Consultative Committee Report

October 2003

Prepared on behalf of:

The Consultative Committee for the Wahleach Water Use Plan

Wahleach Water Use Plan

A Project of BC Hydro

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BC Hydro Contact:

Lower Mainland-Coastal Community Relations

Phone: 1-800-663-1377

Project Team:

Trade-off Analyst and Facilitator:	Graham Long, Compass Resource Management
Resource Valuation Task Manager:	Siobhan Jackson
Aboriginal Relations Task Manager:	Alison Willoughby
Power Facilities Task Manager:	Mike Lewis
Power Studies Task Manager:	Jim McNaughton
Power Modeller:	Kathy Lee
Community Relations Task Manager:	Terry Parsons
Environment/Recreation Task Managers:	Bob Westcott, Alf Leake

Project Manager:

Sue Foster

Phone: 604 528-2737

Fax: 604 528-2905

E-mail: sue.foster@bchydro.com

This report was prepared for and by the Wahleach Water Use Plan Consultative Committee, in accordance with the provincial government's *Water Use Plan Guidelines*.

The report expresses the interests, values and recommendations of the Committee and is a supporting document to BC Hydro's Wahleach Water Use Plan that will be submitted to the Comptroller of Water Rights for review under the *Water Act*.

The technical data contained within this Report was gathered solely for the purposes of developing the aforementioned recommendations, and should not be relied upon other than for the purposes intended.

EXECUTIVE SUMMARY

A Water Use Plan is a technical document that, once reviewed by provincial and federal agencies and accepted by the provincial Comptroller of Water Rights, defines how water control facilities will be operated. The purpose of a water use planning process is to develop recommendations defining a preferred operating alternative using a multi-stakeholder consultative process.

The Wahleach Water Use Plan consultative process was initiated in September 2000 and completed in October 2002. The consultative process followed the steps outlined in the 1998 provincial government's *Water Use Plan Guidelines*. This report summarizes the consultative process and records the areas of agreement and disagreement arrived at by the Wahleach Water Use Plan Consultative Committee. It is the basis for the Wahleach Water Use Plan. Both the Wahleach Consultative Committee Report and the Wahleach Draft Water Use Plan will be submitted to the Comptroller of Water Rights.

Wahleach Hydroelectric Facility

The Wahleach hydroelectric facility is part of the BC Hydro Coastal Region. The facility came into service in 1952. It is situated in the Lower Mainland approximately 25 km west of Hope and 100 km east of Vancouver.

Wahleach Dam is situated at the outlet of Jones Lake Reservoir. Although the lake existed before the hydroelectric facility, the Wahleach Dam has raised its level. The original lake elevation was around 619.0 m and was raised to an operating range of 623.3 m to 641.6 m by the Wahleach Dam. Water is drawn from the reservoir through the Four Brothers Mountain via a 4.2 km tunnel and a 500 m penstock. The penstock connects to a single 60 MW nameplate generator located in a powerhouse on the south bank of the Fraser River. Additional water is supplied by the diversion of Boulder Creek into Jones Lake Reservoir.

The Consultative Committee

The Wahleach Water Use Plan Consultative Committee initially consisted of 16 members. Eleven members actively completed the Wahleach water use planning process. Interests included First Nations archaeology and traditional use, fish, flood control, power generation, water quality and wildlife. The representatives included BC Hydro, provincial and federal agencies, First Nations and local stakeholders. The main Consultative Committee and Subcommittees held a total of twenty-five meetings to work through the steps outlined in the *Water Use Plan Guidelines*.

The Consultative Committee explored issues and interests affected by the operations of BC Hydro's Wahleach hydroelectric facility and agreed to the following objectives for the Wahleach Water Use Plan:

Fisheries

• Jones Creek Non-Anadromous	Maximize fish populations in Jones Creek non-anadromous
• Jones Creek Anadromous	Maximize fish populations in Jones Creek anadromous
• Jones Lake Reservoir	Maximize fish populations in Jones Lake Reservoir
• Herrling Island Sidechannel	Maximize fish populations in Herrling Island Sidechannel
Flooding	Minimize risks to safety and property damage from flooding
Greenhouse Gases	Minimize contributions to climate change
Power Generation	Maximize the net revenue from power generation
Recreation	Maximize quality and quantity of recreational experience
Wildlife	Minimize impacts to wildlife

There were no specific First Nation objectives developed during the Wahleach water use planning process. However, First Nations participated throughout the Wahleach water use planning process to develop fish and wildlife objectives and performance measures, create operating alternatives, and select a preferred operating alternative.

Recommended Operating Alternative

The Consultative Committee developed nine Wahleach water use planning objectives. Performance measures were identified based on these objectives. Operating alternatives were then developed to address the various objectives and run through BC Hydro's Optimization Model, Environment Model and Power Values Model. The Consultative Committee used the modelling results and performance measures to compare how well each operating alternative performed in satisfying the water use planning objectives.

On 7 October 2002, all Consultative Committee members present, excluding Frank Kwak of the Fraser Valley Salmon Society, accepted Alternative SalmonSIR628BCD+Siphon for the Wahleach hydroelectric facility. The recommended operating alternative includes a minimum flow release from the Boulder Creek Diversion Dam, a Jones Lake Reservoir minimum elevation level, a Jones Lake Reservoir fertilization program, a Jones Creek minimum flow, a Jones Creek fish habitat enhancement project, and curtails generation to zero for a two-hour period every twenty-four hours.

The Consultative Committee recommends that the Wahleach hydroelectric facility be operated according to the following operating conditions:

Table 1: Recommended Operating Conditions for the Wahleach Hydroelectric Facility

System Component	Condition	Time of Year	Purpose
Boulder Creek	Minimum flow of 0.14 m^3/s	Year-round	Fish passage above the bypass
Jones Lake Reservoir	Minimum elevation 628 m Fertilization program: $40,000 per year for fertilizer application $40,000 per year for reporting and analysis[1]	Year-round	Jones Lake Reservoir fish and recreation
Lower Jones Creek	Minimum flows:[2] 1.1 m^3/s 0.6 m^3/s Fish habitat enhancement project	15 September to 30 November All other times	Jones Creek fish
Herrling Island Sidechannel	Curtails generation to zero for a two-hour period each day	15 September to 30 November	Avoid fish spawning in high dewatering risk areas in Herrling Island Sidechannel

1. Fertilization program to be reviewed after five years to determine whether costs could be reduced.
2. Subject to available inflows and augment sources from the Boulder Creek bypass valve and the fish water release siphon. Measured at a staff gauge to be installed in Jones Creek near Laidlaw.

At the October 2002 Consultative Committee meeting, the Committee recommended that BC Hydro begin monitoring Boulder Creek inflows and Jones Creek anadromous fish habitat productivity immediately, before the implementation of the Wahleach Water Use Plan.

Consequences of the Recommended Alternative

The expected consequences of the recommended operating alternative are summarized in Table 2. Benefits of the recommended operating alternative, relative to status quo operations, include: an increase in fish habitat in Jones Creek anadromous, and an increase in fish and wildlife habitat and recreation at Jones Lake Reservoir. Costs of the recommended operating alternative, relative to status quo operations, include a decrease in net revenue and an increase in greenhouse gas emissions.

Table 2: Expected Consequences of the Recommended Operating Alternative

Water Use Interest	Consequences Over Status Quo Operations	
Net Revenue	–	Decrease of $626,000 per year over status quo operations
	+	Increase of $604,000 per year over current licensed operations
Fish in Jones Creek	+	Increase in average fish spawning habitat from provision of minimum flows
	+	Increase in fish spawning and rearing habitat from the fish habitat enhancement project
Fish in Jones Lake Reservoir	+	Increase in pelagic and littoral productivity from minimum reservoir elevation level of 628 m and a fertilization program
Wildlife in Jones Lake Reservoir	+	Increase in riparian habitat from minimum reservoir elevation level of 628 m
Fish in Herrling Island Sidechannel	+	Decrease in fish stranding from curtailing generation to zero for a two-hour period every twenty-four hours
	–	Decrease in fish habitat over status quo operations
Fish in Boulder Creek	+	Increase in fish passage from provision of minimum flows
Recreation	+	Increase in recreational opportunities from minimum reservoir elevation level of 628 m
Flood Control	0	Neutral
Greenhouse Gases	–	Increase in greenhouse gas emissions due to reduced hydroelectric generation

Monitoring Program

The Consultative Committee discussed sources of uncertainty associated with implementing the recommended operating alternative. On 7 October 2003, the following monitoring program was accepted by all Consultative Committee members present, excluding Frank Kwak of the Fraser Valley Salmon Society:

- Jones Creek Anadromous – Salmonid Productivity Monitoring
- Jones Creek Anadromous – Channel Stability Assessment
- Jones Creek Anadromous – Pink Salmon Genetic Composition Assessment
- Jones Lake Reservoir – Entrainment Monitoring
- Herrling Island Sidechannel – Chum Salmon Spawning Behaviour Observations

The annual costs of the monitoring program, including development of detailed terms of references and synthesis of monitoring results, vary from $145,000 to $160,000 with an overall average cost of $149,000 per year over the period of the program.

The Consultative Committee recommended that a Wahleach Water Use Plan Monitoring Advisory Committee be established consisting of representatives of:

- BC Hydro
- Community representatives
- First Nations
- Fisheries and Oceans Canada
- Fraser Valley Salmon Society
- Ministry of Water, Land and Air Protection

The Consultative Committee recommended that the mandate of the Wahleach Water Use Plan Monitoring Advisory Committee should be to:

- Manage the implementation of the fish habitat enhancement project in Jones Creek anadromous.
- Review annual monitoring program results and assess the need to recommend a review of the Wahleach Water Use Plan.
- Recommend improvements to the monitoring program within existing Wahleach Water Use Plan budgets.
- Support periodic communication with the public (e.g., newsletters, annual reports).
- Ensure publication of monitoring program reports.
- Nurture co-operation and collaboration to improve the environmental database and to build common understanding (ongoing).

Review Period

Five years after the implementation of the Wahleach Water Use Plan, the Wahleach Water Use Plan Monitoring Advisory Committee will review the results of the monitoring program and assess the need to recommend to BC Hydro a review of the Wahleach Water Use Plan. The Monitoring Advisory Committee will also review the Jones Lake Reservoir fertilization program to determine whether the cost could be reduced. If the Wahleach Water Use Plan is not reviewed five years after implementation, then the Plan will continue for an additional five years.

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1 INTRODUCTION

Water use planning was introduced by the then Minister of Employment and Investment (MEI)[1] and the Minister of Environment, Lands and Parks (MELP)[2] in 1998 as an approach to ensure provincial water management decisions reflect changing public values and environmental priorities. A Water Use Plan is a technical document that, once reviewed by provincial and federal agencies and approved by the provincial Comptroller of Water Rights, defines how water control facilities will be operated. The purpose of water use planning is to understand public values and to develop recommendations defining a preferred operating alternative using a consultative process. This consultative process is outlined in the provincial *Water Use Plan Guidelines* (Province of British Columbia, 1998).

A Water Use Plan is intended to address issues related to the operations of facilities as they currently exist and incremental operational changes to accommodate other water use interests.[3] Water Use Plans are not intended to be comprehensive watershed management plans or to deal with water management issues associated with other activities in the watershed. Treaty entitlements and historic grievances from initial construction of the facility are specifically excluded from Water Use Plans, but can be considered as part of other processes (Province of British Columbia, 2000).

The Wahleach Water Use Plan consultative process was initiated in September 2000 and completed in October 2002. This Consultative Committee Report is a record of the water use issues and interests and the analysis of trade-offs associated with operating alternatives. The purpose of this report is to document the consultative process and present the recommendations of the Wahleach Water Use Plan Consultative Committee. The interests and values expressed in this report will be used by BC Hydro to prepare a Water Use Plan for the Wahleach hydroelectric system. Both the Wahleach Water Use Plan Consultative Committee Report and BC Hydro's Draft Water Use Plan will be submitted to the Comptroller of Water Rights.

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1 The Ministry of Employment and Investment responsible for electricity policy at the initiation of the Water Use Plan program is now part of the Ministry of Energy and Mines.

2 The Ministry of Environment, Lands, and Parks was reorganized in 2001 into the Ministry of Water, Land and Air Protection and the Ministry of Sustainable Resource Management.

3 The focus of a Water Use Plan is to determine how water could be allocated to accommodate different interests. However, there may be opportunities to undertake physical works as a substitute for changes in flow.

2 WAHLEACH HYDROELECTRIC FACILITY

2.1 Description of Current Facility

The Wahleach hydroelectric facility is part of the BC Hydro Coastal Region Generation System. The facility came into service in 1952. It is situated in the Lower Mainland approximately 25 km west of Hope and 100 km east of Vancouver. The facility consists of:

- Boulder Creek Diversion Dam.
- Wahleach Dam at the outlet of Jones Lake Reservoir.
- Jones Lake Reservoir.
- An intake structure 2 km west of Wahleach Dam.
- A 4.2 km-long power tunnel.
- A 500 m-long penstock.
- Wahleach Generating Station.

Wahleach Dam is situated at the outlet of Jones Lake Reservoir. Although the lake existed before the hydroelectric facility, its level has been raised by the Wahleach Dam. Water is drawn from the reservoir through the Four Brothers Mountain via a 4.2 km tunnel and a 500 m penstock. The penstock connects to a single 60 MW nameplate generator located in a powerhouse on the south bank of the Fraser River. Additional water is supplied to the reservoir by the diversion of Boulder Creek into Jones Lake Reservoir.

Jones Lake Reservoir is approximately 600 m above the Wahleach Generating Station, making Wahleach the highest “hydraulic head” generating unit in the BC Hydro hydroelectric system. Hydraulic head is a measure of the vertical distance between the water level in the reservoir and the water level immediately below the turbine outlet. The higher the hydraulic head, the less water is needed to produce a unit of electricity. Therefore, the water in Jones Lake Reservoir has the highest value per unit relative to any other BC Hydro-owned hydroelectric facility.

The current physical structures and other relevant areas in the Wahleach hydroelectric facility boundary include the following:

- **Wahleach Dam:** Wahleach Dam is an earthfill dam with a crest length of 418 m and a normal maximum elevation of 646.2 m. A freecrest overflow spillway is located on the east abutment of the dam. The spillway discharges into an excavated channel which then carries water to Jones Creek approximately 400 m downstream of the dam. In 1969, a fish water release siphon capable of diverting up to 0.85 m^3/s of flow from Jones Lake Reservoir into Jones Creek was added to the top of the dam near to the west abutment of Wahleach Dam. The siphon can be primed at elevations over 637.6 m and becomes deprimed below 636.4 m. Photo 2-1 illustrates Jones Lake Reservoir, Wahleach Dam and the spillway. Figure 2-1 illustrates the characteristics of the Wahleach Dam.

- **Boulder Creek Diversion Dam:** Boulder Creek Diversion Dam is an earthfill dam located approximately 400 m east of the main dam. It has a crest length of 180 m and a variable nominal maximum elevation. The Boulder Creek Diversion Dam diverts flow from Boulder Creek into Jones Lake Reservoir for power purposes. It was originally built with a fish release gate capable of allowing up to 1.4 m^3/s of Boulder Creek flow to continue into Jones Creek below Wahleach Dam to provide flows for an artificial spawning channel. However, over time, erosion at the intake of this gate has resulted in all the water now being diverted to the reservoir at very low flows.

- **Jones Lake Reservoir:** Jones Lake Reservoir is the storage reservoir in the Wahleach hydroelectric facility. It is an oligotrophic lake with a surface area of 460 ha, a maximum depth of 29 m and a mean depth of 13.4 m. See Figure 2-2 for the elevation of Jones Lake Reservoir.

- **Jones Creek:** Jones Creek, which is also known as Wahleach Creek, originates on Cheam Ridge. From the headwaters, the creek flows approximately 3 km north and enters Jones Lake Reservoir. Most of the flow from Jones Creek is diverted through the power tunnel and into the Wahleach Generating Station. The remaining creek water and the water released from the Wahleach Dam flows north, then passes under the Trans-Canada Highway and the Canadian National Railway to the creek's confluence with the Fraser River near Laidlaw. The section of the creek referred to as lower Jones Creek flows from the Wahleach Dam to the confluence of the Fraser River. The total length of lower Jones Creek is approximately 9 km, of which less than 1 km is accessible to anadromous species, as access is blocked by a natural barrier located 100 m above Laidlaw Bridge crossing. Jones Creek is divided into two sections:

  - Jones Creek non-anadromous is the section between the natural barrier and the Wahleach Dam approximately 9 km upstream. This section has an average gradient of 7 per cent, with canyon sections between 10 to 12 per cent. Limited habitat availability has provided habitat for small resident rainbow trout only. Channel instability below 2.8 Mile and 3 Mile creeks has caused minor riparian damage, but due to the high gradient, most sediment deposition is limited to the anadromous section.

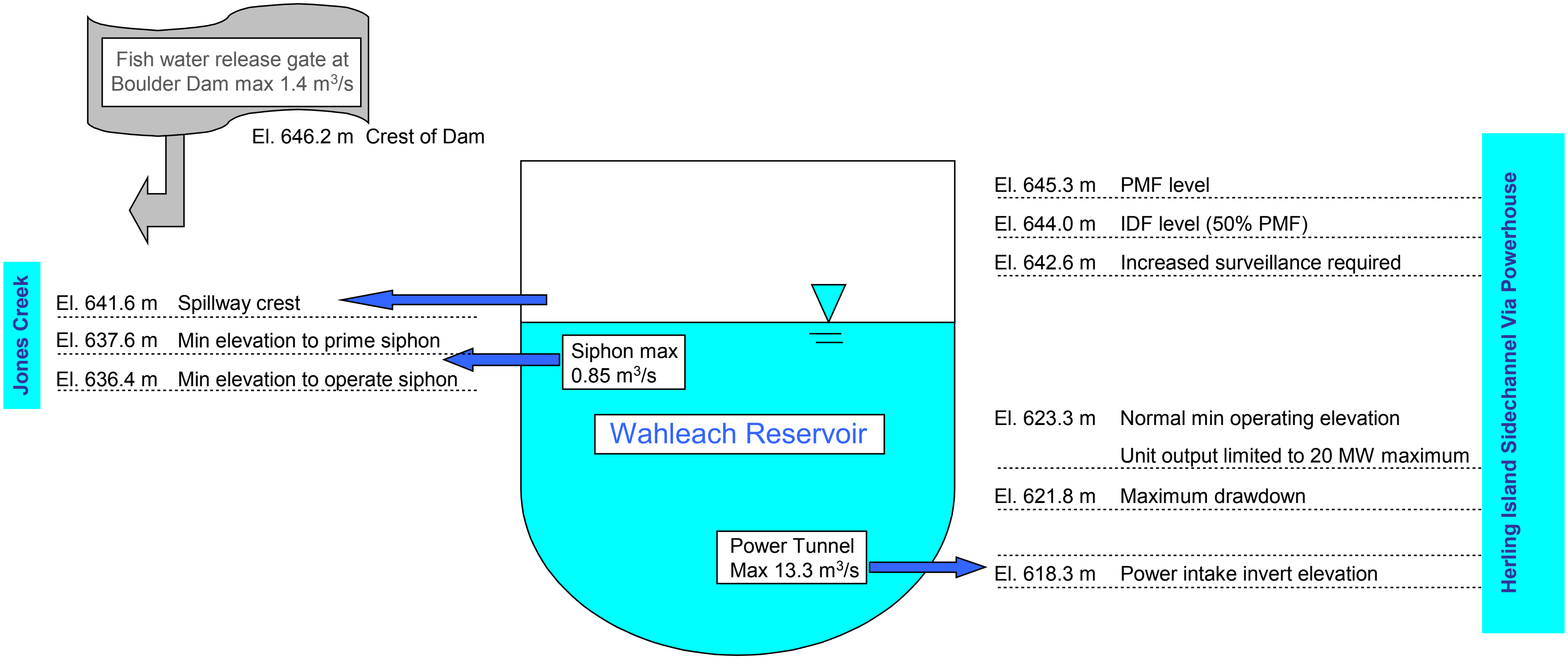
- Jones Creek anadromous is the section between its confluence with the Fraser River and the natural barrier approximately 900 m upstream. This section is plagued by severe slope instability, which has resulted in significant impacts to fish habitat quality. This section is affected by upstream slope instability and has little functional riparian cover or channel control. The channel is very active and is prone to movement and braiding within the year, particularly in the fall and spring seasons.

  In 1954, an artificial spawning channel was constructed in lower Jones Creek anadromous to mitigate for lost fish habitat. In 1995, the spawning channel was destroyed by a massive landslide. There has been no attempt at reconstruction, in light of subsequent analyses recommending a "wait and see" approach to habitat enhancement in the area (Miles and Hartman, 1997).

- **Penstock and Wahleach Generating Station:** Water from Jones Lake Reservoir enters an intake structure on the west side of the reservoir and is carried through a 4.2 km tunnel and a 500 m penstock to the generating station on the south bank of the Fraser River. The station has a 60 MW nameplate Canadian General Electric generator, enough to service 25 000 homes annually. More importantly, it produces generating capacity close to the load centre which can be used to meet the peak demands for electricity.

- **Herrling Island Sidechannel:** Herrling Island Sidechannel is approximately 8 km in length, with the Wahleach Generating Station tailrace entering a pool 1 km south of the channel invert.

Photo 2-1: Jones Lake Reservoir, Wahleach Dam and Spillway



Wahleach Storage Water Licence No. 6409: storage of 59.8 x 10^6 m^3 (48 500 acre-ft) of water for power purposes
Wahleach Diversion Water Licence No. 6408: diversion of 180 x 10^6 m^3 (146 000 acre-ft) per annum, at a maximum rate up to 13.3 m^3/s (470 cfs) for power purposes.
When the Fraser River elevation level is high, the generator must not be operated when the tailwater level exceeds 19.6 m otherwise the tailrace water backs up and would damage the spinning turbine.
PMF maximum daily average inflow is 520 m^3/s
Peak discharge during PMF is 600 m^3/s

Figure 2-1: Characteristics of the Wahleach Dam

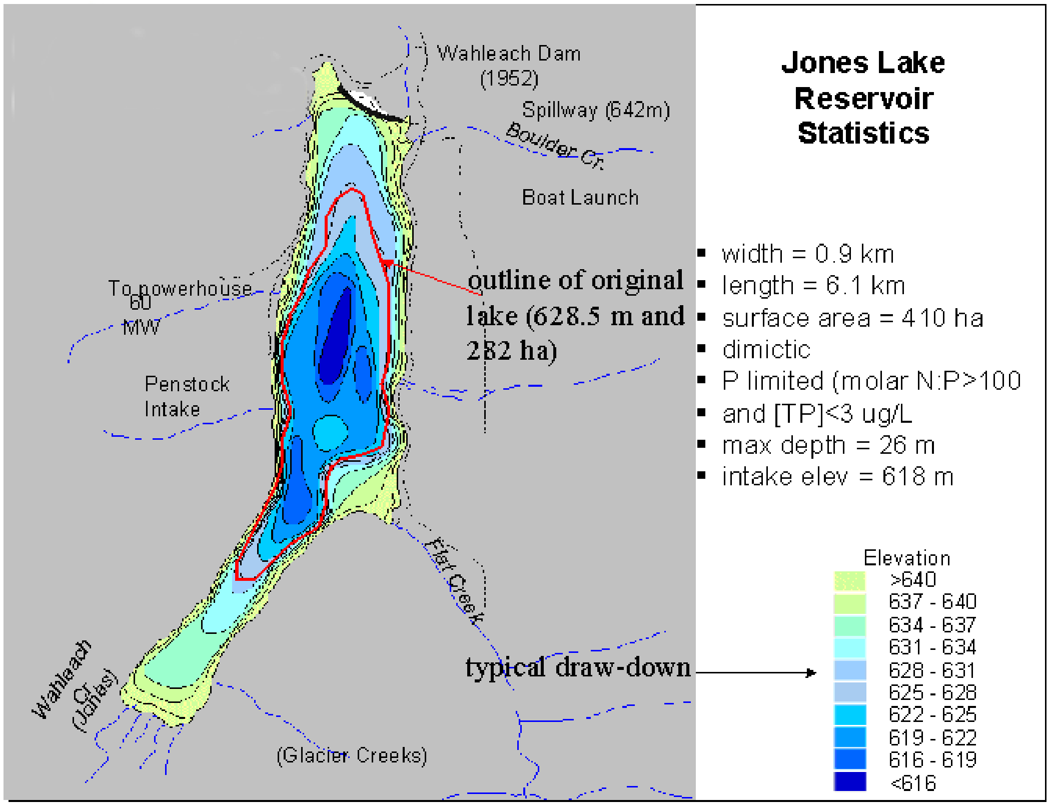


Figure 2-2: Bathymetric Profile of Wahleach Reservoir (Jones Lake) (Perrin, 2000)

2.2 Description of Current Facility Operations

2.2.1 Water Licences Rights And Obligations

BC Hydro is authorized by Wahleach Storage Water Licence #6409 to store 48 500 acre-ft. (59.8 x $10^6 m^3$) of water for power purposes. BC Hydro is authorized under Wahleach Diversion Water Licence #6408 to divert 146 000 acre-ft. (180 x 10^6 m^3) per annum, at a maximum rate of up to 470 cfs (13.3 m^3/s), for power purposes.

The average inflow for the Wahleach facility at ~ 2380 m^3/s-days or ~ 200 x 10^6 m^3 is greater than BC Hydro's diversion licence. Therefore, in some years BC Hydro asks the Comptroller of Water Rights for an Interim Order for permission to use the excess water for power generation.

2.2.2 Agreements, Obligations And Historical Practices

There are no formal agreements or obligations for the operation of the Wahleach hydroelectric facility, but there are some historical practices which are observed when technically possible as described below.

2.2.3 Wahleach Powerhouse Operation

There are no known limits on the rate of increase or decrease on turbine releases. To prevent damage to the turbine deflectors when in generation mode, the loading on the unit should be kept above 15 MW. The Wahleach Generating Station output may be restricted during periods of high tailwater elevations caused by high Fraser River elevations during spring run-off. The generator must not be operated such that the tailwater level exceeds 19.6 m, otherwise the tailrace backs up into the spinning turbine. The generator load shall be curtailed accordingly to maintain the tailwater level at or below 19.6 m. If the tailwater exceeds this level, the unit must not be operated.

2.3 Operating History

During August, the Jones Lake Reservoir elevation level is normally at full pool and then drops slowly until December. A more rapid decline then occurs with a minimum reservoir elevation level attained during April.

Figure 2-3 illustrates the daily Jones Lake Reservoir elevation level for 1987 to 1997.

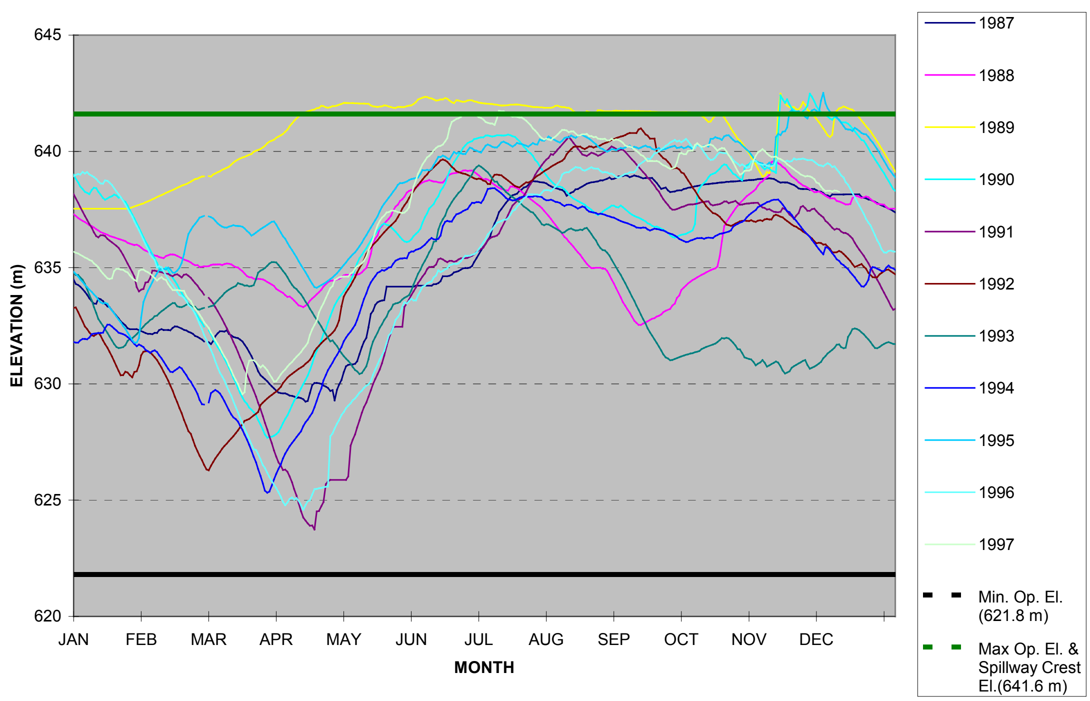


Figure 2-3: Daily Jones Lake Reservoir Elevation Level 1987 to1997

Figure 2-4 illustrates the daily inflow to Jones Lake Reservoir for 1961 to 1999.

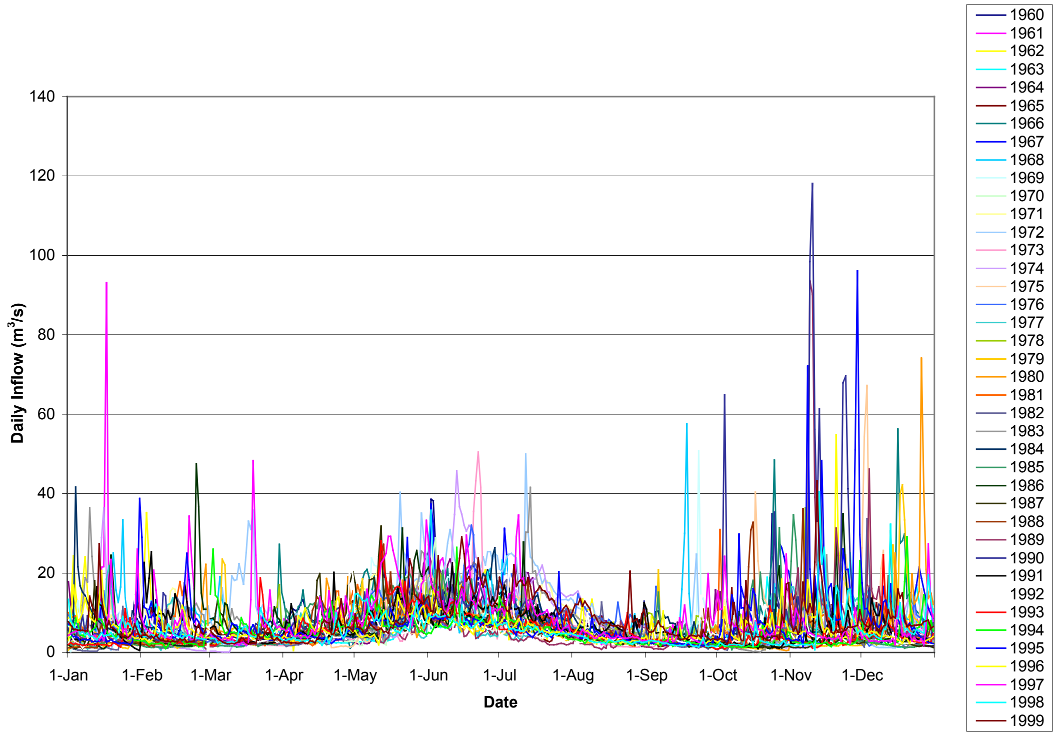


Figure 2-4: Daily Jones Lake Reservoir Inflow 1961 to 1999 (includes Boulder Diversion)

Figure 2-5 illustrates the daily water release for Wahleach Dam from 1987 to 1997. Water release facilities for the Wahleach Dam includes the spill and the fish water release siphon. Spill from the Wahleach Dam flows into Jones Creek.

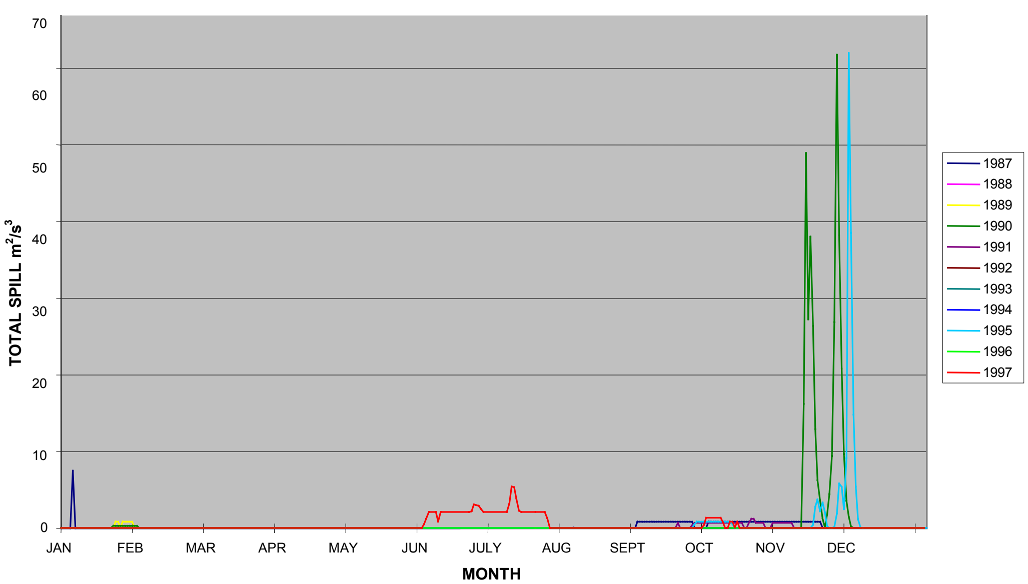


Figure 2-5: Daily Water Release for Wahleach Dam 1987 to 1997

Water released from the fish water release siphon enters Jones Creek immediately downstream of Wahleach Dam. This requires that the Jones Lake Reservoir elevation level be maintained at 634.4 m. In addition to the siphon at Wahleach Dam, the Boulder Creek Diversion Dam was built to provide fish water releases. Using this facility, water passes into Jones Creek immediately below the dam spillway, but does not operate as intended during low flow conditions.

In 1954, as part of a compensation agreement with the Department of Fisheries and Oceans, an artificial spawning channel was constructed to provide spawning habitat for pink salmon which spawn every second year. The spawning channel was located adjacent to Jones Creek, 100 m upstream from its confluence with the Fraser River. In 1995, the spawning channel was destroyed by a large debris torrent. During the years that the spawning channel operated, at the request of the Department of Fisheries and Oceans and the Ministry of Water, Land and Air Protection, flow releases from Jones Lake Reservoir were made to maintain a mean flow of 0.85 m^3/s at the spawning channel during the spawning season (15 September to 31 October); 0.4 m^3/s during incubation (1 November to 31 March); and 0.6 m^3/s during fry outmigration (1 April to 31 May). Fisheries and Oceans Canada may request flow releases to provide fish access to the spawning grounds in Jones Creek anadromous.

Generation at the Wahleach hydroelectric facility varies considerably from month to month. There is no fixed pattern of generation at any time in the year as the facility is used to meet the peak demands for electricity. The Wahleach Generating Station discharges directly into Herrling Island Sidechannel.

Figure 2-6 illustrates the daily generation at the Wahleach Generating Station for 1987 to 1997.

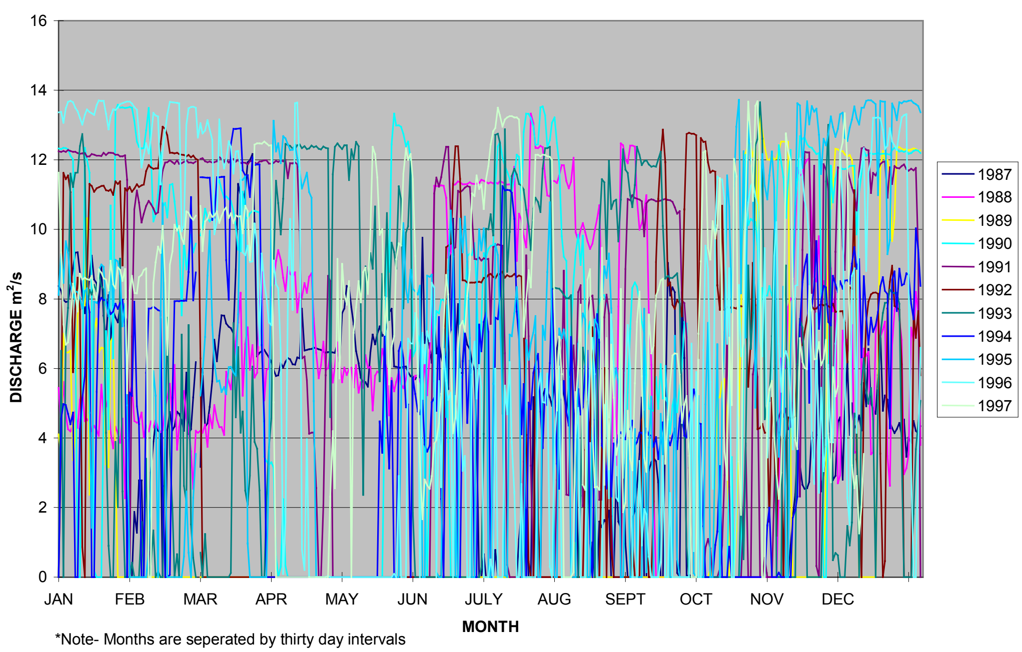


Figure 2-6: Daily Generation at the Wahleach Generating Station 1987 to 1997

3 CONSULTATION PROCESS

The Wahleach water use planning consultative process followed the steps outlined in the provincial *Water Use Plan Guidelines* (Province of British Columbia, 1998).

Table 3-1 summarizes the steps that provide the framework for a structured approach to decision-making.

Table 3-1: Water Use Planning Process

Steps	Components of Water Use Planning Process
1	Initiate Water Use Plan
2	Scope water use issues and interests
3	Determine consultative process
4	Confirm issues and interests of specific water use objectives
5	Gather additional information
6	Create operating alternatives for regulating water use to meet different interests
7	Assess trade-offs between operating alternatives
8	Determine and document areas of consensus and disagreement
9	Prepare a draft Water Use Plan and submit for regulatory review
10	Review the draft Water Use Plan and issue a provincial decision
11	Authorize Water Use Plan and issue federal decision
12	Monitor compliance with the authorized Water Use Plan
13	Review the plan on a periodic and ongoing basis

3.1 Initiation and Issues Scoping

On 9 November 1999, members of the BC Hydro project team met informally with the fish regulatory agencies to determine information relevant to the Wahleach Water Use Plan and to develop a preliminary list of issues and interests.

At this time, a large run of pink and chum salmon had returned to Jones Creek anadromous, and Fisheries and Oceans Canada requested that BC Hydro undertake an assessment of spawner and incubation success to enumerate the fish. BC Hydro undertook the study with the expectation that, by assessing egg-fry survival, the results would provide good information on the suitability of fish habitat in Jones Creek anadromous for the Wahleach Water Use Plan. It was anticipated that the Wahleach water use planning process would start while the studies were underway and that the Consultative Committee would have an opportunity for input. However, the Wahleach water use planning process was delayed until the fall of 2000. As a result, the Consultative Committee, including First Nations, did not have input into these fisheries studies. This issue was discussed at subsequent Consultative Committee and technical subcommittee meetings.

Initiation of the Wahleach water use planning process was publicly announced in a press release on 24 August 2000. In September 2000, advertisements were placed in a number of local newspapers, including the *Chilliwack Progress, Chilliwack Times, Harrison Observer, Hope Standard* and the *Agassiz-Harrison Observer*. BC Hydro contacted regulatory agencies, organizations, industries, local governments, and other groups soliciting interest in the Wahleach Water Use Plan. Those contacted also suggested others in the community who may be interested. BC Hydro also responded to individuals who inquired about the advertisements or news release.

In order to create a better understanding of the issues and interests regarding the Wahleach hydroelectric facility operations, BC Hydro:

- Held three Open Houses including one at the Wahleach Generating Station and two in the City of Chilliwack.
- Developed a Wahleach Water Use Plan questionnaire which was distributed at the Open Houses.
- Conducted reviews of internal Environmental Management Systems and other records to establish a current profile of environmental issues, incidents and activities.

At the first Wahleach Water Use Plan Consultative Committee meeting on 19 October 2000, BC Hydro provided a site tour of the Wahleach and Laidlaw area, including the destroyed spawning channel, the reservoir and recreation facilities, and the generating station.

The issues and interests identified by the above means were discussed and elaborated upon. Issues and interests were added and clarified throughout the Wahleach water use planning process.[1]

In May 2001, BC Hydro submitted a summary report of the identified issues and interests (*Issues Identification Report, BC Hydro, 2001*) to the Comptroller of Water Rights. This report completed Step 2 of the provincial *Water Use Plan Guidelines*. Key interests identified included:

[1] Kator Research Services prepared a reference list summarizing existing documents and reports related to the Wahleach hydroelectric facility.

- Cultural and Heritage.
- Fish.
- Flooding.
- Power Generation.
- Recreation.
- Water Quality.
- Wildlife.

3.2 Consultative Committee Structure and Process

The Wahleach Water Use Plan Consultative Committee was initially comprised of 16 members. Over the course of the Wahleach water use planning process, some members opted to change their status, to observer from Committee member, or to alternate for another Committee member. Those who moved to observer status were comfortable that their interests were represented by other Consultative Committee members. Eleven members actively completed the Wahleach water use planning process. (Refer to Appendix A: Consultative Committee, Observers and Subcommittees.)

In addition to the Consultative Committee, a Fish Technical Subcommittee was formed to focus on specific issues and to provide technical advice to the Committee. Technical subcommittees for First Nations and Recreation interests met on an as-needed basis.

In February 2001, the Consultative Committee developed and adopted a Terms of Reference and a consultation work plan. The Terms of Reference were included in the *Proposed Consultative Process Report: Wahleach Water Use Plan* (BC Hydro, 2001) and submitted to the Comptroller of Water Rights to fulfil Step 3 of the *Water Use Plan Guidelines*.

The Consultative Committee and technical subcommittees met between October 2000 and October 2002 to complete the Wahleach water use planning process. The consultative process included 11 Consultative Committee meetings, 11 Fish Technical Subcommittee meetings, two meetings of the First Nations Subcommittee, and one meeting of the Recreation Subcommittee. The technical subcommittees also held conference calls and communicated by email. Detailed meeting notes recorded the discussions and decisions made at these meetings, including conference calls.

Table 3-2 summarizes the Consultative Committee meeting dates and activities.

Table 3-2: Consultative Committee Meeting Dates and Activities

Consultative Committee Meeting	Water Use Plan Step	Date	Main Points Covered
1	2–3	19 October 2001	Introductions Site Tour Discussed Preliminary Issues
2	4	18 January 2001	Introduced Terms of Reference Introduced Structured Decision Making Developed Objectives Overview of Site (Mike Lewis) Cross Cultural Training
3	4	22–23 February 2001	Approved Terms of Reference Discussed Objectives and Performance Measures Overview of Wahleach Hydroelectric Facility (Jim McNaughton) Specified Bookend Alternatives Overview of Stave Water Use Plan (Charlotte Bemister)
4	4	16 March 2001	First Nations Statement on Fish Interests (Bruce Wright) Reservoir Fish Presentation (Ross Neuman) Presented Jones Creek Spawning Channel and Jones Creek Fish (Dan Sneep) Presented Fisheries Issues Summary (Alf Leake) Developed Fish Objectives and Performance Measures
		25 April 2001	Site Visit Geologist Mike Miles provided professional opinion on the future of lower Jones Creek watershed. Consultative Committee members were invited to attend
5	4–5	7 May 2001	Reviewed Site Visit and Jones Creek Watershed Stabilization Issues Developed Performance Measures Reviewed Bookend Alternatives Evaluated Study Proposals

Table 3-2: Consultative Committee Meeting Dates and Activities (cont'd)

Consultative Committee Meeting	Water Use Plan Step	Date	Main Points Covered
6	6	6–7 June 2001	Overview of Water Licence
			Discussed Boulder Creek Issues
			First Nations Studies Update
			Discussed Greenhouse Gas Performance Measures
			Developed Alternatives
7	6–7	17 October 2001	Discussed Flood Control Performance Measure
			Reviewed Alternative Results
			Discussed Non-operating Alternatives
8	6–7	12–13 December 2001	Reviewed Alternative Results
			Finalized Performance Measures
			Introduced Decision Tools
			Developed Alternatives
		5 June 2002	Reviewed Performance Measures
		(Review Day)	Reviewed Alternative Results
			Comparing Habitats Presentations
9	7	13–14 June 2002	Reviewed Performance Measures
			Reviewed Alternative Results
			Comparing Habitats Presentation
			Discussed Use of Decision Tools
			Rejected Undesirable Alternatives
			Developed Hybrid Alternative
10	8	29–30 July 2002	Reviewed Hybrid Alternative Results
			Selected Preferred Alternative
			Determined Areas of Consensus and Disagreement
			Discussed Review Period
			Discussed Monitoring Program
11	8	7 October 2002	Reviewed Failed Conditional Agreement
			Re-specified AsNeeded Jones Creek Flows and Reservoir Elevation Levels
			Re-considered Alternative Water Delivery Options in Jones Creek
			Determined Areas of Consensus and Disagreement
			Finalized Review Period
			Finalized Monitoring Program

3.3 Community Awareness and Communication

In September 2000, BC Hydro held two public Open Houses in Chilliwack, and one public Open House at the Wahleach Powerhouse to promote awareness of the Wahleach water use planning process and to invite potential participants.

During the Wahleach water use planning process, BC Hydro issued a number of news releases and newsletters to inform the public about developments in the Wahleach Water Use Plan.

The BC Hydro Water Use Plan Web site also provided information to those interested in the Wahleach Water Use Plan, as well as those interested in Water Use Plans for other BC Hydro facilities.

3.3.1 First Nation Involvement

The Wahleach hydroelectric facility is in the claimed traditional territory of the Stó:lō Nation. Refer to Figure 3-1: Map of Stó:lō Nation. The First Nation Wahleach Water Use Plan representatives included the Stó:lō Nation, participating member Bands of the Stó:lō Nation and the independent Peters Band. BC Hydro held introductory meetings in April 2000 with the First Nation representatives.

Five individual Bands and the Stó:lō Nation were invited to participate in the Wahleach water use planning process. Stó:lō Nation and four Bands accepted. Capacity funding agreements allowed for the participation of one representative from each of the Stó:lō Nation and the four Bands.

The Stó:lō Nation, the Shxw'ow'hamel First Nation, and Seabird Island First Nation participated on the Consultative Committee continuously since initiation of the Wahleach water use planning process. Fish issues, in particular, access to traditional fishing opportunities and the Jones Creek anadromous fish habitat enhancement project were very important to First Nations. The Shxw'ow'hamel First Nation was a member of the Fish Technical Subcommittee. A fisheries consultant was engaged to assist all First Nations at technical subcommittee, Consultative Committee, and preparatory meetings.

The Popkum First Nation received frequent updates on the Wahleach water use planning process, and remained an interested party, but did not attend Consultative Committee meetings after July 2001.

The Peters Band did not attend Consultative Committee meetings after May 2001, but remained an interested party. In January 2002, a meeting to review the progress of the Wahleach water use planning process was held with the Peters Band Chief and Council. At the time, the Peters Band decided not to return to the Wahleach water use planning process.

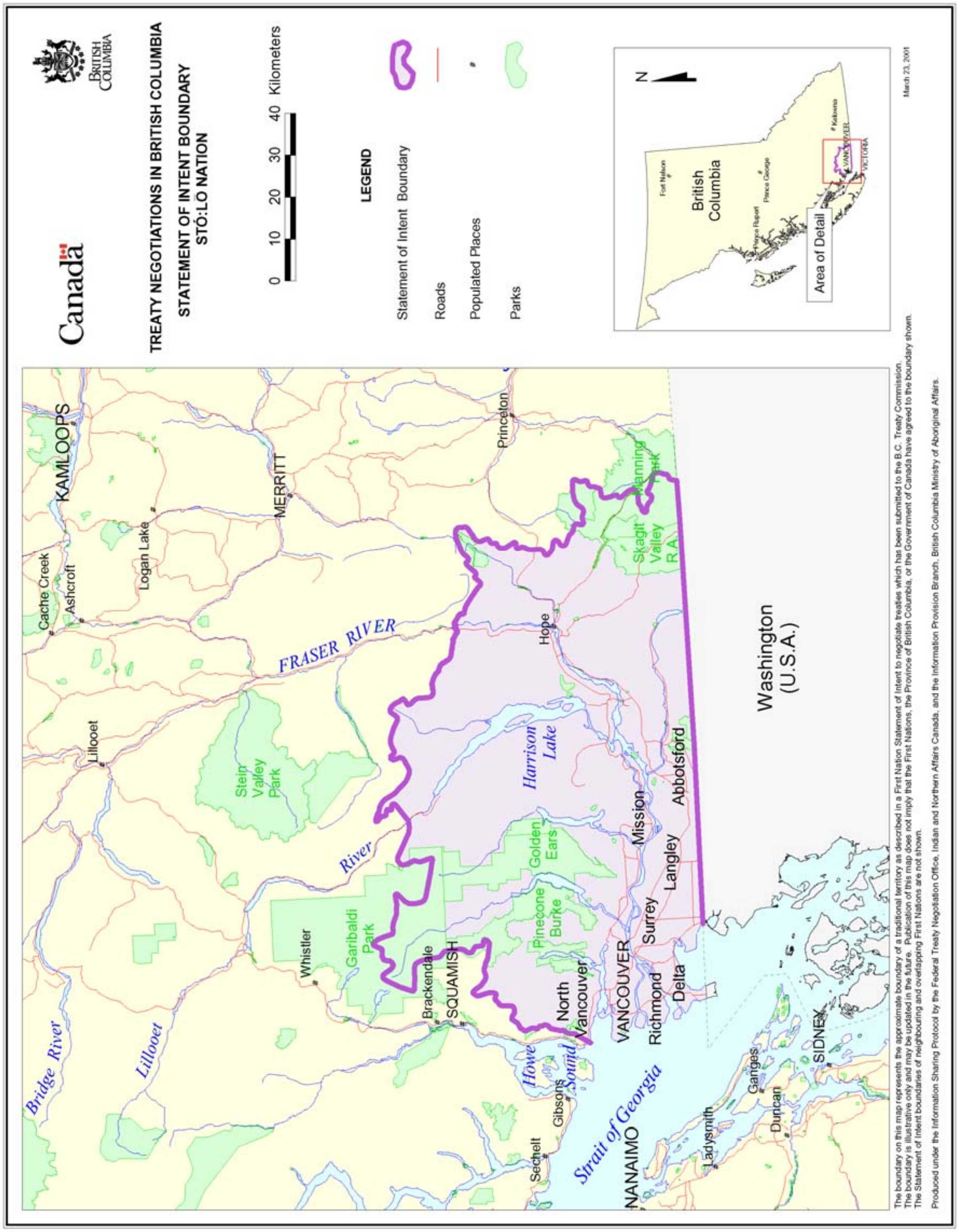


Figure 3-1: Map of Stó:lō Nation

For both the Popkum First Nation and the Peters Band, BC Hydro was informed that the reasons for not attending were unrelated to concerns with the Wahleach water use planning process.

The Cheam Band did not participate in the Wahleach water use planning process. They raised concerns with the process, such as involvement of stakeholders in consultation meetings, historical grievances, protection and priority treatment of aboriginal rights, and inadequate benefits accruing to the First Nation communities from the Wahleach hydroelectric facility. The Cheam Band did receive periodic updates on the status of the Wahleach Water Use Plan.

The Stó:lō Nation conducted two studies in support of the First Nation interests: "Jones Watershed – A Study of Stó:lō Contemporary and Traditional Use" and "Wahleach Water Use Plan Phase 1/Stage 1 Archaeological Study." In January 2002, a meeting was held with the First Nation representatives to review the findings of these studies and determine how the information might be incorporated into a performance measure.

An Aboriginal Relations Task Manager was assigned to BC Hydro's Wahleach Water Use Plan project team. The Task Manager's responsibility was to liaise with the First Nations to ensure their comfort with the process, to ensure information was received and understood, and to determine whether resources were required to support the First Nations involvement and to fund related studies. It was also the Task Manager's responsibility to guide resolution of non-Water-Use-Plan-related issues that were raised during the Wahleach water use planning process.

4 INTERESTS, OBJECTIVES AND PERFORMANCE MEASURES

4.1 Introduction

As per Step 4 of the provincial *Water Use Plan Guidelines*, the Consultative Committee stated specific objectives for desired outcomes in dealing with water use planning issues. This section of the report provides a summary of the issues, objectives, and performance measures developed for the Wahleach Water Use Plan. (Refer to Appendix B: Performance Measure Information Sheets.)

4.1.1 Issues

In the Wahleach water use planning process, the term “issue” meant any problem, need or desire expressed by the Consultative Committee with respect to the way their interests are affected by Wahleach hydroelectric facility operations. These issues may or may not be within the scope of the Wahleach Water Use Plan.

Example issues include:

1. “The forestry access road is dangerous and needs maintaining.”
2. “There should be spawning habitat in Jones Creek.”

As per the *Water Use Plan Guidelines*, issues are within the scope of the Wahleach Water Use Plan if:

- A causal relationship can be drawn between ongoing operational water management decisions and a specific impact(s) on stated values.
- Impacts have the potential to differ under operating alternative scenarios.

In the example above, the availability of spawning habitat is within the scope of the Wahleach Water Use Plan, whereas the status of the access road is not because it cannot be affected by Wahleach hydroelectric facility operations.

Not all the issues raised by the Consultative Committee were within the scope of the Wahleach Water Use Plan. However, in many cases, provisions were made outside the Wahleach water use planning process to address these issues.

4.1.2 Means and Ends Objectives

In the Wahleach water use planning process, issues were probed to reveal implicit Consultative Committee member objectives. For example, by expressing an interest for more Jones Creek fish spawning habitat, a Committee member's implicit objective is to increase fish populations in Jones Creek.

An "ends" or "fundamental" objective is a statement of what is ultimately important to Consultative Committee members. It is devoid of consideration of how it might be attained, or whether it is measurable. Because an ends objective is not prescriptive, it creates opportunities for creativity and compromise. For example, the ends objective for Jones Creek fish is to "maximize populations of fish in Jones Creek." A wide range of activities could further this objective[1].

A "means" or "sub" objective is a statement that summarizes the considerations that need to be addressed to attain an ends objective. Means objectives are associated with a performance measure for determining the impact of an operating alternative on a sub-objective.

Example sub-objectives for Jones Creek fish include:

- Ensure a viable aquatic habitat in the non-anadromous section.
- Maximize effective spawning habitat in the anadromous section.
- Maximize parr rearing habitat in the anadromous section.
- Minimize stranding risk in the anadromous section.

The extent to which these sub-objectives are satisfied is indicative of the extent to which the ends objective, "maximize populations of fish in Jones Creek" is satisfied.

4.1.3 Performance Measures

Performance measures are used to indicate impacts of different operating alternatives on objectives. For example, impacts of an operating alternative on the objective, "maximize effective spawning habitat in the anadromous section of Jones Creek" is measured in units of m^2 of wetted usable area.

4.1.4 Influence Diagrams

Influence diagrams are a technique that was used in the Wahleach water use planning process for conceptualizing how issues and objectives relate to Wahleach hydroelectric facility operations. For example, starting at the left-hand side of Figure 4-1, the oval-shapes represent aspects of the Wahleach hydroelectric facility that BC Hydro can control or influence, and are central to

[1] Note that maximizing populations of fish independent of location *per se*, was not a key objective, as discussed in Section 7.

the development of operating alternatives. Moving further to the right, the diagram illustrates how aspects can influence issues which are related to means objectives and ultimately, the ends objective.

In this example, the reservoir elevation level can influence exposure of standing debris (submerged stumps), which is related to visual quality and safety which contribute to the recreation experience.

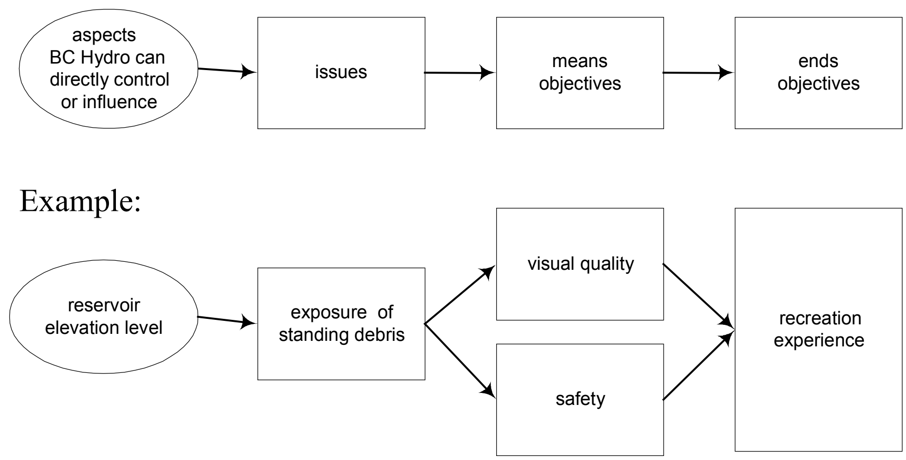


Figure 4-1: Influence Diagram

4.2 Recreation

4.2.1 Issues – Recreation

A wide variety of recreation activities are undertaken throughout the area affected by Wahleach hydroelectric facility operations. While both Jones Creek and Herrling Island Sidechannel are used for recreation activities such as bird and wildlife watching, the Consultative Committee agreed to focus on recreation interests at Jones Lake Reservoir. The Consultative Committee agreed that recreation interests at Jones Creek and Herrling Island Sidechannel are minimally affected by operations and potential operational changes.

