Columbia River Project Water Use Plan

Monitoring Program Terms of Reference

LOWER COLUMBIA RIVER FISH MANAGEMENT PLAN

- **CLBMON-46 Lower Columbia River Rainbow Trout Spawning Assessment**

24 October 2007

TERMS OF REFERENCE FOR THE COLUMBIA RIVER PROJECT WATER USE PLAN MONITORING PROGRAMS LOWER COLUMBIA RIVER FISH MANAGEMENT PLAN

1.0 OVERVIEW

This document presents Terms of Reference for the effectiveness monitoring programs for the Lower Columbia River Fish Management Plan (Table 1). These programs will evaluate the effects of whitefish and rainbow trout flow conditions on the lower Columbia River and provide a physical and ecological health barometer against which the lower Columbia River monitoring programs can be evaluated.

This document provides detailed Terms of Reference for the following programs:

1) CLBMON-42 Lower Columbia River Fish Stranding Assessment and Ramping Protocol: a 13-year program to monitor planned and opportunistic flow reductions to establish impacts of flow reductions on fish populations in the lower Columbia River and the required operational procedures to mitigate ramping impacts.

2) CLBMON-43 Lower Columbia River Sculpin and Dace Life History Assessment: a 5-year program to monitor the life history and habitat use of sculpin and dace, in particular species listed under the federal Species at Risk Act and the BC Wildlife Act, in the lower Columbia River in relation to seasonal operations at Keenleyside Dam.

3) CLBMON-44 Lower Columbia River Physical Habitat and Ecological Productivity Monitoring: a 12-year program to monitor physical habitat parameters, periphyton and benthic invertebrates below Keenleyside Dam to evaluate net change in trophic productivity and overall ecological health in relation to rainbow trout and mountain whitefish flow regimes.

4) CLBMON-45 Lower Columbia River Fish Population Indexing Surveys: a 13-year program to monitor trends in the biological characteristics, distribution and abundance of mountain whitefish, rainbow trout and walleye populations in the lower Columbia River in relation to rainbow trout and mountain whitefish flow regimes.

5) CLBMON-46 Lower Columbia River Rainbow Trout Spawning Habitat Assessment: a 10-year program to monitor the relative abundance, distribution, spawning site selection and timing of rainbow trout spawning in the lower Columbia River in relation to rainbow trout and mountain whitefish flow regimes.

6) CLBMON-47 Lower Columbia River Whitefish Spawning Ground Topographic Surveys: a 3-year program to monitor spawning locations of whitefish in the lower Columbia River using detailed topographic surveys to improve the effectiveness of the whitefish flow regime in the lower Columbia River.

7) CLBMON-48 Lower Columbia River Whitefish Life History and Egg Mat Monitoring: a 5-year program to monitor whitefish life history, including spawning and egg mat sampling in the lower Columbia River, to establish the effectiveness of the current whitefish flow regime on egg survival, juvenile recruitment, and adult populations.

8) CLBMON-49 Lower Columbia River Effects on Great Blue Heron: a 4-year program to determine the importance of Waldie Island as an overwintering site for juvenile and adult heron from the Revelstoke colony.

Table 1 Lower Columbia River Fish Management Plan Monitoring Program Terms of Reference Submission Information

Name of Monitoring Program	Order Clause Fulfilled	Submitted with this Package	Previously Submitted To CWR	Submission Date	Leave to Commence
CLBMON-42 Lower Columbia River Fish Stranding Assessment and Ramping Protocol	Schedule E: 2.a	No	Yes	10 September 2007	No
CLBMON-43 Lower Columbia River Sculpin and Dace Life History Assessment	Schedule E: 2.b	Yes	No	26 October 2007	No
CLBMON-44 Lower Columbia River Physical Habitat and Ecological Productivity Monitoring	Schedule E: 2.c	Yes	No	26 October 2007	No
CLBMON-45 Lower Columbia River Fish Population Indexing Surveys	Schedule E: 2.d	No	Yes	10 September 2007	No
CLBMON-46 Lower Columbia River Rainbow Trout Spawning Habitat Assessment	Schedule E: 2.e	Yes	No	26 October 2007	No
CLBMON-47 Lower Columbia River Whitefish Spawning Ground Topographic Surveys	Schedule E: 2.f	Yes	No	26 October 2007	No
CLBMON-48 Lower Columbia River Whitefish Life History and Egg Mat Monitoring	Schedule E: 2.g	Yes	No	26 October 2007	No
CLBMON-49 Lower Columbia River Effects on Great Blue Heron	Schedule E: 2.h	Yes	No	26 October 2007	No

2.0 MONITORING PROGRAM RATIONALE

The trophic productivity and ecological health of the lower Columbia River and, therefore, the quality and quantity of large river habitat are partially dependent on the operation of Hugh L. Keenleyside (HLK) Dam. As such, the Columbia River Water Use Plan Consultative Committee (WUP CC) recognized operational impacts of the dam on fish productivity of the lower river as a key environmental concern to be addressed during the water use planning process.

