# Falls River Water Use Plan

# Monitoring Program Synthesis Report

- **FLSMON-1 Falls River Presence and Timing of Steelhead and Salmon Monitoring**
- **FLSMON-2 Falls River Fish Spawning Habitat Monitoring**
- **FLSMON-3 Big Falls Reservoir Tributary Access and Potential Stranding Monitoring**
- **FLSMON-4 Big Falls Reservoir Sedge Habitat Monitoring**
- **FLSMON-5 Big Falls Reservoir Backwatering Monitoring**
- **FLSMON-6 Big Falls Reservoir Wildlife Shoreline Habitat Monitoring**

**May 20, 2022**

**Draft Report**

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Falls River Generating Station and Dam (A. Hall 2011).

# Executive Summary

The Falls River Water Use Plan (WUP) was initiated in October 2002 and finalized in May 2003. In April 2006, the Comptroller of Water Rights (CWR) issued an Order (the "WUP Order") under the *Water Act*[1] in response to the Falls River WUP that included the implementation of the WUP operating regime and the undertaking of six monitoring projects to assess for anticipated benefits to fish, fish habitat and possible impacts on shoreline habitat for wildlife. The monitoring programs included four programs that looked at vegetation, wildlife, and habitat availability in the reservoir inundation zone, as well as stranding potential and tributary access. In the Lower Falls River tailrace area, there were two monitoring programs completed that investigated minimum flows, spawning habitat availability and salmon presence and timing. The CWR did not require the undertaking of any physical works projects in the WUP Order.

This document was prepared as a part of the WUP Order Review process. It summarizes the outcomes from the monitoring projects and outlines whether the management questions have been addressed (Table E-1).

Below is a summary of key findings from the Falls River Water Use Plan:

**The study could not confirm that Steelhead or salmon species spawn in the Falls River tailpond**

- While no Steelhead or salmon spawning was observed during the study period, Pink and Chum were observed using the Falls River tailrace as a staging area. The timing for the spawning flow release is appropriate for Pink and Chum.

**Effect of Ordered minimum flow conditions for adequate egg-to-fry survival could not be determined in the Falls River Tailpond**

- The conditions were not adequate during egg and alevin development; however, there was no evidence to support that this was due to minimum flows. Incubation conditions were within the range considered adequate when the tailrace was not influenced by tidal backwatering.

**No migration barriers for Dolly Varden and Cutthroat Trout were observed in tributaries of Big Falls Reservoir, some suitable spawning habitat for Cutthroat Trout. Some stranding areas were noted.**

- There were no migration barriers found for adult Dolly Varden or Cutthroat Trout existing in Falls River, Carthew Creek or Hayward Creek.
- Suitable Cutthroat trout spawning habitat exists in tributaries within the drawdown zone and some suitable habitat for Dolly Varden was identified but no spawning was confirmed.
- The eastern and southern portion of the drawdown zone of Big Falls Reservoir was identified as having potential stranding areas but the modeled reservoir elevation range included the area that would be created by the flashboards, due to the flashboards never being used and subsequently discontinued, the stranding potential is greatly reduced.

[1] The *Water Act* was replaced by the *Water Sustainability Act* in February 2016; however, Orders and Water Licenses continue to be valid and are governed by the new *Water Sustainability Act*.

**Operation of the Big Falls Reservoir resulted in total sedge habitat area decreasing; total shrub/herb habitat increased**

- Vegetation changes are attributed to the lack of inundation that was modeled to occur with the use of flashboards.
- Flashboards were not used for the duration of the monitoring program and are now permanently removed.

**Impacts to mammal dens and bird nests**

- Vulnerable mammal dens were in the elevation zone scheduled to be affected by WUP flashboard operations.
- For bird nests, the effects of WUP flashboard operations would be unlikely to cause nest flooding.
- Flashboards were not used for the duration of the monitoring program and are now permanently removed.

**Table E1. Summary of objectives, management questions, outcomes, and operational implications for the Fall River WUP monitoring projects.**

| Project | Objectives | Management Questions | Response |
|---|---|---|---|
| FLSMON-1 Falls River Presence and Timing of Steelhead and Salmon Spawning Monitoring | To assess the timing of salmon and Steelhead presence and spawning in the Falls River. | 1. Do Salmon and Steelhead spawn in the Falls River tailrace?<br>2. When do salmon and Steelhead spawn in the Falls River tailrace?<br>3. Is the timing for the spawning flow release appropriate for salmon and Steelhead in the Falls River? | 1. The study could not confirm that Steelhead or salmon species use the Falls River tailrace for spawning.<br>2. No Salmon or Steelhead spawning was observed in the Falls River tailrace, but Pink and Chum were observed using the area as a staging area (Aug 1-Oct 15).<br>3. The periodicity review and the presence of Pink and Chum Salmon in from mid to late August to late September suggests the 1 August to 15 October timeframe is appropriate. |
| FLSMON-2 Falls River Fish Spawning Habitat Monitoring | To determine the effects of operations on salmon egg-to-fry survival in the Falls River downstream of the dam in the tailrace. | 1. Do the minimum flows for salmon spawning and egg incubation provided under the WUP operations produce adequate conditions for egg-to-fry survival? | 1. Overall, conditions were not adequate during egg and alevin development, though there was no evidence to support that this was due to minimum flows. The average egg-to-fry survival rate of 3.6% is at the very low end of the range for Chinook salmon. Incubation conditions – both habitat and physiochemical variables measured – were within the range adequate for incubation when the tailrace was not influenced by tidal backwatering. |
| FLSMON-3 Big Falls Reservoir Tributary Access and Potential Stranding Monitoring | To reduce uncertainty related to the presence of migration barriers for adult Dolly Varden char and Cutthroat trout and areas of potential stranding in Big Falls Reservoir. | 1. Are there migration barriers in tributaries within the area of potential drawdown for Big Falls Reservoir?<br>2. Are there locations where fish could be stranded along Big Falls Reservoir shoreline? | 1. No migration barriers for either Dolly Varden or Cutthroat Trout exist in Falls River, Carthew Creek or Hayward Creek within the drawdown zone<br>2. The eastern and southern portion of the drawdown zone of Big Falls Reservoir was identified from a desk top survey as having potential stranding areas but the modeled reservoir elevation range included the area that would be created by the flashboards. Due to the flashboards never being used and subsequently discontinued, the stranding potential is greatly reduced. |
| FLSMON-4 Big Falls Reservoir Sedge Habitat Maintenance Monitoring | To reduce uncertainty related to the effects of reservoir operations on reservoir vegetation in the Big Falls Reservoir. | 1. Does the operation of the Big Falls Reservoir recommended in the WUP maintain the sedge grass community? | 1. From 2007-2017 the total sedge habitat area decreased while shrub/herb habitat increased due to the lack of inundation previously provided from the use of flashboards. Flashboard use was discontinued in 2007 due to Dam safety risk. |

| Project | Objectives | Management Questions | Response |
|---|---|---|---|
| FLSMON-5 Big Falls Reservoir Tributary Backwatering Monitoring | To reduce the uncertainty about the susceptibility of Dolly Varden or Cutthroat trout spawn in the three tributaries to changes in reservoir level. | 1. Are there suitable spawning habitat conditions for Dolly Varden and Cutthroat trout in the tributary habitat in the drawdown zone of the Big Falls Reservoir?<br>2. Do Dolly Varden spawn in tributary habitat in the drawdown zone of the Big Falls Reservoir? | 1. Yes, suitable Cutthroat trout spawning habitat exists in tributaries in the drawdown zone above the 91.0 m elevation. Suitable habitat was noted for Dolly Varden above the 91.0 m elevation, but no spawning was confirmed.<br>2. The study did not find any evidence of Dolly Varden or Cutthroat spawning in tributary habitat within the drawdown zone of the reservoir. |
| FLSMON-6 Big Fall Reservoir Wildlife Shoreline Habitat Monitoring | To document and map dens and nests established by birds and mammals in the drawdown zone of the reservoir. | 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?<br>2. Does the extent of nest and den flooding under WUP operations differ from the flooding that would occur under the base case operations? | 1. Yes, for mammal denning and no, for bird nesting. This study identified that there is active mammal denning during the proposed flashboard installation period; however, the study also concluded that risk of nest flooding associated with the hypothetical WUP flashboard operation was low.<br>2. For mammal dens, yes, because vulnerable dens were in the elevation zone affected by WUP flashboard operations. For bird nests, no, because the effects of WUP flashboard operations would be unlikely to cause nest flooding. |

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# Table of Contents

# List of Figures

# List of Tables

# List of Abbreviations

**CC** Consultative Committee

**CWR** Comptroller of Water Rights

**DFO** Department of Fisheries and Oceans, Canada

**EFO** Environmental Field Operations, BC Hydro

**FLS** Falls

**BC ENV** BC Ministry of Environment and Climate Change Strategy

**TOR** Terms of Reference

**WLR** Water License Requirements

**WUP** Water Use Plan

# Falls River Water Use Plan
# Monitoring Program Synthesis Report

## 1.0 CONTEXT

The Falls River Water Use Plan (WUP) was accepted by the Comptroller of Water Rights (CWR) in 2003. In April 2006, the CWR issued an Order (the "WUP Order") under the *Water Act*[2] in response to the Falls River WUP that included the implementation of the WUP operating regime, and the undertaking of six monitoring projects to assess for benefits to fish, fish habitat and possible impacts on shoreline habitat for wildlife (Comptroller of Water Rights 2006). The CWR did not require the undertaking of any physical works projects in the WUP Order.

The six monitoring projects conducted from 2007 to 2011 were as follows:

***FLSMON-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 in the tailrace.

***FLSMON-2 Falls River Fish Spawning Habitat Monitoring:*** A four-year study to determine the effects of operations on salmon egg-to-fry survival in the Falls River downstream of the dam in the tailrace.

***FLSMON-3 Big Falls Reservoir Tributary Access and Potential Stranding Monitoring:*** A one-year study to survey the location of barriers within the drawdown of the reservoir and identify the location and size of potential areas of stranding along the shoreline of the drawdown zone.

***FLSMON-4 Big Falls Reservoir Sedge Habitat Maintenance Monitoring:*** A two-year study in Year 1 and 5 to document and map vegetation in the drawdown zone of the reservoir (Amended to delay the Year 5 survey until after safety improvements allow the use of flashboards).

***FLSMON-5 Big Falls Reservoir Tributary Backwatering Monitoring:*** A one-year study to survey for redds in the drawdown zone of the three reservoir 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.

***FLSMON-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.

The specific objectives of the Monitoring Program Synthesis Report are to:

1. Provide a summary of the objectives, activities, and results for each of the six monitoring projects;

[2] The *Water Act* was replaced by the *Water Sustainability Act* in February 2016; however Orders and Water Licences continue to be valid and are governed by the new *Water Sustainability Act*.

2. Relate monitor findings to the objectives of the WUP and provide any updates to these project findings from other work conducted after the projects were completed; and
3. Where management questions were not addressed, identify the data gaps that persist.

# 2.0 PROJECT BACKGROUND

## 2.1 Hydroelectric Facilities

BC Hydro's Falls River hydroelectric facility is located within the North Coast Regional District, approximately 50 kilometres southeast of Prince Rupert on Big Falls River immediately upstream of its confluence with the Ecstall River. A short section of the Big Falls River is located below the spillway and flows into Ecstall River, which is a tributary of the Skeena River (Figure 2.1). This site is within the traditional territory of the Lax Kw'alaams First Nation. The facilities are accessible by air or water only.

The Falls River hydroelectric facility is part of BC Hydro's provincially integrated generation system but also plays a role in the reliability of local electricity supply. The Falls River facility 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 Big Falls River via a tailrace downstream of the facility (Figure 2.2). The facility is comprised of the following components:

Concrete Gravity Dam: The dam is approximately 154 m in length and the maximum height of the dam (top of concrete) is 12 m at an elevation is 92.96 m above sea level.

Free Overflow Spillway: The crest of the free overflow spillway is approximately 75 m in length, at an elevation of 90.3 m. Note that when timber flashboards were installed in the past, the elevation was raised to 92.4 m; **however, flashboards are no longer used due to dam safety risks. In August 2021, the stanchions and flashboards were permanently removed and are no longer usable.**

Sluice Gates: There is a concrete crest at elevation 83.82 m with permanent sill logs extending up to the sluice gate sills at elevation 87.17 m. There are two functioning sluice gates – each measuring 6.1 x 6.1 m – that are programmed to open for spill control when the reservoir exceeds a set elevation. These gates are operated automatically by a Programmable Logic Controller (PLC) when the reservoir level is above the sill elevation (87.17 m). The minimum gate opening in the remote-control mode is 0.3 m, releasing approximately 7 $m^3$/s. When the reservoir elevation is at 92.96 m, the combined discharge capacity of the two sluice gates is 317 $m^3$/s.

Undersluice: There is a 1.5 x 1.5 m undersluice below the sluice gates at the sill elevation (inlet invert level) of 81.86 m. The undersluice can only be operated by local manual control and is not currently used for normal operation.

Big Falls Reservoir (or Headpond): The water surface area created by the dam is 340 hectares when the headpond is at an elevation of 92.4 m. The pre WUP operating range for the reservoir was from 92.4 m (with flashboards installed) down to 88.4 m (which is the threshold for a discretionary reduction in unit load to meet previous discharge levels for fish downstream). The live storage capacity of the headpond, the volume of water between the elevations of 85.5 m and 92.4 m (with Flashboard installed), is 11.5 million $m^3$ (133 $m^3$/s-days).

