Columbia River Project Water Use Plan

Revelstoke Flow Management Plan
Annual Report: 2007

- **CLBMON-15a Middle Columbia River Physical Habitat Monitoring**
- **CLBMON-15b Middle Columbia River Ecological Productivity Monitoring**
- **CLBMON-16 Middle Columbia River Fish Population Indexing Surveys**
- **CLBMON-17 Middle Columbia River Juvenile Fish Habitat Use**
- **CLBMON-18 Middle Columbia River Adult Fish Habitat Use**
- **CLBMON-53 Middle Columbia Juvenile Fish Stranding**

Conditional Water Licences for Kinbasket storage (27068 and 39432), Mica diversion (39431), Revelstoke diversion and storage (47215), and Arrow storage (27066)

26 February 2008

BC Hydro Columbia River Project Water Use Plan Revelstoke Flow Management Plan Annual Report: 2007

1 Introduction

This document represents a summary of the status and results of the Revelstoke Flow Management Plan of the Columbia River Water Use Plan (WUP) monitoring programs to 31 January 2008, as per the Columbia River Order under the *Water Act*, dated 26 January 2007. There are six monitoring programs included within this Management Plan:

- CLBMON-15a Middle Columbia River Physical Habitat Monitoring
- CLBMON-15b Middle Columbia River Ecological Productivity Monitoring
- CLBMON-16 Middle Columbia River Fish Population Indexing Surveys
- CLBMON-17 Middle Columbia River Juvenile Fish Habitat Use
- CLBMON-18 Middle Columbia River Adult Fish Habitat Use
- CLBMON-53 Middle Columbia River Juvenile Fish Stranding

2 Background

The water use planning process for BC Hydro's Columbia River project was initiated in August 2000 and completed in June 2004. The conditions proposed in the WUP for the operation of the project reflect the June 2004 consensus recommendations of the Columbia River WUP Consultative Committee (CC).

In July 2006, the Columbia River Draft WUP was submitted to the Comptroller of Water Rights (CWR). The draft WUP was sent out to regulatory agencies, First Nations and interested stakeholders for review. In January 2007, the CWR approved the final WUP and issued an Order to BC Hydro to implement the conditions proposed in the Columbia River WUP and prepare the monitoring programs and physical works Terms of Reference (TOR).

An addendum to the Columbia River WUP was submitted to the CWR in July 2007 after an Environmental Assessment Certificate was issued for the Revelstoke Unit 5 Project. The addendum proposes additional terms and conditions for the Columbia River WUP, as recommended by the Revelstoke Unit 5 Core Committee in December 2006, to address incremental impacts of the operation of the fifth generating unit at Revelstoke Dam.

In August 2007, the CWR accepted the Columbia River Project WUP Addendum resulting from the Revelstoke Unit 5 Project, and issued amendments to the Columbia River Implementation Order to include the commitments made by BC Hydro to undertake additional monitoring programs and physical works associated with the Revelstoke Unit 5 Project.

The following table outlines the dates that Revelstoke Flow Management Plan TOR have been submitted to, and approved by the CWR.

Monitoring TOR	Date Submitted	Date Approved
CLBMON-15a Middle Columbia River Physical Habitat Monitoring	05 March 2007	22 March 2007
CLBMON-15b Middle Columbia River Ecological Productivity Monitoring	05 March 2007	22 March 2007
CLBMON-16 Middle Columbia River Fish Population Indexing Surveys	05 March 2007	22 March 2007
CLBMON-17 Middle Columbia River Juvenile Fish Habitat Use	05 March 2007	22 March 2007
CLBMON-18 Middle Columbia River Adult Fish Habitat Use	05 March 2007	22 March 2007
CLBMON-35 Middle Columbia River Juvenile Fish Stranding		

As outlined in the Columbia River WUP, the Consultative Committee recommended a full review of the Columbia River Water Use Plan 13 years after implementation, unless results of the monitoring program suggest an earlier review is appropriate or significant risks are identified that could result in a recommendation to change operations.