The WUP CC initially explored ways of achieving specific elements of a preferred fish hydrograph for the lower Columbia River through modifying operation of Arrow Lakes Reservoir. However, it became apparent that BC Hydro would have only limited operational flexibility to unilaterally change flows in the lower Columbia River given the need to meet prescribed weekly flow releases at the border under the Columbia River Treaty (CRT). The WUP CC did not consider the existing flexibility to be biologically significant and, therefore, focused on more substantial flow changes that could be made by deviating from CRT flows through annual negotiations with the U.S. These included:

- rainbow trout protection flows, which involve stabilizing or increasing flows from 01 April to 30 June to minimize dewatering and potential egg losses of mid-timed spawning rainbow trout, and
- mountain whitefish flow, which involve limiting maximum flows during the peak spawning period (1 to 20 January) and smoothing flows until hatch (end March) to minimize subsequent egg dewatering and mortality, and maintaining February/March total stage changes less than 0.5 m.

Water levels in the lower Columbia River are typically managed to limit high flows in January and to stabilize or increase flows through to the end of June; flows increase through the summer and flow fluctuations are allowed in the fall as a treaty trade-off for whitefish flows.

During the development of flow management recommendations, it was recognized that there are significant data gaps regarding the effects of flow shaping on the physical environment and ecological productivity of the lower Columbia River. Monitoring projects were designed to examine the effectiveness of these flow options, and to address existing data gaps between flows and other endpoints of interest[1] (Table 1).

The key objectives of the Lower Columbia Monitoring Program are to: 1) evaluate the effects of whitefish and rainbow trout flow conditions on the lower river and, 2) provide a physical and ecological health barometer against which the Middle Columbia monitoring program can be evaluated.

Rainbow Trout Protection Flows

Prior to 1992, the typical flow regime below HLK Dam was characterized by declining discharge over the March to May period, and increasing discharge over the June to July period. This discharge pattern resulted in reduced water levels at Norns Creek Fan (a primary rainbow trout spawning area), causing a significant number of rainbow trout redds constructed at higher elevations to become dewatered when flows were subsequently reduced. Since 1993, BC Hydro has successfully negotiated Non-Power Use Agreements with the U.S., in consultation with the fish agencies, with the aim of providing better flow regimes for rainbow trout spawning below HLK Dam than would normally occur under the CRT operations. BC Hydro has secured these flow changes by providing 1 MAF of storage from Arrow Lakes Reservoir in July-August for U.S. salmon flow augmentation.

An important objective of rainbow trout protection flow is to maintain minimum river levels at Norns Creek Fan between 1 April and 30 June to ensure that eggs deposited after 1 April

[1] A parallel study in the Middle Columbia River will assess the environmental benefits of the establishment of a year-round 142m^3s^{-1} minimum flow release from Revelstoke Dam.

remain wetted until fry emergence occurs, which is typically by the end of June. These flows are designed to minimize potential egg losses for the mid-timed rainbow spawners (April and May) by providing stable or increasing discharge over this period. This is typically achieved by delivering flows between 15 and 20 kcfs from HLK Dam. The initial discharge is set so that there is a high probability that the downstream river level can be maintained until the end of the spawning and incubation period without causing Treaty storage to draft below planned levels under the CRT.

The implementation of the rainbow trout flow policy in the lower Columbia River has coincided with a general increasing trend in rainbow trout population abundance over the past 10 years. While there may be many reasons for this population increase, BC Hydro and the fish agencies view this as a successful management strategy in protecting rainbow trout populations in the lower river. However, the WUP CC recognized that a significant tradeoff exists between providing protection flows in the lower Columbia to protect rainbow trout spawning and incubation, and its negative impact on other interests upstream in Arrow Lake Reservoir and mid Columbia River (i.e., vegetation, wildlife, large river habitat) due to the additional 1 MAF of storage in spring. Because of potential benefits that could be achieved upstream if annual provision of the protection flows were halted, the WUP CC discussed whether it is essential that this flow management be implemented every year to maintain or enhance these populations. It was recognized that a long-term commitment to monitoring would be required to better understand the linkage between rainbow trout flow implementation and population abundance.

Whitefish Flow Management

Despite over a decade of implementing whitefish flow management actions in the lower Columbia River, there remains uncertainty regarding the relationship between flow conditions and egg mortality, and the significance of egg loss to the productivity of the whitefish population. The WUP CC recognized that resolution of this uncertainty is critical for establishing winter flow release regimes for HLK and Brilliant dams.

Mountain whitefish spawn in the lower Columbia and Kootenay rivers during early winter with peak spawning typically occurring during the first three weeks of January each year (see Figure 1, RLL 2001). Eggs are broadcast into the water column, and are distributed throughout a variety of locations and depths depending on river flow conditions during spawning. Flows supplied to the river from HLK and Brilliant dams into the lower Columbia River during whitefish reproductive period are typically high during the peak mountain whitefish spawning period and decline to an annual minimum by 01 April. Flows can vary widely during the spawning and egg incubation periods, and have been observed to dewater whitefish eggs.

