Columbia River Project Water Use Plan

Monitoring Program Terms of Reference

ARROW LAKES RESERVOIR OPERATIONS MANAGEMENT PLAN

- CLBMON-31 Arrow Lakes Reservoir Burbot Life History and Habitat Use Assessment

08 November 2007
ARROW RESERVOIR
OPERATIONS MANAGEMENT PLAN
TERMS OF REFERENCE

1.0 OVERVIEW

This document presents Terms of Reference for monitoring programs under the Arrow Reservoir Operations Management Plan (Table 1). These programs will evaluate the potential effects of Arrow Lakes Reservoir operation on fish habitat and fish populations, wildlife habitat and wildlife populations, and recreational use patterns. In addition, the information gained from these programs will assist in assessing the effectiveness of implementing the soft operational constraints.

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

1) CLBMON-31 Arrow Reservoir Burbot Life History and Habitat Use Assessment: a 5-year monitoring program to identify potential spawning locations in Arrow Lakes Reservoir and the mid Columbia River and assess the potential effects of winter reservoir drawdown and five-unit operations at Revelstoke Dam on burbot spawning success.

2) CLBMON-32 Arrow Reservoir Tributary Fish Migration Access Assessment and Monitoring Program: a 6-year study to assess passage conditions at tributaries to Arrow Lakes Reservoir under a range of operating levels and streamflow conditions to determine threshold reservoir levels below which passage of fish is prevented.

3) CLBMON-36 Kinbasket and Arrow Nest Mortality of Migratory Birds due to Operations: a 10-year monitoring program to determine the effect of reservoir operations in spring/summer on nesting success of breeding birds (including Species at Risk). This will inform on the magnitude and significance of nest mortality due to reservoir operations, and the scope of physical works required to mitigate adverse impacts, and the effectiveness of these works in mitigating nesting failure.

4) CLBMON-37 Arrow Lakes and Kinbasket Reservoirs Amphibian and Reptile Life History and Habitat Use Assessment: a 5-year study to evaluate operational impacts on reptiles and amphibians to address data gaps related to the relative abundance, distribution and seasonal patterns of habitat use, and provide information on possible mitigation strategies (if required) for future consideration. This study needs to be undertaken concurrently with the development of pond designs for Arrow Lakes Reservoir and to include effectiveness monitoring of wildlife physical works on reptile and amphibian habitat.

5) CLBMON-38 Fall Migrating Shorebird and Waterbird Use of the Arrow Drawdown Zone: a 10-year life history and habitat use study of migrating shorebirds and waterbirds in Revelstoke Reach to address data gaps related to the relative abundance, distribution and seasonal patterns of habitat use, and provide information on the magnitude of impact of reservoir operations and possible mitigation strategies for future consideration.

6) CLBMON-39 Neotropical Migrant Use of the Arrow Drawdown Zone: a 10-year monitoring program of neotropical migrants at the Revelstoke Banding Station located at Machete Island to address data gaps related to the relative abundance, distribution
and seasonal patterns of habitat use, and inform on potential impacts of reservoir operations and possible mitigation strategies for future consideration.

7) CLBMON-41 Arrow Lakes Reservoir Recreational Demand Study: a 2-year study to develop performance measures that link all aspects of recreation (shoreline and boating) to reservoir levels, by local/tourist ranking for future decision-making.