BC Hydro will convene a multi-party panel five years after commencing the implementation of this WUP to evaluate the effectiveness of operations and physical works in meeting the stated objectives for Arrow Lakes Reservoir and the lower Columbia River. The outcomes from this process will be used to assess any potential need to review the Arrow Lakes Reservoir component of this WUP. If a replacement Non-Treaty Storage Agreement (NTSA) is negotiated within this 5-year period, it is also recommended that agreement provisions and implications be reported out through this panel. Signing of a new NTSA is not a trigger for panel evaluation or a review of this Water Use Plan recommendation to change operations.

3 Schedule

The following table (Table 3-1) outlines the current schedule for the monitoring programs being delivered under the Revelstoke Flow Management Plan of the Columbia River Water Use Plan.

Table 3-1: Schedule of Columbia River WUP Monitoring Programs Implementation under the Revelstoke Flow Management Plan

Monitoring Programs	2007 WLR YR1	2008 WLR YR2	2009 WLR YR3	2010 WLR YR4	2011 WLR YR5 Interim Review	2012 WLR YR6	2013 WLR YR7	2014 WLR YR8	2015 WLR YR9	2016 WLR YR10	2017 WLR YR11	2018 WLR YR12	2019 WLR YR13 Final Review
CLBMON-15a Middle Columbia River Physical Habitat Monitoring	u/w	■	■	■	■	■	■	■	■	■	■	■	■
CLBMON-15b Middle Columbia River Ecological Productivity Monitoring	u/w	■	■	■	■	■	■	■	■	■	■	■	■
CLBMON-16 Middle Columbia River Fish Population Indexing Surveys	u/w	■	■	■	■	■	■	■	■	■	■	■	■
CLBMON-17 Middle Columbia River Juvenile Fish Habitat Use		■	■	■	■	■							
CLBMON-18 Middle Columbia River Adult Fish Habitat Use		■	■	■	■	■							
CLBMON-53 Middle Columbia River Juvenile Fish Stranding			■		■								

Legend:
■ = Program to be undertaken/initiated in identified year
u/w = Project is underway
✓ = Program completed for the year
× = Program started, but encountered operational or hydrological delays

4 Columbia River WUP Monitoring Programs – Revelstoke Flow Management Plan

This section summarizes the status of the monitoring programs being implemented under the Revelstoke Flow Management Plan of the Columbia River Water Use Plan, as per the Order under the *Water Act,* dated January 26, 2007 and Revelstoke 5 amendments to the Order as per the CWR letter to BC Hydro, dated 23 August 2007.

4.1 CLBMON-15a - Middle Columbia River Physical Habitat Monitoring

4.1.1 Overview

The objectives of this monitoring program are:

1) To measure spatial and temporal differences in the daily and seasonal river water temperature regimes between current operations and the 142 m^3s^{-1} minimum flow regime.
2) To measure spatial and temporal differences in river water TGP levels between current operations and the 142 m^3s^{-1} minimum flow regime.
3) To measure spatial and temporal differences in the daily and seasonal range of river level fluctuation between current operations and the 142 m^3s^{-1} minimum flow regime.
4) To systematically collect seasonal nutrient and electrochemistry data at the reach scale to spatially characterize water quality conditions as they affect biological productivity of the benthic community.
5) To estimate changes in the quantity and spatial distribution of permanently inundated river channel resulting from 142 m^3s^{-1} minimum flow releases.

The Columbia River Water Use Plan Consultative Committee (WUP CC) supported the implementation of a year-round minimum flow release of 142 m^3s^{-1} from Revelstoke Dam to enhance fish populations of the Middle Columbia River.

