Falls River Project Water Use Plan

Monitoring Program Terms of Reference

- **Falls River Presence and Timing of Steelhead and Salmon Spawning Monitoring**
- **Falls River Fish Spawning Habitat Monitoring**
- **Big Falls Reservoir Tributary Access and Potential Stranding Monitoring**
- **Big Falls Reservoir Sedge Habitat Maintenance Monitoring**
- **Big Falls Reservoir Tributary Backwatering Monitoring**
- **Big Falls Reservoir Wildlife Shoreline Habitat Monitoring**

October 2006

Terms of Reference for the Falls River Water Use Plan Monitoring Program

Introduction

This document outlines the Falls River Water Use Plan (WUP) Terms of Reference for the monitoring programs as per the Falls River Order under the Water Act, dated 4 April 2006. These programs will monitor outcomes of the recommended operational changes and provide information on which to base future operating decisions.

1) Falls River Presence and Timing of Steelhead and Salmon Spawning Monitoring: A three-year study to determine the timing of adult salmon and steelhead presence and spawning in the Falls River downstream of the dam and in the tailpond.

2) Falls River Fish Spawning Habitat Monitoring: A three-year study to determine the effects of operations on salmon egg-fry survival.

3) Big Falls Reservoir Tributary Access and Potential Stranding Monitoring: A one-year study over two calendar years to:
   i) Survey the location of barriers within the drawdown zone at three tributaries.
   ii) Identify the location and size of potential areas of stranding along the shoreline in the drawdown zone.

4) Big Falls Reservoir Sedge Habitat Maintenance Monitoring: A two-year study in Years 1 and 5 to document and map vegetation in the drawdown zone of the reservoir.

5) Big Falls Reservoir Tributary Backwatering Monitoring: A one-year study over two calendar years to survey for redds in the drawdown zone of three tributaries or, if necessary, sampling for adult spawners by netting, angling, or direct observation by snorkeling. In addition, collect water temperature and life history data.

6) Big Falls Reservoir Wildlife Shoreline Habitat Monitoring: A three-year study to document and map dens and nests established by birds and mammals in the drawdown zone of the reservoir.

Note: Program numbers correspond to those in Table 3 of the Executive Summary of the Consultative Committee report (BC Hydro 2003).

Description of Facility

The Falls River hydroelectric project is located approximately 50 kilometres southeast of Prince Rupert on Falls River above its confluence with the Ecstall River. A short section of the Falls River is located below the spillway and flows into the Ecstall River, a tributary of the Skeena River.

The Falls River project has a single reservoir. Water flows from intakes from the Big Falls Reservoir through two penstocks to the two generating turbines in the powerhouse. Water from the turbines is discharged into the Falls River via a tailrace downstream of the facility.

The location and general layout of the project is illustrated in Figure 1.

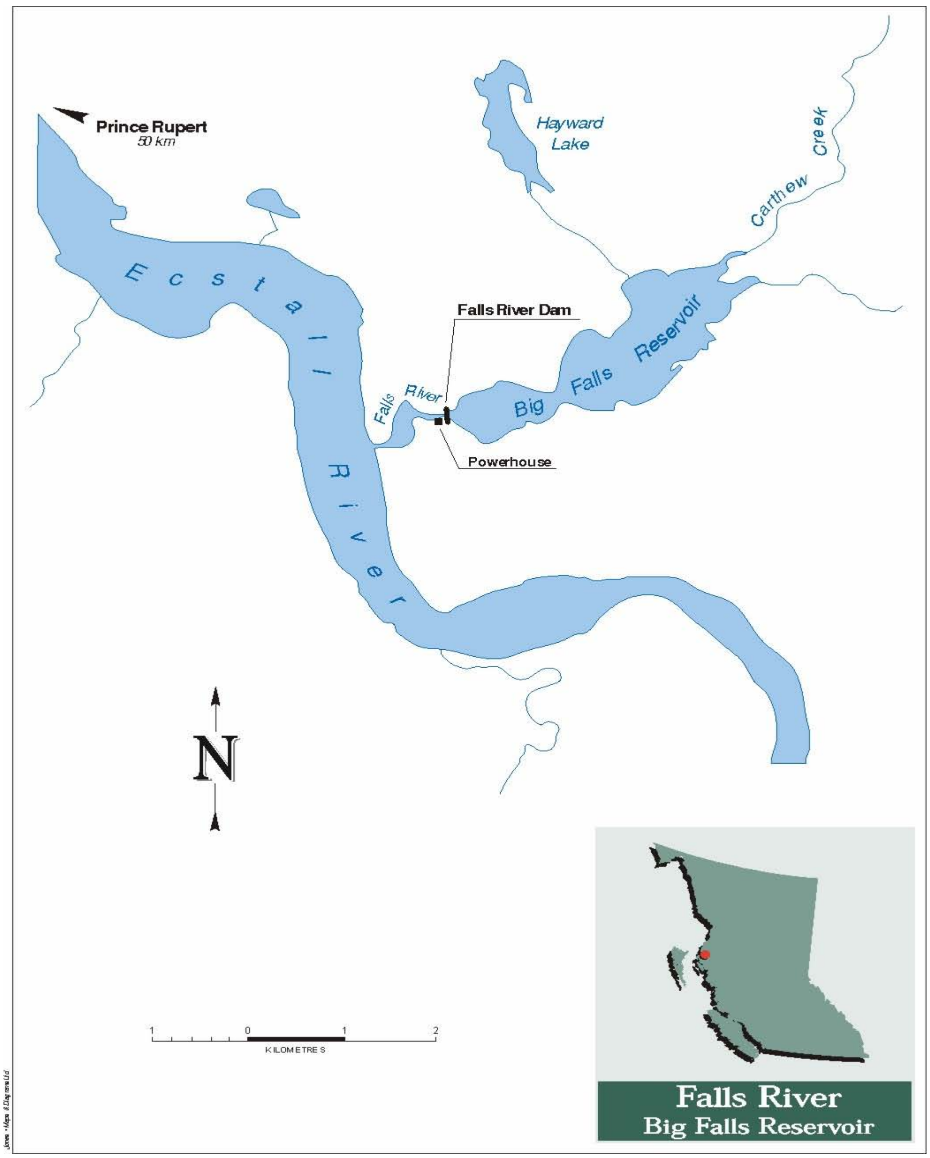


Figure 1: Map of Falls River Project

Falls River Presence and Timing of Steelhead and Salmon Spawning Monitoring

1.0 Monitoring Program Rationale

1.1 Background

The Consultative Committee (CC) for the Falls River Water Use Plan (WUP) expressed concern that flow conditions in the Falls River downstream of the spillway affect the spawning success of salmon and steelhead trout during the fall and spring respectively. The magnitude of discharge in the Falls River and corresponding water depth and velocity over spawning gravels affects available spawning habitat and the selection of spawning locations by adult salmonids. Therefore, the WUP includes seasonal minimum flow recommendations (Table 1-1) that were selected in part to improve conditions for spawning.

Table 1-1: Minimum Discharges to the Falls River for Reservoir Elevations at or Above 88.4 m

Date	Minimum flow (m^3s^{-1})
Year round	2.6
1 Aug - 15 Oct	6.5

Note: Minimum discharges as recommended in the Falls River WUP. If the reservoir elevation drops below 88.4 m, turbine discharge will be reduced to 1.3 m^3s^{-1} to conserve water and ensure that some flows to the river can be maintained.

The minimum flow for 1 August to 15 October (Table 1-1) was selected based on the estimated spawning timing for adult salmon in the Falls River. However, the benefits of this spawning flow were uncertain because the CC had limited information to determine which species are generally present, and the timing for the spawning period for these species (Table 1-2). Therefore, the CC recommended that the presence and spawning timing of salmon and steelhead be monitored to reduce this uncertainty.

Table 1-2: Estimated Spawning Timing for Salmon and Steelhead in the Falls River Tailpond

Species	Arrive	Peak spawn	End of spawn
Chinook	early Aug	mid Aug to mid Sept	late Oct
Chum		mid Aug to late Aug	
Pink	mid Aug	late Aug to mid Sept	Oct
Steelhead		April	

Note: Chinook, chum and pink run timing estimated from historic surveys (DFO 2002). Steelhead timing is listed in Appendix M of BC Hydro (2003).

This document outlines a monitoring program to help determine the presence and timing of spawning salmon and steelhead in the Falls River. This information will be used to help determine whether the timing for the spawning flow is appropriate.

1.2 Management Questions

The key management questions are:

1) Do salmon and steelhead spawn in the Falls River tailpond?

2) When do salmon and steelhead spawn in the Falls River tailpond?

3) Is the timing for the spawning flow release appropriate for salmon and steelhead spawning in the Falls River?

For the purposes of the monitoring program, it is assumed that improved spawning conditions will benefit salmon abundance at the population level by increasing useable spawning habitat. Tests of these assumptions are beyond the scope the program.

1.3 Hypotheses about the Ecological Impacts of Operational Change

The following ecological hypotheses will be examined:

H_1: Salmon are not present and do not spawn in the tailpond from 1 August to 15 October.

H_2: Steelhead are not present and do not spawn in the tailpond.

The hypotheses are stated as null hypotheses, since observing fish presence and evidence of spawning will allow us to reject the null hypotheses. If adults or evidence of spawning are not observed, we will fail to reject the null hypotheses. However, failing to observe adults cannot confirm conclusively that fish are not present.

1.4 Key Water Use Decision Affected

The key water use decision affected by the results of the monitoring program would be the minimum flow release to the Falls River, and the seasonal timing for the minimum flows for spawning and incubation. Changes to the minimum flow could affect the pattern of water storage in the reservoir during periods of low inflow, thus affecting water elevations and ecological values in the reservoir, and power generation. Results of the monitoring could also affect the calculation of performance measures for fish in the Falls River, and thus affect the selection of operating alternatives during future planning processes.

2.0 Monitoring Program Proposal

2.1 Objective and Scope

The primary objective of the monitoring study is to assess the timing of salmon presence and spawning in the Falls River tailpond (Figure 1-1). The geographic scope of the monitoring will be limited to the Falls River tailpond, which is defined as the 180 m long reach from the base of the larger falls (spillway) to top of smaller cascade at the end of the tailpond.

All species observed during the monitoring will be documented. Monitoring will focus on the presence of chinook, chum, and coho salmon because these species were used to calculate the “spawning habitat” performance measure. Chinook salmon spawning was of particular interest to the Fish and Wildlife Technical Committee. Chinook, pink and chum salmon have been documented to spawn in the tailpond. Monitoring will also examine adult steelhead presence and spawning. Steelhead spawning has not been documented in the tailpond.

Fish migration may be affected by annual variations in escapement, run timing and environmental conditions. To examine a range of conditions, monitoring will occur annually over three years.

2.2 Approach

The monitoring approach is to observe adults in the tailpond during the spawning seasons. For the salmon spawning period, one swim will be timed to occur during the peak of spawning, which should correspond to both peak abundance and spawning activity and allow crews to document presence and spawning. One swim near the beginning and another near the end of the run will provide better information on the start and end of the spawning period. The start and end of spawning will be important for future planning to determine the seasonal timing for the minimum flow for salmon spawning.

For steelhead, two swims will occur near the estimated peak of spawning to document presence and spawning activity.

2.3 Methods

2.3.1 Task 1: Project Coordination

Project coordination involves the general administrative and technical oversight of the program. This will include but not be limited to:

1) Budget management.

2) Staff selection.

3) Logistic coordination.

4) Technical oversight in field and analysis components.

2.3.2 Task 2: Periodicity Review

Review and summarize known migration and spawning periodicity for steelhead, Chinook, chum, coho and pink salmon for the Falls River and other nearby watersheds. The purpose is to:

1) Sort out estimated spawning timing for the Falls, which differs between various reports.

2) Collect information on the possibility of an early spawning timing for Chinook salmon, based on spawning timing in nearby watersheds.

2.3.3 Task 3: Snorkel Counts

To observe salmon presence and spawning, three separate swims in the tailpond will occur during the July to October period. The number of swims is estimated based on budget (Table 1-3). The suggested initial schedule for the swims is late July, early September and late October, based on estimated the periodicity in Table 1-2. This schedule can be adjusted based on new information acquired during the monitoring (e.g., Task 2 above). Individual swims may include multiple passes of the relatively small tailpond area.

To observe steelhead presence, spawning, or evidence of spawning, two swims will occur in and around the estimated peak of spawning. Timing of peak spawning is currently estimated to be in April (Table 1-2). This estimate for peak spawning will be revisited under the periodicity review above.

Swims will follow standard snorkel methods. All fish species observed will be documented. Swims will note the activity (e.g., holding, spawning) and condition (e.g., coloration, sexual maturity) of all fish observed. Crews will document the number and location of all redds.

Poor weather that prevents access, and high flows that preclude sampling or limit the efficiency of observations have frequently limited previous sampling. Swims will need to be timed for low inflow periods, during a low tide, and during appropriate plant operations to accommodate the swim. Therefore, a protocol between the BC Hydro Generation Operations planning engineer and the field crew will need to be established for:

1) Communication.

2) Crew safety.

3) Operating protocol.

2.3.4 Task 4: Environmental Data

Crews will record water temperature, weather conditions, total discharge to the Falls River (available from BC Hydro), and tide height for each swim. Crews will also record underwater horizontal visibility (using a dark object or secchi disk).

