Columbia River Project Water Use Plan

Arrow Lakes Reservoir Operations Management Plan
Annual Report: 2008

CLBMON-31 Arrow Lakes Reservoir: Burbot Life History Study

CLBMON-32 Arrow Lakes Reservoir: Tributary Fish Migration Study

CLBMON-36 Kinbasket and Arrow Lakes Reservoir: Nest Mortality of Migratory Birds due to Reservoir Operations

CLBMON-37 Kinbasket and Arrow Lakes Reservoir: Amphibian and Reptile Life History and Habitat Use Assessment

CLBMON-39 Arrow Lakes Reservoir: Neotropical Migrant Use of the Drawdown Zone

CLBMON-40 Arrow Lakes Reservoir: Arrow Lakes Reservoir Shorebird and Waterbird Monitoring Program

CLBMON-41 Arrow Lakes Reservoir: Recreational Demand Study

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

30/06/2009
1 Introduction

This document represents a summary of the status and the results of the Arrow Lakes Reservoir Operations Management Plan of the Columbia River Water Use Plan (WUP) monitoring program to 31 May 2009, as per the Columbia River Order under the Water Act, dated 26 January 2007. There are eight studies included within this Management Plan:

- CLBMON-31 Arrow Lakes Reservoir: Burbot Life History Study
- CLBMON-32 Arrow Lakes Reservoir: Tributary Fish Migration Study
- CLBMON-36 Kinbasket and Arrow Lakes Reservoir: Nest Mortality of Migratory Birds due to Reservoir Operations
- CLBMON-37 Kinbasket and Arrow Lakes Reservoir: Amphibian and Reptile Life History and Habitat Use Assessment
- CLBMON-39 Arrow Lakes Reservoir: Neotropical Migrant Use of the Drawdown Zone
- CLBMON-40 Arrow Lakes Reservoir: Arrow Lakes Reservoir Shorebird and Waterbird Monitoring Program
- CLBMON-41 Arrow Lakes Reservoir: Recreational Demand Study

2 Background

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

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

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

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

The following table outlines the dates that Arrow Lakes Reservoir Operations Management Plan TOR have been submitted to, and approved by the CWR to date:

<table>
<thead>
<tr>
<th>Monitoring Program TOR</th>
<th>Order Clause</th>
<th>Date Submitted</th>
<th>Date Approved</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLBMON-31 Arrow Lakes Reservoir: Burbot Life History Study</td>
<td>Schedule D: 5.a</td>
<td>24 October 2007</td>
<td>20 February 2008</td>
</tr>
<tr>
<td>CLBMON-32 Arrow Lakes Reservoir: Tributary Fish Migration Study</td>
<td>Schedule D: 5.b</td>
<td>24 October 2007</td>
<td>20 February 2008</td>
</tr>
<tr>
<td>CLBMON-40 Arrow Lakes Reservoir: Arrow Lakes Reservoir Shorebird and Waterbird Monitoring Program</td>
<td>Schedule C: 5.e, 5.g</td>
<td>25 January 2008</td>
<td>3 March 2008</td>
</tr>
<tr>
<td>CLBMON-41 Arrow Lakes Reservoir: Recreational Demand Study</td>
<td>Schedule D: 5.a</td>
<td>31 July 2008</td>
<td>11 September 2008</td>
</tr>
</tbody>
</table>
As outlined in the Columbia River WUP, the Consultative Committee recommended a full review of the Columbia River Water Use Plan 13 years after implementation, unless results of the monitoring program suggest an earlier review is appropriate or significant risks are identified that could result in a recommendation to change operations.

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

3 Status

The following table (Table 3-1) outlines the current status and schedule for the studies and physical works being delivered under the Arrow Lakes Reservoir Operations Management Plan of the Columbia River Water Use Plan.

### Table 3-1: Status and Schedule of Columbia River WUP Monitoring Program under the Arrow Lakes Reservoir Operations Management Plan

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WLR YR1</td>
<td>WLR YR2</td>
<td>WLR YR3</td>
<td>WLR YR4</td>
<td>WLR YR5</td>
<td>WLR YR6</td>
<td>WLR YR7</td>
<td>WLR YR8</td>
<td>WLR YR9</td>
<td>WLR YR10</td>
<td>WLR YR11</td>
<td>WLR YR12</td>
<td>WLR YR13</td>
</tr>
<tr>
<td>GLBMON-31 Arrow Lakes Reservoir: Burbot Life History Study</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>GLBMON-32 Arrow Lakes Reservoir: Tributary Fish Migration Study</td>
<td>✓</td>
<td>u/w</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>GLBMON-36 Kinbasket and Arrow Lakes Reservoir: Nest Mortality of Migratory Birds due to Reservoir Operations</td>
<td>✓</td>
<td>u/w</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>GLBMON-37 Kinbasket and Arrow Lakes Reservoir: Amphibian and Reptile Life History and Habitat Use Assessment</td>
<td>✓</td>
<td>u/w</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>GLBMON-39 Arrow Lakes Reservoir: Neotropical Migrant Use of the Drawdown Zone</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>GLBMON-40 Arrow Lakes Reservoir: Arrow Lakes Reservoir Shorebird and Waterbird Monitoring Program</td>
<td>✓</td>
<td>u/w</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>GLBMON-41 Arrow Lakes Reservoir: Recreational Demand Study</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Legend:  
- ✓ = Program to be undertaken/initiated in identified year  
- u/w = Project is underway  
- ✓ = Program completed for the year  
- x = Program started, but encountered operational or hydrological delays
4 Columbia River Project WUP Studies - Arrow Lakes Reservoir Operations Management Plan

This section summarizes the status of the monitoring programs being implemented under the Arrow Lakes Reservoir Operations Management Plan of the Columbia River Water Use Plan, as per the Order under the Water Act, dated January 26, 2007.

4.1 CLBMON-31 Arrow Lakes Reservoir: Burbot Life History Study

4.1.1 Overview

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 back-flooding 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.

4.1.2 Status

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). 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.

4.1.3 Interpretation of Data

This project commenced in October, 2008. The focus of the project is fourfold: 1) to assess horizontal and vertical distributions of adult burbot during the pre-spawning periods (October/November); 2) to locate burbot spawning areas by implanting transmitters into a random sample of mature adult burbot, and tracking them during the December-April period; 3) to measure habitat variables of the areas used for spawning (and elsewhere); and 4) to determine the potential impact of hydro operations on burbot spawning areas and success.

