

**Columbia River Project Water Use Plan**  
**Monitoring Program Terms of Reference**  
**KINBASKET RESERVOIR**  
**FISH AND WILDLIFE INFORMATION PLAN**

- **CLBMON-2 Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring**

**24 October 2007**

## **Terms of Reference for the Columbia River Project Water Use Plan Monitoring Programs Kinbasket Reservoir Fish and Wildlife Information Plan**

### **1.0 OVERVIEW**

This document presents Terms of Reference for monitoring programs under the Kinbasket Reservoir Fish and Wildlife Information Plan (Table 1). These programs will evaluate the potential effects of Mica Dam and Kinbasket Reservoir operations on fish habitat and fish populations, wildlife habitat and wildlife populations.

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

- 1) CLBMON-1 Mica Dam Total Gas Pressure Monitoring and Abatement Program: a 2-year study to determine dissolved gas supersaturation with synchronous condense operation of Units 3 and 4 in relation to Units 1 and 2, which have been previously monitored.
- 2) CLBMON-2 Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring: a 12-year program to monitor trends in the biological characteristics, distribution and abundance of kokanee populations in Kinbasket and Revelstoke reservoirs, and provide information required to link the effects of reservoir operation to population levels.
- 3) CLBMON-3 Kinbasket and Revelstoke Reservoirs Ecological Productivity Monitoring Program: a 12-year study to define the trophic web mechanisms and dynamics of Kinbasket and Revelstoke reservoirs, and determine if changes in pelagic productivity are associated with reservoir operations.
- 4) CLBMON-4 Kinbasket Reservoir Fish Stranding Assessment: a 3-year study to qualitatively evaluate the extent of fish stranding caused by the annual drawdown of Kinbasket Reservoir.
- 5) CLBMON-5 Kinbasket Reservoir Burbot Life History and Habitat Use Assessment: a 3-year study to obtain baseline data on the biological characteristics of burbot populations in Kinbasket Reservoir, and provide information to evaluate potential effects of reservoir operation on burbot population productivity
- 6) CLBMON-6 Kinbasket Reservoir Bull Trout Life History and Habitat Use Assessment: a 3-year study to obtain baseline data on the life history and habitat characteristics of juvenile bull trout in Kinbasket Reservoir, and provide preliminary information to determine if reservoir operations could have an effect on bull trout populations.
- 7) CLBMON-7 Kinbasket Reservoir Rainbow Trout Life History and Habitat Use Assessment: a 3-year study to obtain baseline data on the biological characteristics of rainbow trout in Kinbasket Reservoir, and provide the information required to evaluate the impacts of reservoir water levels on the productivity of rainbow trout populations.
- 8) CLBMON-8 Kinbasket Reservoir Monitoring of the Valemount Peatland: a 3-year monitoring program to address key uncertainties regarding the relative contribution and importance of the current reservoir operating regime to the erosion processes affecting the

wetland, obtain an inventory of plant and wildlife species, and determine whether the long-term viability of the wetland, and associated plant and animal species, are being affected by erosion processes related to reservoir operations, and how these effects may be mitigated.

**Table 1 Kinbasket Reservoir Fish and Wildlife Information 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-1 Mica Dam Total Gas Pressure Monitoring and Abatement Program	Schedule A: 5.a	Yes	No	24 October 2007	No
CLBMON-2 Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring	Schedule A: 5.b Schedule B: 1.a	Yes	No	24 October 2007	No
CLBMON-3 Kinbasket and Revelstoke Reservoirs Ecological Productivity Monitoring Program	Schedule A: 5.c Schedule B: 1.b	Yes	No	24 October 2007	No
CLBMON-4 Kinbasket Reservoir Fish Stranding Assessment	Schedule A: 5.d	Yes	No	24 October 2007	No
CLBMON-5 Kinbasket Reservoir Burbot Life History and Habitat Use Assessment	Schedule A: 5.e	Yes	No	24 October 2007	No
CLBMON-6 Kinbasket Reservoir Bull Trout Life History and Habitat Use Assessment	Schedule A: 5.f	Yes	No	24 October 2007	No
CLBMON-7 Kinbasket Reservoir Rainbow Trout Life History and Habitat Use Assessment	Schedule A: 5.g	Yes	No	24 October 2007	No
CLBMON-8 Kinbasket Reservoir Monitoring of the Valemount Peatland	Schedule A: 5.h	Yes	No	24 October 2007	No