2.3.5 Task 5: Data Entry

The proponent will develop a Microsoft Access database and enter all data. The proponent will also, through consultation with the Ministry of Environment representative from Smithers, enter the fish data into the provincial database using Mini FDIS, http://srmwww.gov.bc.ca/fish/fdis/index.html.

2.3.6 Task 6: Reporting

A brief, summary data report will be prepared in Years 1 and 2 that summarizes fish presence and spawning. The periodicity review will be included in the Year 1 report.

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

1) An executive summary of the entire project.
2) Methods employed.
3) A data summary as described for the annual data reports.
4) A detailed summary of the findings as they relate to the ecological hypotheses and the key management questions.
5) Any recommendations towards future monitoring (if any) needed to determine the spawning periodicity.

All reports will be provided in hard-copy and as Microsoft Word and 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. All photos will be submitted electronically.

2.4 Interpretation of Monitoring Program Results

The key monitoring result is the presence or absence of adult salmon, steelhead, trout and char during each sampling period, the sexual maturity of these fish, and the presence of redds. Observing fish presence and evidence of spawning will allow us to reject the null hypotheses (H_1 and H_2 above). If adults or evidence of spawning are not observed, we will fail to reject the null hypotheses. However, failing to observe adults cannot confirm conclusively that fish are not present.

A possible confounding factor in the interpretation is presence of non-Falls River fish that may hold in the tail pond prior to continuing their migration in the Ecstall River. Thus, observations of spawning activity or redds during the swims will strengthen the inferences that can be drawn from the monitoring data.

2.5 Schedule

Monitoring will occur annually over three years. Section 2.3 describes the general timing for each swim.

2.6 Budget

Table 1-3 summarizes the budget by labour and expenses. A large contingency of 25 per cent is included in the budget to attempt to account for the anticipated challenge of timing swims to days with low discharge to allow snorkelling and suitable weather to allow access. This contingency would only be used if such logistical challenges were encountered. Costs are estimated in 2006 dollars and total inflation costs are included on the second to last line.

Table 1-3: Estimated Costs for the Falls River Presence and Timing of Steelhead and Salmon Spawning Monitoring

Task	Labour		Units			
		Daily rate	Yr 1	Yr 2	Yr 3	Total Cost
Project coordination	Lead biologist	$600	1	1	1	$1,800
Periodicity review	Lead biologist	$600	1			$600
	Technician	$350	1			$350
Snorkel count	Lead biologist	$600	5	5	5	$9,000
	Technician	$350	5	5	5	$5,250
Travel / mobilization	Lead biologist	$600	5	5	5	$9,000
	Technician	$350	5	5	5	$5,250
Develop database	Lead biologist	$600	1			$600
Data Entry	Technician	$350	1	1	1	$1,050
Reporting	Lead biologist	$600	3	3	5	$6,600
	Contingency	25%	$7,369	$6,981	$7,281	$21,631
		Subtotal	*$21,169*	*$19,231*	*$20,731*	*$61,131*
	Expenses	Unit Price				
	Meals	$40	10	10	10	$1,200
	Accommodation (night)	$100	10	10	10	$3,000
	Travel to Prince Rupert (per person)	$700	10	10	10	$21,000
	Charter to site (entire crew)	$1,200	5	5	5	$18,000
	Truck mileage	$0.55	500	500	500	$825
	Dry suit rental (daily rental)	$40	10	10	10	$1,200
	Field supplies [1]	$200	1	1	1	$600
	Report reproduction	$400	1	1	1	$1,200
		Subtotal	*$15,675*	*$15,675*	*$15,675*	*$47,025*
	Inflation	2%	$737	$1,410	$2,228	$4,375
		Total	**$37,581**	**$36,316**	**$38,635**	**$112,532**

[1] Includes stationary and snorkel supplies.

3.0 References

BC Hydro. 2003. Consultative Committee Report: Falls River Water Use Plan. Prepared by the Falls River Water Use Plan Consultative Committee.

Department of Fisheries and Oceans. 2002. Falls River Hydro Dam fisheries restoration feasibility study. Report prepared for BC Hydro Fish and Wildlife Bridge Coastal Restoration Program, by Miller, L., Hjorth, D., Van Tine, J. Report No. 02FA63. Available online: www.bchydro.com/bcrp/reports/lower_mainland.html as viewed May 2006.

Draft Water Use Plan for Falls River Project, dated August 2003.

Order of the Comptroller of Water Rights, File No. 76975-35, dated 4 April 2006.

Falls River Fish Spawning Habitat Monitoring

1.0 Monitoring Program Rationale

1.1 Background

The Consultative Committee (CC) for the Falls River Water Use Plan (WUP) expressed concern that flow conditions in the Falls River may affect available spawning habitat and egg incubation success for salmon. To address these concerns, the CC recommended a minimum flow of 6.5 m^3s^{-1} to maintain available spawning habitat during the salmon spawning period of 1 August to 15 October, and a year-round minimum flow of 2.6 m^3s^{-1} (reduced to 1.3 m^3s^{-1} if the elevation of the Big Falls Reservoir drops to 88.4 m local datum) to help ensure incubation success. However, the estimated influence of WUP flows on spawning and egg incubation were highly uncertain as they were estimated from models with uncertain parameter estimates (see Appendix G of BC Hydro 2003). As a result of these uncertainties, the CC recommended a monitoring plan to determine the effects of these flows on incubation success.

Salmon egg-to-fry survival was selected as an indicator variable for monitoring because:

1) Egg-to-fry survival should be sensitive to flow conditions.

2) Egg-to-fry survival can have a large effect on salmon abundance at the population level because salmon mortality prior to emergence from spawning gravel is higher than for any other period during the salmon life cycle.

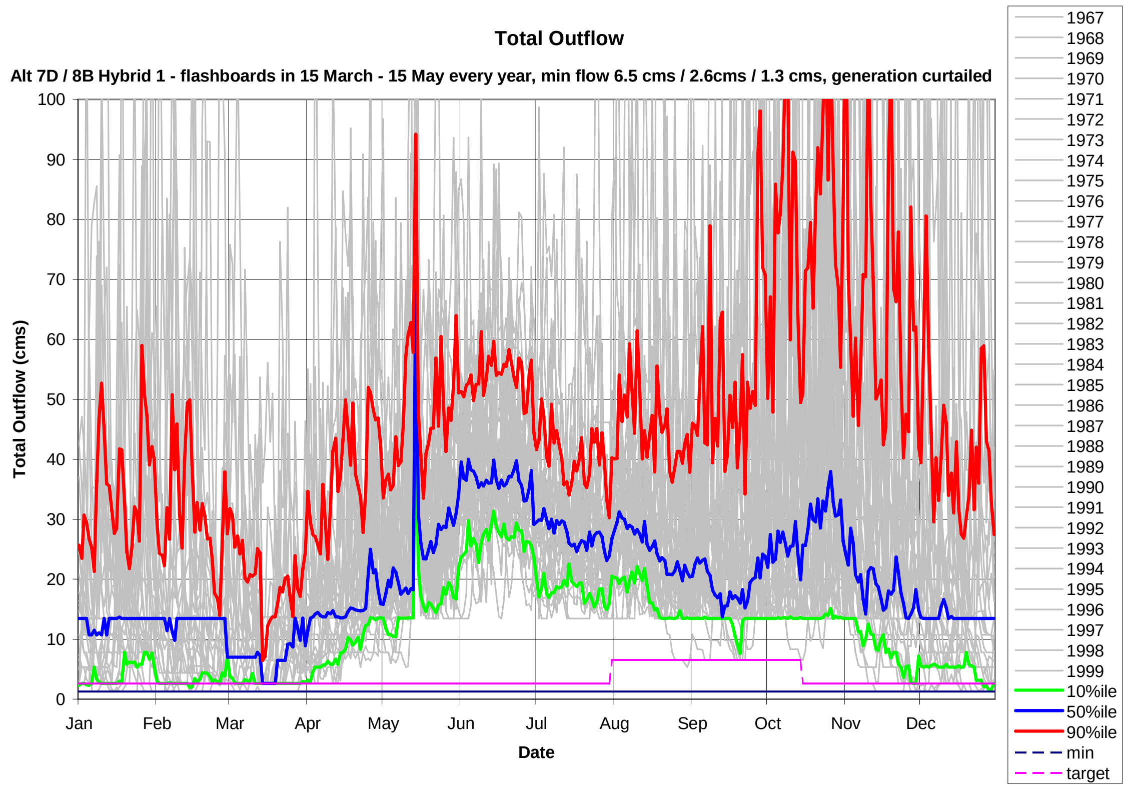
This document outlines a monitoring program that will monitor the influence of these minimum flows on salmon egg-to-fry survival.

Discharge to the Falls River

Understanding the operation of the Falls River hydro system is important to determine the potential effects of low flows on egg-to-fry survival. The Big Falls Reservoir has limited storage and water spills from the dam 60 per cent of the year on average (BC Hydro 2003). Prior to the WUP process, a year-round minimum flow of 1.3 m^3s^{-1} was required in the Falls River. The 2.6 m^3s^{-1} minimum flow was implemented voluntarily by BC Hydro at the end of the WUP process. Implementation of a minimum flow of 6.5 m^3s^{-1} during the spawning period will occur following approval of the WUP from the BC Comptroller of Water Rights.

Discharge to the Falls River under the new WUP operations was modelled based on historic inflows (Figure 2-1). The model estimated that discharge during the incubation period will normally be much greater than the 2.6 m^3s^{-1} minimum flow (e.g., median discharge near 13 m^3s^{-1}). Low flows down to the 2.6 m^3s^{-1} (or 1.3 m^3s^{-1}) minimum flow are likely to occur infrequently and for a short duration during the incubation period (Figure 2-1). Low flows are likely to occur each year while the reservoir is filling following installation of the flashboards on or around 15 March (Figure 2-1).

The experimental design for the monitoring plan does not directly test alternative minimum flows because flow greater than the minimum (2.6 m^3s^{-1}) will likely occur for the duration of the monitoring. High flows during the incubation period will limit the ability of the monitoring program to test the benefits of minimum flow. However, monitoring over a three-year period will increase the likelihood of sampling a range of flow conditions, including low flows. Monitoring will "opportunistically" sample years that differ in the frequency and duration of low flows down to the 2.6 m^3s^{-1} (or 1.3 m^3s^{-1}) minimum flow. The effect of the 2.6 m^3s^{-1} minimum flow relative to other minimum flows will be inferred from these data (e.g., by using the data to model the effect of flow on incubation).



Note: (Alt 10, also known as Alt 7D / 8B Hybrid 1). Discharge estimates were modelled based on historic inflows. From Figure I-30 of the CC report (BC Hydro 2003).

Figure 2-1: Total Discharge to the Falls River under the WUP Operating Alternative

1.2 Management Questions

The key management question is:

1) Do the minimum flows for salmon spawning and egg incubation provided under the WUP operations produce adequate habitat conditions for egg-to-fry survival?

1.3 Detailed Hypotheses about the Ecological Impacts of Operational Change

The primary objective of the monitoring program is to reduce uncertainty related to the benefits of the minimum flows to salmon spawning and egg incubation in the Falls River. A key assumption that underlies the rationale for minimum flows for incubation is that minimum flows affect egg-to-fry survival. Minimum flows can be important for incubation because they:

1) Keep redds wetted to avoid desiccation,

2) Ensure sufficient intra-gravel flow, or

3) Prevent freezing of the redd.

The CC assumed that a minimum water depth and velocity of 0.05 m and 0.02 m^3s^{-1}, respectively, are required throughout the incubation period to ensure incubation success (see Appendix G of BC Hydro 2003). Therefore, the ecological hypothesis[1] that will be examined is:

H_1: Low water flows affect the egg-to-fry survival of chinook salmon in the Falls River.

1.4 Key Water Use Decision Affected

The key water use decision affected by the results of the monitoring program is the magnitude of the minimum flow in the Falls River during the incubation period that is needed to ensure adequate habitat conditions for egg-to-fry survival. This decision has important implications for ecological and power generating values. Opportunities to increase salmon abundance were of high interest to the CC. Alternatively, maintaining a minimum flow in the Falls River can affect power generation, fish, and wildlife in the Big Falls Reservoir.

2.0 Monitoring Program Proposal

2.1 Objective and Scope

The primary objective of the monitoring program is to reduce uncertainty related to the benefits of the minimum flows to the incubation of chinook salmon eggs in the Falls River. The study area will include the Falls River from the falls just downstream of the dam to the confluence with the Ecstall River, with a focus on spawning areas in the tailpond. The tailpond is where most fish habitat is located downstream of the dam. Monitoring will occur annually over three years.

2.2 Approach

The monitoring approach is to assess the quality of egg incubation habitat and egg-to-fry survival. Egg incubation habitat will be characterized by measuring physicochemical parameters that influence it. Egg-to-fry survival will be based on the survival of fertilized eggs to the emergence stage held within incubation capsules in the streambed. Measuring and monitoring survival over the entire development period from egg to fry can be difficult, so the survival rate for developmental stages within the egg-to-fry period will act as an index. Hereafter within this terms of

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[1] For clarity, the hypotheses are stated as the alternate hypotheses. Analyses will test the null hypotheses of no effect or difference.

reference, egg-to-fry survival will refer to survival of water hardened fertilized eggs to the emergence stage. Monitoring will occur at three study sites within the study area. Year 1 will assess only the physicochemical parameters and Years 2 and 3 will assess both physicochemical parameters and chinook egg-to-fry survival.