The conceptual approach to whitefish flow management is to stabilize (to the degree possible) regulated flow releases into the lower Columbia River during whitefish reproduction. This requires additional agreements outside of the CRT, including 1) the Whitefish Operating Agreement, which allows storage at Kinbasket and Arrow Lakes reservoirs during the January to reduce Arrow outflow, and 2) the Fall Provisional Storage Agreement and March Whitefish Flow Agreement, which allows for a provisional draft of Arrow Lakes Reservoir and higher releases during the fall in compensation to the U.S. for lost energy benefits associated with stabilization of winter flow.

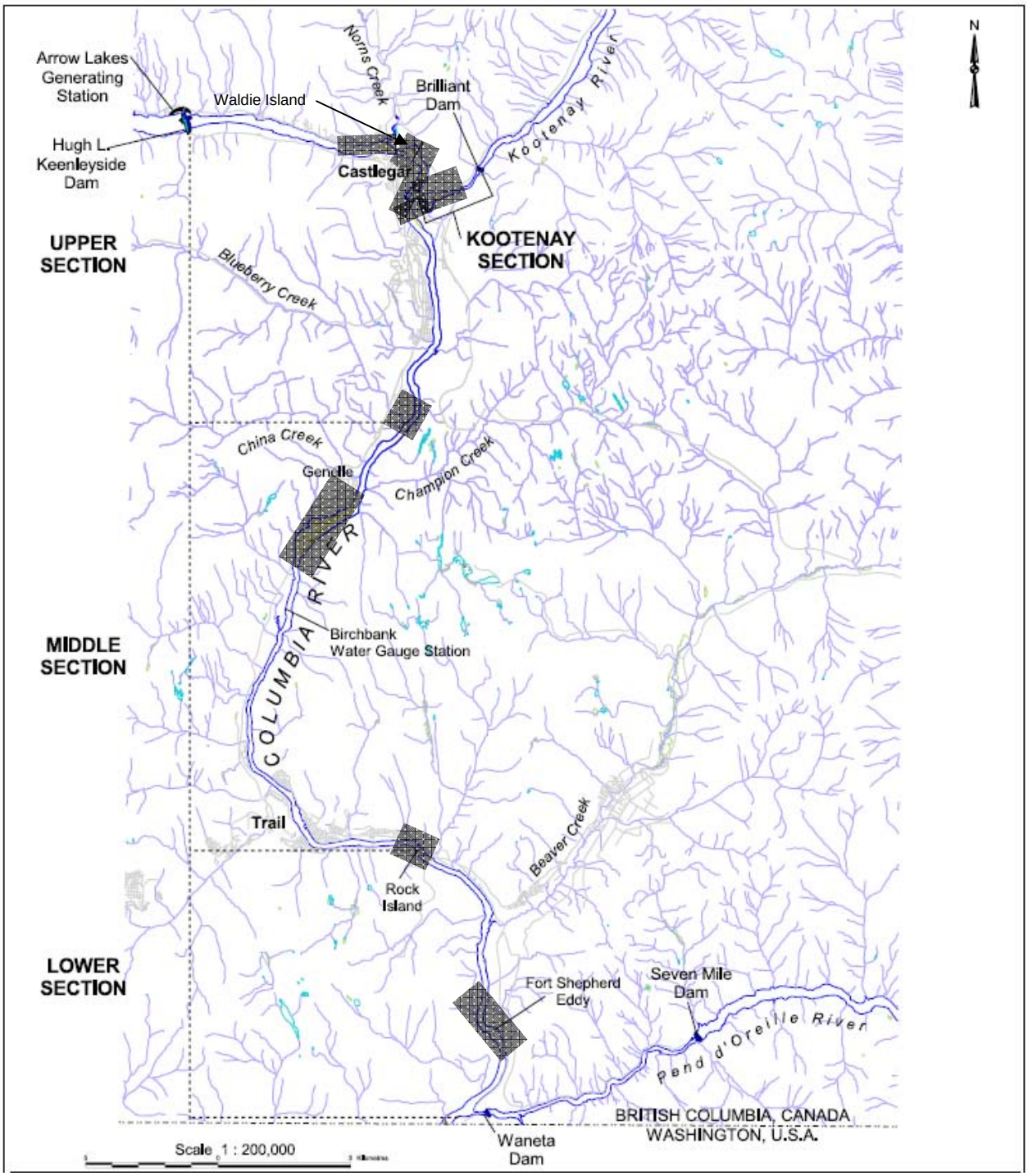
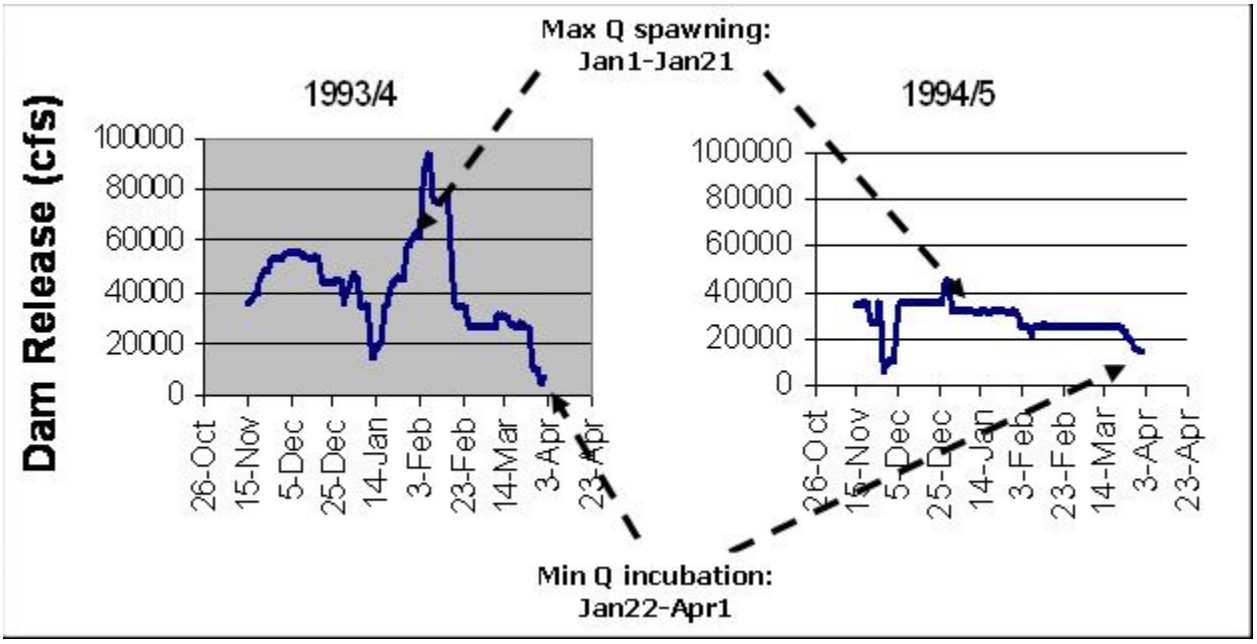


