Falls River Water Use Plan

Monitoring Program Terms of Reference

- **FLSMON-4 Big Falls Reservoir Sedge Habitat Maintenance Monitoring**

Revision 1
July 4, 2016

FLSMON-4 Big Falls Reservoir Sedge Habitat Maintenance Monitoring Monitoring Program Terms of Reference

REVISION RATIONALE

On October 24, 2012, the Falls River Water Use Plan (WUP) Interim Review was held in Prince Rupert, BC, in order to review the status and results to-date of the Falls River Water Use Plan (WUP) monitoring studies. One of the discussions during the review focused on the results of FLSMON-4 Big Falls Reservoir Sedge Habitat Maintenance Monitoring. This study was intended to determine if the operation of the Big Falls Reservoir maintained the sedge grass community. The intended operation included the use of flashboards that are modular bulkheads placed across the crest of the dam to increase the water level behind the dam. This study was not completed as originally planned because of a new understanding of potential dam safety risks that prevented flashboard installation at the dam. The monitoring that has been completed to-date has shown benefits to sedge and wildlife despite not installing the flashboards (WUP Interim Review, BC Hydro 2012). There are no current plans to improve the dam to allow flashboard installation as it is not economically feasible.

As a result, the Monitoring Committee recommended that, prior to the Falls River WUP Order review, another season of sedge monitoring should be completed to get a better understanding of the any changes in the sedge community over the review period. Terms of Reference (TOR) Revision 1 is the result of the Monitoring Committee's recommendation. Key changes to the original TOR are outlined in Table 1.

Table 1: Key changes and rationale to the FLSMON-4 TOR Revision 1

Section	Change	Rationale
Overall	• Changed sampling schedule, to reflect current plan. • Made minor text changes.	• Sampling in Year 5 was not conducted. • Sampling near the end of the WUP period is still valuable to assess the effect of reservoir operations on vegetation community change over time (specifically the high value sedge community).
1.1 Background	• Added an additional operating regime (the existing regime) to compare to historical operations. • Inserted text explaining how the existing reservoir operating regime is different from the operations recommended by the Consultative Committee (CC), and why these operations were not implemented as intended. • Inserted Existing Operating regime into Table 4-1. • Inserted Figure 4-4, existing operations hydrograph.	• Flashboards could not be used due to dam safety issues; therefore existing reservoir operations are not the same as operations recommended by the CC.

Section	Change	Rationale
1.2. Key Water Use Decision Affected	• Removed reference to flashboards. • Changed key water use affect. • Explained why a later monitoring interval survey is relevant.	• Flashboards could not be used due to dam safety issues; therefore existing reservoir operations are not the same as operations recommended by the CC. • Measuring sedge community change over time is important to quantify the potential effects of the current operation of Big Falls Reservoir on the sedge ecosystem that has formed since dam construction.
1.3 Management Questions (MQ)	• Added text and a paragraph explaining how the original intention of the MQ will still be answered.	• Current reservoir operations are not the same as the CC recommended operations. • The proposed program will now measure impacts from the current operations.
1.4 Detailed Hypothesis	• Added text and a paragraph explaining how the original intention of the hypothesis will still be tested. Removed H_2 from this section	• Now current reservoir operations will be analyzed, instead of the operations recommended by the CC. • H_2 was removed because it does not address existing operations and it is not relevant.
2.3 Methods	• Made minor text changes.	• Updated TOR to reflect sampling schedule.
2.6 Budget	• Changed Year 5 to later interval monitoring. • Added budget units to reflect 2016 dollars. • Kept Year 1 budget and units for historical comparison.	• Updated budget to reflect scheduling and method adjustments.