## 2.0 MONITORING PROGRAM RATIONALE

Early on in the Columbia River Water Use planning (WUP) process, the WUP Consultative Committee (WUP CC) recognized that there was a great deal of uncertainty regarding whether the lack of constraints on operation of Kinbasket Reservoir was having a significant impact on fish and wildlife and associated habitat. A number of key hypothesized impacts were identified during the issue scoping phase (e.g., entrainment at Mica Dam, and interruption of natural sturgeon recruitment processes).

However, a general lack of data on the relative abundance, distribution, life history and seasonal patterns of habitat use and supporting ecosystem processes in the upper Columbia River and Kinbasket Reservoir, precluded incorporation of these concerns into Water Use Plan assessments.

The WUP CC explored alternative ways of operating Kinbasket Reservoir to provide benefits to fish and wildlife by imposing minimum elevation constraints. However, the ability to track the performance of the alternatives was limited to use of habitat-based measures (pelagic productivity), which were developed based on limited site-specific data and professional judgment. Initial modeling results showed that some improvements to pelagic productivity could be achieved through a minimum elevation constraint, but that this constraint would incur a high cost in foregone power generation. While the WUP CC agreed to stop exploring water management options for Kinbasket Reservoir for more cost-effective non-operational works, it was acknowledged that this decision was based on a number of uncertain assumptions about reservoir ecology and the influence of reservoir operations. The WUP CC underscored the need for better information to support future decision-making as a key outcome of the Columbia River Water Use planning process.

The operational link for many of the proposed monitoring studies, developed to address current data gaps, was considered tenuous given that there were no operational changes being considered for Kinbasket Reservoir. However, the WUP CC recognized that a large obstacle to recommending operational or physical works for the reservoir was the lack of quantitative data on fish and wildlife populations. Therefore, the proposed monitoring studies were accepted as meeting the Water Use Plan monitoring criteria, because they are the only tool available to validate the assumptions made by the WUP CC when deciding on operational changes.

Although no operating changes were considered for Revelstoke Reservoir, the WUP CC recommended that some of the fish-related studies in Kinbasket be linked to studies in Revelstoke to provide a comparison of trends to inform on operational impacts.