Figure 1 **Map of the Columbia River below Hugh Keenleyside dam showing the study area boundaries, known whitefish spawning areas (grey hatched boxes), Great Blue heron overwintering habitats at Waldie Island, and reach breakdown used for whitefish population index monitoring program initiated in 2001, and proposed for the whitefish adaptive management program.**

Operationally, whitefish flow management is achieved by minimizing the difference between the maximum flow during the peak spawning period (January 1 -21, Q_{Smax}) and the minimum flow prior to egg hatch (January 22 – Apr 1, Q_{Imin}). The relative degree of flow stabilization (and risk of egg loss) is indexed by a simple hydrologic metric, Q_{Smax}-Q_{Imin} (see Figure 2). As a result of annual variation in hydrology, power demand, dam operating conditions, and other factors that govern the flow regime of the Columbia River, there is variation in the success of stabilization efforts. Figure 3 shows the relative degree of stabilization achieved prior (1984-1994) to and after (1995-2005) implementation of whitefish flow management actions.



Flow Stabilization Index (Q_{Smax}-Q_{Imin}) = **Maximum Flow (Jan 1 to Jan 21)** - **Minimum Flow (Jan 22 to Apr 1)**

Figure 2 **Example of computation of the Q_{smax}-$Q_{i\ min}$ flow stabilization index and patterns of daily flow releases from Hugh Keenleyside Dam during whitefish reproduction periods before (1993/4) and after (1994/5) the implementation of WFM practices.**