During the first week of the field program in October, several decompression trials were conducted to determine the most effective procedure to minimize decompression trauma on burbot captured at depth and lifted to the surface. During the decompression trials, 51 traps were set between 15 and 22 October at three depth strata (10 m, 20 m, and 30 m) in the areas around Galena Bay and Shelter Cove (Upper Arrow Lake). In total, 124 burbot were brought to the surface, examined for decompression symptoms, and bio-sampled.

By the end of the week a satisfactory lifting procedure was developed and experimental trapping began in the four major strata comprising the Arrow Lakes Reservoir. The objectives were to quantify burbot Catch-Per-Unit-Effort (CPUE) in each of the strata and to capture a random sample of adult burbot for subsequent tracking.

In November, experimental fishing and tagging focused on the uppermost reaches of Upper Arrow Lake, and in the free-flowing reach of the Columbia River below Revelstoke Dam. From 1 to 6 November, 28 complete trap-sets were performed, plus 20 traps that were set in October were hauled. Of the 43 burbot caught from these sets, 16 were tagged. Of these, 20 were sexually mature, 18 were immature, and 5 were unknown. Mature fish ranged widely in length (590 to 960 mm TL) and weight (840 to 5615 g). The mature fish were largely of unknown sex (n=15), with only 4 identified as males, and 1 as a female.
Between January and March 2009, three telemetry and acoustic surveys were conducted between Revelstoke and Castlegar. The surveys were conducted with a fixed wing float plane with radio antennae attached to the wing and an acoustic microphone attached to one of the pontoons. The aircraft would fly until a radio signal was detected, it would then land on the water and conduct an acoustic survey with the hydrophone in order to get a more precise location of the fish. In total, the surveys resulted in only 8 of 40 implanted fish being detected. Although disappointing, there was a known risk that few fish would be detected due to the size (230km long) and depth of the reservoir. The report is still in draft stage with a final report expected in August 2009.

Several interesting results came out of the sampling program from year one.

- Burbot trapping trial results suggested that more time should be allowed for decompression to occur. An extra 24 hours was added to the existing Ministry of Environment decompression procedure.

- Burbot gonad observations from the decompression trials indicated that there was a wide range in apparent readiness to spawn, suggesting that there could be a wider variation in the onset of spawning than was previously documented.

- No burbot were detected in any tributary stream during the survey period, suggesting limited tributary spawning.

- The size and depth of the reservoir means that other tracking methods may need to be employed in order to increase detection rates. The consultant is proposing to implant Vemco acoustic tags in a number of burbot in order to test the detection effectiveness of sturgeon-VR2W receivers located between Revelstoke and Beaton Flats.

### 4.2 CLBMON-32 Arrow Lakes Reservoir: Tributary Fish Migration Study

#### 4.2.1 Overview

The Columbia River Water Use Plan Consultative Committee (WUP CC) identified that seasonal changes in the elevation of Arrow Lakes Reservoir have the potential to negatively affect the ability of key fish populations (namely kokanee, bull trout and rainbow trout) to access critical spawning habitats in the Arrow Lakes tributaries. Reduced success in upstream passage can result from a variety of effects associated with the topographic configuration of the tributary fan, including gradient, channel depth and velocity, morphology (braiding), and sub-surface conveyance of tributary outflow.

Several studies have been conducted on Arrow Lakes Reservoir, either specifically to assess tributary access issues (as was the case during the WUP) or to track spawning populations for escapement assessment purposes. General summaries are provided below.
Rainbow Trout

In evaluating the effects of reservoir elevations on tributary access, the WUP CC assumed that the effects of low spring reservoir elevation on spawning rainbow trout are, in part, mitigated by increased stream flow during tributary freshet. However, because there was significant uncertainty regarding the interactive effect of reservoir elevation and tributary stream flows, BC Hydro conducted aerial overflights in April 2001 to collect additional information, using a qualitative assessment methodology for tributaries in the Upper and Lower Arrow Lakes. Other studies (Wilson 1999, BC Hydro unpublished data 1999) have been conducted with no observation of passage issues. It is recognized that timing and spawning distribution are largely unknown for rainbow trout in the Arrow Lakes Reservoir.

Bull Trout

There have been some spawning studies of bull trout in Arrow tributary streams (Decker et al. 2006; Bray and Mylechreest, 2007). However, neither study documented or reported any observations of bull trout passage issues related to reservoir levels.

Kokanee

From 1996 to present, BC Hydro has conducted several tributary access assessments in Arrow Lakes Reservoir during kokanee spawning in the fall (Bayes and Olmsted 1997, CCRIFC 2006, BC Hydro 1998, 2004-2006, and Wilson 1999). To date, no studies have reported significant access issues related to low reservoir conditions, but low flow access issues have been observed in a small number of tributaries to the Lower Arrow, as observed during assessments undertaken in 2001 and 2003 (BC Hydro unpublished data).

At the conclusion of the WUP process, the CC recommended that an assessment and monitoring study be conducted to ensure that current operations of Arrow Lakes Reservoir do not negatively impact tributary access, and to provide the information required to inform future WUP reviews. Since that time, a preliminary review of the existing information has indicated that much of the program recommended in the WUP has already been conducted. To ensure the tributary access issue is fully resolved, the program has been modified from the recommended program to include a review of existing information, with an adaptable field program to assess extreme Arrow Lakes Reservoir conditions during spawning periods of interest. These terms of reference (TOR) outline the approach that best serves the objectives set out in the WUP while ensuring that key information already collected is utilized appropriately.

4.2.2 Status

The monitoring program will be conducted annually over a 7-year period (2008-2017). The first year of the program is a literature review, followed by 5 years of field work. A data report will be prepared after each year of monitoring to summarize the methods employed during the program, data analyses and study findings. The data report will include recommendations related to the review of soft operating constraints. Upon completion of the study, a comprehensive report will be prepared in 2014.
4.2.3 Interpretation of Data

The Arrow Lakes Reservoir has the capacity to fluctuate from a minimum elevation of 418.64 m to a maximum of 440.75 m, with full pool being 440.14 m and the average mean annual fluctuation of 15.5 m (BC Hydro, 2007). The lowest reservoir levels typically occur in the spring, overlapping with rainbow trout upstream migration and spawning activity, with lower levels again experienced in late summer/early fall when kokanee and bull trout spawning migrations are occurring. Although kokanee within the Arrow Lakes Reservoir have been monitored extensively, there is relatively little known about rainbow trout and bull trout migration and spawning distributions, particularly within the drawdown zone.

