Columbia River Project Water Use Plan

Monitoring Program Terms of Reference

LOWER COLUMBIA RIVER
FISH MANAGEMENT PLAN

- **CLBMON-43 Lower Columbia River Sculpin and Dace Life History Asssessment**

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.

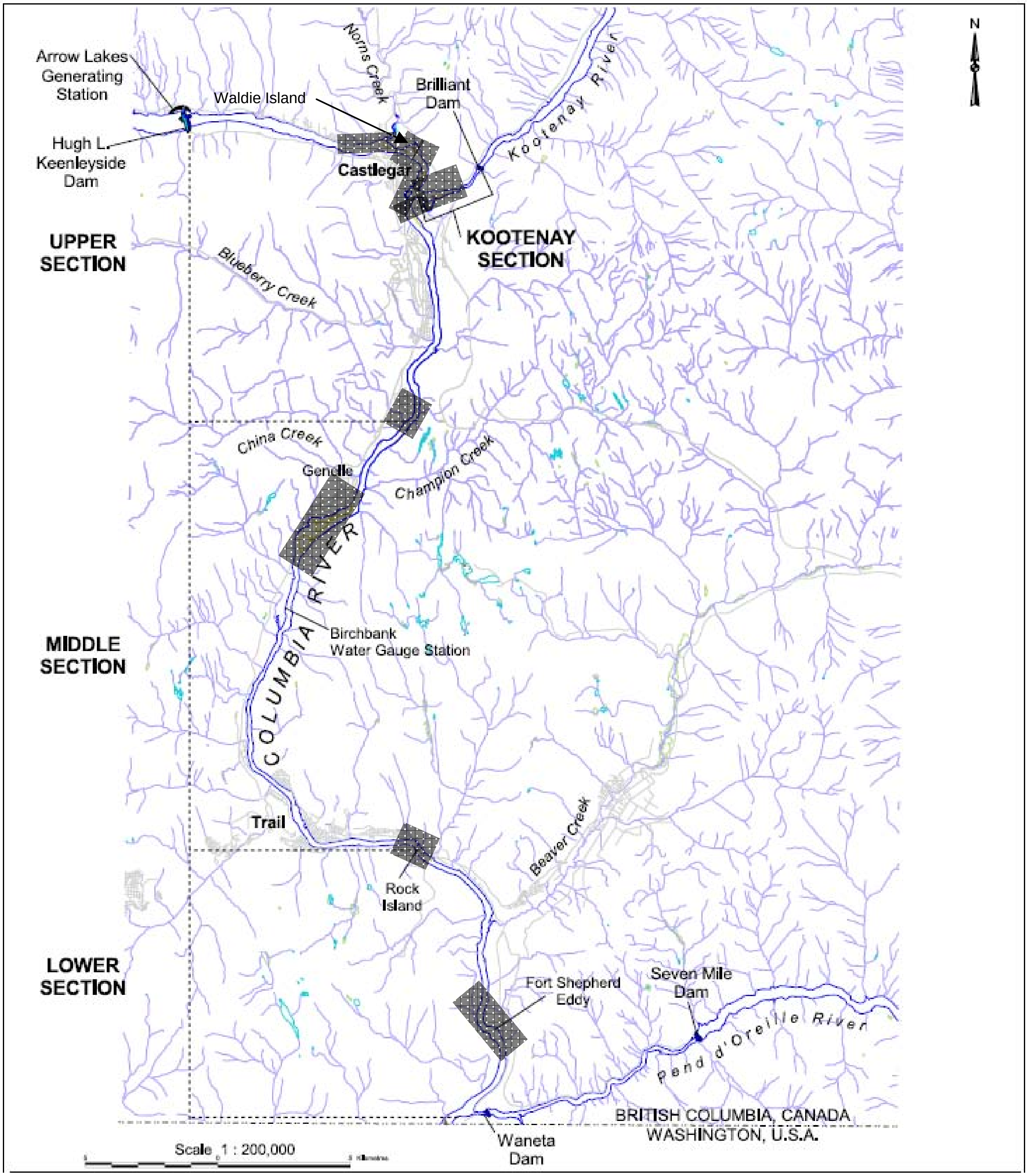
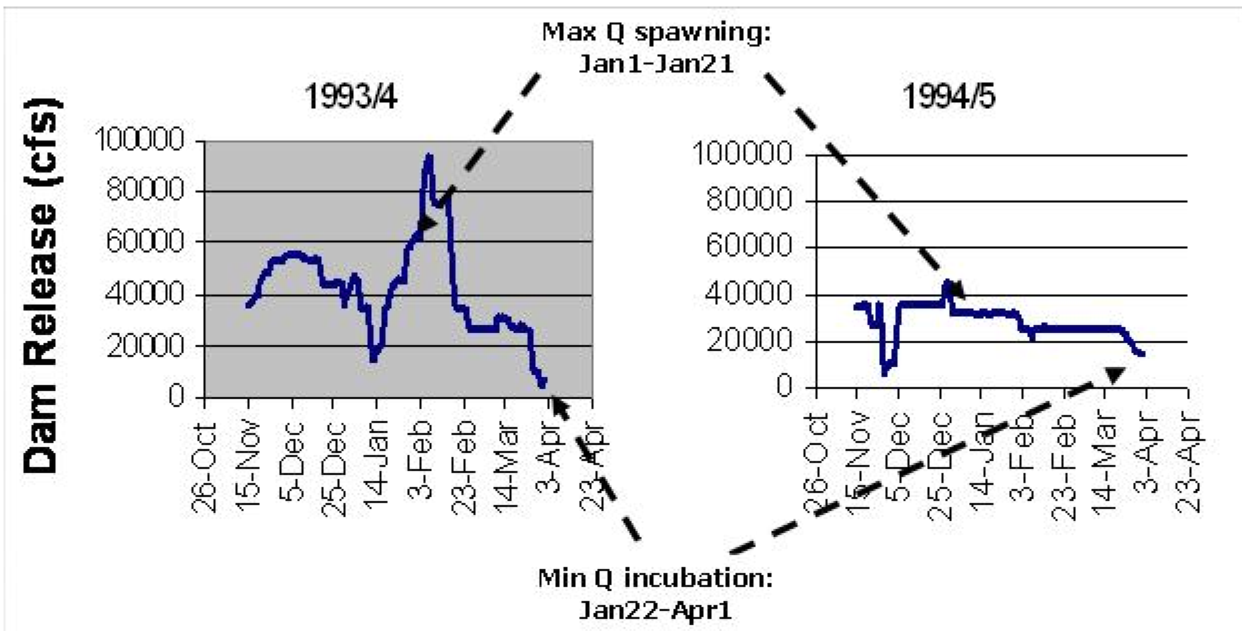