To monitor the effectiveness of the minimum flow for meeting environmental objectives, the WUP CC recommended the implementation of a program to document physical habitat characteristics of the Middle Columbia River to compare how the implementation of a minimum flow affects physical habitat conditions for benthic organisms and fish. The collection of physical habitat data was also anticipated by the WUP CC as a fundamental information requirement for supporting other monitoring programs associated with the RFMP. The intent was to ensure that it would be possible to construct a logical linkage between the operation of Revelstoke Dam and ecological response indicators for the productivity of the benthic community, changes in fish habitat use, and productivity of fish populations.

The key water use planning decision affected by the results of this monitoring program is the implementation of the 142 m^3s^{-1} minimum flow release from Revelstoke Dam. The questions addressed in this monitoring program are directly related to estimating how the operation will affect key physical monitoring indicators to describe large river habitat conditions. These physical habitat time series data and the associated inferences regarding effects on habitat conditions are a key component of the interpretation of four other integrated monitoring programs recommended for the Revelstoke Flow Management Program. This information is critical for constructing a logical linkage between the operation of Revelstoke Dam

and response indicators for the productivity of the benthic community, changes in fish habitat use, and productivity of fish populations.

This monitoring program involves establishing fixed index monitoring stations to collect physical habitat data in each reach of the study area for a systematic time series on water temperature, water quality, and water level conditions. These stations coincide with periphyton/benthic substrate locations for CLBMON-15b Ecological Productivity, since the data collected will be used in this study to help understand the influence of physical habitat conditions on the benthic community.

The empirical data will be used to provide a fundamental description of physical habitat conditions in each reach of the study area and to investigate how dam releases, tributary inflows, and reservoir operation impact key physical habitat characteristics. Monitoring data will be used to test hypotheses about how minimum flow affects water temperature, water quality, and river level fluctuation. The empirical data will also be used to calibrate existing hydraulic models of the Middle Columbia River. These models will be applied to estimate how the observed pattern of dam releases, tributary inflows, and reservoir operation affect the total wetted area of flowing large river habitat, as well as patterns of inundation that influence the productivity of benthic communities.

The data generated from this monitoring program will be archived in an electronic database and used as covariates in analyses conducted in other components of the RFMP, which investigate the influence of physical habitat on ecological productivity, fish population response measures, and fish habitat use.

4.1.2 Status

This monitoring program was initiated in June 2007 and will be carried out over 13 years. A contract was awarded to Golder Associates Ltd. (Castlegar) to conduct the study in 2007. The first program report is expected in April 2008.

4.1.3 Interpretation of Data

At this time, there are no data to interpret for this monitoring program.

4.2 CLBMON- 15b - Middle Columbia River Ecological Productivity

4.2.1 Overview

The objectives of this monitoring program are:

1) To design and implement a systematic long term program for indexing the productivity and diversity of key benthic community taxa (periphyton and invertebrates) in the Middle Columbia River.
2) To assess the response of the benthic community taxa (periphyton and invertebrates) of Middle Columbia River to a minimum flow release from Revelstoke Dam.
3) To investigate and quantify the relationship between habitat attributes and benthic composition, abundance, and biomass within the four reaches of the Middle Columbia River

The Columbia River Water Use Plan Consultative Committee (WUP CC) supported the implementation of a year-round minimum flow release of 142 m^3s^{-1} from Revelstoke Dam to enhance fish populations of the Middle Columbia River.

A key environmental objective of the minimum flow release is to enhance the productivity and diversity of benthic communities (referred to by the WUP CC as 'ecological health'). The benthic community of the Middle Columbia River was established as a key monitoring variable in the Revelstoke Flow Management Program (RFMP) because: 1) the productivity and diversity of the benthic community serves as a general indicator of ecosystem health, and 2) the benthic community determines the type and amount of food available to support juvenile and adult life stages of key fish populations. This monitoring program is therefore intended to: 1) provide long-term data on the productivity of benthic communities as a measure of the ecological health of the river, and 2) assess how the recommended minimum flow release influences benthic productivity as it relates to the availability of food for fish in the Middle Columbia River.