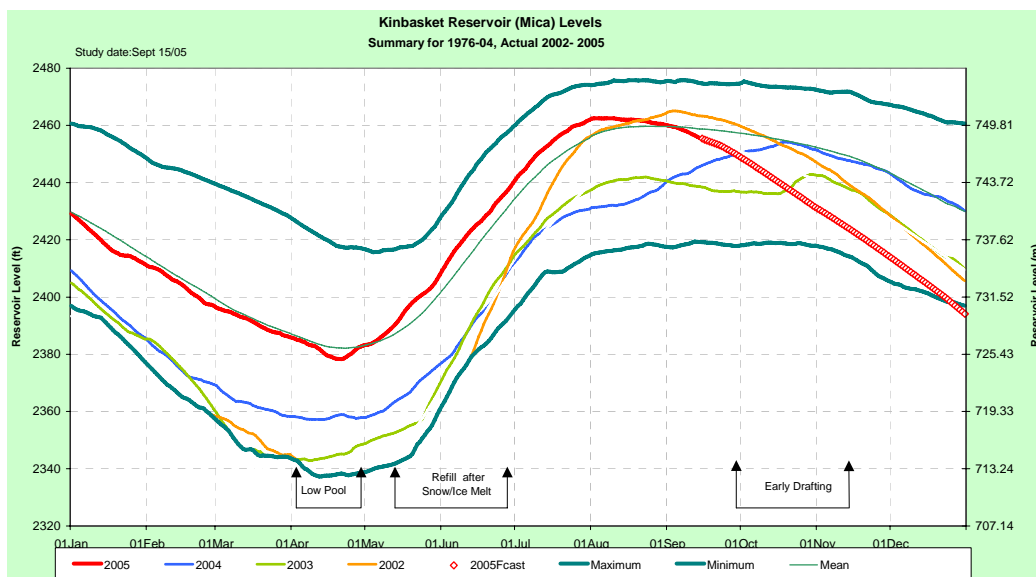


Figure 1 Seasonal pattern of water level drawdown and refill for Kinbasket Reservoir

## **Monitoring Study No. CLBMON-2 Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring**

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### **1.0 MONITORING PROGRAM RATIONALE**

#### **1.1 Background**

Under the terms of the water license for Kinbasket Reservoir, BC Hydro is obliged to provide compensation for fisheries losses caused by construction of Mica Dam by making funds available to undertake rehabilitation of fish habitat and stocks. After an initial stabilization period of nine years, a fish stocking program was initiated by the Government of British Columbia Fish and Wildlife Branch. It was recognized that annual water level fluctuations in the reservoir would severely limit littoral productivity, and it was thought that reservoir conditions would be most conducive to a pelagic species such as kokanee. Between 1982 and 1985, about 654,000 kokanee fry and 504,200 kokanee eggs were introduced into Upper Columbia streams (RL&L et al. 2001). These releases were successful in establishing a self-sustaining population of kokanee in Kinbasket Reservoir, which now also contributes kokanee to Revelstoke Reservoir. Annual surveys of kokanee spawning escapements have shown that the spawning population in Kinbasket Reservoir has become widely distributed in tributary streams throughout the upper Columbia Basin, and may still be expanding (Oliver 1995; Manson 2006; BC Hydro unpubl. data).

As part of the Fisheries Management Plan developed under the former Mica Fish and Wildlife Compensation Program, a stock assessment program was initiated in 1991 to determine the status of introduced kokanee in Kinbasket Reservoir. The objectives of this study were to establish baseline information on the distribution, abundance, growth and age structure of pelagic fish populations, and to establish a program to monitor kokanee populations in Kinbasket and Revelstoke reservoirs. Hydroacoustic surveys and supporting trawl and gill net studies were conducted over the following three-year period (1991-93) (Sebastian et al. 1995). Since 2001, additional hydroacoustic and trawl surveys have been undertaken annually by the Ministry of Environment as part of BC Hydro's Large River Index Program to monitor long-term trends in the abundance and distribution of kokanee in the two reservoirs (Sebastian 2004, 2005, 2006).

During the Columbia River Water Use Plan (WUP), the Consultative Committee (CC) acknowledged the importance of developing time series datasets on the abundance, life history and habitat use of fish populations in Kinbasket Reservoir to assess how reservoir operating parameters (minimum or maximum annual elevation) impact reservoir productivity and fish populations. Significant data gaps in understanding of the fundamental characteristics of the reservoir fish community limited the WUP CC's ability to develop appropriate fish population performance measures. These data gaps made it necessary to rely on habitat-based measures and qualitative judgments to assess how well the proposed alternatives met the overall ecosystem objectives of the system and to support critical trade-off decisions for the reservoir.

Given that kokanee are a key ecosystem driver in Kinbasket Reservoir that also support an important local sport fishery, the WUP CC supported continuation of assessments in

Kinbasket and Revelstoke reservoirs. Information gained through this monitoring program will help to determine factors that are most important in the regulation of these pelagic fish populations, and will allow better predictive capability when exploring potential operational changes during future reviews of the Columbia River Water Use Plan.