At Jones Lake Reservoir, BC Hydro maintains two campground areas with 28 and 33 campsites, picnic tables and fire rings, and two day-use picnic areas. Recreation activities include hiking, camping, fishing, boating, swimming, mountain biking, canoeing, picnicking and wildlife viewing.

Figure 4-2 illustrates the recreation facilities at Jones Lake Reservoir.

Although it is not known how many recreational visitors Jones Lake Reservoir receives, recreation interests on the Consultative Committee emphasized the relative importance of the reservoir given the scarcity of comparable recreation sites in the lower Fraser Valley.

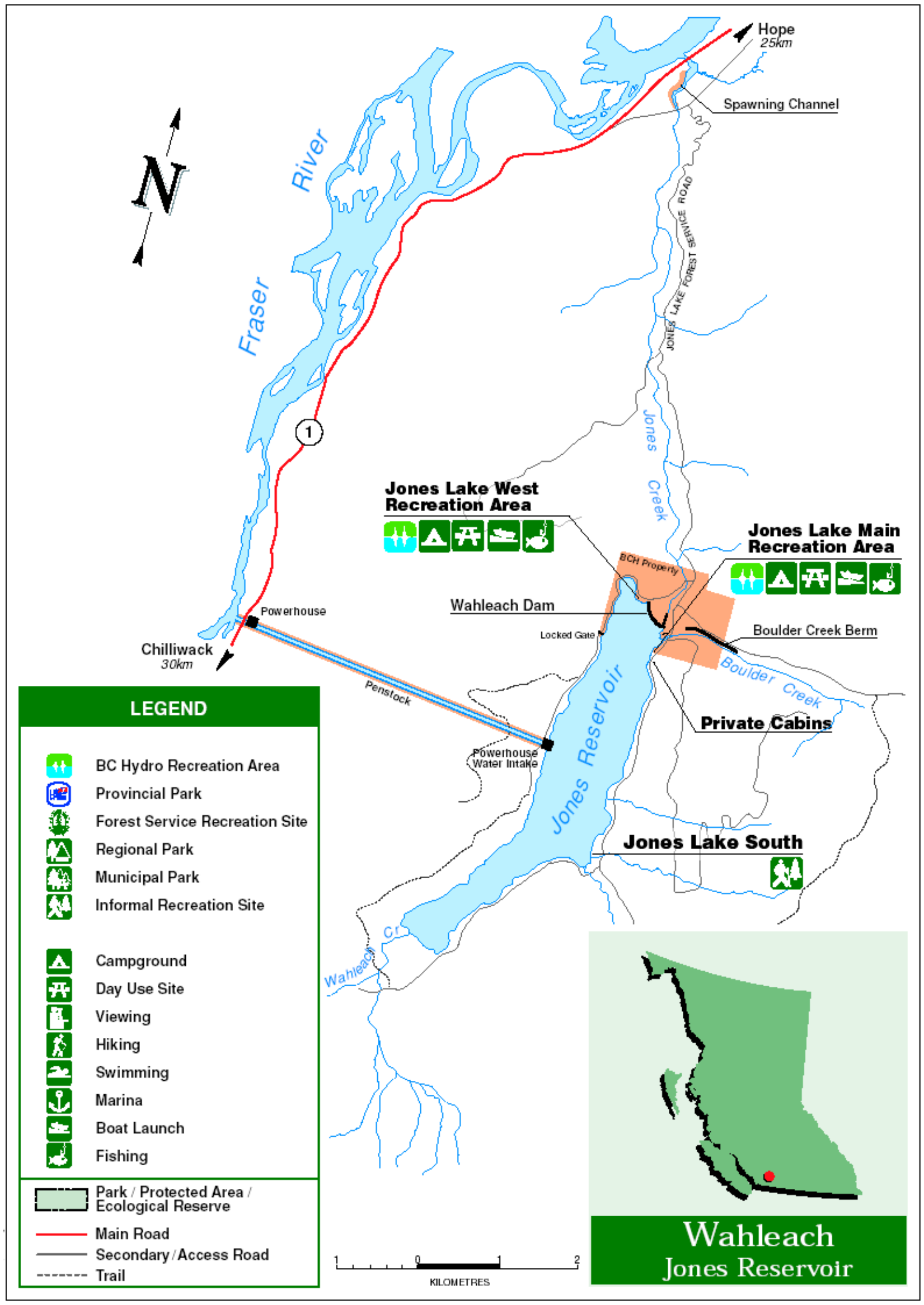


Figure 4-2: Recreation Facilities at Jones Lake Reservoir

Table 4-1 summarizes the recreation issues identified by the Consultative Committee and how each issue was addressed.

Table 4-1: Recreation Issues

Issue	Description	Decision
Road access and maintenance from Laidlaw to Jones Lake Reservoir	The 9 km forest access road is steep, rough and not maintained on a regular basis	Outside the scope of Water Use Plans
Rowdy Campers	Jones Lake Reservoir has evolved to become attractive to rowdier users due to the area's limited access and remote location (from police coverage)	Outside the scope of Water Use Plans
Public Safety – standing debris	At lower reservoir elevations users may encounter standing debris (stumps etc.) snagging fishing gear or posing potential boating hazards)	Incorporated into objectives and performance measures
Public Safety – floating debris	Floating debris (wood, etc.) is a hazard to recreational users of the reservoir[1]	Initially developed into a performance measure, later rejected due to inability to control through operations
Public Safety – free spills	The Wahleach Dam and spillway area is not normally staffed by BC Hydro. Concern for public safety around spillway when free-spills occur	Incorporated into objectives and performance measures
Aesthetics	Low reservoir elevations look unattractive	Incorporated into objectives and performance measures
Boat access to the water	Low reservoir elevations make boat launching difficult	Incorporated into objectives and performance measures
Shoreline erosion	Erosion of reservoir shoreline	Outside the scope of Water Use Plans
Garbage in water, water turbidity	Water not always clean	Outside the scope of Water Use Plans

1. Although trees were removed prior to filling of the reservoir, debris (stumps, floating logs and deadheads) surrounds most of the reservoir edge. From 1992–1994, 32 ha at the north end of the reservoir was cleared of debris.

Figure 4-3 illustrates how the issues in Table 4-1 are linked to operations.

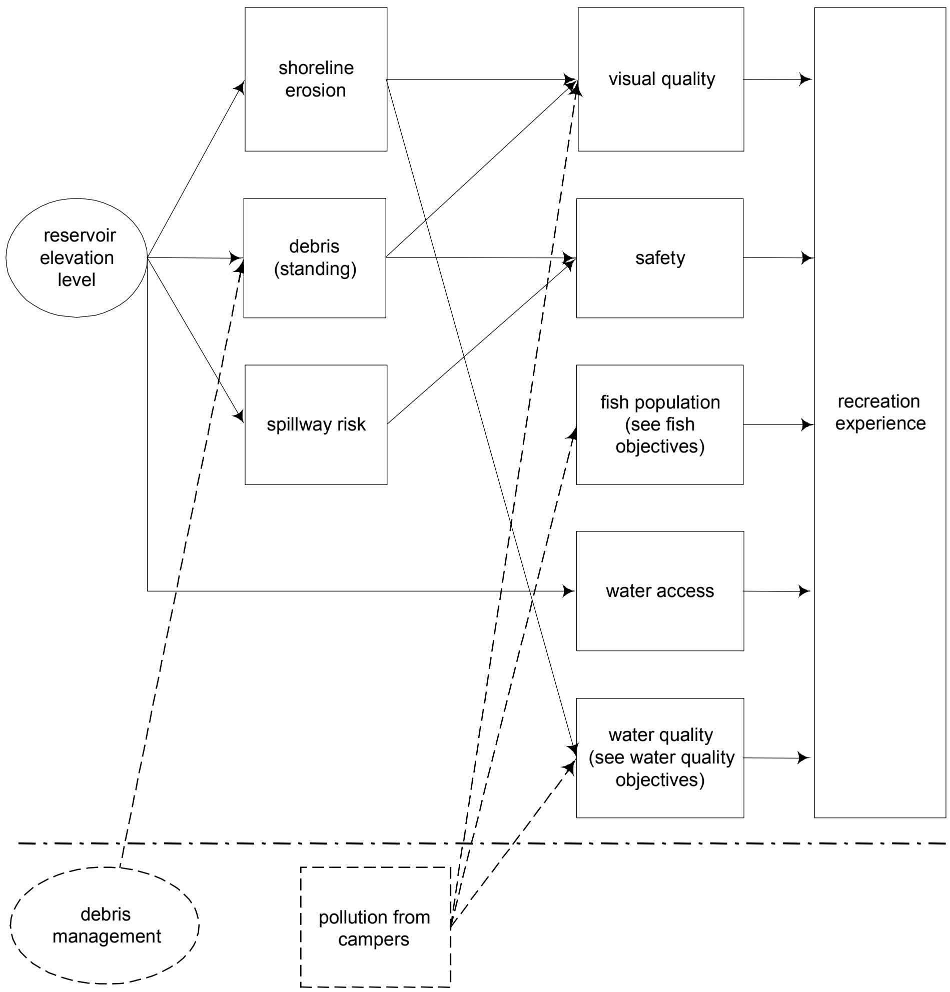


Figure 4-3: Relationship of Recreation Issues to Operations[1]

Moving from left to right, reservoir elevation levels can influence shoreline erosion, standing debris, spillway risk and water access issues. These issues are related to visual quality, safety and water access which contribute to the recreation experience. Jones Lake Reservoir fish issues are discussed in Section 4.3.

[1] Dotted shapes and arrows represent either non-Water Use Plan or a highly uncertain issue.

4.2.2 Objectives and Performance Measures – Recreation

The ends objective for ***Recreation*** is to ***maximize the quality and quantity of the recreation experience***. Since this objective is not directly measurable, two sub-objectives and associated performance measures were developed.

The first sub-objective for ***Recreation*** is to ***maximize recreation quality.*** Visual quality (aesthetics), safety and water access are improved by a similar set of conditions. Visual quality is considered best when the reservoir nears full pool and unsightly standing debris is largely submerged. Standing debris as a boating safety and swimming issue is somewhat mitigated at higher reservoir elevations. Recreationalists prefer higher reservoir elevations for gaining access to the reservoir, for boat launching and for swimming.

The performance measure for this sub-objective called ***recreation quality*** is defined as ***the number of days that the reservoir is within the range between full pool and three metres below full pool (638.6 m to 641.6 m).*** This performance measure estimates the quality of recreation in the reservoir under different operating alternatives.

While some recreation safety interests are embedded within this performance measure, another contributor to recreation quality is spillway safety.

The second sub-objective for ***Recreation*** is to ***minimize spillway safety risk***. On Jones Lake Reservoir, the configuration of the spillway does not provide a physical barrier to keep recreationalists, particularly children, off the spillway. Therefore, reducing the number of spills could play an important role in ensuring recreationalists' safety.

The performance measure for this sub-objective called ***spillway safety risk*** is defined as ***the number of days on which spill events occur***. This performance measure estimates the quantity of spillway risk at the reservoir under different operating alternatives.

All performance measures for ***Recreation*** are calculated during the primary recreation period of interest between 15 May to 15 September.

4.3 Fish

Jones Lake Reservoir, Jones Creek and Herrling Island Sidechannel provide a variety of habitat for numerous fish species and other aquatic organisms. Wahleach hydroelectric facility operations can affect fish populations through changes in Jones Lake Reservoir elevation levels and changes in flows in Jones Creek and Herrling Island Sidechannel. (Refer to Appendix C: Wahleach System-Wide Fish Habitat Descriptions Information Sheet.)

4.3.1 Issues – Jones Creek Non-Anadromous Fish

Thought to be originally barren, Jones Creek non-anadromous now supports a small resident rainbow population likely based on stock from entrained individuals during spills over the Wahleach Dam throughout the years of operation. It is unknown whether current flows in Jones Creek non-anadromous are adequate to sustain the rainbow population, or if this population survives through a mix of opportunistic spawning and supplemental entrained individuals.

Rainbow fry and adults were fish species sampled in Jones Creek non-anadromous. There may be kokanee and cutthroat trout individuals entrained in Jones Creek from Jones Lake Reservoir, but it is not expected that these species will survive because:

- Kokanee require lake rearing as part of their life history approach.
- Cutthroat stocks in Jones Lake Reservoir are sterilized to control their population size, and therefore could not sustain a population without direct supplementation.

It is unknown what quality or quantity of fish habitat is available in Jones Creek non-anadromous. Data collected during the Wahleach water use planning process suggests that approximately 20 fish per unit is supported in “leakage” flow conditions, during the low flow period in August (Leake, 2002).

The habitat is largely a steep boulder cascade, with two barriers to access within the canyon section. The average gradient is 7 per cent, but is 12 per cent in the canyon section below 2.8 Mile Creek. Sediment loading below the 2.8 Mile Creek confluence is severe, and will likely continue to reduce habitat quality. Habitat above 3 Mile Creek is likely not affected by sediment inputs.

Flow is provided to Jones Creek non-anadromous mainly through tributaries along the length of the creek, most notably from 2.8 Mile Creek and 3 Mile Creek. However, it is unlikely that there is significant additional inflows immediately below the Wahleach Dam spillway.

4.3.2 Issues – Jones Creek Anadromous Fish

Since construction of the Wahleach Dam in the 1950s, fish habitat conditions in Jones Creek anadromous have varied considerably. Pre-dam flows were diverted from the mainstem between the Laidlaw Bridge and the Lorenzetta Creek confluence into a man-made spawning channel, which was operated September to May each year. Starting in the late 1980s, the spawning channel was under continual repair due to sediment accumulation. In 1993 and 1995, debris torrents destroyed the spawning channel.

The Jones Creek spawning channel was accepted by local people, particularly the First Nations, as an important area for fish production and for its educational and cultural value. During the Wahleach water use planning process, several Consultative Committee members expressed an interest in re-establishing the spawning channel to improve fish values in Jones Creek anadromous.

Table 4-2 summarizes the fish habitat conditions of Jones Creek anadromous from pre-impoundment (1934 to 1954), the spawning channel era, and the current status (Leake, 2002).

Table 4-2: Habitat Conditions in Jones Creek Anadromous

Attributes	Pre-Impoundment (1934–1954)	Spawning Channel Era (1954–1955)	Current Status (1999–2001 Enumeration Data)
Length of Habitat	1.2 km	1.4 km (creek + channel)	0.8 km
Pink Salmon	4250	2639	3124
Pink Egg to Fry Survival	10–12%[1]	12%	1.0%[2]
Chum Salmon Returns	443	284	459
Chum Egg to Fry Survival	10–12%[1]	36%	0.6%[2]
Average Flow	7.8 m^3/s	Creek: 1.0 m^3/s Channel: 0.6 m^3/s	1.0 m^3/s

1. Estimated to be similar to Fraser River natural survival rates.
2. Based on 1999 enumeration data only (White Pine, 2000).

Prior to impoundment, Jones Creek anadromous was known to the Stó:lō Nation as a productive area for a variety of species of fish. McHalsie (2001) cites Federenko (1983) in noting that there were six anadromous fish species including five species of salmon and steelhead. However, sockeye and chinook may have been lost to the system prior to impoundment (McHalsie, 2001).

While steelhead were present in Jones Creek prior to impoundment, the creek was not considered good for steelhead due to its small size and limited habitat (Leake, 2002). Following impoundment, much of the fish diversity was lost with the installation of the Jones Creek spawning channel that focused on the production of pink salmon. Since the installation of the spawning channel, steelhead were no longer seen spawning in Jones Creek.

Both the Province and Fisheries and Oceans Canada acknowledge that the provision of flows for steelhead may not result in the resumption of steelhead spawning in Jones Creek, but may increase the rearing potential for juveniles from the Fraser River or adjacent streams. For the Wahleach Water Use Plan, steelhead was used as an indicator species for developing flow requirements in the spring and summer spawning (1.2 m^3/s) and incubation (0.6 m^3/s) periods (Leake, 2002).

4.3.3 Issues – Jones Creek Non-Anadromous and Anadromous Fish

Lower Jones Creek is the portion of the creek between the Wahleach Dam and the confluence of the Fraser River. The lower Jones Creek watershed is plagued by severe slope instability which has resulted in significant impacts to habitat quality in the lower reaches. The total length of this section is approximately 9 km, of which less than 1 km is accessible to anadromous species. A natural barrier is located 100 m above Laidlaw Bridge crossing. Current hydrology provides a Mean Annual Discharge of 1.5 m^3/s measured at the Laidlaw Bridge primarily from 2.8 Mile Creek and 3 Mile Creek inflows. However, 60 per cent of the days modelled on record indicate a Mean Annual Discharge of less than 1.0 m^3/s at the Laidlaw Bridge. Prior to dam construction, Mean Annual Discharge at the Laidlaw Bridge was approximately 7.8 m^3/s (Leake, 2001).

Table 4-3 summarizes the Jones Creek fish issues identified by the Consultative Committee and on how each issue was addressed.

Table 4-3: Jones Creek Fish Issues

Issue	Description	Decision
Watershed instability and water quality	Can the Jones Creek watershed be stabilized to prevent future debris torrents?	Outside the scope of Water Use Plans
Status of spawning channel and existing infrastructure	What should happen to the spawning channel infrastructure remaining in Jones Creek anadromous?	Outside the scope of Water Use Plans. Addressed by Fisheries and Oceans Canada and BC Hydro (See Section 4.3.5)
Provision of flows to sustain aquatic populations in Jones Creek	Can steps be taken to increase the reliability of flows for fish in Jones Creek?	Incorporated into objectives and performance measures
Improving effective habitat in Jones Creek	How much habitat is available in Jones Creek and how can it be improved through operations?	Incorporated into objectives and performance measures
Avoiding fish stranding	Is fish stranding a problem, and how can the risk be minimized?	Incorporated into objectives and performance measures
Status of the Boulder Creek Diversion Dam fish release gate	Various physical structures at the facility have different roles in the provisions of fish flows.	Discussed in Section 6

Figure 4-4 illustrates how Jones Creek fish issues in Table 4-3 are linked to operations.

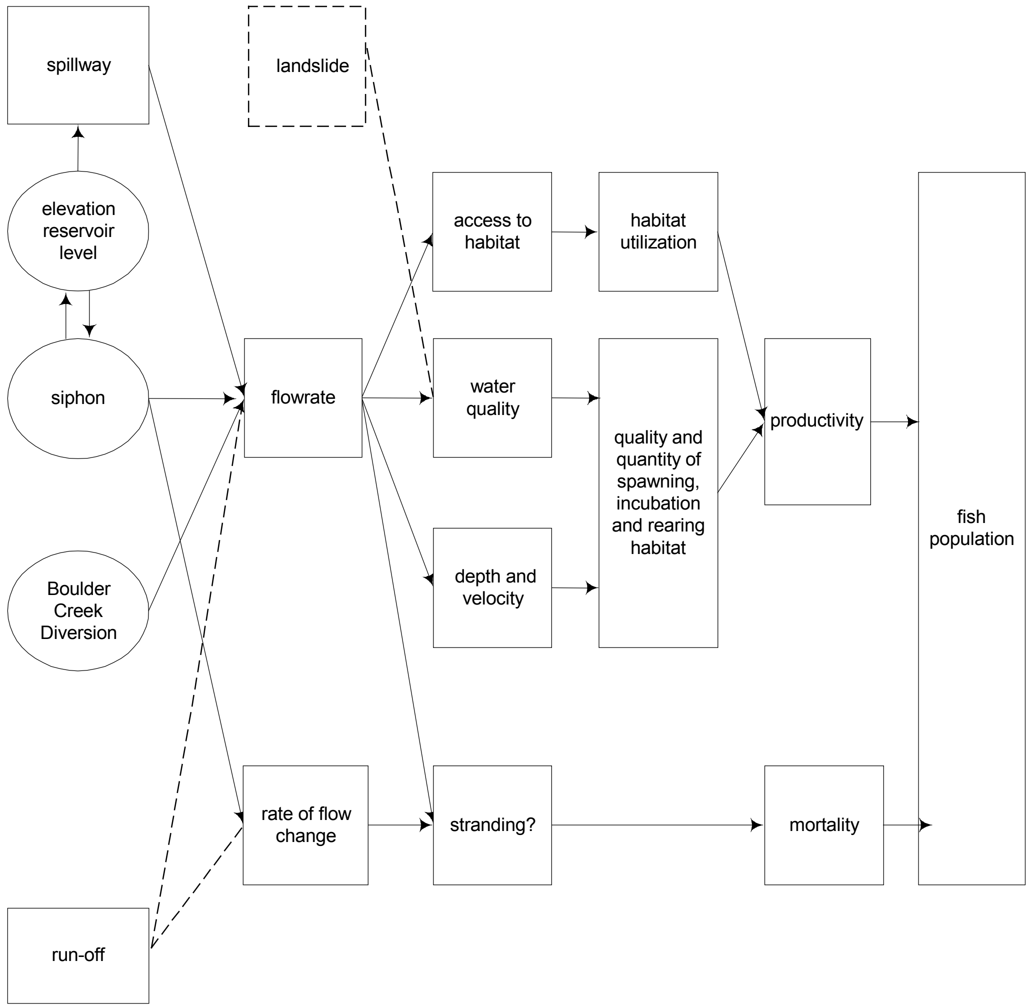


Figure 4-4: Relationship of Jones Creek Fish Issues to Operations

Moving left to right, the Wahleach Dam spillway, Jones Lake Reservoir elevation levels, the fish water release siphon, and the Boulder Creek Diversion Dam can influence the flowrate and rate of flow change. Both flowrate and rate of flow change can influence access to habitat, water quality, depth and velocity, and stranding. These issues are related to habitat utilization, and the quality and quantity of spawning, incubation and rearing habitat. These mean objectives measure productivity and mortality, which contribute to fish populations in Jones Creek.

4.3.4 Jones Creek Watershed Stability

Logging-related sediment production caused on-going maintenance concerns throughout the spawning channel's history. These problems became more severe after forest harvesting activity increased in the tributary basins in the 1970s (Leake, 2001).

In 1993 and 1995, storm events caused numerous slope failures in the 2.8 Mile Creek and 3 Mile Creek basins which are tributaries to the lower Jones Creek watershed. Historic forestry harvesting and unmaintained road networks created or exacerbated, many of these landslides. The resulting debris torrents, which consisted of slurries of mud, rock and woody debris, flowed down these tributaries into Jones Creek. In 1993, sizeable quantities of sediment and woody debris were deposited at the 2.8 Mile Creek confluence with Jones Creek. In 1995, channel instability, associated with downstream sediment movement, destroyed the Jones Creek spawning channel and deposited large quantities of gravel at the confluence with the Fraser River.

Figure 4-5 illustrates the areas of instability in the Jones Creek watershed boundary.

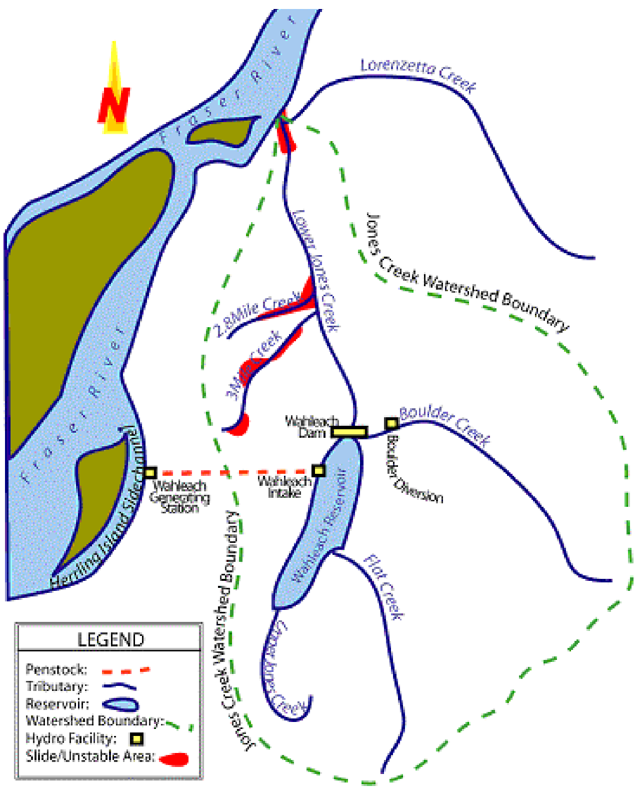


Figure 4-5: Areas of Instability in the Jones Creek Watershed Boundary

In April 2001, Geomorphologist Mike Miles undertook an assessment of the stability of Jones Creek and investigated the fisheries habitat enhancement options for Jones Creek anadromous. A number of existing reports were reviewed to identify slope or hydrotechnical stability issues which were used to determine what type of fisheries mitigation works were feasible in Jones Creek anadromous. On 25 April 2001, an on-site meeting was held with Mike Miles and the Consultative Committee. (Refer to Appendix D: Implications of Slope and Channel Instability in the Lower Jones Creek Watershed on Water Use Planning.)

The following questions were identified for this project:

1. What is the present slope stability status in the Jones Creek watershed downstream of the Wahleach Dam?

2. How much sediment is stored in the stream channel upstream of the Jones Creek fan?

3. What factors contributed to the 1993 and 1995 events that caused the spawning channel and mainstem habitats to be damaged?

4. What is the likelihood that damaging events, similar to those in 1995, will re-occur?

The following questions were examined when reviewing the information and on-site meeting notes:

1. What are the flow release options for the Jones Creek anadromous reach which can be accommodated by the existing dam infrastructure?

2. What are the flow release options that can reduce the impacts of sediment source problems from the 2.8 Mile Creek slide area confluence with Jones Creek?

3. What physical habitat enhancements could be undertaken in Jones Creek anadromous which would replace the spawning channel and withstand future debris torrents?

4. In lieu of (3) above, what other opportunities are available for enhancing fish habitat conditions in Jones Creek anadromous?

The assessment undertaken by Mike Miles at the request of the Consultative Committee indicates that:

- Any rebuilt facility similar in function and location to the old Jones Creek spawning channel may be significantly impacted by upstream slope instability or sediment movement every 2 to 5 years for at least the next 30 to 50 years.

- Habitat benefits of flow release options for Jones Creek are between 4100 m^2 and 5200 m^2 depending on the species and flow, which ranges from 0.5 m^3/s to 1.8 m^3/s, and that current sediment loads reduce egg to fry survival (0.6 per cent to 1.0 per cent) through channel instability and transition (loss of habitat) and limiting respiration of eggs (reduced quality of habitat).

- The cost of building a spawning channel varies from $100,000 for a groundwater fed channel to $400,000 for a compensation channel off-site, with regular maintenance costs between $2,000 and $15,000 per year respectively. However, due to the watershed instability, these costs can escalate from $300,000 to $400,000 per slide event, unless a separate channel infrastructure is built.

- The least risk approach to rebuilding Jones Creek habitat is to open up the lower section of the creek through regrading of stream banks and by relocating or removing existing dyking to allow reformation of a natural channel and fish habitat development. The estimated cost (excluding rebuilding or protecting Trans Mountain's pipeline) is $200,000 with regular maintenance costs of $15,000 per year.

In October 2001, the Consultative Committee agreed that the post regulation flows are too small to cause a significant risk to property damage in lower Jones Creek. However, the 1995 storm event indicates that sediment or debris movement and its associated effects on channel stability, pose significant risks to developments in the Jones Creek fan.

4.3.5 Agreement On Restoration Activities In Jones Creek Anadromous

On 11 April 2002, Fisheries and Oceans Canada and BC Hydro held a meeting to discuss the future of the Jones Creek spawning channel infrastructure. Dan Sneep, the Fisheries and Oceans Canada Committee member, prepared the following memo for the Consultative Committee (Sneep, 2002):

"[At that meeting] the parties agreed that a 'decommissioning' of the spawning channel, based on the recommendations in the Miles and Hartman report, could be considered as a means of facilitating the natural recovery of lower Jones Creek. An on-site meeting, attended by Department of Fisheries and Oceans and BC Hydro staff as well as Mike Miles, was held on 24 April 2002, to assess the present status of the lower creek and develop potential restoration options. The options considered included removal of the upper and lower spawning channel weirs, reconfiguration of some of the bank armouring structures, and relocation of setback dikes to allow the creek to move through a greater extent of its floodplain, while protecting existing structures such as the pipeline, bridges, and highway. The parties agreed that the stakeholders responsible for these and other interests in the lower creek would be consulted in the development of the proposed works."

This agreement was integrated into the recommendations of the Consultative Committee as described in Section 7.

4.3.6 Objectives and Performance Measures – Jones Creek Non-Anadromous Fish

The ends objective for ***Jones Creek Non-Anadromous Fish*** is to ***maximize fish populations in Jones Creek non-anadromous***. Given the canyon nature of Jones Creek non-anadromous, the Fish Technical Subcommittee recommended that the objective is to maintain a viable aquatic habitat by ensuring a minimum flow for resident fish and other aquatic life.

The ***Jones Creek Non-Anadromous Fish*** sub-objective is to ***provide viable aquatic habitat***.

The performance measure for this sub-objective called ***viable aquatic habitat*** is defined as ***the number of days a viable aquatic ecosystem is provided***. There are four performance measures:

- Number of days flows are greater than 10 per cent of the natural Mean Annual Discharge (MAD)
- Number of days flows are greater than 10 per cent of the natural MAD in August
- Number of days flows are greater than 20 per cent of the natural MAD
- Number of days flows are greater than 20 per cent of the natural MAD in August

These performance measures estimate the quantity of viable aquatic ecosystem in Jones Creek non-anadromous under different operating alternatives.

The Consultative Committee recommended a flow target of 10 per cent or 20 per cent of the Mean Annual Discharge in accordance with provincial fisheries "modified tenant instream flow standards." Although this performance measure is calculated year-round, August is highlighted given the impacts that low inflows during this month have on coastal fish species.

The number of days in which >400 per cent Mean Annual Discharge occurred is calculated as an indicator of possible displacement events.

4.3.7 Objectives and Performance Measures – Jones Creek Anadromous Fish

The ends objective for ***Jones Creek Anadromous Fish*** is to ***maximize fish populations in Jones Creek anadromous.***

The first ***Jones Creek Anadromous Fish*** sub-objective is to ***maximize the effective spawning habitat***.

The performance measure for this sub-objective, called ***effective spawning habitat*** is defined as ***the weighted usable area of effective spawning habitat provided for the following fish species and time periods:***

- Chum salmon: 15 September to 1 December
- Pink salmon: 15 September to 1 December
- Steelhead trout: 1 December to 1 June

This performance measure estimates the quantity of effective habitat in Jones Creek anadromous that is not dewatered over the spawning incubation periods of each fish species under different operating alternatives. These fish species were chosen as indicators as they are either predominant users of the habitat (as is the case for chum and pink salmon) or are representative of other fish species that may use the habitat during that time period.

At various points in the Wahleach water use planning process, fry numbers were substituted for habitat area in Jones Creek and Herrling Island Sidechannel to provide the Consultative Committee with qualitative and quantitative values of fish for each area.

Table 4-4 summarizes the assumptions used by the Fish Technical Subcommittee to convert habitat areas to fry numbers in Jones Creek.

Table 4-4: Conversion of Habitat Area to Fry Numbers in Jones Creek

Description	Pink	Chum
Spawning area required m^2 per pair	5	9
Spawning capacity at maximum wetted usable area	881	455
Egg to fry ratio	1.0%	0.6%
Fecundity	1800	3300
Fry production at maximum spawn cap	15 862	9013

The second ***Jones Creek Anadromous Fish*** sub-objective is to ***maximize the effective rearing habitat***.

The performance measure for this sub-objective called ***effective rearing habitat*** is defined as ***the number of area-days of habitat provided for steelhead trout parr/fry rearing defined as 1 June to 15 September***. This performance measure estimates the quantity of parr/fry rearing habitat in Jones Creek anadromous under different operating alternatives. This species was chosen as an indicator because its parr/fry habitat requirements are greater than other species, and their time periods for rearing aligns well with other species. Although this performance measure did not vary significantly between the operating alternatives, the Consultative Committee was reluctant to remove it from consideration.

The third ***Jones Creek Anadromous Fish*** sub-objective is to ***minimize stranding risk***.

The performance measure for this sub-objective called ***stranding risk*** is defined as ***the number of days flows drop below 0.6 m^3/s or flows drop below 15.3 m^3/s at the Laidlaw Bridge***. This performance measure estimates the relative risk of fish stranding in Jones Creek anadromous under different operating alternatives. Stranding of fish and invertebrates (interstitial stranding,[1] isolation in pools, beaching, and dewatering of eggs) may cause direct and indirect mortality of these fauna and may have a negative impact on ecosystem productivity. Data have shown that when flows drop below 0.6 m^3/s, significant portions of the area would be dewatered. It is hypothesized that similar impacts would occur when flows drop below bankfull (15.3 m^3/s), where floodplain areas become dewatered. In both instances of dewatering fish, stranding and mortality are much more likely than in between these operations. This performance measure highlights stranding risk rather than events, because it is not known whether stranding would actually occur in such events.

Table 4-5 summarizes a weighted index developed by the Fish Technical Subcommittee to indicate the relative impact of an operating alternative on Jones Creek anadromous fish.

Table 4-5: Jones Creek Anadromous Fish Performance Measures Weighted Index

Performance Measure	Relative Weight
Spawning habitat (average)	0.4
Rearing habitat (average)	0.2
Stranding (0.6 m^3/s)	0.4

The above weights were attributed by considering the range of swing of performance measures across operating alternatives. A sensitivity analysis illustrated that this index was not sensitive to the weightings.

4.3.8 Issues – Jones Lake Reservoir Fish

Before the 1920s, Jones Lake was barren of fish. Successful stocking programs between 1926 and 1938 resulted in large numbers of kokanee and rainbow in the lake, making Jones Lake a very popular angling destination. Impoundment in 1952 resulted in an increased reservoir size, and productivity increases in the years following riparian inundation continued until the mid-1970s. At that point, productivity inputs from the inundated zones declined, and the combined effect

[1] Interstitial stranding occurs where juvenile fish are caught in crevices between substrate materials.

of siltation from slides and over-fishing resulted in populations dwindling to lows observed in mid-1990.

Restocking and fertilization programs that started in 1995 have resulted in:

- Successful revival of the kokanee fishery in Jones Lake Reservoir.
- Improved rainbow populations.
- Reduced stickleback populations.

The two main fish species of interest in Jones Lake Reservoir are kokanee and rainbow trout. In 1999, kokanee abundance was recorded at 24 500 fish, and angler success was rated at two fish per hour. (Perrin 2002, cited in Neuman 2002).

Table 4-6 summarizes the Jones Lake Reservoir fish issues identified by the Consultative Committee and how each issue was addressed.

Table 4-6: Jones Lake Reservoir Fish Issues

Issue	Description	Decision
Continuation of fertilization program	A BC Hydro-funded fertilization program had recently been cancelled.	Could be considered a non-operation physical works in lieu of an operation[1]
Access to tributaries	Are there barriers to tributary access that could prevent access under certain operating conditions?	Not considered an issue (White Pine 2001)
Littoral and pelagic productivity	How might operations affect productivity in the shoreline area and the body of the reservoir?	Incorporated into objectives and performance measures
Stranding	Could fish be stranding during drawdowns?	Not considered an issue (White Pine 2001)
Entrainment	Could fish be drawn to their deaths through the turbine?	Incorporated into objectives and performance measures
Shoreline spawning	Does inundation or stranding of shoreline spawned eggs occur?	Not considered an issue (White Pine 2001)

1. The Jones Lake Reservoir fertilization program was recommended by the Consultative Committee in lieu of operations.

Figure 4-6 illustrates how Jones Lake Reservoir fish issues in Table 4-6 are linked to operations.

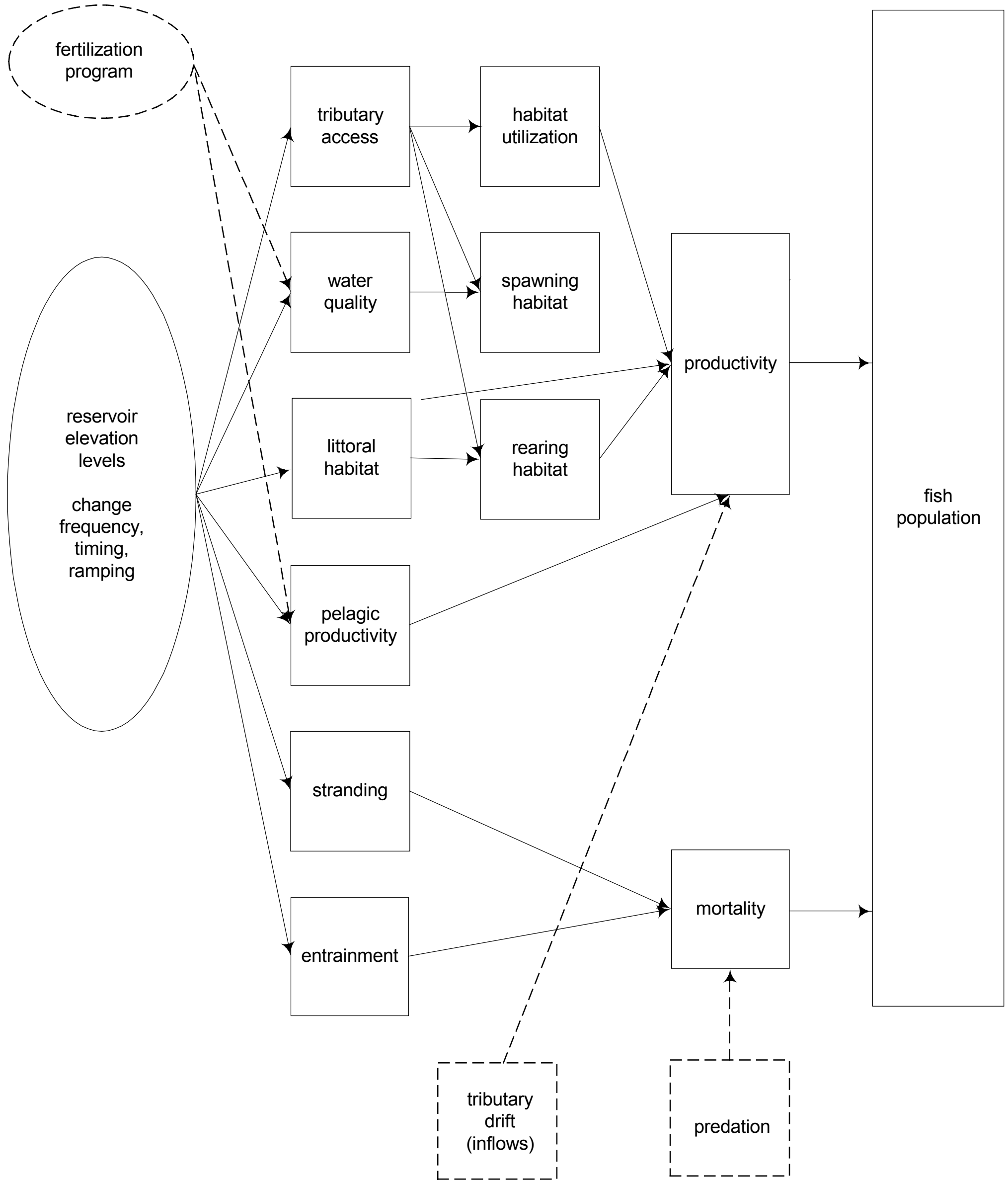


Figure 4-6: Relationship of Jones Lake Reservoir Fish Issues to Operations

Moving left to right, Jones Lake Reservoir elevation levels, along with the amount of change, frequency, timing, and ramping can influence tributary access, water quality, littoral habitat, pelagic productivity, stranding and entrainment. These issues are related to habitat utilization, spawning habitat and rearing habitat. These mean objectives measure productivity and mortality, which contribute to fish populations in Jones Lake Reservoir.

4.3.9 Objectives and Performance Measures – Jones Lake Reservoir Fish

The ends objective for ***Jones Lake Reservoir Fish*** is to ***maximize reservoir fish populations.***

The first ***Jones Lake Reservoir Fish*** sub-objective is to ***maximize littoral productivity***.

The performance measure for this sub-objective called ***Effective Littoral Zone (ELZ)*** is defined ***as the cumulative area, in hectares, that has the potential to function as productive littoral habitat over the course of one year***. This performance measure estimates the impact of changes in littoral productivity on food availability for fish stocks in Jones Lake Reservoir under different operating alternatives. Potentially productive areas are characterized as those that receive adequate light for photosynthetic activity and remain wetted for specified time periods. The amount of potential productive area was estimated using a complex algorithm that built on previous work undertaken for the Bridge River Water Use Plan (BC Hydro 2003). A thorough review and amendments to the performance measure were made during a one-day workshop with the Fish Technical Subcommittee and productivity specialists Chris Perrin and John Stockner.

The second ***Jones Lake Reservoir Fish*** sub-objective is to ***maximize pelagic productivity***.

Three performance measures were used to assess the impacts of operating alternatives on pelagic productivity in Jones Lake Reservoir. The pelagic zone is the large open water area of a reservoir that produces phytoplankton and zooplankton. The latter is an important food source for pelagic-feeding species such as kokanee.

The first performance measure called ***volumetric pelagic productivity*** is defined as a ***cumulative, seasonal-adjusted weighted volume of the pelagic zone***. This performance measure estimates the impact of changes in pelagic productivity on food availability for fish stocks in Jones Lake Reservoir under different operating alternatives.

The second performance measure called ***risky pelagic productivity*** is defined as ***the number of days the Wahleach hydroelectric facility withdraws water from the photic zone***. This performance measure estimates the impact of changes in pelagic productivity on food availability for fish stocks in Jones Lake Reservoir under different operating alternatives. The photic zone is the top-most layer of water that is penetrated by light, and is the most important area for pelagic productivity.

The ***standard deviation of pelagic productivity*** was also calculated.

The third ***Jones Lake Reservoir Fish*** sub-objective is to ***minimize entrainment risk***.

Fish entrainment is the drawing of fish into the intake of the penstock that leads to the Wahleach Generating Station, which results in the loss of resident fish to reservoir populations. Fish are assumed to be entrained as a function of the volume of water in the reservoir (i.e., the less the water, the higher the entrainment risk), and as a function of turbine flow. The Fish Technical Subcommittee developed a risk-based algorithm for representing entrainment, although no information was available on the actual extent of entrainment.

The performance measure for this sub-objective called ***entrainment risk is an index that is a function of turbine flow and elevation***. This performance measure estimates the entrainment risk under different operating alternatives.

To enable the Consultative Committee to trade off between Jones Lake Reservoir fish and other interests, a weighted index of the scaled impacts of littoral, volumetric pelagic and entrainment was developed by the Fish Technical Subcommittee.

In Table 4-7, the weights were attributed by considering the range of swing of performance measures across operating alternatives. A sensitivity analysis illustrated that this index was not sensitive to the weightings.

Table 4-7: Jones Lake Reservoir Fish Performance Measure Weighted Index

Performance Measure	Relative Weight
Effective Littoral Zone	0.4
Volumetric Pelagic Productivity	0.2
Entrainment	0.4

4.3.10 Issues – Herrling Island Sidechannel Fish

Prior to development of the Wahleach hydroelectric facility, Herrling Island Sidechannel received Fraser River freshet mainstem overflow, between April and October, and only minor tributary flow from two creeks from November to March (Mean Annual Discharge < 5 cfs). After development, the Wahleach Generating Station diverted an annual average of 6.5 m^3/s into Herrling Island Sidechannel, significantly increasing winter flows, and accommodating successful spawning by chum and pink salmon through the winter months (Leake, 2002).

Over decades, the period of Fraser River influence has been reduced due to annual material deposition at the Herrling Island Sidechannel invert. Currently, Fraser River influence is limited to 1 May to 10 September, three out of four years.

Herrling Island Sidechannel supports four main species of fish: white sturgeon, cutthroat trout, chum salmon and pink salmon. Only two species, chum and pink salmon, were regarded by the Fish Technical Subcommittee as primarily impacted by operations. These species use the sidechannel when the Wahleach Generating Station operations influence water levels greatest from September to May. Sturgeon and cutthroat use the sidechannel primarily in the late spring and summer when the increased Fraser River flows influence the water levels.

Estimates from the Chilliwack Hatchery (Fisheries and Oceans Canada, 1999), put the Herrling Island Sidechannel chum salmon run between 80 000 and 130 000 adults for the spawning season, with peak counts between 20 000 and 30 000 adults. These are estimates only, as there have been no accurate counts conducted in the sidechannel.

Fish habitat assessments conducted in 1999 (Alken), indicate that six out of ten habitat units observed in Herrling Island Sidechannel were suitable for spawning, with large gravel dominating substrate conditions. Spawning habitat is considered those wetted areas of glides[1] and riffles[2] which have suitable substrate for chum spawning. It does not consider depth and velocity preferences due to the lack of transect data. This area is 90 000 m^2 at no Wahleach Generating Station discharge, and is 140 000 m^2 at full capacity (13.3 m^3/s).

In the Herrling Island Sidechannel, the availability of spawning habitat may be a limiting factor for fish populations. During spawning, the provision of increased spawning habitat due to high discharges from the Wahleach Generating Station may be lost to dewatering in the future. This limits the effectiveness of a spawning fish population, since potentially productive spawners are drawn into unproductive areas.

In the Herrling Island Sidechannel, the dominant substrate is large gravel and small gravel. Fine gravel is cleared by continuous base flows and by freshet flows in the summer. Typical Fraser River egg to fry survival is 9 to 11 per cent. It is expected that Herrling Island Sidechannel would result in similar survival rates to natural conditions if power generation were kept stable. Lower survival rates are expected if power generation peaks daily during the incubation period.

Table 4-8 summarizes Herrling Island Sidechannel fish issues identified by the Consultative Committee and how each issue was addressed.

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1 Glide is a habitat unit where the water flow can be described as deep and swift, with laminar surface and steady current.

2 Riffle is a habitat unit with shallow water flowing over small substrate size, with a steady current and turbulent surface.

Table 4-8: Herrling Island Sidechannel Fish Issues

Issue	Description	Decision
Gravel build-up is slowly blocking off the channel	Gravel deposition is altering the dimensions and flows through the channel. Several parties have indicated an interest in removing gravel from the channel to increase flows.	Outside the scope of Water Use Plans
Peaking operations may be leading to fish mortality	As a peaking plant, Wahleach has high flow variations on a daily basis discharged into the Herrling Island Sidechannel.	Incorporated into objectives and performance measures
Availability of spawning and rearing habitat	Are fish populations limited by the provision of habitat?	Incorporated into objectives and performance measures

Figure 4-7 illustrates how Herrling Island Sidechannel fish issues in Table 4-8 is linked to operations.

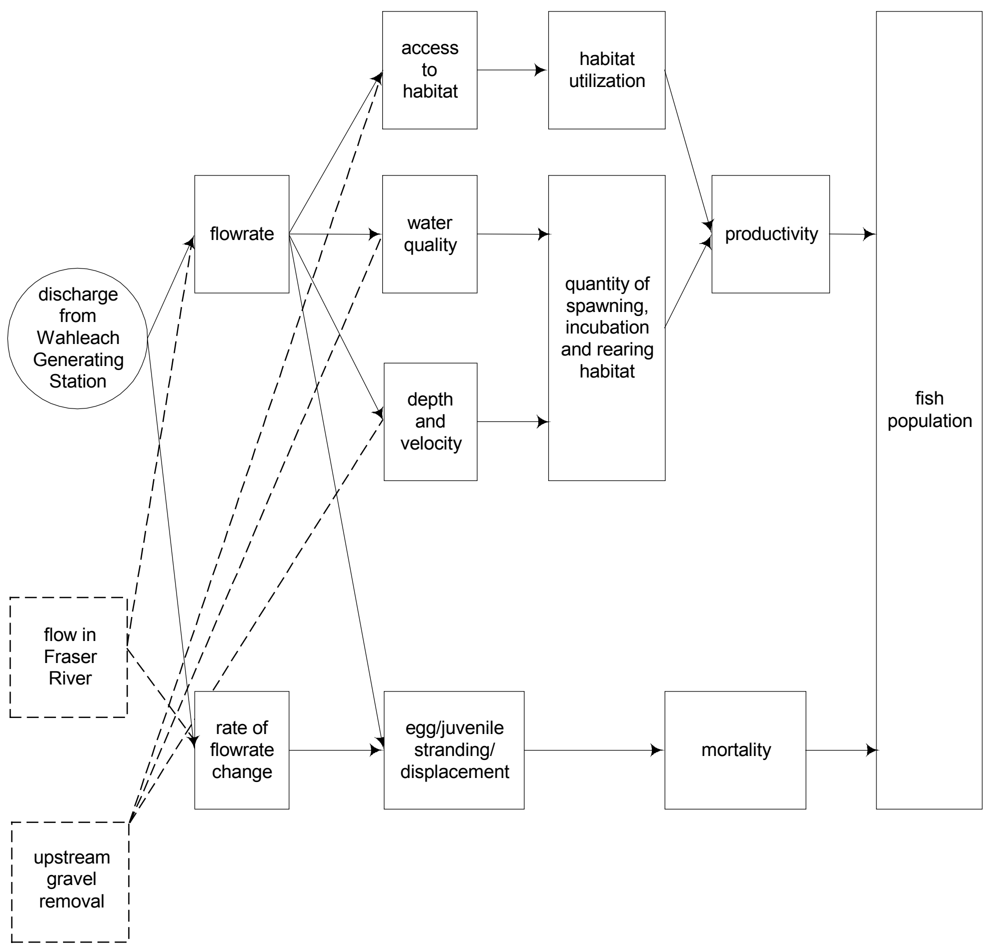

Figure 4-7: Relationship of Herrling Island Sidechannel Fish Issues to Operations

Moving left to right, discharge from the Wahleach Generating Station and flow in the Fraser River can influence the flowrate and rate of flowrate change. Both flowrate and rate of flowrate change can influence access to habitat, water quality, depth and velocity, and egg/juvenile stranding/displacement. These issues are related to habitat utilization, and the quality and quantity of spawning, incubation and rearing habitat. These mean objectives measure productivity and mortality, which contribute to fish populations in Herrling Island Sidechannel.

4.3.11 Objectives and Performance Measures – Herrling Island Sidechannel Fish

The ends objective for ***Herrling Island Sidechannel Fish*** is to ***maximize fish population in Herrling Island Sidechannel.***

The first ***Herrling Island Sidechannel Fish*** sub-objective is to ***maximize effective spawning habitat.***

The performance measure for this sub-objective called ***effective spawning/rearing habitat*** is defined as ***the area, in hectares, that has the potential to provide spawning/rearing habitat that is successful to the end of incubation***. This performance measure estimates the quantity of effective spawning/rearing habitat under different operating alternatives. This performance measure is modified by the cumulative amount of spawning habitat lost during spawning.

At various points in the Wahleach water use planning process, fry numbers were substituted for habitat area in Jones Creek and Herrling Island Sidechannel to provide the Consultative Committee with qualitative and quantitative values of fish in each area.

Table 4-9 illustrates the assumptions to convert habitat areas to fry numbers in Herrling Island Sidechannel.

Table 4-9: Conversion of Habitat Area to Fry Numbers in Herrling Island Sidechannel

Description	Pink	Chum
Spawning area required m^2 per pair	5	9
Spawning capacity at maximum wetted usable area	9 066	1263
Egg to fry ratio	13.0%	9.0%
Fecundity	1800	3300
Fry production at maximum spawn cap	2 121 350	375 243

The second ***Herrling Island Sidechannel Fish*** sub-objective is to ***minimize habitat variation***.

The performance measure for this sub-objective called ***habitat variability*** is defined as ***the area, in hectares, of habitat dewatered cumulatively between 1 September and 15 May.*** This performance measure estimates the quantity of habitat dewatered cumulatively between 1 September and 15 May under different operating alternatives. Dewatering occurs when discharge from the Wahleach Generating Station drops, disrupting spawning and rearing salmonids through changes in area and suitability of habitat.

4.4 Power Generation

4.4.1 Issues – Power Generation

The Wahleach hydroelectric facility currently generates approximately 245 GWh (million kilowatt hours) annually. The output from the facility can supply the equivalent of approximately 25 000 homes. The estimated value of this electricity currently exceeds $14 million per year.

The Wahleach hydroelectric facility provides ancillary services that help maintain the reliability of the BC Hydro interconnected power system. Some examples of ancillary services include voltage control, generation reserves and dynamic scheduling. While the Wahleach hydroelectric facility plays an important role in providing ancillary services, for the purposes of the Wahleach Water Use Plan, only the annual value of power generation is considered.

The primary issue for power generation is that constraining the volume, timing and flexibility of generating practices may negatively impact the value of the power generation.

Figure 4-8 illustrates how Power Generation issues are linked to operations.

Moving left to right, run-off and the Boulder Creek Diversion Dam can influence Jones Lake Reservoir elevation levels. Fraser River levels, Jones Lake Reservoir elevation levels, the fish water release siphon, and the Wahleach Generating Station can influence the quantity and timing of power generation. These issues are related to the financial value of power generation, which contributes to generation at the Wahleach hydroelectric facility.

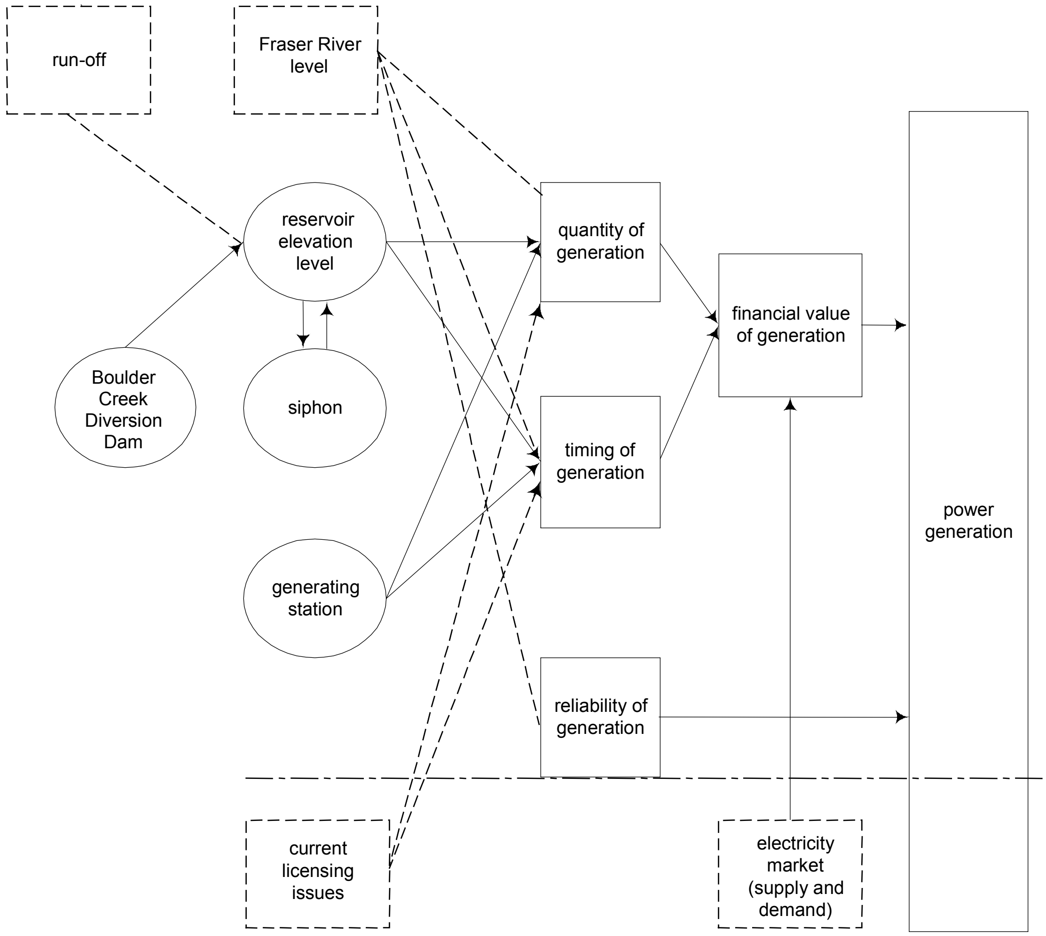

Figure 4-8: Relationship of Power Generation Issues to Operations

4.4.2 Objectives and Performance Measures – Power Generation

The ends objective for ***Power Generation*** is to ***maximize the net revenue from power generation.***

The ***Power Generation*** sub-objective is to ***maximize the annual revenue from power generation.***

The performance measure for this sub-objective called ***annual revenue*** is defined as ***the quantity of annual electricity revenue*** using the standard Value of Energy (VOE) model and assumptions used in the Water Use Plan Program. The VOE represents the long-term value of a unit of energy that is generated by the BC Hydro system.