### Table 1 Arrow Reservoir Operations Management Plan Monitoring Program Terms of Reference Submission Information

<table>
<thead>
<tr>
<th>Name of Monitoring Program or Physical Works</th>
<th>Order Clause Fulfilled</th>
<th>Submitted with this Package</th>
<th>Previously Submitted To CWR</th>
<th>Submission Date</th>
<th>Leave to Commence</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLBMON-31 Arrow Reservoir Burbot Life History and Habitat Use Assessment</td>
<td>Schedule D: 5.a</td>
<td>Yes</td>
<td>Yes</td>
<td>24 October 2007</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>13 November 2007</td>
<td></td>
</tr>
<tr>
<td>CLBMON-32 Arrow Reservoir Tributary Fish Migration Access Assessment and Monitoring Program</td>
<td>Schedule D: 5.b</td>
<td>Yes</td>
<td>No</td>
<td>24 October 2007</td>
<td>No</td>
</tr>
<tr>
<td>CLBMON-36 Kinbasket and Arrow Nest Mortality of Migratory Birds due to Operations</td>
<td>Schedule A: 6.a</td>
<td>No</td>
<td>No</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Schedule C: 5.c</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLBMON-37 Arrow Lakes and Kinbasket Reservoirs Amphibian and Reptile Life History and Habitat Use Assessment</td>
<td>Schedule A: 6.b</td>
<td>No</td>
<td>No</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Schedule C 5.d</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLBMON-38 Fall Migrating Shorebird and Waterbird Use of the Arrow Drawdown Zone</td>
<td>Schedule C: 5.e</td>
<td>No</td>
<td>No</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Schedule C: 5.g</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLBMON-39 Neotropical Migrant Use of the Arrow Drawdown Zone</td>
<td>Schedule C: 5.f</td>
<td>No</td>
<td>No</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>CLBMON-41 Arrow Lakes Reservoir Recreational Demand Study</td>
<td>Removed from Conditional List and Ordered (letter from CWR to BC Hydro dated 23 April 2007)</td>
<td>No</td>
<td>No</td>
<td></td>
<td>No</td>
</tr>
</tbody>
</table>
2.0 PROGRAM RATIONALE

Early in the Columbia River water use planning process, a distinction was made between those operating alternatives that required some negotiation with the United States, and those that could be implemented unilaterally by BC Hydro. The latter category included a wide range of alternatives, focusing primarily on Arrow Lakes Reservoir. It was assumed that BC Hydro had several mechanisms through which it could unilaterally change flows, including the Non-Treaty Storage Agreement (NTSA) with the United States. This was particularly important in achieving a rapid drawdown of Arrow Lakes Reservoir in the late summer and early fall periods to benefit migratory birds and vegetation.

With the release provisions of the NTSA having expired in June 2004, the Consultative Committee was presented with a modification to how the Columbia River water use planning process must consider the Arrow Lakes Reservoir operating alternatives. The spring and summer reservoir elevation constraints explored by the Consultative Committee are the only changes that BC Hydro could implement unilaterally once ordered by the Water Comptroller. Any change in the summer and fall constraints would have to wait until negotiations with the United States are completed and, therefore, would not occur over the short term. Further, without the NTSA in place, all of the alternatives would have significantly higher financial costs and perhaps a different balance between Arrow Lakes and Kinbasket reservoir levels.

While several options for completing the Columbia River Water Use Plan were discussed by the Consultative Committee, consensus agreement was reached around developing soft constraints for Arrow Lakes Reservoir to meet the interests and stated objectives of the Committee. It was acknowledged that BC Hydro would have to balance these trade-offs internally through choosing its water management strategy. This balance would be informed by the expressed values of the Committee, the efficacy of the physical works, and the knowledge gained through the monitoring program to guide operational decisions.

In supporting soft constraints for Arrow Lakes Reservoir, the Consultative Committee acknowledged that long-term data collection will be critical to assessing its impacts on fish, vegetation, wildlife and recreation interests. Given considerable uncertainties around the response of vegetation, wildlife and fish resources to operation of the reservoir, a number of assumptions were built into the modeling of constraints, which require verification through ongoing monitoring.
Monitoring Study No. CLBMON-31
Arrow Lakes Reservoir Burbot Life History and Habitat Use Assessment

1.0 MONITORING PROGRAM RATIONALE

1.1 Background

Burbot were identified by the Columbia River Water Use Plan Consultative Committee (WUP CC) as a species of concern in Arrow Lakes Reservoir because of the lack of data available on their biology and the hypothesized negative impact of reservoir operations on spawning success and egg survival. This species has long been a valued sport fish in the Columbia River system but has recently become a species of concern in the Kootenay region where some populations are experiencing significant declines in abundance (Arndt and Baxter 2006). Since the release of the Consultative Committee Report (BC Hydro 2005), a stock assessment of the population(s) of burbot in Arrows Lake Reservoir indicated that they are widely distributed throughout the reservoir and their abundance is high relative to other sampled populations within BC lakes (Arndt and Baxter 2006). Despite these data, dam operations may be hampering the productivity of burbot population(s) in Arrow Lakes Reservoir, as little is known how dam operations are affecting spawning success.