Figure 1 **Map of the Columbia River below Hugh Keenleyside dam showing the study area boundaries, known whitefish spawning areas (grey hatched boxes), Great Blue heron overwintering habitats at Waldie Island, and reach breakdown used for whitefish population index monitoring program initiated in 2001,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

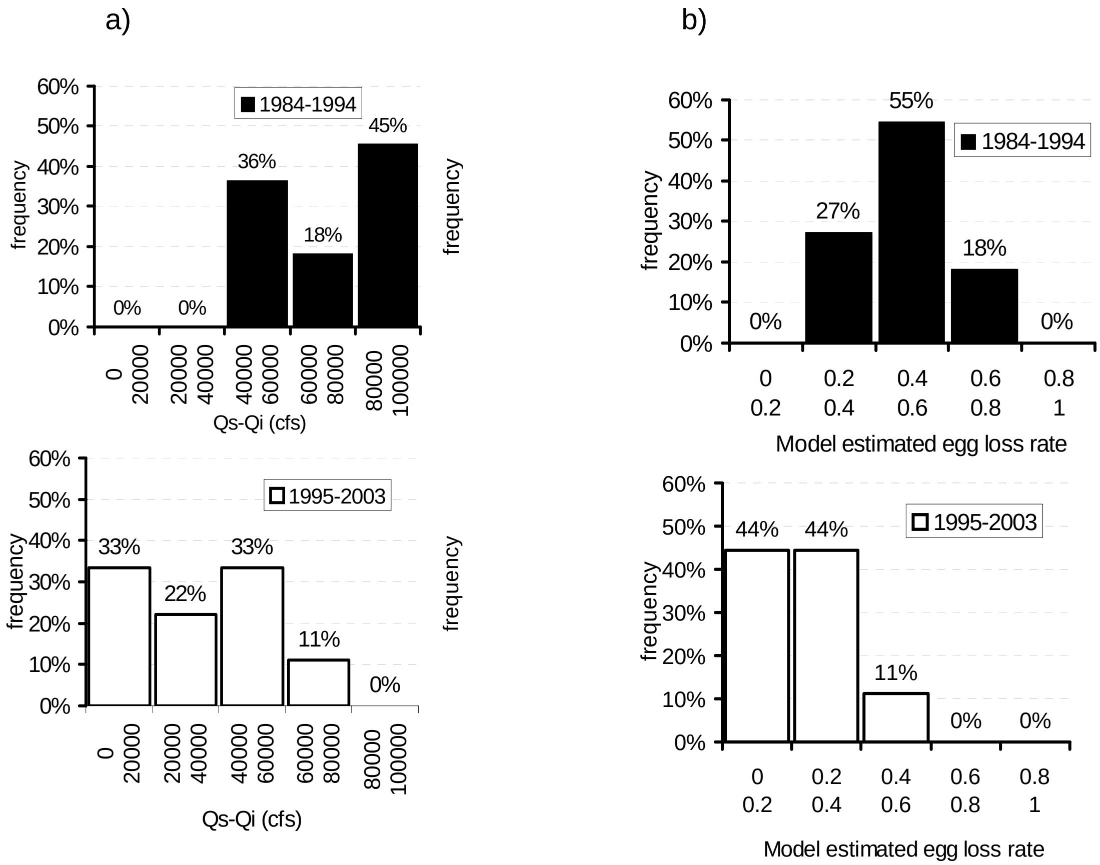


Figure 3 **Distributions of flow stabilization index ($Q_{Smax} – Q_{Imin}$) and modelled egg losses for periods before and after the implementation of WFM. a) $Q_{Smax} – Q_{Imin}$ is difference between the maximum spawning flows during peak spawning (Jan 1 – Jan 21, Q_{Smax}) and the minimum egg incubation 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

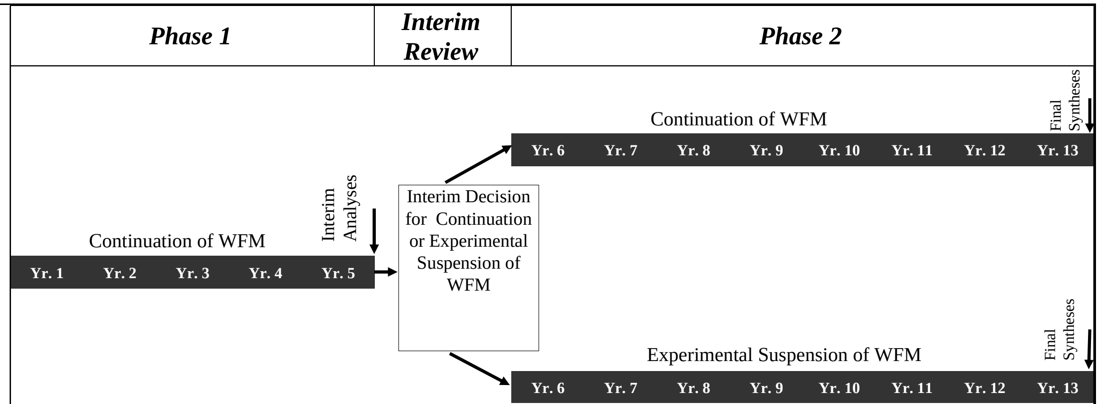
H_3: Increased young-of-the-year recruitment results in a stable or increasing abundance of the reproductively active adult whitefish population (i.e., F.L. >250 mm)

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.



#	Monitoring Program	2008	2009	2010	2011	2012		2013	2014	2015	2016	2017	2018	2019	2020
CLBMON-45 Lower Columbia River Fish Population Indexing															
	Systematic Field Sampling Pgm.	X	X	X	X	X		X	X	X	X	X	X	X	X
	Fish Population Data Synthesis						XXX								XXX
CLBMON-47Lower Columbia River Whitefish Spawning Ground Topographic Surveys															
	Topographic Surveys			X	X										
	Egg Loss Model Dev & Applic.					X	XXX								XXX
CLBMON-48 Lower Columbia River Whitefish Life History and Egg Mat Monitoring															
	Spawner Assessments	X	X	X	X	X									
	Juvenile Assessments	X	X	X	X	X									
	Egg monitoring		X	X	X	X									
CLBMON-49a Lower Columbia River Effects of Whitefish Flows on Great Blue Heron Use of Waldie Island															
	Winter Heron Abundance		X	X	X										
	Foraging Habitat Assessment		X	X	X		X								X