Penstock: Two steel pipes (each 1.83 m in diameter) carry water from the intake at the headpond to the powerhouse. Penstock #1 is 233 m in length and Penstock #2 is 235 m in length. Invert intake elevations for P1 and P2, are 82.30 and 83.84 m, respectively.

Powerhouse: The powerhouse holds two 3.5 megawatts (MW) Francis generating turbine units with a normal combined maximum output of 7 MW.

Generating Unit #1 (G1) and Generating Unit #2 (G2) have combined maximum discharge capacities of 21.7 $m^3$/s.

**Table 2.1. Falls River Facility general information. BC Hydro 2006a.**

| | |
|---|---|
| Dam Name | Falls River Dam |
| Year of Completion | 1930 |
| Dam Type | Concrete gravity |
| Dam Use | Hydroelectric generation |
| Dam Height | 12 m |
| Spillway Type | Free flow |
| Generating Station | Falls River Generation Station |
| Nameplate Capacity | 7 MW |
| Storage | 11.5 million $m^3$ |
| Reservoir Name | Big Falls Reservoir |
| Water Course | Falls River |
| Drainage Area | 246 $km^2$ |
| Reservoir Operating Range | 88.4 m – 90.3 (92.4 m if flashboards installed) |
| Nearest City | Prince Rupert |

## 2.2 Historic Falls River Facility Operations

The Big Falls Reservoir has relatively small storage capacity and narrow operating range. Prior to 2007 flashboards (timber panels to increase reservoir elevation) were installed on or around 15 May to surcharge the reservoir until 15 November when they were removed for the winter. The flashboards increased the operating elevation from 90.3 m to 92.4 m. Due to dam safety risk, flashboards are no longer used. As a result, the maximum normal operating elevation is currently 90.3 m.

Historic operations had few constraints. A minimum discharge of 1.3 $m^3$/s was implemented in the early 1990's to maintain suitable fish habitat downstream of the generation station. Just prior to initiating the WUP process, BC Hydro also adopted the practice of reducing generation when the reservoir decreased to 88.4 m to improve the ability to maintain minimum flows during periods of low inflows.

During periods of high inflows, when the reservoir reaches 92.5 m (0.1 m above spillway) the sluice gates open automatically to control further rise of the reservoir.

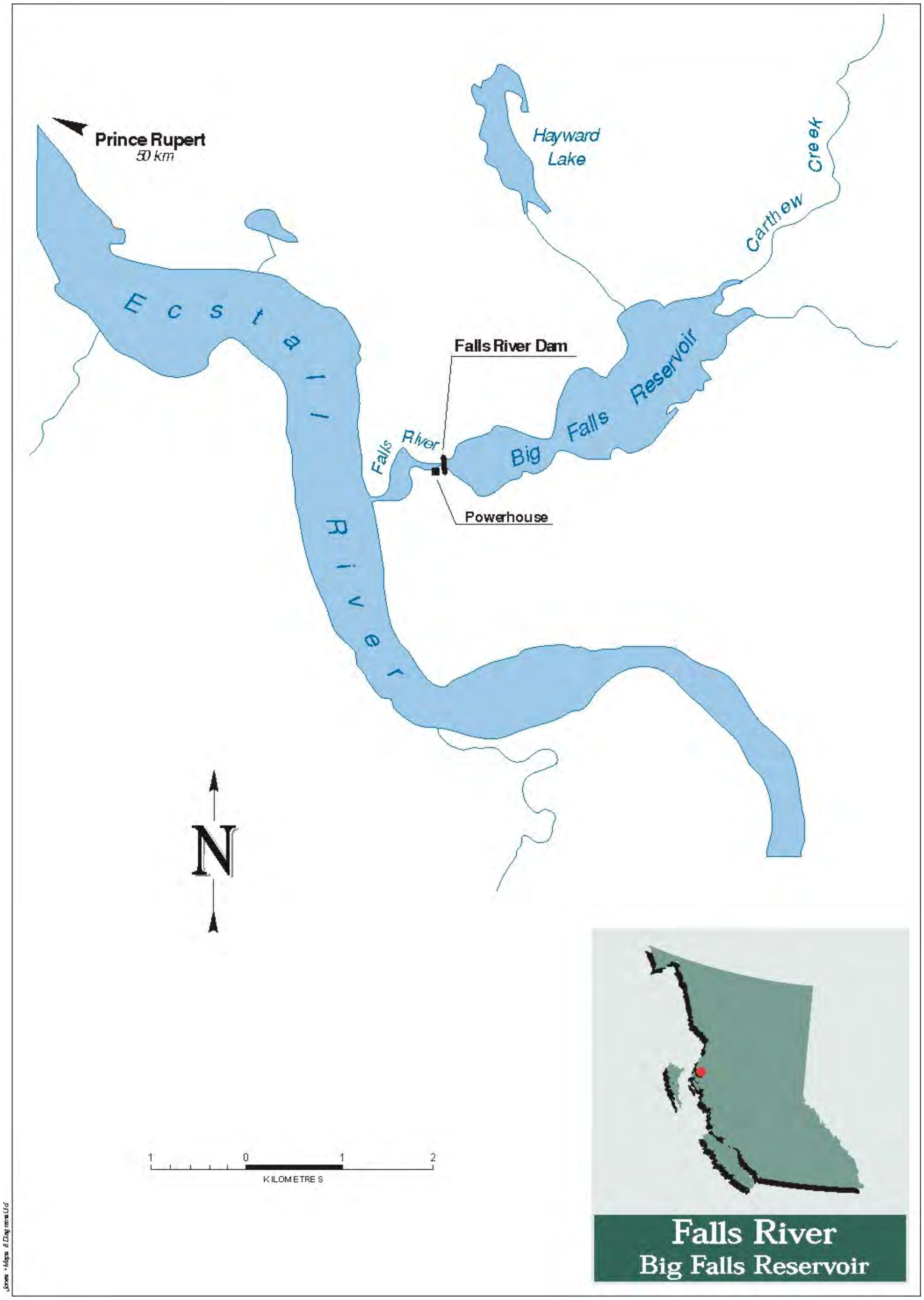


**Figure 2.1. Site map of Falls River Facility (powerhouse location not accurate).**


**Figure 2.2. Falls River Dam and Downstream Components**

## 3.0 Falls River WUP Process

The Falls River WUP process was implemented over a 5-year period starting in 2002 which followed the Water Use Guidelines developed by the Province (Province of British Columbia 1998). The process created the following outputs (in chronological order):

- Falls River WUP: Report of the WUP Consultative Committee (BC Hydro 2003) – documentation of the structured decision-making process which evaluated operating alternatives against objectives represented by the WUP Consultative Committee, and documented uncertainties that would define the study project for implementation following WUP approval.
- Falls River WUP (BC Hydro 2006) – submitted by BC Hydro to the (Comptroller of Water Rights) CWR as the summary of operating constraints and implementation commitments (monitors) to be appended to its Water Licences.
- Falls River Hydroelectric Facility Order (Comptroller of Water Rights 2006) – the *Water Sustainability Act* Order issued by the CWR to implement the WUP

as a condition of the two conditional water licenses (120736 and 120739) associated with the Falls River Hydroelectric projects.

- Water Licence Requirements (WLR) Terms of Reference (TOR; BC Hydro 2006) – for monitors ordered by the CWR; management questions and methodologies were prepared to address uncertainties defined in the WUP consultative process and submitted to the CWR for Leave to Commence.
- Project progress and annual watershed reports – reports summarizing annual data collection results for ordered projects were prepared and watershed activities were summarized each year in a watershed report and submitted to the CWR.

All reports are available on BC Hydro's WUP website at:

https://www.bchydro.com/about/sustainability/conservation/water_use_planning/northern_interior/falls_river.html

The WUP Consultative Committee identified uncertainty of the benefits associated with the following operating conditions (Table 3.1):

- Big Falls Reservoir Levels
- Minimum and maximum flows in Falls River downstream of dam by season, and
- Return to minimum flows as soon as possible after outages.

The monitoring projects were ordered to address the data gaps and uncertainties in the Falls River WUP and to assess whether the anticipated benefits from changes made under the WUP were achieved. Results from monitoring projects are reviewed upon completion as part of BC Hydro's WUP Order Review process, and the results are used and considered along with other values and information collected to support considerations and decisions during the WUP Order Review.

All WUP Terms of reference, including any revisions and addenda are reviewed by agencies and circulated to First Nations for review and comment prior to submission to the Comptroller of Water Rights.

The operating conditions under the Falls River WUP Order issued by the CWR are shown in Table 3-1.

**Table 3.1. WUP operating conditions for the Falls River Hydroelectric system (BC Hydro 2006a).**

| System Component | Constraint | Time of Year | Purpose |
|---|---|---|---|
| River | Minimum discharge 2.6 cms when reservoir is at or above EL 88.4 m. Minimum discharge 1.3 cms when reservoir is below EL 88.4 m. | Year round | Maximize habitat for fish in the river. |
| River | Minimum discharge 6.5 cms when reservoir is at or above EL 88.4 m. | 1 August – 15 October | Maximize fall spawning habitat for fish in the river. |
| River | Minimum discharge 2.6 cms when reservoir is at or above EL 88.4 m. | 16 October – 31 July | Maximize fall spawning and rearing habitat for fish in the river. |
| River | Maximum discharge 2.6 cms when reservoir is at or above EL 88.4 m and less than EL 92.0 m. | 15 March – 1 May | Maximize sedge flooding. |
| River | Unplanned outages – return to minimum flows as soon as possible. Planned outages – ensure the provision of minimum flow through the sluice gates before shutting down both generation units. | Year round | Ensure minimum discharge. |
| River | Ramping rates when discharge is between 1.3 cms and 6.3 cms – maximum rate of increase at the turbine of 1.3 cms over 10 minutes. | 15 February - 15 March | Avoid flushing juvenile fish from rearing habitat. |
| River | Ramping rates when discharge is between 1.3 cms and 6.3 cms – that the total project outflow changes at a maximum of 1.3 cms over 10 minutes. | 1 November – 15 April | Avoid stranding spawning and rearing fish. |
| River | No other ramping constraints. | Year round | |
| Reservoir | Free spill elevation of the Falls River Dam to 92.4 m. | 15 March - 1 May | Maximize sedge grass community maintenance. |
| Reservoir | Free spill elevation of the Falls River Dam to 90.3 m. | 15 May – 15 February | Maximize sedge grass community maintenance. |
| Reservoir | Flashboard operation discretionary. | 2 May- 15 May<br>16 February – 14 March | Allow operations to transition between reservoir elevation levels. |

# 4.0 ORDERED MONITORING PROJECT SUMMARYS

## 4.1 FLSMON-1 Falls River Presence and Timing of Steelhead and Salmon Spawning Monitoring

### 4.1.1 Project Summary

The Falls River WUP Consultative Committee recommended studying the presence and timing of Steelhead and Salmon spawning in the tailrace to understand if WUP operations would affect spawning success. Based on the limited information available, the Consultative Committee recommended a higher year-round minimum flow of 2.6 $m^3/s$ when the reservoir is at or above 88.4 m (which was higher than the pre-WUP minimum flow of 1.3 $m^3/s$) and flows of 6.5 $m^3/s$ during the spawning period (1 Aug – 15 Oct). These flows were assumed to benefit spawning success by increasing the quantity and quality of spawning habitat in the tailrace area. The results from this study were anticipated to allow a rudimentary comparison of WUP to future operations.

| Objectives | Management Questions[1] | Response |
|---|---|---|
| To assess the timing of salmon and Steelhead presence and spawning in the Falls River | 1. Do Salmon and Steelhead spawn in the Falls River tailrace?<br>2. When do salmon and Steelhead spawn in the Falls River tailrace?<br>3. Is the timing for the spawning flow release appropriate for salmon and Steelhead in the Falls River? | 1. The study could not confirm that Steelhead or salmon species use the Falls River tailrace for spawning.<br>2. No Salmon or Steelhead spawning was observed in the Falls River tailrace, but Pink and Chum were observed using the area as a staging area (Aug 1-Oct 15).<br>3. The periodicity review and the presence of Pink and Chum Salmon in from mid to late August to late September suggests the 1 August to 15 October timeframe is appropriate. |

[1]BC Hydro 2006b

### 4.1.2 Project Approach

This monitoring project was conducted from April 2007 to November 2009. The project was undertaken by Cambria Gordon and Metlakatla Fisheries. Annual reports were compiled for each of the three monitoring years. The final annual report in 2009 summarized the results for all study years. All reports are available on BC Hydro's WUP website:

https://www.bchydro.com/toolbar/about/sustainability/environmental_responsibility/water-use-plans/northern-interior/falls-river.html

This study surveyed the Falls River tailrace (Figure 4.1.1.) throughout the expected spawning period of Chinook, Chum and Pink salmon and Steelhead trout over a three-year timeframe using a combination of snorkelling, angling and shore-based surveys. The tailrace area is approximately 180 m long by 100 m wide and extends from the base of the 50 m falls to a smaller 4 m high falls that becomes submerged at tides above 4.5 m. The surveys were intended to identify presence or absence of fish and to identify spawning activity through the presence of redds. Surveys were conducted in spring summer and fall in order to capture the spawning period for all species. The study team noted the presence of adults and their species and if redds were present. Based on known species life history, redds were assigned to species based on the timing of construction, redd size and substrate size. The primary objective of the study was to assess if the timing of higher minimum flows during August 1 – to October 15 correspond with salmon spawning and thus, could potentially improve spawning conditions.