For some alternatives, non-operational physical works to the Wahleach hydroelectric facility were included that required a capital investment. In these instances, capital costs were levelized over their economic project life according to standard BC Hydro accounting procedures and included as annual expenditures. Net Revenue, is the difference between annual revenue and the annualized costs of non-operational physical works.

4.5 Greenhouse Gas Emissions

4.5.1 Issues – Greenhouse Gas Emissions

Greenhouse gas (GHG) is the broad term applied to carbon dioxide, methane and other gases that, when emitted into the earth's atmosphere, contribute to global climate change. While impacts will vary from region to region, there is wide consensus among scientists that global climate change will have significant environmental, social and economic impacts over the coming decades.

One potential outcome of the Wahleach Water Use Plan is an overall reduction in power generation by the Wahleach hydroelectric facility. If this were to occur, GHG emissions are expected to increase, given the source of replacement power[1] is primarily combined cycle natural gas turbine generation, a more GHG intensive energy source than hydro-resources.

Figure 4-9 illustrates how the GHG emission issue is linked to operations.

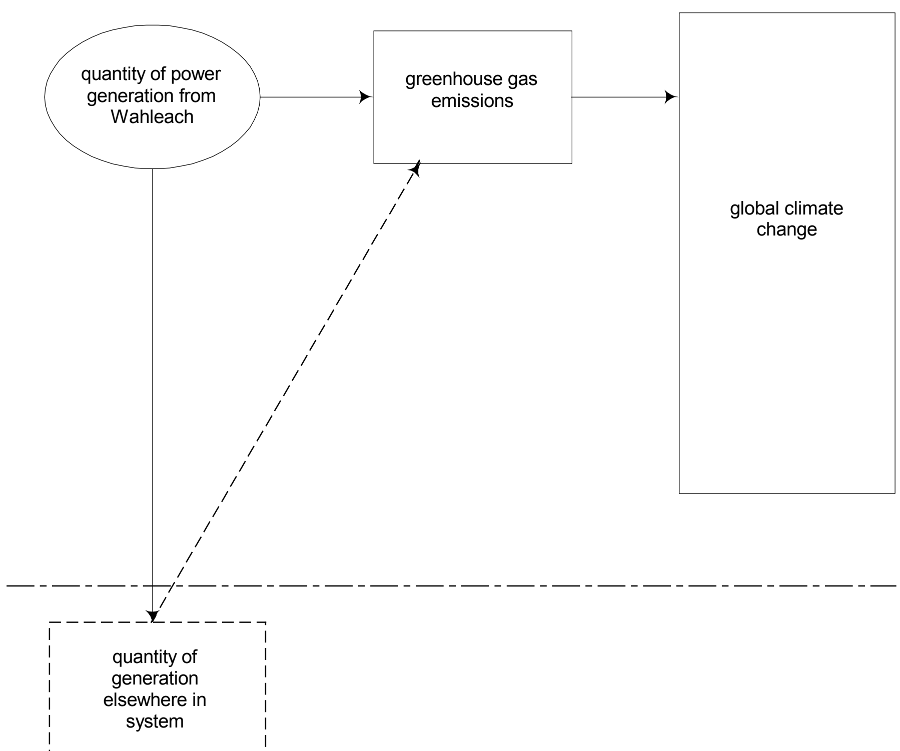

Figure 4-9: Relationship of Greenhouse Gas Emission Issues to Operations

1 BC Hydro's 2000 Integrated Electricity Plan.

Moving left to right, the quantity of power generation from the Wahleach hydroelectric facility can influence GHG emissions, which contributes to global climate change.

Throughout the Wahleach water use planning process, the inclusion of the GHG emissions performance measure generated considerable controversy amongst Consultative Committee members. The Ministry of Water, Land and Air Protection Committee member felt that GHG emissions is a system-wide issue and should not be considered in individual water use plans. A number of Consultative Committee members requested information regarding the significance of the value of the GHG emission performance measure.

Table 4-10 summarizes a number of references for the GHG emission issue.

Table 4-10: Reference Greenhouse Gas Emissions Data

Source of Emissions	Annual GHG Emissions Tonnes CO_2e/yr	Reference
Average Home in British Columbia	5	Environment Canada
Replacing the full Wahleach hydroelectric facility annual average production	75 000	245 GWh x 306 kilotonne/GW/h
BC Hydro System (2000)	2 276 000	BC Hydro 2001 Greenhouse Gas Report
Province of British Columbia (1998)	61 100 000	Environment Canada
Western Grid (Western System Coordinating Council) – 1998	343 000 000	BC Hydro Water Use Plan Greenhouse Gas Information Sheet
Canada (1999)	682 000 000	Natural Resources Canada
	Other:	
GHG damage cost range[1]	\$5 to \$25/t CO_2e	Shaffer et al. (2001): Burrard Cost Benefit Analysis Report

1. Estimation of GHG damage costs is uncertain given the lack of information on the timing and characteristics of climate change impacts.

4.5.2 Objectives and Performance Measures – Greenhouse Gas Emissions

The end objective for ***Greenhouse Gas*** is to ***minimize contributions to climate change.***

The ***Greenhouse Gas emissions*** performance measure called ***kilotonnes of CO_2e/GWh*** is defined as ***the quantity of carbon dioxide emissions relative to Alternative SQLicence***. This performance measure estimates the kilotonnes of carbon dioxide equivalent per gigawatt-hour of foregone power generation under different operating alternatives.

There was significant discussions amongst the Consultative Committee members regarding the baseline operating alternative to be used to calculate foregone power generation. The BC Hydro Committee members supported a baseline of actual, historic operations as per Alternative SQSiphon. The Fisheries and Oceans Canada and the Ministry of Water, Land and Air Protection Committee members supported a baseline of licensed operations as per Alternative SQLicence. Alternative SQLicence was subsequently adopted by the Consultative Committee as the baseline operating alternative to calculate foregone power generation.

The standard measure for quantifying GHG emissions is metric tonnes of carbon dioxide equivalent (t CO_2e). Some GHGs are more powerful than others in terms of their ability to trap heat in the atmosphere. In order to compare GHGs, they are converted to carbon dioxide equivalents by multiplying their mass by a factor referred to as Global Warming Potential. In the case of fossil fuel combustion, three greenhouse gases [carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)] are produced, with CO_2 comprising approximately 99 per cent of these emissions and methane and nitrous oxide contributing very small amounts.

The Water Use Plan Management Committee concluded that the figure of 306 t CO_2e/GWh should be used to quantify GHG emissions implications of Water Use Plans.

4.6 Wildlife

4.6.1 Issues – Wildlife

A study undertaken for the Wahleach Water Use Plan indicates that the study area is either known or thought to be used by a large number of plants and animals, including 10 amphibians species, 49 bird species and 22 mammal species (Robertson Environmental, 2001). However, not all of these species would be potentially impacted by Wahleach hydroelectric operations.

Jones Lake Reservoir elevation levels can influence wildlife populations by influencing the health of riparian and wet meadowland habitat. Wet meadow habitat is the wetlands around the reservoir which are connected to the highest water elevation. Riparian habitat is the vegetated area immediately surrounding the waterbody.

Jones Lake Reservoir elevation levels may influence the amount of wet meadow and riparian habitat available for species such as amphibians, birds and mammals (i.e., mountain beaver, mink, snowshoe hares). A wet meadow and healthy riparian community will ensure food production, foraging habitat and in the case of amphibians, habitat for reproduction.

In addition, there are connections between fish productivity and wildlife populations in Jones Lake Reservoir. Due to the difficulty in measuring wildlife populations and determining the factors that affect wildlife, the Consultative Committee developed objectives for habitat and assumed that if habitat is maintained, wildlife populations will benefit.

While there are likely to be impacts on wildlife in Jones Creek and Herrling Island Sidechannel, the Consultative Committee focused on wildlife impacts at Jones Lake Reservoir.

Figure 4-10 illustrates how Wildlife issues are linked to operations.

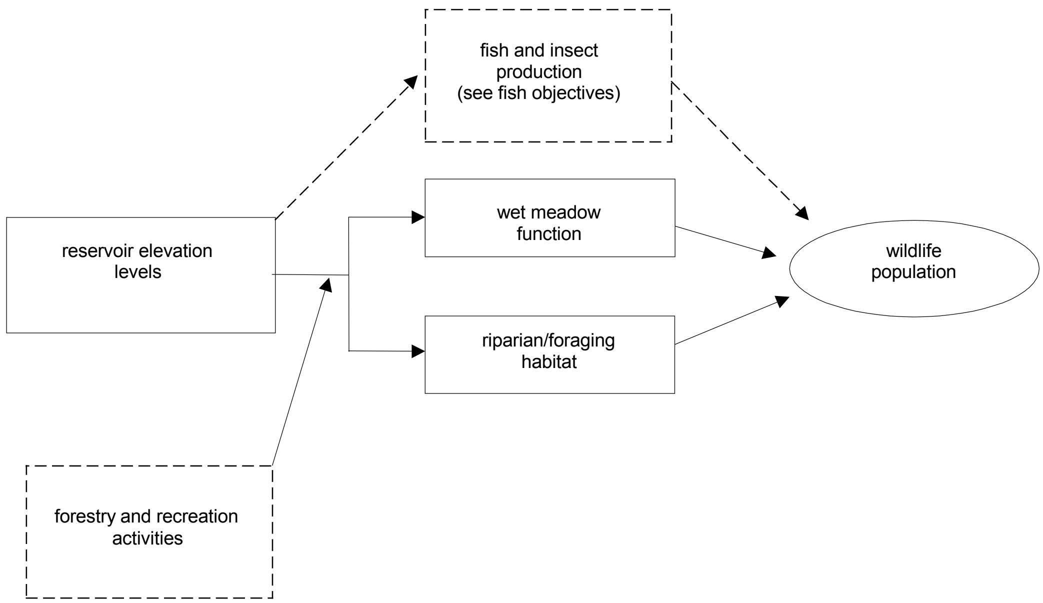

Figure 4-10: Relationship of Wildlife Issues to Operations

Moving left to right, Jones Lake Reservoir elevation can influence fish and insect production, wet meadow function, and riparian foraging habitat. These issues are related to wildlife populations at Jones Lake Reservoir.

4.6.2 Objectives and Performance Measures – Wildlife

Oikos Environmental (2001) noted that Jones Lake Reservoir riparian habitats, and in particular, the large wetland at the southern end of the reservoir, are important wildlife habitats. Therefore, plant communities were profiled by elevation bands within the reservoir to determine wildlife habitat types. These bands are used differently and at different times by each wildlife species.

The Jones Lake Reservoir elevation level fluctuations and duration of inundation affect the viability and distribution of plant communities in the riparian zone around the reservoir, and the wildlife species that utilize those communities. Assuming that plant communities in the riparian zone around the reservoir influence wildlife populations, the performance measure will assess the changes in the availability of usable riparian habitat with each operating alternative.

The wildlife performance measure is designed to determine how each plant community is impacted by the operational change, and how wildlife are affected by those changes.

Three distinct plant community types were identified: Wetted Areas, Willow Sedge and Sedge Grass. For each of these community types, a performance measure was developed that was a function of habitat area (ha) and the relative utility of each area for wildlife values.

The ends objective for ***Wildlife*** is to ***minimize impacts to wildlife***.

The ***Wildlife*** sub-objective is to ***maximize the available habitat of wetted, willow-sedge, and sedge-grass areas***.

The performance measure for this sub-objective called ***wetted willow*** is defined as ***the quantity of wetted, willow-sedge, and sedge-grass area***.

The Fish Technical Subcommittee developed a weighted index to clarify impacts on wildlife for the Consultative Committee. The ratio of 2:1:1 for wetted, willow-sedge and sedge-grass areas respectively, was a compromise between the opinions of various subcommittee members.

4.7 Flood Control

4.7.1 Issues – Flood Control

Located on the banks of the Fraser River, residents of Laidlaw have occasionally experienced property damage due to flooding events from that river, and from the nearby Lorenzetta Creek. The elevation the river reached during the major Fraser River flood of 1948 is commemorated on the sides of the barns of several local residents. More recent and minor floods occurred in the mid-1990s.

Since the Wahleach Dam was built, there appears to have been no flooding damage caused as a result of BC Hydro operations. However, some minor damage has been associated with the debris torrent of 1995. Local residents contacted during the Wahleach water use planning process did not express a concern with flooding from the Wahleach hydroelectric facility. They attributed flooding risk to the Fraser River.

In the 1994 Wahleach Spillway Rehabilitation study, the bankfull discharge for Jones Creek was estimated to be 250 m^3/s[1]. A one in 200-year natural inflow for Jones Creek without any contribution from spilling is estimated to be

[1] Ref. BC Hydro 1994 – *Wahleach Dam Spillway Rehabilitation Report on Early Notification System for flood flows in Wahleach Creek*. BC Hydro Report No. H2836 - 1994.

approximately 83 m^3/s. Therefore, a 250 m^3/s natural inflow would likely have a return period of longer than 1000 years.

The maximum daily spill from the Wahleach Dam from 1960 to date is approximately 65 m^3/s. The maximum daily reservoir inflow to Jones Lake Reservoir from 1960 to current is approximately 120 m^3/s. Therefore, even when the reservoir is at full pool when spill commences, the maximum possible daily spill is approximately 120 m^3/s, which is less than bankfull.

While inflow data indicates that flooding impacts as a result of operations alone is unlikely, it is significant that Lorenzetta Creek and Jones Creek converge then flow into the Fraser River.

Figure 4-11 illustrates a map of Jones Creek and Lorenzetta Creek.

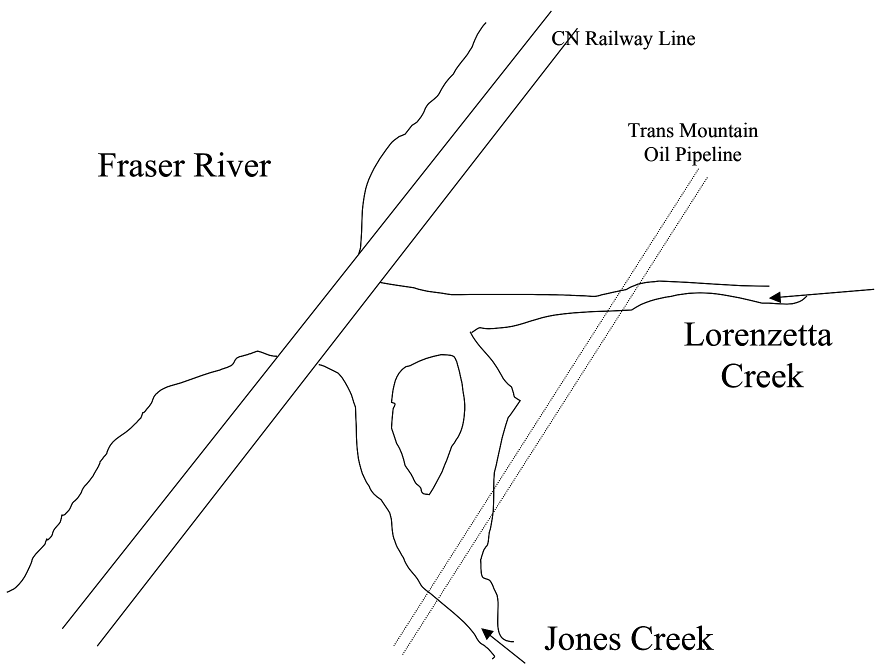

Figure 4-11: Map of Jones Creek and Lorenzetta Creek

From the 1994 Spillway Rehabilitation Study, the bankfull discharge for Lorenzetta Creek is estimated to be approximately 30 m^3/s which corresponds to a one in thirty year natural Lorenzetta Creek inflow event. Therefore, regardless of Jones Lake Reservoir operations, there will be periodic overbank flooding of Lorenzetta Creek which may cause flooding in the town of Laidlaw.

The two flood inundation maps created for the 1998 Flood Communications Plan (BC Hydro, 1998) shows areas inundated with and without spills from Wahleach Dam. The extent of inundated areas for three different flow scenarios (50, 100 and 200 year events) in Jones Creek were determined using a hydraulics model and are shown on each of the two maps.

As shown in the first map (Figure 4-12) some areas would be inundated by natural floods without any contribution from spill. The second map (Figure 4-13) shows the inundated area caused by floods coupled with spill. The staff gauge levels (at a few bridges) that would correspond to these events were also determined.

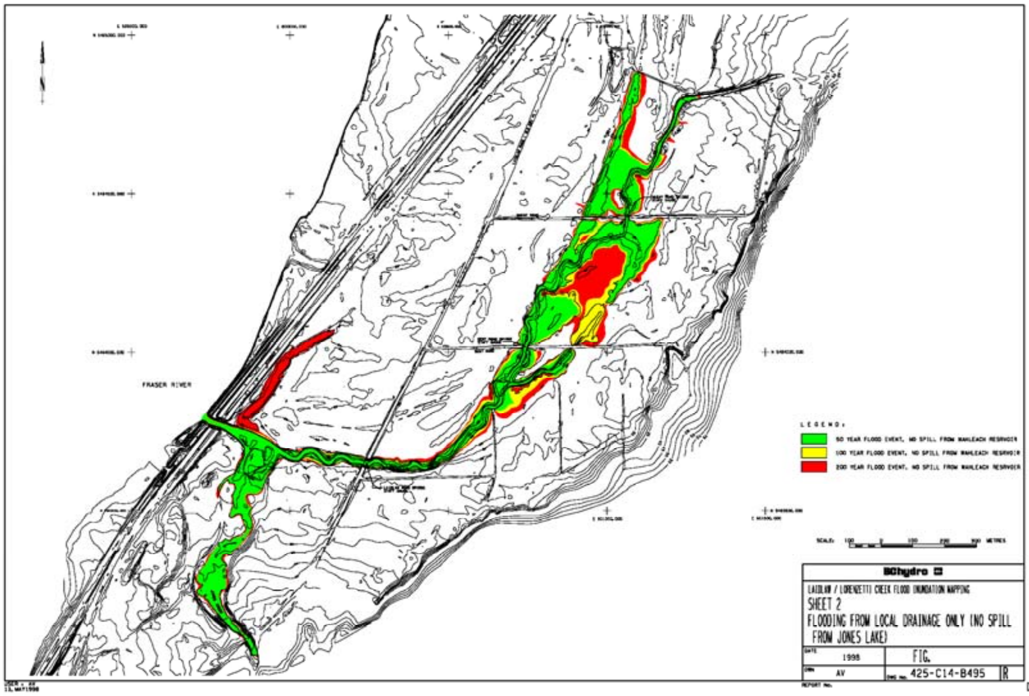

Figure 4-12: Flooding from Local Drainage Only

In Figure 4-13, the different coloured areas represent the following:

- Red – areas inundated as a result of a 265.7 m^3/s Jones Creek flow (including spill) at Jones Creek/Lorenzetta Creek confluence.
- Yellow – areas inundated as a result of a 233.0 m^3/s Jones Creek flow (including spill) at Jones Creek/Lorenzetta Creek confluence.
- Green – areas inundated as a result of a 200.7 m^3/s Jones Creek flow (including spill) at Jones Creek/Lorenzetta Creek confluence.

The Consultative Committee agreed that the areas on the map in Figure 4-13 subject to inundation to the extent of the green areas would not result in any physical damage to property or pose a significant safety risk. Therefore, any Jones Creek flow (including spill) less than 200 m^3/s would not pose a flooding risk.

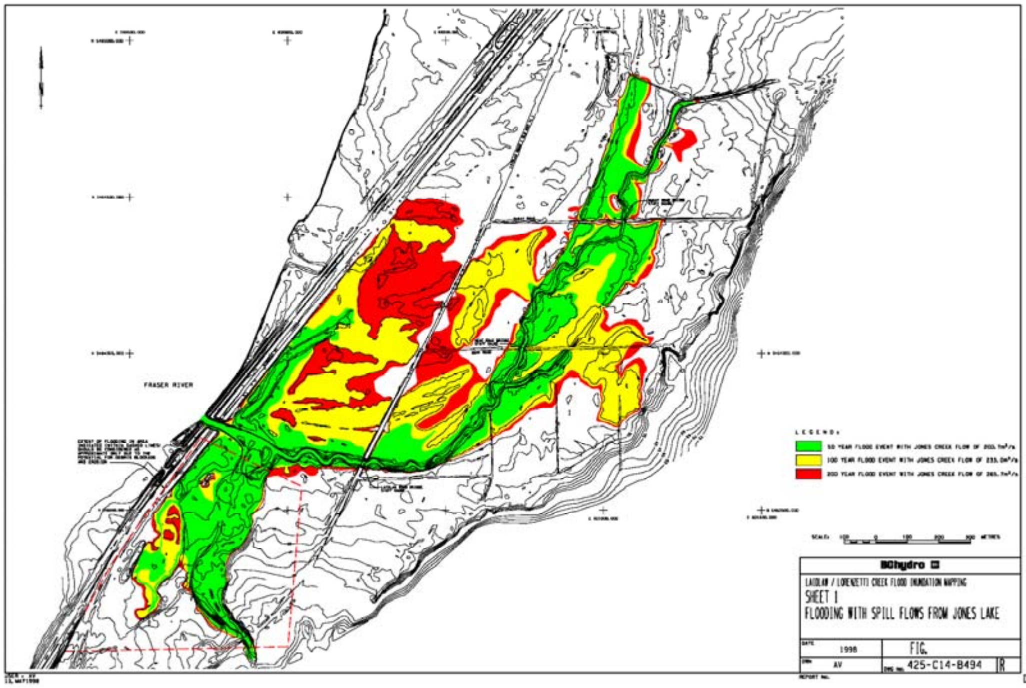

Figure 4-13: Flooding with Spill Flows from Jones Lake Reservoir

However, the 1998 Flood Communications Plan does not consider Fraser River levels. At times of high Fraser River levels, Wahleach Dam discharges into Jones Creek could contribute to a backwater effect along Lorenzetta Creek that would exacerbate flooding along Lorenzetta Creek and possibly some flooding along lower Jones Creek. Whether this has an impact on flooding could only be quantified by developing a full hydraulic model with flood plain cross sections, which was not undertaken during the Wahleach water use planning process.

Eric Isaacson, a local resident and Consultative Committee member noted the elevation of water on a staff gauge at Laidlaw Road was 27.2 m during a recent Fraser River high water event. While operations of the Wahleach hydroelectric facility had no influence on this event, if a large discharge from the Wahleach Dam occurred at that time, operations would have contributed to flood damage in the area. The elevation of 27.2 m at the staff gauge was defined as a "red flag" warning elevation, meaning that any operations likely to increase water levels above this figure could potentially lead to flood damage.

4.7.2 Objectives and Performance Measures – Flood Control

The ends objective for ***Flood Control*** is to ***minimize risks to safety and property damage from flooding***.

The ***Flood Control*** sub-objective is to ***minimize red flag flood risk in Laidlaw.***

The performance measure for this sub-objective called ***Red Flag Flood Risk*** is defined as ***the number of days the staff gauge at Laidlaw Road Bridge is above 27.2 m while Wahleach Dam is discharging***. A relationship (as shown in Figure 4-14) was developed between Fraser River elevations, Lorenzetta Creek flows and the Wahleach Dam discharge required to bring the water level above the 27.2 m Red Flag warning elevation. This relationship was developed using the hydraulic model used in creating the maps from the 1998 Flood Communication Plan. This performance measure was calculated as the number of days over a 40 year period and the average number of days per year that contained a Red Flag day.

The number of days in which the combined flows at the confluence of Lorenzetta and Jones Creeks exceeded 200 m^3/s was also calculated. However, no operating alternative modelled during the Wahleach water use planning process reached this figure.

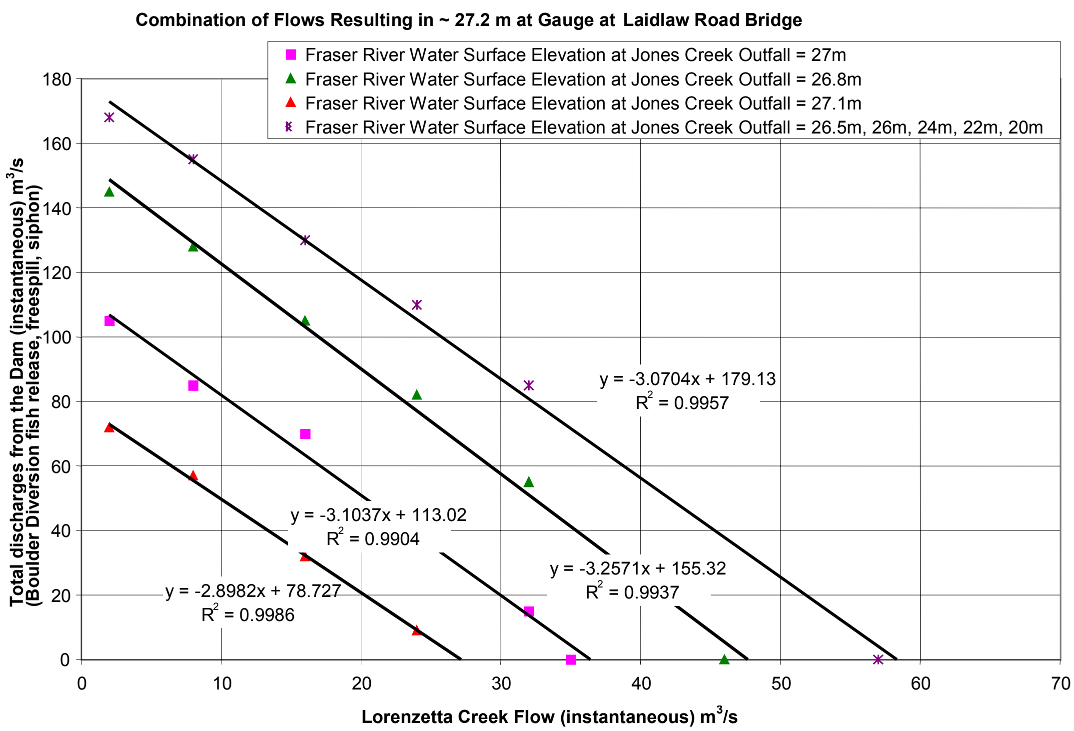

Figure 4-14: Conditions Resulting in a Red Flag Flood Warning Day

4.7.3 First Nation Culture and Heritage

In other Water Use Plans, the First Nations have expressed interest in adapting reservoir elevations and water flows for the benefit of cultural practices including:

- Specifying desired flows or elevations to coincide with festivals or spiritual gatherings.

- Specifying desired flows or elevations to ensure access to (or to deny access to) spiritually significant areas or trails by boat.
- Specifying desired flows or elevations to prevent the erosion of special sites either in the reservoir drawdown zone or in an area of creek directly affected by flows.
- Specifying periods of deep reservoir drawdowns to enable detailed archeological studies of sites usually inundated.

Accommodating such interests in a Water Use Plan requires knowledge of historical and current cultural uses of the project area. Knowledge of many First Nation activities historically undertaken within the Wahleach hydroelectric facility area has been lost.

During the Wahleach water use planning process, an archaeological overview survey was undertaken to identify any areas of historical cultural significance that may be impacted by operations. The study, prepared by Dave Schaepe and not released to the Consultative Committee, did not identify specific spiritual sites within the project area.[1] However, study activities were limited to the reservoir, and consequently the study was not considered complete by the Stó:lō Nation. (Refer to Appendix E: Executive Summary of First Nation Studies.)

On this, McHalsie (2001) comments, "This study was not comprehensive given constraints of time, money and availability of informants to participate in interviews. Further research is necessary to identify spiritual sites used in the past. Future activity in the watershed will involve going out and identifying new spiritual sites as part of the process. Thus the Stó:lō Nation may have further recommendations regarding operations of the Wahleach Dam in the future."

McHalsie (2001) notes that, "What the Stó:lō Nation currently does in this watershed has already been limited by encroachment, alienation of lands, and decisions in which it had no participation. Considerable knowledge has been lost through the passing of Elders and the truncation of traditional and spiritual practices under assimilationist policies such as residential schools."

McHalsie does point out that current and future cultural uses of the area are an important issue for the First Nations. He comments that, "In October 2001, the Shxw'ow'hamel Siy̲a̲:m Council expressed interest in the future use of the area encompassing Hunter and Jones Creeks for spiritual use, hunting and gathering. This reserve is also in the process of re-establishing trails which have been used traditionally, and is re-using the women's fasting grounds."

[1] Although McHalsie had previously identified one culturally significant site in the vicinity of Jones Creek (McHalsie (2001).

After several meetings with the First Nations, it was agreed that although culturally significant sites affected by operations may be identified through further study, there was no information to base specific Wahleach Water Use Plan objectives at this time.

However, the First Nation interests in the Wahleach Water Use Plan, were not isolated to cultural heritage issues. The First Nations participated throughout the Wahleach water use planning process to develop fish and wildlife objectives and performance measures, create operating alternatives, and select a preferred operating alternative through trade-off analysis. McHalsie (2001) made a number of statements on the overall goals of the Stó:lō Nation with respect to the Wahleach Water Use Plan, some of which were possible to address within the Wahleach water use planning process. McHalsie (2001) writes: "It is important to note the principle or ultimate goal upon which Stó:lō is basing its approach, which is:

There should be an attempt to 'restore' conditions of the ecosystem in the Jones Creek watershed project area… Stó:lō Nation recognizes that this is impossible as a result of the relative changes in flows in Jones Creek, and the lake levels pre- and post-dam. Thus a more realistic goal is to attempt to rehabilitate the area, move towards conditions which more closely resemble those prior to dam construction. A combination of human interventions and time will be necessary for this to occur…"

"Accomplishing this goal involves the following actions:

1. Stabilize the hillslopes and reducing sedimentation in the upslopes of the watershed (…this point is beyond the purview of BC Hydro…).
2. Increase flows in Jones Creek considerably.
3. Establish patterns of changes in water levels of the lake and Jones Creek, which mimic natural patterns (seasonally/annually) as closely as possible.
4. If necessary, re-establish indigenous plants in the riparian/littoral zone of the lake through natural or other means."

In discussions of McHalsie's study, First Nations agreed that a primary objective was not to "mimic natural patterns" as an end in itself, but rather to generally improve conditions for fish and wildlife, with the understanding that mimicking natural patterns would likely be a good way of optimizing those objectives. In other words, the "end" of altering operations for the benefit of fish and wildlife was more important than the "means" by which this was brought about. Thus, First Nations' objectives were broadly aligned with other fish and wildlife interests of the Consultative Committee.

4.8 Other Issues Considered But Not Included in the Wahleach Water Use Plan

4.8.1 Water Quality

At the February 2001, Consultative Committee meeting, there was a discussion on a potential linkage between Jones Lake Reservoir activities, flows in Jones Creek and the Peters Band well water quality. One suggestion was that fertilizer introduced to the reservoir was having a significant impact on the Peters Band's well water quality. Based on limited data and geographical considerations, the Consultative Committee concluded that the existence of such a link was unlikely. However, it was recognized further groundwater site investigation and evaluation would be needed.

In early 2001, Marc Zubel, Regional Hydrogeologist with the Ministry of Water, Land and Air Protection undertook a preliminary groundwater resource assessment of the Peters Band's land to evaluate the potential linkage between the outflow of Jones Creek and groundwater resources on their land.

On 10 May 2001, Marc Zubel and Sylvia Letay of the Chilliwack regional sub-office, in the company of Clarence Peters of the Peters Band, conducted a site investigation. Ten water well sites were inspected, including sanitary conditions around the wellhead and land use activities in the immediate area. Water level measurements were taken in nine wells using an electronic water level instrument. Marc Zubel also referred to Health Canada bacteriological reports on samples of groundwater taken from the Peters Band wells during the past five years that indicated the presence of unsatisfactory concentrations of coliform bacteria in five of twelve wells.

In his final report, Marc Zubel (2001) concludes that coliform bacteria is most likely coming from a localized source possibly from animal activities near the well, septic system failure, or within the residential water distribution system.

On the issue of a possible link to Wahleach hydroelectric operations, Marc Zubel writes:

"The quantity of slow release nutrients that is applied into the lake in the summer is considered very small and is controlled by scientifically determined needs to maximize fish productivity and minimize excess nutrient build-up in the lake. However, if excess nutrients are generated, they may travel from the lake into Jones Creek during high lake water level conditions when lake water spills over the dam and discharges into Jones Creek. By the time it reaches the Fraser River, it is unlikely that any measurable residual levels of nutrients would be found in the creek water due to dilution. Once the creek enters the Fraser River, the water quality is then overwhelmed by the quality of the Fraser River water, and would have virtually no direct input on the quality of groundwater in the Peters Aquifer." Marc Zubel concludes that, "Besides further site investigations, stream flow measurements, dye tests, test drilling, independent water quality sampling and laboratory analyses may be required to address other possible source(s) of coliform contamination and confirm the degree of connectivity between Wahleach Lake and the Peters Aquifer."

4.8.2 Trans Mountain Oil Pipeline

Figure 4-11 illustrates the approximate location of an underground oil pipeline owned and operated by the Trans Mountain Oil Pipeline Company. Early in the Wahleach water use planning process it was recognized that any changes to operations in Jones Creek could impact the interests of this company. Therefore, the Trans Mountain Oil Pipeline Company was invited to participate in the Wahleach water use planning process, but declined.

4.9 Summary of Objectives and Performance Measures

Table 4-11 summarizes the final Wahleach Water Use Plan objectives and performance measures developed by the Consultative Committee. The last column in the table is the Minimum Significant Incremental Change which is discussed in Section 7.

Several performance measures continued to evolve through the rounds of operating alternative development. Therefore, some performance measures in the consequence tables in the initial rounds of trade-offs were modified later in the Wahleach water use planning process.

Table 4-11: Wahleach Water Use Plan Objectives and Performance Measures

Interest	Ends Objective	Sub-Objective	Performance Measure	Units of Measure	Minimum Significant Incremental Change (%)
Recreation	Maximize quality and quantity of recreation experience	Maximize recreation quality	Recreation Quality	Days reservoir is between 638.6 m to 641.6 m	5
		Minimize spillway safety risk	Spillway Safety	Days of spill	5
Jones Creek Non-Anadromous Fish	Maximize fish populations in Jones Creek Non-Anadromous	Provide a viable aquatic habitat	Viable Aquatic Habitat	Days at 10%, and 20% MAD	20
Jones Creek Anadromous Fish	Maximize fish populations in Jones Creek Anadromous	Maximize the effective spawning habitat	Effective Spawning Habitat	m^2	20
		Maximize the effective rearing habitat	Effective Rearing Habitat	m^2	20
		Minimize stranding risk	Stranding Risk	Index	20
Jones Lake Reservoir Fish	Maximize reservoir fish populations	Maximize littoral productivity	Effective Littoral Zone	Area Days	20
		Maximize pelagic productivity	Volumetric Pelagic Productivity	m^3	20
		Minimize entrainment risk	Entrainment Risk	Index	20
Herrling Island Sidechannel Fish	Maximize fish populations in Herrling Island Sidechannel	Maximize effective spawning habitat	Effective Spawning/ Rearing Habitat	m^2	20
		Minimize habitat variation	Habitat Variability	m^2	20
Power Generation	Maximize the net revenue from power generation	Maximize the annual revenue from power generation	Annual Revenue	$	5
			Levelized Costs	$	5
			Net Annual Revenue	$	5
Greenhouse Gas Emissions	Minimize contributions to climate change		Kilotonnes of $C0_2e$/GWh	$C0_2e$/GWh	5
Wildlife	Minimize impacts to wildlife	Maximize available habitat	Wetted Willow-Sedge, and Sedge-Grass Area	m^2	20
Flood Control	Minimize risks to safety and property damage from flooding	Minimize Red Flag Flood Risk in Laidlaw	Red Flag Flood Risk	Days staff gauge at Laidlaw Road Bridge is above 27.2 m with discharges from Wahleach Dam	10

5 INFORMATION COLLECTED

During the process of identifying issues, structuring objectives and developing performance measures in the Wahleach water use planning process, a number of questions were raised by the Consultative Committee. As a result, a number of studies were undertaken to improve the knowledge base on the Wahleach system. These studies were evaluated by the Consultative Committee using the eligibility criteria developed by the Water Use Plan program. (Refer to Appendix F: Evaluating the Eligibility of Studies in Water Use Planning.)

Table 5-1 summarizes the information collected during the Wahleach water use planning process.

Table 5-1: Summary of Information Collected

Interest	Information Collected	Description/Rationale
Jones Lake Reservoir Fish	Digital elevation model (DEM)	Using pre-existing bathymetric data (Limnotek, 1998) and digital elevation data from the dam reconstruction (1991), a DEM was created for use with reservoir performance measures.
	Spawning habitat use assessment and spawning survey	A study was undertaken to assess spawning use in tributaries and the reservoir shoreline within the drawdown zone. Additionally, both rainbow and kokanee spawners were counted over their respective spawning periods in each of the main tributary streams.
	Drawdown zone stranding potential survey	Coinciding with the spawning habitat use study, technicians assessed the risk of fish stranding in the drawdown zone and mapped key areas of risk.
	Sediment spectro-analysis (carried out by Power Facilities)	Analysis of sediment core samples to determine the biological history of the reservoir, and to understand the implications of dam construction and operations on productivity.
Jones Creek – Anadromous Fish	Habitat-flow study	In the 800 m of Jones Creek anadromous, seven cross sections were surveyed over flows ranging from 0.5 to 2.0 m^3/s, collecting habitat information at each flow (depth, velocity, substrate).
	Transect stability analysis	To establish the relationship between flow and channel stability, erosion and deposition in Jones Creek anadromous, surveys were analyzed over the time period of the flow study.
	Flow monitoring	A data collection platform and staff gauge was installed in Jones Creek anadromous. Flows were monitored over the study period to calibrate modelled inflow data and meet study requirements.
	Adult escapement and fry outmigration study	Pink and chum spawners were enumerated in the fall, and a program set up in the spring to assess outmigrant fry to determine the current fry production of the system.

Table 5-1: Summary of Information Collected (cont'd)

Interest	Information Collected	Description/Rationale
Jones Creek Non-Anadromous Fish	Review of watershed stability implications	Site visit and report summary by Mike Miles to outline the Wahleach Water Use Plan considerations of watershed stability issues for lower Jones Creek habitat management.
	Stream survey	Presence-absence assessment of the non-anadromous section of Jones Creek to determine the habitat values.
Herrling Island Sidechannel Fish	Establishment of a semi-permanent flow gauge to assess flows	Used to validate flows occurring during the transect work to develop the fish performance measure.
	Herrling Island Sidechannel fish stranding study (in partnership with Power Facilities)	Completed an assessment of stranding risk in the sidechannel to evaluate current flow ramping at Wahleach Generating Station. Fry were enumerated over the study period to correlate stranding figures.
	Habitat mapping analysis (completed pre-Water Use Plan)	Developed habitat maps of wetted areas based on photo flights of three operations during low Fraser River levels. Used in development of performance measures for this portion of the Wahleach system.
Jones Lake Reservoir Wildlife	Riparian ecosystem mapping	Vegetation surveys conducted along representative transects were used to assess impacts of current operations on plant community composition in the reservoir drawdown zone.
Wahleach System Wildlife	Review of wildlife resources	Preliminary investigation of wildlife resources in the Wahleach system and possible operational impacts to be reviewed within the Wahleach Water Use Plan.
Cultural and Heritage	Study of Stó:lō Nation contemporary and traditional use	Interviewed community elders to determine if their traditional/future uses would be impacted by Wahleach hydroelectric operations.
	Partial archaeological overview of the watershed. (lower Jones Creek not completed)	Phase 1/Stage 1 archaeological assessment to determine if any heritage resources were in the watershed that may be affected by current or future Wahleach hydroelectric operations.
Lower Jones Creek Flooding	Review of flood risk studies	Analysis of flood risk studies conducted in the Jones Creek fan was completed to inform the Consultative Committee on flood potential in the area.

6 OPERATING ALTERNATIVES

In Step 6 of the Wahleach water use planning process, the Consultative Committee defined and evaluated various operating alternatives for the Wahleach hydroelectric facility. The BC Hydro project team simulated these operating alternatives using computer models for the Wahleach hydroelectric facility. The Consultative Committee used the modelling results and performance measures to compare how well each operating alternative performed in satisfying their objectives.

This section describes the specified constraints of the Wahleach operating alternatives and the modelling process.

6.1 Modelling Operating Alternatives

Several models were used to predict the impacts of the Wahleach operating alternatives on the performance measures (Figure 6-1).

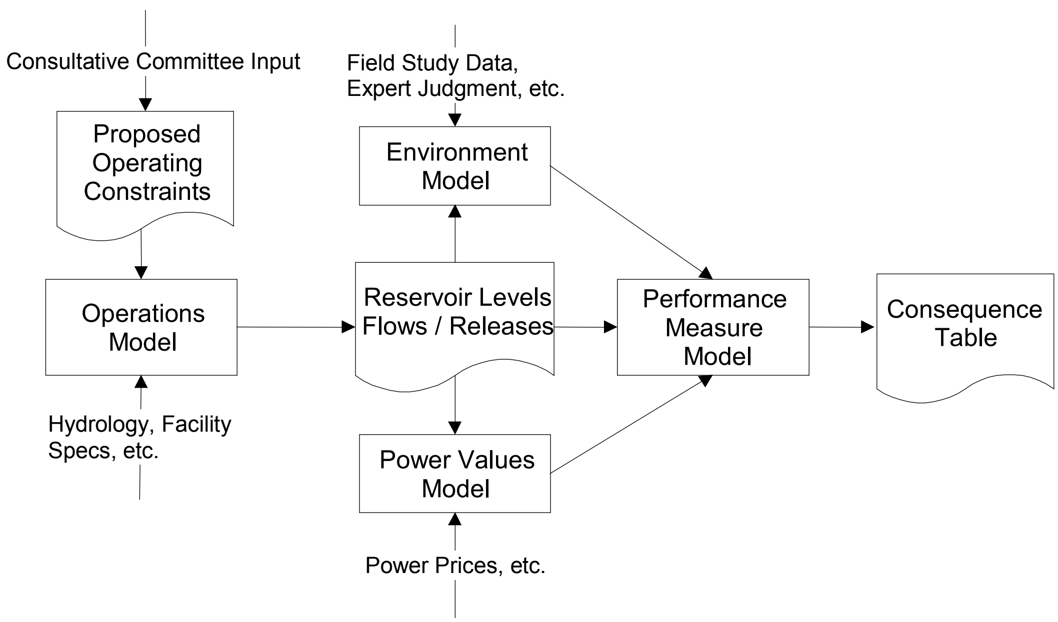

Figure 6-1: Overview of Wahleach Water Use Plan Models

Once the Consultative Committee developed an operating alternative, the modellers used the BC Hydro Operations Model to simulate operation of the Wahleach hydroelectric facility according to the specified constraints of each alternative.

Software development for the Operations Model was centred on the A Mathematical Programming Language (AMPL) and CPLEX commercial software packages. AMPL is a modelling language for mathematical programming which enables conversion of a problem from a “modeller’s form” to the “algorithm’s form.” AMPL transforms a mathematical formulation to computer code. The transformed problem is solved by CPLEX, a package of mathematical solvers for linear and non-linear programming. For the Wahleach hydroelectric facility, it uses 40 years (1960 to 1999) of estimated historic Jones Lake Reservoir inflow data. These historic inflows are routed through the Wahleach hydroelectric facility in accordance with physical capacities and with consideration of the specified operating constraints.

The Operations Model optimizes facility operations for power generation, within specified constraints. For each operating alternative, the Operations Model provides the daily reservoir elevation levels, daily spill discharge, daily turbine discharge and daily power generation output files over 40 years of simulated operation. These outputs serve as inputs to the Environmental Model and the Power Values Model to calculate the performance measures for each operating alternative.

The Environment Model is a Visual Basic program that simulates the dynamics of the performance measures. A series of Excel spreadsheets is used to store model parameters, physical characteristics of the system (e.g., reservoir surface area as a function of elevation, etc.) and the hydrologic scenarios (e.g., schedules of discharge and reservoir elevations associated with each alternative). Output (performance measures and various diagnostic indicators) can be viewed as data sets, time series graphs and/or maps. This model is used to calculate the environmental and social performance measures defined in Section 4.

Power generation from the Operations Model are routed through a Power Values Model that uses information about energy prices, dispatchability, and facility characteristics to calculate the annual value of the power generation that will be produced under each operating alternative.

The modellers ran numerous iterations to develop an optimum operating alternative while respecting physical and operating constraints. The Consultative Committee used the performance measures to evaluate the relative performance and trade-offs between the operating alternatives.

6.2 Specifying Operating Alternatives

The specified constraints for the Wahleach operating alternatives included minimum flows in Boulder Creek, minimum flows in Jones Creek, elevation levels in Jones Lake Reservoir, and minimum discharges in Herrling Island Sidechannel. Once these constraints were satisfied, the next priority was to maximize power generation.

Table 6-1 summarizes the operating alternatives that were modelled in the Wahleach water use planning process. Creating and evaluating operating alternatives is an iterative process. In the first round of operating alternatives, the Consultative Committee developed five alternatives. Round 1 operating alternatives demonstrated how the Wahleach hydroelectric facility responded when minimum flows in Jones Creek, minimum reservoir elevation levels in Jones Lake Reservoir, and minimum discharges in Herrling Island Sidechannel were imposed. Round 1 operating alternatives also demonstrated to the Consultative Committee the process of specifying operating alternatives and interpreting the model outputs and performance measures.

Based on the learning experience of the Round 1 operating alternatives, the Consultative Committee developed and evaluated operating alternatives in Rounds 2, 3 and 4 to seek a balance between competing water use objectives. Rounds 5 and 6 operating alternatives introduced non-operational physical works in lieu of operations.

6.3 Issues Addressed in Specifying Alternatives

6.3.1 Defining Current Operations

In the Wahleach water use planning process, the Consultative Committee agreed to model current operations. However, there was significant discussion amongst the Consultative Committee members regarding the definition of current operations. Some Consultative Committee members felt the definition of current operations was a critical issue because of its potential to influence the value judgments of the Committee during the trade-off process.

BC Hydro's diversion licence for the Wahleach hydroelectric facility, caps the annual volume of water that can be diverted to Herrling Island Sidechannel at 2084.5 m^3/s-days, or 180.1 x 10^6 m^3. However, the average inflow for the facility is greater at ~2380 m^3/s-days, or ~200 x 10^6 m^3. As a result, in some years BC Hydro must decide whether to spill the excess water into Jones Creek, or to ask the Comptroller of Water Rights for an Interim Order for permission to use the excess water for power generation.

From the construction of the Wahleach hydroelectric facility in 1952, until the destruction of the Jones Creek spawning channel in the mid-1990s, BC Hydro released water into Jones Creek only as required for the spawning channel. Otherwise, the excess water was passed through the Wahleach Generating Station with the informal approval of the Comptroller of Water Rights.

BC Hydro believed that the diversion limit in the licence was calculated in error and was never intended to require BC Hydro to release more water into Jones Creek than what was specified for the spawning channel (Jim McNaughton, personal communication). During the Wahleach water use planning process, the Office of the Comptroller of Water Rights confirmed that the annual limit was introduced into the licence when the design for the Wahleach Powerhouse was finalized and the licensee wanted to increase the licensed maximum rate of diversion from 5.7 m^3/s to 13.3 m^3/s. This was achieved without applying for additional rights by adding an annual limit equivalent to 5.7 m^3/s all year (180.1 million cubic metres) and granting the authority to divert at a rate of 13.3 m^3/s.

Throughout the Wahleach water use planning process, it was emphasized that the mandate of the Consultative Committee was to find the best balance of water use across the range of interests. It was confirmed that existing licence rights were being addressed in a separate process and would be referred to when considering the new licensing requirements of the Wahleach hydroelectric facility.

Nevertheless, some Consultative Committee members believed that BC Hydro was not entitled to generate power using water above its existing water diversion licence. Furthermore, regardless of the origin of the diversion licence limit, any excess water should be allocated to Jones Creek for the benefit of fish. Therefore, current operations should be defined as the manner in which BC Hydro would operate the Wahleach hydroelectric facility if the current diversion licence were fully enforced, assuming no issuance of Interim Orders.

In order to move forward in the Wahleach water use planning process, the Consultative Committee agreed to model two distinct current operations alternatives as follows:

- **Status Quo Siphon (SQSiphon):** Assumes no licence restrictions, and an average annual release of three weeks into Jones Creek via the fish release siphon.
- **Status Quo Licence (SQLicence):** Assumes a diversion limit of 180.1×10^6 m^3 per year is strictly enforced.

Table 6-1: Summary of Operating Alternatives

Round	Operating Alternative	Jones Creek Constraints	Reservoir Constraints	Herrling Island Sidechannel Constraints	Notes
Round 1	StatusQuo	–	*Minimum elevation 628 m 1 Jan–31 Dec*	–	• Intended to represent status quo operations.
	JCSpill	Minimum flow of 1.2 m^3/s 1 Jan–31 May Minimum flow of 0.75 m^3/s 1 Jun–14 Sep Minimum flow of 1.1 m^3/s 15 Sep–31 Dec	–	–	• Intended to represent an operation focused on providing Jones Creek fish flows.
	JCSiphon	Minimum flow of 0.85 m^3/s 1 Jan–31 Dec	*Avoid spills*	–	• Intended to represent an operation focused on providing Jones Creek fish flows via the fish water release siphon.
	HerrMin	*Minimum flow of 1.2 m^3/s 1 Jan–31 Mar* *Minimum flow of 0.75 m^3/s 1 June–14 Sep* *Minimum flow of 1.1 m^3/s 15 Sep–31 Dec*	–	Minimum flow 5.9 m^3/s 1 Sep–1 May	• Intended to represent an operation focused on providing Jones Creek fish flows via the fish water release siphon and providing Herrling Island Sidechannel fish flows.
	Rec	–	Minimum elevation 638.6 m 15 May–15 Sep	Minimum flow 5.4 m^3/s 1 Sep–31 May	• Intended to represent an operation focused on maximizing the recreation objective and providing Herrling Island Sidechannel fish flows.
Round 2	SQSiphon	Minimum flow of 0.85 m^3/s 15 Sep–5 Oct	*Minimum elevation 628 m 1 Jan–31 Dec*	–	• Intended to represent current operations. • Assumes a 3-week annual release to Jones Creek. • Requests for Interim Orders are granted. • A Jones Lake Reservoir minimum elevation level of 628 m was modelled to represent an informal agreement between the Ministry of Water, Land and Air Protection and BC Hydro. BC Hydro does occasionally draw down below 628 m under exceptional circumstances.
	SQLicence	Maximum diversion: 180.1×10^6 m^3 per year			• Intended to represent current licensed operations. • No Interim Orders are granted.

1. Entries in italics were specified as secondary constraints, to be yielded as and if required when modelling.

Table 6-1: Summary of Operating Alternatives (cont'd)

Round	Operating Alternative	Jones Creek Constraints	Reservoir Constraints	Herrling Island Sidechannel Constraints	Notes
Round 2 (cont'd)	JCAGen	Minimum flow of 1.2 m^3/s 1 Jan–31 May Minimum flow of 0.75 m^3/s 1 Jun–14 Sep Minimum flow of 1.1 m^3/s 15 Sep–31 Dec	–	–	• Intended to represent an operation focused on providing generous Jones Creek fish flows. • The Fish Technical Subcommittee recommended a preferred flow regime for Jones Creek anadromous fish upon considering the flow – habitat relationships for steelhead trout and chum and pink salmon. The regime is a composite of preferred flow requirements for various fish species at different times of year. • The fish water release siphon delivers 0.85 m^3/s of flow. Since for the period of 15 September to 1 June the specified minimum flow was greater than this, the Jones Lake Reservoir elevation level was maintained at the freecrest level (641.6 m) to ensure that free spill could make up the difference between the siphon flow and the specified minimum flow.
	JCAMod	Minimum flow of 0.85 m^3/s 1 Jan–31 Dec	*Avoid spills*	–	• Intended to represent an operation focused on providing moderate Jones Creek fish flows and avoid spills.
	HSC5.9	*Minimum flow of 1.2 m^3/s 1 Jan–31 Mar* *Minimum flow of 0.75 m^3/s 1 Jun–14 Sep* *Minimum flow of 1.1 m^3/s 15 Sep–31 Dec*	–	Minimum flow 5.9 m^3/s 1 Sep–31 May	• Intended to represent an operations focused on providing a relatively high and reliable base flow to Herrling Island Sidechannel. • The Fish Technical Subcommittee recommended a minimum flow of 5.9 m^3/s in Herrling Island Sidechannel representing 20% of the average flow from the turbine from 1 September to 31 May under current operations. A minimum flow through the Wahleach Generating Station during the salmon-spawning season is expected to increase fish habitat and avoid fish stranding and dewatering.

1. Entries in italics were specified as secondary constraints, to be yielded as and if required when modelling.

Table 6-1: Summary of Operating Alternatives (cont'd)

Round	Operating Alternative	Jones Creek Constraints	Reservoir Constraints	Herrling Island Sidechannel Constraints	Notes
Round 2 (cont'd)					• BC Hydro modellers were also asked to provide flows in Jones Creek. However, physical facility limitations prevent significant flows at both Jones Creek and Herrling Island Sidechannel. Although some intermittent flow through the fish water release siphon does occur in this operating alternative, the performance measures indicate that these are relatively insignificant.
	ResRec	–	Minimum elevation 638.6 m 15 May–15 Sep	*Minimum flow 5.4 m^3/s 1 Sep–31 May*	• Intended to represent an operation focused on maximizing the recreation objective and providing Herrling Island Sidechannel fish flows.
	Rec/HSC5.4	–	Minimum Elevation 638.6 m 15 May–15 Sep	Minimum flow 5.4 m^3/s 1 Sep–31 May	• Intended to represent an operation focused on maximizing the recreation objective and providing Herrling Island Sidechannel fish flows.
Round 3	SQSiphon	Minimum flow of 0.85 m^3/s 15 Sep–5 Oct	*Minimum elevation 628 m 1 Jan–31 Dec*	–	• As above in Round 2.
	SQLicence	Max diversion: $180.1*10^6$ m^3 per year	–	–	• As above in Round 2.
	PowerOnly	–	–	–	• Intended to represent an operation focused on maximizing the power generation objective.
	BOI	First available 0.4 m^3/s from Boulder Creek, 1 Jan–31 Dec	–	–	• Alternative JCAGen demonstrated the flows that could be delivered to Jones Creek to benefit fish using the current Wahleach hydroelectric facility. Some Consultative Committee members felt that while Alternative JCAGen would likely produce valuable fish benefits in Jones Creek, similar benefits could result with non-operational physical works that may minimize the impact on other interests. • Alternative BOI included a $1 million investment to reconfigure the Boulder Creek Diversion Dam to enable it to divert the first 1.4 m^3/s of flow in Boulder Creek to Jones Creek.

1. Entries in italics were specified as secondary constraints, to be yielded as and if required when modelling.

Table 6-1: Summary of Operating Alternatives (cont'd)

Round	Operating Alternative	Jones Creek Constraints	Reservoir Constraints	Herrling Island Sidechannel Constraints	Notes
Round 3 (cont'd)	JCAGen	Minimum flow of 1.2 m^3/s 1 Jan–31 May Minimum flow of 0.75 m^3/s 1 Jun–14 Sep Minimum flow of 1.1 m^3/s 15 Sep–31 Dec	–	–	• As above in Round 2.
	JCAModB	Minimum flow of 0.85 m^3/s 1 Jan–31 Dec	–	–	• Intended to represent an operation that uses the fish water release siphon to provide specific minimum flows in Jones Creek anadromous year-round. Consequently, the Jones Lake Reservoir elevation level was maintained above the siphon intake (636.5 m) year-round.
	JCAModC	Minimum flow of 0.85 m^3/s 1 Oct–28 Feb	Minimum elevation 638.6 m 15 May–15 Sep	–	• Intended to represent an operation that uses the fish water release siphon to provide specific minimum flows in Jones Creek anadromous during the winter and maximize the recreational objective in the summer.
	WinterSiphon	Minimum flow of 0.85 m^3/s 1 Sep–30 Apr	–	–	• Intended to represent an operation that uses the fish water release siphon from 1 September to 30 April. Although there is flexibility to drawdown the reservoir during the rest of the year, there is little or no benefit to power generation to drawdown the reservoir outside the constrained period. Therefore, Jones Lake Reservoir is maintained above the fish water release siphon level (636.6 m) for almost the entire year.