The primary measures of interest will be:

1) Relative egg-to-fry survival across years and sites.

2) The relationship between egg-to-fry survival and water discharge.

3) The relationship between water discharge and physicochemical parameters of the incubation habitat.

These data will be used to determine which factors affect egg-to-fry survival. In particular, the relationship between incubation success and measures of low flow (e.g., minimum daily flow) will be examined. The Ecstall River is tidally influenced at the confluence of the Falls River, so the logistics of sampling should be considered when planning the site visits. Sampling at low tide will minimize difficulties related to collecting the data and enable assessment of the habitat when discharge from the dam has the largest effect on depth and velocity of the Falls River.

2.3 Methods

The monitoring study will occur over three years. In the first year, sites will be selected that represent potential chinook spawning habitat. At each site, incubation habitat will be assessed by measuring substrate composition and physicochemical parameters of the surface water and hyporheic zone on three sampling periods. In Years 2 and 3, fertilized eggs will be obtained from a hatchery and buried in the gravel at each site within incubator capsules. Percent survival of eggs will be determined by sampling capsules at two developmental stages – hatching and just prior to emergence. At each site visit during study Years 2 and 3, assessment of the incubation habitat will take place as in Year 1.

Table 2-1: Tasks Required in Each Year of the Monitoring Study

Task	Year 1	Year 2	Year 3
Site selection	X		
Measure incubation habitat	X	X	X
Obtain eggs		X	X
Install incubators		X	X
Sample incubators		X	X

2.3.1 Task 1: Select Study Sites (Study Year 1 Only)

Three study sites will be selected in Year 1 of the monitoring study and their location should remain the same location for the entire study. Sites should represent a range of physical habitat but be typical to chinook spawning habitat in the river. Site selection will consider the logistics of assessing the incubation habitat (Task 2), and that incubation capsules can be placed (Task 4) and retrieved (Task 5) over a range of flow conditions. Sites may correspond to those used during previous assessments.

2.3.2 Task 2: Measure Characteristics of Incubation Habitat (for Study Years 1–3)

Substrate composition and physicochemical parameters will be measured over three sampling periods:

1) Egg capsule installation (or expected time if in Year 1 of study).

2) Shortly after hatch (or expected time if in Year 1 of study).

3) Just prior to emergence (or expected time if in Year 1 of study).

Data collection in the study area should be timed to coincide with low tide.

Substrate Composition

To track potential changes in surface substrate composition, Wolman pebble counts (see Bain 1999) will be conducted at each site during each visit. Disturbance to the incubator installation site should be minimized. Surface composition will provide a rapid, qualitative indication of differences among sites and disturbance which may add value to analysis of drivers for incubation success. Substrate composition will be summarized for Wolman count estimates as percent composition of all bed material size distribution, as per BC RIC Standards (RIC 2001).

Physicochemical Parameters

In study Years 1–3, physicochemical assessments will be conducted at each study site by taking continuous and spot measurements. On the initial visit of each year of study, an artificial redd at each site should be constructed prior to sampling the intragravel conditions.

Continuous Measurements

- Water temperature.
- River stage.
- Discharge.

Temperature loggers will be installed during the initial site visit of each study year and downloaded at each subsequent site visit. Two temperature loggers should be buried 25 cm deep together at each site in case of malfunction and a temperature logger should also be installed to measure river surface water temperature. Loggers should be placed in housing that will shield them from damage during inflow events and secured to a fixed object to ensure they remain submerged.

A river stage logger, suitable for the extreme flow fluctuations in the Falls River, will be installed near the sampling sites and operated during the incubation period. Elevations will be referenced to a permanent benchmark using survey gear.

Records of total discharge into the Falls River, from the powerhouse and spill, during the sampling period will be obtained from BC Hydro.

Spot Measurements

The following data will be collected at low tide, if possible, from several locations at each study site:

- Hydraulic head.
- Hydraulic conductivity.

Using piezometers, estimates of hydraulic head and hydraulic conductivity will be taken from several locations at each study site (following the methods such as Lee and Cherry 1978). Hydraulic head measurements will be taken at each sampling period. Hydraulic head measurements will indicate the direction of the hydraulic gradients and movement of groundwater flow at different river stages and flow. Measurements for hydraulic conductivity will be taken in triplicate to determine the capability of the substrate to transmit water.

Data collected from the intragravel water and the surface water is required from each incubation capsule site at each sampling period for:

- Dissolved oxygen.
- Conductivity.
- Alkalinity.
- Salinity.
- pH.

Measurements should be taken in triplicate near each incubator (or if in Year 1 where incubator would be situated). Intragravel water can be obtained using a piezometer and pump such that the sampled water is from 25 cm below the surface of the substrate (i.e., at the same depth in gravel as the incubation capsules). Surface water estimates can be measured adjacent to the piezometer. Estimates of dissolved oxygen, conductivity, and alkalinity will provide an indication of the temporal variability in the influence of groundwater and surface water on the incubation habitat as surface water flow changes. Dissolved oxygen measurements will indicate if oxygen levels are adequate for egg-to-fry survival. Salinity and pH will be tested to address concerns of saltwater intrusion and water acidity on egg loss noted in the CC report.

Data collected from the surface water only is required at each sampling period for:

- Water velocity.

Velocity of the river at each site will be measured at 0.6D and just above the substrate using a electromagnetic-sensored flow meter (e.g., Marsh McBirney Flo-Mate 2000) to determine if standing water is occurring during periods of little spill and tidal inundation. Measurement should be taken near each incubator or if in Year 1 where incubator would be situated.

2.3.3 Task 3: Obtain Eggs and Transport to Study Area (Study Years 2 and 3 Only)

In study Years 2 and 3, chinook salmon gametes will be acquired in late August from a chinook population in the region that has similar run timing to the Falls River (e.g., Deep Creek Hatchery). Late August is within the peak spawning period for chinook in the area (DFO 2002). Prior to egg collection, appropriate individuals (agency staff, hatchery managers) will be contacted to ensure that the chinook egg takes are approved and a control batch can remain at the hatchery for the study period.

Approximately 720 eggs will be needed to fill the 24 incubator capsules. Artificial fertilization will occur at the hatchery using a mix of eggs and milt from multiple individuals. Fertilized eggs will be water hardened at the hatchery before transporting them in water-filled coolers to the study site. Six capsules, each containing 30 eggs, will remain at the hatchery as a control batch.

2.3.4 Task 4: Install Egg Incubation Capsules (Study Years 2 and 3 Only)

In study Years 2 and 3 at each study site, divers will construct an artificial redd for the six incubation capsules. Digging a series of pits in the gravel in an upstream progression (DeVries 1997), the capsules, each containing 30 fertilized eggs, will be buried horizontally at a depth of 25 cm within the substrate. Capsules should be fixed in place using rebar driven in upstream. To avoid risk of mechanical shock to the eggs, rebar will be driven into the streambed prior to placing the egg capsules in the gravel. Locations of capsules will be well marked, and have a site and capsule ID tag attached to the rebar. The rebar should be almost flush with the substrate to ensure no boating or float plane hazards are created at any flow or tide.

A variety of incubator designs may be suitable for the Falls River. Given the fluctuating flows, designs similar to Dumas and Marty (2006) or Baxter and McPhail (1999) that are able to hold 30 eggs mixed with spawning gravel will be suitable for reducing loss of incubators. Holes in the capsule should be small enough to prevent escape of alevins, as the egg source for the study is a donor brood stock.

A data sheet will be prepared in advance of the incubator installation to ensure that the site descriptions, installation issues, capsule ID, and locations (collected by GPS, and IDs marked on a hand-drawn map for each site) are clearly recorded

2.3.5 Task 5: Sample the Incubators (Study Years 2 and 3)

Incubation success will be measured on two sampling periods:

1) Shortly after hatch.

2) Just prior to emergence.

Alternatively, if altering the timing of sampling is possible such that one of the sampling periods occurs after the flashboard installation (around 15 March), this would potentially provide an opportunity to obtain measurements at low flow (Figure 2-1). On each sampling period, three random egg capsules from each site will be extracted and assessed individually for survival by counting the number of live eggs and alevins. Sampling new (i.e., previously undisturbed) capsules at each of the two retrieval periods will avoid any detrimental effects of handling on egg-to-fry survival. The capsules sampled at a site at each retrieval period are replicates and having capsules in triplicate for each site and retrieval period will compensate for potential loss of individual incubator capsules due to scour, fungal loss, or some other cause.

Arrangements should be made for hatchery staff to sample three egg capsules at the hatchery on each sampling period. The same procedure would follow as in the field. Three egg capsules will be assessed individually for survival and capsules sampled on the second sampling period should be different than those sampled during the first sampling period.

2.3.6 Task 6: Data Entry

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

2.3.7 Task 7: Reporting

Annual Data Summary

Each year, a data report will be prepared outlining the following:

1) An executive summary of the data.
2) Methods, including mapping of assessment sites.
3) Environmental data collected, presented in tabular and graphical form.
4) Egg-to-fry survival data from the study sites and control site summarized in tabular and graphical form.
5) A short section summarizing the data collection program and outlining any recommendations.

Analysis of Incubation Success

At the end of data collection, the influence of flow on incubation success over the monitoring period will be analyzed to test the ecological hypothesis. The analysis will also include examining the relationship between surface water flow and physicochemical parameters of the hyporheic environment to determine the significance and nature of the relationship. Appendix A proposes an approach for analysis.

Final Report

After the final year of data collection, a final report will be prepared that will include:

1) An executive summary of the entire project.
2) The data summary as described in the annual reports, including a comparison of results among years.

3) The analysis of incubation success.

4) A detailed summary of the findings as they relate to the ecological hypothesis and the key management question.

5) Based on these results for chinook salmon, a discussion on the inferences on incubation conditions for other species that spawn in the tailpond.

6) Any final recommendations towards future monitoring (if any) needed to determine minimum flow requirements for chinook salmon incubation.

All reports will be provided in hard-copy and as Microsoft Word and 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. All photos will be submitted electronically.

2.4 Interpretation of Monitoring Program Results

Egg-to-fry survival over the three-year study period will be assessed in response to water flow. The results of the study will also provide information on the response of the physicochemical parameters of the incubation habitat to changes in flow and consequently, implications for egg-to-fry survival based on the response. Results of the physicochemical nature of the incubation habitat can be compared to published biostandards for chinook salmon to determine the adequacy of incubation conditions. If a relationship between incubation success and low flows is established, it may be possible to retrospectively model what flows would have been during the monitoring period if pre-WUP operating rules were employed, and thus compare the pre-WUP and WUP operations. Such a comparison is beyond the scope of these Terms of Reference and may be performed during future planning processes.

Monitoring results for Chinook salmon will also provide information to infer incubation conditions for other species that spawn in tailpond.

2.5 Schedule

Monitoring is scheduled to occur annually over three years. Section 2.3 describes the general timing for each task.

2.6 Budget

Table 2-2 summarizes the budget by labour and expenses. A large contingency of 25 per cent is included in the budget to attempt to account for the anticipated challenge of timing data collection days with low discharge and suitable weather to allow access. This contingency would only be used if such logistical challenges were encountered. The budget assumes that three visits to the site are required per year. Costs are estimated in 2006 dollars and total inflation costs are included on the second to last line.

Table 2-2: Estimated Costs for the Falls River Fish Spawning Habitat Monitoring

Task	Labour		Units			
		Daily rate	Yr 1	Yr 2	Yr 3	Total Cost
Project coordination	Lead biologist	$600	3	3	3	$5,400
Site selection, install river stage recorder, and physical measurements	Lead biologist	$600	4			$2,400
	Technician	$350	4			$1,400
	Diver 1	$1,000	4			$4,000
	Diver 2	$1,000	4			$4,000
Egg collection, place baskets, and physical measurements	Lead biologist	$600		2	2	$2,400
	Technician	$350		2	2	$1,400
	Diver 1	$1,000		2	2	$4,000
	Diver 2	$1,000		2	2	$4,000
Monitor baskets pre-emergence, and physical measurement	Lead biologist	$600		1	1	$1,200
	Technician	$350		1	1	$700
	Diver 1	$1,000		1	1	$2,000
	Diver 2	$1,000		1	1	$2,000
Retrieve bakets, and physical measurements	Lead biologist	$600		1	1	$1,200
	Technician	$350		1	1	$700
	Diver 1	$1,000		1	1	$2,000
	Diver 2	$1,000		1	1	$2,000
Sample control eggs	Lead biologist	$600		1	1	$1,200
	Technician	$350		1	1	$700
Travel / mobilization	Lead biologist	$600	3	3	3	$5,400
	Technician	$350	3	3	3	$3,150
	Diver 1	$1,000	3	3	3	$9,000
	Diver 2	$1,000	3	3	3	$9,000
Develop database	Lead biologist	$600	1			$600
	Technician	$350	1			$350
Data Entry	Technician	$350	1	1	1	$1,050
Reporting	Lead biologist	$600	5	5	5	$9,000
	Technician	$350	1	1	1	$1,050
	Analyst	$700	1	1	3	$3,500
	Contingency	25%	$12,634	$11,698	$11,898	$36,231
		Subtotal	*$40,434*	*$39,498*	*$41,098*	*$121,031*
	Expenses	Unit Price				
	Meals	$40	16	18	18	$2,080
	Accommodation (night)	$100	16	18	18	$5,200
	Truck mileage	$0.55	350	350	350	$578
	Travel to Prince Rupert (per person)	$700	12	12	12	$25,200
	Charter to site (entire crew)	$1,200	3	3	3	$10,800
	Jet boat + fuel	$250		1	1	$500
	Incubation boxes	$50		18	6	$1,200
	Piezometers	$100	9	3	3	$1,500
	Temperature loggers	$215	7	2	2	$2,365
	River stage recorder and logger	$3,500	1			$3,500
	Field supplies [1]	$2,000	1	1	1	$6,000
	Report reproduction	$400	1	1	1	$1,200
		Subtotal	*$22,738*	*$18,993*	*$18,393*	*$60,123*
	Inflation	2%	$1,263	$2,363	$3,641	$7,268
		Total	**$64,435**	**$60,854**	**$63,132**	**$188,421**

[1] Includes rental of meters for flow, DO, conductivity meter, salinity, pH, alkalinity kit, GPS, and camera.