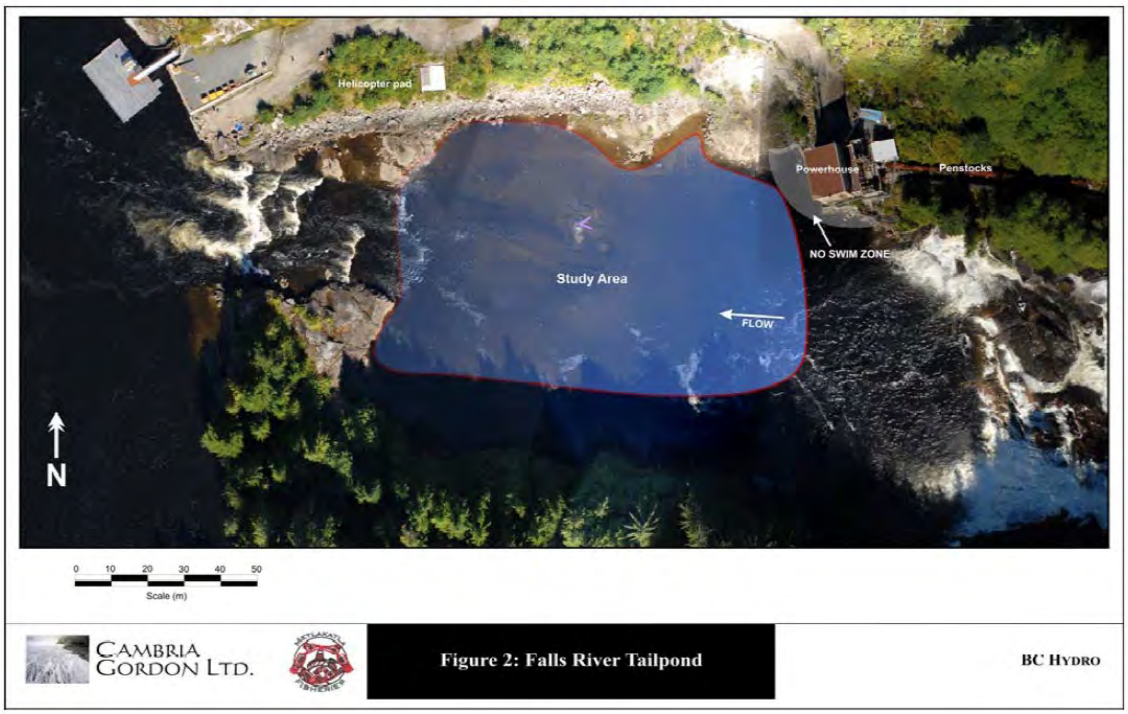


Figure 4.1.1. Falls River tailrace study area. Snorkel surveys occurred in the shaded area. (Cambria Gordon/Metlakatla Fisheries. 2009).

### *4.1.2.1 Steelhead and Salmon Spawning Periodicity Review*

A periodicity review was completed in 2007, to provide background information with respect to fish use and timing on the Ecstall and Falls Rivers, in order to schedule swims at the best potential times to observe fish. Logistical and safety considerations, such as site conditions and access (reservoir and flow levels, tides, weather) also influenced survey timing (FLSMON1 2009).

#### *4.1.2.2 Fish and Redd Survey Methods*

Steelhead and salmon surveys were conducted each year for a total of 22 snorkel surveys over the study period. Combinations of snorkel swim, angling and shore-based observations were used during each survey. In some instances, the surveys were spread over two days with snorkeling and angling occurring on consecutive days. Two to four-person snorkel surveys were the primary method to detect both fish presence and redds. Snorkelers attempted to survey the entire tailrace area over a series of two to three passes. Snorkel surveys excluded the area immediately below the powerhouse as a safety measure. As well, the survey area was restricted if the lower cascade was exposed (tide level below 6 m) to prevent the possibility of being swept over the lower cascade. Redds were distinguished from 'test digs' through a combination of visual characteristics and excavation of the disturbed area for the evidence of eggs.

Environmental variables were also collected to characterize survey conditions including water temperature, weather conditions, flow, and underwater visibility (Secchi depth or visual estimation. Temperature loggers were installed on the south side of the tailrace and recorded water temperature for the entire study period.

#### *4.1.2.3 Angling Survey*

Anglers fished both with and without baited hooks. Angling occurred in the area next to the powerhouse as this area was not included in snorkel surveys as a safety measure. Effort was recorded as the minutes the hook was fishing per survey. Anglers also visually surveyed the river-right side of the tailrace for fish and redds.

### 4.1.3 Interpretation of Data

#### *4.1.3.1 Fish Presence and Timing Review*

The estimated period when Steelhead and salmon were present or spawning in the Falls River are reported in Table 4.1.1. This was generally similar to the periods outlined in the TOR for FLSMON-1 (BC Hydro 2006b, Table 1-2).

**Table 4.1.1. Timing of Steelhead surveys (March-May) and Salmon Surveys (June-November) for each of the three study years. Solid bars indicate the estimated spawning periods for each of the target species based on the periodicity review.**

| | | | Mar | | | | | Apr | | | May | | | | | Jun | | | | Jul | | | | Aug | | | | | Sep | | | | Oct | | | | Nov | | | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Week | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
| Year 1 (2007) | | | | | X | X | | | | X | | | | | | | | | | | | | X | | | X | | | X | | | | | | X | | | | | |
| Year 2 (2008) | | | | | | | | X | | | X | X | | | | X | | | | | | | X | | | | | X | | X | | | | | | | | | | |
| Year 3 (2009) | | | | | X | | | | | | X | | X | | | | | | | | | | X | | X | | | X | | | X | | | | | | X | | | |
| Estimated Spawning Period: Steelhead | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Chinook | | | | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | |
| Pink | | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | |
| Coho | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Chum | | | | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | |
| Sockeye | | | | | | | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | |

#### *4.1.3.1 Steelhead Presence and Spawning*

The study found no evidence of either Steelhead presence or spawning during any surveys 2007-2009. No adult Steelhead or redds were observed and no adult Steelhead were captured by angling during spring surveys. Each year, two of the three annual surveys had good underwater visibility conditions (> 4 m).

**Table 4.1.2. Results of snorkel and angling surveys of the Falls River tailrace conducted 2007-2009 during the expected Steelhead presence and spawning period.**

| Survey Date (YY-MM-DD) | Survey Conditions | Steelhead | | Other Species Observed / Captured |
|---|---|---|---|---|
| | | Snorkelling | Angling | |
| 2007-04-04 | Good | 0 | NA | None |
| 2007-04-12 | Good | 0 | NA | None |
| 2007-05-07 | Poor | 0 | 0 | None |
| 2008-04-22 | Good | 0 | NA | None |
| 2008-05-13 | Good | 0 | NA | 1 stickleback |
| 2008-05-27 | Poor | 0 | NA | 1 stickleback |
| 2009-03-09 | Poor | 0 | 0 | 2 juvenile coho |
| 2009-04-12 | Good | 0 | 0 | None |
| 2009-04-21 | Good | 0 | NA | None |

#### *4.1.3.2 Salmon Presence and Spawning*

The study found no evidence of salmon spawning during any of the late summer and fall surveys 2007-2009. Shore based surveys by anglers did confirm the presence of Pinks in 2007 (approx. 25 fish) and 2009 (approx. 15 fish) and Chum in 2009 (2 fish). Table 4.1.2 summarizes the support from the study that salmon were present during the period of elevated minimum flow (1 August – 15 October). Table 4.1.3 contains results from each survey. All fish observations occurred during August and early September; however, use of the area by fish likely continued into September based on the presence of test redds at the end of September. No salmon were either captured by angling or sighted by snorkelers even during surveys when Pink and Chum were observed from shore. Several test digs were found by snorkelling in 2009 that were attributed to Pink salmon based on size and timing with Pink salmon observations; however, they were not considered evidence of spawning since no eggs were found when excavated.

Considering that no adult salmon were observed by snorkelers, even when salmon were observed during concurrent shore-based surveys, raises the possibility that the snorkel survey methods had a low probability of detecting fish.

As in the case for Steelhead, there is somewhat greater confidence that the absence observing salmon redds indicated that spawning did not occur. Locating Pink test digs provides some assurance that the surveys were capable of detecting redds if they were present. However, the occurrence of high flows (>100 $m^3$/s) prior to several surveys in September and October increased the risk that redds were ‘flattened’ or covered in scour by the high flows and were subsequently not distinguishable from the surrounding substrate.

**Table 4.1.3. Results of snorkel and angling surveys of the Falls River tailrace conducted 2007-2009 during the expected period of Chinook, Coho, Chum and Pink salmon presence or spawning.**

| Survey Date (yy-mm-dd) | Survey Conditions | Method | Observed | | | | Captured | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Chinook | Chum | Coho | Pink | Chinook | Chum | Coho | Pink | Test digs | Redds |
| 2007-07-31 | Poor | Snorkel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2007-08-30 | Poor | Snorkel angling | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2007-09-21 | Poor | Angling | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2007-10-26 | Good | Angling | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2008-07-30 | Poor | Angling | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2008-09-10 | Good | Snorkel Angling | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2008-09-23 | Good | Snorkel Angling | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2009-08-04 | Good | Angling | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2009-08-05 | Good | Angling | 0 | 2 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2009-08-21 | Moderate | Snorkel Angling | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2009-09-01 | Good | Snorkel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 0 |
| 2009-09-02 | Good | Snorkel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 0 |
| 2009-09-30 | Good | Snorkel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 |
| 2009-11-18 | Good | Snorkel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2009-11-19 | Good | Angling | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Answers to Management Questions

***1. Do salmon and steelhead spawn in the Falls River tailrace?***

The study provided no support that Steelhead or any late-summer or fall spawning salmon species use the Falls River tailrace for spawning. No Steelhead redds were found and no salmon redds were found during three years of monitoring.

There was support of Pink and Chum salmon presence in the tailrace. Approximately 25 and 15 Pink salmon were observed in the late August surveys in 2007 and 2009, respectively. Two Chum salmon were observed during the late August survey in 2009. No other adult salmon were captured or observed.

***2. When do salmon and steelhead spawn in the Falls River tailrace?***

The study provided no evidence that spawning occurs in the tailrace during the expected spawning period of either Steelhead or salmon.

*Is the timing for the spawning flow release appropriate for the salmon and Steelhead in the Falls River?*

The periodicity review and the presence of Pink and Chum salmon from mid-August to late September suggests the August 1 to October 15 spawning flows are appropriate.

## 4.2 FLSMON-2 Falls River Fish Spawning Habitat Monitoring

### 4.2.1 Project Summary

The Falls River WUP Consultative Committee expressed a concern that flow conditions in the Falls River may affect available spawning habitat and egg incubation success for salmon. To address these concerns, the Consultative Committee recommended a minimum flow of 6.5 $m^3/s$ to maintain available spawning habitat during the salmon spawning period (August 1 to October 15), and a year-round minimum flow of 2.6 $m^3/s$ (reduced to 1.3 $m^3/s$ if the elevation of the Big Falls Reservoir drops to 88.4 m) 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. As a result of these uncertainties, the Consultative Committee recommended a monitoring plan to provide baseline information about incubation success under WUP operations and to improve the understanding how this is influenced by flow.

| Objectives | Management Questions[1] | Response |
|---|---|---|
| To determine the effects of operations on salmon egg-to-fry survival in the Falls River downstream of the dam in the tailrace. | 1. Do the minimum flows for salmon spawning and egg incubation provided under the WUP operations produce adequate conditions for egg-to-fry survival? | 1. Overall, conditions were not adequate during egg and alevin development, though there was no evidence to support that this was due to minimum flows. The average egg-to-fry survival rate of 3.6% is at the very low end of the range for Chinook salmon. Incubation conditions – both habitat and physiochemical variables measured – were within the range adequate for incubation when the tailrace was not influenced by tidal backwatering. |

[1]BC Hydro 2006c

### 4.2.2 Project Approach

This monitoring project was conducted from June 2008 to June 2011 by Cambria Gordon and Metlakatla Fisheries. Annual reports were compiled from 2009 to 2011. The final year report summarized results for all study years and addressed the management questions listed above. All reports are available on BC Hydro's WUP website:

https://www.bchydro.com/toolbar/about/sustainability/environmental_responsibility/water-use-plans/northern-interior/falls-river.html

The general approach to this monitoring project was to assess the quality of egg incubation habitat and to quantify egg-to-fry survival in the tailrace. Egg incubation habitat was characterized by measuring physicochemical parameters important to egg-to-fry survival. Egg-to-fry survival was based on the survival of eyed Chinook eggs to the emergence stage held within incubation capsules in the streambed. Monitoring occurred at three study sites within the study area. Year 1 assessed only the physicochemical parameters and Years 2 and 3 assessed both physicochemical parameters and chinook egg-to-fry survival.

Management Question:

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

The primary measures of interest included:

1. The average egg-to-fry survival across all years and sites – This addresses the primary objective of whether WUP operations provide enough flow for incubation. Results would be compared with published values from other rivers or with future monitoring under different operating conditions.
2. The relationship between egg-to-fry survival and water discharge – This anticipates that actual flows during incubation would differ between the two years of incubation monitoring. Any finding would be considered preliminary considering that monitoring would include only a single year under each discharge level.
3. The relationship between water discharge and physicochemical parameters of the incubation habitat – This investigates the potential physiochemical mechanisms that influence the success of incubation and how they are affected by flow.

