Columbia River Project Water Use Plan

Monitoring Program Terms of Reference

KINBASKET AND ARROW LAKES RESERVOIR REVEGETATION MANAGEMENT PLAN

- **CLBMON-10 Kinbasket Reservoir Inventory of Vegetation Resources**

3 April 2007

KINBASKET AND ARROW LAKES RESERVOIR REVEGETATION MANAGEMENT PLAN TERMS OF REFERENCE

1.0 OVERVIEW

This document presents Terms of Reference for the physical works and effectiveness monitoring programs for the Kinbasket and Arrow Lakes Reservoir Revegetation Management Plan (Table 1). These programs will implement revegetation physical works, monitor representative planting sites under various revegetation treatments, map vegetation distribution by elevation, identify riparian wildlife habitat and monitor wildlife utilization patterns in response to revegetation efforts in Kinbasket and Arrow Lakes reservoirs, and the mid Columbia River.

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

1) CLBWORKS-1 Kinbasket Reservoir Revegetation Program: a 5-year reservoir-wide planting program to enhance sustainable vegetation growth within the drawdown zone of Kinbasket Reservoir to benefit fish, wildlife, aesthetics, dust control and recreation.

2) CLBWORKS-2 Mid Columbia River and Arrow Lakes Reservoir Revegetation Program: a 5-year reservoir-wide planting program to enhance sustainable vegetation growth within the drawdown zone of the mid Columbia River and the Arrow Lakes Reservoir to benefit fish, wildlife, aesthetics, dust control and recreation.

3) CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts: a 10-year program to evaluate plant survival and monitor representative planting sites under the various revegetation treatments in Kinbasket Reservoir.

4) CLBMON-10 Kinbasket Reservoir Inventory of Vegetation Resources: a 10-year program to assess and map vegetation distribution by elevation and identify riparian wildlife habitat within Kinbasket Reservoir.

5) CLBMON-11 Kinbasket and Arrow Lakes Reservoirs Effectiveness Monitoring of Revegetation and Wildlife Physical Works: a 12-year program to monitor wildlife utilization patterns in response to revegetation efforts in Kinbasket Reservoir, the mid Columbia River and Arrow Lakes Reservoir.

6) CLBMON-12 Mid Columbia River and Arrow Lakes Reservoir Monitoring of Revegetation Efforts: a 10-year program to evaluate plant survival and monitor representative planting sites under the various revegetation treatments in the mid Columbia River and Arrow Lakes Reservoir.

7) CLBMON-13 Monitoring of Mosquito Populations in the Revelstoke Area: a 2-year program to monitor the distribution and abundance of larval and adult mosquitoes in relation to physical environmental variables (elevation, temperature) and biotic variables (habitat) in the Revelstoke area.

8) CLBMON-33 Arrow Lakes Reservoir Inventory of Vegetation Resources: a 10-year program to assess and map vegetation distribution by elevation and identify riparian wildlife habitat in relation to inundation cycles and revegetation efforts in the mid Columbia River and Arrow Lakes Reservoir.

9) CLBMON-34 Arrow Lakes Reservoir Vegetation Composition and Analysis: a 10-year program to monitor vegetation distribution and composition by elevation in relation to inundation cycles to establish plant status in the mid Columbia River and Arrow Lakes Reservoir.

10) CLBMON-35 Arrow Lakes Reservoir Plant Response to Inundation: a 5-year program to evaluate responses of plants of different ages, seedlings to mature plants, and species to inundation cycles in the mid Columbia River and Arrow Lakes Reservoir.

Table 1 Kinbasket and Arrow Lakes Reservoir Revegetation Management Plan Physical Works and Monitoring Program Terms of Reference Submission Information