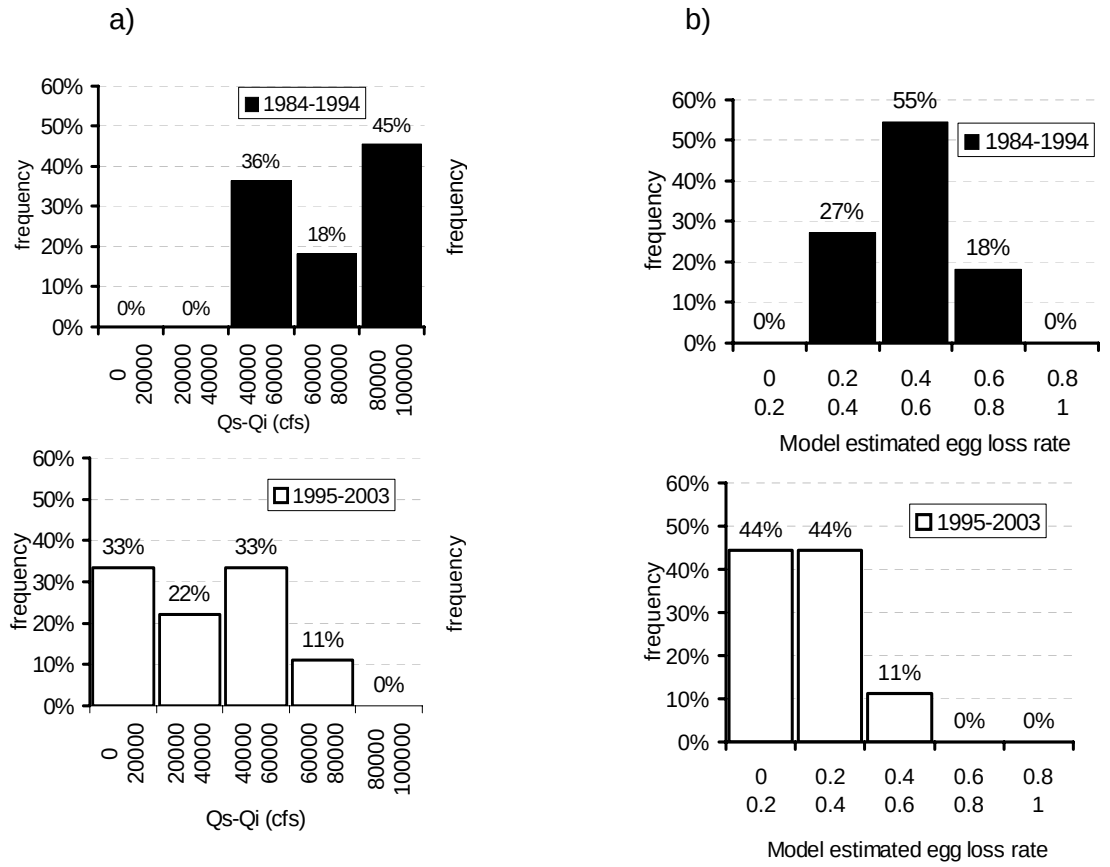


Figure 3 **Distributions of flow stabilization index ($Q_{Smax} - Q_{Imin}$) and modelled egg losses for periods before and after the implementation of WFM. a) $Q_{Smax} - Q_{Imin}$ is difference between the maximum spawning flows during peak spawning (Jan 1 – Jan 21, Q_{Smax}) and the minimum egg incubation flows (Jan 22- Apr 1, Q_{Imin}) for historical operation (1984-1994, black bars) and during WFM implementation (1995-2005, white bars); b) Estimated egg loss observed prior to (black bars) and after (white bars) the implementation of WFM .**

The biological rationale for whitefish flow management is based on three hypotheses that link the physical effects of flow variation to inter-annual abundance of the adult population:

H_1: Management of flow in the lower Columbia River during peak spawning (Jan 1- Jan 21) and stabilization of post spawning flows (22 Jan -01 Apr) will reduce egg losses resulting from dewatering.

H_2: Reduced egg losses increase the recruitment of young-of-the-year whitefish

H_3: Increased young-of-the-year recruitment results in a stable or increasing abundance of the reproductively active adult whitefish population (i.e., F.L. >250 mm)

To determine the effectiveness of whitefish flow management for conserving whitefish populations, the WUP CC recommended a 13-year phased adaptive management program (Figure 4). In Phase 1 of the program, standard whitefish flows will be implemented for five years to provide a total of 12 continuous years (2000-2012) of population index monitoring

coincident to implementation of this flow regime (Years 1–7 Pre-Water Use Plan; Years 8-12 under the Water Use Plan). The objectives of this phase of the program are to: 1) extend time series of systematic whitefish population monitoring to allow quantitative assessment of the influence of WFM on the whitefish population, and 2) fill critical gaps in understanding about the life history, biology, and spawning habitats of whitefish to support management hypotheses testing. Winter flows will be actively managed through the existing flow management framework with the objective of providing an egg loss risk exposure consistent with that observed during the period of implementation (1995-2003, Figure 3). Continuation of fish population index surveys will provide uninterrupted time series of population data. Biological monitoring will be implemented to improve understanding of the whitefish life history and reproductive biology, as well as better description of the physical characteristics of key spawning locations. These data will be combined with historical information for the refinement of the existing egg loss model, to test key model assumptions, or to, where possible, modify the model to provide more reliable egg loss estimates.

The CC was also concerned with potential negative effects of whitefish flow management on overwintering habitats used by Great Blue herons in the lower Columbia River. Monitoring has indicated a heron aggregation during the fall and early winter periods near to and upstream of the confluence of the Kootenay and Columbia rivers. This period corresponds to a period of high and variable flow releases prior to whitefish spawning, which are operationally required to allow stabilized flows during the peak of whitefish reproduction. To address this concern, a monitoring program was recommended to better understand seasonal patterns of heron movement and how the whitefish flow management effects shallow-water foraging habitat utilization by Great Blue heron.

At the end of Phase 1, an Interim Analysis of the biological effectiveness of whitefish flows will be conducted. Annual flow data, egg loss risk estimates, patterns of young of the year recruitment, and trends in abundance of the adult population will be analyzed to test the three primary conceptual hypotheses linking flow management to biological effects on whitefish populations. The primary objectives of the Interim Analysis will be to: 1) document the relationship between winter flow conditions, egg dewatering and the population response of whitefish under the WFM regime, and 2) support a decision regarding experimental suspension of whitefish flow management in Phase 2 of the adaptive management program (see Figure 4).

In Phase 2 of the program, an experimental suspension of flow management was recommended as option by the CC, where deemed safe and informative to do so. The objective will be to increase the contrast in annual egg loss conditions more aggressively to test the biological response of the population without flow protection. The target level of winter flow stabilization is that observed prior to implementation of whitefish flow management (Figure 3). During Phase 2 of the program, adult population index monitoring will continue for an additional 7 years to provide a total of 20 years of systematically collected population data. In the final year of Phase 2, a comprehensive data synthesis will be undertaken. A Final Synthesis will integrate results from all aspects of the program to re-test the three conceptual hypotheses underpinning whitefish flow management, and to contrast biological responses of whitefish under the two alternative winter flow management regimes. The Final Synthesis will be used to inform the decision regarding the long-term continuation of protection flows during the planned review of the Columbia River Water Use Plan.