A review of existing data indicated that, of the 194 tributaries to the Upper and Lower Arrow Lakes Reservoirs, 83 are documented as being fish bearing watercourses. The remaining 111 streams were not deemed to be fish bearing given excessive gradients or ephemeral flow regimes. Of the 83 tributaries, rainbow trout (adfluvial and/or resident life histories) have been identified within 75, kokanee have been identified to utilize 60 for spawning, and bull trout occur in 27 tributaries (adfluvial and/or stream resident life histories). Barriers to fish passage within the drawdown zone were identified in 9 fish bearing streams, with 5 attributed to waterfalls, 2 to persistent debris and 2 velocity barriers as a result of high gradients and braiding. The combination of low stream flows in late summer and channel braiding within the drawdown zone has been identified as posing an access concern for fall spawners (previous work has largely focused on kokanee, rather than fall spawning bull trout). There were 23 fish bearing streams identified as having potential access issues within the drawdown zone, including waterfalls, debris jams, low stream flows and braiding. There were 2 streams where barrier presence was unknown, and 51 streams with no identified access issues associated with the drawdown zone and reservoir operations.

Kokanee spawning within suitable substrates of the drawdown zone was documented in 18 tributaries. The extent of rainbow trout and bull trout spawning within the drawdown zone is unknown. Based on physical stream characteristics, it was assumed that there were 25 streams with spawning potentially occurring in the drawdown zone, 23 streams where gradients and bedrock presence was not conducive to spawning, and 19 streams where there was insufficient information to make an assumption on spawning use. A potential concern with rainbow trout spawning in the drawdown zone is that reservoir inundation will occur during the development stage, preventing fry emergence and increasing mortality. Additionally, fry emergence typically occurs in July when the reservoir is at or approaching full pool; therefore, fry that have emerged will be in a lacustrine environment and susceptible to increased predation at an earlier development stage than if they were able to rear in low velocity areas of their natal stream.

For 2009, the consultant will conduct the first of five years of field surveys for this project. This will involve spring and fall electrofishing assessments of high priority streams, as well as documentation of the physical attributes of the drawdown zone associated with those streams. The annual report for 2010 will provide more detail regarding recommendations to BCH for operational direction for the Arrow Lakes Reservoir.
4.3 CLBMON-36 Kinbasket and Arrow Lakes Reservoir: Nest Mortality of Migratory Birds due to Reservoir Operations

4.3.1 Overview

Riparian habitats along the impounded portions of the Columbia River provide important nesting habitat for birds. At Revelstoke Reach, located at the north end of the Upper Arrow Lakes Reservoir, 74 species of birds have been documented, of which 41 are known to breed in the area (Boulanger et al. 2002). Thirty-five species are thought to be affected by the operations of the Arrow Lakes Reservoir (Manning, Cooper and Associates 2003).

In the Kinbasket Reservoir, significant areas of riparian habitat occur along Canoe Reach, Columbia Reach and Bush Arm (Hawkes et al. 2007); however, there is little information available on bird use in the drawdown zone. Due to the operation of these reservoirs, birds that rely on the drawdown for breeding habitat are vulnerable to rising water levels during spring and early summer through inundation of breeding and foraging habitat and by flooding of active nests. Further, the loss of breeding habitat may increase competition for breeding territories, and limit access to foraging areas. These additional pressures may reduce juvenile survival resulting in lower productivity.

During the Columbia River Water Use Planning Process (WUP), the Consultative Committee identified nest mortality of birds as a key issue. One of the concerns identified was whether the drawdown zones function as a population sink, reducing the overall productivity and viability of bird populations that breed in these habitats. To address these uncertainties, the Consultative Committee proposed that a study be undertaken to (1) determine the use of riparian habitats by breeding birds in the drawdown zone, (2) determine the degree and significance of nest mortality caused by the operations of the Kinbasket and Arrow Lakes Reservoirs, (3) investigate the direct and indirect impacts of reservoir operations on the productivity and survival of birds that utilize riparian habitat within the drawdown zone, (4) inform and evaluate the effectiveness of physical works and revegetation efforts to enhance nesting success and bird productivity, and (5) assess the implementation of the soft constraints and any incremental impacts resulting from the addition of unit 5 at Revelstoke Dam.

The objectives of this monitoring program are designed to address the uncertainties raised by the Consultative Committee. This information will provide an assessment of the impact that reservoir operations have on resident bird populations that utilize Kinbasket and Arrow Lakes Reservoirs and assess measures to mitigate these impacts through habitat enhancement via physical works and revegetation.

4.3.2 Status

This monitoring program was initiated in May 2008 and will continue until 2017. Progress reports will be provided annually and detailed reports will be provided in years 2012 and 2017. The next annual report is expected in March 2010. A sampling protocol was prepared in 2008 that describes the study design, sampling methods, and animal handling procedures in detail.
4.3.3 Interpretation of Data

The monitoring program was initiated in 2008 to study the effects of reservoir operations on resident birds utilizing the drawdown zone of Kinbasket and Arrow Lakes Reservoirs. Study areas were set up in Canoe Reach (Kinbasket Reservoir) and Revelstoke Reach (Arrow Lakes Reservoir). Fifteen permanent nest monitoring plots were established in each reservoir with reference plots established in habitats immediate adjacent the reservoir. Nest surveys, nest monitoring, mist netting and banding of birds, and monitoring of juvenile survival were conducted between late May and early August 2008. Three focal species were selected to assess reservoir operations on juvenile survival: Yellow Warbler, Willow Flycatcher, and Savannah Sparrow.

In Canoe Reach, 75 nests of 16 species were found. Five species (Savannah Sparrow, Spotted Sandpiper, Killdeer, Wilson’s Snipe, and Northern Harrier), all ground nesters, were found nesting exclusively in the drawdown zone and were absent from the reference sites. Eleven other species were detected in reference plots above the drawdown zone. No species were found to nest in both the drawdown zone and in reference plots above the drawdown zone. Savannah Sparrow was the most common nesting species detected, accounting for 31% of all nests found (23 nests).

In Canoe Reach, 49 of the 75 (65%) nests found fledged at least one young. Nest success for all species combined was similar in and above the drawdown zone. Predation was the major cause (81%) of nest failure. No nest failures were attributed to reservoir operations.