3.0 References

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Appendix A

The study will likely provide a range of water flow conditions that will enable analysis of the effect of flow conditions on egg-to-fry survival and incubation habitat conditions in the Falls River.

The following analyses are recommended provided that statistical assumptions are met. A survival analysis should be performed using logistic regression (i.e., count data of individual eggs surviving or dying) and a generalized linear model. Key elements of the model include: site as a block, year as a factor, sampling period as a factor, and flow as a covariate.

Further analysis should include:

- Testing for correlations between physicochemical parameters and flow.
- Testing for differences between physicochemical measurements of intragravel water and physicochemical measurements of surface water (e.g., using ANOVA and regression).
- Testing for differences in physicochemical parameters between sites (e.g., using ANOVA and regression).

For a given parameter if a correlation with flow is found, then the parameter can be substituted for flow in the model and the results compared to the original model. If no correlation is found, then the given parameter can be added to the model as an additional covariate. Testing for differences in physicochemical parameters between intragravel water and surface water will indicate the influence of surface water on the hyporheic zone. The third analysis of examining physicochemical parameters between sites will indicate how similar the incubation habitat is within the study area.

Big Falls Reservoir Tributary Access and Potential Stranding Monitoring

1.0 Monitoring Program Rationale

1.1 Background

The Consultative Committee (CC) for the Falls River Water Use Plan (WUP) expressed concern that the operation of the Big Falls Reservoir and associated seasonal reservoir elevations could affect access to tributaries by cutthroat trout and Dolly Varden because migration barriers may be present in the drawdown zone of the reservoir. Air photo interpretation (Lewis 2002) suggests that migration barriers are likely not present in the three key spawning tributaries where they enter the reservoir because the tributaries have low gradients (0.5 to 1 per cent) within the normal operating drawdown zone (88.4 to 92.4 m local datum). However, analysis of reservoir bathymetry (Lewis 2002) suggests that migration barriers may be present at elevations <88.4 m. As a result, the CC developed a performance measure for tributary access that used a minimum elevation threshold of 88.4 m. This performance measure was one of the performance measures used to evaluate reservoir operating alternatives. However, the presence of migration barriers has not been verified, and thus the accuracy of this performance measure and hence its utility for management has yet to be determined.

The CC was also concerned that rapid drawdowns of the reservoir could strand fish along the reservoir shoreline throughout the drawdown zone. However, areas of potential stranding and the risk of stranding at such sites has not been determined. No performance measure was developed for reservoir stranding.

To help reduce these uncertainties, the CC recommended that migration barriers in the drawdown zone for the three key tributaries, and areas of potential fish stranding on the reservoir shoreline be monitored. This section outlines a monitoring program that will survey for migration barriers and areas of potential stranding in the Big Falls Reservoir.

1.2 Management Questions

The key management questions are:

1) Are there migration barriers in tributaries within the area of potential drawdown for Big Falls Reservoir?

2) Are there locations where fish could be stranded along the Big Falls Reservoir shoreline?

Answering these questions will help future planning processes determine whether reservoir operations can affect tributary access and reservoir stranding.

1.3 Detailed Hypotheses

The primary hypotheses[2] to be tested are:

H_1: There is a barrier to adult fish migration in tributaries at elevations near or below 88.4 m.

H_2: Fish are stranded along the reservoir shoreline during reservoir drawdowns.

1.4 Key Water Use Decision Affected

The key water use decision affected by the results of the monitoring program would potentially be the operation of the Big Falls Reservoir, particularly reservoir elevations during spawning periods, and the rate of reservoir drawdown. Reservoir operations can affect wildlife, power production, fish habitat in the reservoir and tributaries, and flows for fish downstream in the Falls River.

2.0 Monitoring Program Proposal

2.1 Objective and Scope

The primary objective of the monitoring study is to reduce uncertainty related to the presence of migration barriers for adult cutthroat and Dolly Varden, and areas of potential fish stranding in the Big Falls Reservoir. The geographic scope of the monitoring will include the drawdown zone of the Big Falls Reservoir (elevations <92.4 m).

2.2 Approach

The monitoring approach is to conduct a one time survey for barriers and areas of potential stranding.

Barriers

The monitoring approach will be to visually survey the reservoir to identify potential barriers to fish migration. The monitoring approach suggested in the CC Report (BC Hydro 2003) was to survey the reservoir drawdown zone opportunistically when the reservoir elevation is <88.4 m, at any time during the five-year monitoring period. However, the WUP recommended that the reservoir elevation be maintained >88.4 m throughout the year, and modelling during the WUP suggested that reservoir elevations would rarely drop below 88.4 m and only for short periods of time during the winter (Figure 3-1). Reservoir elevations fluctuate daily with changing inflows and generation is curtailed if the reservoir drops to 88.4 m. Thus it would be logistically challenging to mobilize a field crew to this remote location during these chance events, and administratively challenging to have a crew on standby over five years.

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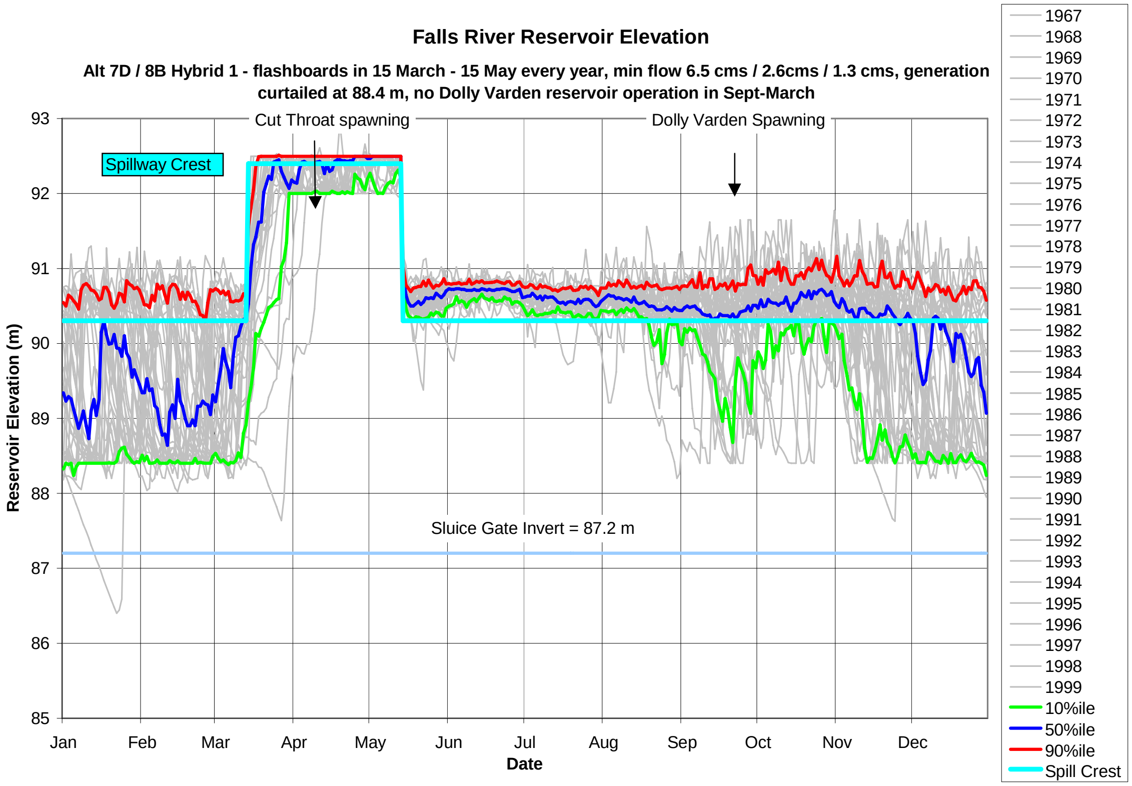
2 For clarity, hypotheses are stated as alternate hypotheses. Analyses will test the null hypothesis of no effect or difference.



Note: Elevations were modelled based on historic inflows. From Figure I-29 of the CC report (BC Hydro 2003).

Figure 3-1: Reservoir Elevations in the Big Falls Reservoir under the Operating Alternative (Alt 10 or Alt 7D / 8B Hydrid 1)

The monitoring approach outlined here recognizes that sampling will likely occur at reservoir elevations up to ~90.5 m. Underwater observations for barriers can be achieved using snorkeling, a viewing tube from a boat, and a depth sounder from a boat. Alternatively, field crews could coordinate with facility operators to obtain reservoir elevation <88.4 m. However, the methods described here assume that such low reservoir elevations are not available for sampling.

Stranding

The monitoring approach will be to visually survey the reservoir drawdown zone to identify any areas along the shoreline where water has pooled and could strand fish. Stranding will be assessed when reservoir elevations are dropping. One potential time for the assessment would be shortly after the flashboards are removed (between 2 May and 14 May).

2.3 Methods

2.3.1 Task 1: Migration Barrier Survey

One survey will document potential migration barriers in the three key tributaries: Big Falls Creek, Carthew Creek, and the Unnamed Creek that drains Hayward Lake.

Surveys will occur from a boat, on foot or by snorkelling. At elevations where stream is flowing at the time of the survey, potential barriers will be assessed based and vertical drop and water velocity. At elevations where the stream channel is backwatered at the time of the survey, the presence of barriers will be inferred form observations of vertical drops in the backwatered stream channel. At elevations where the stream channel is backwatered, it will not be possible to assess water velocity. All areas of the stream channel will be photodocumented.

While there are no standard water velocity and height criteria to determine migration barriers, the maximum swimming speeds and jumping abilities for adult cutthroat trout and Dolly Varden will be used to evaluate potential barriers (see Section 2.4 below).

2.3.2 Task 2: Shoreline Stranding Survey

The entire shoreline will be examined by boat to identify areas along the shore where water has pooled to create isolated habitats that strand fish. These isolated pools will be examined on foot and measured for area (length and width) and maximum depth. In addition, comments on substrate, available cover, and fish presence will be recorded. If extensive areas are identified it might be necessary to monitor them for several days to determine if they de-water and kill fish or persist and provide suitable habitat.

2.3.3 Task 4: Data Entry

All data including photographs will be entered into a Microsoft Access database.

2.3.4 Task 5: Reporting

A report will be compiled which will include:

1) An executive summary of the entire project.

2) Methods employed.

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

4) Any recommendations towards future monitoring (if any) needed to determine if barriers are present and if shoreline stranding can occur.

All reports will be provided in hard-copy and as Microsoft Word and 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. All photos will be submitted electronically.

2.4 Interpretation of Monitoring Program Results

Barriers

While there are no standard water velocity and height criteria to determine migration barriers for cutthroat trout and Dolly Varden, the maximum swimming speeds and jumping abilities for adult cutthroat trout and bull trout (e.g., Bjornn and Rieser 1991; Whyte et al. 1997) will be used to evaluate potential barriers. Both species are known to inhabit steep streams.

Stranding

The occurrence of stranding locations will be documented, and this information will be useful for future planning processes.

2.5 Schedule

For planning purposes, data collection is scheduled to occur in Year 2 of the monitoring program. However, data collection may occur at an appropriate time during the five-year monitoring period. Sections 2.2 and 2.3 outline potential seasonal timing for each task.

2.6 Budget

Table 3-1 summarizes the budget by labour and expenses. Costs are estimated in 2006 dollars and total inflation costs are included on the second to last line.