Name of Monitoring Program or Physical Works	Order Clause Fulfilled	Submitted with this Package	Previously Submitted To CWR	Submission Date	Leave to Commence
CLBWORKS-1 Kinbasket Reservoir Revegetation Program	Schedule A: 1.a	No	No		No
CLBWORKS-2 Mid Columbia River and Arrow Lakes Reservoir Revegetation Program	Schedule C: 1.a Schedule D: 1.a	No	No		No
CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts	Schedule A: 2.a	No	No		No
CLBMON-10 Kinbasket Reservoir Inventory of Vegetation Resources	Schedule A: 2.b	Yes	No	April 2007	No
CLBMON-11 Kinbasket and Arrow Lakes Reservoirs Effectiveness Monitoring of Revegetation and Wildlife Physical Works	Schedule A: 4.c Schedule C: 5.a Schedule D: 2.a	No	No		No
CLBMON-12 Mid Columbia River and Arrow Lakes Reservoir Monitoring of Revegetation Efforts	Schedule C: 2.a Schedule D: 2.b	No	No		No
CLBMON-13 Monitoring of Mosquito Populations in the Revelstoke Area	Schedule C: 5.b	No	No		No
CLBMON-33 Arrow Lakes Reservoir Inventory of Vegetation Resources	Schedule C: 2.b Schedule D: 2.c	Yes	No	April 2007	No
CLBMON-34 Arrow Lakes Reservoir Vegetation Composition and Analysis	Schedule C: 2.b Schedule D: 2.c	No	No		No
CLBMON-35 Arrow Lakes Reservoir Plant Response to Inundation	Schedule C: 2.c Schedule D: 2.d	No	No		No

2.0 PROGRAM RATIONALE

The Columbia River Water Use Plan Consultative Committee (WUP CC) recognized the value of riparian vegetation surrounding Kinbasket and Arrow Lakes reservoirs for enhancing littoral productivity, providing physical, structural and biological character for wildlife habitat, protecting cultural heritage sites, and providing aesthetic benefits (e.g., reduction of dust storms) within the drawdown zone. As a result, the protection and enhancement of high quality riparian vegetation emerged as a key environmental objective for Columbia River Water Use Plan, and operational, as well as non-operational alternatives to maximize vegetation diversity and wildlife habitat were a fundamental consideration throughout the water use planning process.

The WUP CC supported reservoir-wide revegetation programs for Kinbasket and Arrow Lakes reservoirs in lieu of maintaining lower elevations during the growing season than those provided under current operations, to maximize vegetation growth in the drawdown zones. The revegetation approach consists of multi-year programs with intervention over five years to facilitate long-term vegetative cover in those areas that have good potential to become self-sustaining. Key environmental and social objectives of the revegetation program are to maximize vegetation growth in the drawdown zone and provide benefits to littoral productivity, wildlife habitat, shoreline erosion and archaeological site protection.

Monitoring programs and physical works Terms of Reference presented herein collectively form the Kinbasket and Arrow Lakes Reservoir Revegetation Management Plan (RMP).

2.1 Kinbasket Reservoir Revegetation Program

During the WUP process, the regulation of reservoir filling and changes to minimum annual elevations were explored by the WUP CC as a means of achieving a number of environmental and social benefits for Kinbasket Reservoir; however, modeling of these alternatives revealed that these incremental changes in operations would incur very high costs in foregone power generation. In addition, preliminary work on developing revegetation strategies for the drawdown zones of Kinbasket Reservoir (Carr and Moody, 2003) indicated that the greatest limiting factor to vegetation establishment was not the operation of the reservoir, but lack of initial vegetation establishment, which could be addressed through targeted planting. The WUP CC therefore agreed to reject further analysis of operating alternatives for the purpose of enhancing vegetation potential, and recommended instead a revegetation program for Kinbasket Reservoir, aimed at maximizing vegetation growth in the drawdown zone to meet the environmental and social objectives stated above. The program will be implemented through the revegetation physical works CLBWORKS-1 (Kinbasket Reservoir Program Physical Works).

In association with the revegetation program, the WUP CC recommended effectiveness monitoring to ensure that the Kinbasket Reservoir revegetation efforts are providing the intended environmental and social benefits over the long term. The monitoring program includes the following Terms of Reference:

- Kinbasket Reservoir Monitoring of Revegetation Efforts (CLBMON-9)
- Kinbasket Reservoir Inventory of Vegetation Resources (CLBMON-10)

2.2 Mid Columbia River and Arrow Lakes Reservoir Revegetation Program

Riparian vegetation in Arrow Lakes Reservoir, and in particular Revelstoke Reach, presently extends over an elevation range of about 10 m (430 m to 440 m). Expansion of vegetation into the lower elevations has been largely the result of a fall rye seeding program that began in the early 1990s, which has facilitated the spread of natural vegetation (sedge and grass). A series of low water years during the 1990-1999 period also allowed the establishment of natural vegetation by providing seedlings sufficient growing time to develop into mature plants that are capable of tolerating subsequent extended inundation. These factors have worked in concert over the past decade to allow the establishment and persistence of extensive areas of natural vegetation, which now dominate the drawdown zone of Revelstoke Reach and smaller areas in the main body of Arrow Lakes Reservoir (Moody 2003).