The key water use planning decision affected by the results of this monitoring program is the implementation of the 142 m^3s^{-1} minimum flow release from Revelstoke Dam. Information required for this decision is whether a 142 m^3/s minimum flow from Revelstoke Dam will increase: 1) the abundance and diversity of benthic organisms, and 2) the abundance of sub-adult and adult life stages of fish populations in the Middle Columbia River.

This monitoring program involves establishing index monitoring stations in each river reach for periphyton growth and benthic production during the peak growing season. Artificial substrata will be deployed at different elevations to test the effectiveness of a future minimum flow on periphyton and benthic production.

4.2.2 Status

This monitoring program was initiated in July 2007 and will be carried out over 13 years. A contract was awarded to Golder Associates Ltd. (Castlegar) to conduct the study in 2007. The first program report is expected in April 2008.

4.2.3 Interpretation of Data

At this time, there are no data to interpret for this monitoring program.

4.3 CLBMON-16 – Middle Columbia River Fish Population Indexing Surveys

4.3.1 Overview

The objective of this monitoring program is to systematically collect fish population data prior to and following the implementation of the 142 m^3s^{-1} minimum flows to quantitatively assess changes in abundance, growth, survival, and spatial distribution of key fish species in the Middle Columbia River.

Secondary objectives include: 1) building on earlier investigations to further refine the sampling strategy, sampling methodology, and analytical procedures required to establish a long-term monitoring program for fish populations in the Middle Columbia River; 2) to identify gaps in understanding, data and current knowledge about fish

populations and procedures for sampling them, and 3) to provide recommendations for future monitoring and fisheries investigations.

The Columbia River Water Use Plan Consultative Committee (WUP CC) supported the implementation of a year-round minimum flow release of 142m^3s^{-1} from Revelstoke Dam to enhance fish populations of the Middle Columbia River.

A key environmental objective of the minimum flow release was to increase the abundance and diversity of fish populations in the Middle Columbia River. To address uncertainties regarding the effectiveness of the minimum flow releases for enhancing the productivity and diversity of fish populations, the WUP CC recommended a long term fish population monitoring program. This program is intended to document changes in the abundance, biological condition, and spatial distribution of sub-adult and adult life stages of key fish species using the Middle Columbia River, and to quantify the response of key fish populations to the implementation of minimum flow releases.

The key operating decision that will be affected by this monitoring program is the implementation of the 142 m3s-1 minimum flow release from Revelstoke Dam. This program specifically seeks to determine whether a 142 m3/s minimum flow from Revelstoke Dam will benefit fish populations in the Middle Columbia River.

This monitoring program involves the application of a systematic fish sampling protocol on an annual basis in the study area over the period of the Columbia Water Use Plan. Using established field sampling and analytical techniques for population estimation, catch-at-age analysis and population modeling, a quantitative assessment of temporal patterns in population abundance, mean size-at-age, survival, and distribution for each key species will be undertaken to assess the benefits of the 142 m^3s^{-1} minimum flow releases. Given the uncertainty about factors that control fish populations, a weight-of-evidence approach will be applied to interpret fish population index information. Inferences about the patterns and/or trends in fish abundance, growth and survival in relation to the implementation of minimum flow releases will be interpreted in conjunction with inferential support provided by the physical habitat and ecological productivity monitoring, as well as juvenile fish and habitat use programs.

4.3.2 Status

This monitoring program was initiated in October 2007 and will be carried out over 13 years. A contract was awarded to Golder Associates Ltd. (Castlegar) to conduct the study in 2007. The first program report is expected in April 2008.

4.3.3 Interpretation of Data

At this time, there are no data to interpret for this monitoring program.

4.4 CLBMON-17 – Middle Columbia River Juvenile Habitat Use

4.4.1 Overview

The objectives of this monitoring program are to:

1) Provide information on use of the Middle Columbia River by juvenile fish and the suitability of habitats in this reach to meet critical life history requirements (i.e., rearing) of fish populations.
2) Assess the effectiveness of the implementation of the 142 m3/s minimum flow for increasing the recruitment of juvenile life stages of key fish species of the Middle Columbia.