The WUP CC hypothesized that the greatest potential impact of reservoir operations on burbot populations may be the dewatering effect of winter drawdown on spawning success and egg survival in sites along the shoreline and in lower sections of tributaries. While burbot spawning time and locations in Arrow Lakes Reservoir have not been documented, this species typically spawns between late January and late February, either in shallow lake habitats or low velocity stream habitats, and has an egg incubation period of about 1.5 months (McPhail 1997; Taylor and McPhail 2000). It can be expected that spawning and egg incubation in the Arrow Lakes system likely occurs between January and April, which coincides with the period when reservoir water levels decline. Winter drawdown could also affect burbot spawning habitat in tributary streams of Arrow Lakes Reservoir. In a radio telemetry study of adult burbot in Duncan Reservoir, the extent of spawning migration into the upper Duncan River appeared to be influenced by reservoir water levels and related impacts on back-flooding and stream velocity (Spence and Neufeld 2002). As backflooding from Duncan Reservoir declined, burbot tended to move downstream into areas with lower water velocities than the locations they had abandoned. Since stream spawning burbot tend to spawn in low velocity stream habitats (McPhail 1997), the burbot may have been moving downstream to more suitable lower velocity spawning sites.

In addition to the concerns of the WUP CC, the Revelstoke Unit 5 Core Committee also expressed concern that operation of five generating units at Revelstoke Dam could affect burbot below the dam in the mid Columbia River. Specifically, the Core Committee was concerned that burbot spawning migration and spawning habitat could be affected by increased water velocities associated with five-unit operations. Burbot are characterized as having low stamina and swimming endurance (Jones et
al. 1974 cited in Paragamian et al. 2002); thus, spawning success could be affected if flows are greater than the fish are capable of swimming (Paragamian et al. 2002).

To address the concerns of the WUP CC and the Revelstoke Unit 5 Core Committee, this study will fill data gaps on the potential operating impacts on burbot populations so that mitigative strategies can be developed if needed.

1.2 Management Questions

The fundamental management questions to be addressed by this monitoring program:

1) Where are Arrow Lakes Reservoir burbot spawning?

2) If there are spawning areas in the mid Columbia River, does the change in flow regime due to addition of a fifth generating unit at Revelstoke Dam affect the spawning migration and spawning habitat of burbot in the river?

3) Does winter drawdown of Arrow Lakes Reservoir cause the dewatering of burbot spawning habitat and affect spawning success?

4) Can modifications be made to the operation of Arrow Lakes Reservoir to protect or enhance spawning success of the burbot population(s)?

The monitoring program will also build upon the 2005 stock assessment by providing data on biological characteristics of the burbot populations in Arrow Lakes Reservoir.

1.3 Management Hypotheses

The primary aim of this monitoring program is to provide baseline information on burbot populations in Arrow Lakes Reservoir to better inform on the relationship between reservoir operations on spawning success and egg survival. It is designed to specifically test the following management hypotheses$^1$:

$H_1$: Winter drawdown of Arrow Lakes Reservoir does not cause dewatering of burbot spawning habitat.

$H_2$: Spawning migration of burbot in the mid Columbia River does not change as a result of alterations in flow regime due to addition of a fifth generating unit at Revelstoke Dam.

$H_3$: Spawning habitat of burbot in the mid Columbia River does not change as a result of alterations in flow regime due to the addition of a fifth generating unit at Revelstoke Dam.

$^1$ For clarity, the hypotheses are stated as alternative hypotheses to the null hypotheses of no effect or difference.
1.4 Key Water Use Decision Affected

Implementation of the proposed monitoring program will provide information to support more informed decision making with respect to the need to balance (i) storage in Arrow Lakes Reservoir and (ii) power generation at Revelstoke Dam with impacts on fish populations in the reservoir. Specifically, it will provide the information that is required to support future decisions around maintaining the current operating regime or modifying operations to protect reservoir burbot populations. It may have implications for the operation of the fifth generating unit at the Revelstoke facility, which is set to begin operations in fall 2010.