Recognizing the importance of this vegetation, the WUP CC explored several operating alternatives, designed to maintain existing vegetation in Revelstoke Reach and Arrow Lakes Reservoir, by imposing lower reservoir elevations for longer periods during the early part of the growing season (late spring and early summer). Modeling of these alternatives showed that stricter elevation constraints would provide varying levels of protection to vegetation, but could incur very high costs in lost power generation in some years. There was also concern around the high level of uncertainty in many of the assumptions used to develop elevation constraints, particularly around the relative importance of timing, duration and depth of inundation on the distribution, biomass and diversity of vegetation.

To address these concerns, the WUP CC recommended a multi-year revegetation program in areas between elevations 434 m and 440 m that have a good potential to become self-sustaining after five years of treatment as a more cost-effective means of maximizing vegetation growth in the drawdown zone of Revelstoke Reach and Arrow Lakes Reservoir. The goal of the program is to provide benefits to littoral productivity, large river habitat, wildlife habitat, shoreline erosion and archaeological site protection. The program will be implemented through the CLBWORKS-2 (Mid Columbia and Arrow Lakes Reservoir Revegetation Program Physical Works). The WUP CC agreed that annual monitoring of the revegetation program would be critical to evaluate the effectiveness of planting efforts, and confirm the effectiveness of techniques for vegetation and wildlife habitat enhancement. The monitoring program includes the following Terms of Reference:

- Arrow Lakes Reservoir Monitoring of Revegetation Efforts (CLBMON-12)
- Arrow Lakes Reservoir Inventory of Vegetation Resources (CLBMON-33)
- Arrow Lakes Reservoir Vegetation Composition and Analysis (CLBMON-34)
- Arrow Lakes Reservoir Plant Response to Inundation (CLBMON-35)

2.3 Additional Monitoring Programs

Two additional programs are included in the Kinbasket and Arrow Lakes Reservoir Revegetation Management Plan (RMP), specifically:

- Kinbasket and Arrow Lakes Reservoirs Effectiveness Monitoring of Revegetation and Wildlife Physical Works (CLBMON-11)
- Monitoring of Mosquito Populations in the Revelstoke Area (CLBMON-13)

CLBMON-11 will provide qualitative data on mammal use of the Kinbasket and Arrow reservoir drawdown zones, with the goal of assessing the benefits of revegetation efforts and physical works to wildlife.

The goal of CLBMON-13 is to gain a better understanding of the species, life history and habitat requirements of mosquito species occupying habitats in the Revelstoke area, to determine the effect that dam discharge and reservoir management have on mosquito levels in the area. Because water pockets that form in revegetated areas and in other vegetated spots when reservoir levels recede may provide additional mosquito breeding habitat, this program will also examine potential effects of revegetation efforts in the drawdown zone on mosquito production (species and abundance).

3.0 References

Carr, W.W. and A.I. Moody. 2003. Mica - Revelstoke - Keenleyside Water Use Plan: Potential areas for vegetation establishment in the Kinbasket Reservoir. Report prepared for BC Hydro.

Moody, A.I. 2003. Mica-Revelstoke-Keenleyside Water Use Plan: potential areas for vegetation establishment in the Arrow Lakes Reservoir. Prepared for BC Hydro.

Monitoring Study No. CLBMON-10
Kinbasket Reservoir Inventory of Vegetation Resources

1.0 MONITORING PROGRAM RATIONALE

1.1 Background

During the Columbia River Water Use (WUP) planning process, the WUP Consultative Committee (WUP CC) recognized the value of vegetation in improving aesthetic quality, controlling dust, protecting cultural heritage sites from erosion and human access, and enhancing littoral productivity and wildlife habitat. The WUP CC further recognized that the most significant opportunity for accomplishing these objectives lay in enhancing riparian and wetland vegetation, as well as the riparian/wetland interface, as these are the only areas that can be substantially affected by changes in BC Hydro operations.