A total of 149 nests of 31 species were found in Revelstoke Reach. Of these, 132 nests from 27 species were found in the drawdown zone and 17 nests from nine species were found in the reference plots above the drawdown zone. Yellow Warbler accounted for 38% (50 of 132 nests) of all nests found within the drawdown zone and 34% of all nests. Of the 149 nests found, 57 successfully fledged at least one young. However, the fate of 25 nests could not be determined, which in many cases was due to access issues caused by rising water levels. The overall success rate of nests with known outcomes was 46%. Predation was attributed to the failure for 27 nests (22%). The failure of 18 nests (15%) of nine species was directly caused by reservoir operations. In Revelstoke Reach, most nests (71%) occurred at elevations of 438.0 m to 439.9 m, and few nests (29%) were found below 437 m.

The breeding bird communities in the Arrow Lakes Reservoir and Kinbasket Reservoir were remarkably different. Only 7 of 40 species were found to nest in both reservoirs. Differences were also observed between the communities found within drawdown zone and reference plots above the drawdown zone. In Canoe Reach, five species were found nesting in the drawdown zone, whereas 11 species were found to nest above the drawdown zone. In Revelstoke Reach, the results were the opposite with 27 species found nesting in the drawdown zone and only nine species above the drawdown zone in the reference plots.
The focal species approach to assess reservoir operations on juvenile survival was evaluated. In Revelstoke Reach, Yellow Warbler appears to be a suitable choice for willow shrub/cottonwood forest habitat but the other two focal species either did not nest in the drawdown zone (Savannah Sparrow) or did not occur in sufficient numbers to provide an adequate sample size (Willow Flycatcher). In Canoe Reach, the Savannah Sparrow appears to be a suitable focal species for grass meadow habitats but the other two species do not. Although Yellow Warblers were observed on private lands above the drawdown zone, drawdown zone habitats do not appear to provide suitable nesting habitat. The Willow Flycatcher does not occur in Canoe Reach and is replaced by its close relative the Alder Flycatcher. Consequently, no single species appears to be a suitable as a focal species for both reservoirs and it is recommended that other species such as the Spotted Sandpiper and Cedar Waxwing be evaluated as possible focal species in future years.

Additional recommendations from Year 1 of the study include:

- adding new nest plots at sites where vegetation enhancement or physical works are implemented in both reservoirs
- expand nest plots in Kinbasket Reservoir to include Bush Arm, add new reference nest plots in Arrow Lakes Reservoir or in nearby areas
- begin nest surveys in mid May in Arrow Lakes Reservoir and late May in Kinbasket Reservoir

4.4 CLBMON-37 Kinbasket and Arrow Lakes Reservoir: Amphibian and Reptile Life History and Habitat Use Assessment

4.4.1 Overview

During the Columbia River Water Use Planning process (WUP), the Consultative Committee expressed concerns related to the potential impacts of the reservoir operations on amphibians and reptiles. However, a lack of information with respect to the abundance, distribution, life history, and habitat use made it difficult to assess the impact of current operations and operating alternatives of the Arrow Lakes and Kinbasket Reservoirs on these species. The Consultative Committee therefore recommended a multi-year life history and habitat study to evaluate the operational impacts of the Arrow Lakes and Kinbasket Reservoirs, and to evaluate the effectiveness of physical works and revegetation on amphibians and reptiles.

The primary objectives of this study are to determine:

1) which species of reptiles and amphibians occur within the drawdown zone of Arrow Lakes and Kinbasket reservoirs,
2) which habitats reptiles and amphibians use in the drawdown zones of Arrow Lakes and Kinbasket reservoirs,
3) if reservoir operations influence or impact reptiles and amphibians utilizing the drawdown zone of Arrow Lakes and Kinbasket reservoirs, and
4) whether physical works or revegetation projects can mitigate impacts to reptiles and amphibians resulting from reservoir operations.
4.4.2 Status

This monitoring program was initiated in May 2008 and will continue annually for three years until 2010 and then every other year until 2018. Progress reports will be provided annually and detailed reports will be provided in years 2013 and 2018. The next annual report is expected in March 2010. A sampling protocol was prepared in 2008 that describes the study design, sampling methods, and animal handling procedures in detail.

4.4.3 Interpretation of Data

The first year of this study (2008) consisted of information gathering and reconnaissance surveys to determine the distribution of amphibians and reptiles in the Kinbasket and Arrow Lakes reservoirs. This information will form the basis of a multi-year monitoring program that will occur in Years 2 and 3, and then every other year other until 2018. Between 12 May and 24 September 2008, visual encounters surveys, nocturnal calling surveys, nocturnal road surveys, egg mass surveys and larval surveys were conducted in and adjacent to the drawdown zones of Kinbasket and Arrow Lakes reservoirs. Areas surveyed included Revelstoke Reach, Beaton Arm, Burton Creek, Edgewood, Deer Park, and Syringa Provincial Park in Arrow Lakes Reservoir; and Beavermouth, Bush Arm, Encampment Creek, and Canoe Reach in Kinbasket Reservoir.

Eight species were documented in Arrow Lakes Reservoir including Western Toads, Columbia Spotted Frogs, Pacific Treefrog, Long-toed Salamanders, Western Terrestrial Garter Snakes, Common Garter snakes, Painted Turtles, and Northern Alligator Lizards. Western Toads were the most commonly encountered amphibian in Arrow Lakes Reservoir, while Common Garter Snakes were the most commonly encountered reptile. In Kinbasket Reservoir, five species were documented including Western Toads, Columbia Spotted Frogs, Long-toed Salamanders, Western Terrestrial Garter Snakes, and Common Garter snakes. Columbia Spotted Frogs were the most commonly encountered amphibian and Common Garter Snakes were the most commonly encountered reptile. Breeding ponds utilized by Western Toads, Columbia Spotted Frogs, and Long-toed Salamanders were identified in the drawdown zone of both reservoirs.

Several areas in each reservoir were identified for the implementation of the long-term monitoring of amphibian and reptiles populations. These areas are recommended either because of their accessibility, or more importantly, because of the size of the amphibian and/or reptile communities. In some cases (e.g., Revelstoke Reach), many different species are using similar habitats in the drawdown zone, making it easy to monitor several species at once.

A habitat suitability index model was developed for Long-toed Salamanders in the Valemount Peatland of Canoe Reach to test the utility of this approach in mapping potential breeding habitats for this species in the drawdown zone. The output of this model suggests that this approach has merit and it will be refined in 2009.

In 2008, reservoir levels in Arrow Lakes Reservoir rose rapidly in late May, which was not ideal for monitoring. In future years, an earlier start to the field session is recommended. Other recommendations include:
1. Investigate the potential of using radio telemetry on Western Terrestrial, Common Garter Snakes, and Painted Turtles to identify seasonal patterns of habitat use.

