Columbia River Project Water Use Plan

Monitoring Program Terms of Reference

KINBASKET RESERVOIR FISH AND WILDLIFE INFORMATION PLAN

- **CLBMON-3 Kinbasket and Revelstoke Reservoirs Ecological Productivity Monitoring Program**

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.

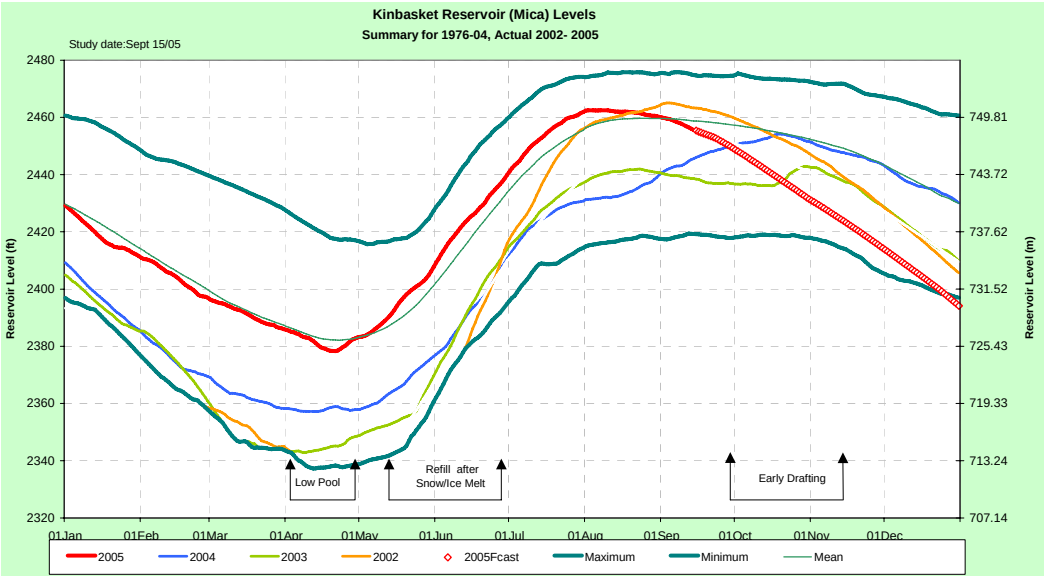

Figure 1 Seasonal pattern of water level drawdown and refill for Kinbasket Reservoir

Monitoring Study No. CLBMON-3
Kinbasket and Revelstoke Reservoirs
Ecological Productivity Monitoring Program

1.0 MONITORING PROGRAM RATIONALE

1.1 Background

During the Columbia River Water Use Plan (WUP) process (BC Hydro 2005a and b), the WUP Consultative Committee (WUP CC) found it difficult to make informed decisions regarding operational changes for Kinbasket and Revelstoke reservoirs because of the lack of data describing basic ecological processes. The WUP CC acknowledged the importance of understanding reservoir limnology and the influence of current operations on ecosystem processes for planning future water management activities. For this reason, the WUP CC recommended a monitoring program to provide long-term data on reservoir limnology and the productivity of aquatic communities, which could also be used as parameters for any experimentation and modeling of operational effects on trophic production and, ultimately, fish populations.

Introductions of kokanee eggs and fry into Kinbasket Reservoir between 1982 and 1985 were successful in establishing a self-sustaining population. Given that kokanee are the main forage fish in Kinbasket and Revelstoke reservoirs, the future value of fish populations is strongly linked to biological production in the pelagic zone of these reservoirs. This is particularly true in Revelstoke Reservoir, where substantial recruitment of kokanee by entrainment through Mica Dam, coupled with natural kokanee recruitment from spawning in tributary streams, may be producing a population that is not sustainable if food production is not sufficient to support the increased planktivory. While kokanee populations have been monitored periodically since the 1990s and annually since at least 2001 using hydroacoustic surveys and escapement counts, only four years (1976 and 2003-2005) of limnological investigations have been conducted in the reservoir (B.C. Research 1976; BC Hydro unpubl. data). Primary productivity has been measured only twice in Kinbasket Reservoir at a single station, once in 1976 (B.C. Research 1977) and again in 2002 (Stockner and Korman, 2002). Pelagic productivity in Revelstoke Reservoir has received slightly more attention, mostly in the years following impoundment (1980s), but also recently in 2003 (BC Hydro unpubl. data). Together, these data provide the basis for a longer term sampling program to investigate trends in pelagic productivity of Kinbasket and Revelstoke reservoirs and any links with reservoir operations.