Table 3-1: Estimated Budget for the Big Falls Reservoir Tributary Access and Potential Stranding Monitoring

Task	**Labour**		Units	
		Daily rate	Yr 2	Total Cost
Project coordination	Lead biologist	$600	2	$1,200
Survey	Lead biologist	$600	3	$1,800
	Technician	$350	3	$1,050
Travel / mobilization	Lead biologist	$600	1	$600
	Technician	$350	1	$350
Data Entry	Technician	$350	1	$350
Reporting	Lead biologist	$600	5	$3,000
	Contingency	25%	$3,444	$3,444
		Subtotal	*$11,794*	*$11,794*
	Expenses	Unit Price		
	Accommodation	$100	6	$600
	Meals	$40	6	$240
	Travel to Prince Rupert (per person)	$700	2	$1,400
	Charter to site (entire crew)	$1,200	1	$1,200
	Boat supplies	$20	3	$60
	Truck mileage	$0.55	50	$28
	Travel	$1,000	1	$1,000
	Field supplies	$500	1	$500
	Report reproduction	$400	1	$400
		Subtotal	*$5,428*	*$5,428*
	Inflation	2%	$696	$696
		Total	**$17,918**	**$17,918**

3.0 References

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Big Falls Reservoir Sedge Habitat Maintenance Monitoring

1.0 Monitoring Program Rationale

1.1 Background

The Consultative Committee (CC) for the Falls River Water Use Plan (WUP) expressed some concern that changes to the operation of the Big Falls Reservoir would 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 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 WUP operational changes in the Big Falls Reservoir.

Reservoir Elevations

To understand the potential effects of WUP reservoir operations on reservoir vegetation, it is important to understand how WUP operations differ from existing operations. The installation of flashboards, timing of the maintenance shutdown, seasonal reservoir elevation targets, and minimum flow releases to the Falls River affect reservoir elevations. Of these, the timing of the installation of flashboards is key for reservoir vegetation because it determines the period that shoreline vegetation is inundated. Flashboards can 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).

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 (Figure 4-3).

These 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 marginally economical and hence flashboard use was discontinued. WUP operations stipulate that flashboards be installed to provide high reservoir elevations during the period from approximately 15 February to 15 May (Table 4-1) in order to:

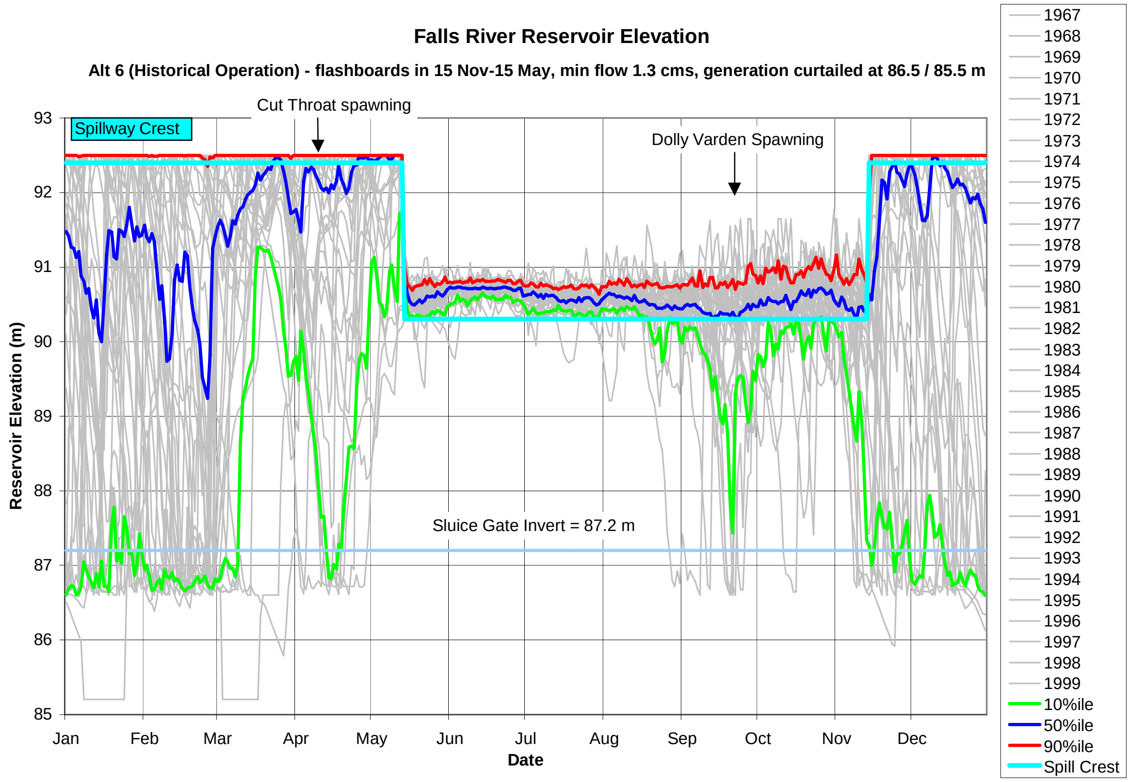
1) Maintain the sedge grass community by inundating non-wetland species.

2) Minimize inundation of cutthroat trout redds in reservoir tributaries. It is expected that this flashboard installation will begin February 2007.

Table 4-1: Timing of the Installation of Flashboards at the Falls River Dam under Three Operating Regimes

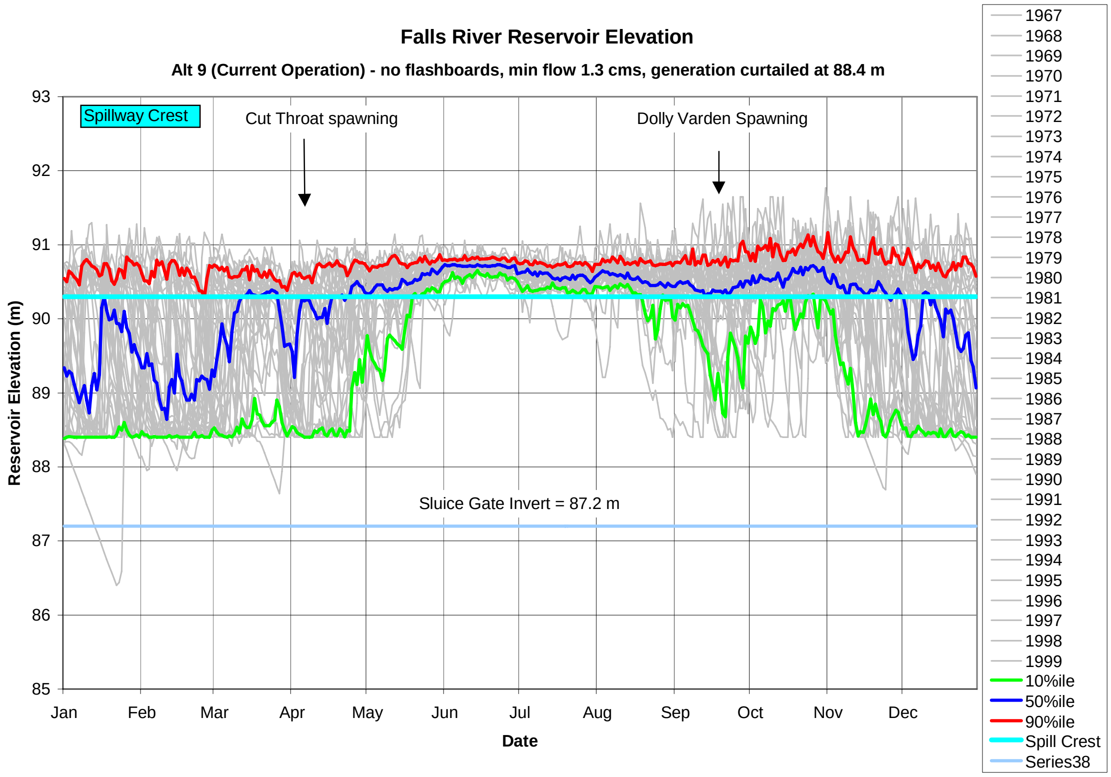
	Flashboards installed (earliest)	Flashboards removed (latest)	Years implemented
Historic operations	~ 15-Nov	~15-May	up to 2002
Post-safety review operations	Not installed	Not installed	2002 through mid-2006
WUP operations	15 Feb to 15 Mar	1 May to 15 May	Beginning mid-206

The effects on reservoir vegetation of operational changes for dam safety in 2002 are not known. The response of vegetation to changes in operations is expected to occur at the time-scale of years to decades. Thus, the interpretation of monitoring results to determine the effects of WUP operations on reservoir vegetation will potentially be confounded by these relatively recent operational changes.



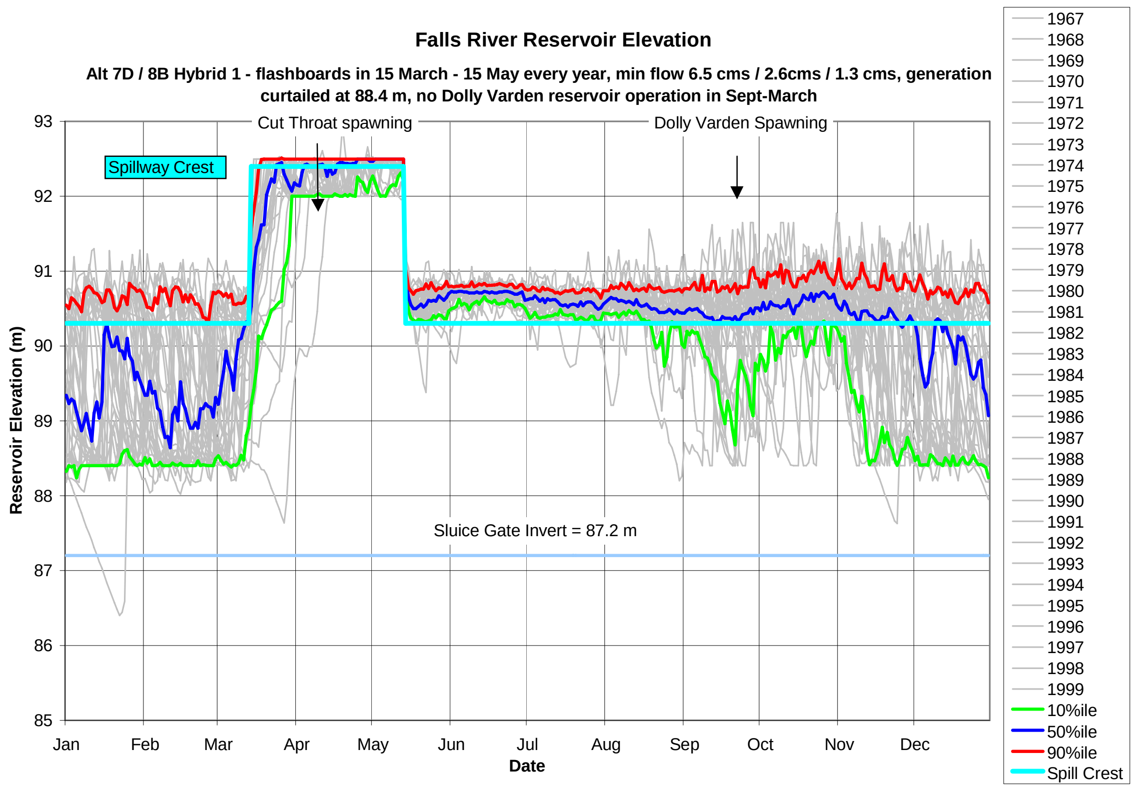
Note: Elevations were modelled based on historic inflows. From Figure I-11 of the CC report (BC Hydro 2003).

Figure 4-1: Reservoir Elevations in the Big Falls Reservoir under the "Historic Operations" Operating Alternative (Alt 6)



Note: Elevations were modelled based on historic inflows. From Figure I-25 of the CC report (BC Hydro 2003).

Figure 4-2: Reservoir Elevations in the Big Falls Reservoir under the "Current Operations" Operating Alternative (Alt 9A).



Note: Elevations were modelled based on historic inflows. From Figure I-29 of the CC report (BC Hydro 2003).

Figure 4-3: Reservoir Elevations in the Big Falls Reservoir under the “WUP Operations” Operating Alternative (Alt 10 or Alt 7D / 8B Hydrid 1)

1.2 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 will provide information to help calculate the “sedge community maintenance” performance measure (BC Hydro 2003) during future planning processes.

1.3 Detailed Hypothesis

The primary hypotheses to be tested are:

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

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

This null hypothesis and sub-hypothesis is based on the premise that seasonal reservoir elevations during the vegetation growing period under the WUP will be sufficiently similar to previous operations, from an ecological perspective, that there will be little change in reservoir vegetation. Operations under the WUP will include a period of inundation during the early portion of the growing season and low water during the latter portion of the growing season.

H_2: Inundation for 28 days or more during the period from 15 February to 15 May prevents the succession of non-wetland species into the sedge grass community.

This hypothesis[3] examines a key assumption that was used in the calculation of the "sedge habitat maintenance" performance measure. Based on a literature review, the Fish and Wildlife Technical Committee estimated that a minimum of 28-days inundation from 15 February to 15 May was needed to prevent succession.

1.4 Key Water Use Decision Affected

The key water use decision affected by the results of the monitoring program would potentially be the operation of the Big Falls Reservoir, particularly the operation of the flashboards from 15 February to 15 May. Monitoring will provide information to reduce uncertainty regarding the 28-day inundation assumption which was used to calculate the "sedge community maintenance" performance measure. Thus, monitoring results may affect the calculation of this or similar performance measures during future planning processes, and, therefore, potentially affect the chosen operational alternative. Reservoir operations affect power generation, fish and wildlife habitat in the reservoir and tributaries, and flows for fish downstream in the Falls River.

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:

1) Mapping the distribution of reservoir vegetation within the drawdown zone of the Big Falls Reservoir.
2) 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.

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[3] For clarity, this hypothesis is stated as the alternate hypotheses. Analyses will test the null hypotheses of no effect or difference.