1. Entries in italics were specified as secondary constraints, to be yielded as and if required when modelling.

Table 6-1: Summary of Operating Alternatives (cont'd)

Round	Operating Alternative	Jones Creek Constraints	Reservoir Constraints	Herrling Island Sidechannel Constraints	Notes
Round 3 (cont'd)	RecOnly	–	Minimum elevation 638.6 m 15 May–15 Sep	*Minimum flow 5.4 m^3/s* *1 Sep–31 May*	• Intended to represent on operation that maintains the Jones Lake Reservoir elevation level 3 metres below full pool during the recreation season of Victoria Day to Labour Day. • BC Hydro modellers were also asked to attempt to provide a minimum flow in Herrling Island Sidechannel. • The Fish Technical Subcommittee recommended a flow 5.4 m^3/s representing 10% of the average Wahleach turbine flow from 1 September to 31 May under current operations. A minimum flow through the Wahleach Generating Station during the salmon-spawning season is expected to increase fish habitat and avoid fish stranding and dewatering.
	HSC5.9	*Minimum flow of 0.85 m^3/s* *1 Jan–31 Dec*		Minimum flow 5.9 m^3/s 1 Sep–31 May	• As above in Round 2.
Round 4	SQSiphon	Minimum flow of 0.85 m^3/s 15 Sep–5 Oct	*Minimum elevation 628 m* *1 Jan–31 Dec*		• As above in Round 2.
	JCAModB	Minimum flow of 0.85 m^3/s 1 Jan–31 Dec			• As above in Round 3.
	WinterSiphon	Minimum flow of 0.85 m^3/s 1 Sep–30 Apr			• As above in Round 3.
	WinterSiphonB	Minimum flow of 0.85 m^3/s 1 Mar–30 Apr 1 Sep–31 Oct			• Intended to represent an operation that uses the fish water release siphon from 1 September to 31 October and from 1 March to 30 April. • It was hypothesized that by not specifying siphon use from November to March, the reservoir drawdown would reduce the negative impacts to power generation, thereby creating a compromise between Alternatives WinterSiphon and SQSiphon.

1. Entries in italics were specified as secondary constraints, to be yielded as and if required when modelling.

Table 6-1: Summary of Operating Alternatives (cont'd)

Round	Operating Alternative	Jones Creek Constraints	Reservoir Constraints	Herrling Island Sidechannel Constraints	Notes
Round 5	WSBPump	Minimum flow of 0.85 m^3/s 1 Mar–30 Apr and 1 Sep–31 Oct (Assumes pump as delivery mechanism)	Fertilize in lieu of JCAModB operations	Herrling Island Sidechannel Operating Protocol to disrupt salmon spawning in high-risk areas and thereby improve fish values	• Intended to represent an operation that uses a pump to provide minimum flows specified in Alternative WinterSiphonB.
	AsNeeded/WSB	AsNeeded – Understood at the time to be: Minimum flow of 0.6 m^3/s 1 Jun–15 Aug Minimum flow of 1.1 m^3/s 15 Sep–1 Dec Minimum flow of 1.2 m^3/s 1 Jan–31 May (Assumes pump as delivery mechanism)	Mimic reservoir profile of WinterSiphonB Fertilize in lieu of JCAModB operations	Herrling Island Sidechannel Operating Protocol	• Intended to represent an operation that is a variation on Jones Creek and Jones Lake Reservoir trade-off. • At the time of development, modelling was not available for this alternative so it was assumed that Jones Lake Reservoir elevation levels were similar to previous operating alternatives.
	MinElevation	AsNeeded – Understood at the time to be: Minimum flow of 0.6 m^3/s 1 Jun–15 Aug Minimum flow of 1.1 m^3/s 15 Sep–1 Dec Minimum flow of 1.2 m^3/s 1 Jan–31 May (Assumes pump as delivery mechanism)	*Minimum elevation 628 m 1 Jan–31 Dec* Fertilize in lieu of JCAModB operations	Herrling Island Sidechannel Operating Protocol	• Intended to represent an operation that is a variation on Jones Creek and Jones Lake Reservoir trade-off. • At the time of development, modelling was not available for this alternative so it was assumed that Jones Lake Reservoir elevation levels were similar to previous operating alternatives.

1. Entries in italics were specified as secondary constraints, to be yielded as and if required when modelling.

Table 6-1: Summary of Operating Alternatives (cont'd)

Round	Operating Alternative	Jones Creek Constraints	Reservoir Constraints	Herrling Island Sidechannel Constraints	Notes
Round 5 (cont'd)	AsNeeded	AsNeeded – Understood at the time to be: Minimum flow of 0.6 m^3/s 1 Jun–15 Aug Minimum flow of 1.1 m^3/s 15 Sep–1 Dec Minimum flow of 1.2 m^3/s 1 Jan–31 May (Assumes pump as delivery mechanism)	Fertilize in lieu of JCAModB operations	Herrling Island Sidechannel Operating Protocol	• Intended to represent an operation that is a variation on Jones Creek and Jones Lake Reservoir trade-off.
	WS/Fert	Minimum flow of 0.85 m^3/s 1 Sep–30 Apr (Assumes siphon as delivery mechanism)	Fertilize in lieu of JCAModB operations	Herrling Island Sidechannel Operating Protocol	• Intended to represent an operation that is a variation on Jones Creek and Jones Lake Reservoir trade-off. • At the time of development, modelling was not available for this alternatives so it was assumed that Jones Lake Reservoir elevation levels were similar to previous operating alternatives.
	Spawning C	Minimum flow of 0.85 m^3/s, Six weeks around September/October (Assumes siphon as delivery mechanism) Construct spawning channel	*Minimum elevation 628 m 1 Jan–31 Dec*	Herrling Island Sidechannel Operating Protocol	• Intended to represent an operation that uses the fish water release siphon to provide minimum flows to the Jones Creek spawning channel.

1. Entries in italics were specified as secondary constraints, to be yielded as and if required when modelling.

Table 6-1: Summary of Operating Alternatives (cont'd)

Round	Operating Alternative	Jones Creek Constraints	Reservoir Constraints	Herrling Island Sidechannel Constraints	Notes
Round 6	SalmonSIR628 Pump	Salmon SIR flows: Minimum flow of 1.1 m^3/s 15 Sep–30 Nov Minimum flow of 0.6 m^3/s all other times (Assumes pump as delivery mechanism) Fish habitat enhancement project, rebuild in event of damage	Minimum elevation 628 m Fertilize in lieu of JCAModB operations	Herrling Island Sidechannel Operating Protocol	• Intended to represent an operation that uses a pump to provide salmon spawning, incubation, and rearing flows.
	SalmonSIR631 Pump	Salmon SIR flows: Minimum flow of 1.1 m^3/s 15 Sep–30 Nov Minimum flow of 0.6 m^3/s all other times (Assumes pump as delivery mechanism) Fish habitat enhancement project, rebuild in event of damage	Minimum elevation 631 m Fertilize in lieu of JCAModB operations	Herrling Island Sidechannel Operating Protocol	• Intended to represent an operation that uses a pump to provide salmon spawning, incubation, and rearing flows.

1. Entries in italics were specified as secondary constraints, to be yielded as and if required when modelling.

Table 6-1: Summary of Operating Alternatives (cont'd)

Round	Operating Alternative	Jones Creek Constraints	Reservoir Constraints	Herrling Island Sidechannel Constraints	Notes
Round 6 (cont'd)	SalmonSIR628 BCD+Siphon	Salmon SIR flows: Minimum flow of 1.1 m^3/s 15 Sep–30 Nov Minimum flow of 0.6 m^3/s all other times (Assumes Boulder Creek Diversion Dam and fish water release siphon as delivery mechanism) Fish habitat enhancement project, rebuild in event of damage	Minimum elevation 628 m Fertilize in lieu of JCAModB operations	Herrling Island Sidechannel Operating Protocol	• Intended to represent an operation that uses a pump to provide salmon spawning, incubation, and rearing flows.
	SalmonSIR631 BCD+Siphon	Salmon SIR flows: Minimum flow of 1.1 m^3/s 15 Sep–30 Nov Minimum flow of 0.6 m^3/s all other times (Assumes Boulder Creek Diversion Dam and fish water release siphon as delivery mechanism) Fish habitat enhancement project, rebuild in event of damage	Minimum elevation 631 m Fertilize in lieu of JCAModB operations	Herrling Island Sidechannel Operating Protocol	• Intended to represent an operation that uses a pump to provide salmon spawning, incubation, and rearing flows.

1. Entries in italics were specified as secondary constraints, to be yielded as and if required when modelling.

6.3.2 Fish Flow Releases into Jones Creek

Prior to the destruction of the Jones Creek spawning channel in 1995, for six weeks every other year in September or October, BC Hydro provided a flow of 0.85 m^3/s to the creek via the fish release siphon. After the destruction of the spawning channel, BC Hydro, in consultation with Fisheries and Oceans Canada, assessed the need to augment the Jones Creek flows via the fish water release siphon in odd numbered years. Additionally, in years that BC Hydro requested a variance to their licence, the Comptroller of Water Rights required BC Hydro to release fish flows into Jones Creek.

Table 6-2 summarizes the actual flow releases into Jones Creek from 1995 to 2002. The variability in flow releases presented a challenge to BC Hydro modellers, as the Operations Model assumes all operational constraints are constant from year to year. Consequently, different minimum flows were specified in the two current operations alternatives.

Table 6-2: Actual Flow Releases into Jones Creek 1995 to 2002

Year	Siphon Flow Start Date	Siphon Flow Stop Date	Total Days of Flow
1995	25 September	12 October	18
1996	–	–	–
1997	3 June	25 July	53
1997	29 September	7 October	5
1997	10 October	31 December	83
1998	1 January	29 January	29
1999	1 August	27 September	58
1999	9 October	31 December	84
2000	1 January	15 January	15
2001	22 September	23 October	32
2002	27 September	7 November	42

6.3.3 Maintenance Outages

For each Wahleach operating alternative, BC Hydro modellers assumed one month of zero flow through the Wahleach Generating Station each year to represent planned maintenance outages. In Rounds 1 and 2 operating alternatives, the outage period was placed in early summer, as is the current practice, given that the high Fraser River elevation level at this time of year means the Wahleach Generating Station cannot be operated. However, it was hypothesized that this practice could be problematic for a number of operating alternatives. Having a month of forced zero flow during the freshet is appropriate if there has been a deep reservoir drawdown during the winter. When there is no such drawdown, this outage timing leads to major spills during the freshet, negatively impacting power generation. This is not how BC Hydro would operate the Wahleach hydroelectric facility under these conditions. Therefore, the Consultative Committee expressed an interest in moving the zero flow period to a more suitable time of year.

For Alternatives JCAModB, JCAModC and WinterSiphon, the one-month maintenance outage was modelled at different times of year. These variations were developed by the BC Hydro modellers in order to ascertain the range of power generation values associated with these operating alternatives. Subsequent analysis of the performance measures indicated minor differences across the variations of each operating alternative, thus confirming that the issue was insignificant.

6.4 Iterations of Operating Alternatives

Rounds 1 and 2: Rounds 1 and 2 operating alternatives allowed the Consultative Committee to explore the major trade-offs inherent in the Wahleach hydroelectric facility. These operating alternatives were created concurrently with a number of performance measures. As a result, some Round 1 or Round 2 operating alternatives were re-specified.

Round 3: As specified in the *Water Use Plan Guidelines*, the water use planning process is intended to address issues related to the operation of facilities as they currently exist, and incremental changes to operations to accommodate other water uses. As per the *Creating Water Use Plan Alternatives* information sheet, physical works such as changes to facility structures are excluded, except to the extent that they may provide a preferred alternative, in lieu of changes in water flows or reservoir elevation levels, which is both technically feasible and cost effective. A Water Use Plan may also combine changes in physical works with changes in flows and reservoir elevation levels.

Early in the Wahleach water use planning process, prior to developing Round 3 operating alternatives, the Consultative Committee considered a number of non-operational physical works intended to improve fish habitat in Jones Creek.

Table 6-3 summarizes a number of non-operational physical works to the Wahleach hydroelectric facility to provide flows to Jones Creek anadromous and how each option was addressed. The options that the Consultative Committee viewed as potentially viable were selected for more in-depth study and analysis. In some cases, a conceptual design was undertaken to develop preliminary cost estimates. Most of the non-operational physical works discussed in Round 3 operating alternatives were rejected due to excessive costs, safety issues or lack of expected benefits.

Round 4: Alternatives SQSiphon, JCAModB and WinterSiphon from Round 3 were carried forward into Round 4. Alternative WinterSiphonB was created by combining elements of Alternatives SQSiphon and WinterSiphon.

Rounds 5 and 6: Rounds 5 and 6 operating alternatives incorporated a number of non-operational physical works including a Jones Lake Reservoir fertilization program, a Jones Creek spawning channel, a Jones Creek fish habitat enhancement project, Boulder Creek Diversion Dam reconfiguration, and a Wahleach Dam pump. All Round 5 and 6 operating alternatives included an Operating Protocol designed to prevent fish stranding in Herrling Island Sidechannel.

Table 6-3: Non-operational Physical Works

Option	Description	Consultative Committee Decision
1. Remove Boulder Creek Diversion Dam, operate with siphon	This option would involve the use of mechanical equipment to physically remove the Boulder Creek Diversion Dam, permitting all water in Boulder Creek to flow directly into Jones Creek at a confluence below Wahleach Dam.	Rejected on the basis of negative annual revenue impacts.
2. Reconstruct Boulder Creek Diversion Dam to divert flows from Boulder Creek into Jones Creek even at low flow conditions	This option would not require an enlargement of the diversion conduit. Thus less than 100% of the flow would be diverted under high flow conditions.	Developed into Alternative BOI, and further refined in Round 6 operating alternatives.
3. Reconstruct Boulder Creek Diversion Dam to divert all inflows from Boulder Creek into Jones Creek with full control of flow	The discussion related to Option 1 above would apply to this option. The diversion of all inflows from Boulder Creek into Jones Creek would require a larger than currently exists energy dissipation structure at the confluence of Boulder Creek and Jones Creek. This is required because the area downstream of the spillway would be readily eroded by the large flows. The banks of the old Boulder Creek would have to be armoured to prevent the creek from overflowing its banks and damaging the dam, road, campground or spillway.	Rejected on the basis that flows in excess of those described in Option 2 are not required.
4. Construct Low Level Outlet through Wahleach Dam	A Low Level Outlet through Wahleach Dam could provide flows from Jones Lake Reservoir to Jones Creek at any operating level. Constructing this type of structure at the Wahleach Dam has several technical concerns.	Rejected on the basis of safety and cost concerns.

Table 6-3: Non-operational Physical Works (cont'd)

Option	Description	Consultative Committee Decision
4. Construct Low Level Outlet through Wahleach Dam (cont'd)	Wahleach Dam is not built on bedrock and therefore, has material downstream of and under the dam that is subject to erosion. As a result, there would have to be an energy dissipation and training structure at the outlet. For a 5 foot diameter outlet, this structure would have to be fairly large. Wahleach Dam is an earthfill dam and therefore, is subject to erosion. Standard design practice is to not incorporate any horizontal passages through an earthfill dam. Also, it is not standard practice to install them after construction of a dam. There are likely to be significant safety concerns associated with this option.	
5. and 6. Provide flows to the fish spawning channel by diverting water from the Fraser River upstream of Laidlaw or from Lorenzetta Creek	These options assume that flows could be provided to the fish spawning channel via 5 km of buried plastic pipeline and a buried perforated intake pipe in the bed of the Fraser River or Lorenzetta Creek using an Armco type of control gate.	Rejected on the basis that water chemistry differences would be harmful to fish, and that there would be negative impacts to these two areas.
7. Provide water from other sources, such as ground water wells	A number of water wells exist that could possibly be used to provide flows to lower Jones Creek anadromous.	Rejected on the basis that water chemistry differences would be harmful to fish and concerns about reliability of pumps.
8. Restore the fish spawning channel, or rebuild in another location to withstand a debris torrent to provide flows via Jones Creek	This option was addressed by Mike Miles in his report, but the Consultative Committee expressed an interest in hearing other opinions given the keen interest in this issue.	Bruce Usher (MWLAP) and Matt Foy (F & O) agreed with Miles that at this time there are no practical circumstances under which a successful Jones Creek-fed fish spawning channel could be constructed. Matt Foy noted that while a large deflection berm may possibly divert debris away from the channel, other water quality issues will severely reduce the viability of a spawning channel in that location. The Consultative Committee later considered the possibility of an 'ephemeral' spawning channel.

Table 6-3: Non-operational Physical Works (cont'd)

Option	Description	Consultative Committee Decision
9. Restore natural channel	Recommended in Hartman and Miles (1997) report, includes removal of downstream weirs initially installed to restrict spawning access to the spawning channel prior to 1995, and riparian enhancement through a planting program. Also requires modified stream banks (nhc, 1996) be set back to allow channel forming flows opportunity to reshape and re-align the channel to a more natural sinuosity and shape. There is a requirement to maintain the natural shape of the channel following events of sediment and debris deposition in the channel.	Addressed in the Fisheries and Oceans Canada and BC Hydro Agreement (Sneep, 2002).
10. Stabilize the watershed area	In his report Mike Miles emphasized the importance of allowing the watershed to stabilize before undertaking significant works of any kind in Jones Creek anadromous. Mike also emphasized the disproportionate costs involved in restoring the watershed as opposed to allowing nature to stabilize the area over a period he approximated to be 50 years or so.	Outside scope of the Wahleach Water Use Plan.
11. Groundwater Channel (no pumping)	A single, separate groundwater channel may be a viable option in creating fish habitat enhancement in Jones Creek anadromous, given that groundwater recharge rates can support in excess of 0.57 m^3/s (20 cfs) pumping for the pink spawning season. Costs are in excess of $100,000, but maintenance may be minimal.	Not considered a viable option.

7 TRADE-OFF ANALYSIS

In Step 7 of the Wahleach water use planning process, the Consultative Committee examined the trade-offs associated with the operating alternatives described in Section 6. The operating alternatives varied in the benefits they provided. Natural rates of inflow and Jones Lake Reservoir storage capacity impose limits on how much water is available to satisfy the range of water use objectives. Necessarily, there are trade-offs on what can be achieved with a finite supply of water. For instance, maintaining high flows for fish habitat in Jones Creek means under some conditions there may be less water available for power generation or for supporting a large, productive littoral zone in Jones Lake Reservoir. The trade-off process involved discussions of the relative value among water use objectives: gaining more of some values in exchange for less of others.

The Consultative Committee sought the operating alternative that best balanced the range of water use objectives specified in Section 4. This section documents the trade-off process and values that Consultative Committee members placed on different water use objectives.

The Consultative Committee used the performance measure values to compare the operating alternatives. Selection of the preferred operating alternatives involved the following steps:

1. Assess trade-offs among operating alternatives with reference to the performance measures.
2. Eliminate performance measures that do not vary across operating alternatives.
3. Eliminate operating alternatives that the Consultative Committee agrees are “dominated” by other operating alternatives. A fully dominated operating alternative is inferior in every respect to another single operating alternative. A practically dominated operating alternative is inferior in enough respects to another single operating alternative as to warrant the rejection of that operating alternative.
4. If possible, combine elements of operating alternatives to design better operating alternatives and repeat.
5. Assess degree of Consultative Committee consensus on remaining operating alternatives.

7.1 Round 1 and Round 2 Trade-offs

Details of the Round 1 and 2 trade-offs are not provided in this report. The following section highlights a number of trade-offs that helped the Consultative Committee specify subsequent operating alternatives for the Wahleach hydroelectric facility.

- **Fish in Jones Creek/Jones Lake Reservoir versus Power Generation:** Providing flows for fish in Jones Creek requires that the elevation level of Jones Lake Reservoir be held above 636.5 m for the fish water release siphon to function, or be above full pool at 641.6 m for free spilling. In order to gain fish benefits in Jones Creek and Jones Lake Reservoir, there is a negative impact on power generation resulting from having to forego winter drawdown of the reservoir.

- **Fish in Jones Creek/Jones Lake Reservoir versus fish in Herrling Island Sidechannel:** Providing flows for fish in Jones Creek via the fish water release siphon and maintaining a high and stable Jones Lake Reservoir elevation level results in limited flexibility to provide minimum flows for fish in Herrling Island Sidechannel. Given the primary species of interest is salmonids for both Jones Creek and Herrling Island Sidechannel, the timing of flows to benefit fish in each area is the same. Therefore, any operating alternative could provide flows either for Jones Creek and Jones Lake Reservoir fish or Herrling Island Sidechannel fish at any given time, but could not do both simultaneously.

Given that Jones Lake Reservoir objectives could potentially be mitigated through other operations or physical works, the key trade-off is providing flows for either Jones Creek or Herrling Island Sidechannel. Key factors that were balanced in considering the trade-off between Jones Creek fish and Herrling Island Sidechannel fish are summarized below. Throughout the Wahleach water use planning process, the Consultative Committee dedicated considerable effort to identifying and clarifying the extent of each factor to enable a fully informed decision.

1. **The potential of operating alternatives to positively impact Jones Creek fish population and fish habitat versus Herrling Island Sidechannel fish population and fish habitat.**

   Providing specific flows in Jones Creek results in a large positive impact to a small fish population and area of fish habitat. Providing equivalent flows in Herrling Island Sidechannel results in a small positive impact to a large number fish population and area of fish habitat. Flow modifications to the Herrling Island Sidechannel were thought to make a prime fish habitat area somewhat better. Nonetheless, some Consultative Committee members expressed concern for the long-term survival of Jones Creek fish without supplemental flows.

2. **The relative magnitude and quality of Jones Creek fish habitat versus Herrling Island Sidechannel fish habitat.**

   The Herrling Island Sidechannel fish habitat affected by Wahleach hydroelectric operations is both larger and of better quality compared to Jones Creek fish habitat. Small modifications to operations or habitat physical works in Herrling Island Sidechannel are likely to have greater positive impact on fish populations than could be made via operations to Jones Creek.

3. **The relative historical and cultural contexts of Jones Creek fish habitat versus Herrling Island Sidechannel fish habitat.**

   Throughout the Wahleach water use planning process, the importance of finding the best balance of interests based on current facilities was emphasized. However, the Consultative Committee considered the history of activities in the watershed to be an important factor in balancing the impacts of operating alternatives on fish and other interests. Jones Creek and Jones Lake Reservoir have been negatively impacted by historical, non-operational activities such as dam construction and watershed instability resulting from poor logging practices. By contrast, Herrling Island Sidechannel has generally benefited from increased flows from the Wahleach Generating Station. It was hypothesized that benefits to Herrling Island Sidechannel included a net increase in the fish populations and the variety of fish species.

   The Consultative Committee acknowledged that providing flows in Herrling Island Sidechannel versus Jones Creek was the most effective means of increasing fish populations in the Wahleach system. However, some Consultative Committee members expressed an interest in providing adequate flows to Jones Creek anadromous in recognition of the historically productive and natural habitat that previously existed for a variety of fish species.

7.1.1 Providing Jones Creek Flows

Rounds 1 and 2 operating alternatives highlight a number of trade-offs within the Wahleach system resulting from the physical infrastructure's capabilities to provide flows to Jones Creek and Herrling Island Sidechannel. The Wahleach hydroelectric facility is capable of providing flow releases to Jones Creek by the fish water release siphon, the Boulder Creek Diversion Dam, and by free spilling.

Given the limited capability of the Wahleach hydroelectric facility to provide flows in Jones Creek, early in development of the operating alternatives the Consultative Committee was interested in evaluating non-operational physical works in lieu of operations.

7.1.1.1 Fish Water Release Siphon

The Wahleach Dam fish water release siphon discharges a maximum of 0.85 m^3/s. The Jones Lake Reservoir elevation level must be above 637.6 m to prime the siphon. The siphon may deprime at elevation level 636.4 m.

Figure 7-1 illustrates the Jones Lake Reservoir hydrograph for Alternative SQSiphon.

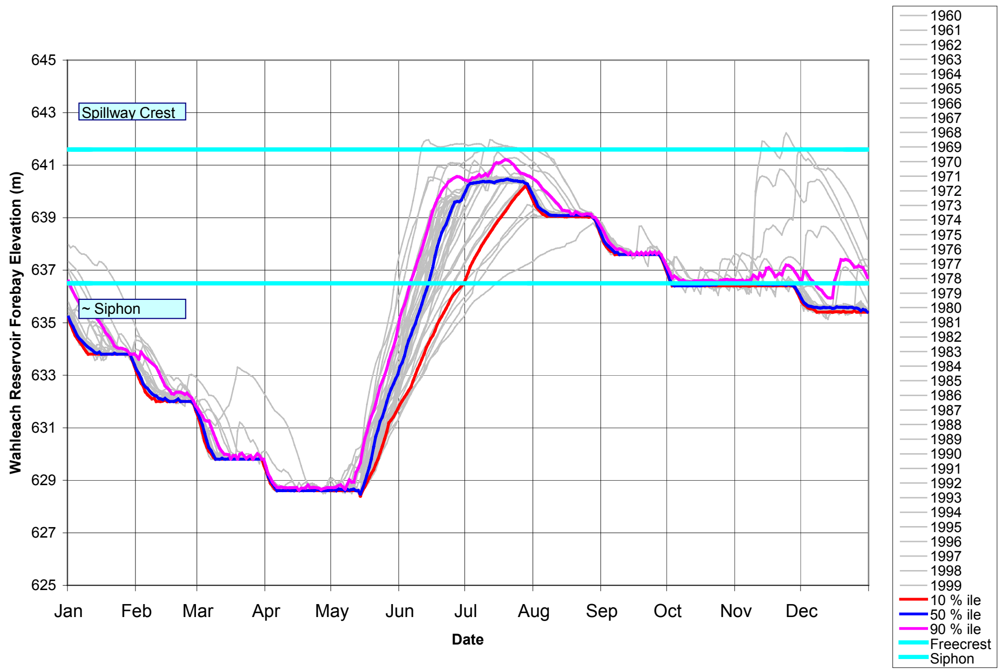

Figure 7-1: Jones Lake Reservoir Hydrograph for Alternative SQSiphon

Alternative SQSiphon, most closely resembles actual current operations. The dark blue line is a hypothetical "median year" for this alternative, and is a composite of all the median elevation values for each day of the year under the constraints detailed above. The magenta and red lines are 90th and 10th percentile elevation values that illustrate the variability in inflows. Each grey line represents modelled operations for actual specific years of inflow data.

Alternative SQSiphon specifies a three week annual flow release into Jones Creek. In order to release water into Jones Creek via the fish water release siphon, the Jones Lake Reservoir elevation level must be above the siphon elevation. For modelling purposes, the siphon is assumed to be available at the reservoir elevation of 636.5 m. Therefore, for Alternative SQSiphon, use of the siphon is only possible from June to October.

Figure 7-2 illustrates the Jones Lake Reservoir hydrograph for Alternative WinterSiphon.

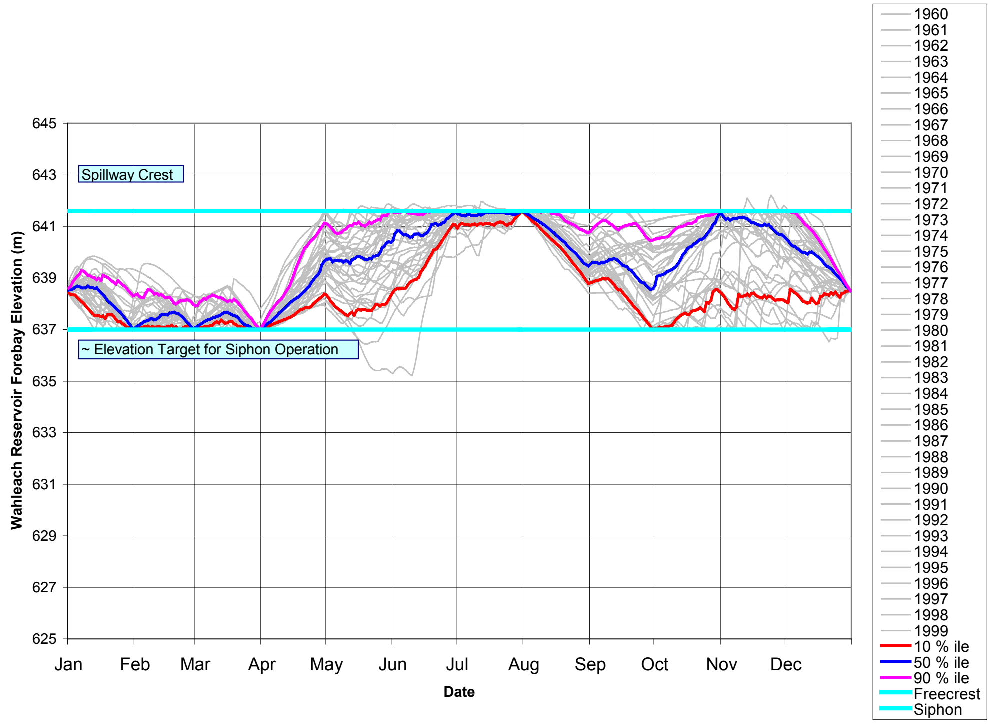

Figure 7-2: Jones Lake Reservoir Hydrograph for Alternative WinterSiphon

Alternative WinterSiphon specifies a minimum flow of 0.85 m^3/s in Jones Creek from 1 September to 30 April. Since the fish water release siphon is the only means of delivering this flow other than spilling, the Jones Lake Reservoir elevation level must be maintained above the siphon elevation during this period. To maintain siphon operation for the long duration, the target reservoir elevation during this peak period is set at 637 m as opposed to 636.5 m to provide a buffer.

The two examples above illustrate how a specified flow in Jones Creek impacts Jones Lake Reservoir and power generation.

7.1.1.2 Boulder Creek Diversion Dam

The primary function of the Boulder Creek Diversion Dam is to divert water from Boulder Creek to Jones Lake Reservoir. A fish release bypass within the diversion is capable of providing up to 1.4 m^3/s of Boulder Creek flow to Jones Creek.

In the years immediately following its construction in the 1950s, the earth around the intake to the Boulder Creek Diversion Dam release bypass eroded. As a result, the full flow of water through the fish release bypass can only be achieved at high flow periods in Boulder Creek. At low flow periods, water from Boulder Creek passes beneath the intake of the fish release bypass, and is almost entirely diverted to Jones Lake Reservoir. However, it is at low flow periods from August through to May when water is most required by fish in Jones Creek. Even at high flows, relatively minor volumes of water are diverted[1].

When this Boulder Creek Diversion Dam malfunction was identified in the 1950s, it is thought that BC Hydro engineers concluded that satisfactorily repairing and preventing future erosion would be difficult, and instead installed the fish water release siphon over the Wahleach Dam to provide flows to the Jones Creek spawning channel.

7.1.1.3 Free Spills

Due to the lack of functionality of the Boulder Creek Diversion Dam fish release bypass in low flow periods, the only operational means of providing flows into Jones Creek in excess of 0.85 m^3/s via the fish water release siphon is by free spilling.

The Wahleach Dam has a spillway with a freecrest elevation of 641.6 m. Therefore, in order to provide flows into Jones Creek via free spilling, the Jones Lake Reservoir elevation level must be maintained above the freecrest elevation of 641.6 m.

Figure 7-3 illustrates the Jones Lake Reservoir hydrograph for Alternative JCAGen.

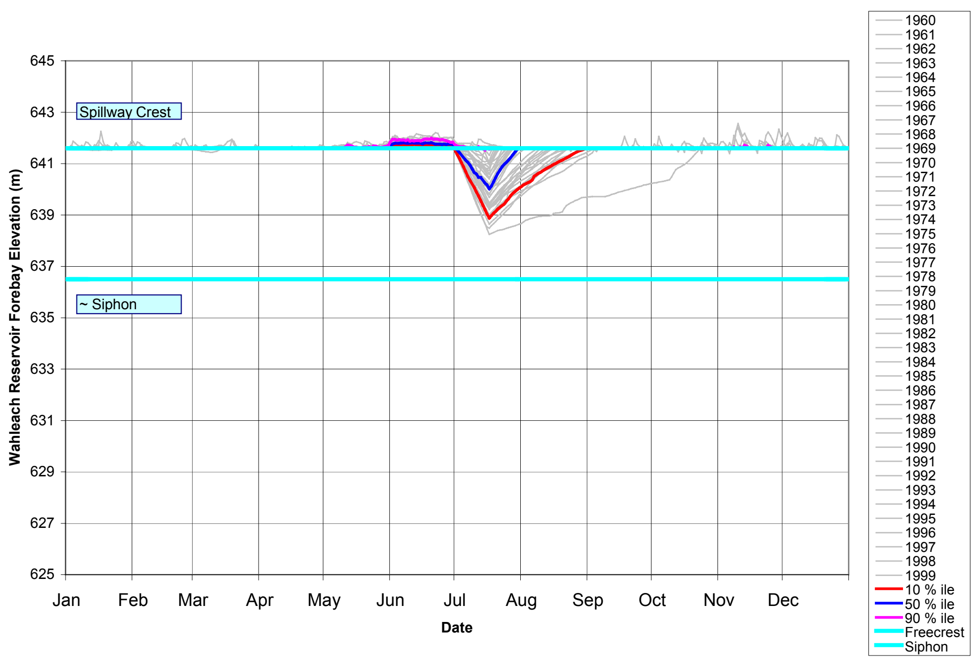

Figure 7-3: Jones Lake Reservoir Hydrograph Alternative JCAGen

[1] Current flow rates were estimated and a stage-discharge curve estimated after consideration of the present state of the inlet to the bypass.

Alternative JCAGen specifies minimum flows in Jones Creek of 1.2 m^3/s from 1 January to 31 May; 0.75 m^3/s from 1 June to 14 September; and 1.1 m^3/s from 15 September to 31 December. In Alternative JCAGen, from 15 September to 31 May, the specified minimum flow in Jones Creek is in excess of the 0.85 m^3/s deliverable by the fish water release siphon and by the Boulder Creek Diversion Dam fish release bypass. In order to provide the flows above 0.85 m^3/s, the Jones Lake Reservoir elevation level must be maintained at the freecrest elevation of 641.6 m to allow free spills, thus having a negative impact on power generation.

Alternative JCAGen illustrates how a specified flow in Jones Creek impacts Jones Lake Reservoir and power generation.

7.1.2 Providing Herrling Island Sidechannel Flows

During the Wahleach water use planning process, the Consultative Committee had limited information on the extent of operational impacts to Herrling Island Sidechannel fish. The Fish Technical Subcommittee hypothesized that the peaking nature of the Wahleach Generating Station may be detrimental to fish by creating habitat in the tailrace of the generator during peak generation periods, then reducing or eliminating that habitat during off peak generation periods. This irregular flow pattern could potentially be detrimental to fish throughout their lifecycle, although during the spawning period, fish would be particularly vulnerable to the hazards of dewatering, inundation and stranding.

Early in the Wahleach water use planning process, it was hypothesized that a regular, base flow would not only reduce dewatering, inundation and fish stranding, but could also increase fish habitat. Therefore, a number of operating alternatives were developed that included a base flow for the period of low Fraser River levels from September to May. Outside this time period, it was agreed that Wahleach hydroelectric operations would have an insignificant effect on Herrling Island Sidechannel fish given the much larger influence of the Fraser River.

7.2 Understanding the Modelling Results

During Round 3 trade-offs, modelling results were presented to the Consultative Committee in a variety of ways. These included hydrographs illustrating the hydrological behaviour of Jones Lake Reservoir, fish water release siphon flow into Jones Creek, spills into Jones Creek, flows at Laidlaw and discharges into Herrling Island Sidechannel.

Consequence tables were used to illustrate the impact of each operating alternative on objectives and performance measures.

Table 7-1 illustrates a sample consequence table.

Table 7-1: Sample Consequence Table

Objective	Performance Measure	Units	What's Good	Minimum Significant Increment of Change	Alternatives	
					SQSiphon	SQLicence
Recreation						
	Recreation Quality	Days	More	5%	71	112
	Spill Safety Risks	Days	Less	5%	0	19

In the first column, Recreation is the "ends" objective. In the second column, Recreation Quality and Spill Safety Risks are the performance measures. In the third column, days are the unit of measure. In the fourth column, "what's good" is the direction of preferred change. For Recreation Quality, more is good, but for Spill Safety Risks, less is good. In the fifth column, 5 per cent is the Minimum Significant Increment of Change.

Subsequent columns show that for Alternative SQSiphon, the median performance measure value for Recreation Quality is 71 days and for Alternative SQLicence, the median value for Recreation Quality is 112 days.

Figure 7-4 illustrates the range of the Recreation Quality performance measure values, represented by the bold line, due to annual variations in inflows. Comprehensive consequence tables were also used to show median, 10th percentile and 90th percentile values for performance measures based on 40 years on inflow data. For example, Alternative SQSiphon scored 71 days in the median year, 79 days in the 90th percentile year (i.e., one year in ten) and 48 days in the 10th percentile year (i.e., one year in ten).

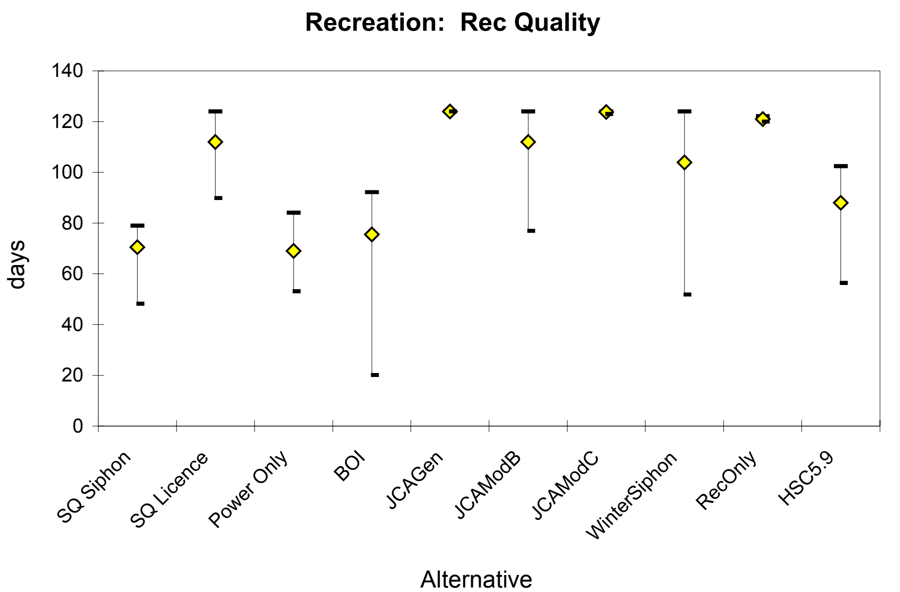

Figure 7-4: Recreation Quality Performance Measure Box Plot

7.3 Uncertainties and Limitations

There are a number of uncertainties and limitations associated with the quality of information used during Step 6 – Creating Alternatives and Step 7 – Trade-off Analysis.

- **Inflow data quality:** The Operations Model uses 40 years of historical inflow data input for the Jones Lake Reservoir.
- **Inflow variation:** There is significant variation in the 40 years of historical inflow data for Jones Lake Reservoir. Performance measures behave differently when inflows are high compared to when they are relatively low. From Round 3 onwards, performance measures for the operating alternatives were presented for the highest 90th percentile, the lowest 10th percentile, and the average median value.
- **Model configuration accuracy:** During the Wahleach water use planning process, an Operations Model called A Mathematical Programming Language (AMPL) was used to model to the operating alternatives.

  The AMPL is configured to meet the constraints specified in an operating alternative. Subsequent to meeting the specified constraints, the operating alternative will be optimized for power generation. In some instances, several iterations of modelling are required for an operating alternative.
- **Operating alternative specification ambiguity:** Operating alternatives were specified in terms of hard or soft constraints (e.g., minimum flows and minimum elevations). The Operations Model must meet a hard constraint. Soft constraints are desirable, but can be relaxed should other impacts become excessive in the opinion of BC Hydro modellers. Consequently, several operating alternatives were remodelled during the initial rounds of trade-offs.
- **Performance measure relationship to objectives:** Most performance measures are not direct measures of the ends objective. For example, the number of Recreation Quality days can be extracted from modelling data. However, the number of days does not indicate how or to what degree recreation quality will improve.
- **Minimum significant increment of change:** Given the combined uncertainties listed above, beginning in Round 3 trade-offs, the Minimum Significant Increment of Change (MSIC) for each performance measure was presented. (Refer to Appendix G: Calculating the Least Significant Difference Between Performance Measures.)

The MSIC indicates the degree of significance to be attributed to the difference between two performance measure values. Any two operating alternatives with a difference in performance measure values that falls within the MSIC may be considered less significant than those differences that are larger than the MSIC.

For example, in Table 7-1, the MSIC for Recreation Quality is 5%. The difference between the Recreation Quality performance measure for Alternative SQSiphon and Alternative SQLicence is (100-(71 days/112 days*100) = 37%. Given this difference is greater than the 5% MSIC, the two operating alternatives may perform differently for Recreation Quality. However, if the Recreation Quality performance measure for SQLicence was 74 days, then 100-(71 days/ 74 days)*100 = 4%. Given this difference is less than the 5% MSIC, two operating alternatives may perform similarly for Recreation Quality.

Given the complex nature of the fish performance measures, the Fish Technical Subcommittee recommended a general MSIC of 20% for all the fish performance measures. The Fish Technical Subcommittee members also stated that they reserved the right to rely on professional judgment with respect to the significance between different operating alternatives.

7.4 Round 3 Trade-offs

Table 7-2 summarizes the consequence table for Round 3 trade-offs. Alternatives SQSiphon, SQLicence, PowerOnly and BOI are power focused. Alternative JCAGen, JCAModB, JCAModC, and WinterSiphon specify minimum flows for Jones Creek fish and minimum Jones Lake Reservoir elevation levels to benefit fish and recreation. Alternatives RecOnly and HSC5.9 provide minimum flows to Herrling Island Sidechannel to benefit fish.

The following is a summary of the key Round 3 trade-offs:

- Of the two current operations alternatives, Alternative SQLicence performs better than Alternative SQSiphon for Recreation Quality (112 days versus 71 days) and Reservoir Fish Index (44 points versus 8 points).

  Alternative SQSiphon performs better than Alternative SQLicence for Jones Creek Anadromous Fish Index (25 points versus 21 points) and Spill Safety Risk (0 days versus 19 days) and Annual Revenue ($14.7 million versus $13.5 million).

- The operating alternatives do not show significant differences in Herrling Island Sidechannel performance measures, with two exceptions. Alternative HSC5.9 provides a minimum flow for Herrling Island Sidechannel to avoid habitat variation associated with peaking operations. As a result, Alternative HSC5.9 provides 7000 m^2 Cumulative Habitat Variability, versus over one million m^2 Cumulative Habitat Variability for most other operating alternatives. Alternative RecOnly performs similarly to Alternative HSC5.9 for Herrling Island Sidechannel fish resulting from the 5.4 m^3/s minimum flow.

- Alternative HSC5.9 also performs better for Jones Creek Anadromous Effective Rearing and Spawning Habitat with improvements of approximately 8 to 24 per cent over Alternatives SQSiphon, SQLicence, PowerOnly, BOI, JCAGen, JCAModB, JCAModC, and WinterSiphon. However, most of this improvement is within the MSIC for these performance measures.

- Although not illustrated in Table 7-2, Herrling Island Sidechannel performance measures show a large range of variation within the 10^{th} and 90^{th} percentiles. For the Effective Rearing performance measure, this range is approximately 2000 m^2 to 20 000 m^2 for Alternatives SQSiphon, SQLicence, PowerOnly, BOI, JCAGen, JCAModB, JCAModC, and WinterSiphon. The median value of Effective Rearing is generally consistent across the above mentioned operating alternatives. Even for Alternatives RecOnly and HSC5.9, which provide minimum flows to Herrling Island Sidechannel, the inter-percentile range is very large. Therefore, operational changes are not thought to be a major factor in determining the fish habitat characteristics of Herrling Island Sidechannel.

- Alternatives JCAGen and BOI provide minimum flows of twenty per cent of Mean Annual Discharge (MAD) in Jones Creek non-anadromous for a significant portion of the year. Twenty per cent of MAD is considered to be the minimum required for rearing fish. Alternatives JCAGen and JCAModB, ensure a ten per cent of MAD in Jones Creek non-anadromous throughout the year. Alternative BOI does not sustain this flow for 17 days in the median year.

- Impacts on Jones Lake Reservoir vary considerably across operating alternatives. Alternatives JCAGen, JCAModB and WinterSiphon, improve the Littoral Zone by at least 80 000 m^2 in annual cumulative littoral productivity in the median year. Alternatives SQSiphon, PowerOnly, BOI and HSC 5.9 provide less than 3000 m^2 in annual cumulative littoral area.

- Alternative SQSiphon performs worst for Recreation Quality. Alternatives SQLicence, JCAGen, JCAModB, JCAModC and RecOnly maintain Jones Lake Reservoir elevation levels in the preferred range throughout the summer recreation period.

- Operating alternatives that maintain high Jones Lake Reservoir elevation levels performed better for the Wildlife Index given the weighting towards wetted areas. Alternatives SQSiphon, PowerOnly and BOI perform worst for the Wildlife Index.

- According to the performance measures, there are no operating alternatives modelled that threaten to flood Laidlaw in isolation of other circumstances. However, operating alternatives other than Alternatives PowerOnly and SQSiphon may lead to an average of one day per year in which a release is made to Jones Creek at a time that coincides with very high Fraser River levels. This event has been defined as a Red Flag Index event. If high Fraser River levels are already flooding property, releases from the Wahleach hydroelectric facility will exacerbate the problem.

- The GHG Emissions performance measure is negatively correlated to the Power Generation and Annual Revenue performance measures. Alternative JCAGen performs the worst for GHG Emissions with 27 kilotonnes of CO_2e per year relative to Alternative SQLicence.

- Annual Revenue ranges from $8.0 million for Alternative JCAGen to $14.7 million for Alternatives SQSiphon and PowerOnly. Alternative JCAGen results in $8 million Annual Revenue despite being at freecrest elevation for most of the year by opportunistically generating the portion of inflows that are in excess of the flows specified for Jones Creek. Alternative SQSiphon results in slightly less Annual Revenue than Alternative PowerOnly, although the difference is within the MSIC.

7.4.1 Trade-off Analysis Techniques

Two analytical techniques were used to help the Consultative Committee members understand how each operating alternative performed at meeting their own and others' values as represented in the performance measures. These two techniques were intended to be complementary and to generate discussion. The direct ranking technique relies on high-level judgment. The swing weighting technique breaks the problem down into interest-by-interest level judgments.

7.4.1.1 Direct Ranking

For the direct ranking technique, Consultative Committee members were asked to assign 100 points to the operating alternative that they believed best represented an optimum balance across the range of water use objectives. Other operating alternatives were then assigned a number between 0 and 100 that reflected how effective they believed that operating alternative was relative to the 100 points. The output was a ranked list of operating alternatives for each Consultative Committee member.

Table 7-2: Consequence Table for Round 3 Trade-offs

Objective/ Location	Performance Measure	Units	What's Good	Minimum Significant Increment of Change	SQ Siphon	SQLicence	Power Only	BOI	JCA Gen	JCA ModB	JCA ModC	Winter Siphon	RecOnly	HSC5.9
					Median	Median	Median	Median	Median	Median	Median	Median	Median	Median
Recreation														
	Rec Quality	Days per year	More	5%	71	112	69	76	124	112	124	104	121	88
	Spill Safety Risks	Days per year	Less	5%	0	19	0	0	48	0	0	0	2	0
Annual Revenue														
	Annual Revenue[1]	$m per year	More	5%	14.7	13.5	14.7	11.8	8.0	12.3	13.1	12.9	12.6	12.7
Fish – Jones Creek														
	NA – Viable habitat – Q>10% MAD	Days per year	More	20%	19	24	0	348	365	365	151	242	2	189
	NA – Viable habitat – Q>20% MAD	Days per year	More	20%	0	23	0	260	218	0	0	0	2	3
	NA – Viable habitat – Q>400% MAD	Days per year	Less	20%	0	0	0	0	0	0	0	0	0	0
	Anad – Spawning – Ave	WUA (m^2)	More	20%	680	676	679	2181	2588	2643	728	1952	686	760
	Anad – Rearing – ST Parr	WUA (m^2)	More	20%	3372	2944	3123	3914	4017	4162	3446	3931	3056	3961
	Anad – Stranding Q<0.6 m^3/s	Days Q <0.6 m^3/s due to Ops	Less	20%	14	14	15	1	0	0	9	4	14	7
	Anad – Fish Index		More	20%	24.7	20.9	22.1	71.3	81.4	83.8	31.0	64.2	22.0	37.5
Fish – Reservoir														
	Littoral Productivity	Ann Cum Area (000 m^2)	More	20%	1826	15 469	1490	1360	96 548	87 447	19 847	82 302	42 664	2797
	Entrainment	Risk (0–1 scale)	Less	20%	0.50	0.21	0.48	0.46	0.00	0.17	0.19	0.18	0.21	0.39
	Pelagic – Productivity	Ave Daily Volume (million m^3)	More	20%	16	24	17	19	27	25	25	25	24	18
	Reservoir Fish Index		More	20%	8.4	43.5	10.8	15.5	87.2	69.1	48.4	66.9	52.6	19.5

Note: The columns SQ Siphon through HSC5.9 are grouped under the printed heading "Alternatives".

1. Net annual revenue is reported for Alternative BOI that includes annualized costs of non-operational physical works.

Table 7-2: Consequence Table for Round 3 Trade-offs (cont'd)

Objective /Location	Performance Measure	Units	What's Good	Minimum Significant Increment of Change	Alternatives									
					SQ Siphon	SQLicence	Power Only	BOI	JCA Gen	JCA ModB	JCA ModC	Winter Siphon	RecOnly	HSC5.9
					Median	Median	Median	Median	Median	Median	Median	Median	Median	Median
Fish – Herrling Island Sidechannel														
	Spawning – Average Sp	WUA (m^2)	More	20%	15 708	14 577	14 768	14 427	14 167	14 140	14 419	14 202	17 528	17 078
	Spawning – Average Cum Hab var	WUA (000 m^2)	Less	20%	1235	1059	1187	1137	888	1134	1102	1117	53	7
	Rearing Average	WUA (m^2)	More	20%	10 630	10 388	10 472	10 237	10 099	10 191	10 276	10 246	12 608	12 434
Wildlife														
	Wetted Area	Area (000 m^2)	More	20%	2286	4271	1356	2068	5027	4584	4522	4577	4484	3723
	Sedge–Grass	Area (000 m^2)	More	20%	2314	624	3302	2629	15	377	440	369	414	997
	Sedge–Willow	Area (000 m^2)	More	20%	257	41	189	152	–	71	59	78	107	169
	Wildlife Weighted Average	Area (000 m^2)	More	20%	1786	2302	1551	1729	2517	2404	2386	2400	2372	2153
Flood														
	Red Flag Index	Events over 40 years	Less	10%	16	48	5	62	70	62.2	62.2	62.2	63	62
	Average Red Flag Days	Days per year	Less	10%	0.4	1.2	0.125	1.55	1.75	1.555	1.555	1.555	1.575	1.55
	Red Flag Years	Number of years	Less	10%	4	10	4	10	13	10.2	10.2	10.2	10	10
	Days when Confluence >200 m^3/s	Total over 40 years	Less	10%	0	0	0	0	0	0	0	0	0	0
GHG														
	GHG relative to SQLicence	$KtCO_2e$ per yr	Less	5%	-7.7	0.0	-8.2	8.3	27.4	0.0	-0.4	-0.2	-0.3	-0.7

7.4.1.2 Swing Weighting

For the swing weighting technique, Consultative Committee members were provided the best and worst median performance measure values across the operating alternatives. For example, in the Round 3 Consequence Table, the best median performance measure value for Recreation Quality is 124 days and the worst was 69 days. Consultative Committee members were asked to consider a hypothetical operating alternative that scored the worst point in this range across all performance measures (e.g., Recreation Quality is 69 days, Spills is 48 events, Annual Revenue is $8.0 million, etc.). The Consultative Committee members were offered the opportunity of "swinging" one of the performance measures from its worst value to its best value. This performance measure was awarded 100 points. The Consultative Committee members could then swing the second most desirable performance measure from its worst to its best score. This performance measure was scored relative to the 100 points given to the first performance measure. This process continued until all performance measure swings were ranked and scored.

By multiplying these swing weights by scaled performance measure scores, a simple arithmetic function resulted in a preferred order of operating alternatives based on individual Consultative Committee member values.

A practice trade-off session was held at the end of Round 2 trade-offs and was repeated for Round 3 trade-offs. Figure 7-5 illustrates the output of the Round 3 trade-off. Consultative Committee members are anonymously listed in rows, and their ranking of the operating alternatives using the two trade-off analysis techniques is shown in columns. For clarity, ranks of 1 and 2, the most preferred operating alternatives, are shown in green. Ranks 3 and 4 are shown in yellow. The least preferred operating alternative, rank 10, is shown in red.

Rank of Alternatives by Stakeholder and by Method

		Alternatives									
CC Member	**Weighting/ Ranking Method**	SQ Siphon	SQ Licence	Power Only	BOI	JCAGen	JCAMod B	JCAMod C	WinterSiphon	RecOnly	HSC5.9
1	Direct	7	6	10	9	1	1	5	1	4	8
	Swing	9	6	10	8	1	2	5	3	4	7
2	Direct	8	10	9	5	3	2	4	1	7	6
	Swing	9	8	10	6	1	2	7	3	4	5
3	Direct	9	8	10	7	4	1	3	1	4	5
	Swing	8	9	10	4	6	1	7	2	3	5
4	Direct	5	8	9	4	10	1	7	6	2	3
	Swing	9	8	10	6	7	1	5	2	3	4
5	Direct	2	3	1	9	10	8	3	7	6	5
	Swing	1	8	2	9	10	7	3	4	5	6
6	Direct	2	1	2	7	4	7	6	7	4	10
	Swing	7	5	8	9	10	1	4	3	2	6
7	Direct	3	2	1	9	4	6	4	10	7	7
	Swing	9	7	10	8	1	2	6	3	4	5
8	Direct	1	3	2	9	10	8	4	7	6	5
	Swing	1	7	2	9	10	6	8	5	4	3

Figure 7-5: Preference for Round 3 Operating Alternatives

Some Consultative Committee members were challenged by the task of weighting either the operating alternatives and/or their values. For example, some Consultative Committee members ranked one operating alternative highest using the direct ranking technique and lowest using the swing weighting technique. Subsequent to the ranking exercise, the facilitator met with individual Consultative Committee members to ensure their views were accurately represented.

Figure 7-5 indicates that the Consultative Committee members ranked Alternatives SQSiphon, SQLicence, PowerOnly, JCAGen, JCAModB and WinterSiphon lowest or highest. The Consultative Committee showed the least interest in Alternatives WinterSiphon, RecOnly and HSC5.9.

Several Consultative Committee members commented that they were asked to select the operating alternative that represented the best balance of interests rather than their individual interests. As a result, some Consultative Committee members said they had ranked Alternative JCAModB higher than Alternative JCAGen, for example. Although the Alternative JCAGen performs better for Jones Creek and Jones Lake Reservoir fish, they felt that Alternative JCAModB represented a better balance of interests. Similarly, several Consultative Committee members said they ranked Alternative SQSiphon higher than Alternative PowerOnly as it represented a better balance of the Consultative Committee interests.

7.4.2 Eliminating Operating Alternatives

The Consultative Committee used a spreadsheet tool to help eliminate non-preferred or practically dominated operating alternatives. The primary purpose of the spreadsheet tool was to inform subsequent discussions.

7.4.2.1 Alternatives HSC5.9 and RecOnly

Moving From Alternative:	**HSC5.9**
To Alternative:	**RecOnly**
In the MEDIAN YEAR, Results In:	

	Recreation
Green	An increase in Rec Quality of 33 days
Red	An increase in Spill Safety Risks of 2 days
	Annual Revenue
Yellow	A decrease in Net Annual Revenue of 0.1 $m per year
	Fish – Jones Creek
Yellow	A decrease in NA – Viable habitat – Q>20% MAD of 0.5 days per year
Red	A decrease in Anad – Fish Index of 15.4
	Fish – Reservoir
Green	An increase in Reservoir Fish Index of 33.1
	Fish – Herrling Sidechannel
Yellow	An increase in Spawning – Average Sp of 449.8 WUA (sq m)
Red	An increase in Spawning – Average Cum Hab var of 46.5 WUA (sq m)
	Wildlife
Yellow	An increase in Wildlife Weighted Average of 219.2 Area (000 sqm)
	Flood
Yellow	An increase in Red Flag Index of 1 Events over 40 years
	GHG
Red	An increase in GHG inc relative to SQ License of 0.4 kTCO2e per year

Figure 7-6: Comparison of Trade-offs between Alternatives HSC5.9 and RecOnly

Figure 7-6 illustrates the trade-offs between Alternatives HSC5.9 and RecOnly. The data is extracted from Table 7-2. Alternative HSC5.9 is the base operating alternative being considered for elimination. Alternative RecOnly is the proposed preferred operating alternative.

Green indicates that the difference in the performance measure between the two alternatives is significant with the proposed preferred alternative (Alternative RecOnly) performing better than the base operating alternative (Alternative HSC5.9).

Yellow indicates that there may be no significant difference in the performance measure between the two alternatives (i.e., they fall within the MSIC).

Red indicates that the difference in the performance measure between the two alternatives is significant with the proposed preferred alternative (Alternative RecOnly) performing worse than the base operating alternative (Alternative (HSC5.9).

Alternative RecOnly performs better (green) than Alternative HSC5.9 by:

- Increase in Recreation Quality of 33 days.
- Increase in the Jones Lake Reservoir Fish Index by 33.1 points due to a 15-fold increase in cumulative annual littoral productivity in the median year.

Alternative HSC5.9 performs better (red) than Alternative RecOnly by:

- Decrease in Spill Safety Risk of two days.
- Increase in Jones Creek Anadromous Fish Index of 15 points.
- Decrease in Herrling Island Sidechannel Average Cumulative Spawning Habitat Variation of 46 500 m^2.
- Decrease in GHG emissions of 0.4 $KtC0_2$ equivalent per year relative to Alternative SQLicence.