## 1.2 Management Questions

Key management uncertainties encountered during development of the Columbia River Water Use Plan related to how current operation of Kinbasket Reservoir impacts the productivity of pelagic fish populations, and how changes in operation would affect population levels in Kinbasket and Revelstoke reservoirs. Concerns focused on kokanee, as this species is the key driver of the ecosystem, providing an important food source for other sportfish species (e.g., bull trout) and a source of nutrients to the ecosystem. The most important issues to be addressed for kokanee populations in Kinbasket Reservoir were identified as: potential effects of annual water level fluctuations on the physical dynamics of the reservoir (thermal stratification, water circulation patterns and water retention time); resulting impacts on pelagic habitat and productivity. The fundamental management questions to be addressed through the monitoring program are:

- 1) What are the trends in annual distribution, abundance and biological characteristics of kokanee populations in Kinbasket and Revelstoke reservoirs?
- 2) What role does reservoir operation play in the productivity of kokanee populations?
- 3) What are the key habitat factors that contribute to changes in productivity of the Kinbasket Reservoir kokanee population?
- 4) Can modifications be made to operation of Kinbasket Reservoir to protect or enhance kokanee populations in Kinbasket or Revelstoke reservoirs?

The intention of this monitoring study is to collect annual time series data as a foundation for further correlation analysis. Results of this monitoring program will be integrated with the Kinbasket and Revelstoke Ecological Productivity Monitoring program (refer to CLBMON-3) to enable inferences regarding the role of current operating conditions in pelagic productivity and productivity of reservoir kokanee populations.

## 1.3 Management Hypothesis

The primary hypothesis (and sub-hypotheses) associated with these management questions are associated with direct operational impacts of Kinbasket Reservoir on kokanee populations:

- H<sub>1</sub>: The productivity of kokanee populations is limited by habitat impacts directly related to operation of Kinbasket Reservoir.
- H<sub>1A</sub>: Operation of the reservoir reduces kokanee population abundance in Kinbasket Reservoir due to entrainment from the reservoir.
  - H<sub>1B</sub>: Operation of the reservoir reduces pelagic productivity, which affects abundance and growth of kokanee.

H<sub>2</sub>: Abundance, distribution, and growth of kokanee in Revelstoke Reservoir are limited by impacts directly related to operation of Kinbasket Reservoir (through entrainment).

Results from CLBMON-3 (Kinbasket and Revelstoke Reservoirs Ecological Productivity Monitoring program) will provide additional data to inform the above hypotheses.

## 1.4 Key Water Use Decision Affected

During development of the Columbia River WUP, efforts were made to explore alternative ways of operating Kinbasket Reservoir by imposing minimum elevation constraints that would effectively support fish, as well as navigation and recreation interests. Given the lack of data for reservoir fish populations, performance of the proposed operational changes was measured by predicted changes in pelagic productivity based on limited reservoir data. While some improvements to pelagic productivity were predicted under the proposed operating constraints, the response of fish populations to incremental changes in pelagic productivity was uncertain. The WUP CC decided that these benefits did not justify the high costs in foregone power generation, and consequently agreed not to alter operation of the reservoir. This trade-off decision was based on uncertain assumptions regarding the effects of reservoir operations on pelagic productivity and fish populations.

Implementation of the proposed monitoring program will provide information required to support more informed decision-making with respect to the need to balance storage in Kinbasket Reservoir with impacts on fish populations. Specifically, it will provide information required to support future decisions around maintaining the current operating regime or modifying operations to protect reservoir fish populations.

## 2.0 MONITORING PROGRAM PROPOSAL

### 2.1 Objectives and Scope

The overall objectives of the monitoring program are to: 1) monitor trends in the biological characteristics, distribution and abundance of kokanee populations in Kinbasket and Revelstoke Reservoirs; and 2) provide information required to link the effects of reservoir operation to population levels. The program will provide an improved understanding of the effects of reservoir operation on kokanee populations, and the implications of entrainment on kokanee populations, which will assist in future decisions regarding the operation of Kinbasket Reservoir.