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 approach is to measure reservoir vegetation using aerial photography both prior to and following implementation of the WUP reservoir operations. These measurements will be ground-truthed with transects to determine community boundaries and species composition. Vegetation measurements in Year 1 will document conditions “prior” to the implementation of WUP operational changes. WUP operations will be implemented in Year 1; however, given the expected 3-5 year time scale for the response of vegetation (Moodie 2003), measurements in Year 1 can be considered pre-implementation. Measurements will be repeated in Year 5 to document vegetation changes following implementation of the WUP operating regime. 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 year 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 in Year 1 (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).

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 in Years 1 and 5. 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 cap set by the CC (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 analyzed in Years 1 and 5.

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 Years 1 and 5.

Geo-referencing of Key Vegetation Locations

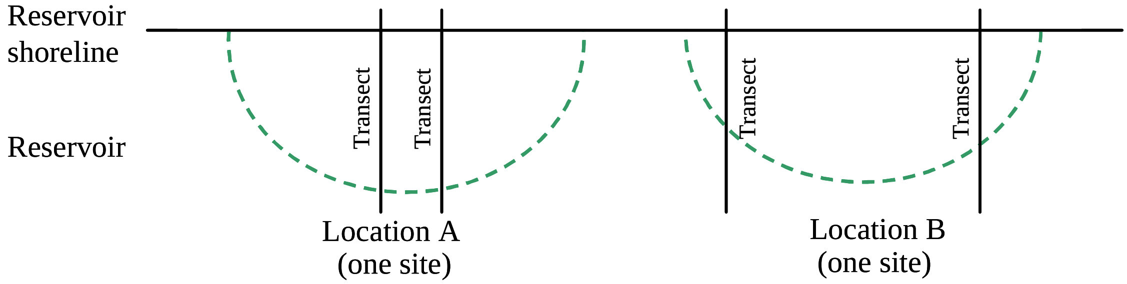
To verify the accuracy of the air photo interpretation, boundaries of the large, primary vegetation locations around the reservoir will be measured with a GPS. The keys areas with vegetation are located at the eastern end of the reservoir and near the tributary estuaries (Moodie 2003).

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 and. At each location, 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[4]. The same transects will be sampled in Years 1 and 5. 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.

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



Note: Two hypothetical vegetation transects are shown for each "primary location" or site.

Figure 4-4: Schematic Representation (aerial-view) of the Reservoir Shoreline, and two "primary locations" of Reservoir Vegetation.

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 photodocumentation standards (Anon 1996).

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 Year 1 that summarizes the extent and species composition of reservoir vegetation communities.

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

1) An executive summary of the entire project.
2) Methods employed.
3) A data summary as described for the annual data reports.
4) Changes in these characteristics over time.
5) A detailed summary of the findings as they relate to the ecological hypotheses and the key management questions.
6) A final assessment of the effects of the new operating regime on reservoir vegetation.

7) Any recommendations towards future monitoring (if any) needed to determine the response of reservoir vegetation to reservoir operations.

All reports will be provided in hard-copy and as Microsoft Word and 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. 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 the implementation of the new operating regime. The primary measurement variables will be the area of the sedge community. Given the natural variability in plant communities and the limited scope of the monitoring to two years of assessment, 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. Given the short duration of the monitoring program, sampling in only two years, the changes in reservoir operations in the years prior to the implementation of the WUP operations, it may be difficult to attribute an observed change in reservoir vegetation to specific operations under the WUP. However, 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 during the WUP.

2.5 Schedule

Monitoring is scheduled to occur in Years 1 and 5 of the monitoring program. The appropriate seasonal timing to acquire air photos and for ground-truthing will be based on trade-offs between:

1) Observing vegetation during the growing season.

2) Having appropriate reservoir elevations.

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

2.6 Budget

Table 4-2 summarizes the budget by labour and expenses. A large contingency of 25 per cent is included in the budget to attempt to account for the anticipated challenge of timing data collection days with low discharge and suitable weather to allow access. This contingency would only be used if such logistical challenges were encountered. Costs are estimated in 2006 dollars and total inflation costs are included on the second to last line.

Table 4-2: Estimated Budget for the Big Falls Reservoir Sedge Habitat Maintenance Monitoring

Task	Labour		Units		
		Daily rate	Yr 1	Yr 5	Total Cost
Project coordination	Lead biologist	$600	1	1	$1,200
Air photo interpretation	Lead biologist	$600	3	3	$3,600
GIS mapping	GIS technician	$600	2	2	$2,400
Ground truthing	Lead biologist	$600	3	3	$3,600
	Technician	$350	3	3	$2,100
Travel / mobilization	Lead biologist	$600	1	1	$1,200
	Technician	$350	1	1	$700
Develop database	Lead biologist	$600	1		$600
Data entry	Technician	$350	1	1	$700
Analysis	Lead biologist	$600	2	2	$2,400
	Technician	$350	1	1	$700
Reporting	Lead biologist	$600	5	5	$6,000
	Technician	$350	1	1	$700
	Contingency	25%	$6,394	$6,244	$12,639
		Subtotal	*$19,644*	*$18,894*	*$38,539*
	Expenses	Unit Price			
	Accommodation	$100	6	6	$1,200
	Meals	$40	6	6	$480
	Truck mileage	$0.55	50	50	$55
	Boat and fuel	$20	3	3	$120
	Travel to Prince Rupert (per person)	$700	2	2	$2,800
	Charter to site (entire crew)	$1,200	1	1	$2,400
	Air photos	$7,900	1	1	$15,800
	Field supplies	$500	1	1	$1,000
	Report reproduction	$400	1	1	$800
		Subtotal	*$12,328*	*$12,328*	*$24,655*
	Inflation	2%	$639	$3,250	$3,889
		Total	**$32,611**	**$34,471**	**$67,083**

3.0 References

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Big Falls Reservoir Tributary Backwatering Monitoring

1.0 Monitoring Program Rationale

1.1 Background

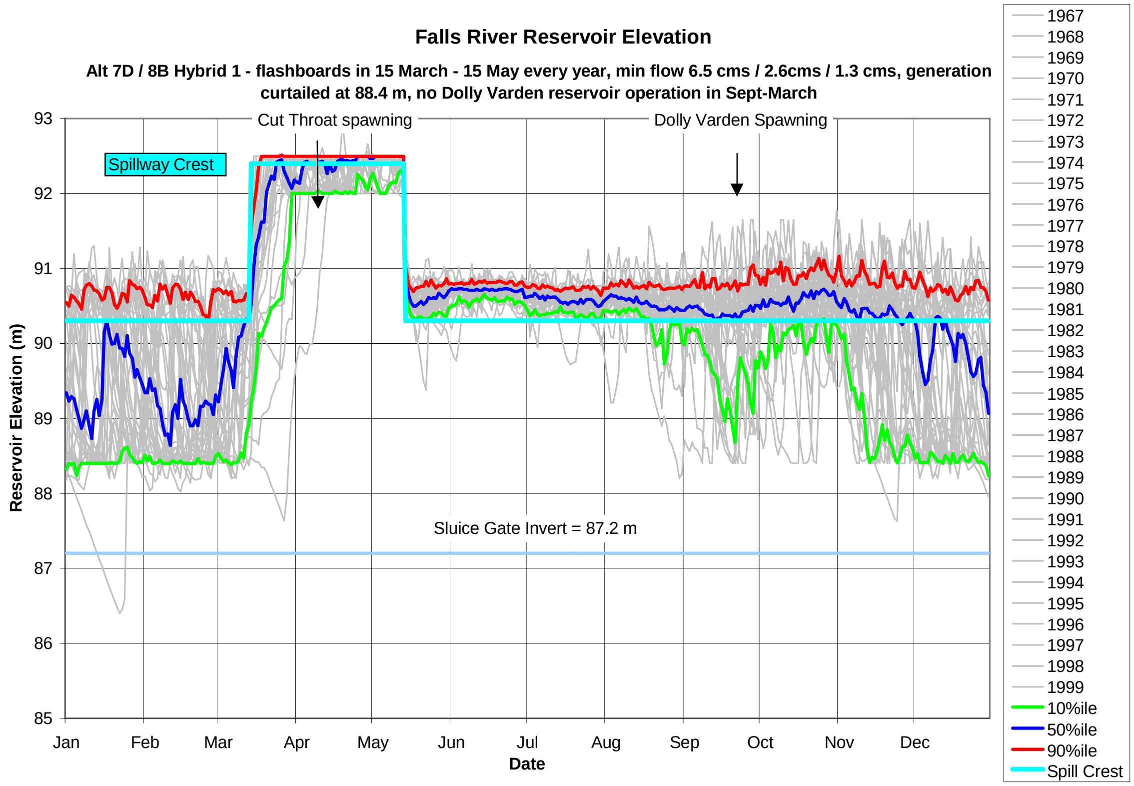
The Consultative Committee (CC) for the Falls River Water Use Plan (WUP) expressed concern that the operation of the Big Falls Reservoir may affect spawning and incubation habitat conditions for Dolly Varden char (Salvelinus malma) and cutthroat trout (Oncorhynchus clarki) in sections of tributaries that flow through the reservoir drawdown zone. Backwatering or inundation of the connecting tributaries occurs when reservoir levels rise. The affected sections of the tributaries become part of the reservoir, losing their channel-like features as stream flow is reduced (or no water flow) and water deepens. If Dolly Varden[5] or cutthroat trout spawn in sections of tributaries within the drawdown zone, the redds are then susceptible to inundation from rising reservoir levels. Redd inundation after spawning and before fry emergence will potentially reduce egg-to-fry survival by affecting (a) intra-gravel water flow which supplies oxygen and removes metabolic wastes from eggs and alevins, and (b) the rate of sediment deposition on redds which influences an alevin's ability to emerge from the gravel.

To prevent Dolly Varden and cutthroat trout from spawning in the drawdown zone, and thus minimize the risk of redd inundation, the CC developed a number of reservoir operating alternatives for the WUP that would maintain high reservoir levels (> 90.3 or 92.0 m, local datum) during their spawning seasons. Dolly Varden and cutthroat trout spawn from 1 September – 30 October and 1 April – 15 May, respectively (see Appendix G of BC Hydro 2003). However, the CC recommended the reservoir operating alternative that maintains high reservoir levels, by installing flashboards at the Dam, during the cutthroat trout spawning period only (Table 5-1, Figure 5-1). The CC did not recommend an operating alternative that maintains higher reservoir levels (>90.3 m, without the use of flashboards) during the Dolly Varden spawning period and lower reservoir levels (<90.3 m) during the Dolly Varden egg incubation period.

Table 5-1: Reservoir Elevations of Interest when Specifying Reservoir Operating Alternatives Designed to Minimize the Inundation of Fish Spawning Areas in Reservoir Tributaries

Reservoir elevation	Description
<90.3 m	90.3 m = spillway elevation during bull trout spawning period under the WUP alternative. Also the minimum elevation target during the bull trout spawning period, for operating alternatives that were not selected during the WUP
90.3 to 91.0 m	91.0 m = normal high reservoir elevation during bull trout spawning under the WUP operating alternative.
91.01 to 92.4 m	92.4 m = spillway elevation and median reservoir elevation during cutthroat spawning under the WUP alternative, flashboards installed
>92.4 m	Elevations unaffected by reservoir operations (under any operating alternative)

[5] Past observations of Dolly Varden may have been bull trout (*S. confluentus)* (Lewis 2002).



Note: Elevations were modelled based on historic inflows. From Figure I-29 of the CC report (BC Hydro 2003).

Figure 5-1: Reservoir Elevations in the Big Falls Reservoir under the "WUP Operations" Operating Alternative (Alt 10 or Alt 7D / 8B Hydrid 1)

The benefit to the Dolly Varden population was uncertain because:

1) It is not known if fish spawn in the drawdown zone of the reservoir or if habitat in the drawdown zone is suitable for spawning.

2) The effects of inundation on egg-to-fry survival are not known; incubation conditions of inundated redds may remain adequate for survival.

To help reduce these uncertainties, the CC recommended monitoring spawning in the drawdown zone. This section outlines a monitoring program for the drawdown zone of the Big Falls Reservoir to determine if suitable lotic spawning habitat is available for either species, as well as to determine the occurrence of spawning Dolly Varden. Monitoring will include surveying for Dolly Varden during their spawning period. The potential of cutthroat trout spawning in the drawdown zone will be based on detection of suitable spawning habitat, as reservoir operations inundate the drawdown zone during the spawning period likely discouraging cutthroat trout from spawning in this area (Figure 5-1).

1.2 Management Questions

The key management question for this monitoring program is:

1) Are there suitable spawning habitat conditions for Dolly Varden or cutthroat trout in the tributary habitat in the drawdown zone of the Big Falls Reservoir?

2) Do Dolly Varden spawn in tributary habitat in the drawdown zone of the Big Falls Reservoir?

If the monitoring program determines that Dolly Varden spawn in the drawdown zone, future planning processes may examine:

1) Whether reservoir operations affect key physicochemical parameters known to affect egg incubation (i.e., water temperature and intra-gravel flow).

2) Whether reservoir operations affect the egg-to-fry survival in these redds.

3) What proportion of the spawning population spawns in the drawdown zone.