The Columbia River Water Use Plan Consultative Committee (WUP CC) supported the implementation of a year-round minimum flow release of 142 m^3s^{-1} from Revelstoke Dam to enhance fish populations in the Middle Columbia River.

A key environmental objective of the minimum flow release was to increase the recruitment of juvenile life stages of fish to habitats in the Middle Columbia River. Previous inventory studies of fish populations in the Middle Columbia River below Revelstoke Dam have found that the mainstem river habitats are used primarily by sub-adult and adult life stages, implying that mainstem habitats of the Middle Columbia are unsuitable or unnecessary for juvenile fish. This monitoring program is aimed at obtaining a better understanding about how juvenile life stages use large river habitats in the Middle Columbia River, and to assess if the pattern of habitat use is influenced by the provision of minimum flow releases.

The key water use decision affected by this monitoring program is the implementation of the 142 m3s-1 minimum flow release from Revelstoke Dam. A key environmental objective of the provision of the minimum flow release is to improve mainstem habitat conditions for juvenile life stages of key Middle Columbia River fish populations. Inferences from this study will be interpreted alongside results of the other RFMP monitoring programs to provide an overall assessment of the benefits of minimum flow releases for fish populations.

This monitoring program involves the development and implementation of a systematic sampling program to infer changes in recruitment of juvenile life stages to large river habitats in the Middle Columbia River in response to the minimum flow. Habitats available to juveniles will be characterized, and fish sampling, based on stratified random approach, will be conducted annually during two contrasting characteristic habitat conditions - low and high Arrow Reservoir elevation. Given the wide range of habitats, reservoir elevations and flow conditions to be examined, a range of standard sampling approaches will be required in representative habitats within the study area. Sampling will be conducted in mainstem habitats and lowermost reaches of selected fish-bearing tributaries that flow into the Middle Columbia River. Results from initial testing will be used to develop a systematic survey approach to produce repeatable indices of the relative abundance of juvenile

4.4.2 Status

This monitoring program will be initiated in 2008 and will be carried out over six years. Contract award is scheduled for March 2008. The first program report is expected in April 2009.

4.4.3 Interpretation of Data

At this time, there are no data to interpret for this monitoring program.

4.5 CLBMON-18 – Middle Columbia River Adult Fish Habitat Use

4.5.1 Overview

The objectives of this monitoring program are to:

1) Provide detailed information on the seasonal pattern of residence and movement of selected fish species in the Middle Columbia River.
2) Provide detailed information on daily patterns of habitat use and activity of selected species of fish in the Middle Columbia River in response to flow fluctuations.
3) Determine whether fish vary their seasonal and diel patterns of habitat use in response to the implementation of the 142 m^3s^{-1} minimum flow release from Revelstoke Dam.

The Columbia River Water Use Plan Consultative Committee (WUP CC) supported the implementation of a year-round minimum flow release of 142 m^3s^{-1} from Revelstoke Dam to enhance fish populations of the Middle Columbia River.

A key uncertainty related to the minimum flow release, as expressed by the WUP CC, was how the implementation of this flow would affect and/or benefit fish populations that use the Middle Columbia River. This monitoring program will document the pattern of seasonal habitat use and daily activity of sub-adult and adult life stages of fish populations that use large river habitats in the Middle Columbia River, and assess if the pattern of habitat use is influenced by the provision of minimum flow releases.