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1.0 Monitoring Program Rationale

1.1 Background

The Consultative Committee (CC) for the Falls River Water Use Plan (WUP) identified that changes to the operation of the Big Falls Reservoir could affect vegetation in the drawdown zone (hereafter "reservoir vegetation") of the Big Falls Reservoir. In particular, high ecological value was placed on maintaining the sedge grass community (located at the eastern end of the Reservoir) to benefit birds, wildlife and aquatic species. Reservoir vegetation is sensitive to the frequency and duration of inundation. Vegetation communities present at various elevations in the drawdown zone are determined by historic reservoir operations. For the Big Falls Reservoir, the existing band of sedge habitat is present in the drawdown zone between 90.3 and 92.4 m (local datum). The community appears to have been maintained by periodic inundation under historic operations that kills trees and other less flood-tolerant species (Moodie 2003). The Fish and Wildlife Technical Committee estimated that in order to maintain the sedge community, it should be inundated for a period long enough to prevent the succession of non-wetland species (i.e., shrubs and trees) into the sedge community, but exposed long enough to allow the sedge to grow. Based on a literature review, the Fish and Wildlife Technical Committee estimated that a minimum of 28-days inundation from February to May was needed to prevent succession. However, the exact elevation, timing, duration and frequency of inundation needed to maintain the sedge community is unknown.

To help reduce this uncertainty, the CC recommended that reservoir vegetation be monitored. This section outlines a monitoring program that will monitor the response of reservoir vegetation to the proposed operation of the Big Falls Reservoir.

Reservoir Elevations

To understand the potential effects reservoir operations have on reservoir vegetation, it is important to understand how historic operations, post-2002 dam safety review operations, planned WUP operations and existing operations differ from each other. Falls River dam is equipped with the means to install flashboards which are modular bulkheads that are placed across the crest of the dam to increase the water level in the reservoir. Flashboards were originally recommended to be installed at the Falls River Dam to increase the normal maximum reservoir elevation (i.e., the elevation at which spilling begins), which benefits power generation by increasing storage and head (the elevation drop). The timing of the installation of the flashboards was key for reservoir sedge habitat benefits, because the CC felt the period that shoreline vegetation was inundated was important in order to control the succession of non-wetland species (i.e., shrubs and trees) into the sedge community.

Reservoir elevations in the Falls River Reservoir, for the purposes of this document, are divided into:

1) Historic operations (Figure 4-1).
2) Post-2002 Dam safety review operations (Figure 4-2).

3) WUP operations, implemented in mid-2006 but shut down in 2007 due to an improved understanding of dam safety risks (Figure 4-3).

4) Existing operations, 2007- current (Figure 4-4).

These four operations differ in the timing of the installation and removal of flashboards (Table 4-1), and other factors. A dam safety review in 2002 effectively reduced the period during which flashboards could be installed (Table 4-1). Subsequently, it was determined that flashboard installation over this short period of time was only marginally economical and hence it did not make economic sense to upgrade the facility to reduce dam safety risks and accommodate the longer term use of flashboards. WUP operations stipulate that flashboards be installed to provide high reservoir elevations during the period from approximately February 15 to May 15 (Table 4-1) in order to: 1) Maintain the sedge grass community by inundating non-wetland species; 2) Minimize inundation of cutthroat trout redds in reservoir tributaries. It was expected that flashboard installation would begin February 2007.

During spring 2007, mechanical issues were encountered during the recommended operation of the flashboards. These issues raised additional dam safety concerns and their use was discontinued entirely. As a result, it was not possible to install flashboards as per the schedule recommended by the CC. Vegetation sampling was completed during the summer of 2007 as per Year 1 of the Terms of Reference (TOR). This sampling was completed prior to understanding the mechanical and dam safety risks associated with operation of the flashboards. TOR Addendum 1 was submitted in December 2007 including a revised schedule for Year 5 and Year 10 sampling intervals. The addendum assumed the dam safety risks with the flashboards could eventually be resolved. However they have not been resolved and no changes are expected in the foreseeable future with regard to resuming flashboard use. The dam operation then continued without the use of the flashboards. The purpose of this TOR Revision is to update the monitoring program to reflect the reservoir operations.

Table 4-1: Timing of the installation of flashboards at the Falls River Dam under four operating regimes.