2. Consider the effects of the proposed wildlife physical works in Arrow Lakes Reservoir on amphibian and reptile populations.

3. Collaborate with the principal investigators on other WLR projects to expand the number of people gathering data on amphibians and reptiles when working the drawdown zone of Kinbasket Reservoir.

4.5 CLBMON-39 Arrow Lakes Reservoir: Neotropical Migrant Use of the Drawdown Zone

4.5.1 Overview

The Columbia Basin is located along an important corridor for songbirds that migrate between breeding grounds in Alaska, the Yukon and British Columbia and wintering grounds in southern US, Mexico, and Central and South America. The broad valley bottom floodplain of Revelstoke Reach, located at the north end of Arrow Lakes Reservoir, provides important riparian stopover habitat for species of songbirds migrating through this flyway.

Since 1988, neotropical bird migration has been monitored during the fall migration period at the Columbia River Revelstoke Migration Monitoring Station on Machete Island, near Revelstoke, BC. The migration station has recorded over 60 species of neotropical migrants during fall migration (Jarvis 2001). Neotropical birds migrate through the station from mid July to the end of September, with migration peaking in mid August.

During the Columbia River Water Use Planning Process, the Consultative Committee recognized that data on the relative abundance, distribution, and seasonal patterns of habitat use were needed to assess the impact of Arrow Reservoir operations on neotropical migrants and provide information with respect to mitigation strategies. The Consultative Committee recommended that monitoring be conducted to determine how reservoir operations and the implementation of the soft constraints affect the abundance and diversity of neotropical migrants in Revelstoke Reach during fall migration by capitalizing on the established Migratory Bird Monitoring Station on Machete Island.

The objectives of this monitoring program are to:

1) determine the migration patterns of neotropical migrants in Revelstoke Reach,

2) assess whether reservoir operations affect migratory populations of neotropical migrants that use the area as a stopover site,
   a) Examine the effects of reservoir operation, as they relate to habitat availability and quality in Revelstoke Reach during fall migration.
   b) Identify species that have a higher likelihood of being affected by reservoir operations.
3) determine whether there are specific times during the migratory season when minor adjustments to flow rates or water levels will enhance the ability of the drawdown area to support migratory birds, and

4) provide information with respect to how wildlife physical works or revegetation can enhance riparian habitat for migratory songbirds.

4.5.2 Status

This monitoring program was initiated in May 2008 and will continue until 2017. Progress reports will be provided annually and detailed reports will be provided in years 2012 and 2017. The next annual report is expected in March 2010. A sampling protocol was prepared in 2008 to describe the study design, sampling methods, and animal handling procedures.

4.5.3 Interpretation of Data

In 2008, a 10-year monitoring program was initiated to (1) determine the effects of reservoir operations on the use of the drawdown zone by fall neotropical migrant birds, and (2) to assess the physiological effects of reservoir operations on neotropical migrants that use the drawdown zone. The study area was confined to Machete Island, a treed upland area of about 30 ha located between the north end of the Revelstoke Airport and the confluence of the Columbia and Illecillewaet Rivers.

Between July 17 and September 29, 2008, mist nets were used to capture birds along fixed netting lanes. The mist nets (up to 12) were opened 30 minutes before sunrise and remained open, weather permitting, for 6 hours each day and checked on 30 minute intervals to determine if any birds were captured. Four focal species were chosen for further processing of blood and feathers for the physiological component of the study: Common Yellowthroat (Geothlypis trichas), Yellow Warbler (Dendroica petechia), Orange-crowned Warbler (Vermivora celata), Wilson’s Warbler (Wilsonia pusilla). Two additional nets were opened occasionally and call playback was used for these species to obtain blood samples for corticosterone analysis. Captured birds were banded and measured. Feather samples were obtained from several regions of the body for feather isotope analysis and approximately 100 µl of blood was obtained from the four focal species for physiological analyses. Arrow Lakes Reservoir levels were high throughout the field season (mean M ASL = 438.7, std deviation = 0.516) and reduced the amount of terrestrial habitat available for use by migratory birds. The high water levels also affected the number of nets that could be deployed during the first 3 weeks of the study.

The cumulative net effort for all mist nets deployed was 3511.25 net hours. A total of 2611 birds (including recaptured animals) were captured at a capture rate of 0.74 birds/net hour. The number of new birds banded in 2008 was 1908. The number of recaptures (birds that had been banded in previously) accounted for 27% (n = 703) of the total captures and included 34 species. In contrast, the number of birds captured in 2008 was approximately 5% less than the long-term average and about 36% less than the all-time high in 2006. Since captures in 2008 were similar to the
long-term average and trapping effort was about 21% greater than average, it seems that 2008 was a “slow” year.

Six species accounted for 52.2% of all newly captured and banded birds: Common Yellowthroat (*Geothlypis trichas*) 22.4%, Yellow-rumped Warbler (*Dendroica coronata auduboni*) 8.0%, Swainson’s Thrush (*Catharus ustulatus*) 6.7%, Orange-crowned Warbler (*Vermivora celata*) 5.2%, Yellow Warbler (*Dendroica petechia*) 5.2%, and American Redstart (*Setophaga ruticilla*) 4.8%. Migration was heaviest between August 16 to September 15, with a strong peak migration occurring during September 1-7. Of the 994 captured birds that could be identified to sex, 298 (29.9%) were female and 696 (69.9%) were males. Three quarters of the birds (1431) captured in 2008 were hatched in 2008 (hatch year; HY) birds and the remaining 25% were at least 1 year old or older (after hatch year; AHY). Twenty-five captured birds of 10 species were reported to have minor injuries. These injuries included lumpy growths on legs (9), injured legs (n=6), bruised or dented skull (3), tail dropped while being handled (3), toe nail missing or deformed (3), broken mandible (1). Three captured birds died during the capture or handling processes and two birds were eaten by predators before they could be extracted from mist nets.

Feather isotopes analysis was used to determine whether the birds sampled were resident birds or migratory. Three hundred and nineteen birds were sampled for feather isotope analyses. Most individuals had feathers taken from three areas on the body resulting in 926 samples; but only 871 were analyzed since 55 samples were deemed unreliable. Isotope signatures from locally breeding Yellow Warblers provided a reference. The results suggest that Orange-crowned and most Yellow Warblers sampled were migrants. Isotope signatures for Wilson’s Warblers suggested that sampled birds were from more southerly latitudes. As this seems unlikely, samples of locally breeding Wilson’s Warblers will be required. Common Yellowthroats captured were a mixture of local birds and birds that originated from more northerly breeding areas. These data will be used to control for the origin of the birds (migrants versus residents) in the assessing the physiological health of the birds.