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-43
Lower Columbia River Sculpin and Dace Life History Assessment

1.0 MONITORING PROGRAM RATIONALE

1.1 Background

During the Columbia River Water Use Plan (WUP) process, the Consultative Committee (WUP CC) noted that the lack of biological information precluded explicit consideration of shallow water dwelling threatened and endangered fish species in the lower Columbia River. Specifically, data were too limited to assess the potential risks to threatened/endangered sculpins and dace species, as may be posed by the seasonal operations of Hugh L. Keenleyside (HLK) Dam. Consequently, the CC recommended a study to determine the relative abundance, distribution, life histories, and habitat use of sculpins and dace in the lower Columbia River between HLK Dam and the US border. The goal of the study is to provide a qualitative assessment of the risks that the operation of HLK Dam may pose for federally listed species of sculpin and dace.

Four species of sculpins (*Cottus*) occur in this portion of the Columbia River watershed: prickly sculpin (*C. asper)*; shorthead sculpin (*C. confusus)*; Columbia sculpin (*C. hubbsi)*, and torrent sculpin (*C. rhotheus)*. Of the four species, two (the Columbia sculpin, and the shorthead sculpin) are listed by COSEWIC (the Canadian Committee on the Status of Endangered Wildlife in Canada) and are on the SARA (Species at Risk Act) legal list. The shorthead sculpin is listed as threatened, and the Columbia sculpin as a species of special concern. Two species of dace (*Rhinichthys spp.*) occur in the same area - the longnose dace (*R. cataractae)*, and the Umatilla dace (*R. umatilla*). Additionally, a third dace (the leopard dace, *R. falcatus*) is known from lower Arrow Lake but has not been recorded below (HLK) Dam. Of the three dace species, the longnose dace has not been assessed by COSEWIC and is not listed. The leopard dace is listed, but not considered at risk, and the Umatilla dace is listed as a Species of Special Concern. The Columbia sculpin range extends outside of the watershed in southeastern B.C. and more robust populations are found further west (e.g. the Similkameen and Kettle rivers). Similarly, larger populations of Umatilla dace are found near the Columbia in the Slocan River system.

Some of these species - especially the sculpins - have tangled and confusing taxonomic histories. For example, at one time the Columbia sculpin was confused with the torrent sculpin and, more recently, with an eastern North American species (*C. bairdii*). Acceptance of its status as a distinct species is relatively recent (Nelson et al. 2004), and its Canadian distribution is much more restricted than was thought when its status was reviewed by COSEWIC. Consequently, there is potential for this species to be upgraded to a higher risk category when it is reassessed.

Ecological information is very limited for the species of sculpin and dace found in the lower Columbia River. For the sculpins, prickly and torrent sculpins appear to be relatively abundant in the mainstem Columbia below Hugh L. Keenleyside Dam (RL&L Environmental Services Ltd. 1995). In contrast, the shorthead sculpin apparently is rare in the main river, but common in the lower reaches of tributary streams like Norns, Champion, Blueberry, and Beaver creeks (McPhail 2003). Although most of the Columbia sculpins collected between the dam and the US border were found in the mainstem Columbia River, they do not appear to be abundant in the river. Thus, in terms of its habitat use, abundance, and the potential impacts of the seasonal operations of HLK Dam on the Columbia sculpin's life cycle, almost nothing is known for this species. In contrast to the Columbia sculpin, the two species of dace are relatively abundant in the main river (RL&L Environmental Services Ltd. 1995; AMEC Earth & Environmental Ltd. 2003).

1.2 Management Questions

The key management questions addressed by this monitoring program are:

1) How do water level fluctuations (diel and seasonal) in the lower Columbia River affect the distribution and habitat use of sculpins and dace, especially the listed species?

2) What seasonal and diel habitat shifts do sculpins and dace (especially the listed species) make in response to water level fluctuations?

3) Do the operations of Hugh L. Keenleyside Dam alter these natural movements? Specifically, does this risk of stranding increase?

4) Which operations, and at what season, pose the highest risk of stranding or interference with the normal life cycles of sculpins and dace?

1.3 Detailed Questions

Because existing knowledge regarding the relative abundance, distribution, life histories, and habitat use of sculpins and dace in the lower Columbia River is so limited, this study is set up as a descriptive rather than experimental approach. As such, it is designed to provide baseline information on species occurrence, spawning and rearing habitat and overwintering information, rather than testing specific management hypotheses or measuring biological response to different treatments. The study is also expected to inform on decisions regarding seasonal operations of HLK and the effect on listed sculpin and dace species.