Operation Regime	Flashboards installed (earliest)	Flashboards installed (latest)	Years implemented
Historic operations	~15-Nov	~15-May	Up to 2002
Post-2002 safety review operations	Not installed	Not installed	2002 through mid-2006
CC Recommended Operations	15 Feb to 15 Mar	1 May to 15 May	Planned: beginning mid-2006 Actual: a short period in early 2007
Existing operations	Not installed	Not installed	Mid-2007 to current

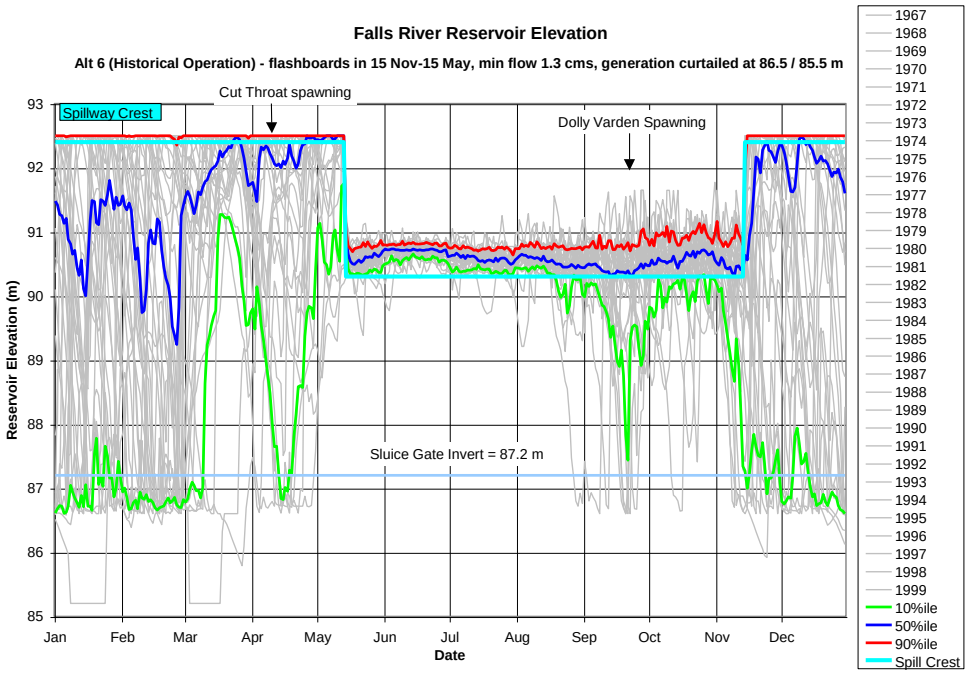

Figure 4-1: Reservoir elevations in the Big Falls Reservoir under the "Historic Operations" operating alternative (Alt 6). Elevations were modelled based on historic inflows. From Figure I-11 of the CC report (BC Hydro 2003).

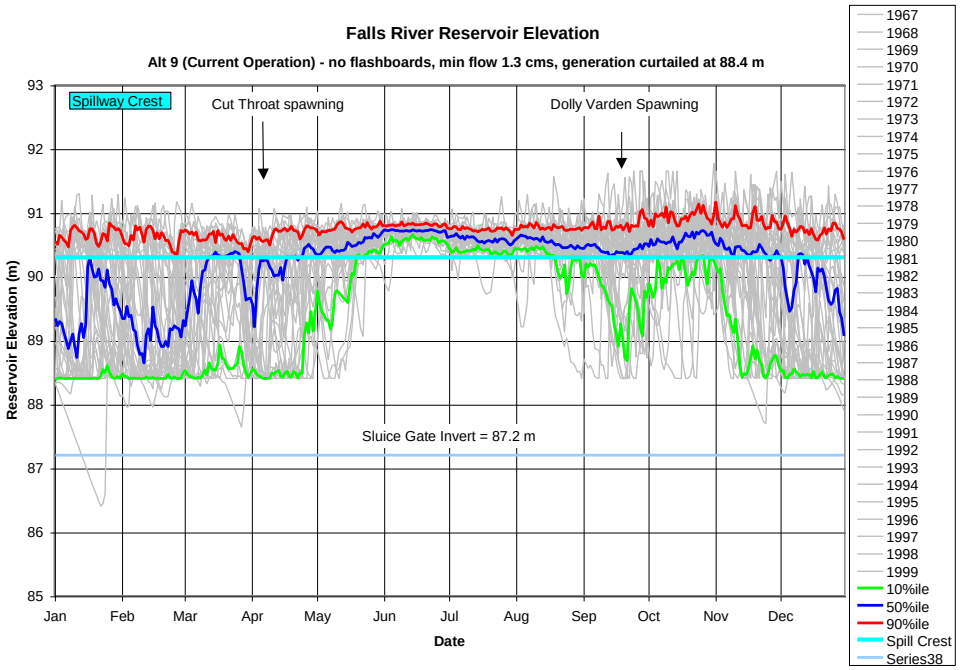

Figure 4-2: Reservoir elevations in the Big Falls Reservoir under the "Post-2002 Dam Safety Review Operations" operating alternative (Alt 9A). Elevations were modelled based on historic inflows. From Figure I-25 of the CC report (BC Hydro 2003).