In lieu of operational changes, the WUP CC supported a reservoir-wide revegetation program for Kinbasket Reservoir compatible with the current operating regime to maximize vegetation growth in the drawdown zone. The program was proposed as a multi-year project requiring intervention over five years to facilitate long-term vegetation cover. As part of the WUP process, a study was undertaken to identify areas with the highest potential for successful vegetation establishment (Moody and Carr 2003). While most of the shorelines of Kinbasket Reservoir appeared to be unsuitable for vegetation development due to coarse substrates and steep slopes, 68 sites were found to support existing vegetation with greatest abundance in Bush Arm (1169 ha) and Canoe Reach (698 ha). An additional 1802 ha of shoreline were identified as having either high or moderate potential for enhancement.

In accepting the current operating regime of Kinbasket Reservoir, the WUP CC made several assumptions regarding vegetation tolerances to inundation and responses to changes in the hydrologic pattern, based on information gained from studies in the Arrow Lakes Reservoir (Moody 2002a, b). Specifically, it was assumed that a change in hydrology (relative to historic) should dictate trends in vegetation by affecting the amount of land that is vegetated (area) at lower elevations within the drawdown zone, or by affecting the amount of plant growth produced per unit area (biomass) and the number of species in the area (diversity) at upper elevations within the drawdown zone. Given differences in the elevation, climate and operating regime of the two reservoirs, the WUP CC recognized the inherent uncertainties of any assumptions related to the response of vegetation to reservoir operating conditions, and acknowledged the importance of long-term data collection for assessing the effects of the operating regime on vegetation at different spatial scales.

The vegetation inventory and monitoring program, as outlined in these terms of reference, is therefore intended to address key uncertainties related to the relative contribution and importance of the current reservoir operating regime (i.e. timing, duration and depth of inundation, and multi-year stresses) on the maintenance of existing vegetation communities[1] delineated at the landscape scale. The primary

[1] Vegetation communities will be defined based on a common set of attributes that can be inferred from remotely-sensed data

objective of this study will be to provide information on how vegetation communities at the landscape scale respond to long-term variations in water levels, and whether changes to the reservoir's operating regime may be required to maintain or enhance existing shoreline vegetation and the ecosystems it supports.

1.2 Management Questions

The primary management questions to be addressed by the Kinbasket Reservoir Vegetation Inventory program are:

- What are the existing riparian and wetland vegetation communities in the Kinbasket Reservoir drawdown zone between elevations 754m to 741m (approximate[2])?
- What are the spatial extents, structure and composition (i.e., relative distribution and diversity) of these communities within the drawdown zone between elevations 754m to 741m (approximate[2])?
- How do spatial extent, structure and composition of vegetation communities relate to reservoir elevation and topo-edaphic site conditions (aspect, slope, soil moisture, etc.)?
- Does the current operating regime of Kinbasket Reservoir maintain the spatial extent, structure and composition of existing vegetation communities in the drawdown zone?
- Are there operational changes that can be implemented to maintain existing vegetation communities at the landscape scale more effectively?

If results of the monitoring indicate that the operating regime does not adequately maintain the vegetation communities and their associated fauna at the landscape level, future decisions regarding reservoir operations may be affected, because of the high value placed on vegetated shorelines by many interest groups. The information gained through the inventory is also intended to assist in determining the scope of the KIN Revegetation Program Physical Works (CLBWORKS-1) by informing on whether existing vegetated areas can be enhanced and expanded under the present operating regime.

1.3 Management Hypotheses

The primary hypothesis (and sub-hypotheses) to be tested by this monitoring program is whether the current reservoir operating strategy maintains existing vegetation communities at the landscape scale within the drawdown zone of Kinbasket Reservoir.

The management hypothesis and the sub-hypotheses that will be tested directly with the proposed monitoring program are:

H_0: Under the current operating regime, there is no significant change in existing vegetation communities at the landscape scale in the drawdown zone of Kinbasket Reservoir over the monitoring period.

[2] Locations suitable for successful establishment and development of vegetation communities are tied to the average reservoir level and currently occupy a zone in the upper elevations of the reservoir, above 741 m.

H_{0A}: There is no significant change in the spatial extent (number of hectares) of vegetation communities within the existing vegetated zones of Kinbasket Reservoir.

H_{0B}: There is no significant change in the structure and composition (e.g. distribution and diversity) of vegetation communities within the existing vegetated zones of Kinbasket Reservoir.