#### *4.2.2.1 Study Site*

The lower Falls River extends approximately 1.4 km from the base of the Falls River Dam to its confluence with Ecstall River. The tailrace is approximately 180 m long by 100 m wide and situated between the upper 50 m falls immediately below the dam and the smaller 4.5 m high falls (Figure 4.2.1). At high tide levels, both the lower falls and tailrace become backwatered.

Three incubations areas were selected on the river-left side of the tailrace based on ease of access, and gravel depth and quality. During Year 1 and 2, one of the three areas shared the same location used in the 2003-2004 incubation study in the hopes results could be compared to pre-WUP operations (Figure 4.2.2). In Year 3, this area was relocated to the site of spawning gravel enhancement. Approximately 100 m$^3$ of gravel was deposited as part of a restoration project in August 2009 (Tan coloured box, Figure 4.2.3). Three incubation sites were clustered in each of the three areas.

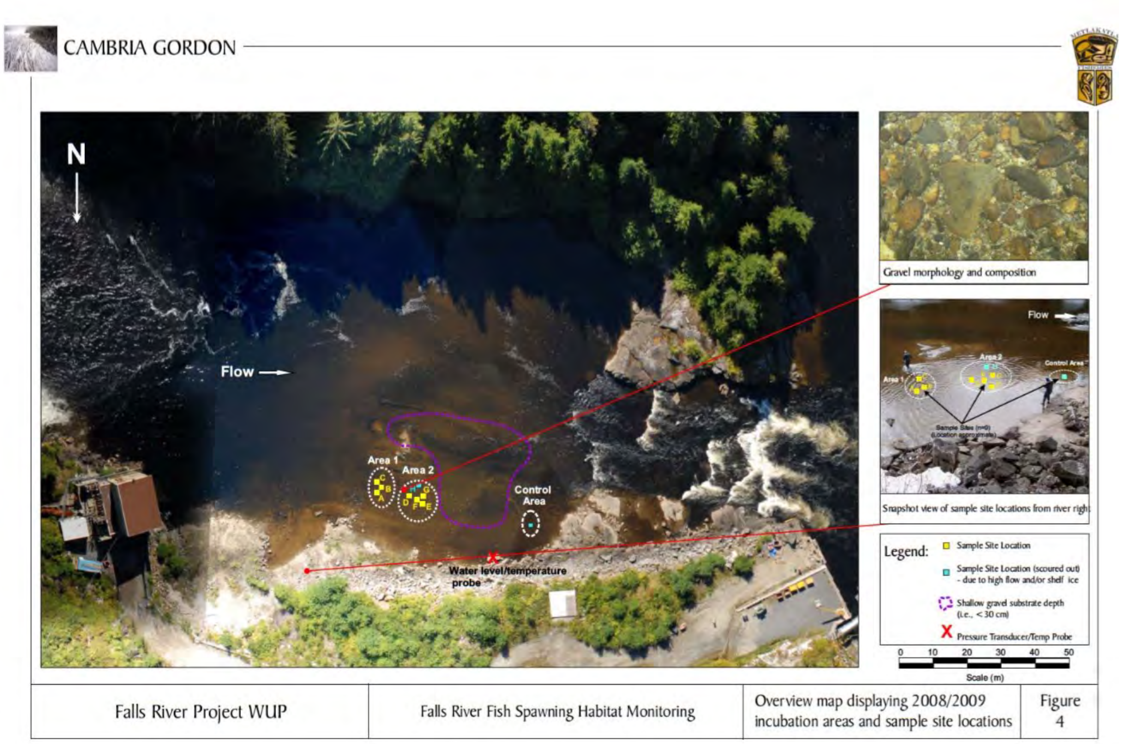


**Figure 4.2.2. Location of the three incubations sites in the Falls River tailrace during the 2007-2008 physiochemical monitoring and 2008-2009, the first year of incubation monitoring (Cambria Gordon/Metlakatla Fisheries 2009).**

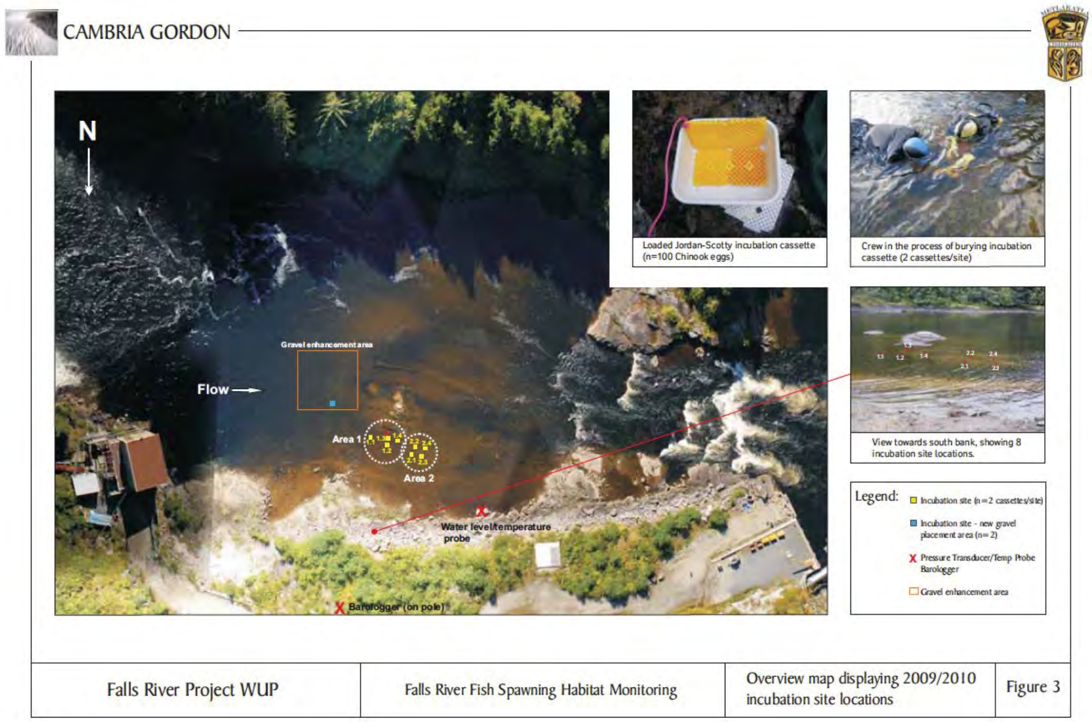


**Figure 4.2.3. Location of the three incubations sites in the Falls River tailrace during 2009-2010, the second year of incubation monitoring. (Cambria Gordon/Metlakatla Fisheries. 2009).**

#### *4.2.2.2 Physiochemical Monitoring*

The following physiochemical monitoring was carried out as part of the project:

Substrate – Wolman pebble counts were conducted at each location at three time intervals: installation of egg incubators (September), post-hatch (December-February) and emergence (April/May) during each study year. The exception to this was the gravel augmentation site (Location 3) in Year 3, where the water depth was too great for any physiochemical monitoring.

Water temperature, depth, velocity, water quality, intragravel dissolved oxygen, pH and conductivity were also measured at each of the three sites in each incubation areas during the installation, post-hatch and emergences sampling intervals. In Year 2, intragravel dissolved oxygen measurements were competed by extracting a subsurface water sample. Questioning the accuracy of the Year 2 method, this changed in Year 3 to using optical sensors capable of directly measuring dissolved oxygen at the depth of the egg cassettes. Intragravel temperature loggers were buried at a depth of 20 cm at each incubation area for the study period.

#### *4.2.2.3 Incubation Success*

Jordan-Scotty incubation cassettes were loaded with Chinook eggs and buried in the incubation sites. Eyed Chinook salmon eggs were selected based on their availability from the Kitimat Hatchery and low risk of damage during transport (Guimond and Burt 2008). Each cassette was loaded with 100 eyed eggs and pairs of incubation cassettes were buried 15 to 20 cm apart in artificial redds excavated to a depth of 25-30 cm. Cassettes were oriented perpendicular to the flow. A total of 18 cassettes were installed in Year 2 and 24 in Year 3. Each year, a group of eggs were also incubated at the Kitimat Hatchery to demonstrate the viability of the donor eggs used in the study.

Incubation was assessed at the hatch phase (December – February) and at emergence (April-May). These dates were estimated based on calculated accumulated thermal units (ATU) from temperature monitoring during Year 1 and ATU data for Chinook salmon egg incubation from the Department of Fisheries and Oceans (DFO 2003).

### 4.2.3 Interpretation of Data

Incubation area 1 and 2 were in the same location in both years whereas the third area was in a different location each year. For comparisons on a year effect, only sites 1 and 2 were used.

#### *4.2.3.1 Incubation Habitat Suitability*

Substrate size, water temperature, water velocity, and water depth were all within range considered favourable for Chinook Salmon incubation during Year 2 and 3. The natural substrate in areas 1 and 2 was similar in size between sites and years. Minimum water depth (0.05 m) and velocity (0.02 m/s) were maintained in both years and intragravel water temperatures did not drop below freezing during the incubation period during either study year.

Long-term Intragravel dissolved oxygen levels may have decreased to levels below those suitable for incubation in Year 2. The report indicated that the average daily dissolve oxygen levels could be lower due to the lower water exchange during tidal flooding when water velocities in the tailrace can reach zero. All measurements were collected during the periods without the tidal influence, which could skew the results towards higher dissolved oxygen levels than if measurements included the full range of tidal conditions.

#### *4.2.3.2 Discharge during Incubation*

The mean discharge (generation and spill combined) was 26.3 $m^3/s$ in Year 2 and 28.8 $m^3/s$ in Year 3. Peak flows in Year 1 and Year 2 exceeded 120 $m^3/s$ on four and three occasions, respectively. Minimum discharge levels remained above 2.6 $m^3/s$ other than during single events in Year 2 (1.85 $m^3/s$ on December 12, 2009) and Year 3 (1.3 $m^3/s$ on January 16, 2011).

#### *4.2.3.3 Incubation Success*

This monitoring program completed a thorough investigation into the habitat parameters known to directly affect egg-to-fry survivorship (dissolved oxygen and temperature), followed by a study of the influence of discharge on these key parameters. The results showed consistently high correlation between discharge and intragravel dissolved oxygen (R2 = 95 – 97.4%) as well as intragravel temperature (R2 = 68.4 - 69.9%). While the correlation between tidal height and habitat parameters such as intragravel pH and conductivity was high (R2 = -1.00 – 1.00, and 0.64 – 0.99%) respectively, a weak correlation existed between tidal height and intragravel dissolved oxygen.

These key results point to discharge having a clear influence on the parameters known to affect egg-to-fry survivorship. The results of the incubation cassette survivorship show a very high egg survivorship to the hatch phase (75.8 - 98.5%) but much lower survivorship to the emergence of fry (2.3 – 10.5%). It is unclear if the rate of survivorship to emergence is a product of the intragravel conditions or due to the cassettes creating abnormal conditions for the eggs (i.e., creating a barrier to water exchange rates). For the purposes of the FLSMON-2 study, the evidence of survivorship to hatch shows the WUP flows are likely to provide tailrace conditions which are suitable for Chinook egg incubation (Beblow 2011).

**Answers to Management Questions**

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

Overall, conditions were not adequate during egg and alevin development, though there was no evidence to support that this was due to minimum flows. The average egg-to-fry survival rate of 3.6% is at the very low end of the range for Chinook salmon. The study indicated incubation conditions – both habitat and physiochemical variables measured – were within the range adequate for incubation when the tailrace was not influenced by tidal backwatering. The lack of physiochemical monitoring during tidal backwatering is a data gap.

## 4.3 FLSMON-3 Big Falls Reservoir Tributary Access and Potential Stranding Monitoring

### 4.3.1 Project Summary

The Falls River WUP Consultative Committee expressed a 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. The Consultative Committee was also concerned that rapid drawdowns of the reservoir could strand fish along the reservoir shoreline throughout the drawdown zone.

This monitor was developed to identify if there are migration barriers or potential stranding sites within the WUP operation range of the Big Falls Reservoir. This potential drawdown zone includes the area within the range during normal operations (88.4 – 92.4 m). Cambria Gordon Ltd. (CGL) and Metlakatla Fisheries were retained by BC Hydro to complete tributary backwater monitoring at BC Hydro's Falls River hydroelectric facility on Big Falls Reservoir. This study summarized results from a one-year study (completed over two years).

| Objectives | Management Questions[1] | Response |
|---|---|---|
| To reduce uncertainty related to the presence of migration barriers for adult Dolly Varden and Cutthroat trout and areas of potential stranding in Big Falls Reservoir. | 1. Are there migration barriers in tributaries within the area of potential drawdown for Big Falls Reservoir?<br>2. Are there locations where fish could be stranded along Big Falls Reservoir shoreline? | 1. No migration barriers for either Dolly Varden or Cutthroat Trout exist in Falls River, Carthew Creek or Hayward Creek within the drawdown zone<br>2. A portion of the drawdown area (88.4 – 92.4 m) in the eastern and southern portion of the reservoir was identified from a desktop survey as high-risk standing areas. |

[1]BC Hydro 2006c

### 4.3.2 Project Approach

This monitoring project was conducted during 2009 and 2010 by Cambria Gordon and Metlakatla Fisheries. A single report was compiled in 2010 that summarized results for the study and addressed the management questions listed above. All reports are available on BC Hydro's WUP website:

https://www.bchydro.com/content/dam/hydro/medialib/internet/documents/planning_regulatory/wup/northern_interior/2011q4/flsmon-5_yr1_2011-07-01.pdf

The general approach to this monitor used a combination of air photo and bathymetry map analysis followed by field surveys to identify barriers to upstream migration of spawning Dolly Varden and Cutthroat trout and to identify potential stranding sites.