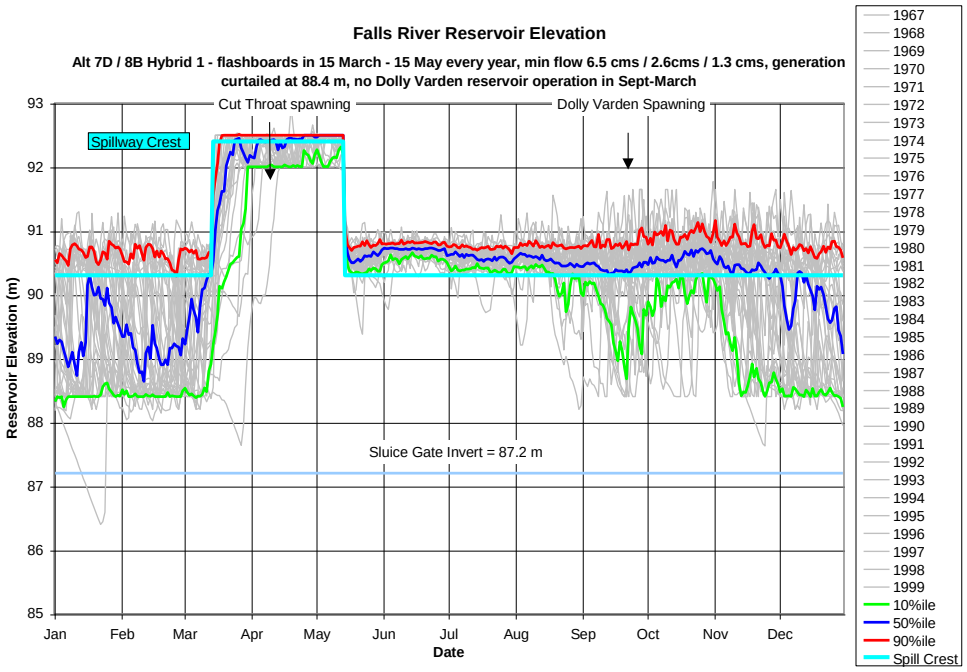

Figure 4-3: Reservoir elevations in the Big Falls Reservoir under the "CC Recommended Operations" operating alternative (Alt 10 or Alt 7D / 8B Hydrid 1). Elevations were modelled based on historic inflows. From Figure I-29 of the CC report (BC Hydro 2003).