The purpose of this monitoring program is to improve our understanding of the ecological productivity of Kinbasket and Revelstoke reservoirs by obtaining a long-term dataset to describe trophic web mechanisms and dynamics. This information is needed to examine the sustainability of fish populations under the current operating regimes, as well as to allow better predictive capability in exploring potential operational changes during future reviews of the Columbia River Water Use Plan.

1.2 Management Questions

At present, there are uncertainties around the influence of potential changes in operation of Kinbasket and Revelstoke reservoirs on pelagic productivity. To address these uncertainties, this monitoring program will focus on:

- Reservoir trophic web mechanisms and dynamics;
- Obtaining measurements of aquatic productivity that can be used as parameters for system modeling;
- Determining key indicators of change in pelagic production that would ultimately affect food availability and, thus, growth of kokanee.

The primary management questions to be addressed by the monitoring program are:

1) What are the long-terms trends in nutrient availability and how are lower trophic levels affected by these trends?
2) What are the interactions between nutrient availability, productivity at lower trophic levels and reservoir operations?
3) Is pelagic productivity, as measured by primary production, changing significantly over the course of the monitoring period?
4) If changes in pelagic productivity are detected, are the changes affecting kokanee populations?
5) Is there a link between reservoir operation and pelagic productivity? What are the best predictive tools for forecasting reservoir productivity?
6) How do pelagic productivity trends in Kinbasket and Revelstoke reservoirs compare with similar large reservoir/lake systems (e.g., Arrow Lakes Reservoir, Kootenay Lake, Okanagan Lake, Williston Reservoir)?
7) Are there operational changes that could be implemented to improve pelagic productivity in Kinbasket Reservoir?

1.3 Management Hypotheses

The primary hypotheses (and sub-hypotheses) associated with these management questions are:

H_1: There is no change in pelagic productivity in Kinbasket and Revelstoke reservoirs over the course of the monitoring period.

H_{1A}: Nutrient availability is not affected by reservoir operations.

H_{1B}: Pelagic productivity is not affected by reservoir operations.

H_2: Long-term trends in pelagic productivity have no effect on kokanee populations in Kinbasket Reservoir.

1.4 Key Water Use Decision Affected

Implementation of the proposed monitoring program will provide information to support decisions around the need to balance storage in Kinbasket Reservoir with impacts on fish populations. Specifically, the program will provide information required to support future decisions around maintaining the current operating regime or modifying

operations through adjusting minimum or maximum elevations to sustain reservoir fish populations.

2.0 MONITORING PROGRAM PROPOSAL

2.1 Objective and Scope

The objective of the monitoring program is to define the trophic web mechanisms and dynamics of Kinbasket and Revelstoke reservoirs, and to determine if changes in pelagic productivity are associated with reservoir operations. The program will be implemented annually over the12-year period of the Columbia River Water Use Plan.

2.2 Approach

The monitoring program will be implemented in a phased approach in conjunction with the Kinbasket/Revelstoke Reservoir Kokanee Population Monitoring program (CLBMON-2). Sampling will be planned on a 4-year cycle, thereby taking advantage of information gained in each sampling period to define the data needs for future years. Sampling protocols and analyses will be compatible with previous sampling programs, as well as with the Arrow Lakes Reservoir and Kootenay Lake Fertilization projects, to provide a long-term, large-scale data set on the Columbia River reservoir system.

Due to the limitations imposed by budget and logistical constraints of sampling such a large reservoir, a phased sampling plan will likely need to be developed. As with the fertilization projects, it is anticipated that an annual meeting will be required to review results, to refine methodologies, and to finalize the upcoming year's work plan to take advantage of annual learnings. This will facilitate planning and allow for a sampling program more responsive to unanticipated results or logistical challenges.