The scope of the monitoring program will be to study kokanee populations in Kinbasket and Revelstoke reservoirs through completion of annual hydroacoustic and midwater trawl surveys. Time series data (12 years) will be collected to monitor the status of the reservoir kokanee populations, to verify and compare population trends in abundance, and to interpret causes of inter-annual variation (e.g., variation in year class strength due to entrainment or environmental effects). In concert with similar surveys being conducted in Arrow Lakes Reservoir, the time series data will serve as a useful indicator of productivity in Kinbasket and Revelstoke Reservoirs, and will contribute to an assessment of long-term trends for the Columbia River system.

## **2.2 Approach**

The general approach of the monitoring program will be to collect a long-term dataset on kokanee populations in Kinbasket and Revelstoke Reservoirs to resolve current gaps on how reservoir operations affect abundance, distribution and age structure over time. This task will be accomplished by:

- a) Collecting time series information on the abundance, distribution and biological characteristics of kokanee populations. Pelagic productivity data will be collected under CLBMON-3;
- b) Correlating the abundance of younger ages (recruitment) of kokanee with reservoir operating parameters and environmental conditions;
- c) Defining recruitment changes associated with operating impacts or environmental conditions based on age composition and trend data;
- d) Examining trends in growth and distribution changes with reservoir operations.

These data will be reviewed in conjunction with data obtained through the Kinbasket and Revelstoke Ecological Productivity Monitoring program (CLBMON-3) and other large lake/reservoir programs (e.g. from Arrow and Kootenay systems) to improve our understanding of how pelagic productivity influences trends in kokanee growth and abundance.

## **2.3 Tasks**

### **2.3.1 Task 1: Project Coordination**

Project coordination will involve the general administrative and technical oversight of the program. This will include, but not be limited to 1) budget management, 2) study team management, 3) logistic coordination, 4) technical oversight for field and analysis components, and 5) facilitation of data transfer among related investigations.

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 Sampling**

Hydroacoustic and trawl surveys will be conducted annually in Kinbasket and Revelstoke reservoirs to monitor trends in the distribution, abundance, and biological characteristics of kokanee in Kinbasket and Revelstoke Reservoirs. Survey design and methods will closely follow existing protocols established in previous surveys (Sebastian in press, Manson 2005).

### **2.3.3 Task 3: Habitat Monitoring / Field Surveys**

To facilitate interpretation observed trends in kokanee abundance, supplemental habitat information will be collected during the hydroacoustic surveys, including: water temperature; conductivity; dissolved oxygen concentrations; and Secchi disc profiles. Reservoir water level at the time of the survey will be recorded to allow determination of surface and limnetic habitat area for extrapolating kokanee abundance.

### **2.3.4 Task 4: Data Analysis**

#### *Physical Habitat*

Sampling locations will be determined by GPS and plotted on a location map. Reservoir water surface elevation will be used to adjust surface area and limnetic habitat areas for the habitat zones surveyed in Kinbasket and Revelstoke reservoirs.

#### *Fish Abundance Estimates*

Several statistics will be computed to show abundance trends over time for each reservoir/year combination, including kokanee density by transect and depth stratum and population size by zone.

#### *Fish Size Distribution*

The acoustic size distribution, along with target strength distribution and fish lengths from trawl samples, will be used to proportion fish into two size classes representing age 0 and age 1-3 fish, as described by Sebastian (2004, 2005).

#### *Evaluation of Operating Impacts*

Analyses will be conducted on a life stage basis to determine if there is a statistical correlation between operating parameters of the reservoir (i.e., minimum elevation, maximum elevation, annual drawdown) and the abundance or growth of kokanee populations in Kinbasket Reservoir. The strength of inferences will depend of the amount of contrast in operations over the duration of the monitoring program.

Data collected under the Kinbasket and Revelstoke Ecological Productivity Monitoring program (CLBMON-3) will also be reviewed as part of this monitoring program to assist in interpreting trends in kokanee population abundance in relation to changes in pelagic productivity.