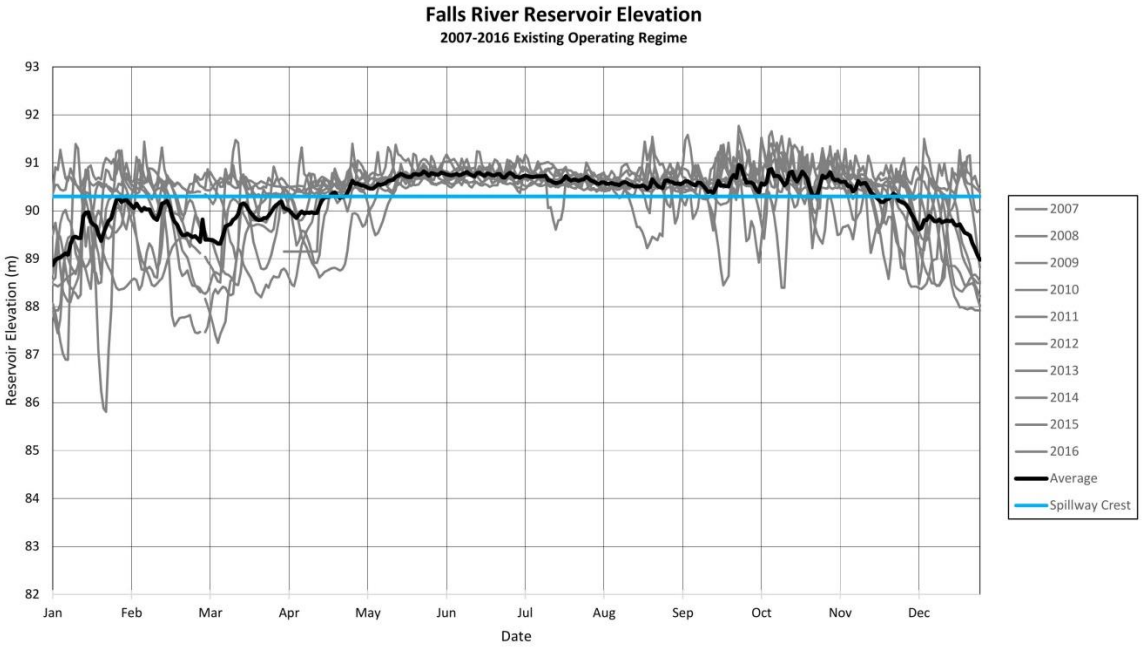

Figure 4-4: Reservoir elevations in the Big Falls Reservoir under the "Existing Operations" Average daily elevation (at forebay) (2016, based on BC Hydro data from 2007-2016).

1.2 Key Water Use Decision Affected

The persistence of the sedge community can be influenced by reservoir operations. Results from the study will help to determine how the sedge community has been affected by reservoir operations.

1.3 Management Questions

The key management question is:

1) Does the operation of the Big Falls Reservoir recommended in the WUP maintain the sedge grass community?

Monitoring was intended to provide information to help calculate the "sedge community maintenance" performance measure (BC Hydro 2003) during future planning processes.

As discussed in Section 1.1, the CC recommended reservoir operations were not implemented as originally intended due to the inability to raise the reservoir level through the use of flashboards at the dam. As a result, this study will not be able to answer:

> "*Does the operation of the* Big Falls Reservoir *recommended in the WUP maintain the sedge grass community?"*

However, by implementing an additional year of survey, this study will be able to answer:

> "*Do existing operations of the reservoir maintain the sedge grass community?*

This alternative management question will be able to inform the WUP order review when it comes to discussing potential operational trade-offs with respect to reservoir operations and the effects on the sedge community.

1.4 Detailed Hypothesis

The primary hypothesis to be tested is:

H_1: The area of the sedge grass community will not change as a consequence of reservoir operations.

- H_{1a}: The species composition of the sedge grass community will not change as a consequence of reservoir operations.

As discussed in Section 1.1 and 1.3, the CC recommended reservoir operations were not implemented. As a result, this study will not be able to answer:

> *H_1: The area of the sedge grass community will not change as a consequence of WUP reservoir operations.*

However, by implementing an additional year of survey, this study will be able to answer:

> *H_1: The area of the sedge grass community will not change as a consequence of reservoir operations.*

This alternative null hypothesis and sub-hypothesis is based on the premise that current reservoir elevations during the vegetation growing period are sufficiently similar to previous operations, from an ecological perspective, that there will be little change in reservoir vegetation.

This alternative null-hypothesis will be able to inform the WUP order review when it comes to discussing potential operational trade-offs with respect to reservoir operations and the effects on the sedge community.

2.0 Monitoring Program Proposal

2.1 Objective and Scope

The primary objective of the monitoring study is to reduce uncertainty related to the effects of reservoir operations on reservoir vegetation in the Big Falls Reservoir. This will be accomplished by:

- Mapping the distribution of reservoir vegetation within the drawdown zone of the Big Falls Reservoir.
- Monitoring changes over time in the areal coverage and plant species composition of vegetated communities within the drawdown zone.

The geographic scope of the monitoring will include the drawdown zone of the Big Falls Reservoir. The existing sedge community is between 90.3 and 92.4 m (Appendix E of BC Hydro 2003). The reservoir generally has steep rocky slopes. However, the eastern portion of the reservoir where Big Falls and Carthew creeks enter the reservoir has a more gentle topography and has extensive sedge habitat. While all areas of the drawdown zone will be examined, monitoring will focus on these areas where vegetation is present.

2.2 Approach

The monitoring schedule is revised to measure community change over the 10-year review period.