2.0 MONITORING PROGRAM PROPOSAL

2.1 Objectives and Scope

The objectives of the monitoring program will be to: 1) identify spawning habitat of burbot in the reservoir and 2) determine if burbot spawning migration and/or spawning habitat is negatively affected by the Revelstoke Unit 5 Project. The objectives will be met by collecting the data necessary to draw inferences and to test the hypotheses outlined in Section 1.3. The monitoring program will be conducted annually over a 5-year period, and will focus on reservoir burbot populations (i.e., not fluvial populations restricted to tributaries). Monitoring of potential spawning locations will include the reservoir near the mouth of Mosquito Creek, the mid Columbia River, and a minimum of 2-3 additional reservoir sites identified by this monitoring program or professional expertise. Data collection, data analyses and reporting will also be undertaken annually over the study period, and a final study report will be produced in Year 5 that summarizes the results of the monitoring program and the conclusions that can be drawn pertaining to the management questions and hypotheses. This study is not intended to address potential impacts on larval or juvenile burbot.

2.2 Approach

Burbot habitat use will be assessed using a combination of trapping and tagging telemetry methods. Basic biological characteristics, size and maturity will be assessed for trap-captured burbot. Since mean catch rates of burbot in traps have been found to be well correlated with changes in burbot abundance (Bernard et al. 1993), trap catch rates will be used to provide an estimate of relative burbot abundance to compare with earlier work (Arndt and Baxter 2006). A sub-sample of burbot captured in the traps will be tagged and tracked during their spawning season using aerial and boat surveys. If potential burbot spawning locations are identified during the aerial or boat surveys, ground/snorkel surveys will be conducted to confirm the presence of burbot spawning activity. The location and habitat conditions of confirmed burbot spawning locations will be thoroughly documented.

2.3 Tasks

2.3.1 Task 1: Project Coordination

Project co-ordination will involve the general administration and technical oversight of the assessment study. This will include but not be limited to 1) budget management, 2) study team selection, 3) logistics co-ordination, 4) technical oversight in field and analysis components, and 5) facilitation of data transfer among relevant projects.
A safety plan must be developed and submitted to the BC Hydro contact, for all aspects of the study involving field work, in accordance with BC Hydro procedures and guidelines. Specific safety training may be required.

2.3.2 Task 2: Field Studies

An annual field sampling program will be initiated to identify burbot spawning areas that may be affected by reservoir drawdown, impact of Revelstoke Unit 5 on spawning, and determine if reservoir operation is affecting egg survival. Additional biological information on the burbot will be obtained at the time of tagging. A methodology for obtaining this information is described below; however, alternative scientifically defensible methods will be considered.

**Trapping**

Prior to the spawning season, annual trapping will be employed to sample burbot from Arrow Lakes Reservoir. Trapping methods will be similar to those used in past (and ongoing) burbot studies in British Columbia lakes (e.g., Spence 1999; Spence and Neufeld 2002; Neufeld 2005; Arndt and Baxter, 2006).

To obtain results that are broadly applicable to burbot populations in Arrow Lakes Reservoir, a statistically sound sampling design should be employed in the trapping of burbot. At the same time, some sampling effort should be focused in areas of suspected high burbot abundance (i.e., hotspots) including those sites sampled in Arndt and Baxter (2006).

Burbot capture should be conducted during the October-November period, as spawning is expected to occur between January and April.

**Biological Sampling and Tagging**

The primary source of movement data will be from telemetry tagging. The use of Combined Acoustic Radio Tags (CART) is a suggested means of monitoring burbot movement as these tags will provide coverage in both deep and shallow water. Surgical methods will be consistent with previous burbot studies (e.g., Spence and Neufeld 2002; Arndt and Baxter 2006). A minimum of 20 burbot will be selected each year for telemetry tagging. Selected burbot should come from as wide a geographic area as possible and should not show significant signs of decompression trauma at the time of tagging. Any fish suffering severe decompression trauma will be euthanized and the otoliths taken for ageing. Sexual maturity of tagged and sacrificed burbot will be assessed.

**Telemetry Tracking and Spawning Habitat Surveys**

Telemetry tracking and ground reconnaissance will be undertaken during the typical burbot spawning and egg incubation period of each study year (January through April). Radio tracking by air and acoustic tracking by boat will be employed to identify the locations of tagged burbot. Spawning areas are presently unknown, so more tracking effort may be required in the first year of study. Locations of tracked burbot will be georeferenced, mapped and photographed. During the trapping/tagging phase of the field study, a fixed receiver will be installed along the mid Columbia near the Illecillewaet River. If burbot migrate this far upstream, then their movements in
relation to flow may be observed. The fixed receiver will be removed during the final boat tracking session.