Since there has been some initial work on determining phytoplankton and zooplankton composition, it is anticipated that the first phase of the sampling program will concentrate on developing a nutrient budget for the reservoir and determining index stations for reservoir monitoring. Several years may be required to collect the appropriate data that will produce a model suitable for predicting nutrient inputs. For example, at least one dry, normal and wet year should be represented in order to provide suitable parameters. The first phase will also be used to determine index monitoring stations on the reservoir and/or tributaries for subsequent phases. The following phases are expected to focus on the dynamics of higher trophic levels (plankton) and refining the reservoir productivity model.

2.3 Tasks

2.3.1 Task 1: Project Management

Project management will involve the general administrative and technical oversight of the project. This task will be completed by a senior scientist and will include, but not be limited to: 1) budget management; 2) study team management;3) logistic coordination; 4) technical oversight of field and analysis components; and 5) 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: Sampling Program

The first task will be to develop a detailed sampling program for the first phase of the study, including selection of reservoir and tributary sampling stations, sample collection methods, parameters for measurement, scheduling and logistics, data management, and quality control practices.

Some preliminary limnological data were collected on Kinbasket Reservoir by the Province of BC in 1977 (BC Research 1977), and in each year of 2003 – 2005 (BC Hydro, unpublished data). Most of the sampling was conducted at four stations accessed from the Mica Dam: Canoe Reach Station, Wood Arm Station, Columbia Reach Station, and Mica Forebay Station. Chemical and biological sampling was conducted on Revelstoke Reservoir in 2003 (BC Hydro, unpublished data) from three stations located at: the Revelstoke Dam Forebay, Powerline Crossing upstream of Downie Arm, and at Pitt Creek.

Because selection of the Kinbasket stations was limited by accessibility, proximity to one main access point and by budget constraints, the stations do not encompass the length of the reservoir. For example, no sampling has occurred in the Bush Pool area, the former Kinbasket Lake, or the reservoir/Columbia River interface. It is expected, therefore, that the first task will be to determine a sampling program to more fully represent the entire reservoir. It is expected that an annual meeting of the technical design team will be required to refine the annual work plan and methodologies.

2.3.3 Task 3: Field Sampling

Phase 1 - Nutrient Budget and Primary Productivity

Phosphorus is selected for the budget because it is the main nutrient that can limit primary production in British Columbia reservoirs (Perrin et al. In Press, Stockner et al. 2005). The phosphorus budget will be calculated for each of the phosphorus size fractions. Those fractions can be approximated by analysis for total phosphorus (TP) and total dissolved phosphorus (TDP). Particulate phosphorus (PP) can be determined by the difference between TP and TDP. The relative importance of sources of phosphorus loading to the reservoirs will be quantified using standard chemical budgeting procedures.

Water sampling from the reservoir stations will be required as early in May as possible (beginning of spring), as well as in June (end of spring and beginning of summer), September (end of summer and beginning of fall), December (end of fall and beginning of winter), and March of the following year (end of winter and beginning of spring). Selection of tributaries to sample will be based on an assessment of their relative contribution to the reservoir and seasonal accessibility as sampling should occur once a

month. Sampling for the nutrient budget will be carried out over at least three years and should include a representative dry, normal, and wet year.

Reservoir primary productivity analyses will be conducted using standard C^{14} methods. Availability of accredited personnel and C^{14} to carry out the sampling may be a significant issue, as very few people hold the appropriate licenses. Reservoir stations should be sampled once each year for primary productivity.

Phase 2/3 – Reservoir Productivity

Once initial results are analysed, regular collection of chemical and biological (e.g., phytoplankton and zooplankton) measurements may be undertaken at index stations to support meaningful time series analysis, in which variability in measurements is not confounded by changes in sampling location.

Reservoir stations would be sampled on a monthly basis over the period of April through October, using a sampling design that is consistent with previous years of sampling, and which includes additional sampling for nutrients and electrochemical parameters to allow for nutrient budget calculations.