### **2.3.5 Task 5: Reporting**

A brief technical report of the findings of the program will be prepared annually, which will include results of between-year trend analyses that determine whether abundance, age, growth rates and distribution of kokanee are changing over time with reservoir operations.

Results will be reviewed annually in conjunction with other relevant data, and an interim synthesis report will be prepared in Years 4 and 8 of the study. Upon completion of the monitoring program (Year 12), a comprehensive final synthesis report will be prepared for use in the next review of the Columbia River Water Use Plan, 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; and
- e) a detailed summary of the findings as they relate to the ecological hypotheses and the key management questions.

Because this program will be implemented in a phased approach in conjunction with the Kinbasket/Revelstoke Reservoir Ecological Productivity Monitoring Program (CLBMON-3), interim and final report preparation for these two studies will be synchronized in Years 4, 8 and 12.

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 proposed monitoring program will provide valuable information to address three specific categories of uncertainty as it relates to operational impacts of Kinbasket Reservoir on kokanee populations.

- 1) The monitoring program will provide a comprehensive long term data set to quantitatively establish the basic biological characteristics (abundance, distribution and growth rates) of kokanee populations in Kinbasket and Revelstoke Reservoirs.
- 2) Data collected during the monitoring program will allow quantitative inferences in the trends in kokanee abundance to be made in relation to reservoir operations, and will help determine the impact of the current operating regime of Kinbasket Reservoir on kokanee production. Supplemental data on habitat conditions, in conjunction with results of the Kinbasket and Revelstoke Ecological Productivity Monitoring program (CLBMON-3), will be analyzed to support inferences about the relationship between operations and observed trends. Time series data available for nearby systems (Arrow, Kootenay, Okanagan) will be used to assist in interpreting observed trends in kokanee abundance.
- 3) Analyses will be conducted to determine whether there is a statistical correlation between operations of the reservoir and the abundance or growth of kokanee populations. Qualitative inferences will then be drawn on the relative importance of pelagic productivity in limiting population abundance.

## **2.5 Schedule**

It is proposed that this program be conducted annually over 12 years of the Columbia River Water Use Plan implementation (2008-2019). Note that conditions on these reservoirs, particularly Kinbasket, can be dangerous and unpredictable and that sampling may be altered, interrupted or curtailed in any given year.

## **2.6 Budget**

The total annual budget for the Kinbasket and Revelstoke Reservoir Kokanee Population Monitoring Program is estimated at \$66,110 (in 2004 dollars). The estimated budget breakdown by task is provided below in the Table CLBMON-2-1. This cost estimate is higher than the one developed by the WUP CC (\$50,000 in 2004 dollars), because the budget was based on a breakdown for previous years' work, which was undertaken by the Ministry of Environment (MoE). The current budget is based on expected costs

associated with awarding/implementing the program through a competitive bid process, and also includes costs for travel.

## 2.2 REFERENCES

Manson, H. 2006. Kinbasket Reservoir & Upper Columbia River Kokanee Spawner Index – 2005. Columbia Basin Fish and Wildlife Compensation Program.

RL&L Environmental Services Ltd. 2001. Water Use Plans - Environmental information review and data gap analysis. Volume 1: Upper Columbia - Mica and Revelstoke Projects. Prepared for BC Hydro, Burnaby, B.C. by RL&L Environmental Services in association with Robertson Environmental Services Ltd., Pandion Ecological Research Ltd., Bruce Haggerstone Landscape Architect, Pomeroy & Neil Consulting Ltd. and DVH Consulting. 498 pp.

Sebastian, D. 2006. In press. Kinbasket and Revelstoke Reservoirs acoustic and trawl surveys: Summary report (2001-2005). Ministry of Environment.

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## PERSONAL COMMUNICATION

Dale Sebastian. Aquatic Ecosystem Science Section, Biodiversity Branch, Ministry of Environment. November 2005.