The new schedule involves repeating the original vegetation survey conducted in 2007. This survey will observe the effects of reservoir operation on the sedge community over time. Results from this survey will utilize data collected for the first initial monitoring period and compare it to data collected at the later interval near the end of the WUP review period (by 2018). Results from this comparison will be used to quantify whether these effects are negative, positive or neutral. Results from both years will be summarized in the final report after data has been collected.

The monitoring approach is to measure reservoir vegetation using aerial photography at two intervals over the WUP review period. These measurements will be ground-truthed with transects to determine community boundaries and species composition. Vegetation measurements in the first interval of field work will document conditions “prior” at the beginning of the WUP review period. Measurements will be repeated at the later interval to document changes in the sedge community. Monitoring will focus on larger scale changes in the extent of the sedge community.

2.3 Methods

2.3.1 Task 1: Identify Vegetation Communities and Boundaries

In the first interval of monitoring, crews will identify and characterize distinct vegetation communities in the Falls River reservoir. This task can be coordinated with the ground-truthing component of the monitoring (Task 4 below).

Changes in the extent of these communities will be of primary interest to the monitoring program. Thus, criteria will be developed to identify boundaries between communities (e.g., the boundary between the sedge community and upland forest community).

Species composition and vegetation community structural stage will also be important as this will indicate if the sedge meadows are shifting to forests.

2.3.2 Task 2: Acquire Air Photos

Low level (1:5,000), spatially geo-referenced colour air photos will be obtained for the Falls River Reservoir first interval of monitoring and then again for the later monitoring interval. The optimal seasonal timing to acquire air photos will depend on obtaining sufficient vegetation growth for air photo analysis and relatively low reservoir elevations (see Figure 4-3).

The Falls River Reservoir is a challenging location to obtain air photos given the poor weather conditions (Jack Matches, BC Hydro Photogrammetry Services, personal communication). A key challenge in the implementation of this monitoring program will be whether air photos can be obtained at specific times, and within the program budget (Table 4-2).

2.3.3 Task 3: Vegetation Mapping from Air Photo Analysis

Air photos will be used to develop GIS based maps of reservoir vegetation. Air photo analysis will document the extent, density, and community composition of the reservoir vegetation. GIS based maps will then be developed after air photo interpretation is verified or adjusted from the ground-truthing (below). Air photos will be obtained and analyzed for both monitoring intervals.

Air photos will be viewed stereoscopically and plant community boundaries in the reservoir drawdown zone will be delineated on aerial photographs. The polygon boundaries drawn on the air photos will then be digitized to a digital map.

2.3.4 Task 4: Ground-truthing

The distribution of vegetation determined during the air photo analysis will be ground-truthed to verify the location and boundaries of vegetation communities (with GPS). The density, species composition, and vigour of the aquatic vegetation will also be collected. Ground-truthing will include:

1) Geo-referencing of key vegetation locations.
2) Vegetation transects.
3) Ground-level photo monitoring.

Ground-truthing will occur during both monitoring intervals.

Geo-referencing of Key Vegetation Locations

To verify the accuracy of the air photo interpretation, boundaries of the large, primary vegetation locations around the reservoir will be measured with a GPS. The keys areas with vegetation are located at the eastern end of the reservoir and near the tributary estuaries (Moodie 2003).

Vegetation Transects

To document site topography, and the extent and species composition of reservoir vegetation composition, vegetation will be sampled along transect lines at key sites. Permanent transect locations will be established at key sites where vegetation is present. At each site, transects will be located at random along the shoreline

(Figure 4-4) and run perpendicular to the shore extending through the vegetation communities. Permanent benchmarks will be established to reference the location of each transect and quadrat (locations verified with GPS), and elevations referenced to known reservoir elevations[1]. The same transects will be sampled for both monitoring intervals. The location and elevation of vegetation community boundaries along each transect will be documented with a survey level and stadia rod (verified with GPS) or similar method. The boundaries between vegetation communities will be a key measurement that can be used to verify the accuracy and precision of the air photo interpretation. The total number of transects is estimated at five based on budget.

Species composition and per cent aerial coverage of the vegetation communities will be measured along the transect using quadrat sampling, methods will be comparable to both intervals of monitoring and will be sized at the appropriate resolution for species composition monitoring.

