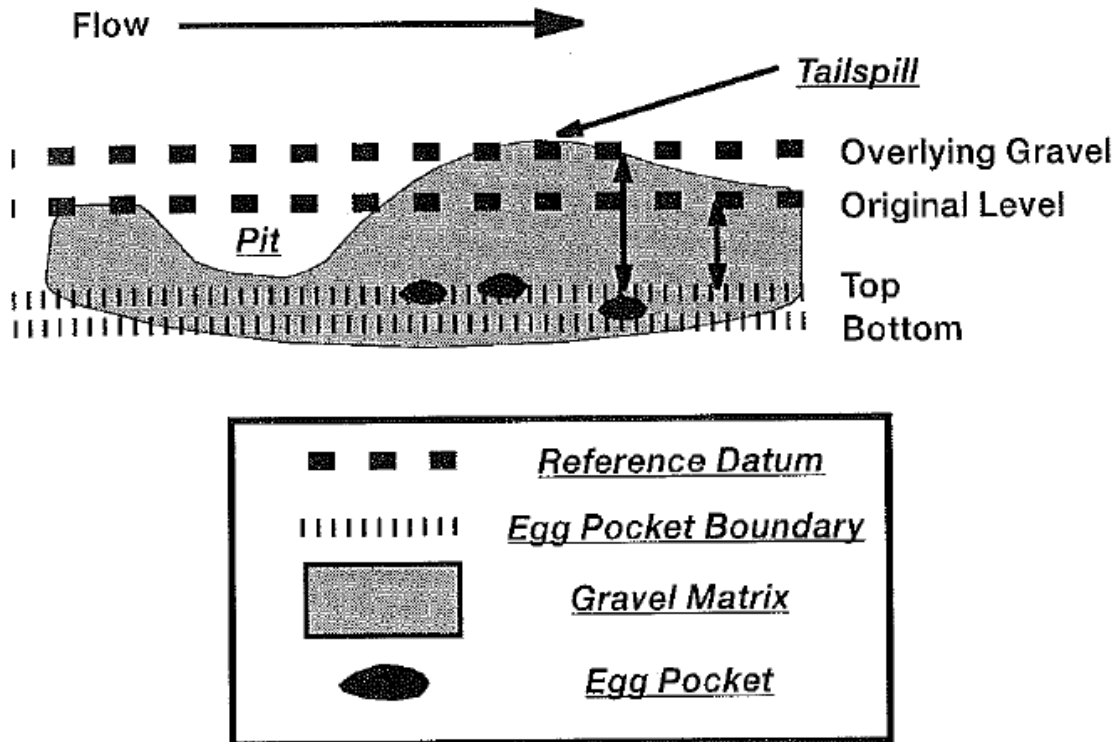


Figure 2-1: Schematic of a generic salmonid redd depicting geometries applicable to scour studies (taken from Devries 1997).

Juvenile Rearing

In addition to the work being conducted for the Juvenile (fry and parr) Standing Stock Assessment component of the Lower Coquitlam River Fish Productivity Index (COQMON#7) during critical period streamflow, a minimum of 5 of the 10 sampling sites will be used to assess habitat requirements for juveniles. As per survey methods used in the stock assessment, habitat characteristics (depth, velocity, substrate category and cover) are to be collected along representative transects. In addition, and where possible, habitat characteristics will be collected at or adjacent to fish capture locations. sites will contain a wide variation of habitat conditions, but will be chosen to (a) represent rearing habitats in reaches 2 and 3; and (b) increase the likelihood of finding an adequate sample size of coho and steelhead trout juveniles. Paired snorkel evaluation at each sample location will qualify whether electrofishing sites offer the best capture conditions for various species and life-stages. The sites may contain off channel habitats to increase the sample size of coho juveniles. The following will be conducted at each site:

In selecting index sites to assess habitat requirements (a minimum of 5 of the ten stock assessment sites), consider: (a) that the sites are representative of rearing habitats in reaches 2 and 3; and (b) that the sites have a high likelihood of finding an adequate sample size of coho and steelhead trout juveniles.