After evaluating the performance of the two operating alternatives, the Consultative Committee agreed that the benefits of Alternative RecOnly out-weighed those of Alternative HSC5.9.

The Consultative Committee agreed to eliminate Alternative HSC5.9 since it is considered inferior to Alternative RecOnly.

7.4.2.2 Alternatives BOI and JCAModB

Moving From Alternative:
BOI
To Alternative:
JCAModB
In the MEDIAN YEAR, Results In:

Recreation
An increase in Rec Quality of 36.5 days
No change in Spill Safety Risks of 0 days
Annual Revenue
An increase in Net Annual Revenue of 0.5 $m per year
Fish – Jones Creek
A decrease in NA – Viable habitat – Q>20% MAD of 259.5 days per year
An increase in Anad – Fish Index of 12.5
Fish – Reservoir
An increase in Reservoir Fish Index of 53.6
Fish – Herrling Sidechannel
A decrease in Spawning – Average Sp of 287.9 WUA (sq m)
A decrease in Spawning – Average Cum Hab var of 3.2 WUA (sq m)
Wildlife
An increase in Wildlife Weighted Average of 674.6 Area (000 sqm)
Flood
An increase in Red Flag Index of 0.2 Events over 40 years
GHG
A decrease in GHG inc relative to SQ License of 8.3 kTCO2e per year

Figure 7-7: Comparison of Trade-offs between Alternatives BOI and JCAModB

Figure 7-7 illustrates the trade-offs between Alternatives BOI and JCAModB. Alternative BOI is the base operating alternative being considered for elimination. Alternative JCAModB is the proposed preferred operating alternative.

Alternative JCAModB performs better (green) than Alternative BOI by:

- Increase in Recreation Quality of 37 days.
- Increase in the Jones Lake Reservoir Fish Index of 54 points due to a 64-fold increase in cumulative littoral productivity in the median year.
- Increase in Wildlife Weighted Average of 676 000 m^2.
- A decrease in GHG emissions of 8.3 $KtCO_2$ equivalent per year relative to Alternative SQLicence.

Alternative JCAModB performs better than Alternative BOI for almost all other performance measures or the difference in the performance measure is within the MISC. A more detailed breakdown of the Jones Creek anadromous fish performance measures indicate that spawning, stranding and rearing performance measures are all improved in Alternative JCAModB within the MSIC.

Alternative BOI performs better (red) than Alternative JCAModB by:

- Increase in Jones Creek Non-Anadromous Fish Viable Habitat of >20 per cent MAD of 259.5 days per year due to a near-constant flow provided below the Wahleach Dam.

After evaluating the performance of the two operating alternatives, the Consultative Committee agreed that the benefits of Alternative JCAModB outweighed those of Alternative BOI.

The Consultative Committee agreed to eliminate Alternative BOI given its poor performance measure values for recreation quality and Jones Lake Reservoir fish, combined with minor benefits to Jones Creek fish over Alternative JCAModB.

7.4.2.3 Alternatives PowerOnly and JCAGen

Moving From Alternative:
Power Only
To Alternative:
JCAGen
In the MEDIAN YEAR, Results In:

Recreation
An increase in Rec Quality of 55 days
An increase in Spill Safety Risks of 48 days
Annual Revenue
A decrease in Net Annual Revenue of 6.7 $m per year
Fish – Jones Creek
An increase in NA – Viable habitat – Q>20% MAD of 217.5 days per year
An increase in Anad – Fish Index of 59.3
Fish – Reservoir
An increase in Reservoir Fish Index of 76.4
Fish – Herrling Sidechannel
A decrease in Spawning – Average Sp of 600.8 WUA (sq m)
A decrease in Spawning – Average Cum Hab var of 298.9 WUA (sq m)
Wildlife
An increase in Wildlife Weighted Average of 966.4 Area (000 sqm)
Flood
An increase in Red Flag Index of 65 Events over 40 years
GHG
An increase in GHG inc relative to SQ License of 35.6 kTCO2e per year

Figure 7-8: Comparison of Trade-offs between Alternatives PowerOnly and JCAGen

Figure 7-8 illustrates the trade-offs between Alternatives PowerOnly and JCAGen. Alternative PowerOnly is the base operating alternative being considered for elimination. Alternative JCAGen is the proposed preferred operating alternative.

Alternative PowerOnly represents operating the Wahleach hydroelectric facility exclusively for power generation. Alternative JCAGen represents operating the facility exclusively for the benefit of environmental and social values in Jones Creek and Jones Lake Reservoir.

The Consultative Committee agreed to eliminate both Alternatives PowerOnly and JCAGen as neither was likely to lead to a consensus preferred operating alternative.

7.4.2.4 Alternatives SQLicence and JCAModC

Moving From Alternative:
SQ Licence
To Alternative:
JCAModC
In the MEDIAN YEAR, Results In:

Recreation
An increase in Rec Quality of 11.8 days
A decrease in Spill Safety Risks of 19 days
Annual Revenue
A decrease in Net Annual Revenue of 0.4 $m per year
Fish – Jones Creek
A decrease in NA – Viable habitat – Q>20% MAD of 22.9 days per year
An increase in Anad – Fish Index of 10.1
Fish – Reservoir
An increase in Reservoir Fish Index of 4.9
Fish – Herrling Sidechannel
A decrease in Spawning – Average Sp of 158.1 WUA (sq m)
An increase in Spawning – Average Cum Hab var of 42.8 WUA (sq m)
Wildlife
An increase in Wildlife Weighted Average of 84 Area (000 sqm)
Flood
An increase in Red Flag Index of 14.2 Events over 40 years
GHG
A decrease in GHG inc relative to SQ License of 0.4 kTCO2e per year

Figure 7-9: Comparison of Trade-offs between Alternatives SQLicence and JCAModC

Figure 7-9 illustrates the trade-offs between Alternatives SQLicence and JCAModC. Alternative SQLicence is the base operating alternative being considered for elimination. Alternative JCAModC is the proposed preferred operating alternative.

The BC Hydro Consultative Committee members were concerned with the increase in the Spill Safety Risk of 19 additional days in Alternative SQLicence compared to Alternative JCAModC.

Alternative JCAModC performs better (green) than Alternative SQLicence by:

- Increase in Recreation Quality of 12 days.
- Decrease in Spill Safety Risk of 19 days.
- Increase in Jones Creek Anadromous Fish Index of 10 points, including a six-event per year drop in stranding risk.
- Decrease in GHG emissions of 0.4 KtCO_2 equivalent per year, relative to Alternative SQLicence.

Alternative SQLicence performs better (red) than Alternative JCAModC by:

- Increase in Jones Creek Non-Anadromous Fish Viable Habitat of >20 per cent MAD of 22.9 days per year.
- Decrease in Red Flag Index of 14.2 events over 40 years.

After evaluating the performance of the two operating alternatives, the Consultative Committee agreed that the benefits of Alternative JCAModC outweighed those of Alternative SQLicence.

The Consultative Committee agreed to eliminate Alternative SQLicence since it is considered inferior to Alternative JCAModC.

7.4.2.5 Alternatives JCAModC and WinterSiphon

Moving From Alternative:
JCAModC
To Alternative:
WinterSiphon
In the MEDIAN YEAR, Results In:

Recreation
A decrease in Rec Quality of 19.9 days
No change in Spill Safety Risks of 0 days
Annual Revenue
A decrease in Net Annual Revenue of 0.2 $m per year
Fish – Jones Creek
A decrease in NA – Viable habitat – Q>20% MAD of 0.1 days per year
An increase in Anad – Fish Index of 33.2
Fish – Reservoir
An increase in Reservoir Fish Index of 18.5
Fish – Herrling Sidechannel
A decrease in Spawning – Average Sp of 216.4 WUA (sq m)
An increase in Spawning – Average Cum Hab var of 15.3 WUA (sq m)
Wildlife
An increase in Wildlife Weighted Average of 14.6 Area (000 sqm)
Flood
No change in Red Flag Index of 0 Events over 40 years
GHG
An increase in GHG inc relative to SQ License of 0.2 kTCO2e per year

Figure 7-10: Comparison of Trade-offs between Alternatives JCAModC and WinterSiphon

Figure 7-10 illustrates the trade-offs between Alternatives WinterSiphon and JCAModC. Alternative JCAModC is the base operating alternative being considered for elimination. Alternative WinterSiphon is the proposed preferred operating alternative.

Alternative WinterSiphon performs better (green) than Alternative JCAModC by:

- Increase in Jones Creek Anadromous Fish Index of 33 points due to a 1200 m^2 increase in spawning habitat.
- Increase in Reservoir Fish Index of 19 points due to an increase in littoral productivity.

Alternative JCAModC performs better (red) than Alternative WinterSiphon by:

- Increase in Recreation Quality of 20 days.
- Increase in Jones Creek Non-anadromous Fish Viable Habitat of >20 per cent of 0.1 days per year.
- Decrease in GHG emissions of 0.2 KtCO_2 equivalent per year relative to Alternative SQLicence.

After evaluating the performance of the two operating alternatives, the Consultative Committee agreed that the benefits of Alternative WinterSiphon outweighed those of Alternative JCAModC.

The Consultative Committee agreed to eliminate Alternative JCAModC since it is considered inferior to Alternative WinterSiphon.

7.4.2.6 Alternatives RecOnly and JCAModB

Moving From Alternative:
RecOnly
To Alternative:
JCAModB
In the MEDIAN YEAR, Results In:

Recreation
A decrease in Rec Quality of 9 days
A decrease in Spill Safety Risks of 2 days
Annual Revenue
A decrease in Net Annual Revenue of 0.2 $m per year
Fish – Jones Creek
A decrease in NA – Viable habitat - Q>20% MAD of 2 days per year
An increase in Anad – Fish Index of 61.8
Fish – Reservoir
An increase in Reservoir Fish Index of 16.5
Fish – Herrling Sidechannel
A decrease in Spawning – Average Sp of 3388.2 WUA (sq m)
An increase in Spawning – Average Cum Hab var of 1080.3 WUA (sq m)
Wildlife
An increase in Wildlife Weighted Average of 31.6 Area (000 sqm)
Flood
A decrease in Red Flag Index of 0.8 Events over 40 years
GHG
An increase in GHG inc relative to SQ License of 0.3 kTCO2e per year

Figure 7-11: Comparison of Trade-offs between Alternatives RecOnly and JCAModB

Figure 7-11 illustrates the trade-offs between Alternatives RecOnly and JCAModB. Alternative RecOnly is the base operating alternative being considered for elimination. Alternative JCAModB is the proposed preferred operating alternative.

In this comparison, there is a trade-off between Jones Creek fish and Herrling Island Sidechannel fish.

Alternative JCAModB performs better (green) than Alternative RecOnly by:

- Decrease in Spill Safety Risks of 2 days.
- Increase in Jones Creek Anadromous Fish Index of 62 points.
- Increase in the Jones Lake Reservoir Fish Index of 17 points.

Alternative RecOnly performs better (red) than Alternative JCAModB by:

- Increase in Recreation Quality of 9 days.
- Increase in Herrling Island Sidechannel Average Spawning Habitat of 3388 m^2 or 20 per cent of Wetted Usable Area.
- Decrease in Herrling Island Sidechannel Average Cumulative Spawning Habitat Variation of 1080 m^2.

At this time, Alternative RecOnly was the most dominant remaining operating alternative that provided a minimum flow in Herrling Island Sidechannel. Removal of Alternative RecOnly required agreement by the Consultative Committee that Herrling Island Sidechannel fish would not be the primary interest for the Wahleach Water Use Plan.

At this time, the Consultative Committee was divided on whether benefits to Jones Creek fish outweighed benefits to Herrling Island Sidechannel fish. On a number of occasions, the Consultative Committee had been briefed by the BC Hydro project team and the Fish Technical Subcommittee on the relative values of fish in both Jones Creek and Herrling Island Sidechannel, including an assessment of fry emergence numbers and qualitative factors.

The main issue for Herrling Island Sidechannel fish was habitat stability. It was hypothesized that spawning fish may be stranded in Herrling Island Sidechannel when peak flows are suddenly curtailed. A solution was proposed where the Wahleach Generating Station would curtail generation to zero for a few hours every day to disturb the spawning of fish in high risk areas and enable them to find suitable spawning areas. Subsequently, Fisheries and Oceans Canada investigated the efficacy of the proposal and recommended to the Consultative Committee that a Herrling Island Sidechannel Operating Protocol be included in the Wahleach Water Use Plan. Given that the Wahleach hydroelectric facility is a peaking plant, the operation is expected to involve little or no cost.

The Consultative Committee agreed to include a Herrling Island Sidechannel Operating Protocol in the Wahleach Water Use Plan to address negative impacts to Herrling Island Sidechannel fish habitat variation. The Operating Protocol specified that from 15 September to 30 November, BC Hydro curtail generation to zero for a two-hour period every twenty-four hours. There is no time of day conditions. At all other times, BC Hydro can generate at maximum capacity.

The Herrling Island Sidechannel Operating Protocol was applied to all subsequent operating alternatives. With implementation of the Operating Protocol, the Cumulative Habitat Variation performance measure was similar to Alternative RecOnly in all the operating alternatives.

The Consultative Committee agreed to eliminate Alternative RecOnly since it is considered inferior to Alternative JCAModB.

At this stage, the Consultative Committee could go no further in trading off Alternatives SQSiphon, JCAModB and WinterSiphon. These operating alternatives differed substantially only in the amount of time allocated to flow releases into Jones Creek, as summarized in Table 7-3.

Table 7-3: Timing of Flows in Jones Creek for Three Operating Alternatives

Name	Timing of Flows in Jones Creek
SQSiphon	6 weeks in September every other year (modelled as 3 weeks per year)
JCAModB	All year
WinterSiphon	1 September to 30 April

The Consultative Committee sought advice from the Fish Technical Subcommittee on how Alternatives SQSiphon and WinterSiphon could be combined by altering flows in Jones Creek. The Fish Technical Subcommittee recommended that flows were needed in the fall for spawning and in the spring for incubation of salmonids. It was also recommended that flows could be supplemented on an as-needed basis on any given day, rather than according to a fixed calendar schedule. Consequently, Alternative WinterSiphonB was created with minimum flows in Jones Creek specified for 1 September to 31 October and for 1 March to 30 April.

Upon completing Round 3 trade-offs, the Consultative Committee requested the BC Hydro project team consider some operating alternatives that included non-operational physical works.

7.5 Round 4 Trade-offs

Table 7-4 illustrates the consequence table for Round 4 trade-offs.

Table 7-4: Consequence Table for Round 4 Trade-offs

Objective/Location	Performance Measure	Units	What's Good	Minimum Significant Increment of Change	Alternatives			
					SQSiphon	**JCAMODB**	**WinterSiphon**	**WinterSiphonB**
Recreation	Rec Quality	Days per year	More	5%	71	112	104	104
	Spill Safety Risks	Days per year	Less	5%	0	0	0	0
Annual Revenue	Net Annual Revenue	$m per year	More	5%	14.7	12.3	12.9	13.6
Fish – Jones Creek	NA – Viable habitat – >10% MAD	Days per year	More	20%	19	365	242	122
	NA – Viable habitat – >10% MAD	Days per year	More	20%	0	0	0	0
	NA – Viable habitat – >10% MAD	Days per year	Less	20%	0	0	0	0
	Anad – Spawning – Ave	WUA (m^2)	More	20%	680	2643	1952	1105
	Anad – Rearing – ST Parr	WUA (m^2)	More	20%	3372	4162	3931	3930
	Anad – Stranding Q<0.6 m^3/s	Days Q<0.6m^3/s due to Ops	Less	20%	14	0	4	9
	Anad – Fish Index		More	20%	24.7	83.8	64.2	42.6
Fish – Reservoir	Littoral Productivity	Ann Cum Area (000 m^2)	More	20%	1826	87 447	82 302	71 362
	Entrainment	Risk (scale: 0–1)	Less	20%	0.50	0.17	0.18	0.19
	Pelagic – Productivity	Average Daily Volume (000 m^3)	More	20%	16	25	25	24
	Reservoir Fish Index		More	20%	8.4	69.1	66.9	62.0
Fish – Herrling Island Sidechannel	Spawning – Average Sp	WUA (m^2)	More	20%	15 708	14 140	14 202	14 371
	Spawning – Average Cum Hab var	WUA (m^2)	Less	20%	1235	1134	1117	1106
	Rearing Average	WUA (m^2)	More	20%	10 630	10 191	10 246	10 360

Table 7-4: Consequence Table for Round 4 Trade-offs (cont'd)

Objective/Location	Performance Measure	Units	What's Good	Minimum Significant Increment of Change	Alternatives			
					SQSiphon	JCAMODB	WinterSiphon	WinterSiphonB
Wildlife	Wetted Area	Area (000 m^2)	More	20%	2286	4584	4577	4557
	Sedge – Grass	Area (000 m^2)	More	20%	2314	377	369	365
	Sedge – Willow	Area (000 m^2)	More	20%	257	71	78	88
	Wildlife Weighted Average	Area (000 m^2)	More	20%	1786	2404	2400	2392
Flood	Red Flag Index	Events over 40 years	Less	10%	16	62.2	62.2	62.2
	Average Red Flag Days	Days per year	Less	10%	0.4	1.555	1.555	1.555
	Red Flag Years	Number of years	Less	10%	4	10.2	10.2	10.2
	Days when Confluence >200 m^3/s	Total over 40 years	Less	10%	0	0	0	0
GHG	GHG Relative to SQ Licence	$KtCO_2e$ per year	Less	5%	-7.7	0.0	-0.2	-3.9

7.5.1.1 Alternatives SQSiphon, WinterSiphonB and WinterSiphon

Moving From Alternative:
SQ Siphon
To Alternative:
WinterSiphonB
In the MEDIAN YEAR, Results In:

Recreation
An increase in Rec Quality of 33.8 days
No change in Spill Safety Risks of 0 days
Annual Revenue
A decrease in Net Annual Revenue of 1.1 $m per year
Fish – Jones Creek
No change in NA – Viable habitat – Q>20% MAD of 0 days per year
An increase in Anad – Fish Index of 17.9
Fish – Reservoir
An increase in Reservoir Fish Index of 53.6
Fish – Herrling Sidechannel
A decrease in Spawning – Average Sp of 1337 WUA (sq m)
A decrease in Spawning – Average Cum Hab var of 129.5 WUA (sq m)
Wildlife
An increase in Wildlife Weighted Average of 606.1 Area (000 sqm)
Flood
An increase in Red Flag Index of 46.2 Events over 40 years
GHG
An increase in GHG inc relative to SQ License of 3.8 kTCO2e per year

Figure 7-12: Comparison of Trade-offs between Alternatives SQSiphon and WinterSiphonB

Figure 7-12 illustrates the trade-offs between Alternatives SQSiphon and WinterSiphonB. Alternative SQSiphon is the base operating alternative being considered for elimination. Alternative WinterSiphonB is the proposed preferred operating alternative.

Alternative WinterSiphonB performs better (green) than Alternative SQSiphon by:

- Increase in Recreation Quality of 34 days.
- Increase in Jones Creek Anadromous Fish Index of 18 points.
- Increase in the Jones Lake Reservoir Fish Index of 54 points, due to a 40-fold increase in effective littoral area.
- Increase in Wildlife Weighted Average of 606 100 m^2.
- Increase in Red Flag Index of 46.2 events over 40 years.

Alternative SQSiphon performs better (red) than Alternative WinterSiphonB by:

- Increase in Annual Revenue of $1.1 million.
- Decrease in GHG emissions of 3.8 KtCO_2 equivalent per year relative to Alternative SQLicence.

Moving From Alternative:
WinterSiphon
To Alternative:
WinterSiphonB
In the MEDIAN YEAR, Results In:

	Recreation
Yellow	An increase in Rec Quality of 0.4 days
Yellow	No change in Spill Safety Risks of 0 days
	Annual Revenue
Green	An increase in Net Annual Revenue of 0.8 $m per year
	Fish – Jones Creek
Yellow	No change in NA – Viable habitat – Q>20% MAD of 0 days per year
Red	A decrease in Anad – Fish Index of 21.6
	Fish – Reservoir
Yellow	A decrease in Reservoir Fish Index of 4.9
	Fish – Herrling Sidechannel
Yellow	An increase in Spawning – Average Sp of 169.1 WUA (sq m)
Yellow	A decrease in Spawning – Average Cum Hab var of 11.5 WUA (sq m)
	Wildlife
Yellow	A decrease in Wildlife Weighted Average of 8.5 Area (000 sqm)
	Flood
Yellow	No change in Red Flag Index of 0 Events over 40 years
	GHG
Green	A decrease in GHG inc relative to SQ License of 3.7 kTCO2e per year

Figure 7-13: Comparison of Trade-offs between Alternatives WinterSiphon and WinterSiphonB

Figure 7-13 illustrates the trade-offs between Alternatives WinterSiphon and WinterSiphonB. Alternative WinterSiphon is the base operating alternative being considered for elimination. Alternative WinterSiphonB is the proposed preferred operating alternative.

Alternative WinterSiphonB performs better (green) than WinterSiphon by:

- Increase in Annual Revenue of $800,000.
- Decrease in GHG emissions of 3.7 KtCO_2 equivalent per year relative to SQLicence.

Alternative WinterSiphon performs better (red) than WinterSiphonB by:

- Increase in Jones Creek Anadromous Fish Index of 21.6 points.

While Alternative WinterSiphonB did improve fish performance measure values over Alternative SQSiphon and increased Annual Revenue over Alternative WinterSiphon, some Consultative Committee members thought Alternative WinterSiphonB provided insufficient fish benefits for the negative impact on Annual Revenue of $1.1 million.

7.6 Round 4 Degree of Consensus

At this point, the Consultative Committee could not eliminate any more operating alternatives. The facilitator requested that each Consultative Committee member verbally state their degree of support for Alternatives SQSiphon, WinterSiphon, WinterSiphonB and JCAModB. Possible declarations were:

- I fully **Endorse** the operating alternative.
- I **Accept** the alternative, I can live with it.
- I **Block** the alternative, I cannot live with it.

Table 7-5 summarizes the level of support for Round 4 operating alternatives by Consultative Committee member. An “E” in a green box indicates that the Consultative Committee member Endorses an operating alternative. An “A” in a yellow box indicates Accept, and a “B” in a red box indicates Block. A further option was proposed “AC,” representing Accept with Conditions.

Table 7-5: Preference for Round 4 Operating Alternatives

Consultative Committee Member	Organization	Alternative			
		SQSiphon	WinterSiphon	WinterSiphonB	JCAModB
Ross Neuman	Ministry of Water, Land and Air Protection	**Block**	Accept with Conditions	Accept with Conditions	Endorse
Eric Isaacson	Local resident	Accept	Accept	Endorse	Accept
Frank Kwak	Fraser Valley Salmon Society	**Block**	Accept with Conditions	**Block**	Endorse
Dan Sneep	Fisheries and Oceans Canada	**Block**	Endorse	Accept with Conditions	Endorse
Tim Peters	Stó:lō Nation	**Block**	Endorse	**Block**	Accept
Mike Lewis	BC Hydro	Accept	**Block**	**Block**	**Block**
Dorell Carlson	BC Hydro	Accept	**Block**	**Block**	**Block**
Russ Knutson	Chilliwack Forest District	Accept	Accept	Endorse	Accept
Genevieve George	Shxw’ow’hamel First Nation	**Block**	Accept with Conditions	Accept	Endorse
Dean Jones	Shxw’ow’hamel First Nation	**Block**	Accept	Accept	Endorse

Table 7-6 summarizes the written supporting rationale for why Consultative Committee members endorsed, accepted or blocked each operating alternative.

Table 7-6: Consultative Committee Comments on Round 4 Operating Alternatives

Committee Member	Comment
Ross Neuman	Alternative SQSiphon is bad for fish. Increase in revenue over licence not justifiable given impacts on fish – Block. Alternative WinterSiphon, accept with conditions (res fish index ~20% decrease from Alternative JCAGen), would accept with fertilization. Also 21% compared to Alternative JCAGen, wants to see capability to increase water in Jones Creek in dry years (e.g., pumping), feels $600k increase over licence is acceptable. Alternative WinterSiphonB, 29 per cent decrease in res fish index. Would accept with fertilization, but thinks the hydrograph is too jerky and unnatural, would like to see pumping smooth this out, $ same as licence. Alternative JCAModB, feels cost of $1.2M over licence is acceptable.
Eric Isaacson	Alternative WinterSiphonB Endorse. Best all around for him from all he has heard. First choice should have been Alternative JCAModB but doesn't like it.
Frank Kwak	Blocked Alternative SQSiphon, not good for fish. Littoral zone is poor. Alternative WinterSiphon, accept, with fertilization and fish stocking program (any water taken with acre/feet should be split with BC Hydro and fish benefits). Alternative WinterSiphonB a further drop, Block. Alternative JCAModB, endorses because fish benefits are the best.
Dan Sneep	Block Alternative SQSiphon because it is status quo, doesn't represent any compromise or improvement in other interests, fish and other interests have suffered and Water Use Plans is about trying to achieve incremental gains or improvements. Endorse Alternative WinterSiphon, represents variety of fish improvements, move toward compromise on all sides, more natural creek hydrograph. Alternative WinterSiphonB, further compromise for fish and other interests, but still some gains seen and improvement and benefits. Doesn't like creek hydrograph, blocky and weird, need to look at that. May be able to use power benefits to support some non-op changes as well as Alternative WinterSiphonB (e.g., pump) to make the best use of the water. Alternative JCAModB, fish friendly and represents Fisheries and Oceans interests, recognize that it is at one end of the spectrum.
Tim Peters	Alternative SQSiphon, Block not good for fish values. Alternative WinterSiphon, endorse with compensation for better habitat, room for consensus. Alternative WinterSiphonB, less fish potential than Alternative WinterSiphon so would Block. Alternative JCAModB, good for fish, but it is very expensive so accept.
Russ Knutson	Alternative WinterSiphonB, endorse, best balance of all interests. Recognize shortfalls in others, so would accept but not endorse
Mike Lewis	Alternative SQSiphon would accept but would prefer to see spawning channel and fertilization. There is otherwise little to no fish value in lower Jones Creek so why put expensive water there?

Table 7-6: Consultative Committee Comments on Round 4 Operating Alternatives (cont'd)

Committee Member	Comment
Dorell Carlson	Accept on Alternative SQSiphon, Block other three alternatives because they focus on Jones Creek and reservoir fish values. Was hoping Alternative WinterSiphonB would close the gap for revenues and fish values, but doesn't see it. Feels the reality is the nature of the system at Wahleach is the water is very valuable (high head value) and therefore all water down Jones Creek is significant cost. Also, comparing Jones Creek fish with Herrling Island Sidechannel fish impacts, see better fish production in Herrling Island Sidechannel with power benefits as well, trade-off falls on Herrling Island Sidechannel fish values. Also, nature of the quality of habitats (Jones Creek and reservoir) impacted by other physical events affect the reality of the habitats. How the table looks at the dollar trade-offs, inappropriate to view the dollars as BC Hydro dollars, because they are provincial dollars into the social benefit. BC Hydro flows through both costs and revenues to customers and government. Must be clear that the dollars are provincial dollars, no BC Hydro impact.
Genevieve George	Block Alternative SQSiphon bad for fish. Alternative WinterSiphon, accept but would like the spawning creek in Jones Creek as a non-op alternative with it, plus some other non-ops. Alternative WinterSiphonB, accept with similar non-operations. Alternative JCAModB endorsed for fish benefits
Dean Jones	Block Alternative SQSiphon, ups the income from licence and isn't fish friendly. Alternative WinterSiphon and Alternative WinterSiphonB more fish friendly, but Alternative JCAModB are best of all for fish benefits (can't put a price on fish). More Rec Quality days than with Alternative SQSiphon. More fish in Jones Creek and Herrling Island Sidechannel.

7.6.1 Areas of Consensus and Disagreement

At this point, the Consultative Committee felt that it had fully explored operating alternatives, and had articulated areas of agreement and disagreement, as required by the *Water Use Plan Guidelines*.

Areas of consensus on operating alternatives include:

- Improvements to Herrling Island Sidechannel could be attained by implementing the Operating Protocol.[1]
- Recognition that both Jones Creek fish and Jones Lake Reservoir fish are important and that some flow in Jones Creek is desired.
- Interest in further examining non-operational physical works in lieu of operational changes.

[1] BC Hydro subsequently requested that the Consultative Committee reconsider possible non-operational enhancements to the Herrling Island Sidechannel given the relative costs and benefits of improvements compared to Jones Creek.

Areas of disagreement on operating alternatives included:

- Whether the fish benefits in Jones Creek and Jones Lake Reservoir are worth the negative impact on annual revenue and fish in Herrling Island Sidechannel.

- Whether Alternative SQSiphon or Alternative SQLicence represents current operations.

7.6.2 Round 5 Trade-offs

In Round 5 operating alternatives, the Consultative Committee developed a number of alternatives that included both operational changes and non-operational physical works to meet fish objectives in Jones Creek and Jones Lake Reservoir.

Rather than model a large number of operating alternatives that included combinations of operational aspects and physical works, an interactive spreadsheet tool enabled the Consultative Committee to develop and estimate the impacts of the alternatives. To facilitate this approach, some new operating alternatives were specified by referring to previous alternatives. For example, in Table 7-7, for the new Alternative AsNeeded/WinterSiphonB, a "WinterSiphon-like" reservoir profile was specified to resemble the conditions of the reservoir modelled under the existing Alternative WinterSiphon. Therefore, Alternative AsNeeded/WinterSiphonB could be expected to have similar reservoir performance measure values to Alternative WinterSiphon. In Table 7-7, the specification of "Reservoir Profile" in each new operating alternative refers to an existing alternative.

In Round 5 trade-offs, only the performance measures considered significant by the Consultative Committee were presented. Later in the Wahleach water use planning process, all of the performance measures were calculated and presented. Note that at this stage, fish performance measures are presented in terms of fry numbers according to the assumptions in Section 4. The non-operational physical works in lieu of operations are discussed below.

Table 7-7 summarizes the consequence table for Round 5 trade-offs.

Table 7-7: Consequence Table for Round 5 Trade-offs

Summary of Specifications		**SQSiphon**	**JCAModB**	**WinterSiphon**	**WinterSiphonB**	**WinterSiphonB Pump**
	Flow Mechanism	Siphon	Siphon	Siphon	Siphon	Pump
	Flow Regime in Jones Creek	SQ Siphon	JCAModB	WinterSiphon	WinterSiphonB	WinterSiphonB
	Spawning Channel in Jones Creek	No	No	No	No	No
	Reservoir Profile	SQ Siphon	JCAModB	WinterSiphon	WinterSiphonB	PowerOnly
	Reservoir Fertilization	No	No	No	No	Yes
Summary of Estimated Major Costs and Benefits						
Revenue	$ millions	14.64	12.37	12.94	13.64	14.01
Jones Creek Fry	No. (000)	3–18	15–110	7–50	5–35	5–35
Reservoir Littoral Productivity	Millions m^2	2	87	82	71	Very High
Recreation	Quality Days	71	112	104	104	69
Herrling Island Sidechannel Fry	No. (000)	800–1700	700–1600	700–1600	700–1600	800–1700
Summary of Specifications		**AsNeeded/ WinterSiphonB**	**Min Elevation**	**AsNeeded**	**WinterSiphon /Fert**	**Spawning C**
	Flow Mechanism	Pump	Pump	Pump	Siphon	Siphon
	Flow Regime in Jones Creek	AsNeeded	AsNeeded	AsNeeded	WinterSiphon	SQSiphon
	Spawning Channel in Jones Creek	No	No	No	No	Yes
	Reservoir Profile	WinterSiphonB	SQSiphon	PowerOnly	WinterSiphon	SQSiphon
	Reservoir Fertilization	Yes	Yes	Yes	Yes	Yes
Summary of Estimated Major Costs and Benefits						
Revenue	$ millions	13.88	14.22	14.37	12.9	14.44
Jones Creek Fry	No. (000)	15–110	15–110	15–110	7–50	500–4000
Reservoir Littoral Productivity	Millions m^2	Very High	Very High	Very High	Very High	Very High
Recreation	Quality Days	104	71	69	104	71
Herrling Island Sidechannel Fry	No. (000)	700–1600	800–1700	800–1700	700–1600	800–1700

In this table, the four remaining operating alternatives are shaded for reference. The Flow Regime in Jones Creek row indicates the flow characteristics of water pumped or siphoned into Jones Creek. For example, Alternative WinterSiphonB includes a minimum flow of 0.85 m^3/s from 1 September to 31 October and from 1 March to 30 April. The AsNeeded flow was not fully defined at the time, but related to supplementing natural flows to meet Jones Creek fish flow targets. The Reservoir Elevation row indicates the Jones Lake Reservoir elevation level of the operating alternative. For example, in Alternative WinterSiphon, Jones Lake Reservoir elevation levels would be similar to Alternative WinterSiphon. The fish benefits in Jones Creek and Jones Lake Reservoir are estimated based on numbers of fry as discussed in Section 4.

7.6.2.1 Pump at Wahleach Dam

The Consultative Committee considered a pump that could provide flows to Jones Creek and be operable at any reservoir elevation level, since the intake of the pump could be placed deeper in the reservoir than the intake of the fish water release siphon. The pump could deliver flows to Jones Creek based on real-time flow readings at a gauge near Laidlaw versus using the siphon continuously during defined calendar periods. The pump could be powered by diesel or by a power line from Laidlaw. The main advantage of a pump over the fish water release siphon was to enable a spring drawdown in Jones Lake Reservoir concurrent with providing minimum flows to Jones Creek resulting in increased opportunities for power generation.

Although the pump could deliver more precise flows, some Consultative Committee members expressed concern regarding its long-term reliability. The levelized annual cost of the pump was initially estimated at $80,000.

A pump would require the following new infrastructure:

- Pump and associated infrastructure.
- Transmission line infrastructure.
- Line maintenance.
- Pump maintenance.
- A power line from the Wahleach Generating Station to the pump.

7.6.3 Jones Creek Spawning Channel

Throughout the Wahleach water use planning process, several Consultative Committee members expressed an interest in re-establishing the artificial spawning channel in Jones Creek anadromous. However, technical experts cautioned that a spawning channel in Jones Creek anadromous would be prone to unpredictable and violent debris torrents for decades, based on the accumulation and inevitable mobilization of debris from the areas around two major tributaries (Hartman and Miles, 1997).

Having examined the costs of operationally providing flows for Jones Creek fish, some Consultative Committee members wished to reconsider re-establishing the artificial spawning channel in Jones Creek anadromous. Although the Consultative Committee recognized that any spawning channel in Jones Creek anadromous would be subject to destruction from periodic debris torrents, some Committee members supported the additional costs of rebuilding the spawning channel after each event.

In Rounds 5 and 6 operating alternatives, the Consultative Committee proposed a fish habitat enhancement project similar in length and location to the original spawning channel on the downstream left of lower Jones Creek. The Consultative Committee acknowledged that prior to the fish habitat enhancement project being reconstructed, the potential impact on the pipeline, the highway and the Fisheries and Oceans Canada and BC Hydro agreement would need to be assessed. It was also proposed that while the original spawning channel received a six-week flow every other year, an annual six-week flow might be more preferable for chum salmon in the new operating regime. The maintenance and annualized infrastructure cost of the fish habitat enhancement project was estimated at $30,000 per year.

7.6.4 Jones Lake Reservoir Fertilization Program

In Round 4, Alternatives SQSiphon, WinterSiphon, WinterSiphonB and JCAModB maintained high Jones Lake Reservoir elevation levels for most of the year to keep the fish water release siphon primed. The Ministry of Water, Land and Air Protection Committee member proposed that the productivity benefits associated with a consistent high reservoir elevation level could at least be partially mitigated by fertilizing the reservoir.

In Rounds 5 and 6 operating alternatives, the Consultative Committee supported a fertilization program in lieu of maintaining a high Jones Lake Reservoir elevation level, but acknowledged that the program would improve littoral and pelagic productivity in the reservoir in excess of what could be achieved through operations. The estimated costs for the fertilization program was $40,000 for fertilization application and from $40,000 to $60,000 for reporting and analysis. Initially, in Round 5 trade-offs, the reporting and analysis component was proposed under the monitoring program. However, after further discussion in Round 6 trade-offs, the Consultative Committee agreed that this component was essential to ensure appropriate fertilization application. (Refer to Appendix H: Post-Consultative Committee Technical Subcommittee Meeting Minutes on Fertilization Program.)

7.7 Round 5 Degree of Consensus

The facilitator requested that each Consultative Committee member verbally state their degree of support for Alternatives WinterSiphonB Pump, AsNeeded WinterSiphonB, Minimum Elevation, AsNeeded, WinterSiphon Fertilization, and Spawning C.

Table 7-8 summarizes the level of support for Round 5 operating alternatives by the Consultative Committee members.

Table 7-8: Preference for Round 5 Operating Alternatives

		Alternative					
Consultative Committee Member	**Organization**	**WinterSiphonB Pump**	**AsNeeded WinterSiphonB**	**Minimum Elevation**	**AsNeeded**	**WinterSiphon Fertilization**	**Spawning C**
Ross Neuman	Ministry of Water, Land and Air Protection	**Block**	Endorse	Accept with Conditions	**Block**	Endorse	**Block**
Eric Isaacson	Local resident	Endorse	Endorse	Accept	Endorse	Accept	Accept
Frank Kwak	Fraser Valley Salmon Society	**Block**	Accept with Conditions	**Block**/Accept with Conditions?	**Block**	Endorse	**Block**
Dan Sneep	Fisheries and Oceans Canada	**Block**	Endorse	Endorse	Accept	**Block**	**Block**
Tim Peters	Stó:lō Nation	**Block**	Accept	**Block**	**Block**	Accept	Endorse
Mike Lewis	BC Hydro	**Block**	**Block**	**Block**/Accept with Conditions	**Block**/Accept with Conditions	**Block**	Endorse
Dorell Carlson	BC Hydro	**Block**	**Block**	**Block**/Accept with Conditions	**Block**/Accept with Conditions	**Block**	Endorse
Russ Knutson	Chilliwack Forest District	Accept	Endorse	Accept	Accept	Accept	Accept
Genevieve George	Shxw'ow'hamel First Nation	**Block**	Accept	**Block**/Accept with Conditions	**Block**	**Block**	Endorse
Dean Jones	Shxw'ow'hamel First Nation	**Block**	Accept	Accept	Accept	Accept	Endorse

7.7.1 Summary of Consultative Committee Values

During the Round 5 trade-off discussions, the Ministry of Water, Land and Air Committee member expressed an interest in having Jones Lake Reservoir function more like a natural lake. The Committee member proposed that "naturalness" correlated to the reservoir elevation level where the less deviation from full pool, the more natural the system. It was proposed that naturalness would improve littoral productivity and other reservoir ecological values not captured in the performance measures. The concept of "naturalness" was an objective that had not been previously incorporated into the analysis and there was no performance measure to determine the performance of an operating alternative.

Amongst the Consultative Committee members, there was a disagreement on the preferred means by which benefits to Jones Creek fish habitat should be improved. Some Consultative Committee members supported redevelopment of the original spawning channel in Jones Creek anadromous to improve fish habitat and provide cultural and educational value. These Consultative Committee members acknowledged that any spawning channel in Jones Creek anadromous would periodically be destroyed by debris torrents. Other Consultative Committee members rejected the spawning channel as being philosophically the wrong solution to the problem. Rather, they supported improving Jones Creek fish habitat by naturalizing the channel and removing existing physical works, and by providing flows. These Committee members did not support recreating an artificial, single-species fish-production zone in one part of Jones Creek, while ignoring the rest of the creek.

The BC Hydro Committee members expressed a preference for Alternative SQSiphon with additional benefits to be provided to Herrling Island Sidechannel fish versus Jones Creek fish. Further, the BC Hydro Committee members proposed that additional water not be diverted into Jones Creek until the slides at 2.8 Mile Creek and 3.0 Mile Creek stabilized over the next several decades. They concluded that the potential fish values in Jones Creek do not support a negative impact to power generation.

In summary, three operating alternatives appeared to have support amongst the Consultative Committee.

Alternative AsNeeded/WinterSiphonB

- Pump to provide AsNeeded flows to Jones Creek
- Reservoir operation as per Alternative WinterSiphonB
- Reservoir fertilization in lieu of operations (e.g., Alternative JCAModB)

This operating alternative was acceptable to all Consultative Committee members, except the BC Hydro Consultative Committee members who considered the negative impact to annual revenue compared to Alternative SQSiphon did not warrant the expected fish benefits.

Alternative Minimum Elevation

- Pump to provide AsNeeded flows to Jones Creek
- Reservoir operation as per Alternative SQSiphon with 631 m minimum elevation level
- Reservoir fertilization in lieu of operations (e.g., Alternative JCAModB)

This operating alternative was endorsed by only one Consultative Committee member, but appeared to have some level of support by all Committee members.

Alternative Spawning C

- Fish water release siphon to provide flows to Jones Creek
- Spawning channel in Jones Creek anadromous to be rebuilt if destroyed by a debris torrent
- Reservoir fertilization in lieu of operations (e.g., Alternative JCAModB)

This operating alternative was supported by half of the Consultative Committee. Consultative Committee members who blocked this operating alternative did not support the 628 m minimum reservoir elevation level or the spawning channel in Jones Creek anadromous.

7.7.2 July Conditional Agreement

Upon further discussion, the Consultative Committee developed Alternative Pump- En631mM$14.3 Cap also referred to as the July Conditional Agreement.

Table 7-9 summarizes the operating conditions of the July 5 Conditional Agreement.

Table 7-9: Operating Conditions for Alternative Pump-En631mM$14.3 Cap

System Component	Condition	Time of Year	Purpose
Reservoir	Minimum elevation 631 m Fertilization program $40,000 per year	Year-round	Jones Lake Reservoir fish and recreation
Jones Creek	AsNeeded flows[1] Fish habitat enhancement project $30,000 per year		Jones Creek fish
Herrling Island Sidechannel	Curtail generation to zero for a two-hour period every twenty-four hours	15 September to 30 November	Avoid fish spawning in high dewatering risk areas in Herrling Island Sidechannel
Revenue	$14.3 million net revenue cap Implement a higher minimum reservoir elevation level if there are funds available after all the proposed conditions are met up to the $14.3 million net revenue cap		

1. Measured at a staff gauge to be installed in Jones Creek near Laidlaw.

The BC Hydro Consultative Committee members specified a $14.3 million net revenue cap for the July Conditional Agreement to limit the risk they were willing to incur to gain the expected benefits.

The facilitator requested that each Consultative Committee member verbally state their degree of support for Alternative Pump-En631mM$14.3 Cap.

Table 7-10 summarizes the level of support for the July Conditional Agreement by Consultative Committee member.

Table 7-10: Preference for July Conditional Agreement

Name	Endorsement	Comments
Ross Neuman	Endorse	I endorse the proposal.
Eric Isaacson	Endorse	I endorse the proposal as outlined in the table discussion.
Frank Kwak	Accept	Accept. I have been assured by everyone on the Consultative Committee, especially Sue Foster, Mike Lewis and Dorell Carlson that if they cannot do 631 m minimum elevation for $14.3 million that we do not have a consensus Water Use Plan and that we will then re-vote and can Block, Accept or Endorse what they come up with for $14.3 million. Only on that condition do I accept. I am afraid that the $14.3 million will be eaten up by pumps and channels etc. and we will wind up with an elevation much lower than 631 m, but this assurance of the above lets me vote accept.
Dan Sneep	Endorse	I endorse the operating alternative. It meets the needs of Jones Creek. I like the fertilization aspect. I understand the desire for a natural reservoir, but it is unfortunate that a performance measure wasn't expressed earlier by which to measure the benefits.

Table 7-10: Preference for July Conditional Agreement (cont'd)

Name	Endorsement	Comments
Tim Peters	Endorse	Endorse. Good for Herrling Island Sidechannel, improvement for Jones Creek, better quality in reservoir for littoral zone equals improvement to wildlife.
Mike Lewis	Endorse	I endorse the (final) operating alternative. This alternative improves fish productivity in lower Jones Creek. It improves fish productivity in the reservoir and it provides a reasonable amount of revenue for the Province. I am concerned about the 631 m reservoir elevation level because there are no measurable or demonstrable benefits that flow from this constraint. I agreed to it to get consensus. I am also concerned about the feasibility and cost of the pumps. This needs to be reviewed in detail. The last issue is that the proposed enhancements to lower Jones Creek are, apparently, unprecedented. There is some uncertainty that they will work.
Dorell Carlson	Endorse	I feel we reached a good balance of values in face of uncertainties that will be investigated. The water down Jones Creek is expected to achieve fish values due to the innovative natural spawning channel proposed. I appreciate Fisheries and Oceans Canada willingness to try to refine the AsNeeded flows. The cap on cost is an important comfort factor. The $440,000 per year revenue/cost trade-off is, I feel, reasonable compared against the performance measure values and the less quantifiable benefits that are anticipated (such as First Nations and others' values) of having a spawning channel.
Russ Knutson	Endorse	I endorse the M$14.3 per year option as presented.
Willy Andrew	Endorse	If these conditions are met the issues have been thoroughly reviewed.
Dean Jones	Endorse	I endorse [this operating alternative] if it's passed. It will be good for fish and for the condition of the lake.

The Consultative Committee conditionally accepted Alternative Pump-En631mM$14.3 Cap as the preferred operating alternative for the Wahleach hydroelectric facility.

All Consultative Committee members agreed to limit their commitment by stating that should Alternative Pump-En631mM$14.3 Cap not be viable, then their acceptance would be withdrawn and the agreement would be considered void.

Alternative Pump-En631mM$14.3 Cap includes a minimum reservoir elevation of 631 m and a fertilization program, estimated to cost $40,000 per year. A number of Consultative Committee members expressed an interest in having Jones Lake Reservoir function more like a natural lake with less deviation from full pool. The Consultative Committee agreed to a minimum reservoir elevation of 631 m under the condition that a higher minimum reservoir elevation level could be considered if funds were available after all the proposed conditions were met in Alternative Pump-En631mM$14.3 Cap up to the $14.3 million net revenue cap when modelling was completed.

The BC Hydro Committee members stated that although they didn't accept the fish benefits associated with the Jones Lake Reservoir fertilization program, they agreed to the program based on the estimated cost of $40,000 per year discussed at the meeting.

Alternative Pump-En631mM$14.3 Cap includes both AsNeeded flows and a fish habitat enhancement project in Jones Creek anadromous. The fish habitat enhancement project incorporates work included in the BC Hydro and Fisheries and Oceans Canada Agreement and additional enhancements to Jones Creek anadromous. The BC Hydro and Fisheries and Oceans Canada Agreement (Sneep, 2002), includes the removal of intake and diversion works associated with the original spawning channel, as well as re-contouring and set-back of existing hardening measures. (Refer to Appendix I: Agreement on Restoration Activities in Lower Jones Creek.) The design will also make contingencies within the existing floodplain for a sidechannel fish habitat enhancement project that would serve both spawning and rearing needs.

The quantity of pink salmon in Jones Creek would likely be significantly increased from currently less than 10 000 fry to over 250 000 fry produced by the fish habitat enhancement project. Increased habitat from the enhancement project is expected to be 2500 m^2, up from 680 m^2 currently. The cost of the fish habitat enhancement project is estimated to cost $30,000 annualized. (Refer to Appendix J: Jones Creek Fish Habitat Enhancement Project.)

The Consultative Committee acknowledged that although the proposed fish habitat enhancement project would be subject to destruction from periodic debris torrents, the Committee supported rebuilding the enhancement project after each event.

Alternative Pump-En631mM$14.3 Cap includes the Herrling Island Sidechannel Operating Protocol which specifies that from 15 September to 30 November, BC Hydro curtail generation for a two-hour period every twenty-four hours. There is no time of day conditions. At all other times, BC Hydro can generate at maximum capacity.

At the conclusion of the July 2002 Consultative Committee meeting, the BC Hydro project team stated that should the agreement not hold, it would prepare the Wahleach Water Use Plan as near as possible to the spirit of this agreement. Consultative Committee members would then be requested to endorse, accept or block the new operating alternative.

7.8 Removal of July Conditional Agreement

Subsequent analysis of the Round 5 July Conditional Agreement by the BC Hydro project team indicated that several of the assumptions for the operational aspects and physical works were inaccurate, and collectively underestimated the costs relative to the benefits as follows:

- The opportunity cost of a minimum reservoir elevation level was understated.

- The annual cost of the pump and associated infrastructure was understated.

  The July Conditional Agreement included a pump estimated to cost \$80,000 annualized. Subsequent analysis estimated the pump to cost \$275,000 annualized which included increased costs for back-up and control systems to address reliability concerns.

- The fish benefits of the AsNeeded flows were overstated.

  The July Conditional Agreement included an AsNeeded flow in Jones Creek to provide for chum and pink salmon spawning, incubation and rearing. However, the costs presented during the Round 5 trade-offs were only for AsNeeded flows for chum and pink salmon for the eight months of September to May for spawning and incubation.

The July Conditional Agreement included a \$14.3 million net revenue cap. Subsequent analysis estimated the net revenue of Alternative Pump-En 631mM\$14.3 Cap at \$13.5 million. Because this difference was large relative to the agreement, BC Hydro re-engaged the Consultative Committee members to try and develop new operating alternatives that would be acceptable to the Committee.

In October 2002, the Fish Technical Subcommittee met to define AsNeeded flows for Jones Creek and Jones Lake Reservoir elevation levels. After considering three options, the Fish Technical Subcommittee recommended AsNeeded flows be defined as those providing for Salmon Spawning, Incubation and Rearing (SalmonSIR). The SalmonSIR AsNeeded flow regime specifies a target minimum flow of 1.1 m^3/s flow from 15 September to 30 November, and 0.6 m^3/s at all other times, measured at a staff gauge to be installed in Jones Creek at Laidlaw. The cost of providing the AsNeeded flow was reduced by not including flows for steelhead trout. At this time, the Fish Technical Subcommittee acknowledged that steelhead trout was not found in the system, that steelhead spawning habitat was not limited, and that rearing habitat did not vary across the operating alternatives.

Figure 7-14 illustrates the SalmonSIR AsNeeded flow regime. The blue area is the daily median Jones Creek inflow, and the purple area is the additional flow needed to be released into Jones Creek to meet the constraints specified.

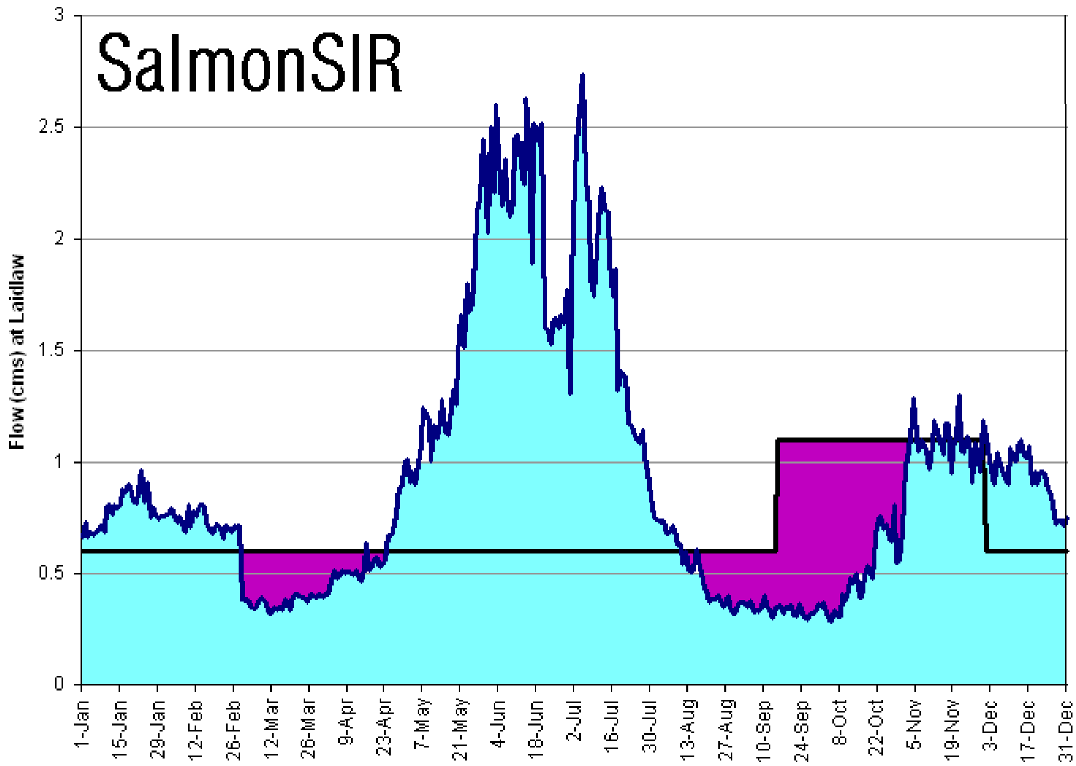

Figure 7-14: SalmonSIR AsNeeded Flow Regime in Jones Creek

In Round 5 operating alternatives, three minimum reservoir elevations 623 m, 628 m and 631 m were modelled. Based on information contained in a report produced by Chris Perrin which reviewed the Jones Lake Reservoir fertilization program in 1996, the Fish Technical Subcommittee expressed concern that 623 m could lead to a catastrophic loss of fish populations in Jones Lake Reservoir (Perrin, 2000).

The Fish Technical Subcommittee suspected that Boulder Creek flows may be insufficient to fully meet the Jones Creek SalmonSIR AsNeeded flows in August and September. Therefore, it was proposed the fish water release siphon be used during these months to supplement flows in Jones Creek if necessary. Providing flows in this manner was referred to as “BCD+Siphon.”

To ensure fish access in Boulder Creek, the operating alternatives modelled specified a minimum flow of a 10 per cent of Mean Annual Discharge in Boulder Creek at all times. Provision of flows to Boulder Creek takes priority over AsNeeded flows to Jones Creek.

Some members of the Fish Technical Subcommittee recommended increasing the cost of the reservoir fertilization program from $40,000 to $100,000. The incremental $60,000 was initially proposed for a monitoring program. However, upon further discussion, it was determined that the additional funds were for reporting and analysis of the fertilization program, and thus, were a component of the overall program. However, the Fish Technical Subcommittee acknowledged that the implementation component of the fertilization program could potentially be reduced over time.

Given the installation of a pump at Wahleach Dam was now estimated to cost $275,000 annualized, a number of options were reviewed to provide flows to Jones Creek at a reduced cost. The BC Hydro project team proposed an option that included reconfiguration of the Boulder Creek Diversion Dam using some form of weir (such as a Tyrolean Weir) to divert AsNeeded flows from Boulder Creek into Jones Creek. A Tyrolean Weir is a low-impact means of diverting water. Water entering the weir from Boulder Creek would be diverted to the reservoir, but some water would pass through holes or ridges in the weir to a duct below, diverting water to Jones Creek. Fish cannot pass into the duct, and provision could be made to ensure fish passage over or around the weir. Flow in the duct is controlled by a control valve. The Tyrolean Weir was estimated to cost $150,000 annualized. (Refer to Appendix K: Reconfiguration of Boulder Creek Diversion Dam.)

7.9 Round 6 Trade-offs

In October 2002, the Consultative Committee reconvened to review four new operating alternatives that were developed by the BC Hydro project team in consultation with Consultative Committee members:

- Alternative SalmonSIR628 Pump
- Alternative SalmonSIR631 Pump
- Alternative SalmonSIR628 BCD+Siphon
- Alternative SalmonSIR631 BCD+Siphon

The new operating alternatives included a minimum flow release from the Boulder Creek Diversion Dam, a James Lake Reservoir minimum elevation level, the Jones Lake Reservoir fertilization program, a Jones Creek minimum flow, a Jones Creek fish habitat enhancement project, and curtails generation to zero for a two-hour period every twenty-four hours.

Prior to conducting the trade-off analysis, Mike Lewis, one of the BC Hydro Committee members requested that the Consultative Committee explicitly:

- Confirm that it is aware of the opportunities for improvements to fish populations in Herrling Island Sidechannel relative to Jones Creek.
- Acknowledge the opportunities for improvements to fish populations in Herrling Island Sidechannel would result in an overall improvement to fish populations in the Wahleach system.
- Acknowledge the quality of habitat in Jones Creek would not improve for decades.
- Is consciously rejecting opportunities for improvements to fish populations in Herrling Island Sidechannel in favour of opportunities for improvements to fish populations in Jones Creek.

To illustrate his point, Mike Lewis used the following (Table 7-11) to illustrate the benefits associated with Alternative SQSiphon combined with the Jones Creek and Herrling Island Sidechannel fish habitat enhancement projects and a reservoir fertilization program. The performance measures indicate the proposed operating alternative could result in higher overall fish populations in the Wahleach system (2.67 million fry) and considerably higher revenue ($14.58 million). In other words, the performance measures indicate that increases to fish populations in the Wahleach system would result by focusing flows in Herrling Island Sidechannel rather than in Jones Creek.