Measurements required to assess trophic status will include TP and TN concentration, chlorophyll-a concentration, and Secchi depths. Measurement of other forms of nitrogen and phosphorus, and water column profiles of electrochemical parameters (pH, TDS, dissolved oxygen, turbidity, temperature) will be also be collected to assist in assessing trophic state, to interpret reservoir function, and to provide indices of fish production.

2.3.4 Task 4: Data Analysis

All data obtained through the monitoring program will be compiled and interpreted to provide a current understanding of the limnological attributes of Kinbasket and Revelstoke reservoirs. Information collected during the first year of study will be appended to that collected in earlier years by BC Hydro to construct a master data file that will expand as subsequent years of data are collected. Descriptions of present status may include, but may not be limited to:

- Reservoir morphometrics including surface area, volume, mean depth, flushing rate and retention time over an annual cycle;
- Evidence of trophic state, including chemical and biological criteria, and a comparison of rates of primary production to other lakes and reservoirs;
- Sources and relative importance of nutrient loading;
- A description of the phytoplankton community that mainly drives primary production;
- An outline of the kokanee food web in each reservoir; and
- A description of zooplankton density, biomass and composition that may contribute to the kokanee food web.

The first year of data analysis should include a compilation of data ready for calculation of the annual nutrient budget. Calculations for portions of the year (i.e., seasons) should be run to ensure that the approach and methods of calculation are appropriate, and to

provide preliminary insight into changes (if any) in the relative importance of the various sources of phosphorus by season.

A model will be developed to examine factors that are most important in determining primary production in Kinbasket and Revelstoke reservoirs. The model will be developed by the project team using a multiple regression analysis or alternative approach (e.g., correspondence analysis), wherein the dependent variable is a size-fractionated measurement of primary production. Dependent variables will include, but not be limited to: bio-available forms of N and P concentrations; photosynthetically active irradiance; turbidity; water depth; TDS; temperature; and concentration of other electrochemical parameters. Observations from all reservoir stations and time of measurement will contribute to this analysis. The influence of glacial turbidity on reservoir productivity should be included in the analysis.

2.3.5 Task 5: Reporting

On completion of each year of study, a brief technical report will be prepared to summarize the field and analytical methods, to compile results of field measurements, and to summarize data analysis and interpretation.

A detailed technical report, which synthesizes data from the previous four years, will be prepared at the conclusion of Years 4 and 8 of the study to assist in setting direction and scope for subsequent years of study. A final report will be completed in Year 12, 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 hypotheses and the key management questions.

Because this program will be implemented in a phased approach in conjunction with the Kinbasket/Revelstoke Reservoir Kokanee Population Monitoring Program (CLBMON-2), 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

Results of the monitoring program will address critical uncertainties related to the current trophic status of Kinbasket and Revelstoke reservoirs and how existing operational regimes of the reservoirs influence aquatic production, and, ultimately, fish populations. Specifically, results will allow for:

- Defining the trophic status of Kinbasket and Revelstoke reservoirs relative to other lakes and reservoirs;

- Quantifying the rate of primary productivity in each reservoir and determining which organisms drive that productivity;
- Showing the relative importance of different sources of nutrients that support that biological production in the reservoirs;
- Identifying the relative importance of different food organisms and sources of production of that food for kokanee (the sentinel fish species in both reservoirs); and
- Providing insight into factors other than nutrients that determine biological production in the reservoirs.

2.5 Schedule

The aquatic productivity monitoring program is scheduled to be completed over a 12-year period (2008-2019) in three phases. The final year will be devoted to a comprehensive synthesis report.

Because conditions on these reservoirs, particularly Kinbasket, are unpredictable, the sampling program may be altered, interrupted, or curtailed in any given year. Components of the sampling program will be scheduled as necessary to provide the safest and most efficient delivery.

2.6 Budget

The estimated annual cost for undertaking the Kinbasket and Revelstoke reservoirs ecological productivity monitoring project is $416,196 (in 2004 dollars). A budget breakdown by project task and year is provided in Table CLBMON-3-2.

3.0 REFERENCES

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

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