1.4 Key Water Use Decision

The key operating decision affected by this monitoring program is the current operating regime for Kinbasket Reservoir. The decision of the WUP CC to support the current regime was based on the assumption that existing vegetation conditions could be maintained over the long term. Inferences from this study will provide an assessment of the effectiveness of the current operating regime to maintain the existing riparian and wetland vegetation communities and associated ecosystems at the landscape scale. Furthermore, by improving the understanding of how vegetation responds to long-term variations in water levels, the program will provide information to support future decision-making around maintaining the current operating regime or modifying operations through adjusting minimum or maximum elevations to maintain and enhance vegetation communities in the drawdown zone of Kinbasket Reservoir.

2.0 MONITORING PROGRAM PROPOSAL

2.1 Objective and Scope

The objective of Kinbasket Reservoir Vegetation Inventory is to document and quantify the landscape-level response of existing riparian and wetland vegetation communities within the drawdown zone to the current operating regime of the reservoir. Specifically, the study will:

- Identify and spatially delineate existing riparian and wetland vegetation communities within the drawdown zone;
- Measure the spatial extent, structure and composition (i.e. distribution and diversity) of the communities in the drawdown zone at repeated time intervals over a 10 year period;
- Assess whether there are changes in the spatial extent, structure and composition of the communities in the drawdown zone over the monitoring period;
- Assess whether observed changes in the spatial extent, structure and composition are attributable to the current operating regime of the reservoir; and,
- Provide information on the effectiveness of the current operating regime at maintaining the existing spatial extent, structure and composition of the communities in the drawdown zone at the landscape level.

This study is part of a larger program designed to assess vegetation response to the reservoir operating regime at multiple scales (landscape, site and species), and as such, the inventory should be designed to coordinate with the objectives of CLBMON-9 Kinbasket Monitoring of Revegetation Efforts, which investigates response of vegetation at the site (local) scale.

2.2 Approach

The vegetation mapping component of the program will involve the use of high-resolution aerial photography in conjunction with the digital elevation model (DEM) for Kinbasket Reservoir to assess the effects of the reservoir operating regime on existing vegetation communities by elevation band. The DEM and vegetation mapping will also be required for the planning and implementation of several other management plans and monitoring programs being undertaken as part of the Columbia River Water Use Plan.

Proposals should demonstrate how the study design will identify: 1) reservoir-wide mapping of changes in vegetation community patterns over time using aerial photography; and 2) analysis of effects of reservoir operations on the observed changes. Specific elements of the study will include:

- Completion of the digital elevation model (DEM) for Kinbasket Reservoir to allow assessment of vegetation structure and composition by elevation band.
- Aerial mapping of baseline conditions in Year 1, followed by repeat mapping in Years 2, 4, 6 and 8, with a final assessment at Year 10 to document changes in the spatial extent, structure and composition of existing vegetation communities.
- Ground sampling to provide quantitative measures of vegetative and other characteristics to support the vegetation mapping component through estimation of vegetation polygon characteristics
- Geographic Information System (GIS) and water level analysis to draw inferences regarding the overall effect of the operational regime on vegetation conditions.

A crucial component of the program will be the definition of attributes by which to measure spatial and temporal changes among vegetation communities. It is expected that any proposed study design will establish a defined set of attributes, which is measured at each time period, and which can be objectively quantified and reproduced. The vegetation mapping program will be incorporated into a GIS that is compatible with BC Hydro's current system. Analysis of the GIS data, in conjunction with analysis of reservoir water levels through use of the DEM, will enable inferences regarding the overall effect of reservoir operations on existing vegetation communities.

As part of the vegetation mapping component, the first year of the inventory will involve the mapping of pocket riparian habitat around the reservoir to identify sites with potential for wildlife habitat enhancement through vegetation management. This information will be utilized in the related monitoring program CLBMON-11 (Kinbasket and Arrow Lakes Reservoir Effectiveness Monitoring of Revegetation and Wildlife Physical Works) to evaluate the response of mammals using the drawdown zone of Kinbasket Reservoir to changes in riparian habitat caused by seasonal water level variations and to the implementation of the revegetation program. Field verification (ground sampling) of vegetation polygons will also focus on these pocket riparian habitats.