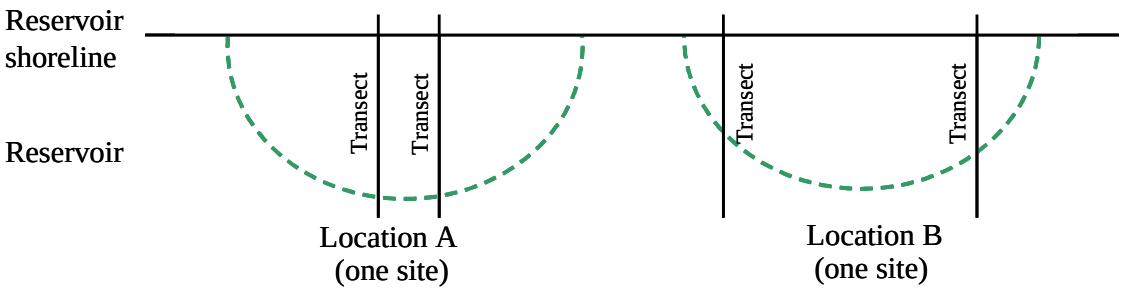

Figure 4-4: Schematic representation (aerial-view) of the reservoir shoreline, and two "primary locations" of reservoir vegetation. Two hypothetical vegetation transects are shown for each "primary location" or site.

Ground-level Photo Monitoring

To further document vegetation changes over time, ground-level photo monitoring will establish photo points (fixed positions) to allow for repeat close-up photography. Photo monitoring is a semi-quantitative procedure that will allow a rigorous documentation of changes over time. Photo monitoring will follow photo-documentation standards (Anon 1996).Where applicable, photos from the first interval and the later monitoring interval will be compared and analyzed for change in community type and species composition using appropriate standards.

2.3.5 Task 5: Data Entry

The proponent will develop a Microsoft Access database and enter all data including photographs.

2.3.6 Task 6: Reporting

A brief, summary data report will be prepared in after the first interval of monitoring that summarizes the extent and species composition of reservoir vegetation communities.

[1] Hourly reservoir elevations during the survey can be obtained from BC Hydro.

Following the later and final interval year of monitoring, a final report will be compiled which will include:

a) An executive summary of the entire project;

b) Methods employed;

c) A data summary as described for the annual data reports;

d) Changes in these characteristics over time;

e) A detailed summary of the findings as they relate to the ecological hypotheses and the key management questions; and

f) Final assessment of the effects of the new operating regime on reservoir vegetation.

All reports will be provided in hard-copy and as Microsoft Word and unprotected Adobe Acrobat (*.pdf) format. The required maps and figures will included as embedded objects in the report. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a Microsoft Access database or Excel spreadsheet. All photos will be submitted electronically.

2.4 Interpretation of Monitoring Program Results

Interpretation of monitoring results will include a quantitative assessment of the changes in spatial extent and species composition of reservoir vegetation associated with existing reservoir operations. The primary measurement variables will be the area of the sedge community. Given the natural variability in plant communities and the limited scope of two years of field work, monitoring will focus on larger scale shifts in the sedge community. The observed patterns will be interpreted based on inundation frequencies imposed by the implemented reservoir operations. Changes in reservoir vegetation are expected to occur at multi-year to decadal time-scales; however extensive flooding over one season can change vegetation composition dramatically. Results should document whether there has been a change in reservoir vegetation, particularly whether there have been large scale changes in the extent of the sedge community, which was of primary interest to the CC.

2.5 Schedule

Field work was scheduled to occur near the beginning of the WUP review period (completed in 2007) and then again at the end of the WUP review period (by 2018). The appropriate seasonal timing to acquire air photos and for ground-truthing will be based on trade-offs between:

a) Observing vegetation during the growing season;

b) Having appropriate reservoir elevations; and

c) Having suitable weather conditions to acquire photos (August or September may be a suitable time for these tasks).

2.6 Budget

Total Revised Program Cost: $85,060.

3.0 References

Anon 1996. A guide to photo documentation for aquatic inventory. Published by the British Columbia Resource Information Committee. Available online: http://ilmbwww.gov.bc.ca/risc/alphastand.htm as viewed May 2006

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Moodie, A. 2003. Falls River Water Use Plan: Vegetation commentary for the Falls River Reservoir. Report prepared for BC Hydro by AIM Ecological Consultants Ltd. April 2003.

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