Indicators of physiological health were measured through analyses of blood metabolites (triglyceride, glycerol, and beta-hydroxybutyrate) and corticosterone (a stress hormone). Plasma metabolite assays provide a means to assess fattening rates of neotropical migrants while corticosterone provides an indication of physiological stress. A total of 336 blood samples to assess plasma metabolites were obtained from the four focal species. Estimated fattening rate (residual plasma triglyceride) varied among species with fattening rates being highest in Wilson’s Warbler and lowest in Yellow Warblers. These results will be compared to those in future years to assess the effect of reservoir operations on blood metabolites.

Corticosterone samples were too few to draw many conclusions but stress responses were found in some individuals, which indicated physiological stress in some individuals.

In 2008, lab analyses showed that techniques designed for this study appear to provide reliable results, however additional effort will be required to obtain corticosterone samples. The four focal species chosen for this study appear to be suitable because 1) they provide a good blend of relatively high abundances and
different population trends, and 2) have a relatively even spread between age classes (AHY/HY) and sex (male/female) ratios compared to other species available. Yellow Warbler’s were the exception with a skewed sex ratio with a greater proportion of males to females, nevertheless sufficient samples can be obtained.

Based on the results of year 1, all of the management questions and hypothesis can be answered with the current study design with the exception of documenting the use of habitats within the drawdown zone of Revelstoke Reach. Documenting habitat use across the use of habitats within the drawdown cannot be determined as only one site (Machete Island) is being monitored.

The consultant has recommended the following work be implemented in future years.

1) Hold a banding station workshop prior to start-up of operations to review banding station protocols, and field training sessions on set up of mist nets, bird extraction techniques from mist nets, handling of captured birds, aging sexing and morphometric data collection from banded birds, banding techniques, bleeding techniques, and feather extraction techniques.

2) Retain Yellow Warbler, Wilson’s Warbler, Orange-Crowned Warbler, and Common Yellowthroats as the four focal neotropical migrant birds for physiological and isotope studies.

3) Feathers from locally breeding Orange-crowned Warbler, Common Yellowthroat and Wilson’s Warbler are needed to establish feather isotope signatures for resident birds.

4) Increase the number of permanent habitat plots.

5) Increase the number of personnel to operate the banding station to conduct the daily census and operate a separate net for obtaining sufficient samples for corticosterone analysis.

6) Provide written roles and responsibilities and ensure the sampling protocols are strictly followed to ensure that samples are properly collected and in sufficient numbers and to clarify staff responsibilities.

7) Review the study design to determine how habitat use in the drawdown can be assessed.

The ToR will be reviewed in light of these recommendations to ensure that the study is addressing the management questions. This review is scheduled to occur in fall 2009.

4.6 CLBMON-40 Arrow Lakes Reservoir: Shorebird and Waterbird Monitoring Program

4.6.1 Overview

Waterbirds include all wetland bird families, including wildfowl (divers, grebes, cormorants, swans, geese, ducks, coots and rails); shorebirds; gulls, terns and herons; and water-dependent birds of prey. Revelstoke Reach (Revelstoke Dam to Shelter Bay) is a relatively flat floodplain located at the higher elevations of the Arrow Lakes Reservoir and attracts considerable use by waterbirds (Bonar 1979; Jarvis &
Woods 2001; Tremblay 1993). From 1991 to 2001, systematic waterbird surveys were conducted along a 12-km stretch of Revelstoke Reach to document seasonal use (Jarvis & Woods 2001). Sixty-five species of waterbirds were documented and both species diversity and abundance declined over the course of the study. In 1991 and 1992, over 20,000 individual waterbirds were observed from 58 species. By the late 1990s and 2000, the number of birds observed was approximately half (between 7,279 and 12,140) and the number of species had declined to 41 species.

During the Columbia River Water Use Planning Process, the Consultative Committee recognized waterbirds and migratory shorebirds as high management priorities in assessing the ecological impacts associated with the operations of the Arrow Lakes Reservoir. Specifically, concerns focused on the loss of available breeding and migratory habitat and the direct loss of nests due to flooding due to high water levels. Protecting and enhancing riparian areas, and maximizing the capacity of the Revelstoke Reach to provide habitat for both shorebirds and waterbirds emerged as key environmental objectives during the Columbia River Water Use Plan.

To monitor the impacts of reservoir operations on waterbirds and shorebirds, the Consultative Committee recommended that monitoring be conducted to 1) determine the abundance, distribution, and habitat use of waterbirds and migratory shorebirds and the productivity of waterbirds in Revelstoke Reach; 2) examine how variation in flow and reservoir water elevations influence seasonal and yearly abundance, distribution, and habitat use of waterbirds and migratory shorebirds and the productivity of waterbirds in Revelstoke Reach; 3) inform how physical works and revegetation can be designed to mitigate adverse impacts to waterbirds and shorebirds resulting from reservoir operations, and 4) assess the effectiveness of physical works and revegetation at enhancing habitat for waterbirds and shorebirds.

### 4.6.2 Status

This monitoring program was initiated in May 2008 and will continue until 2017. Progress reports will be provided annually, and detailed reports will be provided in years 2012 and 2017. The next annual report is expected in March 2010. A sampling protocol was prepared in 2008 to describe the study design, sampling methods, and animal handling procedures.

### 4.6.3 Interpretation of Data

The Arrow Lakes Reservoir Shorebird and Waterbird Monitoring Program is a 10-year program designed to determine the effects of reservoir operations on the abundance, distribution, habitat use, and behaviour of waterbirds and shorebirds. The study area is confined to Revelstoke Reach of Arrow Lakes Reservoir from Revelstoke south to Shelter Bay. Several survey methods were used to monitor waterbirds including fixed-wing aerial surveys for waterbirds, land-based observational surveys for shorebirds and waterbirds, boat-based surveys for shorebirds, waterbird brood counts, raptor nest surveys, and behavioural

---

1 Although shorebirds are commonly considered waterbirds, the CC considered waterbirds and shorebirds as two separate groups.
observations of shorebirds. Surveys were conducted between late May and end of October 2008.