1.3 Detailed Hypotheses

The primary hypotheses[6] to be tested are:

H_1: Tributary habitat in the drawdown zones contains suitable gravel for Dolly Varden or cutthroat trout spawning.

H_2: Dolly Varden spawn in tributary habitat in the drawdown zone of the Big Falls Reservoir.

1.4 Key Water Use Decision Affected

The key water use decision affected by the results of the monitoring program would potentially be the operation of the Big Falls Reservoir during the spawning and incubation periods for Dolly Varden and cutthroat. Specifically, the CC was interested in the impacts of the WUP operating regime to Dolly Varden spawning. Monitoring will help to better estimate these impacts. The benefits of WUP operations to cutthroat trout spawning will be inferred from monitoring Dolly Varden spawning. Results may also affect the calculation of the performance measure associated with the objective to minimize back-watering of spawning and rearing habitat during future planning processes, and, therefore, potentially affect the chosen operational alternative. Reservoir operations affect power production, fish habitat in the reservoir and tributaries, reservoir vegetation and wildlife, and flows for fish downstream in the Falls River.

[6] For clarity, hypotheses are stated as alternate hypotheses. Analyses will test the null hypothesis of no effect or difference

2.0 Monitoring Program Proposal

2.1 Objective and Scope

The primary objective of the monitoring study is to determine whether Dolly Varden and cutthroat trout spawn in tributaries within the drawdown zone of the Big Falls Reservoir. The geographic scope of the monitoring will cover three reservoir tributaries where spawning may occur[7]: Big Falls Creek, Carthew Creek, and the unnamed tributary that drains Hayward Lake. The effective drawdown will be considered elevations <92.4 m (discussed below) and monitoring will focus on these elevations. To ensure that sampling in the drawdown zone is effective at identifying spawning areas, limited sampling will also occur at elevations >92.4 m.

2.2 Approach

The monitoring approach is to assess whether habitat in the drawdown zone is suitable for spawning, and to visually search for evidence of Dolly Varden spawning. The location and corresponding elevation of redds observed in the drawdown zone will be a key result that can be used to estimate the extent of redd inundation due to reservoir operations. This information can also be used during future planning processes to estimate redd inundation under the WUP operating alternative relative to other operating alternatives, design new operating alternatives, and calibrate performance measures to examine inundation concerns.

Elevations for Dolly Varden spawning

Dolly Varden spawning at elevations up to 91 m are susceptible to inundation under the WUP operating alternative. These elevations will be examined by the monitoring study because they are of interest for comparing reservoir operating alternatives. Operating alternatives designed to minimize inundation of Dolly Varden spawning areas are maintained reservoir elevations of >90.3 during the Dolly Varden spawning season, but elevations normally fluctuated up to 91 m (see Figure I-13 BC Hydro 2003, and Table 5-1 this document).

Elevations for cutthroat spawning

Cutthroat spawning at elevations up to 92.4 m are susceptible to inundation under various operating alternatives examined during the WUP. To help make inferences for cutthroat spawning, observations of Dolly Varden spawning will also be made at elevations up to 92.4 m (Table 5-1). That is, if Dolly Varden are found to spawn at elevations up to 92.4 m, then it is possible that cutthroat trout could spawn at those elevations (despite differences in spawning selection between these species), if those elevations were available and not backwatered during the cutthroat spawning period. Under the WUP operating alternative, flashboards are installed to increase the reservoir water level and discourage cutthroat spawning below 92.4 m.

[7] Dolly Varden were captured in Big Falls Creek upstream of the reservoir during the 1990s, and were observed spawning in the upper reaches of Big Falls Creek (summarized in Lewis 2002).

2.3 Methods

Two site visits during the Dolly Varden spawning period are anticipated for this monitoring study. The first site visit will entail physical measurements of the sites (Task 2) and surveying for spawners (Task 3). The second visit requires only surveying for spawners (Task 3).

2.3.1 Task 1: Survey Planning

To help plan the logistics of site access and equipment requirements for the field survey in this remote location, the proponent can obtain the air photos that were acquired in Year 1 of the Big Falls Reservoir Sedge Habitat Maintenance Monitoring Program.

2.3.2 Task 2: Spawning Habitat Assessment

Suitability for spawning will be assessed in the following steps:

Delineate Drawdown Zone

Establish permanent benchmark at the top of the drawdown zone (e.g., using differential levelling from the water elevation at the time of the survey) and use this as the zero distance for stream measurements. Use differential levelling (e.g., survey level and stadia rod) to mark off the key elevations described in Table 5-1. The spawning habitat assessment should survey down to the lowest elevation possible. Median reservoir elevations during the Dolly Varden spawning and sampling period are ~90.5 m (Figure 5-1), and surveys timed for low reservoir elevations would be more informative. Coordination with the facility operators may assist with this timing.

Assess Potential Spawning Gravel

Crews will measure or visually estimate (by foot or snorkel) the area that contains suitable spawning substrate for Dolly Varden and cutthroat. The survey will follow the methods of the “Spawning gravel amount and type” section of the BC Level I Fish Habitat Assessment Procedure (Johnson and Slaney 1996). Substrate criteria for resident trout and char will be used (Ford et al. 1995; McPhail and Baxter 1996). Data will be reported for each tributary elevation section (Table 5-1). Photographs will document potential spawning locations.

This spawning habitat survey will provide a coarse level assessment of spawning potential. Cutthroat trout and particularly Dolly Varden have specific spawning requirements for water depth, velocity, substrate, proximity to cover, and groundwater upwelling (e.g., summary in McPhail and Baxter 1996). Detailed measurements of all of these variables are beyond the scope of this work. Observations of fish spawning (described below) will verify the suitability of these spawning locations.

Site Selection

Two study sites and a control site will be selected in each tributary to determine if physicochemical characteristics of the drawdown zone are suitable for egg incubation. Selected sites should be typical to Dolly Varden spawning habitat. The two study sites should occur within the drawdown zone and the control site occur outside of the drawdown zone (i.e., elevation >92.4 m).

Measurement of Physicochemical Parameters

Continuous Measurements

- Temperature.

To measure ambient temperature of the tributaries, four water temperature data loggers will be installed at each tributary. Two loggers will be placed upstream of the drawdown zone (>92.4 m) and the others placed within the drawdown zone on the first site visit. Loggers should be placed in housing that will shield them from damage. Data will be downloaded from the loggers on the second site visit and if logistically possible (i.e. by another monitoring program), loggers will remain on site to record temperature until the end of the Dolly Varden incubation period. Otherwise, loggers should be removed on the second site visit. Water temperature data will be used to:

1) Determine whether water temperatures are suitable for Dolly Varden spawning (approximately <9ºC), and egg incubation (<5º; reviewed in McPhail and Baxter 1996).

2) Calculate developmental timing, particularly time to hatch, since peak O_2 demand is often prior to hatch. This information could be used to develop the timing for a Dolly Varden spawning performance measure during future planning processes.

Spot Measurements

- Permeability.
- Dissolved oxygen (DO).
- Temperature.
- Velocity.
- Depth.

To determine the ability of the substrate to transmit water to incubating eggs, five replicate measurements of permeability should be taken at each site using a standpipe and pump (e.g., methods described in Barnard and McBain 1994). The standpipe and pump can also be used to obtain measurements of DO and temperature of the intragravel water to assess if levels are adequate to support incubating eggs. Intragravel samples should be collected from a depth of 15 cm below the surface of the substrate and ambient samples of DO and water temperature measurements should be taken adjacent to the intragravel location. Velocity of the surface water will be measured at 0.6D using an electromagnetic-sensored flow meter (e.g., Marsh McBirney Flo-Mate 2000) to determine if standing water is occurring or if stream flow is severely reduced from the inundation. Measurements of DO, temperature, and velocity should be taken in triplicate. Water depth will be delineated based on reservoir elevation.

Substrate Composition

To assess surface substrate composition, Wolman pebble counts (see Bain 1999) will be conducted at each site during each sampling period. Surface composition will provide a rapid, qualitative indication of differences among sites. Substrate composition will be summarized for Wolman count estimates as percent composition of all bed material size distribution, as per BC RIC Standards (2001).

2.3.3 Task 3: Observing Evidence of Spawning

The drawdown zone for all three tributaries will be examined for evidence of Dolly Varden spawning. Surveys will document the presence of mature Dolly Varden, Dolly Varden redds, or active spawning or pairing. Snorkel and foot surveys will be used to observe evidence of spawning. Surveys will extend from the top of the drawdown zone to the reservoir. The location and corresponding elevation of all spawning evidence will be recorded and subsequently tabulated by reservoir elevation category (Table 5-1). From a sub-sample of redds, crews will carefully excavate a small portion of the redd and search for eggs to confirm that observed redds are properly identified.

Snorkel surveys will follow standard snorkel procedures. Underwater visibility will be measured at each site with a dark object or secchi disk. The number, estimated fork length, and maturity (colouration) of all observed fish will be recorded.

If no evidence of spawning is observed in the drawdown zone, the extent of the surveys will be expanded to determine whether spawning Dolly Varden are present outside of the drawdown zone, and whether the observation methods are able to detect spawning. Surveys will be expanded to:

1) Cover the section of the tributary upstream from the drawdown zone.

2) The mouth of the tributary to determine if fish are holding prior to entering the tributary. On Vancouver Island, Dolly Varden are known to enter spawning tributaries as flows increase and water temperatures drop below 4–8ºC (MJL Environmental Consultants 2003).

2.3.4 Task 4: Data Entry

The proponent will develop a Microsoft Access database and enter all data. The proponent will also, through consultation with the Ministry of Environment representative from Smithers, enter the fish data into the provincial database using Mini FDIS, http://srmwww.gov.bc.ca/fish/fdis/index.html.

2.3.5 Task 5: Reporting

Final Report

A report will be compiled which will include:

1) An executive summary of the entire project.

2) Methods employed including mapping of assessment sites.

3) A data summary.

4) Environmental data collected, presented in tabular and graphical form.

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

6) An assessment of the effects of the WUP operating regime on Dolly Varden and cutthroat redd inundation.

7) Any recommendations towards future monitoring (if any) needed to determine whether Dolly Varden or cutthroat are affected by inundation.

All reports will be provided in hard-copy and as Microsoft Word and 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. All photos will be submitted electronically.

2.4 Interpretation of Monitoring Program Results

This monitoring program will assist in reducing the uncertainties relating to the Dolly Varden population that were addressed above in Section 1.1 Background:

1) Are the drawdown zones suitable for spawning?

2) Do fish spawn in the drawdown zones?

3) Does inundation reduce egg-to-fry survival?

4) Does this reduction in egg-to-fry survival have a population level effect on fish populations?

The monitoring program primarily focuses on investigating the first two questions whereas the third and fourth question will depend on the outcome of the previous questions. By investigating the first two questions, there are at least four possible results from the monitoring (Table 5-2). Result 1 would indicate that inundation may affect Dolly Varden redds. The effects of this inundation on the Dolly Varden population may require further examination, which is beyond the scope of the monitoring program (see Section 1.2 above). Results 2 and 4 would indicate that inundation would not affect Dolly Varden. Result 3 is more ambiguous and may result from several uncertainties, such as the current abundance of the Dolly Varden population in the watershed, the timing and location of spawning in the tributaries, and the accuracy of sampling.

Table 5-2: Possible Monitoring Results

Result	H_1: Suitable spawning gravels present?	H_2: Evidence of Dolly Varden spawning observed?	Evidence of spawning outside of drawdown zone?
1	Y	Y	-
2	Y	N	Y
3	Y	N	N
4	N	N	-

Note: These results can be tabulated for each reservoir elevation group in Table 5-1.

Inferences for cutthroat spawning from these data are uncertain. Result 1 would indicate that cutthroat could potentially spawn in the drawdown (if it were not inundated during the cutthroat spawning period under the WUP operations). Result 4 would indicate that cutthroat would not spawn in the drawdown zone. Results 2 and 3 would be ambiguous because selection of spawning sites by cutthroat and Dolly Varden can differ. For example, cutthroat and Dolly Varden were not observed to spawn at the same locations in a Vancouver Island watershed (MJL Environmental Consultants 2003). Cutthroat spawned extensively in tributaries within the drawdown zone whereas few Dolly Varden redds were observed.

The third uncertainty relating to the Dolly Varden population is that inundation of redds may reduce egg-to-fry survival. Results will indicate how incubation conditions change when the tributaries are backwatered. The observed physicochemical nature of the incubation habitat can be compared to published biostandards for Dolly Varden to determine the adequacy of incubation conditions during periods of inundation and non-inundation. The results of this comparison will be used to infer survival success of incubating eggs.

2.5 Schedule

In order to coordinate with other monitoring programs, the tributary inundation monitoring program is scheduled to occur in Year 2 of the Falls River WUP Monitoring Program. Surveys will occur during the Dolly Varden spawning period from 1 September to 30 October.

2.6 Budget

Table 5-3 summarizes the budget by labour and expenses. A large contingency of 25 per cent is included in the budget to attempt to account for the anticipated challenge of timing data collection days with low discharge and suitable weather to allow access. This contingency would only be used if such logistical challenges were encountered. The budget assumes that three visits to the site are required per year. Costs are estimated in 2006 dollars and total inflation costs are included on the second to last line.