Logistical issues may preclude the collection of habitat characteristics for all fish captured in the stock assessment, thereby limiting the statistical power of the data. In such cases, the following steps are to be taken:

- a) *Simplifying the analysis*: focus on correlating index site meso-habitat data (general hydraulic and habitat characteristics) to fish use, which would require data pooling from all 10 index sites; and/or
- b) *Snorkel observations*: following procedures outlined in terms of reference for the Instream Flow Needs study (BC Hydro 1999), habitat characteristics for locations of fish observed through snorkel methods within at least 2 representative index sites will be collected by the crews charged with the stock assessment monitoring program.

Salmon Spawning

During each of the pink, chum and coho peak spawning periods, crews collecting escapement data under the Fall Adult Salmon Escapement Surveys component of the Lower Coquitlam River Fish Productivity Index study program (COQMON#8) will assess salmon spawning habitat requirements. The following steps will be taken:

- a) *Site selection*: Identify and delineate at least 10 well defined spawning sites within the study area. Each site will be divided into approximately three adjacent "lanes" (depending on the diversity of the habitat within the site) extending between the site's upstream and downstream extents. Divisions will be set based on changes in habitat characteristics observed within the site (i.e. lanes may be differentiated by depth, substrate and/or velocity). Site locations, identifiers and approximate site boundaries will be measured and illustrated in field data collection forms.
- b) *Spawner observations*: The number and species of adults spawning in each lane will be noted, and a minimum of three stations within each site will be sampled, collecting habitat characteristics relevant to this study. Data will be organized by "lane" such that the number and species of spawners will be linked to the habitat information collected at the three stations.

Date, crew information, water temperature and information on the run timing will be provided on the data form for consideration during analysis.

2.2.3.2 Data Summary and Analysis

At the end of each component's respective survey periods, the following steps will be taken to evaluate the habitat use data collected in the field:

- a) *Data Summary*: From the data collected during juvenile, spawner and redd surveys, individual site data will be combined into one database for each component, and sorted in species and age categories. "Clumped" data will be extended to individual observations. For example, an observation of 10 coho will be separated into 10 observations;

- b) *Analysis*: The following steps will be taken to develop habitat requirement relationships for each species and life history targeted in this study program:
- i. Species/age data sets are analyzed to test the distribution of observed values for each criteria. Software “kernels” utilize normal and log-normal distribution functions to fit a distribution to the data accordingly. Many data sets are shown to be distributed log-normally. Goodness of fit can be tested using the chi-square test, which has shown that a sample size of at least 30 is required. For high confidence, sample sizes of at least 50 are targeted. If sample sizes are less than 30, surrogate data (such as provincial or regional preference curves) are used.

- ii. Habitat measurements taken to evaluate “available” habitat are sorted and analyzed to test the distribution using the tools outlined in (3) above. “Corrected” use for observation i within distributions of each data set of k observations is derived below:

$$P_{i(\text{corrected})} = \frac{P_{i(\text{fish})} / P_{i(\text{available})}}{\sum_{i=1}^k P_{i(\text{fish})} / P_{i(\text{available})}}$$

where: i = sample
 P = Probability
 k = sample size

- iii. Items (i) and (ii) are repeated for each species/age class for depth, velocity, substrate and cover. The data are then summarized into curves representing species preference by criteria (depth, velocity, substrate and cover).
- c) *Transect Data Analysis*: Using transect data collected under the Coquitlam River Instream Flow Needs study (summarized in BC Hydro 2003a):
- i. composite suitability is to be calculated at each station based on the probability of use functions derived above according to the corrected probability of use observations above.
 - ii. The composite weight is then multiplied by the station width and station widths are summed to obtain weighted usable width for the transect.
 - iii. Weighted usable width is divided by the total width to derive “percent usable width”.
 - iv. The process is repeated for all flows evaluated in 2003 (BC Hydro), and a habitat-flow relationship is derived as described below.

2.2.3.3 Habitat Requirement Review and Assessment

Comparison with BC Instream Flow Standards

Habitat requirements utilized in the LB1 WUP performance measure calculations were imported from BC Ministry of Environment fish use standards (BC MELP 1999).