2.3 Tasks

2.3.1 Task 1: Project Planning and 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 in field and analysis components, and 5) facilitation of data transfer among other investigations associated with the Kinbasket and Arrow Lakes Reservoir Revegetation Management Plan, and the Kinbasket Reservoir Information Plan.

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: Study Design

The proposed study design must allow for a quantitative assessment of the changes in spatial extent, structure and composition in the existing patterns of riparian and wetland vegetation in Kinbasket Reservoir associated with the current operating regime. Variability in reservoir levels will lead to different responses in different plant associations and elevational strata. The statistical design must therefore be sensitive enough to detect differential responses related to hydrologic variability and the seasonal operating regime.

Inferences based on the analysis of vegetation classification and mapping will be influenced by other confounding factors unrelated to operations (e.g., climatic conditions). The effect of such potential co-variates will need to be explicitly addressed in the study design, to ensure that any confounding variables are appropriately identified and accounted for. Therefore, the study design will describe environmental variables to be measured, and demonstrate how the proposed statistical approach will account for co-variation attributed to environmental variables in the analysis. Analysis methods selected should be able to differentiate any relationship between operations and the observed trends from confounding factors.

2.3.3 Task 3: Digital Elevation Model (DEM)

The DEM for Kinbasket Reservoir presently includes flat, low-lying areas in the north end of Canoe Reach, Wood Arm, Sullivan Arm, Bush Arm and the lower end of Columbia Reach. The remaining area of the reservoir not covered by the DEM includes a relatively flat floodplain at the lower end of Canoe Reach and the mid section of the reservoir. Because the DEM currently covers only 60% of the reservoir, the first year of the program will require processing of the digital imagery for the remaining 49 photo sheets, which will involve compiling the DEM and digital planimetric features suitable for producing 1:5,000 scale mapping.

The various data types will be differentiated by level, style, weight and colour. The digital mapping file will include all toponomy. In addition to the primary mapping areas, all main streams/creeks flowing into the reservoir and all roads shall be captured within 500 m of the maximum pond of the reservoir or to the edge of the stereo-model, whichever is lesser.

The DEM shall be comprised of mass points, break lines, structure lines and spot heights, as required to describe the surface. The break and structure line data shall have pen codes to identify the beginning of each data string (i.e., the first record in each line will have a pen code of “1” in the feature code field). Break lines and structure lines must not cross. The mass points shall be collected in a ‘grid-like’ pattern with spacing not to exceed fifteen (15) metres at ground scale.

2.3.4 Task 4: Aerial Photography

Aerial photography will be acquired annually for the first two years of the program, and subsequently at two-year intervals until Year 10, to document any changes in the extent, distribution and diversity of vegetation communities over time under the current operating regime, and provide information on potential wildlife habitats. Aerial photography will be conducted at low water levels during the growing season. The optimal time is during late May to early June when the plants are well advanced, but before reservoir refill causes the vegetation to become inundated. To effectively determine the best timing for aerial photography on an annual basis, consideration will be given to water level data (as provided by BC Hydro) and field observations of site conditions.

Photography will be required at 1:5,000 normal colour scale; however, methods for change detection through analysis of multi-spectral imagery (e.g. near infrared) may also be considered. Consequently, incremental costs for acquisition of multi-spectral imagery in tandem with panchromatic photography should be provided. Aerial photography will include the northern end of Canoe Reach, specifically the Valemont Peatland, which will be assessed for operations-related erosion impacts under CLBMON-8 Kinbasket Reservoir Monitoring of the Valemount Peatland. Because this inventory program will be closely tied to monitoring of revegetation success, aerial photography coverage will also include areas where planting and fertilization efforts are being implemented through the revegetation program physical works (refer to CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts and CLBWORKS-1 Kinbasket Reservoir Revegetation Program Physical Works).

Aerial photography will be carried out according to BC Specifications for Aerial Photography[3]. It is recognized that acquisition of aerial images is an evolving technology, and that improvements in resolution and cost effectiveness may occur over the course of the 10-year program. However, to quantify vegetation change over time in response to the operating regime, it is essential that the methods and resolution remain consistent for the duration of the program. Furthermore, to address subjectivity in photo-interpretation, the study design will describe how this source of variability will be addressed over the 10-year time horizon to ensure that it will be possible to differentiate between-period variation associated with interpretation, and actual changes in vegetation. A standardized method for identifying polygons, based on specific criteria for classification/delineation of different communities, is recommended. Specifically, classification of vegetation communities should be based on a common set of attributes that can be reliably interpreted from the photos, and that are quantifiable, objective and reproducible. It is important that these attributes are directly related to the variables of interest (i.e., those that are likely to be changing). Therefore, any methodology proposed needs to identify the attributes that will be interpreted from the air photos, and demonstrate that (a) these attributes can be reliably estimated, (b) they are appropriate for delineating these types of vegetation communities, and (c) they are related to attributes of the community that are expected to change.