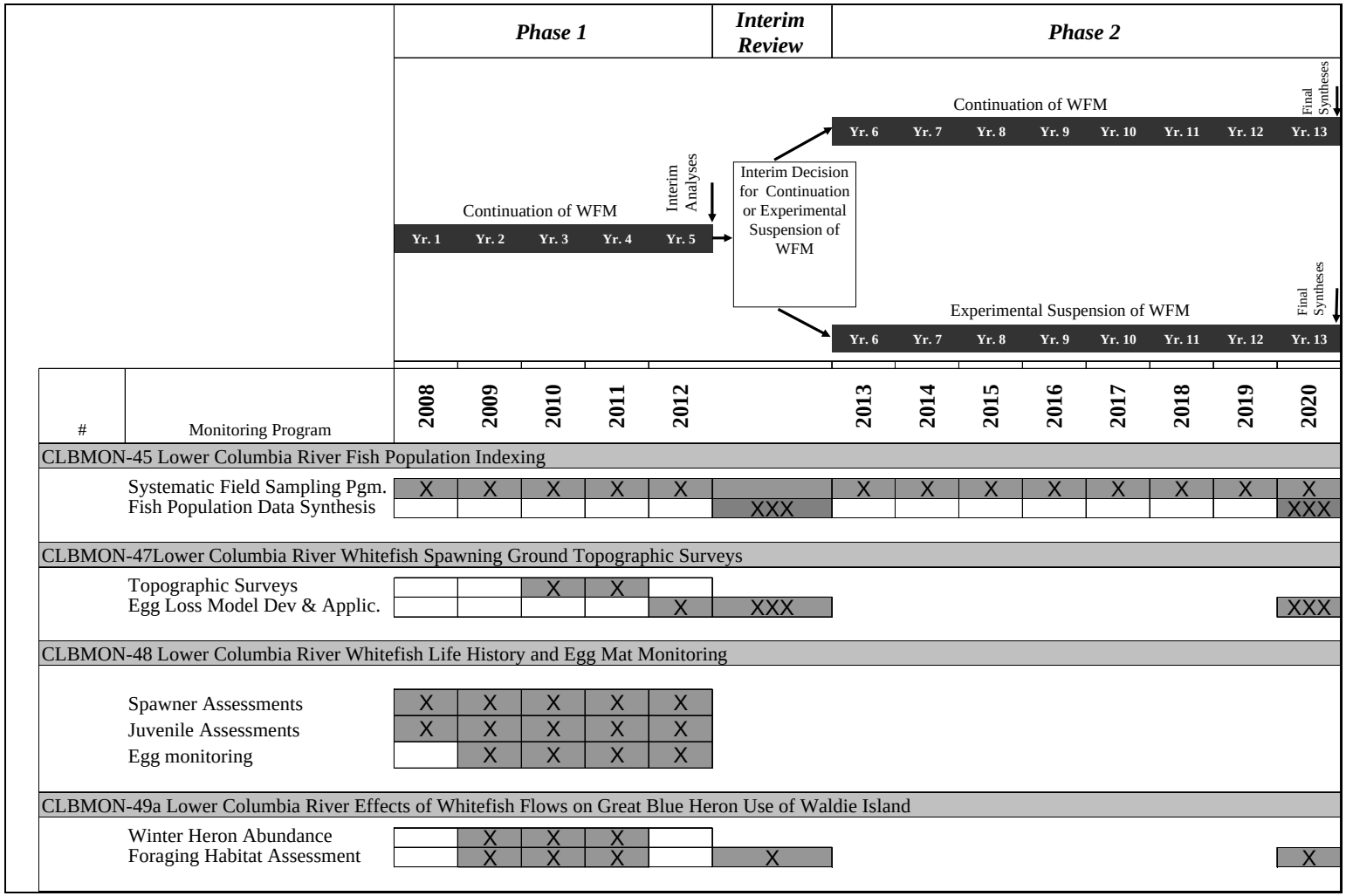


Figure 4 **Conceptual approach and annual schedule for the implementation of monitoring programs and key activities for the evaluation of the biological effectiveness of WFM for the conservation of the mountain whitefish population in the lower Columbia River.**

Monitoring Study No. CLBMON-46
Lower Columbia River Rainbow Trout Spawning Assessment

1.0 MONITORING PROGRAM RATIONALE

1.1 Background

Since 1993, BC Hydro has successfully negotiated Non-Power Use Agreements with the U.S. with the aim of providing more stable flow regimes for rainbow trout spawning below Hugh L. Keenleyside (HLK) Dam than would normally occur under Columbia River Treaty operations. In the past, BC Hydro has secured these flow changes by storing an additional 1 MAF in Arrow Lakes Reservoir for release from July to August for U.S. salmon flow augmentation.