There is enough prior knowledge (e.g., RL&L Environmental Services Ltd. 1995) to establish a high level picture of the distribution of the different species of sculpins and dace that occur in the lower Columbia River; however, the details of their habitat use are unknown. Similarly, there is prior information (e.g., AMEC Earth & Environmental Ltd. 2003) to suggest that there are seasonal and diel habitat shifts in some species, but, more detailed information is needed. The monitoring program should therefore be designed to answer the following specific questions:

- Are there specific spawning areas utilized by the Columbia sculpin and the Umatilla dace and, if so, what are the temporal and biophysical characteristics of these areas?

- Are there specific nursery areas used by Columbia sculpin and Umatilla dace and, if so, what are their biophysical characteristics?

- Are there seasonal and diel shifts in habitat use by these species? How do these shifts relate to water level fluctuations (diel and seasonal)?

- Do different age classes of Columbia sculpin and Umatilla dace use different habitats seasonally? Do diel habitat shifts differ among age classes?

- Are there over-wintering habitats used by these species and, if so, what are their biophysical characteristics?

- Do water level fluctuations (diel and seasonal) affect spawning behaviour, embryo survival, or adult nest guarding behaviour of Columbia sculpin and Umatilla dace?

1.4 Key Water Use Decisions Affected

The key operating decision affected by this monitoring program is the operating regime of Hugh L. Keenleyside Dam. Data from this study will provide information on the potential impacts of water level fluctuations associated with daily and seasonal operations of the dam on listed species of sculpin and dace, and provide recommendations on potential mitigation measures, if required.

2.0 MONITORING PROGRAM PROPOSAL

2.1 Objectives and Scope

The primary objective of this monitoring program is to provide information on the life history and habitat use of six species of shallow water dwelling fish (four sculpins and two dace with special emphasis on Columbia sculpin and Umatilla dace) in the lower Columbia River that may be affected by water level fluctuations resulting from daily and seasonal operations of HLK Dam. More specifically, information will be collected on the spawning habitats used by Umatilla dace and the timing of their spawning period, the abundance of Columbia dace and the habitats used by this species, and the importance of flooded areas at the confluence of tributaries and the main river as nurseries for young-of-the-year sculpins and dace. These nursery areas are the key habitat component of the shorthead sculpin (*C. confusus*) that are likely to be affected by the operations of HLK Dam.

Although the geographic area covered by the monitoring program includes the Columbia River from HLK Dam downstream to the US border, the focus of the study will be limited to a small number of carefully selected sites (approximately four to six) that are monitored seasonally, and a smaller subset of sites that receive diel monitoring. Sites outside of the Columbia River which support more robust populations of the endangered species may be considered as alternatives for sampling. The selection of monitoring sites is crucial and is discussed in more detail in section 2.2.

While information on six species will be collected as part of the monitoring program, three listed species - the Columbia sculpin, the shorthead sculpin, and the Umatilla dace - are the primary targets of the program. The monitoring program should therefore provide data on the seasonal and diel habitats used by these species (i.e., depth ranges, substrates, water velocities and cover characteristics), differences in habitat use among young-of-the-year, juveniles, and adults, as well as the characteristics of spawning sites (time of spawning, depth range, substrate, temperature, and water velocities). While it is known that all sculpins, and the longnose dace are territorial, no information exists on the reproductive behaviour of the Umatilla dace or on how the length of time out of water affects embryo survival for sculpin or dace. Sculpins are known to guard their nests, but it is not known whether adults remain with their nests if the nests are dewatered. The information collected by this monitoring program should address these data gaps to enable more informed decision making with respect to the potential impacts of current dam operations on theses species.

2.2 Approach

The approach of this monitoring program is to use existing information on the life history and ecology of sculpins and dace to choose monitoring sites concentrated in the Columbia River below HLK Dam. Existing prior information should be summarized, information gaps, relative to the questions posed in Section 1.3, should be identified, and methodologies should be proposed that resolve any data collection obstacles encountered in earlier studies.