Table 7-11: Comparison of Fry Production and Costs

Alternative	Net Revenue ($millions)	Number of Fry (millions)[1]	Revenue Compared to SQSiphon ($ millions)	Increase in Number of Fry Compared to SQSiphon (millions)	Incremental $ per Fry Compared to SQSiphon
SalmonSIR623	14.12	2.14	0.51	0.22	2.318
SalmonSIR628	13.99	2.17	0.64	0.25	2.560
SalmonSIR631	13.78	2.17	0.85	0.25	3.400
SQSiphon + Jones Creek Enhancement[2]	14.63	1.92	0	0	
SQSiphon + Jones Creek Enhancement + Herrling Island Sidechannel Enhancement[3]	14.58	2.67	0.05	0.75	0.067

1. Number of pink and chum fry only.
2. Jones Creek Fish Habitat Enhancement: $30,000 per year.
3. Herrling Island Sidechannel Fish Habitat Enhancement: $50,000 per year assumed to produce the same number of fish as the Jones Creek enhancement.

Upon completion of Mike Lewis' presentation, the facilitator requested that each Consultative Committee member verbally state their preference to focus flows in Herrling Island Sidechannel, or in Jones Creek.

Although some Consultative Committee members expressed reservations about focusing flows in Jones Creek, the Committee as a whole chose to stand by its earlier decision. Previously, the Consultative Committee expressed an interest in providing adequate flows to Jones Creek anadromous in recognition of the historically productive and natural habitat that previously existed for a variety of fish species.

The Consultative Committee agreed to target the large benefits that could be made to the small number of fish in Jones Creek rather than the small benefits that could be made to the large number of fish in Herrling Island Sidechannel. The primary reasons cited for doing so emphasized:

- The poor conditions for fish populations in Jones Creek should be corrected.
- The Consultative Committee's commitment to "not write off" fish in Jones Creek.

Table 7-12 summarizes the consequence table for Round 6 trade-offs. (Refer to Appendix L: Round 6 Operating Alternatives Performance Measure Charts.)

Table 7-12: Consequence Table for Round 6 Trade-offs

					Alternatives						
					1	2	3	6	7	8	9
Objective / Location	**Performance Measure**	**Units**	**What's Good**	**Min. Significant Increment of Change**	**July - AllSI631**	**SSIR628 Pump**	**SSIR631 Pump**	**SSIR628 BCD + Siphon**	**SSIR631 BCD + Siphon**	**SQ Siphon**	**SQ Licence**
					Median	Median	Median	Median	Median	Median	Median
Recreation											
	Rec Quality (el. > 638.6m)	days	more	5%	93	86	92	86	92	71	112
	Spill Safety Risks (# spill days)	days	less	5%	0	0	0	0	0	0	19
Annual Revenue											
	Annual Revenue	$m / yr	more	5%	13.93	14.34	14.12	14.36	14.15	14.70	13.47
	Levelized Costs	$m / yr	less	5%	0.41	0.41	0.41	0.28	0.28	0.00	0.00
	Net Annual Revenue	$m / yr	more	5%	13.52	13.93	13.72	14.08	13.87	14.70	13.47
Fish - Jones Creek											
	NA - Viable habitat - Q>10% MAD	days/year	more	20%	0	0	0	0	0	19	24
	Anad - Spawning - ST	WUA (sq m)	more	20%	3,280	2,551	2,563	2,531	2,531	1,253	1,244
	Anad - Spawning - CM	WUA (sq m)	more	20%	1,720	1,720	1,720	1,292	1,292	164	164
	Anad - Spawning - PK	WUA (sq m)	more	20%	800	800	800	800	800	623	620
	Anad - Spawning - Ave	WUA (sq m)	more	20%	1,933	1,690	1,694	1,541	1,541	680	676
	Anad - Rearing - ST Fry	WUA (sq m)	more	20%	2,626	2,838	2,838	2,846	2,846	2,507	2,473
	Anad - Rearing - ST Parr	WUA (sq m)	more	20%	3,859	4,233	4,233	4,231	4,231	3,372	2,944
	Anad - Stranding Q<0.6cms	Days Q<0.6 cms due to Ops	less	20%	2	0	0	2	2	14	14
	Anad - Stranding Q<15.3cms	Days Q<15.3 cms due to Ops	less	20%	1	1	1	1	1	1	2
Fish - Reservoir											
	Littoral Productivity	Ann Cum Area (000 sq m)	more	20%	1,684	1,438	1,677	1,438	1,677	1,826	15,469
	Entrainment	Risk (0-1 scale)	less	20%	0.38	0.42	0.38	0.42	0.38	0.50	0.21
	Pelagic - Risky Days	# days/year	less	20%	0	0	0	0	0	0	0
	Pelagic - Productivity	Ave Daily Volume (million m3)	more	20%	21	20	20	20	20	16	24
	Pelagic - Standard Deviation	STD in Volume (million m3)	less	20%	7	8	7	8	7	7	5
Fish - Herrling Sidechannel											
	Spawning - ST - Habitat Area	WUA (sq m)	more	20%	12,785	13,181	12,921	13,181	12,921	13,587	12,736
	Spawning - CM - Habitat Area	WUA (sq m)	more	20%	5,982	5,982	5,982	5,982	5,982	6,128	5,922
	Spawning - PK - Habitat Area	WUA (sq m)	more	20%	26,197	26,197	26,197	26,197	26,197	27,410	25,072
	Spawning - Average Sp	WUA (sq m)	more	20%	14,988	15,120	15,033	15,120	15,033	15,708	14,577
	Rearing - ST Fry Habitat Area	WUA (sq m)	more	20%	11,455	11,455	11,455	11,455	11,455	11,625	11,364
	Rearing - ST Parr Habitat Area	WUA (sq m)	more	20%	9,489	9,489	9,489	9,489	9,489	9,635	9,411
	Rearing Average	WUA (sq m)	more	20%	10,472	10,472	10,472	10,472	10,472	10,630	10,388
Wildlife											
	Wetted Area	Area (000 sqm)	more	20%	3,481	2,848	3,498	2,848	3,498	2,286	4,271
	Sedge-Grass	Area (000 sqm)	more	20%	1,332	2,098	1,317	2,098	1,317	2,314	624
	Sedge-Willow	Area (000 sqm)	more	20%	203	223	208	223	208	257	41
	Wildlife Weighted Average	Area (000 sqm)	more	20%	2,124	2,004	2,130	2,004	2,130	1,786	2,302
Flood											
	Days when Confluence >200 cms	Total over 40 years	less	10%	0	0	0	0	0	0	0
GHG											
	GHG inc relative to SQ License	kTCO2e / yr	less	5%	-4.0	-6.7	-5.2	-6.7	-5.2	-7.7	0.0

Notes: Performance Measures do not include the positive effects of the fertilization program, the Herrling Island Sidechannel Operating Protocol or Jones Creek fish habitat enhancement project. Levelized Costs are for physical changes: Boulder Creek Diversion Dam flow release infrastructure $150,000; Jones Creek fish habitat enhancement project $30,000; and Jones Lake Reservoir fertilization program $100,000.

7.9.1 Alternatives SSIR628Pump and SSIR631Pump with SSIR628BCD+Siphon and SSIR631BCD+Siphon

The Consultative Committee evaluated the performance of the operating alternatives that utilized a pump at Wahleach Dam versus a reconfigured Boulder Creek Diversion Dam to deliver flows to Jones Creek.

Alternatives SSIR628Pump and SSIR631Pump perform better than Alternatives SSIR628BCD+Siphon and SSIR631BCD+Siphon by:

- Increase of 25 per cent in Jones Creek Fish Anadromous Chum Salmon Habitat. All other listed species and life stages are unaffected.

Alternatives SSIR628BCD+Siphon and SSIR631BCD+Siphon perform better than Alternatives SSIR628Pump and SSIR631Pump by:

- Increase in Net Revenue of $150,000.

Alternatives SSIR631Pump and SSIR631BCD+Siphon perform better than SSIR628Pump and SSIR628BCD+Siphon by:

- Increase in Jones Lake Reservoir Fish Littoral Productivity from 1 400 000 to 1 700 000 cumulative m^2 per year relative to 83 million m^2 in Alternative JCAModB.

In summary, the Boulder Creek Diversion Dam and fish water release siphon approach does not perform as well as the pump approach for Jones Creek anadromous fish. However, the Boulder Creek Diversion Dam and siphon approach results in $150,000 greater net revenues per year compared to the pump approach.

The operating alternatives that maintain a minimum Jones Lake Reservoir elevation level of 631 m result in 300 million m^2 greater littoral productivity compared to alternatives that maintain a minimum reservoir elevation level of 628 m. A reservoir fertilization program would likely exceed such gains by several orders of magnitude. Some Consultative Committee members preferred a minimum reservoir elevation level of 631 m over 628 m as they believed it provided benefits associated with a natural lake system not captured in the performance measures.

Some Consultative Committee members preferred the Boulder Creek Diversion Dam and weir approach, despite the reduced performance measure values for chum salmon spawning, given the concerns regarding the pump reliability.

At this time, the Consultative Committee member for the Fraser Valley Salmon Society rejected all the current operating alternatives, reiterating his preference for Alternative JCAModB. He felt that the fish interests had already conceded too much. He also expressed doubts about the legality of not being able to provide sufficient flows for fish to Jones Creek via the Boulder Creek Diversion Dam reconfiguration approach.

The Consultative Committee agreed to eliminate Alternatives SSIR628Pump and SSIR631Pump as they were considered inferior to Alternatives SSIR628BCD+Siphon and SSIR631BCD+Siphon.

7.10 Round 6 Degree of Consensus

The facilitator requested that each Consultative Committee member verbally state their degree of support for Alternatives SSIR628BCD+Siphon and SSIR631BCD+Siphon.

Table 7-13 summarizes the level of support for Alternatives SSIR628BCD+Siphon and SSIR631BCD+Siphon by Consultative Committee member.

Table 7-13: Preference for SalmonSIR BCD + Siphon Operating Alternatives

Consultative Committee Member	Organization	SSIR628BCD + Siphon	SSIR631BCD + Siphon
Ross Neuman	Ministry of Water, Land and Air Protection	Accept	Accept
Steve Macfarlane	Fisheries and Oceans Canada	Accept	Accept
Edith Grainger	Local resident	Endorse	Accept
Eric Isaacson	Local resident	Endorse	Accept
Frank Kwak	Fraser Valley Salmon Society	**Block**	**Block**
Tim Peters	Stó:lō Nation	Accept	Accept
Jim Harris	Seabird Island First Nation	Accept	Accept
Russ Knutson	Chilliwack Forest District	Accept	Accept
Mike Lewis	BC Hydro	Accept with Condition	**Block**
Dean Jones	Shxw'ow'hamel First Nation	Accept	Accept

The Consultative Committee accepts, with one exception, Alternative SSIR628BCD+Siphon for the Wahleach hydroelectric facility. The recommended operating alternative includes a minimum flow release from the Boulder Creek Diversion Dam, a Jones Lake Reservoir minimum elevation level, a Jones Lake Reservoir fertilization program, a Jones Creek

minimum flow, a Jones Creek fish habitat enhancement project, and curtails generation to zero for a two-hour period every twenty-four hours.

Given concerns related to the quality of inflow data for Boulder Creek, the Consultative Committee recommends that BC Hydro begin monitoring Boulder Creek inflows and Jones Creek anadromous fish habitat productivity immediately, before the implementation of the Wahleach Water Use Plan.

The BC Hydro Consultative Committee members' acceptance of Alternative SSIR628BCD+Siphon was conditional on resolution of the extent of the reservoir fertilization program. Subsequent to the October 2002 Consultative Committee meeting, in discussions between BC Hydro and the Ministry of Water, Land and Air Protection Committee member, the reservoir fertilization program was confirmed to cost $80,000 with a review after five years.

While inflow data for the Jones Lake Reservoir has been recorded for 40 years, inflow data for the Boulder Creek watershed was synthetically developed for the Wahleach water use planning process. Based on this synthetic data, modelling indicates that Boulder Creek inflows should be sufficient to provide the SalmonSIR AsNeeded flows to Jones Creek. However, if the synthetic Boulder Creek inflow data is over estimated, then the Boulder Creek Diversion Dam weir approach may not be as desirable to some Consultative Committee members.

Therefore, the Consultative Committee agreed that a temporary Boulder Creek Diversion Dam structure be put in place until it is determined whether sufficient flows are available from Boulder Creek. Five years after implementation of the Wahleach Water Use Plan, the Boulder Creek inflows will be assessed to determine whether they are sufficient. If the Boulder Creek inflows are deemed to be sufficient, then a permanent Boulder Creek Diversion Dam structure will be constructed.

Table 7-14 summarizes the recommended operating conditions for the Wahleach hydroelectric facility.

Table 7-14: Recommended Operating Conditions for the Wahleach Hydroelectric Facility

System Component	Condition	Time of Year	Purpose
Boulder Creek	Minimum flow of 0.14 m^3/s	Year-round	Fish passage above the bypass
Jones Lake Reservoir	Minimum elevation 628 m Fertilization program: $40,000 per year for fertilizer application $40,000 per year for reporting and analysis[1]	Year-round	Jones Lake Reservoir fish and recreation
Lower Jones Creek	Minimum flows: [2] 1.1 m^3/s 0.6 m^3/s Fish habitat enhancement project	15 September to 30 November All other times	Jones Creek fish
Herrling Island Sidechannel	Curtails generation to zero for a two-hour period each day	15 September to 30 November	Avoid fish spawning in high dewatering risk areas in Herrling Island Sidechannel

1. Fertilization program to be reviewed after five years to determine whether costs could be reduced.
2. Subject to available inflows and augment sources from the Boulder Creek bypass valve and the fish water release siphon. Measured at a staff gauge to be installed in Jones Creek near Laidlaw.

7.10.1 Consultative Committee Comments on Preferred Alternative

Table 7-15 summarizes written comments provided by a number of Consultative Committee members at the conclusion of the October 2002 Consultative Committee meeting or shortly after.

Table 7-15: Consultative Committee Comments on Preferred Alternative

Participant	Comment
Steve Macfarlane	I ACCEPT both SSIR options (El. 628 m, El. 631 m). • I believe both options represent significant progression towards a consensus solution by fish interests with little movement by BC Hydro. • There is high risk in both cases to the ability to meet downstream flows. • I am disappointed by the immobility of BC Hydro (organization-wide) to get over the baggage associated with fertilization and evaluation. It almost broke down the process. • Having the lake at El. 631 m would be better making the lake look more natural. Losing 6 days isn't so bad, 200 000 is not that much compared to 13 900 000. There doesn't seem to be that much difference so lets go for more water in the lake which is better for fish.

Table 7-15: Consultative Committee Comments on Preferred Alternative (cont'd)

Participant	Comment
Ross Neuman	Accept both SSIR628 BCD + Siphon and SSIR631 BCD + Siphon, with a $100,000 reservoir fertilization program. These two options result in a huge reduction in fisheries values from the preferred fisheries option (JCAMod B) and a significant reduction from the July conditional consensus agreement. However, in the interest of reaching agreement (hopefully consensus) I am willing to accept either 631 m or 628 m. Steelhead spawning is significantly reduced July agreement to 628 m (23%) but the amount of habitat required to seed the stream is likely exceeded by 628 m. Chum spawning reductions from the July agreement (25%) are more serious given the greater numbers of chum spawners in the system and the lack of a rearing requirement for chum (i.e., spawning is limiting, not rearing). Littoral productivity decreases (17%) from the July agreement to 628 m are almost certainly biologically significant. These are partially off-set by the fertilization program, however, reservoir fertilization was also a part of the July agreement. I prefer 631 m over 628 m. My reasons are: • The 16% increases in littoral productivity (from 628 m to 631 m) are almost certainly biologically significant. • Pelagic productivity is increased by 5%. While this increase is not as dramatic as littoral productivity increases and likely difficult to measure with fertilization, the difference does exist. 631 m results in greater reservoir stability (less deep drawdowns) which is preferable for aquatic ecosystem health.
Edith Grainger	I ENDORSE the lake level of El. 628 m. This provides reliable hydro production plus provides recreation/fishing. I ACCEPT the lake level of El. 631 m. • There is LESS hydro productivity with this option. Hopefully there will be more recreation/fishing.
Russ Knutson – Chilliwack Forest District **7 October 2002**	I ACCEPT the consensus agreements (recommendations) of today's Water Use Plan meeting, this date.
Eric Isaacson	I ENDORSE El. 628 m because BC Hydro has been operating at that lowest level for years, also the additional revenue of $200,000, compared to El. 631 m = 6 more recreational days is not an economic trade off. After 2 years, we have come down to 2 choices. I ACCEPT El. 631 m as second choice.

8 MONITORING PROGRAM

In addition to recommending a preferred operating alternative for the Wahleach hydroelectric facility, the Consultative Committee recommended a monitoring program designed to address key uncertainties and answer specific questions that may change future decisions on operations. This section describes the Wahleach Water Use Plan monitoring studies, and the criteria used to evaluate them for eligibility under the Water Use Plan Program.

8.1 Proposed Monitoring Studies

At the final Consultative Committee meeting on 7 October 2002, the proposed monitoring program, as summarized in Table 8-1, was discussed. A description of each monitoring study is included, along with the uncertainty being addressed, operational implications, study length, study certainty and total estimated cost. The Consultative Committee evaluated the monitoring studies listed in the table for eligibility under the Water Use Plan Program. (Refer to Appendix M: Eligibility Criteria for Water Use Plan Monitoring Studies.)

8.2 Purpose of Eligibility Criteria for Water Use Plan Monitoring Studies

The Water Use Plan Management Committee developed principles and criteria for screening monitoring programs and the component studies. In the face of uncertainty about the relationship between changes in operation and biological response in the Wahleach hydroelectric facility, a monitoring program is intended to:

1. Assess the effectiveness of the operational changes for the Wahleach hydroelectric facility relative to water use objectives.
2. Assess compliance of BC Hydro with the authorized Water Use Plan for the Wahleach hydroelectric facility.

In the Wahleach water use planning process, the expected biological response in Jones Lake Reservoir, Jones Creek and Herrling Island Sidechannel under the recommended operating alternative, represents the best judgment of Consultative Committee members based on the available information. For instance, the recommended alternative specifies a flow regime in Jones Creek. This in turn is expected to maximize the effective fish spawning habitat area, maximize the rearing habitat and minimize stranding risk in Jones Creek. A monitoring study provides the opportunity to assess how well the recommended operating alternative achieves the ends objective to maximize fish populations in Jones Creek anadromous. Therefore, a monitoring study can provide better data for future decision making and reduce the uncertainty around the biological response to changes in operations.

Table 8-1: Information Matrix for Water Use Plan Monitoring Requests

I	II	III	IV	V	VI	VII	VIII	IX
Study (Water Use Plan, Title of Study, Interest Area)	**Description**	**Data Gap Addressed (list the issue, the competing hypotheses, and the estimates of the probability of these competing hypotheses being true)**	**Amount of learning expected through monitoring (high, medium or low)**	**Estimated Duration of Study Program**	**State the time frame in which this information will be used: before the next Water Use Plan, during the next Water Use Plan, after the next Water Use Plan**	**Estimated Cost (including lost power values)**	**Willingness of Consultative Committee to change water allocation (high, medium, or low)**	**Rating of Study**
Jones Creek Anadromous: Salmonid Productivity Monitoring	Monitor the fish production response to flow/habitat changes in the anadromous reach of Jones Creek	H_0: Changes to minimum flows will not change the productivity of the target species	High	10 years	Initial Data Review: 5 years Final Review: 10 years	$120K per year	High	High
Jones Creek Anadromous: Channel Stability Assessment	Monitor the effect of flow levels and channel migration on chum and pink egg survival	H_0: Changes to minimum flows will not change the spawning success of target species	Medium	10 years	Initial Data Review: 5 years Final Review: 10 years	$8K per year	High	High
Jones Creek Anadromous: Pink Salmon Genetic Composition Assessment	Determine the genetic origin of Jones Creek pink salmon to determine stock status.	H_0: Pink salmon spawners in Jones Creek are strays from the Fraser River run.	Medium	2–4 years	After Review period	$0	Medium	Medium
Wahleach Reservoir: Entrainment Monitoring	Opportunistically inspect tunnel dewatering and spillway outlets for stranded/entrained fish.	H_0: Wahleach spillway and generating station operations do not entrain fish.	10 years	Low	After Review Period	$0	Low	Low–Medium
Herrling Island Sidechannel: Chum Salmon Spawning Behaviour Observations	Monitor spawning habitat use to determine the extent and success of spawners in the sidechannel, and effectiveness of plant operations in mitigating egg stranding.	H_0: Wahleach Generating Station operations do not affect spawning success in the sidechannel	Medium	5–10 years	After Review Period	$35K per year	High	High

8.3 Eligibility of Proposed Monitoring Studies

The proposed monitoring studies were evaluated using the Eligibility Criteria for Water Use Plan Monitoring Studies. The eligibility criteria state that a monitoring program should:

1. Provide information that will help in deciding the best use of water.
2. Have sufficient statistical power to distinguish between operating alternatives (current operations versus preferred operating alternatives) in achieving the Wahleach Water Use Plan objectives.
3. Provide results in a timely manner.
4. Be cost effective.

These criteria can be summed up as efficacy, sensitivity, timeliness and cost effectiveness. Monitoring studies satisfying these criteria are eligible under the Wahleach Water Use Plan.

When the proposed monitoring studies were evaluated, the following studies satisfied the eligibility criteria:

- Jones Creek Anadromous: Salmonid Productivity Monitoring
- Jones Creek Anadromous: Channel Stability Assessment
- Jones Creek Anadromous: Pink Salmon Genetic Composition Assessment
- Wahleach Reservoir: Entrainment Monitoring
- Herrling Island Sidechannel: Chum Salmon Spawning Behaviour Observations

For each of the monitoring studies listed above, a detailed Terms of Reference will be developed once the Comptroller of Water Rights directs BC Hydro to implement the Wahleach Water Use Plan. (Refer to Appendix N: Monitoring Program and Non-Operational Physical Works.)

Table 8-2 summarizes the costs of the recommended monitoring studies.

Table 8-2: Monitoring Program Summary of Costs

Area	Study	Study Component	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Jones Creek Anadromous	Salmonid Productivity Monitoring	Fall Spawner Enumerations[1]	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20
		Fry Outmigration Enumeration[1]	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35
		Spring Spawner Enumeration[2]	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15
		Smolt Enumeration[2]	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35
		Annual Productivity Reporting	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15
	Channel Stability Assessment	Transect Resurveying	$ –	$ –	$ 10	$ –	$ –	$ 10	$ –	$ –	$ 10	$ –
		Egg Stranding/Flow Analysis	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5
	Pink Salmon Genetic Composition Assessment		$ –	$ –	$ –	$ –	$ –	$ –	$ –	$ –	$ –	$ –
Jones Lake Reservoir	Entrainment Monitoring		$ –	$ –	$ –	$ –	$ –	$ –	$ –	$ –	$ –	$ –
Herrling Island	Chum Spawning Behaviour	Flow monitoring and analysis	$ 15	$ –	$ –	$ –	$ –	$ –	$ –	$ –	$ –	$ –
		Spawning Observations[3]	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20
Total			**$ 160**	**$ 145**	**$ 155**	**$ 145**	**$ 145**	**$ 155**	**$ 145**	**$ 145**	**$ 155**	**$ 145**

1. Most effort spent on pink (odd-year) runs.
2. Costs and approach will depend on steelhead abundance and habitat use.
3. Data collected up to year five will be used to evaluate the Wahleach Operating Protocol, and a decision will be made to test a new protocol or not.

8.4 Monitoring Advisory Committee

The Consultative Committee recommended that a Monitoring Advisory Committee is established consisting of representatives of:

- BC Hydro
- Community representative
- First Nations
- Fisheries and Oceans Canada
- Fraser Valley Salmon Society
- Ministry of Water, Land and Air Protection

The Consultative Committee recommended that the mandate of the Wahleach Water Use Plan Monitoring Advisory Committee should be to:

- Manage the implementation of the fish habitat enhancement project in Jones Creek anadromous.
- Review annual monitoring program results and assess the need to recommend a review of the Wahleach Water Use Plan.
- Recommend improvements to the monitoring program within existing Wahleach Water Use Plan budgets.
- Support periodic communication with the public (e.g., newsletter, annual reports).
- Ensure publication of monitoring program reports.
- Nurture co-operation and collaboration to improve the environmental database and to build common understanding (ongoing).

9 IMPLEMENTATION OF RECOMMENDATIONS

The operational changes, the physical works, and the monitoring program recommended by the Consultative Committee will be implemented once the provincial government of British Columbia has approved the Wahleach Water Use Plan.

Once BC Hydro is directed to implement the Wahleach Water Use Plan, design and construction of the Boulder Creek Diversion Dam reconfiguration and the Jones Creek fish habitat enhancement project will be initiated. Fertilization of Jones Lake Reservoir and the operating constraints will be implemented when the new physical plant is constructed and operational.

The Comptroller of Water Rights will review the recommended Wahleach Water Use Plan under provisions of the provincial *Water Act* and will involve First Nations, Fisheries and Oceans Canada, provincial agencies and holders of water licences who might be affected by the changes.

At the October 2002 Consultative Committee meeting, the Committee recommended that BC Hydro begin monitoring Boulder Creek inflows and Jones Creek anadromous fish habitat productivity immediately, before the implementation of the Wahleach Water Use Plan.

A staged approach to implementation will allow for the collection of critical Boulder Creek inflow information to confirm expected benefits and improve future decision-making.

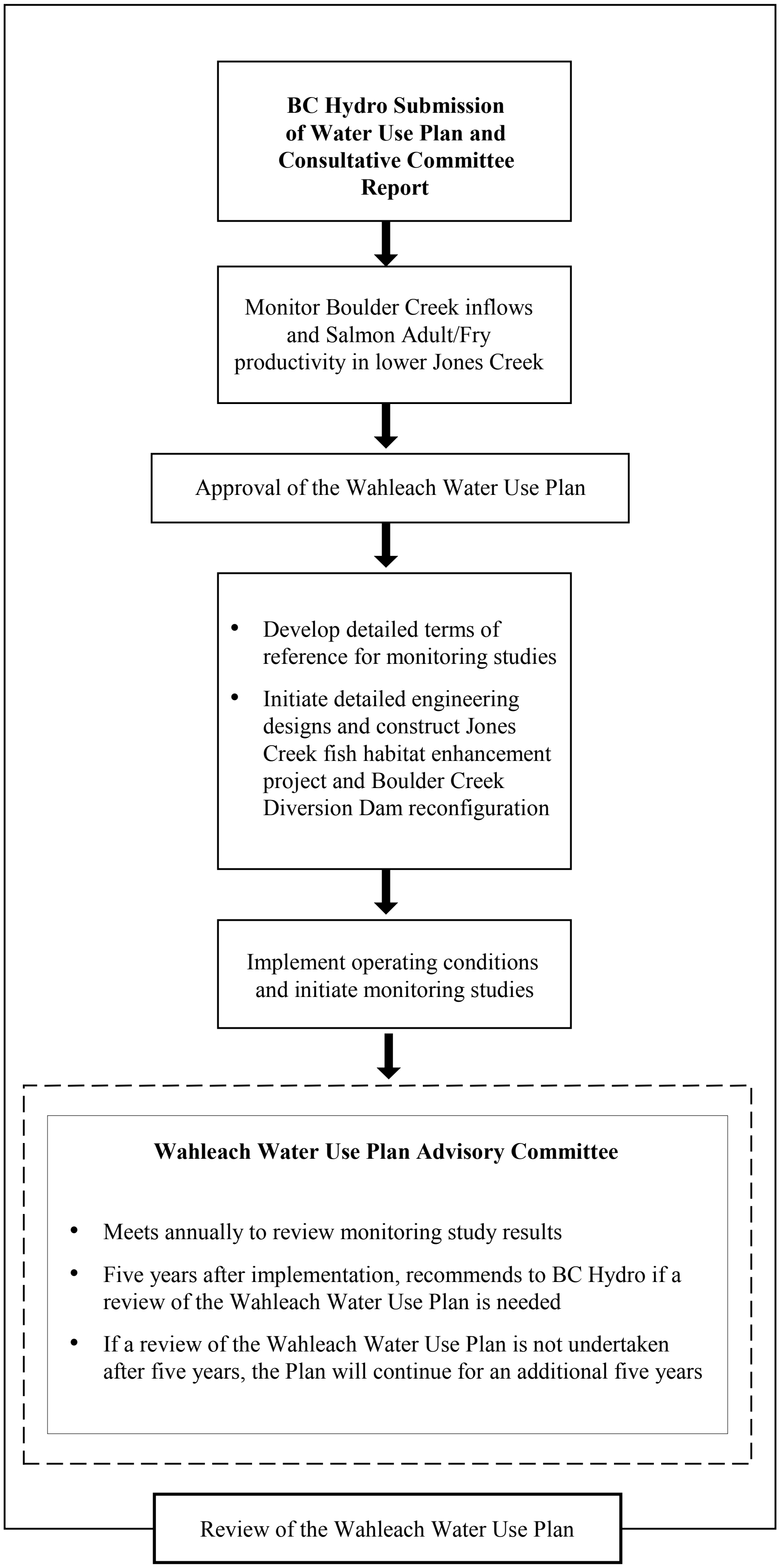

Figure 9-1: Next Steps

10 REVIEW PERIOD

The Consultative Committee recommended that five years after the implementation of the Wahleach Water Use Plan, the Monitoring Advisory Committee will review the results of the monitoring program and assess the need to recommend to BC Hydro a review of the Wahleach Water Use Plan. Alternatively, if the monitoring program study results suggest that a review of the Wahleach Water Use Plan is not needed, the Monitoring Advisory Committee can recommend that a review take place ten years after implementation of the Plan. At this time, the Monitoring Advisory Committee will also review the Boulder Creek flows and the Jones Lake Reservoir fertilization program.

At the earliest, the next review of the Wahleach Water Use Plan will be five years after implementing the Plan.

10.1 Decision Process for Review

Figure 10-1 illustrates the decision process to determine the Wahleach Water Use Plan review period.

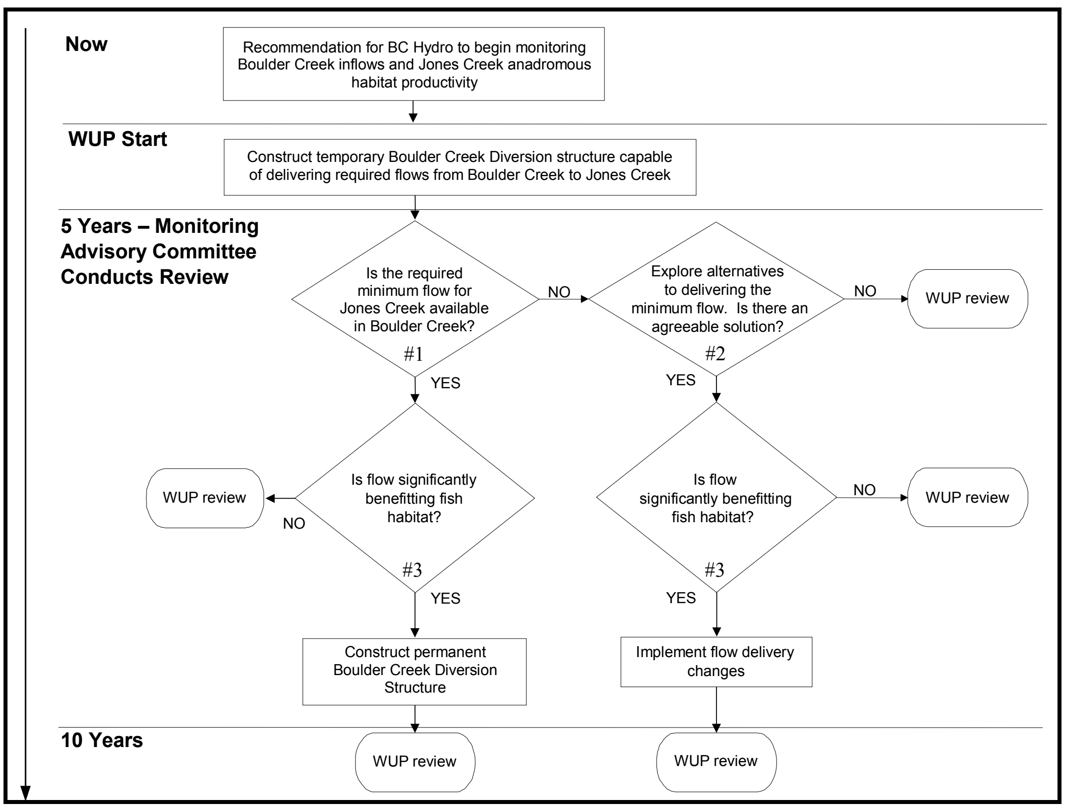

Figure 10-1: Decision Process for Wahleach Water Use Plan Review

Now

The Consultative Committee recommends that BC Hydro begin monitoring Boulder Creek inflows and Jones Creek anadromous fish habitat productivity immediately, before the implementation of the Wahleach Water Use Plan.

Water Use Plan Start

Once the Wahleach Water Use Plan is approved by the Comptroller of Water Rights, the following activities will be undertaken:

- Develop detailed terms of reference for the monitoring studies, construct Jones Creek fish habitat enhancement project and initiate detailed engineering designs for the Boulder Creek Diversion Dam reconfiguration project.
- Once the Jones Creek fish habitat enhancement project and the temporary Boulder Creek Diversion Dam project is constructed, implement operational constraints, reservoir fertilization program and monitoring studies.

Five Years

The Monitoring Advisory Committee will review the Jones Lake Reservoir fertilization program to determine whether the cost could be reduced.

The Monitoring Advisory Committee will review the following sequential criteria and assess the need to recommend a review of the Wahleach Water Use Plan. It is recognized that there may not be enough information at this time to properly review the following criteria.

Criteria #1: Assess Boulder Creek flows into Jones Creek. Are they sufficient?

If yes, go to Criteria #3. If no, go to Criteria #2.

- *Performance Measure a) Bypass Performance:* for Years 1 through 5, has the Boulder Creek bypass met the fisheries target values prescribed in the Water Use Plan; if not, by how much and how often? The following criteria are to be measured in Jones Creek at the Laidlaw Bridge (800 m upstream of the confluence with the Fraser River):
    - C1 Incubation Flows: Bypass delivery needs to provide effective and consistent incubation flows (0.6 m^3/s-1) for pink and chum salmon from 1 December to 30 April.
    - C2 Critical Period Flows: Bypass delivery needs to enhance flows for rearing (0.6 m^3/s-1) from 1 May to 15 September.

- C3 Salmon Spawning Flows: Bypass delivery needs to enhance flows for salmon spawning (1.1 m^3/s-1) from 15 September to 30 November.

Criteria #2: Explore alternative flow delivery mechanisms. Is there an agreeable alternative?

If yes, go to Criteria #3. If no, Wahleach Water Use Plan review triggered.

Adjustments to the flow delivery mechanism could be considered up to the cost estimate for the Boulder Creek Diversion Dam as per the recommended operating alternative. It is anticipated that BC Hydro will recommend an approach for the Monitoring Advisory Committee to review and approve prior to implementation.

Criteria #3: Assess Jones Creek fish habitat response. Has there been a significant response?

If yes, continue Wahleach Water Use Plan for an additional five years. If no, Wahleach Water Use Plan review triggered.

- *Performance Measure b) Productivity*: Was salmon/steelhead productivity in Jones Creek improved by the flow regime?

  - C1 *Fry and Smolt Production*: Expect an increase in fry and smolt production over current if minimum flow requirements are met. Requires two years of base flow monitoring, plus five years of treatment monitoring. Due to the limited review period, directional changes in productivity are the only criteria being evaluated.

  - C2 *Egg to Fry Survival*: Expect an increase in egg survival as a result of increased flows and incubation success. As above, directional changes in spawning success are the only criteria being evaluated.

Adult returns will not be an appropriate measure considering the extended life histories of salmon and steelhead using Jones Creek, and the shortened review period proposed.

Ten Years

If the Wahleach Water Use Plan is not reviewed five years after implementation, then the Plan will continue for an additional five years.

10.2 Water Use Plan Review Triggers

Upon implementation of the Wahleach Water Use Plan, in the event of a major debris torrent, the Monitoring Advisory Committee may recommend a review of the Wahleach Water Use Plan to BC Hydro.

11 SUMMARY OF DECISIONS AND OUTCOMES

The Wahleach Water Use Plan Consultative Committee, made up of representatives of First Nations, federal and provincial agencies, local residents and BC Hydro explored a wide range of operating alternatives for the Wahleach hydroelectric facility. They explored impacts to culture and heritage, fish, power, wildlife, recreation, flooding and water quality across the Wahleach system, as well as relative values.

The Consultative Committee concluded its deliberations with recommendations, which had the support of all Committee members, but one. The recommendations include:

- Alternative SalmonSIR628BCD+Siphon includes a minimum flow release from the Boulder Creek Diversion Dam, a Jones Lake Reservoir minimum elevation level, a Jones Lake Reservoir fertilization program, a Jones Creek minimum flow, a Jones Creek fish habitat enhancement project, and curtails generation to zero for a two-hour period every twenty-four hours.
- A proposed monitoring program.
- A review period for the Wahleach Water Use Plan.
- A Wahleach Water Use Plan Monitoring Advisory Committee.

In addition, the Consultative Committee recommended that BC Hydro begin monitoring Boulder Creek inflows and Jones Creek anadromous habitat productivity immediately, before the implementation of the Wahleach Water Use Plan.

11.1 Expected Consequences of the Recommended Alternative

Table 11-1 summarizes the expected consequences of the recommended operating alternative relative to status quo operations.

Table 11-1: Expected Consequences of the Recommended Operating Alternative

Water Use Interest	Consequences Over Status Quo Operations	
Net Revenue	–	Decrease of $626,000 per year over status quo operations
	+	Increase of $604,000 per year over current licensed operations
Fish in Jones Creek	+	Increase in average fish spawning habitat from provision of minimum flows
	+	Increase in fish spawning and rearing habitat from the fish habitat enhancement project
Fish in Jones Lake Reservoir	+	Increase in pelagic and littoral productivity from minimum reservoir elevation level of 628 m and a fertilization program
Wildlife in Jones Lake Reservoir	+	Increase in riparian habitat from minimum reservoir elevation level of 628 m
Fish in Herrling Island Sidechannel	+	Decrease in fish stranding from curtailing generation to zero for a two-hour period every twenty-four hours
	–	Decrease in fish habitat over status quo operations
Fish in Boulder Creek	+	Increase in fish passage from provision of minimum flows
Recreation	+	Increase in recreational opportunities from minimum reservoir elevation level of 628 m
Flood Control	0	Neutral
Greenhouse Gases	–	Increase in greenhouse gas emissions due to reduced hydroelectric generation

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APPENDIX A CONSULTATIVE COMMITTEE, OBSERVERS AND SUBCOMMITTEES

Table A-1: Wahleach Water Use Plan Consultative Committee

Committee Member	Alternate	Association	Notes
Dean Jones	Genevieve George	Shxw'ow'hamel First Nation	
Tim Peters	Don Hehn	Stó:lō Nation	
Eric Isaacson	Jean Isaacson	Fan out system co-ordinator	
Dorell Carlson		BC Hydro	
Mike Lewis		BC Hydro	
Ross Neuman		Ministry of Water, Land and Air Protection	
Russ Knutson		Chilliwack Forest District	
Edith Grainger		Chilliwack resident	
Jim Harris	Willie Andrew	Seabird Island First Nation	
Sandy Ritchie		Fraser Valley Salmon Society	Replaced by Frank Kwak in June 2002
Dan Sneep	Steve Macfarlane	Fisheries and Oceans Canada	Replaced by Steve Macfarlane in August 2002
Gord Presseau		Sports Fishery Advisory Board	Left process in mid-2002

Table A-2: Wahleach Water Use Plan Observers

Observers	Association
Ted White	Ministry of Sustainable Resource Management
Sheila Creighton	Community Futures Development Corporation of North America
Bob Purdy	Fraser Basin Council
Jesse Brown	Steelhead Society of BC
Dave Minhas	Scott Paper Limited
Harry Murphy	Popkum First Nation
C.A. (Clifford) Peters	Peters Band
Bruce Wright	Nova Pacific Environmental

Table A-3: Wahleach Water Use Plan Subcommittees

Committee Member	Association	Fish Technical Committee	First Nation Archaeology and Heritage	Recreation	Notes
Dean Jones	Shxw'ow'hamel First Nation	✓	✓		
Tim Peters	Stó:lō Nation		✓		
Eric Isaacson	Fan out system co-ordinator			✓	
Harry Murphy	Popkum First Nation		✓		
Dorell Carlson	BC Hydro				
Mike Lewis	BC Hydro				
Ross Neuman	Ministry of Water, Land and Air Protection	✓			
Russ Knutson	Chilliwack Forest District			✓	
Edith Grainger	Chilliwack Resident			✓	
C.A. (Clifford) Peters	Peters Band				
Jim Harris	Seabird Island First Nation		✓		
Bruce Wright	Nova Pacific Environmental	✓			
Sandy Ritchie	Fraser Valley Salmon Society			✓	Replaced by Frank Kwak in June 2002
Dan Sneep	Fisheries and Oceans Canada	✓			Replaced by Steve Mcfarlane in August 2002
Gord Presseau	Sport Fishery Advisory Board	✓			Left process in mid-2000

APPENDIX B PERFORMANCE MEASURE INFORMATION SHEETS

1.0 Recreation Performance Measures

1.1 Recreation Quality

What is the Recreation Quality performance measure?

Recreation quality is defined as ***the number of days that the reservoir is within the range between full pool and three metres below full pool (638.6 m to 641.6 m).*** This performance measure estimates the quality of recreation in the reservoir under different operating alternatives.

Where is this performance measure relevant?

Jones Lake Reservoir.

Why is this performance measure important?

This performance measure assesses the impact of Wahleach hydroelectric facility operations on visual quality, water access, and boating safety (related to standing debris), which contribute to recreation quality.

This performance measure indicates the quality of recreation opportunities available at Jones Lake Reservoir, which affects the quality of life for residents and visitors, and local economic development opportunities through tourism.

How can this performance measure be affected by operational changes?

Reservoir elevation levels can influence shoreline erosion, standing debris, spillway risk and water access issues. These issues are related to visual quality, safety and water access, which contribute to the recreation experience.

Visual quality (aesthetics), safety and water access are improved by a similar set of conditions. Visual quality is considered best when the reservoir nears full pool and unsightly standing debris is largely submerged. Standing debris as a boating safety and swimming issue is somewhat mitigated at higher reservoir elevations. Recreationalists prefer higher reservoir elevation levels for gaining access to the reservoir, for boat launching and for swimming.

What are the key assumptions and uncertainties associated with the impact that this performance measure addresses?

- Minimal recreational use outside the primary recreation period of interest.
- Standing debris risks decrease at higher reservoir elevation levels.

How is the performance measure calculated?

The BC Hydro Operations model provides reservoir elevation levels from specified operating alternatives.

Recreation quality is calculated during the primary recreation period of interest between 15 May to 15 September.

1.2 Spillway Safety Risk

What is the Spillway Safety Risk performance measure?

Spillway safety risk is defined as ***the number of days on which spill events occur***. This performance measure estimates the quantity of spillway risk in the reservoir under different operating alternatives.

Where is this performance measure relevant?

Jones Lake Reservoir.

Why is this performance measure important?

At Jones Lake Reservoir, the configuration of the spillway does not provide a physical barrier to keep recreationalists, particularly children, off the spillway. Therefore, reducing the number of spills could play an important role in ensuring recreationalists' safety.

How can this performance measure be affected by operational changes?

Reservoir elevation levels can influence shoreline erosion, standing debris, spillway risk and water access issues. These issues are related to visual quality, safety and water access which contribute to the recreation experience.

What are the key assumptions and uncertainties associated with the impact that this performance measure addresses?

- Minimal recreational use outside the primary recreation period of interest.

How is this performance measure calculated?

The BC Hydro Operations Model provides reservoir elevation levels from specified operating alternatives.

Spillway safety risk is calculated during the primary recreation period of interest between 15 May to 15 September.

2.0 Power Generation Performance Measure

2.1 Annual Revenue

What is the Annual Revenue performance measure?

Annual revenue is defined as the ***quantity of annual electricity revenue*** using the standard Value of Energy (VOE) model and assumptions in the Water Use Plan Program.

For some alternatives, non-operational physical works to the Wahleach hydroelectric facility were included that required a capital investment. In these instances, capital costs were levelized over their economic project life according to standard BC Hydro accounting procedures and included as annual expenditures. Net Revenue, is the difference between annual revenue and the annualized costs of non-operational physical works.

Where is this performance measure relevant?

Wahleach Generating Station.

Why is this performance measure important?

The Wahleach hydroelectric facility currently generates approximately 245 GWh (million kilowatt-hours) annually. The output from the facility can supply the equivalent of approximately 25 000 homes. The estimated value of this electricity currently exceeds $14 million per year.

The Wahleach hydroelectric facility provides ancillary services that help maintain the reliability of the BC Hydro interconnected power system. Some examples of ancillary services include voltage control, generation reserves and dynamic scheduling. While the Wahleach hydroelectric facility plays an important role in providing ancillary services, for the purposes of the Wahleach Water Use Plan, only the annual value of power generation is considered.

How can this performance measure be affected by operational changes?

The Boulder Creek Diversion Dam can influence Jones Lake Reservoir elevation levels. Fraser River levels, Jones Lake Reservoir elevation levels, the fish water release siphon, and the Wahleach Generation Station can influence the quantity and timing of power generation. These issues are related to the financial value of power generation, which contributes to generation at the Wahleach hydroelectric facility.

How is the performance measure calculated?

Annual Revenue is calculated by multiplying the amount of power generated for a specified operating alternative by the VOE model. The VOE represents the long-term value of a unit of energy generated by the BC Hydro system that is between zero and the market price for electricity. It varies from month to month, and includes time-of-use considerations. Given the Wahleach hydroelectric facility is a peaking plant, if the BC Hydro Operations Model has the Wahleach Generating Station operating 10 hours per day, the VOE will allocate those hours to the most valuable time of day, then distribute the remaining hours across steadily decreasing valuable time periods.

Example:

Alternative A:

Annual Revenue = 100 000 MWh per year x $50 per MWh = $ 5 million per year

Alternative B:

Annual Revenue = 80 000 MWh per year x $50 per MWh = $ 4 million per year

Note that the VOE used above ($50 per MWh) is hypothetical, and varies by month and time of day.

3.0 Fish Performance Measures – Jones Lake Reservoir

3.1 Littoral Productivity

What is the Littoral Productivity performance measure?

Effective Littoral Zone (ELZ), is defined ***as the cumulative area, in hectares, that has the potential to function as productive littoral habitat over the course of one year***. This performance measure estimates the impact of changes in littoral productivity on food availability for fish stocks in Jones Lake Reservoir under different operating alternatives.

Where is this performance measure relevant?

Jones Lake Reservoir.

Why is this performance measure important?

Large storage reservoirs are typically ultra-oligotrophic. In such water bodies, pelagic productivity tends to be low and the contribution of the littoral zone to ecosystem productivity may be important. Littoral zones are an important source of nutrients and the productivity of reservoirs is generally limited by nutrient availability.

Decreases in littoral production and abundance of benthic invertebrates will reduce the food availability for fish. Decreased food availability may limit growth and abundance of fish and affect their condition and quality.

How can this performance measure be affected by operational changes?

Jones Lake Reservoir elevation levels along with the amount of change, frequency, timing, and ramping can influence tributary access, water quality, littoral habitat, pelagic productivity, stranding and entrainment. These issues are related to habitat utilization, spawning habitat and rearing habitat. These mean objectives measure productivity and mortality, which contribute to fish populations in Jones Lake Reservoir.

The greater the area over which conditions are suitable for littoral productivity, the greater the effective littoral zone. Operating alternatives that benefit littoral productivity may include:

- Changing maximum reservoir elevation levels to take advantage of topographic features (flats) that maximize littoral production during the growing season.
- Increasing the time period where the reservoir elevation level is stable during the growing season.
- As the reservoir is drawn down and littoral habitats are exposed, mortality of periphyton and some benthic invertebrates occurs, thereby decreasing the productivity of the community and food availability for fish.
- Any change in the magnitude, timing or rate of drawdown may have a potential impact on littoral productivity.
- It may be possible to enhance the viability of a permanent littoral zone by manipulating reservoir levels.

What are the key assumptions and uncertainties associated with the impact that this performance measure addresses?

- Plants require 30 days of adequate conditions to establish.
- The plant-growing season is April to November inclusive.
- Inundation beyond light levels for plant growth, and desiccation of established areas limits the succession of further plant growth under future conditions.

How is this performance measure calculated?

Effective Littoral Zone (hectare-days)

- Define the conditions required for an area to function as an effective littoral zone.

- Define the timing and duration over which conditions must be suitable for littoral productivity.
- Sum the area of the reservoir that meets the above conditions, multiplied by the average duration under which conditions are met.

3.2 Pelagic Productivity

What are the Pelagic Productivity performance measures?

Volumetric pelagic productivity is defined as a ***cumulative, seasonal-adjusted weighted volume of the pelagic zone***. The pelagic zone is the large open water area of a reservoir that produces phytoplankton and zooplankton – the latter is an important food source for pelagic-feeding species (e.g., kokanee).

Risky pelagic productivity is defined as ***the number of days the Wahleach hydroelectric facility withdraws water from the photic zone***. The photic zone is the top-most layer of water that is penetrated by light, and is the most important area for pelagic productivity.

These performance measures estimate the impact of changes in pelagic productivity on food availability for fish stocks in Jones Lake Reservoir under different operating alternatives.

The ***standard deviation of pelagic productivity*** was also calculated.

Where is this performance measure relevant?

Jones Lake Reservoir.

Why is this performance measure important?

Nutrient and light availability affect phytoplankton productivity in reservoirs, which in turn affects the abundance and biomass of zooplankton. Physical dynamics of reservoirs (turbidity, thermal stratification, water circulation patterns and water retention time) also affect the abundance and distribution of zooplankton.

Reservoir operations may alter the above parameters and affect the amount of food (zooplankton) available to fish, and the amount of food that is discharged from the reservoir.

Decreases in production in pelagic habitats will reduce the food availability for fish species that are pelagic feeders (e.g., kokanee). Decreased food availability may limit growth and abundance of fish and affect their condition and quality.

How can this performance measure be affected by operational changes?

Jones Lake Reservoir elevation levels along with the amount of change, frequency, timing, and ramping can influence tributary access, water quality, littoral habitat, pelagic productivity, stranding and entrainment. These issues are related to habitat utilization, spawning habitat and rearing habitat. These mean objectives measure productivity and mortality, which contribute to fish population in Jones Lake Reservoir.

What are the key assumptions and uncertainties associated with the impact that this performance measure addresses?

- Pelagic productivity is a function of reservoir elevation levels; the higher the reservoir, the more volume is available to photosynthesis.

- Pelagic productivity in the winter is one quarter of that in the summer.

How is this performance measure calculated?

Each day that power is generated, the measure establishes a volume of pelagic productivity based on the depth of light penetration and surface area of water at that depth. Depth of light penetration, defined daily as twice the Secchi depth (a field measurement of light penetration) is calculated each day. The results are weighted 1.0 in the summer and 0.25 in the winter, defined as November to March inclusive and totalled for the entire year. That is, a given volume of water is assumed to lead to four times more phytoplankton and zooplankton on a summer day than the same volume on a winter day.

(equation 1): $$V_{P,x} = \alpha_{GS} \sum_{t_{eGS}}^{j=t_{sGS}} 2 \bullet Z_{s,j} \bullet A_{2Zs,j} + \alpha_{WS} \sum_{t_{eWS}}^{j=t_{sWS}} 2 \bullet Z_{s,j} \bullet A_{2Zs,j}$$

where:

$V_{P,x}$ = Cumulative volume of the pelagic zone for year x

a_{GS} = Weighting factor for growing season (factor = 1)

a_{WS} = Weighting factor for winter season (factor = 0.25)

j = julian day

$Z_{s,j}$ = Secchi depth (m). Twice the Secchi depth is the depth of the euphotic zone

$A_{2Zs,j}$ = Planimetric area (sqm) at twice the Secchi depth for day j

t = start and end timing of the winter and growing seasons

3.3 Entrainment Risk

What is the Fish Entrainment performance measure?

Entrainment risk is an index that is a function of turbine flow and elevation. Fish entrainment is the drawing of fish into the intake of the penstock that leads to the Wahleach Generating Station, which results in the loss of resident fish to reservoir populations. Fish are assumed to be entrained as a function of the volume of water in the reservoir (i.e., the less the water, the higher the entrainment risk), and as a function of turbine flow.

Where is this performance measure relevant?

Jones Lake Reservoir.

Why is this performance measure important?

Fish entrained into the intake of the penstock that leads to the Wahleach Generating Station results in fish losses to the reservoir ecosystem. Fish removed from the reservoir are no longer able to complete their life cycle in the reservoir ecosystem. This can affect the number of fish present and future recruitment (spawning populations).

It was noted that fish losses from reservoirs may result in downstream benefits as surviving fish add to downstream populations, and others add to downstream food availability for fish and wildlife.

How can this performance measure be affected by operational changes?

Jones Lake Reservoir elevation levels along with the amount of change, frequency, timing, and ramping can influence tributary access, water quality, littoral habitat, pelagic productivity, stranding and entrainment. These issues are related to habitat utilization, spawning habitat and rearing habitat. These mean objectives measure productivity and mortality, which contribute to fish population in Jones Lake Reservoir.

What are the key assumptions and uncertainties associated with the impact that this performance measure addresses?

The Fish Technical Subcommittee developed a risk-based algorithm for representing entrainment, although no information was available on the actual extent of entrainment. No entrainment studies were conducted to support the performance measure. Uncertainties surrounding habitat requirements for species life history periods will limit the sensitivity of the performance measure to peaking impacts, species interactions and day and night habitat uses.

How is this performance measure calculated?

Two risk indices, entrainment as a function of turbine flow, and entrainment as a function of reservoir elevation, are calculated and combined for each day of operation.

(equation 2): $$R_{E,x} = \frac{\sum_{365}^{j=1} \alpha_{Gen,j} \bullet R_j}{365}$$

where: $R_{E,x}$ = Risk of entrainment for year x

$a_{Gen,j}$ = weighting factor for generation (factor = 1 if generating, 0 if not)

R_j = risk of entrainment for julian day, j

Daily results will be summarized for each year – median, 10^{th} and 90^{th} percentile results will describe each alternative.

3.4 Reservoir Fish Index

To enable the Consultative Committee to trade off between Jones Lake Reservoir fish and other interests, the Fish Technical Subcommittee developed a weighted index of the scaled impacts of littoral, volumetric pelagic and entrainment. Table B-1 summarizes a weighted index to indicate the relative impact of an operating alternative on Jones Lake Reservoir fish. The weights were attributed by considering the range of swing of performance measures across operating alternatives. A sensitivity analysis illustrated that this index was not sensitive to the weightings.

Table B-1: Jones Lake Reservoir Fish Performance Measure Weighted Index

Performance Measure	Relative Weight
Effective Littoral Zone	0.4
Volumetric Pelagic Productivity	0.2
Entrainment	0.4

4.0 Fish Performance Measures – Jones Creek Non-Anadromous

4.1 Viable Aquatic Habitat

What is the Provision of Viable Aquatic Habitat performance measure?

Viable aquatic habitat is defined as ***the number of days a viable aquatic ecosystem is provided***. This performance measure estimates the quantity of viable aquatic ecosystem in Jones Creek non-anadromous under different operating alternatives.

Where is performance measure relevant?

The total length of lower Jones Creek is approximately 9 km, of which less than 1 km is accessible to anadromous species as access is blocked by a natural barrier located 100 m above Laidlaw Bridge crossing. The lower Jones Creek non-anadromous section is between the natural barrier and the Wahleach Dam.

Why is this performance measure important?

Ten per cent MAD is the accepted threshold denoting a "short-term survival flow" using the Ministry of Water, Land and Air Protection's "Modified Tenant Method." This flow, if sustained for a long period (e.g., greater than 14 days) can represent a significant bottleneck in the productivity of a flow regime.
Twenty per cent MAD is the provincial standard for defining a rearing flow for salmonids in natural rivers in British Columbia. Below this flow, typical river sections become susceptible to a high degree of dewatering, and juvenile rearing and adult rearing habitats are significantly reduced.

How can this performance measure be affected by operational changes?

The Wahleach Dam spillway, Jones Lake Reservoir elevation levels, the fish water release siphon, and the Boulder Creek Diversion Dam can influence the flowrate and rate of flow change. Both flowrate and rate of flow change can influence access to habitat, water quality, depth and velocity, and stranding. These issues are related to habitat utilization, and the quality and quantity of spawning, incubation and rearing habitat. These mean objectives measure productivity and mortality, which contribute to fish population in Jones Creek.

What are the key assumptions and uncertainties associated with the impact that this performance measure addresses?

Twenty per cent MAD is defined by traditional modified tenant instream flow standards as a rearing flow for most natural rivers in British Columbia.
Jones Creek non-anadromous with its steep terrain, fully diverted flow, and marginal habitat is an unlikely candidate for this flow. However, in absence of site-specific data, the 20 per cent MAD was determined to be the appropriate flow.

How is this performance measure calculated?

This performance measure provides a total number of days per year flow releases into Jones Creek meeting the 10 per cent MAD (approximately 0.65 m^3/s) and twenty per cent MAD (approximately 1.3 m^3/s) requirement year-round and during the critical low flow period of August.

The number of days in which >400 per cent MAD occurred is calculated as an indicator of possible displacement events.