During the Columbia River Water Use planning (WUP) process, the Consultative Committee (CC) became aware that halting the annual provision of the rainbow trout protection flows could provide benefits for vegetation, wildlife, fish and recreational objectives in Arrow Lakes Reservoir and the mid Columbia River by releasing the extra 1 MAF of water that would otherwise be held back to provide limited flows between April and June, and flow augmentation to the U.S. during summer. This storage release would keep reservoir levels lower during spring and summer, thereby improving vegetation survival due to later and shorter inundation, and, in turn, improving littoral productivity and wildlife habitat. Given that the rainbow trout flows are viewed as a successful management strategy for protecting rainbow trout populations in the lower Columbia River, this presented a significant trade-off decision for the WUP CC.

The Columbia River WUP CC recommended that BC Hydro continue to pursue the rainbow trout protection flows through negotiations with the U.S., but highlighted a number of high priority items for consideration in future operations (BC Hydro 2005a, 2005b). These items included:

- continuing annual discussions with regulatory agencies as to timing of transition from whitefish flows to rainbow trout protection flows (typically April 1);
- minimizing the volume of water stored in Arrow Lakes Reservoir for the United States;
- delaying the onset of storage in Arrow Lakes Reservoir for as long as possible; and,
- releasing the additional storage of water in Arrow Lakes Reservoir as quickly as possible.

Associated with the recommendation to pursue the annual rainbow trout protection flows was the support by the WUP CC for a substantial monitoring program to address existing uncertainties around operational impacts on key fish resources in the lower Columbia River (BC Hydro 2005a, 2005b). For the rainbow trout population, a continued annual monitoring program was recommended to monitor the status of the population in response to the continued implementation of rainbow trout

flows to better understand the link between the flow management strategy and population abundance. The program outlined in these Terms of Reference is, therefore, designed to monitor the relative abundance, distribution, spawning site selection and timing of rainbow trout spawning in the lower Columbia River to assess the response to variable flows prior to and during the spring spawning period.

1.2 Management Questions

The key management questions addressed by this monitoring program are:

1) Does the implementation of rainbow trout spawning protection flows over the course of the monitoring period lead to an increase the relative abundance of rainbow trout spawning in the lower Columbia River downstream of Hugh L. Keenleyside Dam?

2) Does the implementation of rainbow trout spawning protection flows over the course of the monitoring period lead to an increase in the spatial distribution of locations (and associated habitat area) that rainbow trout use for spawning in the lower Columbia River downstream of Hugh L. Keenleyside Dam?

3) Does the implementation of rainbow trout spawning protection flows over the course of the monitoring period protect the majority of rainbow trout redds (as estimated from spawning timing) from being dewatered in the lower Columbia River downstream of Hugh Keenleyside Dam?

1.3 Management Hypotheses

Three key hypotheses, corresponding to the management questions above, will be tested using data collected during the lower Columbia River Rainbow Trout Spawning Assessment. These hypotheses are related to the relative abundance of rainbow trout spawners in the lower Columbia River, the number of spawning areas that rainbow trout use in the lower Columbia River, and the relative habitat area of spawning areas in the lower Columbia River. The monitoring hypotheses are:

Ho_1: The relative abundance of rainbow trout spawners or redds in the Columbia River mainstem does not increase between the baseline period (1999 to 2006) and the WUP monitoring period associated with the continued implementation of the Rainbow Trout Protection Flow program.

Ho_2: The spatial distribution of locations and the associated habitat area that rainbow trout spawners use in the Columbia River mainstem does not increase between the baseline period (1999 to 2006) and the WUP monitoring period associated with the continued implementation of the Rainbow Trout Protection Flow program.

Ho_3: The proportion of redds dewatered relative to the total redd production for rainbow trout spawning in the Columbia River mainstem does not increase and the WUP monitoring period associated with the continued implementation of the Rainbow Trout Protection Flow program.

1.4 Key Water Use Decision Affected

The key operating decision that will be affected by this monitoring program is the continued annual implementation of the rainbow trout spawning protection flows in the lower Columbia River. Results from the completed study and associated inferences from other monitoring programs in the lower Columbia River will determine if these flows improve or maintain the population status of rainbow trout in the study area. In addition, effects of variation in the timing of transition from whitefish flow to rainbow trout flows will be investigated to determine the effects on the population (e.g., redd dewatering) and to assess tradeoffs resulting from the implementation of these flows compared to an earlier lowering of the Arrow Lakes Reservoir level. Results from this study and related programs will be used to establish the long term operating release requirements for the Hugh L. Keenleyside dam.

2.0 MONITORING PROGRAM PROPOSAL

2.1 Objective and Scope

The primary objective of this monitoring program is to continue the collection annual rainbow trout monitoring data to qualitatively and quantitatively assess changes in the relative abundance, distribution and spawn timing of rainbow trout in the lower Columbia River. Secondary objectives include: 1) determining whether an earlier transitioning from mountain whitefish flows to rainbow trout spawning protection flows reduces the number of early spawning rainbow trout redds that dewater , and 2) to identify whether spawning habitat in the lower Columbia River is fully utilized.

The geographic scope of this monitoring program is the ~55 km long section of the lower Columbia River from HLK Dam to the US border. The priority area for assessment is the portion of the river from the dam to Genelle.