#### *4.3.2.1 Study Site*

The approximately 2 km long x 1 km wide Big Falls Reservoir is oriented east-west. The Falls River dam at its western end and just upstream from the 50 m high falls. The three main tributaries (Hayward Creek, Carthew Creek and Falls River) enter at the eastern end of the reservoir (Figure 4.3.1). Carthew Creek joins Falls River before entering the Big Falls Reservoir. The north shoreline area of the reservoir is characterized by steep upland slopes that drop abruptly into the reservoir. The south and east areas have more gradual transitions and low angle shorelines.

**Figure 4.3.1. Big Falls Reservoir, Falls River, Carthew and Hayward Creeks on September 10, 2007. (Cambria Gordon/Metlakatla Fisheries 2009)**

#### *4.3.2.2 Upper and Lower Limit of Drawdown Area*

The upper and lower boundary of the reservoir drawdown zone (88.4 - 92.4 m) in the tributaries and along the perimeter of the reservoir was defined using desktop maps and field surveys. For the desktop analysis, low-level air photos were overlaid with a bathymetric map (Larratt Aquatic Consulting Ltd 1983). In the field, crews used a survey level and stadia rod to survey elevations from the reservoir water level (elevation known during each survey) upstream to the 92.4 m elevation using differential leveling (adapted from the RISC Manual of BC Hydrometric Standards 2009). This was competed on Falls River and Hayward Creek, but Hayward Creek was not checked in the field due to poor access. The lower reservoir limit (88.4 m) was visually estimated by the crew during surveys in reference to the reservoir elevation on the day of each survey.

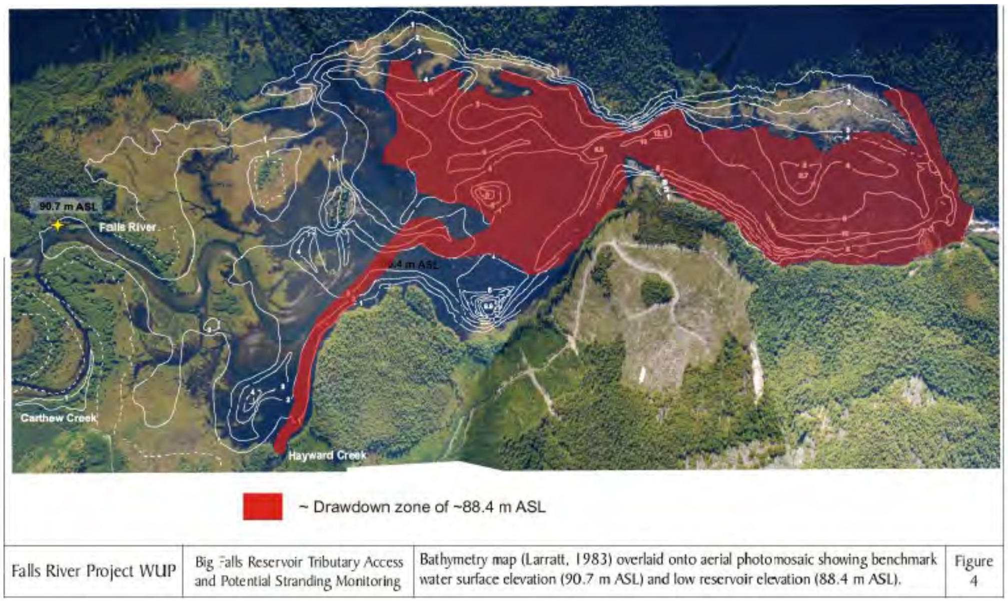


**Figure 4.3.2. Aerial photomosaic with bathymetric map overlaid. Area in red shows the approximate area of the reservoir when filled to 88.4 m (Cambria Gordon/Metlakatla Fisheries. 2009).**

#### *4.3.2.3 Tributary Access Study*

Barriers to upstream fish travel include velocity barriers (confinement and high gradient) and physical barriers (fall and cascades). For physical barriers, the height of the falls and the depth of the plunge pool were both considered in the assessment (Figure 4.3.2).

An initial review of the reservoir and connecting tributaries with low-level air photos using a stereoscope assessed for potential barriers (constrictions, falls and boulders) above the reservoir levels of 88.4 m. Any potential barriers were recorded for later investigation during the field surveys.

Field surveys of the reservoir and tributaries were completed over three separate site visits in 2009 and 2010 (May 13-14, 2009; November 17, 2009; April 13-14, 2010). Boats were used to survey the area where each stream enters the reservoir to identify any potential barriers submerged in the reservoir and to estimate where the channel drops below the minimum standard operating level (88.4 m). Shore surveys were used to identify potential barriers in Carthew Creek (to 91.42 m) and Falls River (to 91.98 m) based on criteria in Table 4.3.1. Hayward Creek was not surveyed, and its assessment instead based on the analysis of the air photo and bathymetric maps and photos from an over-flight completed on April 14, 2010, the last day of the field survey.

**Table 4.3.1. Swimming and jumping capabilities of Cutthroat and Rainbow Trout (adapted from Dane 1979 as cited in Whyte et al. 1997)**

| Species | Life stage | Maximum Swimming Speed (m/s) | | | Maximum jump height (m) |
|---|---|---|---|---|---|
| | | Sustained* | Prolonged** | Burst*** | |
| Cutthroat/rainbow trout | Adult | 0.9 | 1.8 | 4.3 | 1.5 |
| | Juveniles (125 mm) | 0.4 | 0.7 | 1.1 | 0.6 |
| | Juveniles (50 mm) | 0.1 | 0.3 | 0.4 | 0.3 |

* Sustained swimming speeds are the swimming velocities that can be maintained indefinitely.
** Prolonged speeds are the swimming velocities that can be maintained for up to 200 minutes through difficult areas.
*** Burst speeds are the swimming velocities for escape and feeding up to 165 seconds.
(cited in Parker, 2000)

#### *4.3.2.4 Standing Site Survey*

Potential standing sites in the drawdown zone were identified using ground surveys and depended on professional judgement. Criteria to categorize areas as either low or high risk for stranding were qualitative in nature and generalized stranding risk for all species and age classes into two categories:

Low risk

- High angle shoreline
- Low angle mud flats based on the assumption that fish would not occupy these areas when flooded due to low habitat quality.
- Small, low angle sites that have good connectivity to areas wetted down to 88.4 m.

High risk

- Vegetated low angle shoreline as these were considered high habitat quality when wetted.
- Risk increases as connectivity between potential stranding sites and permanently wetted areas decreases.

An initial area review was completed using air photos analyzed with a stereoscope to identify low slope areas within the drawdown zone. Potential high risk standing areas were delineated on the maps for further ground surveys. A subset of areas identified as high risk were included in ground surveys to further assess the stranding potential.

### 4.3.3 Interpretation of Data

#### *4.3.3.1 Migration Barriers*

The study concluded no migration barriers for either Dolly Varden or Cutthroat Trout exist in Falls River, Carthew Creek or Hayward Creek within the drawdown zone (88.4 – 92.4 m) using low level flight photos to document the absence of barriers.

For Falls River and Carthew Creek, this conclusion was based on analysis of air photo/ bathymetric maps, boat-based survey of the channels submerged in the reservoir and a foot survey to the 92.4 m elevation. The assessment for Hayward Creek relied on the bathymetric map and aerial photo information alone. A ground survey would have provided additional certainty of the findings, but its omission was very unlikely to change the conclusion.

##### *4.3.3.2 Stranding Areas*

The CC was also concerned that rapid drawdowns of the reservoir could strand fish along the reservoir shoreline throughout the drawdown zone under WUP operations (flashboards). Potential stranding areas were identified within the drawdown zone of the reservoir. These consist of large, gradually sloping vegetated areas located primarily along the eastern end of the reservoir. Other potential stranding areas also exist along Carthew Creek and the south shore of the reservoir. The monitoring program determined that if the proposed WUP operating regime was implemented (specifically, installation of flashboards and temporary flooding to 92.4 m ASL), further assessment of stranding risk should occur. The project recommended that stranding indicators such as fish use in potential stranding areas (i.e., at the time of year that a drawdown may occur) and operating regime and range and rate of potential drawdowns (i.e., when flashboards are removed in May, how far and how quickly will the drawdown occur, and how can this be controlled?) all be monitored if the flashboards were to be used. As previously noted, the flashboards were never used and therefore the potential stranding risk is reduced. The mud flats extending from the vegetated areas were not considered high stranding risk areas due to their low habitat quality when wetted, thus few fish would use this habitat. The study did not quantify the size of these areas or attempt to identify all areas of high stranding risk.

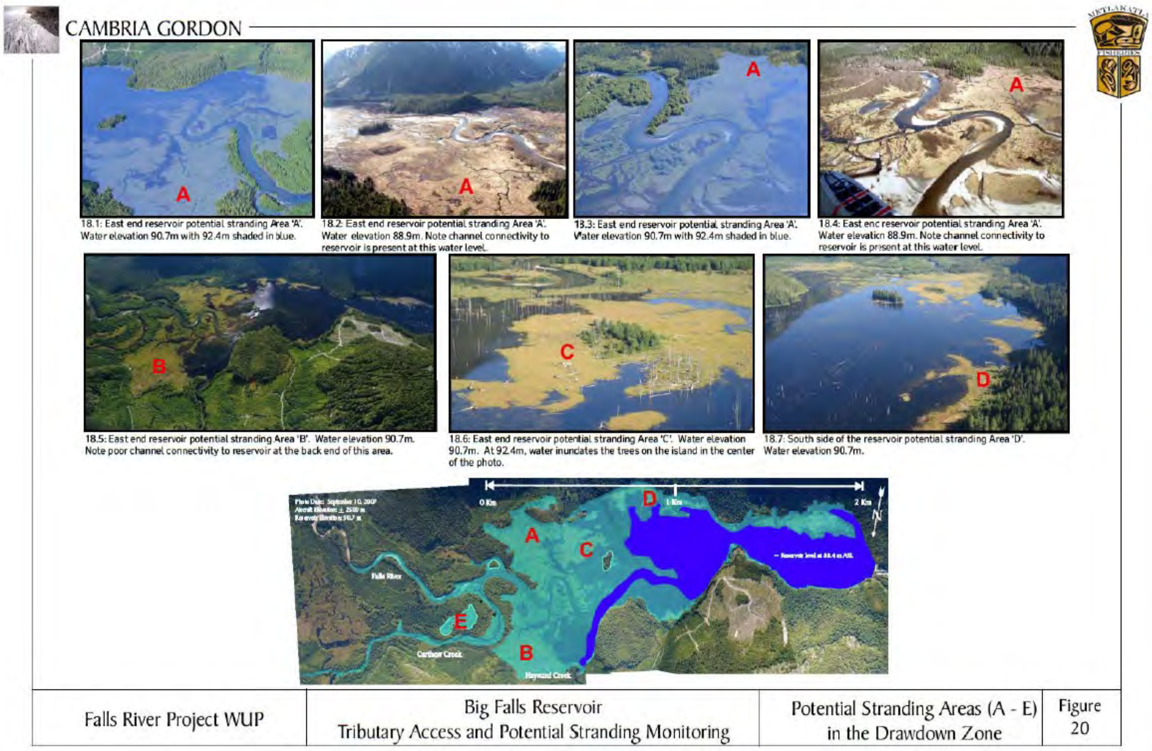


**Figure 4.3.3. Aerial photographs identifying potential stranding areas in the Big Falls Reservoir (Cambria Gordon/Metlakatla Fisheries. 2009).**

### Answers to Management Questions

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

   No, the study confirmed the absence of migration barriers in the Falls River and Carthew Creek drawdown area. Absence of barriers was not confirmed for Hayward Creek since the ground survey did not occur beyond the wetted reservoir area. However, no barriers were identified in the analysis of air photos and bathymetric maps.

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

   A portion of the drawdown area (88.4 – 92.4 m) in the eastern and southern portion of the reservoir was identified as high potential for standing. This included the majority of vegetated habitat based on high habitat quality and low slope. Low angle mud flats were not considered areas of high stranding risk based on the assumption that few fish would occupy areas of lower habitat quality. This reservoir elevation range included the area created by the flashboards, without the added elevation the stranding risk would be greatly reduced.

## 4.4 FLSMON-4 Big Falls Reservoir Sedge Habitat Maintenance Monitoring

### 4.4.1 Project Summary

The sedge community was identified as having high ecological value by the Consultative Committee. The operations recommended by the Consultative Committee to create beneficial conditions for fish and wildlife included retaining the use of flashboards, however due to dam safety concerns the flashboards have been permanently removed. The monitoring completed to-date has shown changes to the sedge and shrub communities as a result of not installing the flashboards (WUP Interim Review, BC Hydro 2012).

| Objectives | Management Questions[1] | Response |
|---|---|---|
| To reduce uncertainty related to the effects of reservoir operations on reservoir vegetation in the Big Falls Reservoir. | 1. Does the operation of the Big Falls Reservoir recommended in the WUP maintain the sedge grass community? | 1. From 2007-2017 the total sedge habitat area decreased while shrub/herb habitat increased due to the lack of inundation previously provided from the use of flashboards. Flashboard use was discontinued in 2007 due to Dam safety risk. |

[1]BC Hydro 2006f

### 4.4.2 Project Approach

This monitoring project was conducted in two years, August 2007, and a later study in September 2017 by Khtada Environmental Services LP (Khtada 2018). The distribution of vegetation in the drawdown zone of the Big Falls Reservoir was mapped and changes in vegetation composition and coverage was monitored over time to understand the effects of reservoir operations on the extent of the sedge community within the eastern portion of the reservoir. Two annual reports were compiled following 2007 and 2017 field monitoring.