This study should provide sufficient information to allow BC Hydro to evaluate the risks of current operations on these species, with particular focus on listed species. Although the chosen sites should be in areas affected by the operation of HLK Dam, areas at the confluence of the main river and tributaries may be biologically important (e.g., as nursery and refuges areas at high water), and should also be included. An alternative is to locate a subset of sites outside of the Columbia River mainstem where the species are more abundant to provide a better opportunity to collect relevant life history data. One or two of the sites should be in areas where Umatilla dace are abundant. Once the sites are chosen, they should be monitored seasonally (spring, summer and late fall; winter sampling is less of a priority if the late fall will provide an indication of overwintering conditions) and a subset of sites should be monitored seasonally over 24-hour periods to assess diel effects. In addition to utilizing data from prior sculpin and dace studies (e.g. AMEC 2003), the contractor should also incorporate information from previous ramping studies, as well as information collected under CLBMON-42 Lower Columbia Fish Stranding Assessment and Ramping Protocol.

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 data base, 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: Literature Review

Although data on sculpins and dace in the area below HLK Dam should be the focus of the literature review, information on the biology of sculpins and dace in other geographic areas also may provide useful data. Thus, the literature review should not only summarize information from previous BC Hydro studies, but also include a literature review of the general biology of sculpins and dace. The review should include a summary of the general downstream effects of dams (e.g., changes in temperature, gas pressures, and fluctuations in flow) on the biology of shallow water dwelling fish species, with a particular focus on sculpins and dace.

2.3.3 Task 3: Field Data Collection

The contractor is responsible for any permits required to capture listed species for scientific data collection purposes.

General habitat use data: If sites are found where some of the target species are abundant, collecting general habitat-use data is relatively straightforward. Although there is no standard collection protocol for these species, depths, water velocities (at the surface and 10 centimeters off the bottom), and substrate size should be measured at the upstream and downstream ends of the collection site, as well as in the middle of the site. Usually, the complete set measurements are made about halfway between the shore and the maximum offshore distance sampled, and depth is measured three times at the upstream and downstream boundaries of the site: once near shore, once in the middle, and once at the deepest end of the site. The area of the site (in square metres) should be measured to provide an estimate of density (by species) and if there are differences in body size (within species) that appear to be related to depth, water velocity, or substrate these should be recorded. Sampling of sites can include both active (intrusive) and passive (non- or less intrusive) sampling techniques. Seining, electrofishing, and dipnetting are examples of active methods forr collecting fish over a large habitat type or specifically within a habitat use area. Passive sampling could include use of snorkel surveys and view tubes, D-ring or drift net sampling, and nest or egg traps. If both techniques are used at one site, care should be taken to ensure the sampling technique does not unduly influence the data set.

Electro-fishing is an effective means of collecting adult sculpins and dace. Three electro-shocking passes through the site gives a measure of abundance. After each pass the catch should be anesthetized, identified, measured, sexed, and a subset marked. The catch should be revived, and when active, returned to the river immediately downstream of the sampling site. Alternatively, a more intensive sampling approach to a site using electro-fishing is an option, to focus on habitat use as opposed to abundance. If adult sculpins are present in the catch, they should be kept separate from smaller fish. It is not possible to anticipate all the conditions the sampling crew will encounter, and it may be necessary to modify this general collection protocol to suit local conditions; however, it is important to standardize whatever methodology is used and apply the same methods where ever possible. Any modifications to methodology must be compatible with the study objectives (section 2.1) and appropriate to provide answers to the questions listed in sections 1.2 and 1.3.

Adult sculpins: Adult sculpins are usually active at night, and shelter in the substrate during the day; however, this diel activity pattern may change seasonally. For adults, more information can be obtained by fully processing a small number of individuals carefully, rather than by processing a large number of individuals rapidly. Each individual should be anesthetized, identified, sexed, marked (preferably tagged), weighed, measured, and then revived and returned to the capture site. Over time, this procedure will provide data on site fidelity (seasonally and annually), nocturnal habitat-use, and diel and seasonal habitat shifts. Sites where each individual is captured should be marked (e.g. via a painted, numbered rock). Marking adult sculpins can be achieved by attaching a fluorescent bead or injecting a florescent dye. Dyeing has the advantage of making fish visible (under UV light) at night in shallow water. Such detailed data collection is time-consuming and should only occur after suitable monitoring sites are established. An option for narrowing spawning times and location parameters may be to distribute nest traps consisting of artificial plates or open boxes of brick or concrete placed in the substrate which are then used by sculpins as nest sites.