Field studies began too late in 2008 to monitor the spring waterbird migration. One aerial survey was conducted in late May with limited results. Land-based observations provided substantial data on waterbirds from late May to end of December, although some survey stations were lost to rising waters in June. The results of 23 land-based surveys conducted between May and October yielded 8856 bird observations. Forty-six species (77% of all known waterbird and shorebird species for Revelstoke Reach) of waterbirds and shorebirds were detected including 22 species of waterfowl, 5 species of gulls and 4 species of shorebirds. The five most common species were Canada Goose (39.2%), American Wigeon (19.3%), American Coot (10.5%), Mallard (8.0%), and Ring-necked Duck (4.9%). Species abundances for waterbirds were similar to that reported in the late 1990s, but shorebird numbers were much lower.

Waterbirds were generally most abundant in the bay formed by the Revelstoke Airport airstrip and Machete Island (26.2% of all birds detected), and on the west side of the airstrip (20.1%). Montana Slough and Cartier Bay also held numerous waterbirds on occasion. Gulls were observed more often in the middle portion of the Reach. Water levels remained near full pool from late June through September which undoubtedly influenced the distribution of waterbirds in the Reach.

Surveys conducted between during November and December indicated changes in waterfowl distribution and species composition. Waterfowl became redistributed away from the Greenbelt Ponds and Airport Marsh area as these froze. Consequently, waterbirds became more abundant in Montana Slough are, which remained open. This is noteworthy as the sites used in the summer and fall are only partially-influenced by reservoir operations (they retain water when the reservoir levels are low and are only influenced when the reservoir reaches full pool) whereas the sites used by waterfowl later in late fall/early winter are highly influenced by reservoir operations.

During the late fall surveys, the number of species observed declined from 46 to 24 species and most species became less abundant as the season progressed. Common Goldeneye and Canada Goose, however, became more abundant after most of the other species had departed, indicating that the Revelstoke Reach may provide over-wintering habitat for diving waterfowl such as Common Goldeneye and surface feeders such as Canada Goose.

Shorebirds were scarce throughout the survey period and only 4 species were detected. Boat-based surveys for shorebirds yielded few observations as shorebirds did not frequent Revelstoke Reach in the summer of 2008 due to high reservoir water levels. Behavioural observations on four focal species (Greater Yellowlegs, Lesser Yellowlegs, Least Sandpiper, Long-billed Dowitcher) were not possible as those species were not detected. In future years, surveys for shorebirds and behavioural observations will not likely be successful if reservoir levels remain high throughout the summer and fall as in 2008.

Waterfowl brood surveys detected 38 broods from 8 species. The largest numbers of young detected were for broods of Canada Goose (131), American Wigeon (68), and
Mallard (42). Some duck broods were not fully grown by late August/early September suggesting late-nesting or renesting after reservoir levels peaked in early July. Several species known to breed in some years in Revelstoke Reach were not detected in 2008.

Fifteen raptor stick nests were located in Revelstoke Reach in 2008. Ten nests were found to be active (adults or nestlings present) and included 7 Osprey, 2 Bald Eagle and 1 Red-tailed Hawk nests. Both Bald Eagle nests were successful with one nest producing two fledglings and the other producing one fledgling. Of the seven active Osprey nests detected, successful reproduction was confirmed in only one nest. Five unoccupied nests were located in 2008 and were most likely occupied in the past by Osprey (3 nests) or Bald Eagle (2 nests). The numbers of active raptor nests detected were similar to a survey in the mid 1990s. No Short-eared Owls or Northern Harriers were detected in 2008; consequently, it is unlikely those species bred in Revelstoke Reach in 2008.

Overall, the study design and survey effort appears to be sufficient to address the management questions and hypothesis as data are collected over time. Recommendations to consider in future years include:

1. Begin surveys in April to capture data on shorebird and waterbird spring migration.
2. Conduct aerial surveys with a slow-flying fixed-wing aircraft or helicopter (preferred).
3. Further work on habitat stratification and polygon designation is required.
4. Discontinue boat-based surveys for shorebird monitoring.
5. Continue ground-based surveys throughout the winter to assess the effect of reservoir levels on winter waterbird use.
6. Further explore the benefits of employing both the Double Observer and Distance Sampling methods.
7. Results from 2008 suggest that few shorebirds utilize Revelstoke Reach during the fall migration period when water levels are high as observed in 2008. A review of the fall shorebird survey is required to ensure that the objectives of this component of the study can be met.
8. Conduct aerial surveys using a helicopter to determine the nesting success of Osprey and continue boat-based surveys to monitor eagle nests.

4.7 CLBMON-41 Arrow Lakes Reservoir: Recreational Demand Study

4.7.1 Overview

Recreational activities include boating, fishing and shoreline use (swimming, nature walks, etc.). Public discussions have repeatedly documented that these recreational uses of the Arrow Lakes Reservoir are strongly influenced by the reservoir water level (they may also be influenced by other factors). Other types of recreational activity were identified in the Arrow Drawdown Zone Management Plan that may or may not be directly linked to reservoir levels such as; hiking, cycling, ATV use, snowmobiles, cross country skiing, horseback riding, bird watching, wildlife viewing, and model airplane flying. However, little systematic information is available on how fluctuating reservoir water levels influence the recreation behaviour of key user
groups. Different recreation activities may have different levels of preferred or optimal water levels.

To this end, it would be desirable to develop a predictive model of recreational use of the Arrow Lakes Reservoir.

4.7.2 Status

The contract for this work was awarded to E. Lees and Associates Consulting Ltd in June 2009. Work will commence in July 2009 and is expected to be completed in 2013.