**Table 4.4.2a Timing of flashboard installation for each of the four stages of reservoir operations (BCH 2016).**

| *Operation Regime* | *Flashboards Installed (Earliest)* | *Flashboards Installed (Latest)* | *Years Implemented* |
|---|---|---|---|
| Pre-2002 Historic operations | ~15-Nov | ~15-May | Up to 2002 |
| Post-2002 dam safety review operations | Not installed | Not installed | 2002 through mid-2006 |

| | | | |
|---|---|---|---|
| Mid-2006 to 2007Consultative Committee recommended operations | 15 Feb to 15 Mar | 1 May to 15 May | Planned: beginning mid-2006 Actual: a short period in early 2007 |
| 2007-current WUP operations | Not installed | Not installed | Mid-2007 to present |

The final year report (2018) summarized results for all study years and addressed the management questions listed above. All reports are available on BC Hydro's WUP website:

https://www.bchydro.com/toolbar/about/sustainability/environmental_responsibility/water-use-plans/northern-interior/falls-river.html

The general approach to this monitor used analysis of oblique aerial photography followed by field surveys to identify vegetation community boundaries in the upper drawdown zone and plant species cover and composition, respectively.

#### *4.4.2.1 Study Site*

The study site is approximately 3 km x 3 km wide bisected by Carthew Creek and includes the eastern part of Big Falls Reservoir where the creek enters the reservoir. The area has low angle shorelines and often gradual transitions from sedge meadows to open water or sparsely vegetated substrate depending on reservoir operations. Mature shrub and forest communities are found at slightly higher elevations where water tables are lower than where sedge communities dominate.

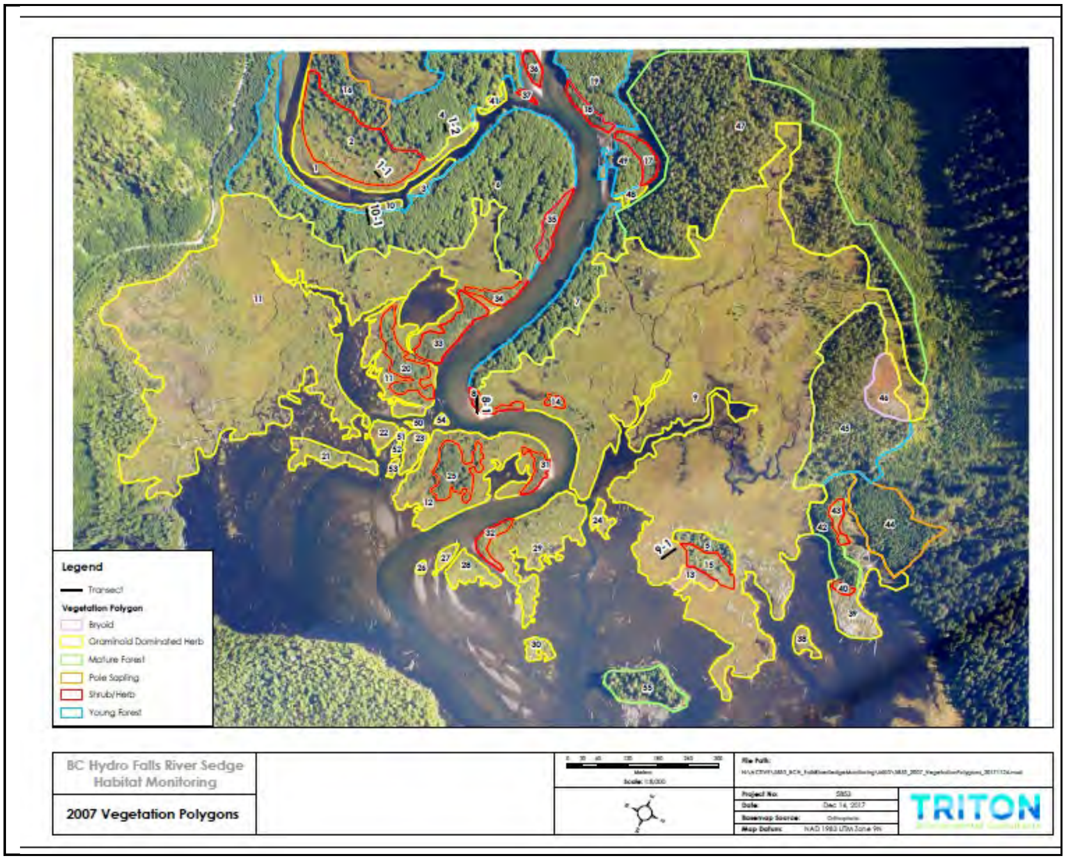


**Figure 4.4.a: Study Area along NE shoreline of Big Falls Reservoir (Khtada Environmental Services LP/Triton Environmental 2018)**

### 4.4.3 Interpretation of Data

The study concluded that current operations without flashboards have resulted in a decrease in sedge community extent between 2007 and 2017. The sedge communities are located between an elevation of 89.8 m and 91.7 m with little change from 2007 in elevations where sedge communities are growing. The total area of sedge communities decreased from 63 ha in 2007 to 42.5 ha in 2017.

Reservoir operations using flashboards up to 2002 and briefly again in 2007 encompassed an elevation range of 88.4 m to the top of flashboards at 92.4 m. With flashboards permanently removed (since 2007), the upper limit of reservoir operations allowed is 91 m with typical operations being to the weir crest of 90.3 metres.

The location of sedge communities in the reservoir has shifted, with exposure of sand bars at the lowered reservoir maximum providing new substrate for sedge colonization. Two hectares of sedge communities have established since 2007. Sedge communities at elevations above reservoir full pool have decreased in extent due to ingress of shrubs and herbs. Overall, the sedge habitat area decreased over 20% being replaced by shrub/herb communities which increased 17%.

**Answers to Management Questions**

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

   This question cannot be answered as flashboards cannot be installed due to dam safety risk; however, monitoring has shown decreased sedge habitat area with increased shrub/herb communities in response to the no flashboard (lower) reservoir regime.

   There was a significant decrease (p-value 0.022, df=4, t=3.64) in sedge community extent along the permanent transects observed between 2007 and 2018. Comparison of 2007 and 2018 mapping shows early successional shrub and herbaceous plant species encroaching into areas previously dominated by sedges due to removal of flashboards from the reservoir operations after 2002 Flashboards were installed for a short period in early 2007.

**Figure 4.4.b: Total vegetation community areas (ha)**

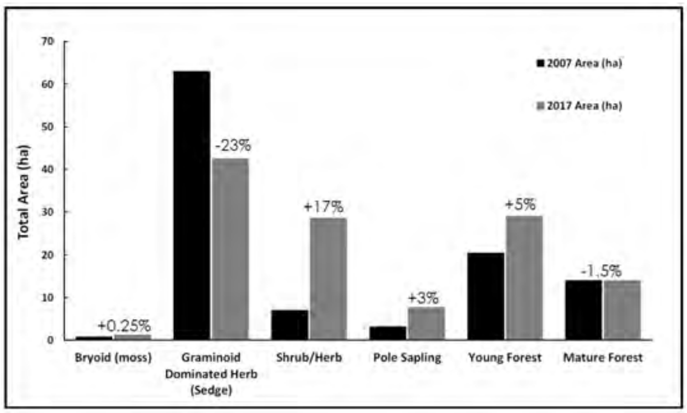


**Table 4.4.a: Sedge community habitat length change**

| Transect # | 2007 Sedge Habitat Length (m) | 2017 Sedge Habitat Length (m) |
|---|---|---|
| 1-1 | 14.5 | 5.0 |
| 1-2 | 29.0 | 19.0 |
| 8-1 | 27.0 | 10.0 |
| 9-1 | 36.0 | 13.0 |
| 10-1 | 12.0 | 9.0 |

## 4.5 FLSMON-5 Big Fall Reservoir Tributary Backwatering Monitoring

### 4.5.1 Project Summary

This monitoring project was initiated to address uncertainty about the effect of Big Falls Reservoir operations on the Dolly Varden Char and Cutthroat Trout spawning and incubation in the sections of the tributaries in the reservoir drawdown zone (Figure 4.5.1). The sections of the tributaries within the drawdown zone lose their stream characteristics (e.g., depth and velocity) as reservoir elevations increase. The Consultative Committee for the WUP was concerned that redds in sections of the tributaries within the drawdown zone could be submerged, potentially reducing egg-to-fry survival due to decreased intragravel water flow, which can lead to inadequate oxygen levels and waste removal. Decreased water velocities at higher reservoir elevations can also increase the rate of sediment deposition on redds, which can decrease the ability of alevin to emerge from the gravel.

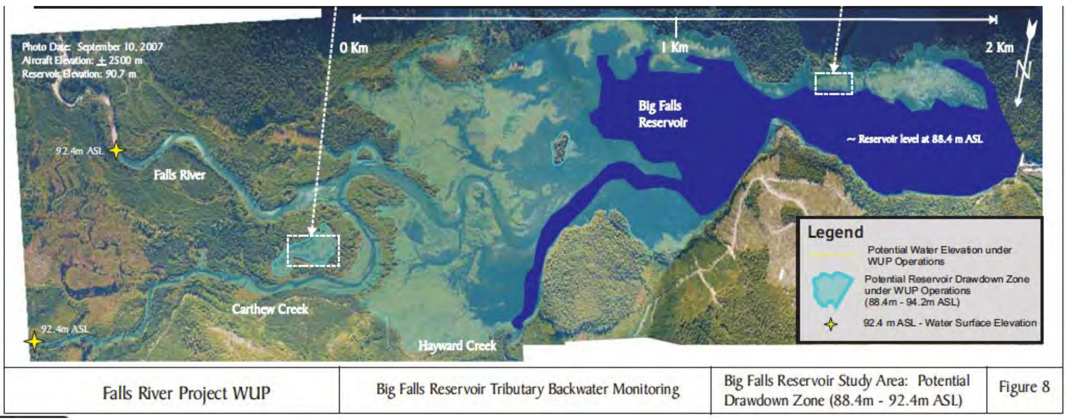


**Figure 4.5.1. Big Falls Reservoir and tributaries. The shaded area represents the drawdown zone of the reservoir with flashboards installed (Cambria Gordon/Metlakatla Fisheries. 2009).**

The Consultative Committee considered several operating alternatives based on maintaining high reservoir elevations to prevent spawning in the drawdown zone as a way to avoid submerging redds prior to emergence. The Big Falls Reservoir has a limited operating range of 88.4 – 90.3 m without flashboards installed and up to 92.4 m with flashboards. The final recommendation from the Consultative Committee was to only maintain high reservoir levels, by installing flashboards during Cutthroat spawning (April – May) but not during Dolly Varden spawning (September – October). Modeled reservoir elevations under this operational regime are shown in Figure 4.5.2. However, dam safety concerns identified in 2007 prevented the use of flashboards, limiting the operating range to 88.4 – 90.3 m. While WUP operations (including using flashboards) were anticipated to benefit Cutthroat, it was unclear for Dolly Varden. Benefits to either species were unclear under the amended WUP operations that didn't include using flashboards. Furthermore, little was known about spawning use of the tributaries within the drawdown zone.

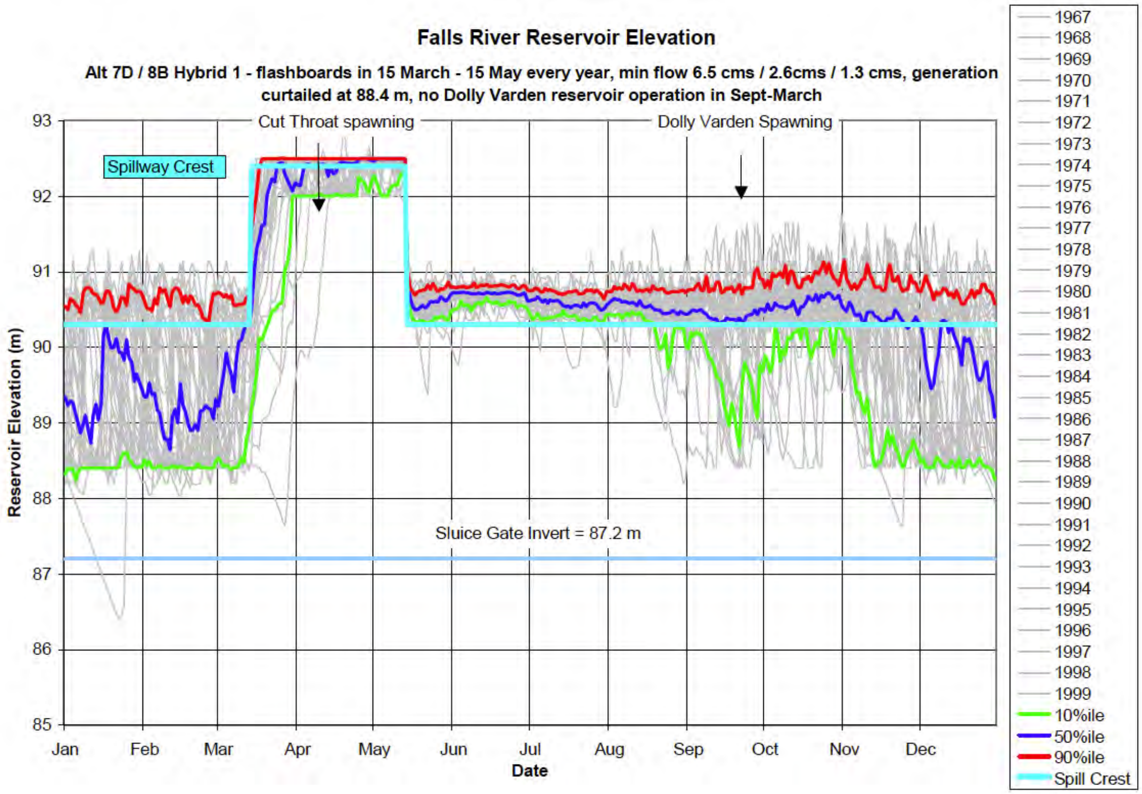


**Figure 4.5.2. Modeled reservoir elevations in Big Falls Reservoir under WUP Operations that include raising the spillway crest (flashboards) during Cutthroat spawning (BC Hydro 2006a).**

| Objectives | Management Questions[1] | Response |
|---|---|---|
| To reduce the uncertainty about the susceptibility of Dolly Varden or Cutthroat trout spawn in the three tributaries to changes in reservoir level. | 2. Are there suitable spawning habitat conditions for Dolly Varden and Cutthroat trout in the tributary habitat in the drawdown zone of the Big Falls Reservoir?<br>3. Do Dolly Varden spawn in tributary habitat in the drawdown zone of the Big Falls Reservoir? | 2. Yes, suitable Cutthroat trout spawning habitat exists in tributaries in the drawdown zone above the 91.0 m elevation. Possibly yes for Dolly Varden above the 91.0 m elevation but surveys were not completed during the Dolly Varden spawning period.<br>3. The study did not find any evidence of Dolly Varden or Cutthroat spawning in tributary habitat within the drawdown zone of the reservoir. |