The key water use planning decision affected by the results of this monitoring program is the implementation of the 142 m^3s^{-1} minimum flow release from Revelstoke Dam. This monitoring program seeks to address the question of how the provision of a minimum flow will affect seasonal and diel patterns of sub-adult and adult fish habitat use in the Middle Columbia River. Information derived from the program will be used to infer whether a minimum flow improves the quality of fish habitat for sub-adult and adult life stages in the Middle Columbia River. The results from this program will be integrated with the four other monitoring programs of the RFMP (Physical Habitat Monitoring, Ecological Productivity Monitoring, Fish Population Indexing Surveys, Juvenile Habitat Use), and will be used to support inferences regarding benefits of the minimum flow for fish. Results from the RFMP and associated inferences will be used to establish the long term operating release requirements for the Revelstoke Dam.

This program involves monitoring the seasonal and daily pattern of adult fish habitat use and quantitative indicators of activity and metabolic energy expenditure for two key species of fish in the Middle Columbia. Methods will use a representative sample of sub-adult and adult bull trout, as well as mountain whitefish, to track and describe seasonal spatial movement and daily activity patterns of these species in relation to flows. Seasonal and daily patterns of activity will be systematically monitored for three years under the existing Revelstoke Dam flow regime, and for an additional three years following the implementation of the 142 m^3s^{-1} minimum flow release regime. Comparison of the monitoring results before and after the implementation of the 142 m3s-1 will be used to test hypotheses about the effects of minimum flow on sub-adult and adult fish.

4.5.2 Status

This monitoring program will be initiated in 2008, and will be carried out over six years. Contract award is scheduled for March 2008. The first program report is expected in June 2009.

4.5.3 Interpretation of Data

At this time, there are no data to interpret for this monitoring program.

4.6 CLBMON-53 Middle Columbia Juvenile Fish Stranding

4.6.1 Overview

During the consultative process for the Revelstoke Unit 5 Project, the Core Committee recommended that a study be undertaken downstream of Revelstoke Dam to investigate juvenile fish stranding risk. The primary concern was the potential effect that increased river stage fluctuations and water velocities due to five-unit operations could have on stranding risk. Potential operational links with Revelstoke 5 operations include: (1) increased access into side channels at flows above 1600 cms; (2) increased suitability at higher discharges that may draw fish into the habitat; (3) higher velocities within mainstem habitats may attract or force juvenile fish into the lower velocity side channels; and (4) increased stranding risk due to longer periods at lower discharges over a 24-hour period under Revelstoke 5.

The study will involve field sampling downstream of the Illecilleweat River, where side channels provide more stable and presumably more productive habitat than more upstream channels where continual dewatering is likely to create more unstable and less productive habitat.

4.6.2 Status

As per a letter from the CWR to BC Hydro, dated 23 August 2007, BC Hydro will submit the Terms of Reference for the Middle Columbia Juvenile Fish Stranding Study by 26 June 2008.

The monitoring program will be initiated in 2009.

4.6.3 Interpretation of Data

At this time, there are no data to interpret for this monitoring program.

5 Revelstoke Flow Management Plan - Monitoring Program Costs

The following table summarizes the approved costs of the monitoring programs under the Revelstoke Flow Management Plan of the Columbia River WUP, as well as the Actual Costs to 31 January 2008.

Table 5-1: Columbia River Monitoring Programs

Description	Costs Approved by Comptroller of Water Rights	Actual Costs to 31 Jan 2008

Monitoring Programs			
CLBMON-15a & 15b Middle Columbia River Physical Habitat and Ecological Productivity Monitoring	Direct Management	$234,426	$24,620
	Implementation	$3,617,028	$179,038
CLBMON-16 Middle Columbia River Fish Population Indexing Surveys	Direct Management	$ 125,650	$12,700
	Implementation	$2,843,547	$103,175
CLBMON-17 Middle Columbia River Juvenile Fish Habitat Use	Direct Management	$59,297	$7,284
	Implementation	$456,500	
CLBMON-18 Middle Columbia River Adult Fish Habitat Use	Direct Management	$57,695	$5,119
	Implementation	$ 820,319	
CLBMON-53 Middle Columbia Juvenile Fish Stranding	Direct Management		
	Implementation		