Young-of-the year sculpins: Most sculpin fry emerge from the nest sites in late June or early July. Most are miniature copies of the adults and can be identified by colour pattern (they are about 10-12 mm long and in the field identification requires a hand lens). On the coast, prickly sculpin (*C. asper*) produce small eggs (about 1.5 mm in diameter) and pelagic larvae that drift downstream into estuaries. It is not known if the interior form of this species also produces pelagic larvae, but if so, they could be sampled with a D-ring or other form of fixed net which captures drifting larvae.

By the beginning of July, newly emerged sculpins are usually found in flooded vegetation associated with the confluences of tributary streams and the main river. They are easily collected with a standard aquarium dip-net. There are some unpublished field observations that suggest different species might prefer different microhabitats (e.g., some species appear to be most abundant over sand substrates with sparse vegetation, and other species may prefer dense vegetation). These seasonally flooded areas may be important nursery sites.

Adult longnose dace: During the day in the summer, adult longnose dace usually shelter under rocks in riffles, often with surface velocities greater than 0.5 m/s. Under laboratory conditions, they forage at night (Culp 1989); however, summer foraging behaviour in nature is unknown. The adults may move into quieter water at night. Longnose dace are abundant in the lower Columbia River, and the species is not listed provincially or federally. Consequently, they do not need to be processed in the same detail as sculpins; however, there is evidence of interactions between age classes in this species (Mullen and Burton 1998). Thus, enough individuals should be measured to detect seasonal or diel differences in habitat use between adults and juveniles.

Adult Umatilla dace: Only limited information is available about the biology of the Umatilla dace. The primary sources for this species are a PhD thesis (Haas 2001), a Habitat Conservation Trust Fund Report (Peden and Orchard 1993), and a report to BC Hydro on sculpins and dace (RL&L Environmental Services Ltd. 1995). These reports suggest that adult Umatilla dace are found in quieter water than longnose dace and may be associated with glides containing boulders. There is also evidence of seasonal shifts in their habitat use and, perhaps, differences in habitat use between the sexes (Peden and Orchard 1993). There is circumstantial evidence (from closely related species) that Umatilla dace may spawn later than longnose dace (on the declining limb of the freshet hydrograph); however, its reproductive biology has not been described. If sites are encountered where adult Umatilla dace are common, each individual should be anesthetized, identified, sexed, marked (preferably tagged), weighed, measured, and then revived and returned to the capture site.

Dace eggs are sticky and will attach to rocks in the spawning area but only those caught in interstices or under rocks escape predation. As a result, locating eggs may require intensive inspection of the substrate in an area where mature dace have been observed. There are reports of dace eggs being collected using frames or boxes constructed of fly-screen, and the use of some form of such an egg trap may be useful for establishing the time and location of spawning.

Young-of the year dace: The fry of longnose dace first appear at about 10-12 mm long, and can be identified by a dark streak on their snout in front of the eyes. The fry of the Umatilla dace are undescribed. Initially, the fry of both dace species are associated with quiet, shallow water and vegetated cover, but as they grow they move into deeper water (< 0.25 m) and forage during the day in mid-water (McPhail 2007). During high water, juvenile longnose and Umatilla dace shelter in flooded vegetation but as the summer proceeds longnose dace move into faster water; however, Umatilla dace appear to aggregate in deeper, quieter water in places where there is a current break (RL&L Environmental Services Ltd. 1995).

Challenges: Identifying sculpins in the field is not easy, and field crews may need some instruction (if necessary, contact jdmcp@shaw.ca) in identifying and sexing sculpins (a hand lens is necessary). Also, locating Umatilla dace spawning sites may be challenging. Most dace develop spawning colours (red lips and red axillae in males) and spawning tubercles. These sexually dimorphic features may give clues as to when and where the species spawns. The females likely are fractional spawners (i.e., not all eggs are spawned at once), but the spawning period may be short (1 or 2 weeks). In a related species (the speckled dace), there are spawning aggregations, and the spawning sites are located in shallow water with sand or fine gravel substrates (Mueller 1984). This information may be useful as a starting point for identifying Umatilla dace spawning locations.