[3] Available at http://ilmbwww.gov.bc.ca/bmgs/airphoto/specs/AIR%20PHOTO%20SPECS-2005.pdf

2.3.5 Task 5: Vegetation Classification, Mapping and Analysis

The objective of this task is to assess the effects of the current operating regime on the spatial limits, structure and composition of existing riparian and wetland vegetation communities within the drawdown zone of Kinbasket Reservoir. Low level (1:5,000 scale) spatially geo-referenced colour air photos will be used to develop maps of vegetation in the drawdown zone that will be integrated with the DEM in a GIS platform that is compatible with current BC Hydro GIS standards. Any spatial data that is collected will conform to BC Hydro's GIS Data Capture Standards (Version 1.4).

Although a wetland classification system exists for BC, this system is based on field assessments of natural wetlands and their associated environmental factors (MacKenzie and Moran 2004). The wetlands formed in reservoirs are controlled by atypical hydrodynamics and, therefore, do not fit within the constraints of the established wetland classification systems. However, existing protocols for vegetation mapping in BC (e.g., Terrestrial Ecosystem Mapping - TEM and Vegetation Resources Inventory -VRI) do offer the full level of detail required for the assessment of vegetation changes proposed by this monitoring program. Any additional approaches for classifications of wetlands that may be developed should be to a standard that can be considered for inclusion in future versions of Wetlands in BC (MacKenzie and Moran 2004).

A starting point for photo interpretation and ground sampling procedures may be found in RISC standards for Vegetation Resources Inventory[4], but alternate approaches for obtaining and interpreting aerial photography (e.g. Sandmann and Lertzman 2003) may also be considered. It should be noted that the additional detail, which can be obtained from the high-resolution aerial photographs, must be reflected in a level of mapping beyond the HF and HG (Herb-forb and Herb-graminoid) classifications used in the RISC inventory standard. To the greatest extent possible, the mapping should distinguish changes in community structure and composition (distribution and diversity). Particular attention should be paid to changes in the distribution and viability of shrub coverage. The mapping should focus on identifying changes in the extent (spatial limits) of vegetation communities between years. To minimize variability and error in these estimates, methods to maintain consistency in the photo interpretation from year to year will need to be established.

2.3.6 Task 6: Ground Sampling of Aerial Photography

To verify vegetation polygon characteristics, ground sampling of vegetation communities should be carried out according to current RISC VRI standards. The relationship between the polygon estimates and ground samples will be used to adjust photo-interpreted polygon estimates. Field work will include collection of any data that may affect attributes of vegetation communities at the landscape level, including gradients in topography, previous disturbances, aspect, slope, elevation, substrate, and soil moisture regime, according to Meidinger (1998). Specific attention should also be paid to First Nations cultural plant species that are found in the project

[4] http://ilmbwww.gov.bc.ca/risc/pubs/teveg/

area by noting information on species, location and abundance. Any spatial data that is collected will conform to BC Hydro's GIS Data Capture Standards (Version 1.4).

In the event that rare plants (e.g. federally or provincially listed species) are found during the ground sampling, this data will be provided to the Conservation Data Center (CDC) by the contractor, using appropriate forms. Similarly, noxious weed species, if encountered, should be identified and weed sites should be entered into the Ministry of Forests and Range Invasive Alien Plant Program Application. These sites should also be explicitly identified during the mapping process to determine if spread of these species is occurring over time.

The first year of the inventory program will also include identification and mapping of pocket riparian habitat around Kinbasket Reservoir. In conjunction with a wildlife biologist, the mapped sites will be prioritized, and then photographed and inventoried during the ground sampling to confirm their value as wildlife habitat. Use of a helicopter will be required to access remote sites and to provide for aerial views of vegetated areas and sensitive wildlife habitats.