Table 5-3: Estimated Budget for the Big Falls Reservoir Tributary Backwatering Monitoring

Task	**Labour**		Units	
		Daily rate	Yr 2	Total Cost
Project coordination	Lead biologist	$600	1	$600
Survey planning	Lead biologist	$600	1	$600
Field survey	Lead biologist	$600	4	$2,400
	Technician	$350	4	$1,400
Travel / mobilization	Lead biologist	$600	2	$1,200
	Technician	$350	2	$700
Data Entry	Lead biologist	$600	1	$600
	Technician	$350	1	$350
Reporting	Lead biologist	$600	5	$3,000
	Contingency	25%	$5,446	$5,446
		Subtotal	*$16,296*	*$16,296*
	Expenses	Unit Price		
	Accommodation	$100	8	$800
	Meals	$40	8	$320
	Boat supplies	$20	4	$80
	Truck mileage	$0.55	50	$28
	Travel to Prince Rupert (per person)	$700	4	$2,800
	Charter to site (entire crew)	$1,200	2	$2,400
	Temperature loggers	$215	12	$2,580
	Field supplies [a]	$1,500	1	$1,500
	Fish collection permit (inspect redds)	$25	1	$25
	Report reproduction	$400	1	$400
		Subtotal		*$10,933*
	Inflation	2%	$1,100	$1,100
		Total	**$28,328**	**$28,328**

[1] Includes rental of survey gear, digital camera, GPS, standpipe and pump, flow meter, DO meter, and dry suits.

Note: This work is scheduled to occur in Year 2 of the Falls River WUP Monitoring Program.

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Big Falls Reservoir Wildlife Shoreline Habitat Monitoring

1.0 Monitoring Program Rationale

1.1 Background

The Consultative Committee (CC) for the Falls River Water Use Plan (WUP) expressed concern that changes to the seasonal operation of the Big Falls Reservoir would flood wildlife nesting and denning sites. Specifically, the CC was concerned that wildlife species may establish nests or dens around the reservoir at elevations below 92.4 m (local datum) during the period prior to flashboard installation, which can occur from 15 February to 15 March each year. Installation of the flashboards can raise the reservoir elevation from 90.3 to 92.4 m and should benefit reservoir vegetation, cutthroat spawning, and power generation. However, nests and dens at these elevations could be at risk of flooding when the flashboards are installed.

One objective during the WUP was to maximize the abundance and diversity of wildlife using the area around the Big Falls Reservoir. A sub-objective was to minimize stranding and/or flooding of bird nest or wildlife dens in the drawdown zone of the reservoir, and specific performance measures were developed to quantify the risk of stranding. Reservoir operating alternatives examined by the Consultative Committee differed in the timing and magnitude of flooding. However, it was not known whether nests and dens are present and susceptible to flooding, and thus it was difficult estimate the effects of flooding on wildlife under various operating alternatives. These alternatives differed in the timing and magnitude of flooding.

To help reduce this uncertainty, the CC recommended that nests and dens be monitored. This section outlines a monitoring program that will determine whether nests and dens are present in the drawdown zone of the Big Falls Reservoir.

1.2 Management Questions

The key management questions are:

1) Is there active nesting and denning in the drawdown zone of the Big Falls Reservoir at elevations and during periods when they may be flooded when flashboards are installed?

2) Does the extent of nest and den flooding under WUP operations differ from the flooding that would occur under the base case operations?

The CC hypothesized that installing flashboards in the spring (Figure 4-3) would benefit reservoir vegetation, cutthroat spawning, and power generation. However, it was not known whether this operating alternative would risk flooding wildlife nests and dens.

1.3 Ecological Hypothesis

The primary hypothesis[8] to be tested is:

H_1: During the period prior to flashboard installation, wildlife nests and dens are present below 92.4 m in the drawdown zone of the Big Falls Reservoir.

1.4 Key Water Use Decision Affected

The key water use decision affected by the results of the monitoring program would potentially be the operation of the Big Falls Reservoir, particularly the operation of the flashboards from 15 February to 15 May. In addition, results may affect the calculation of wildlife performance measures during future planning processes, and, therefore, potentially affect the chosen operational alternative. Reservoir operations affect power generation, reservoir vegetation, fish habitat in the reservoir and tributaries, and flows for fish downstream in the Falls River.

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 wildlife in the drawdown zone of the Big Falls Reservoir. Surveys will estimate the number of nests and dens that are present in the drawdown zone. The geographic scope of the monitoring will include the drawdown zone of the Big Falls Reservoir from 90.3 to 92.4 m.

2.2 Approach

The monitoring approach is to collate existing information on wildlife use in the drawdown zone, and carry out surveys in the drawdown zone to search for nests and dens that may become flooded when flashboards are installed.

2.3 Methods

2.3.1 Task 1: Obtain and Summarize Local Knowledge and Traditional Ecological Knowledge

The proponent will collate existing information on wildlife in the Big Falls Reservoir. The proponent will:

1) Interview individuals that have local knowledge and traditional ecological knowledge, including individuals from local First Nations, Falls River facility staff, and provincial wildlife specialists.

2) Review existing information sources (e.g., the wildlife summary in Section 4.2 of the CC report, BC Hydro 2003).

[8] For clarity, this hypothesis are stated as alternate hypothesis. Analyses will test the null hypothesis none present.

Information on the species present and potential locations of their nest and den sites will be used to help plan the field survey (below).

2.3.2 Task 2: Air Photo Analysis and Survey Planning

To help plan the field surveys, the proponent will obtain and analyze the air photos that are acquired under the Big Falls Reservoir Sedge Habitat Maintenance Monitoring Program (described above)[9]. The drawdown zone at elevations below 92.4 m will be viewed on the air photos to note habitats where nests or dens may be present.

The proponent will plan a field survey of the reservoir drawdown zone (see Task 4 below) based on the air photo interpretation, information obtained under Task 1, and survey budget outlined in Table 6-1.

2.3.3 Task 3: Field Survey

The reservoir drawdown zone below 92.4 m will be surveyed for nests and dens. Nests and dens will be identified by locating entrances, digging, fur and feather signs, tracks and scats. Also, animals may be observed directly.

The following will be collected at each nest or den:

1) Location, measured with GPS.

2) Elevation, measured relative to the water's edge by differential levelling using a survey level and stadia rod. Reservoir elevations during the survey can later be obtained from BC Hydro.

3) A biological description of the den (species, lifestage present etc.).

4) Photos and a site description.

Surveys will occur before flashboards are installed, which can occur between 15 February to 15 March each year.

2.3.4 Task 4: Data Entry

All data including photographs will be entered into a Microsoft Access database.

2.3.5 Task 5: Reporting

A brief, summary data report will be prepared following the first field survey in Year 2 that summarizes the nests and dens that were located in the drawdown zone.

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[9] The air photo component of Task 2 of the Wildlife Monitoring Program may be completed under Task 3 of the Sedge Habitat and Vegetation Monitoring Program, if the same individuals implement these programs.

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

1) An executive summary of the entire project.

2) Methods employed.

3) A summary of local and traditional ecological knowledge.

4) A description of the nests and dens located in the drawdown zone, including a frequency distribution of nests and dens by elevation.

5) A detailed summary of the findings as they relate to the ecological hypothesis and the key management questions.

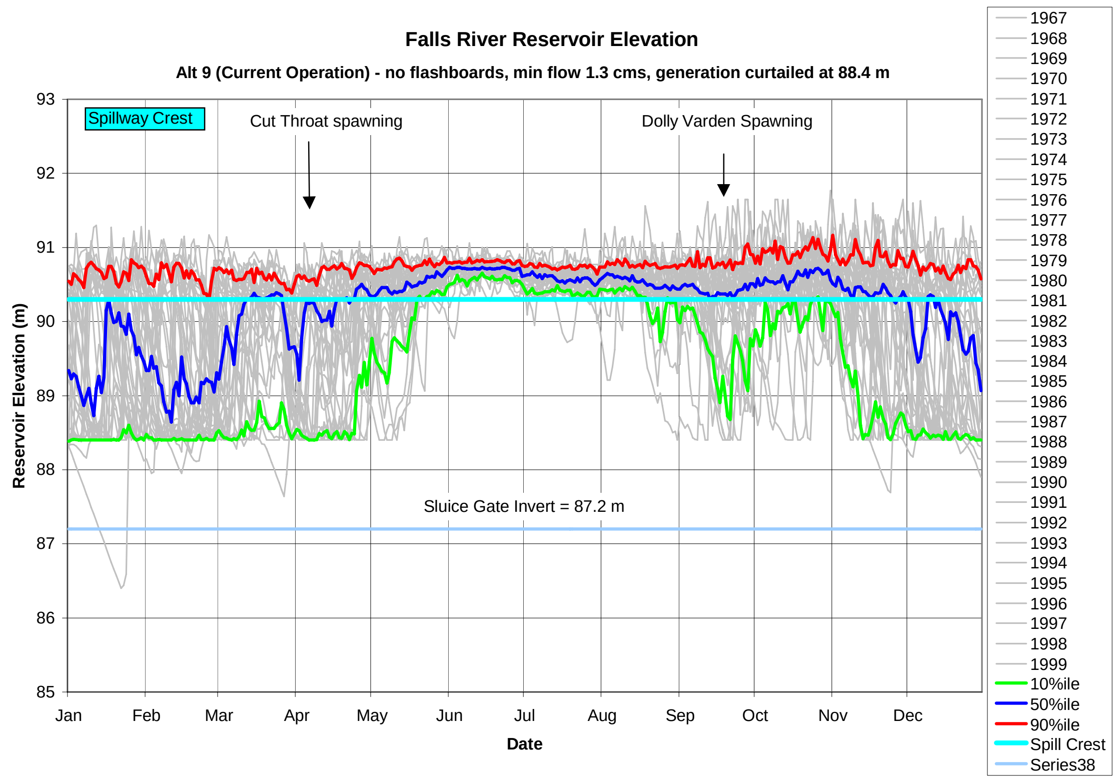
6) A final assessment of the effects of the new operating regime on wildlife nests and dens in the drawdown zone.

7) Any recommendations towards future monitoring (if any) needed to determine the effects of reservoir operations on wildlife.

All reports will be provided in hard-copy and as Microsoft Word and 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. All photos will be submitted electronically.

2.4 Interpretation of Monitoring Program Results

The key result is whether wildlife nests and dens are present and could be flooded when flashboards are installed. The number of nests and dens that are flooded each year under WUP operations will be estimated from the survey data. For comparison, the number of nests and dens that would have been flooded under the pre-WUP, base case operations (no flashboards, elevations <91.0 m, Fig. 6-1) can also be estimated from the survey data.



Note: Elevations were modelled based on historic inflows. From Figure I-25 of the CC report (BC Hydro 2003).

Figure 6-1: Reservoir Elevations in the Big Falls Reservoir under the "Current Operations" or "Base Case" Operating Alternative (Alt 9A)

2.5 Schedule

Monitoring is scheduled to occur in Years 1, 2 and 3 following implementation of the WUP. In Year 1, crews will collate local knowledge, analyze air photos, and plan the field survey. Field surveys will occur prior to flashboard installation in Years 2 and 3.

2.6 Budget

Table 6-1 summarizes the budget by labour and expenses. A large contingency of 25 per cent is included in the budget to attempt to account for the anticipated challenge of timing data collection days with low discharge and suitable weather to allow access. This contingency would only be used if such logistical challenges were encountered. The budget assumes that three visits to the site are required per year. Costs are estimated in 2006 dollars and total inflation costs are included on the second to last line.

Table 6-1: Estimated Budget for the Big Falls Reservoir Wildlife Shoreline Habitat Monitoring

Task	Labour		Units			
		Daily rate	Yr 1	Yr 2	Yr 3	Total Cost
Project coordination	Lead biologist	$600	1	1	1	$1,800
Air photo analysis	Lead biologist	$600	1			$600
Data summary	Lead biologist	$600	3			$1,800
(TEK)	Technician	$350	3			$1,050
Field sampling	Lead biologist	$600		3	2	$3,000
	Technician	$350		3	2	$1,750
Travel / mobilization	Lead biologist	$600	1	1	1	$1,800
	Technician	$350	1	1	1	$1,050
Develop database	Lead biologist	$600	1			$600
	Technician	$350	1			$350
Data entry	Technician	$350	1	1	1	$1,050
Reporting	Lead biologist	$600		5	5	$6,000
	Contingency	25%	$2,188	$2,944	$2,682	$7,814
		Subtotal	*$8,488*	*$10,694*	*$9,482*	*$28,664*
	Expenses	Unit Price				
	Accommodation	$100	2	2	2	$600
	Meals	$40	6	6	4	$640
	Boat and fuel	$20		3	2	$100
	Truck mileage	$0.55	200	50	50	$165
	Travel to Prince Rupert (per person)	$700	2	2	2	$4,200
	Charter to site (entire crew)	$1,200		1	1	$2,400
	Field supplies [a]	$500	1	1	1	$1,500
	Report reproduction	$400		1	1	$800
		Subtotal	*$2,450*	*$4,028*	*$3,928*	*$10,405*
	Inflation	2%	$219	$595	$821	$1,634
		Total	**$11,156**	**$15,317**	**$14,230**	**$40,703**

[1] Includes miscellaneous expenses to obtain local knowledge and traditional ecological knowledge in Year 1. Includes rental of survey gear, digital camera, and GPS in Years 2 and 3.

3.0 References

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