2.2 Approach

Monitoring of rainbow trout flows has been undertaken since 1999 (e.g., Baxter 2004, 2003 and 2002). The approach of this monitoring program, therefore, is to continue annual rainbow trout monitoring from January to July within the study area over the period of implementation of the Columbia WUP. Using the established field sampling and analysis techniques, the study will determine relative population abundance, redd numbers and distribution, spawn timing, and the response of the population to the annual implementation of rainbow trout spawning protection flows.

2.3 Tasks

2.3.1 Task 1: Project Management

Project management will involve the general administrative and technical oversight of the project. This task will include but not be limited to: 1) budget management, 2) study team selection, 3) logistic coordination and querying of the stranding database, 4) technical oversight of field and analysis components, and 5) facilitation of data

transfer among other investigations associated with the Lower Columbia River Fish Management Plan.

2.3.2 Task 2: Field Sampling Program

Aerial and Boat Surveys

The objective of the aerial and boat survey task is to continue implementation of an established monitoring program to track the abundance, distribution, and spawn timing of rainbow trout in the lower Columbia River. The sampling program will be designed to meet the following objectives:

- Conduct relative abundance sampling to document cumulative abundance of rainbow trout spawners and redds in the study area from January to July;
- Quantitatively describe the distribution of spawning locations (and habitat area) in the study area from January to July;
- Quantitatively estimate the annual number of redds that will dewater with the continued implementation of spawning protection flows; and
- Quantitatively estimate the annual spawning timing for rainbow trout in the study area.

All biological sampling and survey protocols will follow those applied in previous years (e.g., Baxter 2004, 2003, 2002). Surveys of rainbow trout spawner and redd abundance will be made using boat and aerial surveys, during which the number of redds and trout are enumerated in different sections of the river throughout the study period. In addition, redds that are identified in shallow water will be measured for their depth in the water column to estimate the number of redds that are at risk of dewatering under different spawning flows scenarios (e.g. variation in timing of implementation). This monitoring program is for assessment only and does not include mitigation of impacts due to implementation of flows.

2.3.3 Task 3: Data Analysis and Reporting

To facilitate effective management of data from the monitoring program, an annual technical report will be prepared, which will include:

- an executive summary;
- a description of the methods employed;
- a data summary;
- a detailed discussion of the findings as they relate to the management questions and hypotheses; and,
- any recommendations for the refinement of field sampling protocols.

A separate report will be produced for the stranding surveys, the flow ramping studies, and any physical habitat manipulation. The report will follow the standard format that is being developed for WUP monitoring programs. All reports will be provided in hard-copy and as Microsoft Word and Adobe Acrobat (*.pdf) format, and all maps and figures will be provided either as embedded objects in the Word file or as separate files.

2.4 Interpretation of Monitoring Program Results

Relative abundance data for rainbow trout spawners and redds are a key information requirement for judging the effectiveness of the rainbow trout spawning protection flows released from Hugh L. Keenleyside Dam. Recent monitoring programs (Baxter 2004, 2003, 2003) have shown an increase in the population over time, and this study will continue to track trends in population levels over the term of the monitoring program. Because the factors that control populations are complex, inferences derived from this monitoring program cannot be used unilaterally to assess fish population response to changes in dam operations. Given the uncertainty about the 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 trout abundance, redd abundance, and spawning timing in relation to the implementation of spawning protection flows will be interpreted in collaboration with results from other monitoring programs. Specifically, the results from this program will be integrated with CLBMON-45 Lower Columbia Fish Population Index Surveys monitoring program to enhance the utility of the information collected during both programs.

2.5 Schedule

The Lower Columbia River Rainbow Trout Spawning Assessment will be conducted annually for at least 10 years during the 12-year implementation period of the Columbia River WUP.

2.6 Budget

The total annual cost for the monitoring program is estimated at $42,453 (in 2004 dollars), and an average annual cost of $52,833 (assuming a 2% rate of inflation and 5% contingency). The annual study budget recommended by the WUP CC in 2004 was $35,000.

Table CLBMON-46-1 provides a detailed breakdown of the costs of the monitoring program.

3.0 REFERENCES

BC Hydro. 2005a. Consultative Committee report: Columbia River Water Use Plan, Volumes 1 and 2. Report prepared for the Columbia River Water Use Plan Consultative Committee by BC Hydro, Burnaby, BC.

BC Hydro. 2005b. Columbia River Project, Draft Water Use Plan. 38 pp. + appendices.

Baxter, J. 2004. Monitoring of Rainbow Trout Spawning and Egg Incubation Studies in the Columbia River: 2004. Report prepared for BC Hydro, Castlegar, BC. 21 pp. + appendices.

Baxter, J. 2003. Monitoring of Rainbow Trout Spawning and Egg Incubation Studies in the Columbia River: 2003. Report prepared for BC Hydro, Castlegar, BC. 19 pp. + appendices.

Baxter, J. and J. Baxter. 2002. Monitoring of Rainbow Trout Spawning and Egg Incubation Studies in the Columbia River: 2002. Report prepared for BC Hydro, Castlegar, BC. 20 pp. + appendices.