[1]BC Hydro 2006f

### 4.5.2 Project Approach

This monitoring project was conducted from May 2009 to April 2011 by Cambria Gordon and Metlakatla Fisheries. A single report compiled July 2011 summarized results for all study years and addressed the management questions listed above. The report is available on BC Hydro's WUP website:

https://www.bchydro.com/toolbar/about/sustainability/environmental_responsibility/water-use-plans/northern-interior/falls-river.html

The general approach to this monitoring project was to measure physiochemical parameters in each of the tributaries during the expected spawning periods for Dolly Varden and Cutthroat trout. This was to evaluate the suitability of potential spawning sites in the drawdown zone as well as to refine the expected spawning and incubation periods based on temperature data from each stream. Foot, snorkel, and boat surveys of each stream documented the presence of spawning and/or adults.

#### *4.5.2.1 Identifying Sections of the Tributaries in the Drawdown Zone*

Mapping the sections of the tributaries within the drawdown zone was carried out in conjunction with mapping for FLSMON-3. The list of elevations mapped is listed in Table 4.5.1.

In the field, crews used a survey level and stadia rod to survey elevations between the reservoir water level (considered a known elevation point) upstream to the point on Falls River and Hayward Creek corresponding to the reservoir elevation of 92.4 m. No surveying was completed on Hayward Creek due to poor access. Elevations were mapped onto the low-level aerial photographs.

**Table 4.5.1. Reservoir elevations of interest when specifying reservoir operating alternatives designed to minimize the inundation of fish spawning areas in reservoir tributaries. (BC Hydro 2006a)**

| Reservoir Elevation (meters above sea level) | Description |
|---|---|
| 90.3 | Spillway elevation without flashboards installed during Dolly Varden Char spawning period under the WUP alternative. |
| 91.0 | Normal high reservoir elevation during Dolly Varden char spawning under the WUP operating alterative. |
| 92.4 | Spillway elevation with flashboards installed and target reservoir level during Cutthroat trout spawning under WUP operations prior to identifying flashboard safety concerns. |

#### *4.5.2.2 Physiochemical Monitoring*

The purpose of physiochemical monitoring was to evaluate if suitable spawning sites exist in the drawdown zone of the tributaries. For Falls River and Carthew Creek, two study sites per stream within the drawdown areas and one control site in Falls River, approximately 200 m upstream of the 92.4 m elevation, were selected to represent typical Dolly Varden spawning habitat.

Intragravel temperature monitoring occurred 2009 -2011 at the downstream sampling sites in Falls River and Carthew Creek (1 Tidbit / stream) as well as at the control site in Falls River (2 Tidbits). Tidbit temperature loggers were buried (depth not reported) at these sites to record conditions during incubation. Information from these was used to estimates spawning periods as well as emergence timing based on accumulated thermal units (ATU).

#### *4.5.2.3 Spawner and Redd Survey*

Cutthroat spawner and redd surveys occurred May 13 -14, 2009 on Falls River and Carthew Creek and then again on Carthew Creek April 28, 2011 (Table 4.5.2). A Dolly Varden spawner and redd survey was conducted on Falls River on November 14, 2009. No Dolly Varden surveys were completed on Carthew Creek and no surveys for either species took place on Hayward Creek. Low spawning potential based on aerial photography and poor access was reported as the reason for not surveying Hayward Creek.

**Table 4.5.2. Date and location of boat and foot surveys of tributaries to Big Falls Reservoir and the species expected to be spawning prior to each survey.**

| | Cutthroat Spawning | | Dolly Varden Spawning |
|---|---|---|---|
| **Stream** | **May 13-14, 2009** | **April 28, 2011** | **November 14, 2009** |
| Falls River | X | | X |
| Carthew Creek | X | X | |
| Haywood Creek | | | |

Surveys used a combination of angling and shore or boat-based observations. Crews opted not to include snorkel surveys based on perceived success of the other methods. Anglers fished for approximately 10 minutes at an unknown number of sites selected for favourable catch rates. The shore and boat survey occurred during the travel to and from the physiochemical sampling sites. The relative proportion of channel length completed by shore versus boat was not described. No surveys occurred upstream of the 92.4 m elevation on either surveyed stream.

### 4.5.3 Interpretation of Data

#### *4.5.3.1 Availability of Suitable Spawning habitat within Drawdown Zone*

Visual assessments found suitable spawning habitat in Falls River and Carthew Creek between 91.0 and 92.4 m, which reflected the zone that could only be submerged with flashboards installed.

Based on the visual surveys, no suitable spawning habitat was found below 91.0 m level in either Falls River or in the short section of Carthew Creek before it joins the Falls River, which reflects the operating range without flashboards installed, as has been the case throughout the WUP monitoring period. There was no physiochemical monitoring below 91.0 m to support the visual assessment, which decreases the level of confidence in this conclusion.

The study provided only limited information to assess the suitability of drawdown zone for Dolly Varden spawning. Substrate sampling from spring sampling likely reflects conditions during the fall; however, the other habitat variables (dissolved oxygen, water velocity) would not reflect conditions during the expected Dolly Varden spawning period (September – October).

**Table 4.5.3. Average intragravel physiochemical conditions at sampling sites in Falls River and Carthew Creek between 91.0 and 92.4 m elevation and at a control site in Falls River above the 92.4 m elevation.**

| | | | | Intragravel | | | | |
|---|---|---|---|---|---|---|---|---|
| Site | Date | Water depth (m) | Velocity (m/s) | Dissolved oxygen (mg/l) | Temp (°C) | pH | Conductivty (µs/cm) | Dominant substrate (mm) |
| Falls 1 | 13-May-09 | 0.4 | 1.02 | 10.5 | 6.5 | 6.9 | 33.4 | Gravel <4 - 54 |
| Falls 2 | 13-May-09 | 0.42 | 0.4 | 13.4 | 5.9 | 7 | 13.6 | Gravel <4 - 38 |
| Falls control | 13-May-09 | 0.28 | 0.36 | 8.5 | 6.4 | 6.5 | 24.3 | Gravel <4 - 49 |
| Carthew 1 | 14-May-09 | 0.47 | 0.47 | 7.8 | 6 | 6.6 | 65.2 | Gravel <4 - 35 |
| Carthew 2 | 14-May-09 | 0.21 | 0.58 | 9 | 6.5 | 6.6 | 19.4 | Gravel <4 - 38 |
| | | | Values for suitable habitat | | | | | |
| Dolly Varden | | 0.05 - 0.4 [1] | 0.1 - 1.0 [1] | 6.0 min [3] | - | 6.5 -9.0 [3] | | Gravel medium-large <100 [1] |
| Cutthroat | | - | 0.2 - 0.5 [2] | 6.0 min [3] | - | 6.5 -9.0 [3] | | Gravel 2 - 50 [2] |

[1] Based on habitat suitability index (HSI >0.75) developed as part of the Kitsault Mine Project Environmental Assessment (2011). See Appendix 9 for details and references. [2] From Table 2 in Beblow 2011. [3] BC Provincial Guidelines (RIC 1998) .

### *4.5.3.2 Evidence of Spawning*

Surveys found no evidence of Cutthroat spawning in the Falls River (1 survey) and Carthew Creek (2 surveys) or Dolly Varden spawning in Falls River (1 survey). No adult or juvenile fish were observed or captured, and no redds were observed on any of the surveys.

No surveys were completed on Hayward Creek and none on Carthew Creek during the expected fall Dolly Varden spawning period. Thus, the study did not have the potential to provide evidence of spawning in these areas.

Surveys included the sections of Falls River and Carthew Creek extending to the upper most physiochemical monitoring sites. The Terms of Reference for this monitor (BC Hydro 2006f) specified that if no adult or redds were observed, surveys should continue up stream until either were detected as a way to confirm the effectiveness of the survey methods. This did not occur as headwater sections were not investigated. Without this, it remains unclear whether the survey methods were capable of detecting fish and redds. Confirming the survey effectiveness becomes especially important if no fish or redds are observed to distinguish between the conclusions that either were present but not detected or were absent.

The low level of detail describing the spawning survey methods and lack of corroboration evidence to confirm their effectiveness increases the likelihood that the absence of observations was a result of the low effectiveness of the sampling methods.

**Answers to Management Questions**

1. Are there suitable spawning habitat conditions for Dolly Varden and Cutthroat Trout in the tributary habitat in the drawdown zone of the Big Falls Reservoir?

Yes, for Cutthroat Trout above the 91.0 m elevation in Falls River and Carthew Creek. Physiochemical samples were within the range suitable for spawning and incubation based on sampling during the expected spring spawning period.

Possibly yes, for Dolly Varden above the 91.0 m elevation in Falls River and Carthew Creek. Physiochemical measurements were not collected during the fall spawning period but values from spring sampling were within acceptable levels for Dolly Varden.

No suitable spawning habitat was identified in the tributaries below the 91.0m elevation based solely on surveyor observations of habitat characteristics. This corresponds to the drawdown zone when flashboards are not in use. The study concluded there was low spawning potential for either species based on aerial alone. However, there were no physiochemical information or field observations to support this.

2. Do Dolly Varden or Cutthroat trout spawn in tributary habitat in the drawdown zone of the Big Falls Reservoir?

   The study provided no evidence of Cutthroat Trout spawning in the drawdown zone of Falls River or Carthew Creek during late April or early May, and no evidence of Dolly Varden spawning in the drawdown zone of Falls River in the fall. Dolly Varden spawning in Carthew Creek remains uncertain. The study provided no information about the occurrence of either species spawning in Hayward Creek.

## 4.6 FLSMON-6 Big Falls Reservoir Wildlife Shoreline Habitat Monitoring

### 4.6.1 Project Summary

The WUP Consultative Committee expressed concern that changes to the seasonal operation of the Big Falls Reservoir would disrupt wildlife nesting and denning in the reservoir drawdown zone. Accordingly, the Falls River WUP identified a key data gap that “there is uncertainty as to whether there is active nesting and denning in the drawdown zone at key elevations and during periods when flooding occurs” (15 February and 15 March). The WUP also stipulated that this data gap would be addressed via a study (FLSMON-6) which would survey the drawdown zone for dens and nests.

| Objectives | Management Questions[1] | Response |
|---|---|---|
| Determine whether nests and dens are present in the drawdown zone of the Big Falls Reservoir[1] | 1. Is there active nesting and denning in the drawdown zone of Big Falls Reservoir at elevations and during periods when they may be flooded when the flashboards are installed?<br>2. Does the extent of nest and den flooding under WUP operations differ from the flooding that would occur under the base case operations? | 1. Yes, for mammal denning and no, for bird nesting. This study identified that there is active mammal denning during the proposed flashboard installation period; however, the study also concluded that risk of nest flooding, associated with the hypothetical WUP flashboard operation, was low.<br>2. For mammal dens, yes, because vulnerable dens were in the elevation zone affected by WUP flashboard operations. For bird nests, no, because the effects of WUP flashboard |

| | | |
|---|---|---|
| | | operations would be unlikely to cause nest flooding. |

[1]BC Hydro 2006f

### 4.6.2 Project Approach

This monitoring project was initiated in August 2007 to consider the risks of den and nest flooding specifically associated with the installation of flashboards in accordance with the Falls River WUP.

FLSMON-6 monitoring was conducted from 2007 to 2009 by Cambria Gordon Ltd and Metlakatla Fisheries. Annual reports were compiled each year. The final Year 3 report summarized results for all study years and addressed the management questions listed above. All reports are available on BC Hydro's WUP website:

https://www.bchydro.com/toolbar/about/sustainability/environmental_responsibility/water-use-plans/northern-interior/falls-river.html

The general approach used by this monitoring project was to rely on empirical field survey data to detect and map nesting birds and denning mammals. Prior to field efforts, information was gathered in Year 1 from local stakeholders and a desktop review was performed to derive a list of target species for consideration. In Year 2 and Year 3, seven separate field visits were made to gather data.