As part of the boat tracking, depth and velocity of the mid Columbia River will be measured to obtain a series of velocity cross-section profiles that are representative of river flow and dam operations over the course of the expected period of burbot spawning migration. Data will also be downloaded from the fixed receiver during boat tracking sessions.

Snorkel or SCUBA surveys (assuming no ice coverage) will be conducted during the expected spawning period (i) near the mouth of Mosquito Creek, (ii) sites in the mid Columbia River and (iii) other potential burbot spawning sites to verify data collected as part of the telemetry monitoring. Habitat characteristics at known burbot spawning locations will be measured during the snorkel/SCUBA survey and during egg incubation once reservoir water levels have dropped. Parameters to be measured in triplicate include but are not limited to: water temperature, water depth, and water velocity. An estimate of substrate composition (% coverage by size category) will be measured by visual assessment.

Subsequent years of data collection may require refinement in methodology based on Year 1 findings.

2.3.3 Task 3: Data Analysis and Reporting

Data analysis will include the following:

- Development of length frequency distributions, length-weight relationships, size-at-age (age analysis limited as otoliths are collected from fish that die during capture/surgery);
- Trap catch rates, with variation in mean catch rates versus sampling areas, water depth and sampling year;
- Summary tracking statistics for individual fish, including analyses specific to migration and velocity to assess potential velocity barriers (by comparing to published biostandards for burbot) in the mid Columbia River, and to spawning to assess impacts of reservoir changes and five-unit operations during spawning;
- Development of relationship between operations at Revelstoke Dam and velocity of mid Columbia River;
- Comparison of observed characteristics of egg incubation habitat to published biostandards for burbot.

Brief technical reports of the monitoring program will be prepared annually. These reports will summarize trap catch rates for burbot, biological characteristics of trap-caught burbot (e.g., size and maturity), movement patterns of telemetry tracked burbot, and physical characteristics of burbot spawning habitats. Recommendations for improving the program will also be included with the reports.

A final technical report will be prepared at the conclusion of Year 5 of the study, which will include:
a) an executive summary;

b) a description of the methods employed;

c) a data summary;

d) a comparison of results between years;

e) a detailed summary of the findings as they relate to the ecological hypothesis and the key management questions including any recommendations for modifications in the operation of Arrow Lakes Reservoir and Revelstoke Dam to protect or enhance spawning success of the burbot population.

f) summary of data gaps and recommendations for improving the program as a monitoring tool in the future

Reports 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

The monitoring program will provide valuable information to address two specific categories of uncertainty related to the operational impacts of Arrow Lakes Reservoir and the Revelstoke Unit 5 Project on burbot populations:

1) Identifying burbot spawning times and locations will enable an assessment of whether reservoir operations have the potential to affect burbot spawning success and, thereby, population productivity. If spawning occurs in shallow water or within the drawdown zone of the tributaries, then burbot spawning success may be affected by operations; whereas spawning in deep water would likely indicate minimal impact on spawning success. Mitigation measures will be discussed (e.g., operation changes or physical works) if results indicate operations may be negatively affecting spawning.

2) The study will provide two years of pre-Revelstoke Unit 5 Project data and three years of data following implementation of the project. If the results suggests that burbot spawning migration or success is negatively affected by the operational changes caused by five-unit operations, then mitigation measures will be discussed (e.g., operation changes or physical works).

Additionally, this program will provide a baseline dataset on the basic biological characteristics of burbot populations in Arrow Lakes Reservoir. This baseline dataset will allow for better assessment of factors affecting burbot productivity and the response of burbot populations to potential future changes in reservoir operations.

2.5 Schedule

The study will be conducted over a 5-year period, and will be initiated in Year 2 of implementation of the Columbia River Water Use Plan (2008).
2.6 Budget

The annual budget for the Arrow Reservoir burbot study is estimated at $206,534 (in 2004 dollars). A fixed station radio receiver and associated equipment will only be purchased if it cannot be acquired from another BC Hydro program or agency at a lesser cost.

3.0 REFERENCES