5.0 Fish Performance Measures – Jones Creek Anadromous

5.1 Effective Spawning Habitat

What is the Effective Spawning Habitat performance measure?

Effective spawning habitat is defined as ***the weighted usable area of effective spawning habitat provided for the following fish species and time periods:***

- Chum salmon: 15 September to 1 December
- Pink salmon: 15 September to 1 December
- Steelhead trout: 1 December to 1 June

This performance measure estimates the quantity of effective habitat in Jones Creek anadromous that is not dewatered over the spawning incubation periods of each fish species under different operating alternatives. These fish species were chosen as indicators as they are either predominant users of the habitat (as is the case for chum and pink salmon) or are representative of other fish species that may use the habitat during that time period.

Where is this performance measure relevant?

The total length of lower Jones Creek is approximately 9 km, of which less than 1 km is accessible to anadromous species, as access is blocked by a natural barrier located 100 m above Laidlaw Bridge crossing. The lower Jones Creek anadromous section is between its confluence with the Fraser River and the natural barrier.

Why is this performance measure important?

The availability of spawning habitat may be a limiting factor for fish populations in Jones Creek anadromous. Increases in habitat area may lead to increases in fish populations.

How can this performance measure be affected by operational changes?

The Wahleach Dam spillway, Jones Lake Reservoir elevation levels, the fish water release siphon, and the Boulder Creek Diversion Dam can influence the flowrate and rate of flow change. Both flowrate and rate of flow change can influence access to habitat, water quality, depth and velocity, and stranding. These issues are related to habitat utilization, and the quality and quantity of spawning, incubation and rearing habitat. These mean objectives measure productivity and mortality, which contribute to fish population in Jones Creek.

What are the key assumptions and uncertainties associated with the impact that this performance measure addresses?

If and when the morphology of Jones Creek anadromous changes, the effective area of spawning habitat will remain relatively the same.

How is this performance measure calculated?

The quantity of spawning habitat available is correlated to the flow in Jones Creek anadromous. For any given flow, the spawning habitat available for the species under consideration can be estimated.

(equation 3): $$A_{ES,j_i} = \underset{j_{eInc}}{\overset{j=j_i}{Min}}\left(A_{S,j}\right)$$

where:

$A_{ES,ji}$ = Area of effective spawning (sqm), calculated as a minimum

j = julian day; i = day of spawning

e_{inc} = end of incubation, determined by date and/or by ATU count

$A_{S,j}$ = Area of spawning on day j

and equation 4 describes how each effective spawning day is rolled up into an output for an operating alternative:

(equation 4): $$A_{ES} = \underset{y_{End}}{\overset{y=y_{St}}{Mdn}}\left(\frac{\sum_{j_{eSp}}^{j=j_{sSp}} A_{ES,j_i}}{j_{sSp}-j_{eSp}+1}\right)$$

5.2 Effective Rearing Habitat

What is the Effective Rearing Habitat performance measure?

Effective rearing habitat is defined as ***the number of area-days of habitat provided for steelhead trout parr/fry rearing defined as 1 June to 15 September***. This performance measure estimates the quantity of parr/fry rearing habitat in Jones Creek anadromous under different operating alternatives. It represents the area-days of habitat provided for steelhead trout parr/fry rearing defined as 1 June to 15 September. This species was chosen as an indicator because its parr/fry habitat requirements are greater than other species, and their time periods for rearing aligns well with other species.

Where is this performance measure relevant?

The total length of lower Jones Creek is approximately 9 km, of which less than 1 km is accessible to anadromous species, as access is blocked by a natural barrier located 100 m above Laidlaw Bridge crossing. The lower Jones Creek anadromous section is between its confluence with the Fraser River and the natural barrier.

Why is this performance measure important?

The availability of rearing habitat may be a limiting factor for fish populations in Jones Creek anadromous. Increases in habitat area may lead to increases in fish populations.

How can this performance measure be affected by operational changes?

The Wahleach Dam spillway, Jones Lake Reservoir elevation levels, the fish water release siphon, and the Boulder Creek Diversion Dam can influence the flowrate and rate of flow change. Both flowrate and rate of flow change can influence access to habitat, water quality, depth and velocity, and stranding. These issues are related to habitat utilization, and the quality and quantity of spawning, incubation and rearing habitat. These mean objectives measure productivity and mortality, which contribute to fish population in Jones Creek.

What are the key assumptions and uncertainties associated with the impact that this performance measure addresses?

If and when the morphology of Jones Creek anadromous changes, the effective area of rearing habitat will remain relatively the same.

How is this performance measure calculated?

The quantity of rearing habitat available is correlated to the flow in Jones Creek anadromous. For any given flow, the rearing habitat available for the species under consideration can be estimated. Refer to equations 3 and 4.

5.3 Fish Stranding Risk

What is the Fish Stranding Risk performance measure?

Fish stranding risk is defined as ***the number of days flows drop below 0.6 m^3/s or flows drop below 15.3 m^3/s at the Laidlaw Bridge***. This performance measure estimates the relative risk of fish stranding in Jones Creek anadromous under different operating alternatives. This performance measure highlights stranding risk rather than events, because it is not known whether stranding would actually occur in such events.

Where is this performance measure relevant?

The total length of lower Jones Creek is approximately 9 km, of which less than 1 km is accessible to anadromous species, as access is blocked by a natural barrier located 100 m above Laidlaw Bridge crossing. The lower Jones Creek anadromous section is between its confluence with the Fraser River and the natural barrier.

Why is this performance measure important?

Stranding of fish and invertebrates (interstitial stranding, isolation in pools, beaching, and dewatering of eggs) may cause direct and indirect mortality of these fauna and have a negative impact on ecosystem productivity. Data have shown that when flows dropped below 0.6 m^3/s, significant portions of the area would be dewatered. It is hypothesized that similar impacts would occur when flows dropped below bankfull (15.3 m^3/s), where floodplain areas become dewatered. In both instances of dewatering fish, stranding and mortality are much more likely than in between these operations.

How can this performance measure be affected by operational changes?

The Wahleach Dam spillway, Jones Lake Reservoir elevation levels, the fish water release siphon, and the Boulder Creek Diversion Dam can influence the flowrate and rate of flow change. Both flowrate and rate of flow change can influence access to habitat, water quality, depth and velocity, and stranding. These issues are related to habitat utilization, and the quality and quantity of spawning, incubation and rearing habitat. These mean objectives measure productivity and mortality, which contribute to fish population in Jones Creek.

What are the key assumptions and uncertainties associated with the impact that this performance measure addresses?

- Flow changes are not attenuated in lower Jones Creek between the dam and anadromous section.
- 15.3 m^3/s is bankfull discharge, as per watershed relationships summarized by Newbury and Gaboury (1993).

How is this performance measure calculated?

For each of the thresholds (0.6 m^3/s and 15.3 m^3/s), the number of days that flows on day 1 were higher than the threshold, and on day 2 they were lower, are added for each year.

5.4 Jones Creek Anadromous Fish Index

To enable the Consultative Committee to trade off between Jones Creek anadromous fish and other interests, the Fish Technical Subcommittee developed an index of Jones Creek fish impacts. This comprised of a weighted index of the scaled impacts of littoral, volumetric pelagic and entrainment. Table B-2 summarizes a weighted index to indicate the relative impact of an operating alternative on Jones Creek anadromous fish. The weights were attributed by considering the range of swing of performance measures across operating alternatives. A sensitivity analysis illustrated that this index was not sensitive to the weightings.

Table B-2: Jones Creek Anadromous Fish Performance Measures Weighted Index

Performance Measure	Relative Weight
Spawning habitat (average)	0.4
Rearing habitat (average)	0.2
Stranding (0.6 m^3/s)	0.4

6.0 Fish Performance Measures – Herrling Island Sidechannel

6.1 Effective Spawning Habitat

What is the Effective Spawning Habitat performance measure?

There are two measures within the Effective Spawning Habitat performance measure.

Effective spawning/rearing habitat is defined as ***the area, in hectares, that has the potential to provide spawning/rearing habitat that is successful to the end of incubation***. This performance measure estimates the quantity of effective spawning/rearing habitat under different operating alternatives. This performance measure is modified by the cumulative amount of spawning habitat lost during spawning.

Habitat variability is defined as ***the area, in hectares, of habitat dewatered cumulatively between 1 September and 15 May.*** This performance measure estimates the quantity of habitat dewatered cumulatively between 1 September and 15 May under different operating alternatives. Dewatering occurs when discharge from the Wahleach Generating Station drops, disrupting spawning and rearing salmonids through changes in area and suitability of habitat.

Where is this performance measure relevant?

Herrling Island Sidechannel.

Why is this performance measure important?

In Herrling Island Sidechannel, the availability of spawning/rearing habitat may be a limiting factor for fish populations. During spawning, the provision of spawning habitat may be then lost to dewatering in the future. This limits the effectiveness of a spawning fish population, drawing potentially productive spawners into unproductive areas.

How can this performance measure be affected by operational changes?

Discharge from the Wahleach Generating Station and flow in the Fraser River can influence the flowrate and rate of flowrate change. Both flowrate and rate of flowrate change can influence access to habitat, water quality, depth and velocity, and egg/juvenile stranding/displacement. These issues are related to habitat utilization, and the quality and quantity of spawning, incubation and rearing habitat. These mean objectives measure productivity and mortality, which contribute to fish populations in Herrling Island Sidechannel.

When the Fraser River is low, discharges from the Wahleach Generating Station may significantly affect the available spawning rearing habitat. Generally, the greater the flow, the larger the habitat created.

What are the key assumptions and uncertainties associated with the impact that this performance measure addresses?

Spawning habitat is a function of wetted area, as indicated by the wetted area assessments completed on the Herrling Island Sidechannel in 1999.

How is this performance measure calculated?

- Effective Spawning Area: As in equations 3 and 4 above, the performance measure calculates the effective spawning habitat limited by discharges that are lower than those spawned in over the duration of egg incubation.

- Dewatered Spawning Habitat: described in equation 5 below.

(equation 5): $$A_{DSH,y} = \sum_{j_{eSp}}^{j=j_{sSp}} A_{S,j} - A_{ES,y}$$

where: $A_{DSH,y}$ = the cumulative dewatered spawning habitat over the spawning season in year y.

$A_{s,j}$ = the area available to spawners on julian day, j

$A_{ES,y}$ = the effective spawning elevation determined for year y from equation 4 above.

The quantity of habitat available is correlated to discharges from the Wahleach Generating Station, using wetted area as a surrogate for habitat. For any given flow, the spawning habitat available for the species under consideration can be estimated.

7.0 Flood Control Performance Measure

7.1 Red Flag Flood Risk

What is the Red Flag Flood Risk performance measure?

Red Flag Flood Risk is defined as ***the number of days the staff gauge at Laidlaw Road Bridge is above 27.2 m while Wahleach Dam is discharging***. The number of days in which the combined flows at the confluence of Lorenzetta and Jones creeks exceeded 200 m^3/s was also calculated.

Where is this performance measure relevant?

Threshold is measured at the Laidlaw Road Bridge.

Why is this performance measure important?

Located on the banks of the Fraser River, residents of Laidlaw have occasionally experienced property damage due to flooding events from that river, and from the nearby Lorenzetta Creek. A locally significant event occurred in 1948, when the elevation the river reached is commemorated on the sides of the barns of several local residents. More recent and minor floods occurred in the mid-1990s.

Since the Wahleach Dam was built, there appears to have been no flooding damage caused as a result of BC Hydro operations. However, some minor damage has been associated with the debris torrent of 1995.

How can this performance measure be affected by operational changes?

Studies determined that Jones Creek flows (including spill) of less than 200 m^3/s would not pose a flooding risk. However, at times of high Fraser River levels, discharges into Jones Creek could contribute to a backwater effect along Lorenzetta Creek that would exacerbate flooding along Lorenzetta Creek and possibly some flooding along lower Jones Creek.

Eric Isaacson, a local resident and Consultative Committee member noted the elevation of water on a staff gauge at Laidlaw Road was 27.2 m during a recent Fraser River high water event. While operations of the Wahleach hydroelectric facility had no influence on this event, if a large discharge from the Wahleach Dam occurred at that time, operations would have contributed to flood damage in the area. The elevation of 27.2 m at the staff gauge was defined as a "red flag" warning elevation, meaning that any operations likely to increase water levels above this figure could potentially lead to flood damage.

How is the Performance measure calculated?

A relationship (as shown in Figure B-1) was developed between Fraser River elevations, Lorenzetta Creek flows and the Wahleach Dam discharge required to bring the water level above the 27.2 m Red Flag warning elevation. This relationship was developed using the hydraulic model used in creating the Thundetron maps from the 1998 Flood Communication Plan. This performance measure was calculated as the number of days over a 40 year period and the average number of days per year that contained a Red Flag day.

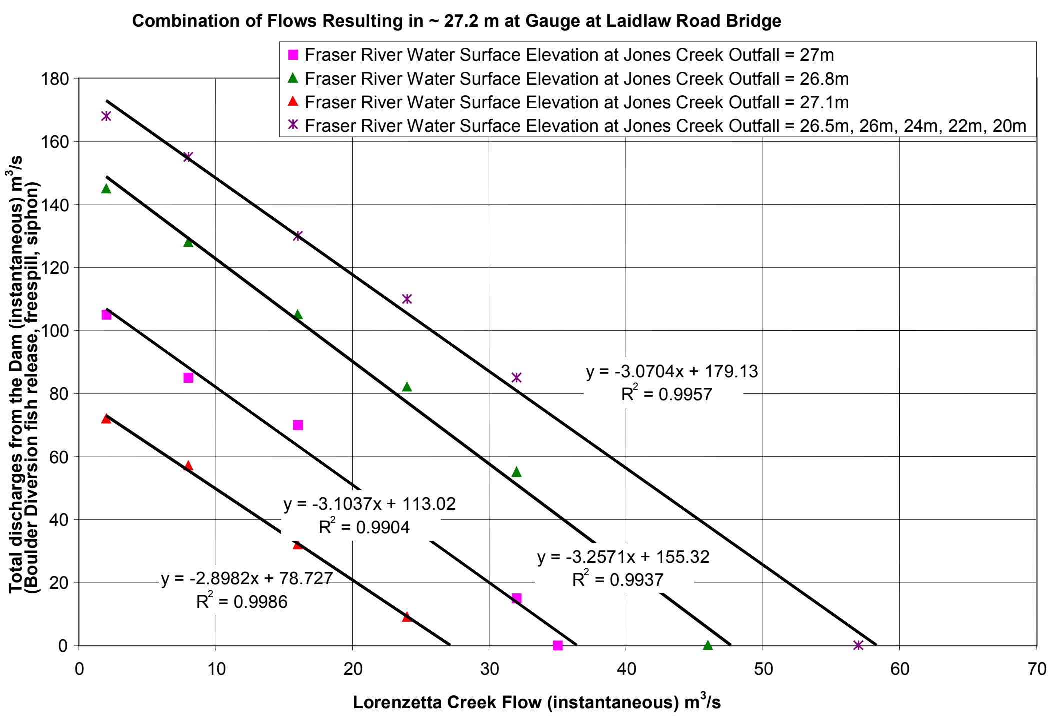

Figure B-1: Conditions Resulting in a Red Flag Flood Warning Day

8.0 Wildlife Performance Measure

8.1 Wetted Willow-Sedge and Sedge-Grass Area

What is the Wetted Willow-Sedge and Sedge-Grass Area performance measure?

Wetted willow, is defined as the ***quantity of wetted, willow-sedge, and sedge-grass area***.

The wildlife performance measure is designed to determine how each plant community is impacted by the operational change, and how wildlife are affected by those changes.

Where is this performance measure relevant?

Jones Lake Reservoir.

Why is this performance measure important?

Jones Lake Reservoir elevation level fluctuations and duration of inundation affect the viability and distribution of plant communities in the riparian zone around the reservoir, and the wildlife species that utilize those communities. Assuming that plant communities in the riparian zone around the reservoir influence wildlife populations, the performance measure will assess the changes in the availability of usable riparian habitat with each operating alternative.

How can this performance measure be affected by operational changes?

Jones Lake Reservoir elevation can influence fish and insect production, wet meadow function, and riparian foraging habitat. These issues are related to wildlife populations in Jones Lake Reservoir.

What are the key assumptions and uncertainties associated with the impact that this performance measure addresses?

Plant communities in the riparian zone around Jones Lake Reservoir influence wildlife populations.

How is the performance measure calculated?

Three distinct plant community types were identified: Wetted Areas, Willow-Sedge and Sedge-Grass. For each of these community types, a performance measure was developed that was a function of habitat area and the relative utility of each area for wildlife values.

The Fish Technical Subcommittee developed a weighted index to clarify impacts on wildlife for the Consultative Committee. Table B-3 summarizes the ratio of 2:1:1 for wetted, willow-sedge and sedge-grass areas respectively, which was a compromise between the opinions of various subcommittee members.

Table B-3: Elevation Ranges of Riparian Ecosystems in Jones Lake Reservoir

Lakeshore Riparian Ecosystem	Mean Lower Elevation (m)	Mean Upper Elevation (m)	Relative Weight in Index*
Wetted Area	641.58	not surveyed	2
Willow-Sedge (WS)	640.91	641.85	1
Sedge-Grass (SG)	639.18	640.91	1

(equation 6): Usable Shoreline Habitat (ha) = $\sum_{i=1}^{4} HA_i \cdot U_i$

Where: HA_I = Habitat Area (ha) of which there are four plant community types under consideration:

U_I = Relative utility of which there are four community-specific values that range between 0 (unusable) to 1 (highly usable by a wide range of species for either reproduction or feeding).

9.0 Greenhouse Gases Performance Measure

9.1 Kilotonnes of CO_2e/GWh

What is the Kilotonnes of CO_2e/GWh performance measure?

Kilotonnes of CO_2e/GWh is defined as ***the quantity of carbon dioxide emissions relative to Alternative SQLicence***. This performance measure estimates the kilotonnes of carbon dioxide equivalent per gigawatt-hour of foregone power generation under different operating alternatives.

Where is this performance measure relevant?

Wahleach hydroelectric facility.

Why is this performance measure important?

Greenhouse Gases (GHG) is the broad term applied to carbon dioxide, methane and other gases that, when emitted into the earth's atmosphere, contribute to global climate change. While impacts will vary from region to region, there is wide consensus among scientists that global climate change will have significant environmental, social and economic impacts over the coming decades.

One potential outcome of the Wahleach Water Use Plan is an overall reduction in power generation by the Wahleach hydroelectric facility. If this were to occur, GHG emissions are expected to increase, given the source of replacement power is primarily combined cycle natural gas turbine generation, a more GHG intensive energy source than hydro-resources.

How can this performance measure be affected by operational changes?

The quantity of power generation from the Wahleach hydroelectric facility can influence GHG emissions, which contributes to global climate change.

What are the key assumptions and uncertainties associated with the impact that this performance measure addresses?

The figure of 306 t CO_2e/GWh used to quantify GHG emissions.

How is this performance measure calculated?

The Water Use Plan Management Committee concluded that the figure of 306 t CO_2e/GWh should be used to quantify GHG emissions implications of Water Use Plans.

APPENDIX C WAHLEACH SYSTEM-WIDE FISH HABITAT DESCRIPTIONS INFORMATION SHEET

The following information sheet was prepared by the environmental task manager on the BC Hydro project team for the Consultative Committee.

1.0 Introduction

This information sheet is meant to be a resource for members of the Wahleach Water Use Plan Consultative Committee to make informed trade-offs between Jones Lake Reservoir, lower Jones Creek (anadromous and non-anadromous reaches), and the Herrling Island Sidechannel (formerly referred to as the Wahleach Slough). It is important to note when reviewing this document that each "sub-system" has its own unique fish habitat value, and that by maximizing for only one part of the system, Consultative Committee members run the risk of minimizing benefits in other parts.

This document will cover the following:

- Fish habitat attributes of each sub-system.
- Comparison of sub-system fish performance measures.
- Examples for direct comparison between sub-systems.

2.0 Jones Lake Reservoir

Prior to the 1920s, Jones Lake was barren to fish. Successful stocking programs between 1926 and 1938 resulted in large numbers of kokanee and rainbow trout in the lake, making Jones Lake a very popular angling destination. Impoundment in 1952 resulted in an increased reservoir size, and fish productivity increases in the years following riparian inundation continued until the mid-1970s. At that point, productivity inputs from the inundated zones dropped off, and the combined effect of operations and over-fishing resulted in fish populations dwindling to all-time lows observed in mid-1990.

Restocking and fertilization programs that started in 1995 have resulted in:

- Successful revival of the kokanee fishery in Jones Lake Reservoir.
- Improved rainbow populations.
- Reduced stickleback populations.

Species of Interest*:* The two main species of interest are kokanee and rainbow trout. Both species spawn in tributaries to the reservoir, and have not been observed spawning along the shoreline. Access to the tributaries is not inhibited by current Wahleach operations, and is not expected to be affected under future operating regimes.

Table C-1 summarizes the periodicity of rearing and spawning for these two species.

Table C-1: Kokanee and Rainbow Periodicity of Rearing and Spawning

Species	Month	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Julian	1	15	32	47	60	74	91	105	121	135	152	166	182	196	213	227	244	258	274	288	305	319	335	349
Rainbow	Spawning																								
	Incubation																								
	Rearing													Rears in Littoral Zone February 15 to November 1											
Kokanee	Spawning																								
	Incubation																								
	Rearing													Rears in Pelagic Zone July 1 to February15											
Littoral	Growth Prd													Depth of Light = 7.46m											
Pelagic	Growth Prd													Depth of Light = 7.46m											

Typical Operations: Typically, the reservoir will be drawn down 15 m in the spring, to accept freshet, regaining its original elevation by mid-summer. Operations in the winter are dependant on inflows, and are stable within a 5 m to 6 m elevation band.

Littoral Area: The littoral zone is considered functional between April and November inclusively (244 days), given an accommodating reservoir operation. Given an average depth of light penetration of 7.46 m for that period, the maximum littoral area is 2 544 814 m^2, if the reservoir is held constant at 634.5 m. To be consistent with the Effective Littoral Zone (ELZ) performance measure,

$$\begin{aligned} ELZ &= \text{Area x Duration} \\ &= 2\,544\,814 \text{ m}^2 \times 244 \text{ d} \\ &= 6.21 \times 10^8 \text{ m}^2\text{-d} \end{aligned}$$

is the maximum ELZ value possible.

Pelagic Area: Kokanee utilize the pelagic zone during the productive period April to November inclusively (244 days). Given an average depth of light penetration of 7.46 m for that period, the maximum pelagic volume is $3.05 \times 10^7 m^3$. To be consistent with the pelagic volume (PV) performance measure,

$$\begin{aligned} PV &= \text{Volume x Duration} \\ &= 3.05 \times 10^7 \text{m}^3 \times 244 \text{ d} \\ &= 7.44 \times 10^9 \text{ m}^3\text{-d} \end{aligned}$$

is the maximum cumulative pelagic volume output possible.

Relative Contribution to Fisheries Productivity: The reservoir is once again an attractive fishery, due in part to fertilization, and in part to management of stickleback stocks through cutthroat trout stocking strategies. However, the relative contributions of either initiative is unknown. It is hypothesized that the decline of kokanee populations in recent decades was due to trophic depression (reduction in reservoir nutrient concentrations), and this hypothesis is supported by the following observations since fertilization and management initiatives have been in place:

- Increased trophic yield (zooplankton and Daphnia increases), including macroinvertebrate production increases.
- Increased survival of rainbow trout, from 4 to 7 years.
- Increased kokanee populations.

3.0 Herrling Island Sidechannel

The Herrling Island Sidechannel is about 8 km in length, with the Wahleach Generating Station tailrace entering a pool 1 km south of the channel invert. Prior to the Wahleach Generating Station development, the Herrling Island Sidechannel received Fraser River freshet mainstem overflow, between April and October, and only minor tributary flow from two creeks from November to March (MAD < 5 cfs). After development, the project diverts an annual average of 6.5 m^3/s into the Herrling Island Sidechannel, significantly increasing winter flows, and accommodating successful spawning by chum and pink salmon through the winter months.

Over the decades, the period of Fraser River influence has been reduced, due to annual material deposition at the sidechannel invert. Currently, Fraser River influence is limited to the 1 May to 10 September, in 75 per cent of the recorded cases.

Fish habitat assessments conducted in 1999 (Alken) indicate that of 10 habitat units observed in Herrling Island Sidechannel, six were suitable for spawning, with large gravel dominating substrate conditions. The Herrling Island Sidechannel is less than one per cent in gradient. Further photo-analysis of various releases from Wahleach Generating Station at low Fraser River levels defined a linear wetted area relationship for the Herrling Island Sidechannel illustrated in Figure C-1 below. While depth and velocity information for the Herrling Island Sidechannel were not collected, it is assumed that the quality of habitat increases with the flow, because depth and velocity conditions are most likely improving according to preferences of chum and pink salmon across flow increases.

Species of Interest: The Herrling Island Sidechannel supports four main species: white sturgeon, cutthroat trout, chum salmon and pink salmon. Only two species, chum and pink salmon, were regarded by the Fish Technical Subcommittee as primarily impacted by operations.

Area of Spawning Habitat: Spawning habitat is considered as those wetted areas of glides and riffles which have suitable substrate for chum spawning. It does not consider depth and velocity preferences due to the lack of transect data. This area is 90 000 m^2 at no Wahleach Generating Station release, and is 140 000 m^2 at full load (13.3 m^3/s).

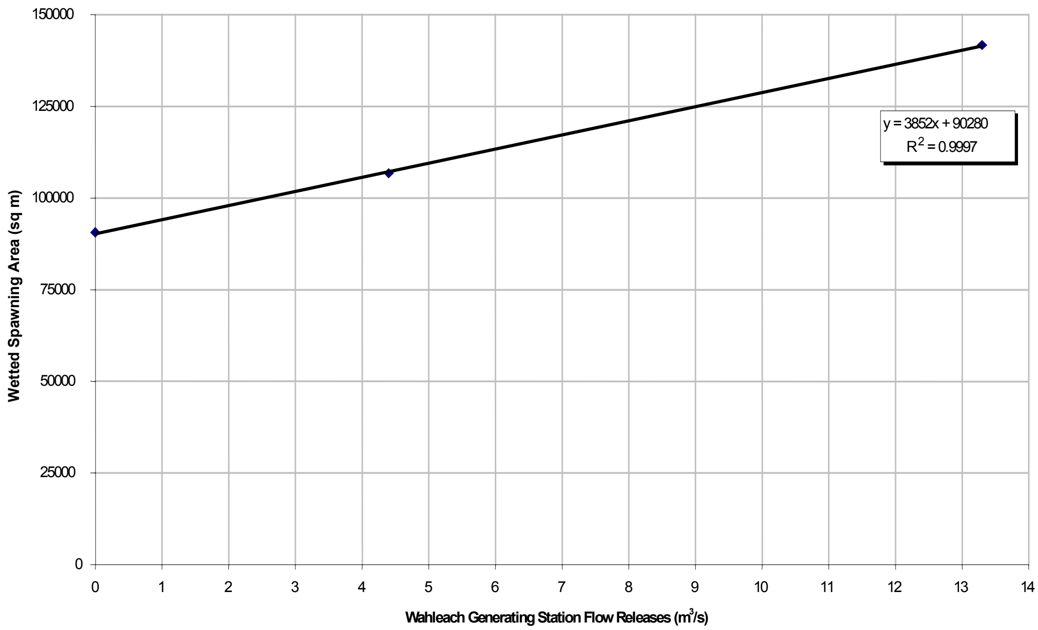

Figure C-1: Wetted Area of Chum and Pink Spawning Grounds for Flow Releases from Wahleach Generating Station at Low Fraser River Levels

Traditional Chum Run Size: Estimates from Chilliwack hatchery (Department of Fisheries and Oceans, 1999), put the Herrling Island Sidechannel chum run between 80 000 and 130 000 adults for the spawning season, with peak counts between 20 000 and 30 000 adults. These numbers are estimates only, as there have been no accurate fish counts conducted in the Herrling Island Sidechannel.

Incubation Success: Wohlmann pebble counts for the Herrling Island Sidechannel show that the dominant substrate is large gravel and small gravel. Fines are cleared by continuous base flows, and by freshet flows in the summer. Typical Fraser River egg to fry survivals are 9 to 11 per cent. It is expected that Herrling Island Sidechannel would result in similar survival rates to natural conditions if power generation were kept stable. Lower survival rates are expected if power generation peaks daily during the incubation period.

4.0 Lower Jones Creek (Anadromous and Non-Anadromous Sections)

Lower Jones Creek is the portion of the creek between the Wahleach Dam and the confluence of the Fraser River. The lower Jones Creek watershed is plagued by severe slope instability which has resulted in significant impacts to habitat quality in the lower reaches. The total length of this section is approximately 9 km, of which less than 1 km is accessible to anadromous species. A natural barrier is located 100 m above Laidlaw Bridge crossing. Current hydrology provides a Mean Annual Discharge of 1.5 m^3/s measured at the Laidlaw Bridge primarily from 2.8 Mile Creek and 3 Mile Creek inflows. However, 60 per cent of the days modelled on record indicate a Mean Annual Discharge of less than 1.0 m^3/s at the Laidlaw Bridge. Prior to dam construction, Mean Annual Discharge at the Laidlaw Bridge was approximately 7.8 m^3/s (Leake, 2001). Refer to Figure C-2.

As described in the technical information sheet supplied to the Consultative Committee in December 2001 (Leake, 2001), the lower Jones Creek watershed is plagued by severe slope instability, which has resulted in significant impacts to habitat quality in the lower reaches. In 1995, the spawning channel constructed as compensation for habitat loss due to the impoundment was wiped out by a massive land slide. There have been no further attempts at reconstruction, in light of subsequent analyses recommending a "wait and see" approach to habitat enhancement in the area (Miles and Hartman, 1997).

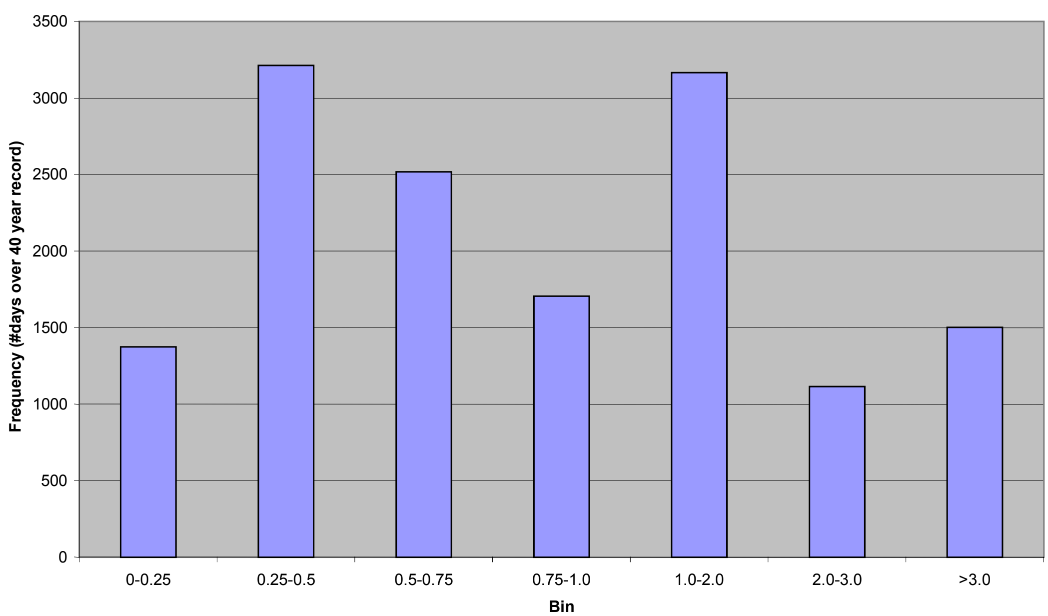

Figure C-2: Frequency Distribution of Modelled Flows in Lower Jones Creek at the Laidlaw Bridge Gauge (n= 14 594 days or 40 years)

4.1 Non-Anadromous Section

Thought to be originally barren, this section of stream now supports a small resident rainbow trout population, which is partly comprised of an active spawning contingent, as seen in recent sampling of upper reach sites where young of year fry were seen. Prior to reservoir stocking, this section of stream was barren, and the current rainbow population is most probably based on stock from entrained individuals during spills over the dam throughout the years of operation. It is unknown whether the current flow regime is adequate to sustain the current population of rainbow, or if this population survives through a mix of opportunistic spawning and supplemental entrained individuals. The Fish Technical Subcommittee has stated that the objective is to sustain populations through increased flow releases from the Wahleach Dam or the diversion bypass valve.

Species of Interest: Rainbow fry and adults were the only species sampled in this reach. There may be kokanee and cutthroat trout individuals entrained into the system from the lake, but these species will not survive in the system because:

- Kokanee require lake rearing as part of their life history approach.
- Cutthroat stocks in the reservoir are sterilized to control their population size, and therefore could not sustain a population without direct supplementation.

Area of Habitat: It is unknown what the quality or quantity of habitat is per the non-anadromous section, although recent sampling suggests that around 20 fish/unit is supported in "leakage" flow conditions, during the low flow period in August (Leake, 2001). The length of the reach is approximately 8 km.

Habitat Quality: The habitat is largely a steep boulder cascade, with barriers to access at two sections within the canyon section. Average gradient over the section is 7 per cent, but is 12 per cent in much of the canyon section below 2.8 Mile Creek. Sediment loading below the 2.8 Mile Creek confluence is severe, and will likely reduce habitat quality. Habitats above 3 Mile Creek are likely not inflicted by sediment inputs.

4.2 Anadromous Section

Since the late 1950s, BC Hydro built and maintained a pink salmon spawning channel which diverted flows from the mainstem between the Laidlaw Bridge and the Lorenzetta Creek confluence, into a man-made spawning channel, which was operated September to May each year. Starting in the late 1980s, the channel was under continual repair, until in 1995, when a landslide in the watershed created a torrent that destroyed the diversion works and infilled the channel. There are three conditions therefore that are worth exploring in this document: pre-impoundment, the spawning channel era, and the current state.

The current state is the default by which the Wahleach Water Use Plan will be comparing habitat benefits. The performance measures indicate that for the range of flows investigated, the habitat benefits are similar to those summarized in Table C-2. However, it should be noted that these habitat areas are not comparable to those expressed in performance measure outputs for other components of the Wahleach system, due to the differing substrate, riparian values, and egg to fry survivals.

Table C-2: Flow and Habitat Relationships in Lower Jones Creek

Species	Life History	Peak Habitat Flow (m^3/s)	Peak Habitat Habitat (sqm)	10% off Peak Flow (m^3/s)	10% off Peak Habitat (sqm)	20% MAD[1] Flow (m^3/s)	20% MAD[1] Habitat (sqm)	Life History Timing
Rainbow trout/ Steelhead	Spawning	1.8	4770	1.2	4290	1.56	4760	1 Dec to 1 Jun
	Rearing – Fry	0.5	4220	0.35	3800	1.56	2510	1 Jun to 15 Sep
	Rearing – Parr	1.4	5230	0.75	4700	1.56	5160	1 Jun to 15 Sep
Pink Salmon	Spawning	1.4	4400	0.8	3960	1.56	4280	15 Sep to 1 Nov
Chum Salmon	Spawning	1.6	4100	1.1	3690	1.56	4100	15 Sep to 1 Dec

1. MAD = Mean Annual Discharge at top end of anadromous reach, 7.829 m^3/s.

Table C-3 summarizes the habitat values of the three states of the Jones Creek channel since 1934.

Table C-3: Habitat Conditions of Jones Creek Anadromous

Habitat Attributes	Pre-Impoundment (1934–1954)	Spawning Channel Era (1954–1995)	Current Status (1999–2001 Enumeration Data)
Length of Habitat	1.2 km	1.4 km (creek + channel)	0.8 km
Pink Salmon Counts	4250	2639	3124
Pink Egg to Fry Survival	10 to 12%[1]	12%	1.0%[2]
Chum Salmon Returns	443	284	459
Chum Egg to Fry Survival	10 to 12%[1]	36%	0.6%[2]
Average Flow	7.8 m^3/s	Creek: 1.0 m^3/s Channel: 0.6 m^3/s	1.0 m^3/s

1. Estimated to be similar to Fraser River natural survival rates
2. Based on 1999 enumeration data only (White Pine, 2000)

5.0 Conclusion

This information sheet is a partial summary of the habitat values in the Wahleach system, and is meant to be a tool for evaluating the performance measures which may have competing values. It is important that evaluations between Jones Lake Reservoir, Jones Creek and Herrling Island Sidechannel, and operating alternatives not focus on the absolute value of each performance measure output for the following reasons:

- Base data collection methods differ between Jones Lake Reservoir, Jones Creek and Herrling Island Sidechannel. Therefore, the outputs are not directly comparable.
- The values of the habitat for each fish species differ between each area; each support their own unique ecosystem, which has not been summarized herein, and therefore, results should not be directly compared.
- Habitat performance measures vary greatly between each area, due to the nature of the base data, and also because of different objectives for each. It should be noted that while the performance measures are intended to explain the benefits of each alternative with respect to biological values, there is difficulty in simplifying outputs for the Consultative Committee to make decisions.

APPENDIX D IMPLICATIONS OF SLOPE AND CHANNEL INSTABILITY IN THE LOWER JONES CREEK WATERSHED ON WATER USE PLANNING

The following information sheet was prepared by the BC Hydro environmental task manager for the Consultative Committee.

1.0 Background

The Jones Creek spawning and rearing channel was constructed in 1954 to mitigate the effects of the Wahleach Dam. This diversion project has reduced the basin area above the anadromous salmon area on the Jones Creek fan from 116 to 26 km^2 and is estimated to have decreased the average annual flow in lower Jones Creek to approximately 18 per cent of its natural value (Anon, 1949). The Jones Creek spawning/rearing channel was the first development of its type in British Columbia.

Storm events in 1993 and 1995 caused numerous slope failures in the Jones Creek watershed downstream of the Wahleach Dam. Historic forestry harvesting and unmaintained road networks created, or exacerbated, many of these landslides. Numerous slope failures occurred in the 2.8 Mile Creek and 3 Mile Creek basins (which are tributaries to the lower Jones Creek watershed – see Figure D-1). The resulting debris torrents, which consisted of slurries of mud, rock and woody debris, flowed down these tributaries into Jones Creek. Sizeable quantities of sediment and woody debris were deposited at the 2.8 Mile Creek confluence with Jones Creek in 1993. In 1995, channel instability, associated with downstream sediment movement, destroyed the Jones Creek spawning/rearing channel and deposited large quantities of gravel at the confluence with the Fraser River. Similar, but less drastic, logging-related sediment production has caused on-going maintenance concerns throughout the spawning/rearing channel's history. However, these problems became more severe after forest harvesting activity moved into the tributary basins in the 1970s.

Following the failure of the spawning/rearing channel, Department of Fisheries and Oceans commissioned independent experts Dr. Gordon Hartman, a professional biologist, and Mike Miles, M.Sc., a professional geoscientist, to evaluate the causes of the failure and recommend an approach to managing the fish compensation issues on the Wahleach system (Hartman and Miles, 1997).

2.0 BC Hydro's Water Use Plan

The Wahleach Water Use Plan provides an opportunity to revisit the Wahleach Dam operating protocols due to changes in social, economic, and environmental interests which have occurred since 1949, when the Wahleach project was designed. Under the Wahleach water use planning process, Consultative Committee members re-examined the Hartman and Miles report to determine how the results of their investigation might influence operation regimes of the Wahleach Dam, or other measures which could be undertaken to enhance fisheries values in Jones Creek.

In the Wahleach water use planning process, physical works in lieu of flow releases can be considered. The cost of the works, the expected benefits and the cost of the flow release will be evaluated by the Consultative Committee.

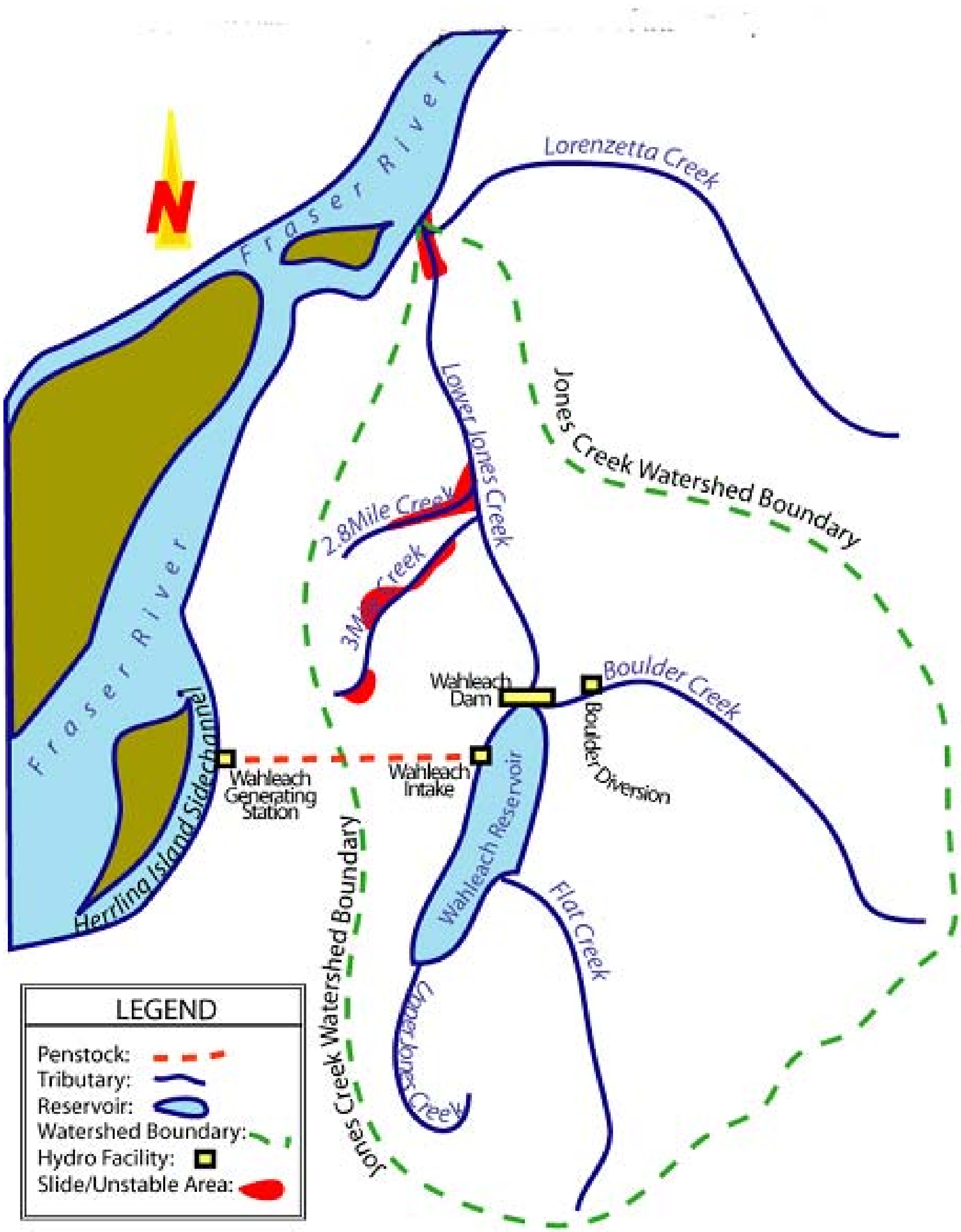

Figure D-1: System Overview with Focus on Areas of Instability in the Jones Creek Watershed

3.0 Methods and Key Questions

3.1 Slope and Channel Stability Characteristics

On 17 and 18 October 2001, the Wahleach Water Use Plan Consultative Committee agreed that the post-regulation flood flows are too small to cause a significant risk of property damage (Condie, 1998; Kerr, 1998; PSE, 1998). However, the 1995 storm event indicates that sediment or debris movement, and its associated effects on channel stability, pose significant risks to developments on the Jones Creek fan.

Reports by Ramsay (1993), C.E. Jones and Associates Ltd. (1996) and Hartman and Miles (1997) were used as a basis for identifying slope or hydrotechnical stability issues which will determine what type of fisheries mitigation works are feasible in the lower Jones Creek channel. The following questions were identified as “performance measure” criteria for this project:

1. What is the present slope stability status in the Jones Creek watershed downstream of Wahleach Dam?
2. How much sediment is stored in the stream channels upstream of the Jones Creek fan?
3. What factors contributed to the 1993 and 1995 events that caused the spawning channel and mainstem habitats to be damaged?
4. What is the likelihood that damaging events, similar to those in 1995, will re-occur?

3.2 Fisheries Habitat Enhancement Options

Manipulating operations at the Wahleach hydroelectric facility to release water into lower Jones Creek may bring benefits to fish habitat, particularly in the anadromous reach on the Jones Creek fan. However, the available methods to control these releases is limited to:

- A free spillway.
- A siphon that delivers low flows at high reservoir elevations only.
- A fish release valve in the Boulder Creek Diversion Dam that can divert limited quantities of water to lower Jones Creek.

Due to the small amount of water which can be released by these facilities, non-operational alternatives have been discussed at length for consideration in the later stages of the Wahleach Water Use Plan.

A variety of reports are available which provide information on fish habitat enhancement options (Ramsay, 1993; nhc, 1996; Hartman and Miles, 1997; Greenbank, 2000; WAH WUP, 2001). As well, a follow-up meeting was held between Mike Miles and the Consultative Committee on site on 25 April 2001 (Miles, personal communication, 2001).

The following key questions were examined when reviewing the information and on-site meeting notes:

1. What are the flow enhancement options for Jones Creek anadromous which can be accommodated by the existing dam infrastructure?

2. What are the flow release options that can reduce the impacts of sediment source problems from the 2.8 Mile Creek slide area confluence with Jones Creek?

3. What physical habitat enhancements could be undertaken in Jones Creek anadromous which would replace the spawning channel and withstand future debris torrents?

4. In lieu of number 3 above, what other opportunities are available for enhancing fish habitat conditions in Jones Creek anadromous?

3.3 Investigation of Slope and Channel Stability Characteristics

3.3.1 What is the present slope stability status in the Jones Creek watershed downstream of the Wahleach Dam?

C.E. Jones and Associates Ltd. (1996) prepared an inventory of landslides in the Jones Creek watershed and assessed the requirements for road deactivation or other measures to mitigate the effect of historic logging activities. Their report indicates that (within the entire Jones Creek watershed), "almost 56 per cent of the landslides occurring in the watersheds originate at roads. An additional 29 per cent originate in harvested blocks. These percentages suggest that harvesting activity has had a significant impact on slope stability. Diversion and concentration of run-off from roads, fill slopes composed of fine grained soils, weathered rock and organic debris, and overstep fill slope angles are all factors which have contributed to the large number of landslides. Over 60 per cent of the landslides either enter a stream channel directly or via a gully system. The impact on fisheries values has been very significant." (p. 6-2-1)

The study by C.E. Jones and Associates Ltd. (1996) located 33 active landslides downstream of the Wahleach Dam which they felt required stabilization. Approximately 70 per cent of the 41 km of road in this area was also determined to require deactivation. At this time, none of this work had been undertaken. On-going slope instability and chronic sediment production will therefore occur periodically until these unstable sites are remediated or naturally stabilized. Without assistance, this process could take on the order of 50 to 100 years.

3.3.2 How much sediment is stored in the stream channel upstream of the Jones Creek fan?

Helicopter inspections in 1996 indicated that mobile in-channel sediment accumulations occurred along both 2.8 and 3 Mile creeks and in the mainstem of Jones Creek between 2.8 Mile Creek and the apex of the Jones Creek fan. As previously discussed, a very large sediment deposit has formed at the lower end of 2.8 Mile Creek and extensive recent sediment accumulations occur on the Jones Creek fan. Approximately 29 100 m^3 of sand and gravel was excavated from this section of channel in 1996 (nhc, 1996), but much of the material was simply placed on the stream banks. All these materials will be susceptible to re-entrainment during future flood flows. In addition, periodic water quality sampling undertaken by BC Hydro in 1997–2000 indicates that fine textured sediments are regularly being transported in the area downstream of 2.8 Mile Creek during periods of even modest stream flows. These observations (which ideally should be confirmed by additional field inspections and measurements) indicate that on-going sediment transport will occur even if all the upslope sediment sources could be stabilized.

3.3.3 What factors contributed to the 1993 and 1995 events which caused the spawning channel and mainstem habitats to be damaged?

Hydrographs showing inflows to the Jones Lake Reservoir during 1993 and 1995 are illustrated in Figure D-2.

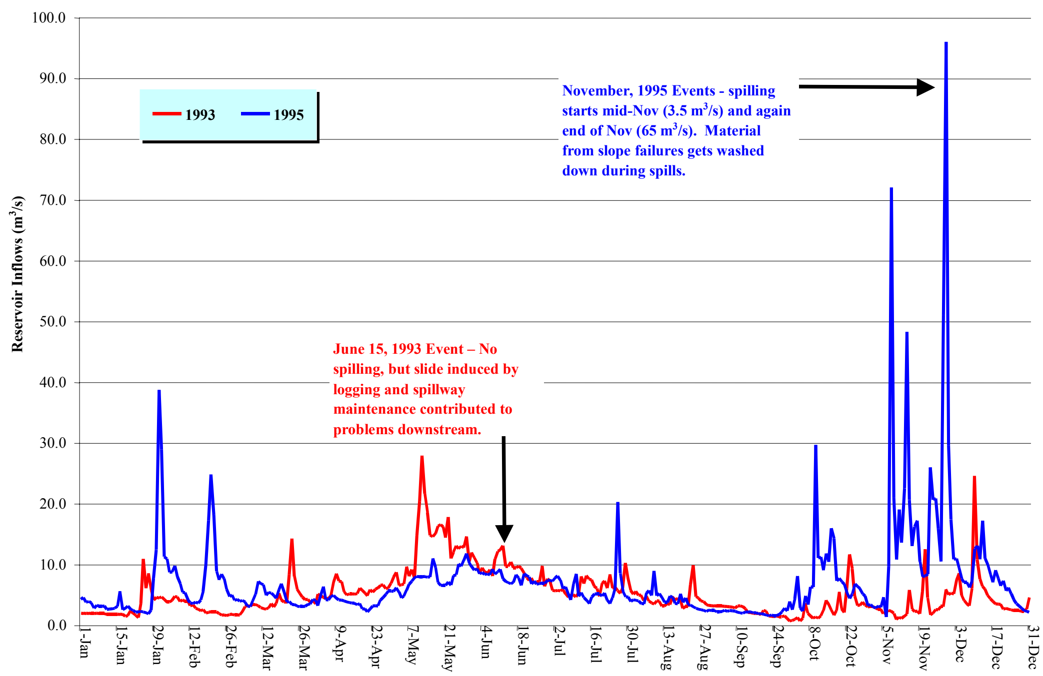

Figure D-2: Daily Average Reservoir Inflows 1993 and 1995

The 1993 event occurred in June after a period of unusually wet conditions (C.E. Jones and Associates Ltd., 1996). Snowmelt might also have been a factor which contributed to numerous landslides in unstable areas of the upper tributary basins. They indicate that "multiple small slides" occurred in the 2.8 Mile Creek watershed and that these "appear to have triggered a massive failure along the stream channel, resulting in a large amount of material entering Jones Creek." (p. 6-2-2). Sediment was also entrained from the spillway rehabilitation work which was being undertaken at the Wahleach Dam. These materials were transported downstream and resulted in over $330,000 damage to the Jones Creek spawning/rearing channel (see Hartman and Miles, 1996, App. 6).

Rainfall events having a maximum 1-day average return period of 15 years resulted in numerous landslides in November 1995. Regional measurements suggest that coincident stream flow values had average return periods of 20 to 35 years. Based on this analysis, Hartman and Miles (1996) concluded that the 1995 event was triggered by "modest precipitation totals combined with wet antecedent conditions, rather than by a single exceptional short-duration event" (p. 26). The resulting large reservoir inflows caused BC Hydro to spill 65 cubic metres per second (m^3/s) of water that contributed to mobilizing portions of the slide material that had settled at the 2.8 Mile Creek confluence with Jones Creek in 1993. These materials completely overwhelmed the spawning/rearing channel on the lower Jones Creek fan.

3.3.4 What is the likelihood that damaging events, similar to those in 1995, will re-occur?

Studies by Church and Miles (1987) indicate that rainfall intensities in the vicinity of Hope are sufficient to exceed commonly applied thresholds for slope instability every two to five years. More recent studies (M. Miles and Associates Ltd., in press) indicate that the predicted affects of climate change will result in more intense short duration rainfall and an increase in the frequency of debris slides or torrents. This implies that significant events, such as those which occurred in 1995, could occur more frequently than once in 20 years. However, the frequency of damaging slides will change over time as buried wood in side cast road spoil rots, or as unstable areas revegetate. Future upslope restoration activity will also affect sediment availability as will the amount of sediment and debris which becomes deposited in the tributary streams. However, based on conditions in 1996 (when Miles and Hartman inspected the watershed) damaging flood events are expected to occur approximately every two to five years and more significant events, similar to those which occurred in 1995, are expected to re-occur at approximately 20 year return periods. Due to the frequency of these events, and the maintenance costs which they incur, Hartman and Miles (1997) recommended that the Jones Creek spawning/rearing channel not be rebuilt until the sediment production from the upstream watershed was stabilized.

3.4 Investigating Fisheries Habitat Enhancement Options

3.4.1 What flow releases will improve habitats downstream for salmonids?

In 2001, the Wahleach water use planning process provided a summary of flow options for optimizing habitats, below in Table D-1. Hartman and Miles (1997) also suggested that a natural stream system will require an increase in water release to maintain habitats for pink, chum, and coho salmon and steelhead.

Table D-1: Flow Requirements for Species of Interest in Jones Creek

		Peak Habitat		10% off Peak		20% MAD[1]		
Species	**Life History**	**Flow (m^3/s)**	**Habitat (sqm)**	**Flow (m^3/s)**	**Habitat (sqm)**	**Flow (m^3/s)**	**Habitat (sqm)**	**Life History Timing**
Rainbow trout/ Steelhead	Spawning	1.8	4770	1.2	4290	1.56	4760	1 Dec to 1 Jun
	Rearing - Fry	0.5	4220	0.35	3800	1.56	2510	1 Jun to 15 Sep
	Rearing – Parr	1.4	5230	0.75	4700	1.56	5160	1 Jun to 15 Sep
Pink Salmon	Spawning	1.4	4400	0.8	3960	1.56	4280	15 Sep to 1 Nov
Chum Salmon	Spawning	1.6	4100	1.1	3690	1.56	4100	15 Sep to 1 Dec

1. MAD = Mean Annual Discharge at top end of anadromous reach, 7.829 m^3/s

The current facilities on the Wahleach Dam and the Boulder Creek Diversion Dam are not able to provide the flexibility of flows needed to optimize habitats in the lower Jones Creek sections. Only those alternatives requiring stable reservoir elevations above 637 m, the required elevation to keep the siphon primed, are habitats in the lower reaches able to provide for salmonids.

Jones Creek habitats in the anadromous section have been unstable and are appear to be unsuitable for incubation. As documented in White Pine (2000), spawned areas were dewatered after the channel shifted late in the November 1999 spawning period. Low base flows, channel transition and instability combined with the sediment depositions on incubating eggs have led to poor fry survival and recruitment for Jones Creek. Fry enumeration for the spawning season showed that egg to fry survivals were 0.6 per cent for chum, and 1.0 per cent for pink salmon, compared with about 10 per cent for other lower Fraser River tributaries (Department of Fisheries and Oceans, 1997), and 40 per cent for the old Jones Creek spawning channel (Hartman and Miles, 1997). For 2001, the channel again shifted late in the spawning period (Hunter, personal communication, 2001).

3.4.2 What flow release options would reduce sediment impacts on the lower reaches? Would spills similar in magnitude to those surrounding the 1995 events lead to similar material transport?

On 25 April 2001, during his meeting with the Consultative Committee, Mr. Miles was asked whether a flushing flow could be recommended that would minimize the apparent impacts of the slide material at the 2.8 Mile Creek confluence. His answer came in two parts:

- The sediment load in Jones Creek is derived from both upslope instability and the remobilization of sediment temporarily stored in the mainstem channel. Flushing flows could remove some of the sediments in the mainstem channel, but upslope sediment sources would continue to adversely impact any facilities constructed on the Jones Creek fan.

- Flushing flows could not remove the material presently stored at the 2.8 Mile Creek confluence.

Given these constraints, sediment transport and deposition will periodically destabilize the anadromous sections of Jones Creek until such time as the upstream source areas are stabilized and material stored in the stream channel has been revegetated or transported out of the system.

3.4.3 What physical habitat enhancement options for Jones Creek could withstand future debris/slide/torrents?

During the discussions of 25 April, Mike Miles and Bruce Usher, Watershed Restoration Program representative, gave the following advice for future habitat enhancement considerations in the anadromous reach:

- Do not re-build a creek-fed spawning channel until sediment production from the watershed is stabilized, as future slides will continue to impact downstream projects for many decades.

- If a spawning channel were to be created before watershed stabilization were achieved, it should ideally be groundwater fed, or fed from an alternative source. They also indicated that protection measures (such as dyking, debris collection basins, debris deflectors, etc.) would be needed to protect any enhancement works from future channel shifting by Jones Creek.