Following the completion of the planned WUP field study (2010), a supplemental desk-top exercise was scheduled into the TOR (BCH 2019) to augment the previous work completed by Cambria Gordon Ltd and Metlakatla Fisheries to assess remaining data gaps regarding timing of potential nesting relative to the WUP flashboard operations. This desk-top assessment relied on records of species breeding distributions in BC and provincial records related to the timing of each species' nesting season. By cross-referencing the timing of nesting for a regionally appropriate list of species with potential to nest in the drawdown zone, the risks associated with the WUP timing of proposed flashboard operations could be addressed.

BC Hydro (2019) identified potential for species to be nesting on the shores of the reservoir (e.g., Common Loon) vulnerable to nest stranding (as well as nest flooding). Nest stranding occurs when water levels recede so that the nest is no longer on the shoreline. Species that are unable to walk (loons, grebes) are unable to access both nesting and foraging habitat when their nests become stranded.

### 4.6.3 Interpretation of Data

This study identified 12 burrows, lodges or dens situated below the full pool (92.4 m asl), and 11 of these were in the zone that would have been affected by flashboard operations). Six of these were considered to be used by American Beaver or River Otter (90.0 to 91.3 m asl) which are aquatic species, so the risk associated with flashboard operations is likely reduced. Two other drawdown zone dens were determined to be used by porcupine (92.0 and 92.3 m asl). The remaining features were burrows made by smaller species (91.4 to 92.3 m asl). Eight of these features were considered to be used for overwintering or as maternal dens, whereas the others had transitory usage (Cambria Gordon 2010).

**Answers to Management Questions**

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?

Yes, for mammal denning and no for bird nesting. This study identified that there is active mammal denning during the proposed flashboard installation period; however, the study also concluded that risk of nest flooding associated with the hypothetical WUP flashboard operation was low.

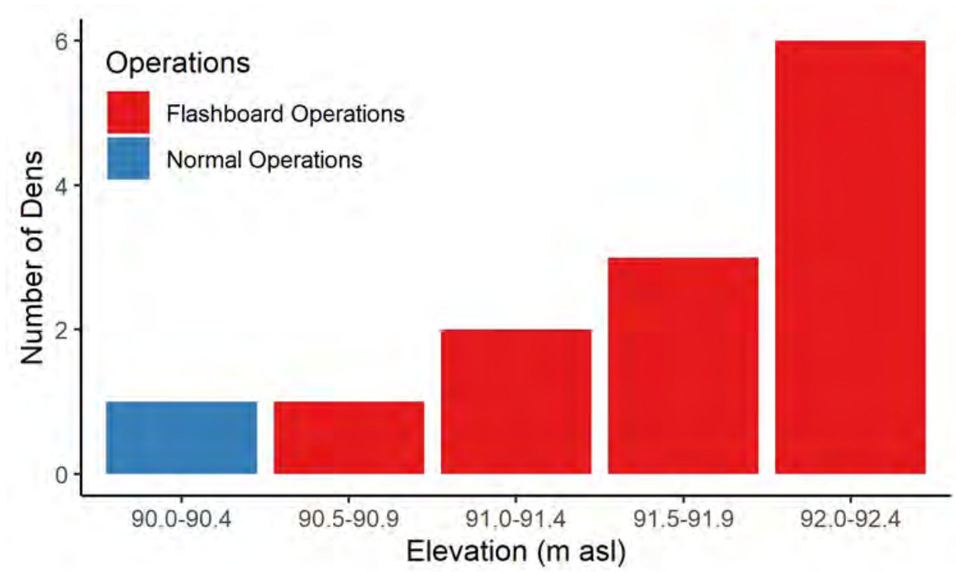


**Figure 4.6.a: Distribution of dens found in the drawdown zone and the proposed flashboard operations that may make them vulnerable to inundation (adapted from Cambria Gordon 2010, Figure 14).**

Five bird species were identified that in theory, could potentially nest early enough to warrant some concern of vulnerability associated with the WUP flashboard operation: Mallard, Song Sparrow, Canada Goose, Killdeer, and Spotted Sandpiper. Only one of these species (Mallard) had the potential to initiate a nest prior to flashboard installation as outlined in the WUP; the other four species could potentially initiate a nest during the flashboard installation period (BC Hydro 2019). However, the expected nesting dates were anticipated to be later than what was shown in the desk-top data, and it was concluded that risk of nest flooding associated with the hypothetical WUP flashboard operation was exceeding low, as concluded in the Final Year 3 Report (Cambria Gordon 2010).

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

For mammal dens, yes, because vulnerable dens (some assumed to be active) were in the elevation zone that would be affected by WUP flashboard operations so the extent of den flooding under WUP operations would have differed from base operations (Cambria Gordon 2010). For bird nests, no, because the effects of WUP flashboard operations would be unlikely to cause nest flooding; therefore, it was concluded that the extent of nest flooding under WUP operations would not differ from base operations (Cambria Gordon 2010, BC Hydro 2019).

## 5.0 REFERENCES

Alaska Department of Fish and Game (ADFG). 1985. Arctic Char Life History and Habitat Requirements. In Alaska Habitat Management Guide.

Applied Ecosystem Management Ltd. 2001. Reconnaissance (1:20,000) Fish and Fish Habitat Inventory of the Falls River Watershed. Prepared for West Fraser Mills Ltd. 290p

Armstrong, R.H., and J.E. Morrow. 1980. The Dolly Varden Char, Salvelinus malma. In

Charrs. E.K. Balon (ed.). Kluwer Boston Inc., Hingham, MA. 928p.

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

BC Hydro. 2006a. Falls River Project Water Use Plan. Revised for Acceptance by the Comptroller of Water Rights.

BC Hydro 2006b. FLSMON-1 TOR Falls River Presence and Timing of Steelhead and Salmon Spawning Monitoring. BC Hydro, 6911 Southpoint Drive, Burnaby, BC. 9p.

BC Hydro 2006c. FLSMON-2 TOR Falls River Fish Spawning Habitat Monitoring. BC Hydro, 6911 Southpoint Drive, Burnaby, BC. 15p.

BC Hydro 2006d. FLSMON-3 TOR Big Falls Reservoir Tributary Access and Potential Stranding Monitoring. BC Hydro, 6911 Southpoint Drive, Burnaby, BC. 9p.

BC Hydro 2006e. FLSMON-4 TOR (Revised 1) Big Falls Reservoir Sedge Habitat Maintenance Monitoring. BC Hydro, 6911 Southpoint Drive, Burnaby, BC. 13p.

BC Hydro 2006f. FLSMON-5 TOR Big Falls Reservoir Tributary Backwatering Monitoring. BC Hydro, 6911 Southpoint Drive, Burnaby, BC. 14p.

BC Hydro 2006g. FLSMON-6 TOR Big Falls Reservoir Wildlife Shoreline Monitoring. BC Hydro, 6911 Southpoint Drive, Burnaby, BC. 9p.

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

BC Hydro. 2019. Falls River Project Water Use Plan FLSMON-6 Big Falls Reservoir Wildlife Shoreline Habitat Monitoring Desktop review of nest flooding risk Study Period: 6 May 2018 – 21 May 2019. Prepared for BC Hydro Water Licence Requirements, Burnaby, BC.

Becker, C.D., D.A. Neitzel, and C.S. Abernethy. 1983. Effects of dewatering on chinook salmon redds: tolerance of four development.

Beblow, J. 2011. Big Falls Reservoir Tributary Backwater Monitoring. Prepared for BC Hydro, 6911 Southpoint Drive, Burnaby, BC. 41p.

Bradford, M.J., Taylor, G.C., Allan, J.A., 1995. An experimental study of the stranding of juvenile coho salmon and rainbow trout during rapid flow decreases under winter conditions. North American Journal of Fisheries Management 15, 473e479.

Brown, R.S and W.C. Mackay *2011.Canadian Journal of Fisheries and Aquatic Sciences*, 1995, 52(5): 983-992

Dunham, J., Rieman, B. and Davis, K. 2001, Sources and Magnitude of Sampling Error in Redd Counts for Bull Trout. North American Journal of Fisheries Management, 21: 343–352

CCME. 1999. Canadian water quality guidelines for the protection of aquatic life. Canadian Council of Ministers of the Environment.

Decker, S., J. Macnair, and G. Lewis. 2010. Coquitlam River Fish Monitoring Program: 2000-2010 Results. Unpublished report prepared for B.C. Hydro Power Facilities, Burnaby, B.C., April 2010.

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:

DFO 2003. Habitat and Enhancement Facts and Figures (Third Edition). Habitat and Enhancement Branch – Fisheries and Oceans Canada.

Cambria Gordon/Metlakatla Fisheries. 2009. Falls River Fish Spawning Habitat Monitoring (Year 1). Falls River Project Water Use Plan.

Cambria Gordon (2010) BC Hydro Falls River Water Use Plan (WUP) Monitoring: Big Falls Reservoir Wildlife Shoreline Habitat Monitoring Planning Final Report, Year 1-3. Prepared for BC Hydro, Water Licence Requirements, Burnaby, BC.

Gallagher, S. P. and Gallagher, C. M. 2005, Discrimination of Chinook Salmon, Coho Salmon, and Steelhead Redds and Evaluation of the Use of Redd Data for Estimating Escapement in Several Unregulated Streams in Northern California. North American Journal of Fisheries Management, 25: 284–300

Guimond, E. and D. Burt. 2007. Puntledge River Egg Incubation Assessment, 2006-2007 Results. Prepared for BC Hydro Puntledge River Water Use Plan project, Burnaby, BC.

Griffith, R.P. 1979. The Spawning and Rearing Habitat of Dolly Varden Char and Yellowstone Cutthroat Trout in Allopatry and in Sympatry with Selected Salmonids. Prepared for Fish Habitat Improvement Section, British Columbia Ministry ofEnvironment.

Halleraker, J., Saltveit, S.J., Harby, A., Arnekleiv, J.V., Fieldstad, H.-P., Kohler, B., 2003. Factors influencing stranding of wild juvenile brown trout (Salmo trutta) during rapid and frequent flow decreases in artificial stream. River Research and Application 19, 589e603.

Hagan, J., and E.B. Taylor. 2001. Resource Partitioning as a Factor Limiting Gene Flow in Hybridizing Populations of Dolly Varden char (Salvelinus malma) and Bull Trout (Salvelinus confluentus). Canadian Journal of Fisheries and Aquatic Sciences 58: 2037-2047

Hickey, D.G. 1981. Salmon observations at Falls River hydroelectric project during 1981. Report by. to B.C. Hydro. Vancouver, B.C. 27 p.

Hickman, T., and R. F. Raleigh. 1982. Habitat suitability index models: Cutthroat trout. U.S.D.!. Fish and Wildlife Service. FWS/OBS-82/10.5. 38 pp.

Kellner, M. 2018. Enhancement and monitoring of nesting habitat for Common Loons (Gavia immer) on Whatshan Lake and Upper Arrow Lakes Reservoirs – 2018. Prepared for Ministry of Forests, Lands and Natural Resource Operations (Fish and Wildlife Compensation Program Section), Nelson, BC.

Khtada 2018. Big Falls Reservoir Sedge Habitat Maintenance Monitoring. Falls River Project Water Use Plan. Khtada Environmental Services LP. 59 p

Korman, J. and J. Schick. 2017. Cheakamus River steelhead juvenile and adult abundance monitoring (year 10). Report prepared for BC Hydro

Korman, J., Schick, J., Melville, C., and D. McCubbing. 2010. Cheakamus River steelhead juvenile and adult abundance monitoring Fall 2009 – Spring 2010. Report prepared for BC Hydro by Ecometric Research, February 2010. http://www.bchydro.com/planning_regulatory/water_use_planning/lower_mainland.html#Cheakamus

Larratt Aquatic Consulting Ltd. 1983. Impact of Wood Debris and Standing Trees on the Productivity of Falls River Reservoir. BC Hydro Library.

McPhail, J. D., and J. S. Baxter. 1996. A review of bull trout *(Salvelinus confluentus)* life-history and habitat use in relation to compensation and improvement opportunities. Fisheries Management Report No. 104, 35 p. Miller, L., D. Hjorth and J. Van Tin. 2002. Falls River Hydro Dam – Fisheries Restoration Feasability Study. Prepared for BC Hydro Fish and Wildlife Bridge Coastal Restoration Program. 33p. Report No. 02FA63

Muhlfeld, C.C, T.E. McMahon, D. Belcer, J. L. Kershner *2009.Canadian Journal of Fisheries and Aquatic Sciences*, 2009, 66(7): 1153-1168

Peterson J, J. Dunham, P. Howell, R. Thurow, S. Bonar. 2002. Protocol for determining bull trout presence. Bethesda, MD: American Fisheries Society. 52 p.

Saltveit, S.J., Halleraker, J.H., Arnekleiv, J.V., Hardy, A., 2001. Field experiments on stranding in juvenile Atlantic salmon (Salmo salar) and brown trout (Salmo trutta) during rapid flow decreases caused by hydropeaking. Regulated Rivers: Research & Management 17, 609e622.

## GLOSSARY

| Common Name | Latin Name |
|---|---|
| Coastal Cutthroat trout | *Oncorhynchus clarki clarki* |
| Dolly Varden char | *Salvelinus malma* |
| Bull trout | *Salvelinus confluentus* |
| | |