2.3.7 Task 7: Data Analysis

The proposal shall clearly outline how the study design and associated analytical approach will quantify the observed changes in spatial extent, structure and composition of vegetation communities at the landscape level and determine the relationships between documented attributes and the reservoir operating regime (i.e. inundation frequencies, duration and depth).

Because these data will be collected as a time series, it should be possible to test for correlations between changes in the spatial extent and composition of vegetation communities in relation to water elevations at annual time scales. Impacts of the operating regime on vegetation communities will be evaluated by assessing the temporal variation in community composition in the vegetated zones between years with respect to reservoir elevations. Such temporal changes could be evaluated using repeated measures MANOVA, ARIMA or other methods for time series analysis (e.g. Rasmussen et al. 1993).

2.3.8 Task 8: Reporting

A brief technical report will be prepared each year of the monitoring program to summarize the methods employed during the program, preliminary data analyses and study findings. A comprehensive report will be prepared after Year 4 and in Year 10 at the conclusion of the study, which will include:

- an executive summary;
- a description of the methods employed;
- a data summary;
- analysis results and a comparison of results among years;
- a detailed summary of the findings as they relate to the ecological hypotheses and the key management questions; and
- any recommendations for operational changes as a result of observed changes in the vegetation communities.

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 Results

The monitoring data will be used to identify linkages between the current reservoir operating regime and changes in the spatial extent, structure and composition of vegetation communities at the landscape scale. Analysis of these relationships should provide a better understanding of the interactions between water levels, inundation frequency and duration, and vegetation survival and distribution.

Data collected during the monitoring program will be used to assess the extent to which management objectives are met by the operating regime. This information will be essential for future decision making regarding the need for operational or non-operational works to maintain and enhance vegetated areas within the drawdown zone.

The inventory will also allow determination of vegetation status and trends in relation to revegetation efforts undertaken in association with the KIN/ARR Reservoir Management Plan (i.e. CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts and CLBWORKS-1 Kinbasket Reservoir Revegetation Program Physical Works).

2.5 Schedule

The monitoring program will be implemented in Years 1, 2, 4, 6, 8 and 10, with aerial photography and ground sampling occurring after vegetation growth has begun, but before water levels inundate the vegetated areas. Field work must be carefully planned to coincide with projected water levels and climatic variability. Completion of the DEM for the remainder of Kinbasket Reservoir and identification of pocket riparian habitat as potential wildlife habitat will be undertaken in Year 1 of the program. Table CLBMON-10-1 provides an overview of tasks by implementation year.

Table CLBMON-10-1 Schedule of tasks for the Kinbasket Reservoir Vegetation Inventory

Task/Year	1	2	4	6	8	10
Acquisition of the DEM	√					
Collection of Aerial Photography	√	√	√	√	√	√
Ground Sampling						
Sample vegetation polygons	√	√	√	√	√	√
Verify pocket riparian habitat	√					
Data Analysis/Reporting						
Data Summary	√	√		√	√	
Detailed Analysis			√			√

2.6 Budget

The total annual cost of the monitoring program is estimated at $238,618 (in 2004 dollars) for Year 1 and $131,801 (in 2004 dollars) for Years 2, 4, 6, 8 and 10. This budget exceeds the original cost estimate developed by the WUP CC ($150,000 for Year 1 and $100,000 for the remaining years, in 2004 dollars), because these costs did not include acquiring the aerial photography ($35,000 per year in 2004 dollars) or completing the DEM for Kinbasket Reservoir ($75,000 in 2004 dollars for Year 1

only). This latter component of the work was not included in the original cost estimate developed by the WUP CC, as it was believed at the time that the DEM was already completed for the entire reservoir. The DEM is considered to be an essential tool for the vegetation inventory, as well as other monitoring studies being undertaken in Kinbasket Reservoir (refer to CLBMON-9 KIN Monitoring of Revegetation Efforts, and CLBMON-4 KIN Fish Stranding Surveys).

In addition, the cost of using a helicopter has been included in the budget to allow access to the more remote sites of Kinbasket Reservoir, and to provide for aerial photographic documentation of vegetated areas and sensitive wildlife habitats. It is believed that this would be a more efficient use of time and resources than attempting to access widely dispersed sites by boat.

Table CLBMON-10-2 provides annual budget estimates assuming a 2% rate of inflation and a 5 % contingency for the duration of the program.

3.0 REFERENCES

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