Locating sufficient numbers of Columbia sculpins to obtain useful data may be difficult. Earlier studies report the Columbia sculpin (under the name of the mottled sculpin, *C. bairdii*) from a number of sites between the Hugh L. Keenleyside Dam and the US border, but never in sufficient numbers in any location to constitute a potential monitoring site. This lack of abundance may indicate the species is genuinely rare, or simply that no one has sampled a habitat where they are abundant. If the former is the case, it may be necessary to use another species (one that typically coexists with Columbia sculpin) as a surrogate for the Columbia sculpin. Of the sculpin species in the study area, the torrent sculpin (*C. rhotheus*) is the most likely surrogate. Mature male sculpins can be identified by their predominantly black spawning colouration.

2.3.4 Task 4: Analysis and Reporting

To facilitate effective management of data from the monitoring program, an annual data report should be prepared each year and a technical report will be prepared at the end of the project. The data reports will concentrate on listing the data and the results of basic analyses, but should also provide a discussion of the methods used and their success or failure, as well as recommendations for technical changes in the program the following year. The technical report 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.

The report will follow the standard format that is being developed for WUP monitoring programs. All reports will be submitted 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

This monitoring program is expected fill existing data gaps on the life history and habitat use of four sculpin and two dace species in the lower Columbia River, which may be affected by water level fluctuations resulting from daily and seasonal operations of HLK Dam.

Comparing the timing of events like spawning and seasonal or diel habitat shifts by sculpins and dace, and the timing of current operating procedures (especially flow adjustments) will improve the ability to assess potential risks to these species downstream of the dam. With reliable data on sensitive aspects of the life histories of these species, it may be possible to make adjustments to operations (e.g. ramping rates) to minimize risk to listed species.

2.5 Schedule

Given the relatively short life span of the species involved (usually 3-5 years), the monitoring program will be conducted annually for five years within the implementation period of the Columbia River Water Use Plan. The monitoring program should start in the spring (as early as April, at least during the first year of study), but the preparatory stages of the program (e.g., the literature review and assessment of potential monitoring sites) should be completed prior to the implementation of field work. For sculpins and longnose dace, surveys for spawning sites should start in the spring (April or May). For Umatilla dace spawning probably occurs just before or just after the peak of the natural hydrograph (late June through July), and in-field monitoring should commence around this time period.

2.6 Budget

A detailed budget for the Lower Columbia River Sculpin and Dace Life History Assessment is provided in Table CLBMON-43-1. The total annual cost is $138,487 (in 2004 dollars), with an average annual cost of $185,301 (including 2% rate of inflation and 5% contingency). This budget is significantly higher than the WUP CC estimate of $75,000 annually; however, the additional cost is required to implement a scientifically viable sampling program. The study cost recommended by the WUP CC was based on expanding the seasonality of shallow water studies that had been initiated in the river (primarily involving work in the summer), and examining swimming performance, depth preference and activity schedules in response to seasonal photoperiod and temperature in a laboratory situation to provide insight into how the species may respond to dam operations. BC Hydro did conduct some additional work in shallow water, although the results added to questions about habitat use. Since that time, Umatilla dace has been listed under the Species at Risk Act (SARA) as a Species of Special Concern, and the mottled sculpin has been redefined as the Columbia sculpin, a rarer species being reassessed by COSEWIC. Both species are expected to be listed at a higher risk category. Under SARA, it would be very difficult to capture and transport any numbers of these fishes for use in a laboratory scenario. As such, the work will have to be carried out in the field and requires a change in approach, which is reflected in the revised budget estimate.

The cost estimate is based on sampling four sites during three field trips for the five years of the program, but in the first year, as many sites as possible should be inspected to help identify the best long term sampling sites. In addition, during the first year, the budget is based on field trips in April, May, June and July, as well as the fall. The four spring-summer trips are included to allow identification of spawning times for the endangered species (cost controls could be achieved by reducing this to three trips appropriately timed). By the second year, it is assumed these times will have been identified, and only a total of three trips in the spring, summer and fall will be necessary.

The budget also assumes a subset of the sites will be located outside of the Columbia River mainstem. The sites selected for budget purposes are the lower Slocan River (for Umatilla dace) and the Similkameen River near Keremeos (for Columbia sculpin). This budget is meant to capture the various options that the consultant may use to define the important life history aspects of the sculpin and dace species. It is not meant to be used in its existing format for bidding purposes, and it is expected bidders will endeavour to submit proposals with budgets lower than the estimated budget. This project, more than most WLR monitoring projects, will require innovative thinking regarding methods and approaches, both before and during the field program to meet the program objectives. Different approaches may be developed over the course of the monitoring program (in this study or elsewhere) that could change preferred methods.

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