4.7.3 Interpretation of Data

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

5 Columbia River Project WUP Studies and Physical Works Costs

The following table summarizes the approved costs of the studies and physical works under the Arrow Lakes Reservoir Operations Management Plan of the Columbia River WUP, as well as the Actual Costs to 31 May 2009.
Table 5-1: Columbia River WUP Monitoring Program Costs

<table>
<thead>
<tr>
<th>Monitoring Programs</th>
<th>Activity</th>
<th>Costs approved by CWR</th>
<th>Total Forecast (Life to Date Actuals and Forecast)</th>
<th>Variance Total to Approved</th>
<th>Explanation</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLUMBIA RIVER ARROW OPERATIONS MANAGEMENT PLAN</td>
<td>CLBMON#31 ARROW BURBOT LIFE HISTORY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Costs approved by CWR</td>
<td>$1,064,812</td>
<td>$1,063,329</td>
<td>$74</td>
<td>Bright underspent in 2008 due to smaller than anticipated amount of data for reporting. May be required in 2009.</td>
<td>Track management costs to determine need for re-submission of TOR budget to CWR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct Management</td>
<td>$87,022</td>
<td>$86,307</td>
<td>$745</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Implementation</td>
<td>$203,513</td>
<td>$203,513</td>
<td>$0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Remissable Implementation</td>
<td>$114,277</td>
<td>$103,450</td>
<td>$10,827</td>
<td>Underspent in 2008. Funds may be required for additional surveys in 2009.</td>
<td>Track implementation costs to determine need for re-submission of TOR budget to CWR</td>
</tr>
<tr>
<td>COLUMBIA RIVER ARROW TRIBUTARY FISH MIGRATION</td>
<td>CLBMON#32 ARROW TRIBUTARY FISH MIGRATION</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Costs approved by CWR</td>
<td>$439,574</td>
<td>$422,802</td>
<td>$16,772</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct Management</td>
<td>$81,842</td>
<td>$67,704</td>
<td>$14,138</td>
<td>Slightly underspent. Forecast revised based on last year's implementation. May require more data in Bush Arm in 2010.</td>
<td>Track management costs to determine need for re-submission of TOR budget to CWR</td>
</tr>
<tr>
<td></td>
<td>Implementation</td>
<td>$357,732</td>
<td>$355,098</td>
<td>$2,634</td>
<td>5% contingency included in approved TOR budget for 2008 and 2009 unused.</td>
<td>Track implementation costs to determine need for re-submission of TOR budget to CWR</td>
</tr>
<tr>
<td>COLUMBIA RIVER ARROW NEST MORTALITY OF MIGRATING BIRDS</td>
<td>CLBMON#36 KIN AND ARROW NEST MORTALITY OF MIGRATING BIRDS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Costs approved by CWR</td>
<td>$4,256,071</td>
<td>$4,010,337</td>
<td>$245,734</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct Management</td>
<td>$204,722</td>
<td>$193,976</td>
<td>$10,746</td>
<td>Slightly underspent. Forecast revised based on last year's implementation. May require more time in Bush Arm in 2010.</td>
<td>Track management costs to determine need for re-submission of TOR budget to CWR</td>
</tr>
<tr>
<td></td>
<td>Implementation</td>
<td>$4,051,349</td>
<td>$3,816,361</td>
<td>$234,988</td>
<td>Contract value significantly less than TOR approved budget. Efficiencies found by awarding multiple contracts to same vendor. Remainder to be used to sample Bush Arm.</td>
<td>Track implementation costs to determine need for re-submission of TOR budget to CWR</td>
</tr>
<tr>
<td>COLUMBIA RIVER ARROW AMPHIBIAN AND REPTILE LIFE HISTORY</td>
<td>CLBMON#37 KIN AND ARROW AMPHIBIAN AND REPTILE LIFE HISTORY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Costs approved by CWR</td>
<td>$1,166,608</td>
<td>$1,135,836</td>
<td>$30,772</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct Management</td>
<td>$127,889</td>
<td>$124,318</td>
<td>$3,571</td>
<td>Slightly underspent. Forecast revised based on last year's implementation.</td>
<td>Track management costs to determine need for re-submission of TOR budget to CWR</td>
</tr>
<tr>
<td></td>
<td>Implementation</td>
<td>$1,038,719</td>
<td>$1,011,518</td>
<td>$27,201</td>
<td>Contract value significantly less than TOR approved budget because 5% contingency included in approved budget for 2008 - 2010 unused.</td>
<td>Track implementation costs to determine need for re-submission of TOR budget to CWR</td>
</tr>
<tr>
<td>COLUMBIA RIVER ARROW NEOTROPICAL MIGRANT USE OF ARROW WATERBIRD AND SHOREBIRD MONITORING</td>
<td>CLBMON#39 ARROW NEOTROPICAL MIGRANT USE OF ARROW WATERBIRD AND SHOREBIRD MONITORING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Costs approved by CWR</td>
<td>$2,150,992</td>
<td>$2,142,357</td>
<td>$8,635</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct Management</td>
<td>$189,932</td>
<td>$181,297</td>
<td>$8,635</td>
<td>Slightly underspent. Forecast revised based on last year's implementation.</td>
<td>Track management costs to determine need for re-submission of TOR budget to CWR</td>
</tr>
<tr>
<td></td>
<td>Implementation</td>
<td>$1,961,060</td>
<td>$1,961,060</td>
<td>$0</td>
<td>TOR needs to be revised to better address research questions. Review will occur in Fall 2009.</td>
<td>Track implementation costs to determine need for re-submission of TOR budget to CWR</td>
</tr>
<tr>
<td>COLUMBIA RIVER ARROW RECREATION DEMAND STUDY</td>
<td>CLBMON#40 ARROW RECREATION DEMAND STUDY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Costs approved by CWR</td>
<td>$2,890,326</td>
<td>$2,707,340</td>
<td>$182,986</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct Management</td>
<td>$189,388</td>
<td>$174,317</td>
<td>$15,071</td>
<td>Highly underspent. Forecast revised based on last year's implementation.</td>
<td>Track management costs to determine need for re-submission of TOR budget to CWR</td>
</tr>
<tr>
<td></td>
<td>Implementation</td>
<td>$2,700,938</td>
<td>$2,533,023</td>
<td>$167,915</td>
<td>Component of YR1 fieldwork was not completed due to water levels (Fall Storage agreement). VR1 used remaining funds to extend the surveys to full fry, the santee</td>
<td>Track implementation costs to determine need for re-submission of TOR budget to CWR</td>
</tr>
<tr>
<td>COLUMBIA RIVER ARROW RECREATION DEMAND STUDY</td>
<td>CLBMON#41 ARROW RECREATION DEMAND STUDY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Costs approved by CWR</td>
<td>$755,561</td>
<td>$721,485</td>
<td>$34,076</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct Management</td>
<td>$71,661</td>
<td>$68,779</td>
<td>$2,882</td>
<td>Highly underspent on contract development.</td>
<td>Track management costs to determine need for re-submission of TOR budget to CWR</td>
</tr>
<tr>
<td></td>
<td>Implementation</td>
<td>$683,900</td>
<td>$653,190</td>
<td>$30,710</td>
<td>Inc. contingency not included in 5-year contract value</td>
<td>Track implementation costs to determine need for re-submission of TOR budget to CWR</td>
</tr>
</tbody>
</table>

BC Hydro