The habitat requirements derived from this study on an annual basis will be compared to these flow standards using statistical tests of significance to determine whether further analysis related to instream flow targets is required. Where significant differences exist between the two habitat requirement relationships, the following steps will be taken to determine flow target effects:

- a) *Transect analysis*: Transect data from the instream flow study conducted during the LB1 WUP (BC Hydro 2003a)- distance, depth, velocity, and substrate measurements taken at a minimum of 20 stations at each cross section – will be integrated with annually-derived habitat requirement relationships to define the proportion of each transect width usable by each fish species;
- b) *Habitat-flow curve analysis*: once usable-width calculations are complete, the transect data for each flow will be integrated spatially to determine the usable area at each flow towards the development of a habitat-flow curve for each species life history and meso-habitat class To develop habitat-flow curves, data will be assumed to fit to typical habitat flow relationships, as described in the following equation:

Equation 2-1: Typical habitat-flow relationship

$$y = Ax^c \bullet e^{nx^b}$$

where:

y = amount of habitat units;

x = amount of flow units;

A = parameter for magnitude; and

n = parameter for the rate of incline/decline of the relationship

c = parameter for the lag response of habitat to flow

b = parameter for the magnitude of the post-peak habitat response to flow

The equation describes habitat flow relationships as single mode maxima functions with its intercept at the origin. Bjornn and Reisser (1991) describe this relationship as typical for spawning and rearing habitats in fish streams. An analysis of alternative line-fit models will be conducted to ensure the appropriate habitat-flow relationships were derived.

- c) *Flow target revisions*: The habitat-flow relationships derived for the LB1 WUP (see BC Hydro 2003a) are to be revised, and the same “Percent of Maximum” targets assessed for the WUP are to be selected using the revised relationships, where warranted. By back calculating the releases required to meet downstream flow targets that achieve the percent of maximum habitat targets, flow targets will be revised for monitoring committee information purposes. Again, statistical tests of significance will be performed to determine whether flow targets derived in the WUP differ significantly with those defined in this study.

2.2.3.4 Reporting and Study Review

Each year, a summary of the data and analysis will be provided, comparing the habitat requirements relationships or habitat-flow relationships between those utilizing the BC MELP flow standards and those derived in the field. The biologist preparing the report is responsible for making recommendations to the monitoring committee to improve the data collection methodology and/or to terminate the program due to a lack of significant difference in results.

If after three years the analysis is inconclusive or does not validate either hypotheses for this study, the monitoring committee and/or BC Hydro may recommend that the study program be terminated upon receipt of a final report. Alternatively, the monitoring committee may recommend continuation of the study to improve data resolution where significant differences exist between habitat-flow relationships under each habitat use standard.

2.2.4 Interpretation of Monitoring Results

As detailed above, the revised habitat flow relationship for the lower Coquitlam River will provide the basis for future planning processes to re-evaluate flow targets in consideration of other important monitoring results, primarily fish production. BC Hydro and the Coquitlam-Buntzen WUP monitoring committee will consider these habitat predictions in their review of all other monitoring information at the end of the review period.

The monitoring committee will review the data reports and recommendations after three years of data collection to determine whether further data collection is required to improve the resolution or validate differences assessed between flow standards utilized in habitat-flow analyses.

2.2.5 Schedule

The following schedule is expected to be followed in order for BC Hydro to meet CWR requirements:

- October-November: Salmon spawning assessments (annually starting October 2007)
- April-May: Steelhead spawning assessments (annually starting April 2008)
- August-September: Juvenile rearing assessments (annually starting August 2008)
- November 15: Annual data report drafted (starting 2008)
- December 15: Annual data report finalized; third year report with recommendations drafted³
- January 15: third year report with recommendations finalized

³ Where data collection is extended beyond Year 3, this timing applies to Year 9 study results as well.

2.2.6 Budget

The annual program budget has an average annual cost of approximately \$9.2K starting in September 2007, with a total inflated cost of \$83.0K over the 9-year monitoring program. A review at Year 3 (after September 2010) could result in the termination of Years 4-9 data collection.