Ramsay (1993), a research assistant with BC Hydro Environmental Affairs, identified three possible options for the development of a new spawning channel, outside of rebuilding the old facilities. These were:

- Build a new, separate, spawning channel with source water from the Wahleach Generating Station penstock. The water would be piped from the penstock and would be free of sediments.
- Build a new, separate, spawning channel with source water from wells drawing off the local water table. Other wells in the area are capable of producing significant quantities of flow (0.4 cfs observed nearby – WAH WUP, 2001a), and a large well may be adequate for spawning channel requirements.
- Build a channel off site as a compensatory approach to impoundment impacts. The Herrling Island Sidechannel may be a suitable area, but the Peter's Island Sidechannel has already undergone an initial feasibility assessment (Parsonage, 1999).

3.4.4 In lieu of separate spawning channel facilities, what are the opportunities for enhancing fish habitat conditions in the Jones Creek anadromous reach?

Hartman and Miles (1997) summarized the impacts of the 1995 storm events and provided recommendations towards rebuilding fish habitats in the Jones Creek anadromous reach. Their report suggested the following options for improving habitats in the Jones Creek anadromous reach:

- Remove the lower and upper weirs to permit fish access to the residual stream habitat.
- Allow the creek to shift laterally on the fan (this would likely require reconstructing Trans Mountain's Oil Pipeline).
- Remove spoil piles and re-establish riparian vegetation along the lower channel.
- Take appropriate measures to minimize sediment production from the upstream watershed.

The Hartman and Miles report also indicated that it may be necessary to initially excavate accumulated sediments if the lower weirs are removed.

The report also suggests that temporary structures to enhance fish habitat could be used where slope regrading and riparian works do not provide fish habitat. However, they indicate that these structures are unlikely to persist in the long term due to the unstable nature of the stream channel. Table D-2 summarizes the estimated costs for these options.

4.0 Summary

The analyses undertaken at the request of the Consultative Committee indicate that:

- Any rebuilt facility similar in function and location to the old Jones Creek spawning channel will be significantly impacted by upstream slope instability or sediment movement every 2 to 5 years for at least the next 30 to 50 years.

- Habitat benefits of flow options for Jones Creek are limited to between 4100 m^2 and 5200 m^2 depending on the species and flow, which ranges from 0.5 m^3/s to 1.8 m^3/s, but that current sediment loads reduce egg to fry survival (0.6 per cent to 1.0 per cent) through channel instability and transition (loss of habitat) and limiting respiration of eggs (reduced quality of habitat).

- The cost of building a spawning channel varies from $100,000 for a groundwater fed channel to $400,000 for a compensation channel off site, with regular maintenance costs between $2,000 and $15,000 respectively. However, due to the watershed instability, these costs can escalate to $300,000 to $400,000 per slide event, unless a separate channel infrastructure were built.

- The least risk approach to rebuilding Jones Creek habitat is to open up the lower river through regrading of stream banks and by relocating or removing existing dyking to allow reformation of a natural channel and fish habitat development. The estimated cost (excluding rebuilding or protecting Trans Mountain's pipeline) is expected to be $200,000 plus a maximum of $15,000 per year for maintenance.

Table D-2: Options for Habitat Enhancement

Options	Intended Use	*Flow Details*		Habitat Area (m^2)	Project Costs ($'000s)	*Maintenance*		Annual Value of Water	Comments
		Source	***Flow (m^3/s)***			***Costs ($'000s)***	***Occurrence***		
Original Channel	Pink Spawning	Jones Creek	0.5	2989	69	20	Annual	200	Inflated costs for maintenance due to 1980–1993 sediment and channel problems. Biannual maintenance was approx. $10,000 to $15,000 before that
Ground-water Fed	Pink/Chum Spawning	Ground-water	~0.5	3000	100	2	Annual	0	Unsure of safety, supply of water source
Penstock Diversion	Pink Spawning	Wahleach Generating Station Penstock	0.5	3000	500–1000	2	Biannual	334	Not using natural source, therefore more lost energy
Peter's Sidechannel	Chum Spawning	Fraser River/ Ground-water	2.1	9000	400	15	Annual	0	Ground-water fed September to May
"Restoring" Lower Jones Creek	All life histories	Jones Creek	Inflows	1500?	100–200	15	Annual	0–200	Flows may be supplemented each year

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APPENDIX E EXECUTIVE SUMMARY OF FIRST NATION STUDIES

EXECUTIVE SUMMARY

Stò:lô Nation, within the framework of exercising its rights and title within its traditional territory has a keen interest in the Jones, or Wahleach Watershed. For this reason, it has conducted a preliminary wholistic study of traditional, contemporary and future use of the entire watershed. This study was done at the request of BC Hydro and the First Nations of the Water Use Planning (WUP) committee as part of the WUP process, which was initiated by the Province to address the operation of hydroelectric facilities. Identification of various uses and activities in the Jones Watershed helped to identify the goals and aspirations that Stò:lô Nation has for the project area and in doing so, identify preferable strategies of dam operation.

The Wahleach Dam was completed in 1952 at the outlet of Wahleach, or Jones, Lake in Stò:lô Nation territory. Stò:lô Nation has taken a more comprehensive approach to the study area than originally requested by BC Hydro, and included the entire Jones Watershed, as well as the area adjacent to the mouth of Jones Creek at the Fraser River, and the Herrling Side Channel.

This research project synthesizes information from a variety of sources, including interviews which were conducted with Stò:lô Elders and others, traditional use studies, oral history data, anthropological and other literature. Wahleach WUP process documents were also reviewed as were relevant fisheries and wildlife studies, and other related scientific literature.

The results of the study demonstrate the great importance of Jones/Wahleach Watershed to Stò:lô Nation in terms of past, present, and future use. Currently, Stò:lô culture is undergoing a process of revival which involves investigation and re-establishment of areas for a variety of uses, such as trails, camp sites and spiritual sites. The interviews of this research project did not identify spiritual sites within BC Hydro's project area definition (between the minimum draw-down water level and maximum flood level of the dam). Several were identified in the greater watershed, however. One transformer site was previously identified in Jones Creek. This study was not comprehensive given constraints of time, money and availability of informants to participate in interviews. Further research is necessary to identify spiritual and other sites used in the past. Future activity in the watershed will involve going out and identifying potential new spiritual sites. Thus Stò:lô Nation may have further recommendations regarding operations of the Wahleach dam in future.

Stò:lô Nation's other major area of focus in the rehabilitation of the ecosystem in the Jones Watershed and project area (as defined by Stò:lô Nation in this report). In practice, accomplishing this goal means moving *towards* conditions which more closely resemble those prior to dam construction. A combination of human-interventions and time will be necessary for this to occur (Hartman and Miles 1997).

Accomplishing this goal involves the following action:

1. stabilize hillslopes and reduce sedimentation in the upslopes of the watershed;
2. remove the fish weir in lower Jones Creek which blocks access to fish habitat;

3. increase flows in Jones Creek considerably;
4. establish patterns of changes in water levels of the lake and flows in Jones Creek which mimic natural patterns (seasonally/annually) as closely as possible; and
5. if necessary, re-establish indigenous plants in the riparian/littoral zone of the lake through natural or other means.

Specific Objectives and Performance Measures suggested by others involved in the WUP process have been reviewed, critiqued and expanded upon in Section 5.0 in which the above actions at times are stated as 'objectives'. Stò:lô Nation is concerned that many of the fisheries PMs are too specific and would require too much money, time, and resources to actually attempt to put into practice. All six fisheries objectives discussed by the WUP Committee could be at least partially accomplished by substantial increases in flows in addition to a strategy of establishing a minimum flow threshold to be maintained at all times, that is, flows would never pass *below* this level. Specific PMs would follow further research to better determine this level in terms of channel morphometry and would reflect some aspects of all six objectives.

Regardless of planning terminology, Stò:lô Nation would like to see the five actions pursued and notes that Number 3-5 apply to BC Hydro's operations of the Wahleach dam. Stò:lô Nation is particularly concerned with the status of fish populations throughout the Jones system, and wildlife and littoral vegetation in the lake. Stò:lô Nation looks forward to the results of a study initiated through BC Hydro which examines riparian/littoral vegetation in dam-influenced lakes. It hopes to dovetail this work with an urgently needed assessment of this vegetation by a Stò:lô plant expert.

Stò:lô Nation remains extremely concerned at the loss of fish habitat and consequent fisheries production in Jones Creek both since the construction of the dam and since the loss of the Jones Creek spawning channel in 1995. These losses affect the Stò:lô's Canadian Constitution S.35 rights to traditional resources access and use.

SUMMARY

This archaeological assessment was conducted on behalf of B.C. Hydro as part of the Wahleach Reservoir water use planning process, for the inclusion in the development of the Wahleach Water Use Plan (WUP). David Schaepe (Stò:lô Nation Archaeologist) directed all aspects of this project under Stò:lô Nation Heritage Investigation Permit 2001-33. All project fieldwork was carried out between June 4-7 2001. This report presents summary information on the background, objectives, methods, results and recommendations of this project.

For the purposes of this archaeological assessment, the (1) the Wahleach Reservoir Basin, (2) Jones Creek, and (3) Herrling Side Channel were defined as subset project areas. The objective of this archaeological assessment was to develop performance measures for the operation of Wahleach Reservoir by B.C. Hydro, taking into account actual and / or potential impacts to 'archaeological sites' and other 'material cultural remains' within the Wahleach Reservoir Basin project area.

A three phase, multi-stage assessment process was developed as a framework process for fulfilling the primary objective of this project. Due to various constraints, funding and otherwise, only Phase I / Stage I of this process has been completed. This entailed the following:

- ***Phase I – Inventory***
  - (a) identify archaeological and other *material cultural remains* within the project area
  - (b) identify and prioritize (by severity of impact and site significance) areas of conflict between cultural heritage sites and reservoir operations – with regards to Phase II evaluation
  - (c) develop a management plan for identified sites and a strategy for implementing such recommendations, including Phase II operations

- ***Stage I – Wahleach Reservoir Basin Project Area Inventory***

- Plan: intensive surface inspection of exposed reservoir basin focusing on the area of exposed mineral soils within the low / high water-level elevations
- Rational: the reservoir basin constitutes the portion of the project area with the highest priority for immediate inventory associated with the greatest potential impacts to material cultural resources; the high degree of soil exposure allows for effective site inventory without conducting sub-surface shovel tests
- Permit requirements: Stò:lô Nation permit
- Access Requirements: low water reservoir level (June 4-10 – low water period for 2001)

In carrying out Phase I / Stage I of this WUP, roughly half of the Wahleach Reservoir shoreline between about 634-640 mASL was inventoried for the presence of cultural heritage sites. None of the reservoir basin below 634 mASL was accessible due to the existing, and rising, water level as of June 4, 2001. No cultural heritage sites were identified as a result of this inventory. As a result, no specific WUP performance measures can be developed at this point of project completion.

It is necessary to complete this WUP project as soon as possible. It is recommended that the remaining portion of the assessment framework be completed in order to determine the need for and develop, if necessary, associated performance measures for inclusion in the Wahleach Reservoir operational plan.

APPENDIX F EVALUATING THE ELIGIBILITY OF STUDIES IN WATER USE PLANNING

The following information was used by the Wahleach Water Use Plan Consultative Committee to evaluate the data collection studies in Step 5 of the *Water Use Plan Guidelines*.

1.0 STUDY PROPOSALS

Studies may include field data collection, analysis and/or model building. The costs and benefits of each study proposed will be described using the "Study Proposal Template." These will be summarized in a summary matrix (Table F-1).

2.0 EVALUATION CRITERIA (See Figure F-1 for Flowchart Summary)

Step 1

Will the study provide information related to the calculation of a performance measure?

- If not, the study is not eligible for Step 5 studies.

Step 2

Is the data gap or uncertainty that this study addresses significant enough to affect the ranking of alternatives?

- A "no" answer should normally disqualify a study from further consideration. For some studies, the answer will be clearly "yes." For others, it may be unclear. Judgment will have to be used.
- In some cases, there may be data gaps that we could fill that would improve a performance measure, but that are unlikely to affect the ranking of alternatives. Examples of cases where an uncertainty exists, but is not likely to affect ranking of alternatives, include:
    - We may not know a parameter value exactly, but we can, with reasonable confidence, establish a range of plausible values for it. If, within that range, the performance measure value does not change significantly, then it is not essential to address the uncertainty.
    - If all alternatives are equally affected by an uncertainty (all biased up or all biased down), the absolute value of the performance measure may be wrong, but the relative ranking of the alternatives is not affected.

Step 3

Can the study provide meaningful, reliable data within the time frame available in the Water Use Plan project schedule?

- If not, the study is not eligible for Step 5 studies.
- In many cases, especially for studies involving fisheries and wildlife, year-to-year variability is significant and it is not possible to draw scientifically defensible conclusions from a single field season. If a study cannot provide data that provides useful information after a single field season, it is not a candidate for Step 5 studies. It may, however, be a candidate for longer term monitoring programs that are conducted as part of *Water Use Plan* implementation. If it turns out that participants feel that a particular uncertainty significantly affects the ability to make responsible decisions at Step 7, then a monitoring program may be designed to address the uncertainty and ensure that better information is available for the next *Water Use Plan* review. Participants may link their recommendations about the timing of the next *Water Use Plan* review to the expected timing of results from long term monitoring programs.

Step 4

Do the benefits outweigh the costs?

- If Steps 1 through 3 are "yes," then it is necessary to look at the cost of a proposed study. There may be a range of study designs that will provide a range of data quality, and these should be evaluated. If the costs for studies in support of a performance measure are very high, then it may be important to consider alternative performance measures. In some cases, a simpler measure may provide better value.

3.0 STUDY PRIORITIZATION

After evaluating each study against the above criteria, it will be assigned one of five priorities:

Priority 1	The information provided by this study is essential for *Water Use Plan*. Responsible decisions cannot be made without it.
Priority 2	This study will provide information that is likely to affect the ranking of alternatives. The benefits clearly outweigh the costs.
Priority 3	This study has benefits, but is of lower priority. Some reasons for lower priority include: • Costs may outweigh benefits. • The benefits may not be significant enough to affect ranking of alternatives. • The performance measure this study addresses has less likelihood of being the "limiting factor" (relative to other performance measures).
Priority 4	This study is not necessary or desirable for *Water Use Plan*.
Priority 5	This study may be important, but cannot be completed within the *Water Use Plan* timeline.

4.0 STUDY APPROVAL

The Consultative Committee will prioritize studies as above, and will make recommendations to BC Hydro about which studies should be approved. However, BC Hydro retains the final decision-making responsibility for study approval, and will make this decision based on the recommendations of the Consultative Committee, the costs and benefits outlined as above (and in the study proposal template), and the availability of resources.

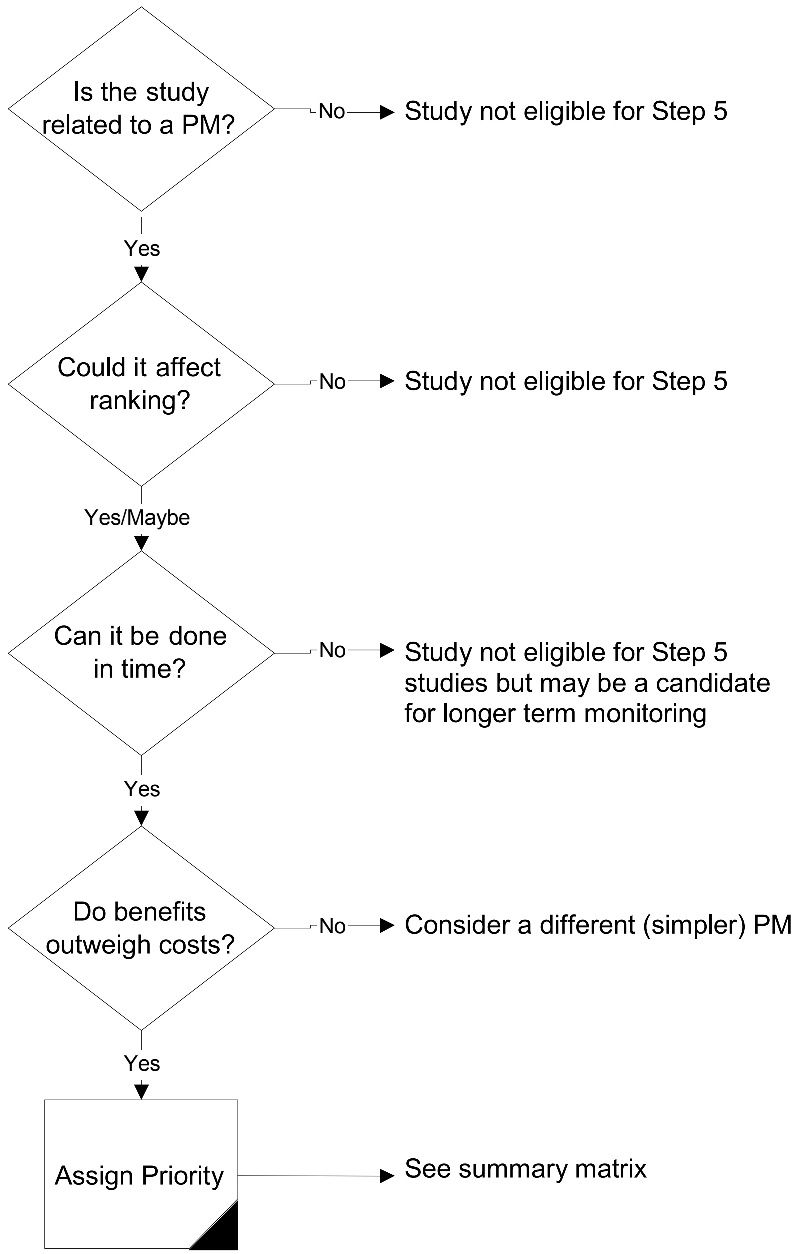


Figure F-1: Guidelines for Prioritizing Step 5 Studies

Table F-1: Summary Matrix for Priority Setting

Study	Cost	Completion Date	Uncertainty or Data Gap Affected	Affects	Benefits Ranking?	Risks	Priority Assigned

Based on the information contained in the Study Proposal Template, the summary table will be completed and used to assign a priority to each study.

APPENDIX G CALCULATING THE LEAST SIGNIFICANT DIFFERENCE BETWEEN PERFORMANCE MEASURES

The following information was prepared by the facilitator for the Wahleach Water Use Plan Consultative Committee.

1.0 Introduction

Towards the end of a Water Use Plan, it becomes important to compare alternatives based on performance measures (PMs). This raises the question, however, of how to decide when two measures are different and when they are the same. In this discussion, we will focus on a PM for fish that measures hectares of expected habitat. Let's say that this measure differs by 10 ha across the alternatives, as shown below in Table G-1.

Table G-1: Performance Measures for Fish Spawning

	Alternatives A (Status Quo)	B	C
PM – hectares of spawning habitat	100	110	110

It is important to keep in mind that these two measures are predictions about how the operations of the dam will impact spawning habitat in the future. There are several reasons why a principled discussion needs to be used in thinking about the differences between these forecast values:

1. An important tool in any trade-off analysis is pairwise comparisons that can eliminate alternatives through simple dominance. This can be done as an early step because it is easy and does not require any difficult value judgments on the part of the participants. However, in order to do this, it is critically important that it is clear to everyone what it means when the analyst says "greater than," "less than", or "equal to." Knowing that the fish PM is (effectively/practically) equal across A and B simplifies this process enormously.

2. Laying out the forecast PM, along with its bounds of significance, is a key part to stating clearly the link between water flows and changes to other categories of interest. By including error bars as in Figure G-1, we can state that Alt B is forecast to give more fish habitat than Alt A (Status Quo), even given the uncertainty around the estimates for Alt B. It is this last part of the claim that will force people to think clearly about what they are asking for, and to make sure that their judgments about hypothesized impacts can stand up to professional scrutiny.

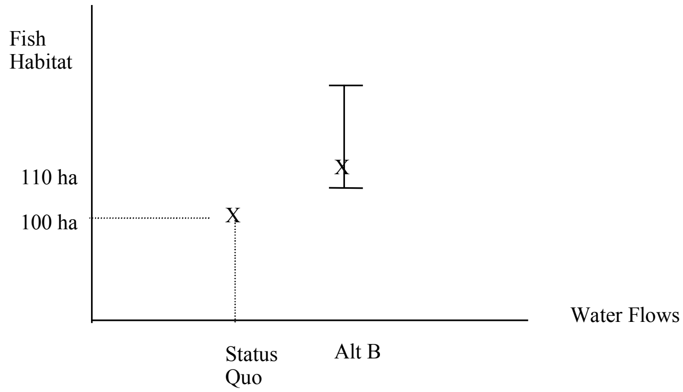


Figure G-1: Least Significant Difference Across Alternatives

3. Finally, if these measures of the least significant differences are not worked out using some principled reasoning (and in particular, in advance of the groups seeing how the alternatives are faring for other interests), then it will be very tempting for people to figure out what a significant difference is based on how it furthers the alternatives that they want to have chosen. This backwards reasoning will subvert the process and must be resisted.

2.0 General Principle for Calculating the Least Significant Difference

The general principle for calculating the least significant difference must be that, given all of the sources of uncertainty, the performance measure itself can be no more certain than its least certain component.

This maxim can be illustrated easily. Say that the PM is a function of two measures, X and Y, in the following way; PM = X x Y. Now imagine that for the Alternative B, X = 11 and Y = 10, and that X is accurate to ± 0.1 units and that Y is accurate to ± 0.2 units. Then it is clear that the PM ought to be expressed as 110, but with a range from 10.9 x 9.8 = 106.82 units to 11.1 x 10.2 = 113.22 units. So in general, this maximum grossly *understates* the level of imprecision in calculated measures.[1] However, I would suggest that measures used in water use planning are far more precise than even this maxim would allow.

[1] As an additional caveat, it is most likely the case that these components of uncertainty accumulate in their impacts. As an example, if there is measurement error, statistical variation, and modelling error, then the forecast PM may be uncertain to a degree far beyond even the largest error of any of these individual measures.

3.0 How to Apply the General Principle for Calculating the Least Significant Difference

The steps for applying this general principle can be easily laid out. While these steps should be applied in every Water Use Plan for all PMs, the degree to which they are applied will probably vary greatly, depending on circumstances.

- Step 1 – List the sources of uncertainty.
- Step 2 – Estimate the magnitude of impact that each component of uncertainty will have on the interpretation of the forecast PM.
- Step 3 – Select the component of uncertainty that will have the largest impact on the interpretation of the forecast. This is best done in subgroups, and having consensus on this judgment is powerful.
- Step 4 – Highlight the degree of uncertainty in the form of the Least Significant Difference and give examples to the subgroup and the Consultative Committee how this is used in a consequence table.

4.0 Listing the Sources of Uncertainty[1]

A quick list of the major sources of uncertainty in Water Use Plans would include:

1. Statistical variation due to fluctuating inflows.
2. Measurement error.
3. Modelling error.
4. Weakness of the link between the PM and the fundamental objective.

The level of uncertainty arising from each of these components needs to be assessed in a different way, and may be of different magnitude depending on the interest area (fish, flooding recreation, etc.).

These components will be discussed below, and then some general observations around when which component will dominate will be added.

[1] An excellent reference to this material is Morgan and Henrion's "Uncertainty: A Guide to Dealing With Uncertainty in Quantitative Risk and Policy Analysis." This list is inspired, in part, from their categorization of uncertainty.

5.0 Statistical Variation Due to Variation in Inflow

Any PM, such as for fish habitat, is a function of policy actions (P) (which may include gate operations, ramping rates, etc.), relationships between fish measures and flows which rely on a certain vector of parameters (**F**), and some random inflows $(\tilde{Q})$. Since the PM is a function of random variables, it too is a random variable, with a mean and variation.

To say that two means are truly different requires one to take into account the dispersion of data (variation) as well as the difference of means. An example of this can be shown in Figure G-1, where the PM (average spawning area) for Alternative B is still above that of A. However, on the right hand side, it is not clear that B (the red graph) is "higher" than A. In fact, it may be that most of the time Alternative B gives measures below that of A, but a few extreme occurrences increase the mean of B.

A well known test to compare means while taking into account their variation is the t-test (a test of the difference of means). The formula for this requires the means and the standard deviations for each PM, and can be found in any introductory statistics book. Excel will also calculate this for you, given the PMs for each alternative in each year.

It would be a mistake to say that the lack of distinction between means is a fault of calculating means. A similar perverse outcome could be arrived at through comparing medians. Non-parametric tests (such as a sign test or a rank test) are then required to say that one median is truly higher than another, given the dispersion of the data.

Carrying out pairwise comparisons will tell you how any two alternatives will compare on a given PM. It will not give you one measure of significance (± 5%). But an overall picture can be painted through looking at these comparisons. For instance, it may be that most means that are around ± 5% of each other are deemed to be the same by a t-test. Then this information is useful to the Consultative Committee. However, the analyst will have to caution that this rule of thumb may vary in any particular comparison.

6.0 Measurement Error

This is also a source of uncertainty, and one that is overlooked in Water Use Plans. It may be that water gauges at high flows are only accurate to ± 5%. It also may be that surveying of river channels and banks have a certain level of accuracy. If both these measures are combined, then the resulting PM can be no more accurate than the least of these measures, and in reality must be considerably less accurate than either.

One common error made in Water Use Plans is to assume that "the error is the same across alternatives, and therefore it does not matter." This "fallacy of constant errors" is misleading. It may be that there is some threshold, below which the PM gets a score of 1 in a year, and above which it gets a score of 0. In this case, having the flows accurate to ± 15% may make a difference in PMs. As well, when it comes to making trade-offs, scaling one PM up or down by a certain factor changes the rate at which trade-offs are made between that measure (say, fish) and another measure (say, money).

One way to test the sensitivity of the PM to measurement error is to vary the measured components within their presumed tolerances, and then track the changes in the PM. This will give the ± measure for this PM. As well, it will give the analyst a hint as to whether different alternatives change their rank as these measures change.

7.0 Modelling Error

One major source of uncertainty is in the application of models. In many cases, several key assumptions need to be made in order to make the link between water flows and the PM in question. These might include: which Habitat Suitability Index curves to use, what portions of the river can be represented by which surveyed sites, what is the discount rate, etc.

Groups may spend a lot of time working through these issues in order to allow modelling to move forward. However, the only way to test for the impact of this on PM calculations is to systematically vary these assumptions and then track the sensitivity of the PMs. This will give the ± measure that the group then needs to use in interpreting PMs. Note that this ± measure may not be the same across alternatives, so some gut feel about how accurate these measures are will need to be used, with the caveat that a more detailed measure of least significant difference may be needed for any specific comparison.

8.0 Link Between the PM and the Fundamental Objective (Practical Significance)

Finally, one needs to look at the link between changes in the PM and changes in the fundamental objective. This exercise is quite different from the ones above, and will require a good deal of professional judgment. It is here that people need to be clear about how sure they are when they make this link.

Note that this is one of many instances when the water use planning process is handing people a double-edged sword. If people are very confident about the link between the PM and the fundamental objective, then once this claim is laid out it can be scrutinized with others' professional judgment. Moreover, if this link is as tight as people say it is, then it can be tested through monitoring and used as a yardstick of success. However, if people are not willing to say with confidence that there is a tight link between the PM and the fundamental objective, then this ambiguity needs to be highlighted as a key uncertainty. If it is the largest uncertainty, then this interpretation will get carried forward to the Consultative Committee to help them interpret the PMs.

9.0 Which Uncertainties Matter Where?

Different interest areas will have different magnitudes of uncertainty for their different components. Below is a brief and incomplete list. Note that across all areas, we have measurement error in the flows, some modelling error in the AMPL runs, and statistical variation in the flow data. When the other areas of uncertainty are low, these become high, as a relative measure.

Table G-2: Relative Measures of Uncertainty for Performance Measures Across Interest Areas

	Statistical Variation	Measurement Error	Modelling Error	Uncertainty Around Link to Fundamental Objective
Fish	Medium	Low	Medium	High
Flooding	High	Medium	Low	Low
Power	High	Low	Low	Very Low
Recreation	High	Medium	Low	Very High
First Nations	Medium	Low	Low	High

10.0 Other Observations

A few other observations regarding the treatment of uncertainty in Water Use Plans need to be made. They are listed below along with some comment.

11.0 Rounding

It has been suggested (by Carl Walters, among others) that we could address some of these issues around uncertainty by rounding off figures appropriately. This is not always correct. If Alternative X has a PM of 103, and Alternative Y has a PM of 107, and this PM is accurate to ± 5%, then rounding these off exaggerates their differences when they really are close to being equal.

12.0 Selecting the Appropriate Units

It is important that the RV folks consider the appropriate units to present to the public before any meetings. Experience has shown that PMs expressed with high degrees of precision tend to remain very precise measures even when uncertainty is discussed. So, whether a PM is measured in square metres, hectares, or per cent, deviation from some benchmark may skew these discussions.

APPENDIX H POST-CONSULTATIVE COMMITTEE TECHNICAL SUBCOMMITTEE MEETING MINUTES ON FERTILIZATION PROGRAM

Development of an Operational Fertilization Program on Wahleach Reservoir

1.0 BACKGROUND

This summary documents the discussions between technical representatives on 4 November 2002, to determine the fertilization program components for the recommended 10-year review period.

On 7 October 2002, the Wahleach Water Use Plan Consultative Committee recommended a package of operating constraints and non-operating programs for the Wahleach hydroelectric facility that would see fisheries benefits in Jones Lake Reservoir, Jones Creek, and Herrling Island (Fraser River) Sidechannel. The reservoir will operate under a fixed minimum operating elevation of 628 m, and an annual fertilization program will be implemented to mitigate impacts of reservoir fluctuations within the new operating range of 628 to 642 m.

Technical representatives present in the discussion were:

- Chris Perrin, Limnotek
- Ross Neuman, Ministry of Water, Land and Air Protection
- Hugh Smith, BC Hydro
- Mike Lewis, BC Hydro
- Alf Leake, BC Hydro

2.0 DISCUSSION

2.1 Program Development and Function

Fertilization at Jones Lake Reservoir was funded between 1995 and 2001 by BC Hydro to compensate for losses in productivity in the reservoir associated with the "footprint" impact of dam construction. The Ministry of Water, Land and Air Protection continued fertilization application in 2002 while the Wahleach water use planning process defined an operating strategy for the system. The program, as it was traditionally operated, was unique and complex – part of a fisheries management strategy focusing on kokanee production. The strategy was three fold:

- Long-term fertilization of the reservoir to enhance food resources in the reservoir.
- Short-term supplementation of juvenile kokanee for initial stock enhancement.
- Short-term supplementation of sterile cutthroat to reduce stickleback populations, and free up food resources for kokanee.

For 5 years, between $60,000 to $80,000 per year was spent assessing the biological response to the management actions taken. Costs of assessment reduced over time, as response indicators were refined and efficiencies were gained in reporting. Historically, Limnotek consulting firm was responsible for the addition of fertilization and assessment of reservoir benefits. Their typical program is summarized in Table H-1.

Table H-1: Summary Cost Estimate for Components of Annual Wahleach Fertilization

Component		**Amount**
Fertilizer addition		$41,000
Limnology sampling		$12,500
Fish sampling using gill nets and minnow traps		$15,800
Hydro-acoustics		$13,200
Spawner survey		$7,100
Reporting	Annual Data Summary	$5,500
	Biannual Review	$11,000
	Full Analysis and Review	$18,000

1. Source: Perrin, personal communication, 2002

The first five years of the project were to focus on establishing kokanee populations, and managing the effective application of reservoir fertilization. For the projected long-term, the program was to focus on the maintenance of kokanee stocks through annual fertilizer additions. Due to difficulties in establishing the kokanee populations, the first step of the program took longer than expected. While kokanee stocks appear to be established at present, further study is warranted to ensure benefits can be sustained by fertilization.

2.2 Wahleach Water Use Plan Fertilization Program

Objective and Performance Measures

For the Wahleach Water Use Plan, it is recommended that the objective of the fertilization program continue to be to restore and maintain kokanee abundance. To determine if this objective is being met, the following performance measures must be evaluated over the review period:

- Spawner abundance: annual assessments of tributary spawning by kokanee.
- Reservoir population: biannual estimate of population and density distribution of all fish species.
- Zooplankton production*:* biannual estimate of zooplankton production in the reservoir.

Schedule and Review

Because of the unresolved status of these performance measures to date, it is recommended that two years of full fertilization assessment be completed at the start of the review period, prior to embarking on a review every two years of fisheries and zooplankton production in the reservoir. There will be three levels of reporting over the review period:

- Annual Data Summary: study results will be summarized for each performance measure on an annual basis ($5,500).
- Biannual Review: study results are summarized for entire program period; program performance reviewed and recommendations provided ($11,000).
- Full Analysis and Review: after the first four years of study, a comprehensive evaluation of the program's performance as per above, peer reviewed and published ($20,000).

Table H-2 summarizes the proposed Wahleach Water Use Plan Fertilization Program components.

All costs are estimates and subject to change upon review by the Ministry of Water, Land and Air Protection and Limnotek staff. It is expected that the program costs will be finalized by the week of 12 November 2002, once agency staff have confirmed Alouette fertilization staff involvement, and an internal review is completed.

Table H-2: Wahleach Water Use Plan Fertilization Program Components

Component	Frequency	Description		Options		
				A	B	C
				Cost ($'000s)[1]		
Fertilizer addition	Annual	Purchase of fertilizer; application; project management		41.0	34.0	20.0
Limnology Sampling	Biannual	Zooplankton and phytoplankton analysis		5.5	5.5	5.5
Hydro-acoustic study and fish sampling	Biannual (and first 2 years)	Hydro-acoustic sampling for density distribution and population estimates; trawling and gill netting required as calibration for the hydro-acoustic work.		29.0	25.0	19.0
Spawner survey	Annual	8 weekly surveys of tributary spawners		7.1	7.1	7.1
Report	Annual	Data Report		5.5	5.5	5.5
	Biannual	Review and Data report		11.0	11.0	11.0
	4 year Review	Comprehensive evaluation of methods and performance		20.0	20.0	20.0
Total	Annualized	Capital investment of boat ($20,000) and facility roof ($25,000)[2]	Without	74.5	65.5	48.5
			With	80.5	71.5	54.5

1. (A) Limnotek provided services
   (B) Ministry of Water, Land and Air Protection provided services
   (C) Ministry of Water, Land and Air Protection provided services – sharing Alouette Res. program resources
2. Assumed 10% over 10 years for boat; 25 years for roof: ~$6,000/yr

APPENDIX I AGREEMENT ON RESTORATION ACTIVITIES IN LOWER JONES CREEK

Fisheries and Oceans Pêches et Océans

MEMORANDUM NOTE DE SERVICE

To / À: Wahleach Water Use Plan Consultative Committee

From / De: Dan Sneep

Security Classification - Classification de sécurité
UNCLASSIFIED
Our file - Notre référence
Your File - Votre référence
Date: **26 April 2002**

Subject / Object: **AGREEMENT ON COMPENSATION ACTIVITIES IN LOWER JONES CREEK**

The following provides a summary of recent discussions between BC Hydro and Fisheries and Oceans Canada (DFO) regarding compensation activities in lower Jones Creek, and describes the potential implications of these developments on the Wahleach Water Use Planning (WUP) process.

By way of background, during the development of the Wahleach hydroelectric facilities by BC Electric Company (predecessor of BC Hydro) in the early 1950s, the federal Department of Fisheries (predecessor of DFO) advised BC Electric of their responsibilites to preserve salmon in lower Jones Creek. In response, BC Electric agreed to build a spawning channel for pink salmon (chum used it as well) and to provide sufficient flow down Jones Creek to operate it. The spawning channel functioned to support these runs of fish until the mid-1990s, when debris flows originating in Jones Creek tributaries destroyed the channel. These debris flows are ongoing, the result of historic logging in these tributary watersheds that has left them highly unstable and susceptible to washouts during rain and snowmelt events.

Following the destruction of the spawning channel by a debris flow event in 1995, an assessment of the status and prospects for the spawning channel and lower Jones Creek was conducted by Mike Miles, a fluvial geomorphologist, and Gordon Hartman, a fisheries biologist. They concluded that given the ongoing instability of the watershed, it was not feasible to rebuild the channel. Their recommendation was to remove the spawning channel infrastructure (i.e., wiers, dikes) to allow the creek to move throughout its original floodplain, which would increase its capacity to recover from periodic debris flows and provide improved habitat conditions for fish. Their report formed the basis for subsequent discussions between DFO and BC Hydro, in which BC Hydro committed to providing some form of compensation in lower Jones Creek for the Wahleach facilities. The parties agreed at that time that this new approach to compensation in lower Jones Creek would be developed in conjuction with the upcoming Wahleach WUP process.

This new approach to compensation was discussed at a meeting between DFO and BC Hydro on April 11, 2002. At that meeting the parties agreed that a "decommissioning" of the spawning channel, based on the recommendations in the Miles and Hartman report, would be an appropriate means of addressing compensation requirements in lower Jones Creek. An on-site meeting, attended by DFO and BCH staff as well as Mike Miles, was held on April 24, 2002, to assess the present status of the lower creek and develop potential restoration options. These options included removal of the upper and lower spawning channel

Canada

wiers, reconfiguration of some of the bank armouring structures, and relocation of setback dikes to allow the creek to move through a greater extent of its floodplain, while protecting existing structures such as the pipeline, bridges, and highway. The parties agreed that the stakeholders responsible for these and other interests in the lower creek would be consulted in the development of the proposed works. The next steps in the process will be for a BC Hydro project team to develop a detailed plan for the project in cooperation with DFO habitat restoration staff over the course of the coming year, with the actual physical work to be undertaken next summer.

The potential implications of this work on the current WUP process should be minimal, given that the proposed project is likely more than a year from actual implementation. However, anticipating the potential improvement of habitat in lower Jones Creek may influence the value placed on that component of the Wahleach system by the CC. The decommissioning of the spawning channel should not affect the habitat-based performance measures for lower Jones Creek, at least over the short-term. Mike Miles' recommendation as to flows to facilitate the rehabilitation of the lower creek was to provide a suitable base flow for fish habitat requirements; this is addressed by the current WUP performance measures and operating alternatives for the lower creek.

The implications of this project on the WUP will not be fully realized until the work is complete. As such, my recommendation to the CC would be to incorporate a trigger within the present WUP, that once the spawning channel decommissioning is complete, and the flow regime that would best provide for habitat restoration and fish requirements in lower Jones Creek is understood, the WUP would be re-opened to incorporate these considerations.

I hope that this has provided an adequate summary of the discussions and issues related to compensation activities in lower Jones Creek. Let me know if you have any comments or questions.

Dan Sneep, R.P. Bio.

APPENDIX J JONES CREEK FISH HABITAT ENHANCEMENT PROJECT

The recommended Alternative Salmon SIR628BCD+ Siphon includes a fish habitat enhancement project in Jones Creek anadromous as follows:

- Intake facilities to ensure adequate flow in the channel for fish spawning, incubation and rearing needs.
- Localized bank hardening to ensure channel integrity during storm events.
- Several spawning platforms and rearing ponds with complexing (large woody debris, large boulders, etc.).
- Road access for regular maintenance requirements.
- Signage and facilities for community information and access.

The sidechannel portion of the habitat enhancement project will differ from the original spawning channel design in several ways:

- The design of the channel will allow for regular maintenance and reconstruction expected in the floodplain.
- The channel will be operated year-round to serve the requirements of fall spawners and year-round rearing species, through spawning platforms and rearing pools.
- The channel development will not pursue the level of productivity achieved by the original spawning channel. Instead, the focus will be on maintaining a year-round stable habitat for mainstem refugia and stock preservation.
- The intake works will be designed to percolate flows such that storm events will not require repeated maintenance of the facilities.
- The lack of fish diversion structures on the mainstem will allow returning adults access to both parts of the system, affecting overall fish productivity, but maintaining the restorative principles implicit in the Fisheries and Oceans Agreement on Restoration Activities in Lower Jones Creek.

APPENDIX K RECONFIGURATION OF BOULDER CREEK DIVERSION DAM

1.0 Background

In October 2002, the Wahleach Water Use Plan Consultative Committee recommended an operating alternative that included a minimum flow in lower Jones Creek anadromous and a minimum flow release from the Boulder Creek Diversion Dam. The Boulder Creek Diversion Dam diverts flow from Boulder Creek into Jones Lake Reservoir. The Diversion Dam was originally built with a fish release gate capable of allowing up to 1.4 m^3/s of Boulder Creek flow to continue into Jones Creek to provide flows for an artificial spawning channel. However, over time, erosion at the intake of this gate has resulted in all the water now being diverted to the reservoir at very low flows.

2.0 Wahleach Water Use Plan Conditions

From 15 September to 30 November, BC Hydro will provide a minimum flow of 1.1 m^3/s into Jones Creek to be measured at a staff gauge to be installed in Jones Creek near Laidlaw. At all other times, BC Hydro will provide a minimum flow of 0.6 m^3/s into Jones Creek to be measured at a staff gauge to be installed in Jones Creek near Laidlaw.

To the extent that Boulder Creek inflows are available, BC Hydro will provide a minimum flow of 0.14 m^3/s from the Boulder Creek Diversion Dam into Boulder Creek downstream of the bypass facility year-round.

The Wahleach Water Use Plan minimum flow conditions will limit the operation of the works and will require a capital investment to undertake structural modifications to the discharge facilities at the Boulder Creek Diversion Dam. Therefore, the recommended operating alternative included a reconfigured Boulder Creek Diversion Dam at an estimated cost of $1.5 million.

3.0 Boulder Creek Diversion Dam Infrastructure

The recommended conditions for the Wahleach hydroelectric facility will not come into effect until implemented under the Water Act. For the first five years of operations, BC Hydro will install and maintain temporary infrastructure at the Boulder Creek Diversion Dam to meet the conditions outlined above. During this period, the following studies will be undertaken.

1. Assessment of Boulder Creek inflows.

2. Assessment of Boulder Creek channel stability.

3. Jones Creek anadromous salmonid productivity monitoring.

BC Hydro will undertake permanent structural modifications to the discharge facilities at the Boulder Creek Diversion Dam upon review of the results of the monitoring program and the availability of Boulder Creek inflows five years after implementation of the Wahleach Water Use Plan. A detailed design and hydraulic assessment will be conducted prior to construction.

During the Wahleach water use planning process, BC Hydro prepared a preliminary design for a weir at the Boulder Creek Diversion Dam. The preliminary design is subject to modifications.

Figure K-1 illustrates the main components of the weir based on an existing 1:500 scale survey (1994) of Boulder Creek as follows:

- A 22 m long and 3 m high (1.5 m buried) diversion weir made of reinforced concrete and extending across Boulder Creek. The sketch shows the weir conceptually positioned immediately downstream of the existing intake structure.

- A stilling basin adjacent to the intake structure measuring approximately 10 m by 4 m and lined with reinforced concrete to facilitate clean-out of accumulated bed load.

- Replacement of the existing 600 mm diameter culvert pipe with a new 900 mm diameter pipe (likely CSP). The condition of the existing pipe needs to be inspected, but is assumed to likely require replacement due to possible advanced corrosion. Hydraulic analysis is required to confirm the sizing of new pipe to ensure sufficient flows can be conveyed.

- New pre-cast end wall structures both at the intake (with trash rack) and outlet ends of the diversion pipe. The need to replace the existing intake structure would be determined after detailed site inspections and confirmation of the final optimum design.

- A new Armtec standard type sluice gate and manual control mechanism. This is required if the pipe size is increased to 900 mm, or if the existing gate needs to be replaced.

- Erosion protection of approximately 50 m of the left bank by excavation, reprofiling, placement of key blocks (large boulders retrieved from the creek bed) or concrete lock blocks (same as seen on the right bank), riprap slope armouring and infill concrete. Riprap may be salvaged from the creek excavations, but an allowance is made for trucking in suitable rock from the nearby quarry.

- Large keystone blocks (again salvaged from the creek bed) would be positioned along the upstream edge of the concrete weir structure to protect against erosion and undermining. Similar keyblocks would also be placed along the toe of the weir to provide energy dissipation and prevent scour erosion.

- Local sections of the diversion dam (right bank) slope are being undermined. These sections would be reinstated using suitable keyblocks and infill concrete as required.

- A provision is included for sediment control, ditching, pumping and diversions during in-stream works.

- The former, now overgrown, Boulder Creek channel below the diversion dam would be hand cleared. An allowance is included for replacing the twin 600 mm CSP culverts at the Jones Creek FSR crossing.

Figure K-2 illustrates a Tyrolean weir, which incorporates a transverse intake channel along the downstream face of the weir. This could be supplemented with a static inclined concave wedge wire screen that utilizes the Coanda effect, which allows clean water to drop into the underlying channel while debris is discharged off the downstream end of the screen. In this case, the weir would be positioned just upstream of the intake structure. The advantage of this concept is that the weir and intake channel could be designed to be self-cleaning while maximizing flow interception.

References

Lawrence, M. (BC Hydro). (2002). BC Hydro Inter-office memo to A. Leake – Wahleach WUP – Boulder Creek Rehabilitation of Diversion Dam and Flow Diversion (File: WAHWUP – F600). Created for the Wahleach Water Use Plan, Burnaby, B.C.

Figure K-1: Plan View of Bypass Facility Rehabilitation Option Proposed by BC Hydro Engineering Staff Courtesy of Lawrence, 2002

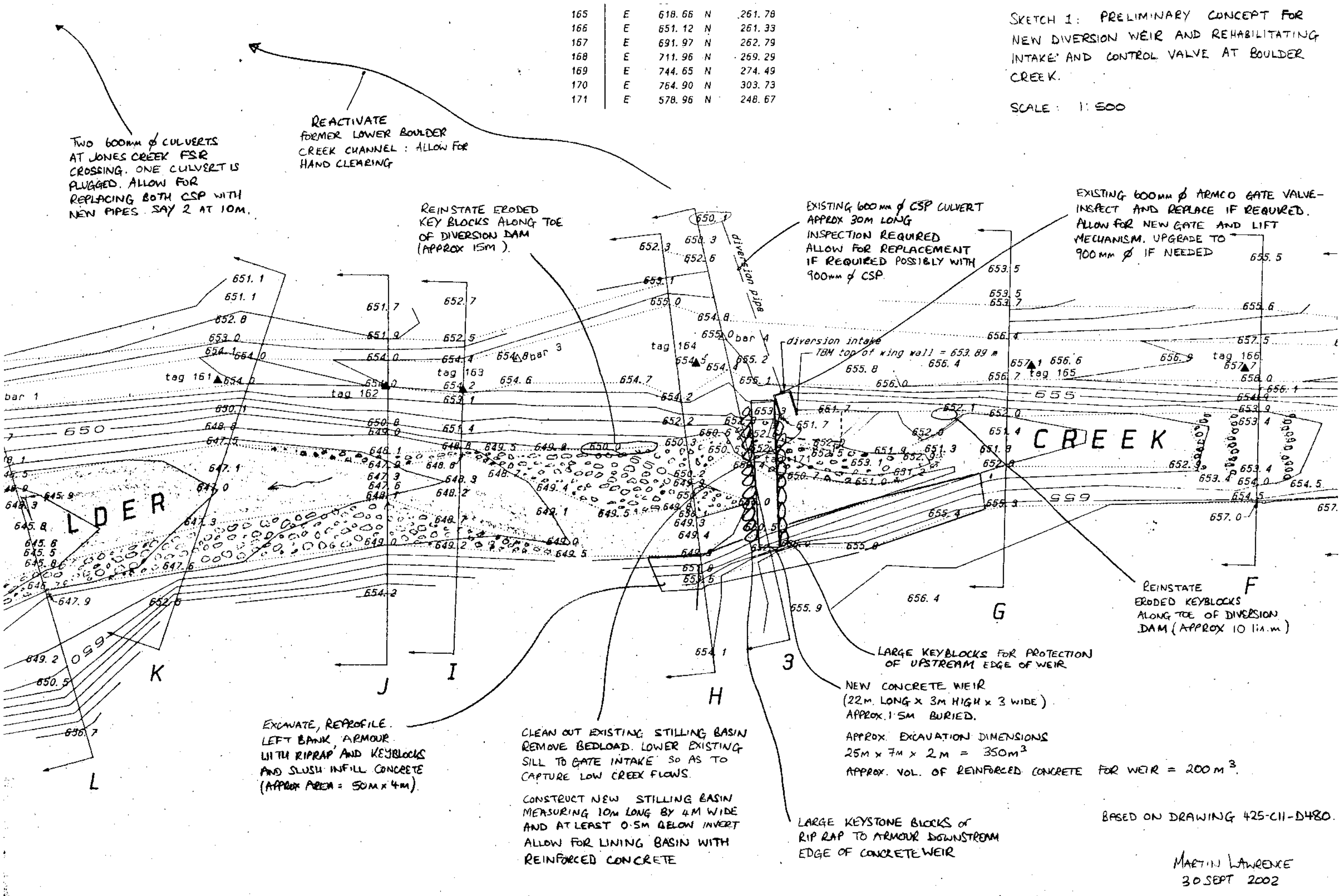


Figure K-2: Tyrolean Weir Option for Boulder Creek Diversion Dam Bypass Facility

10931 00/05

COMPUTATION SHEET

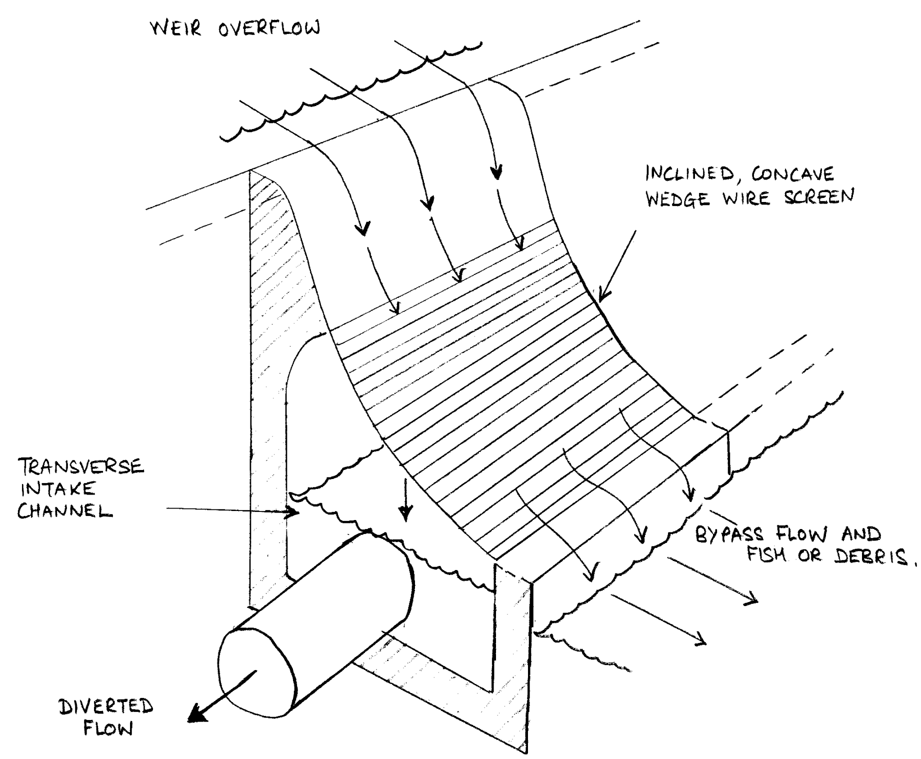
BChydro

Project WAHLEACH WUP - BOULDER CREEK. Sheet ____ of ____

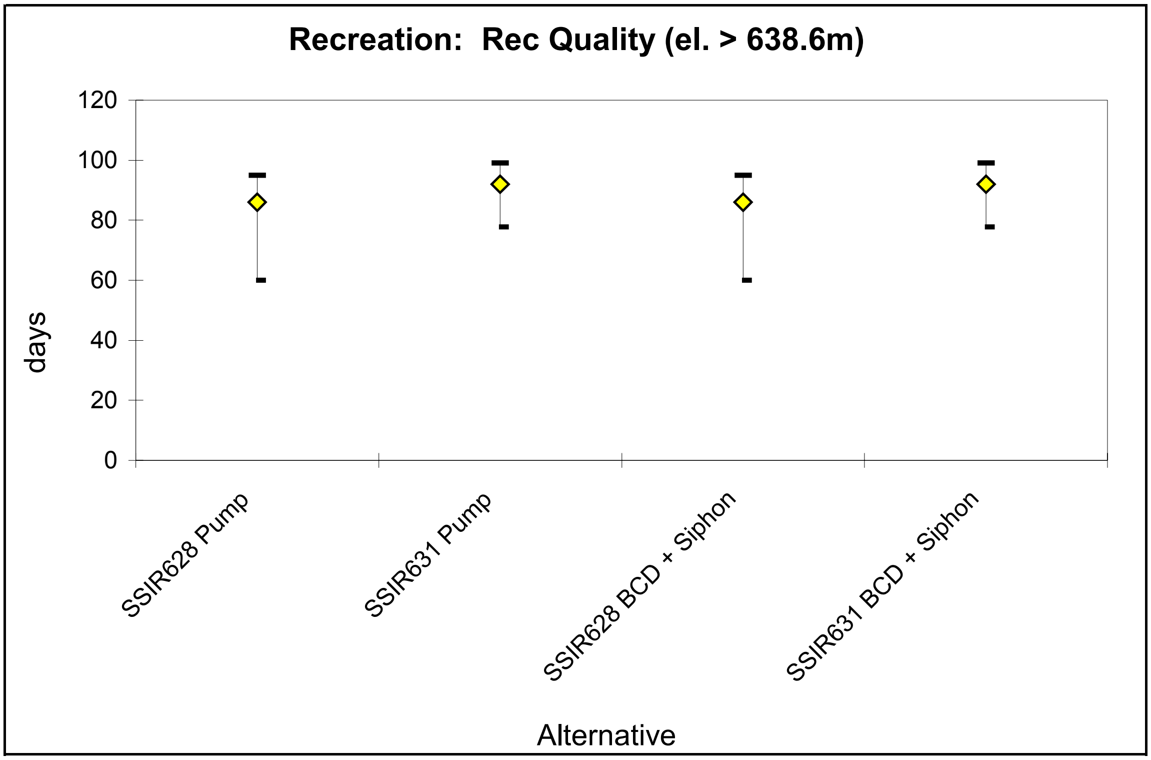
Computation of ____

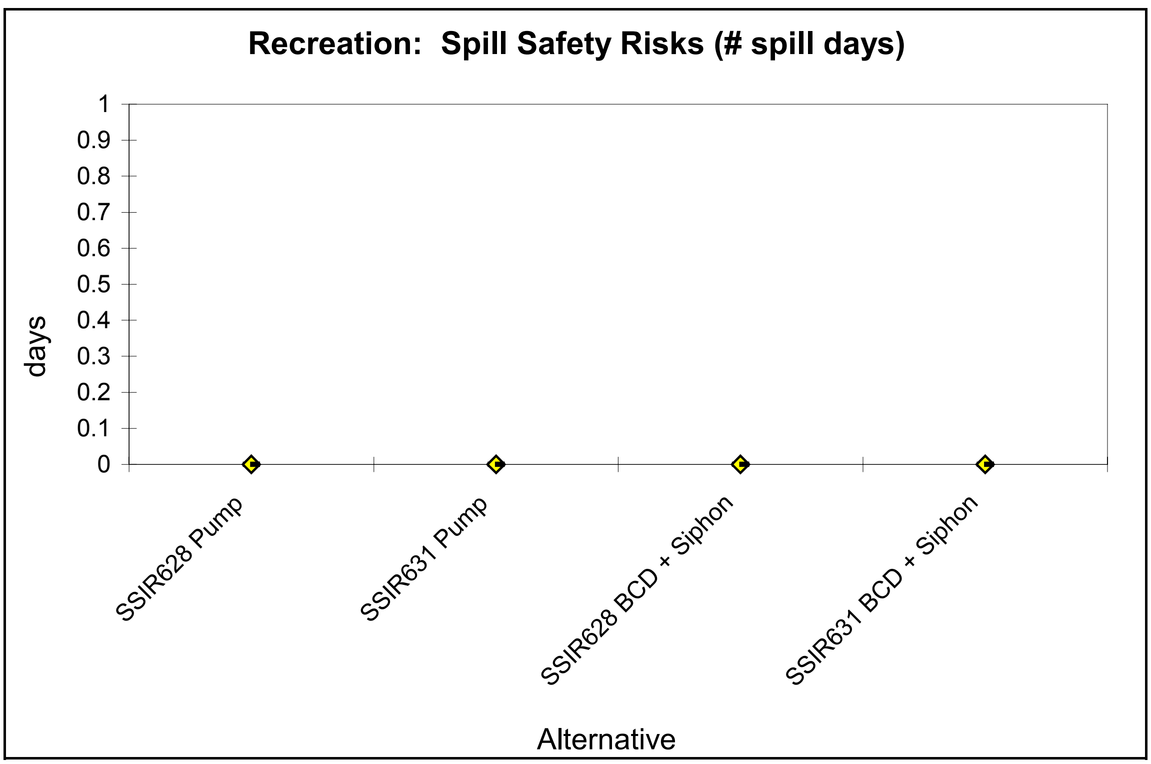
Computed by MARTIN LAWRENCE Date 30 SEPT 2002.

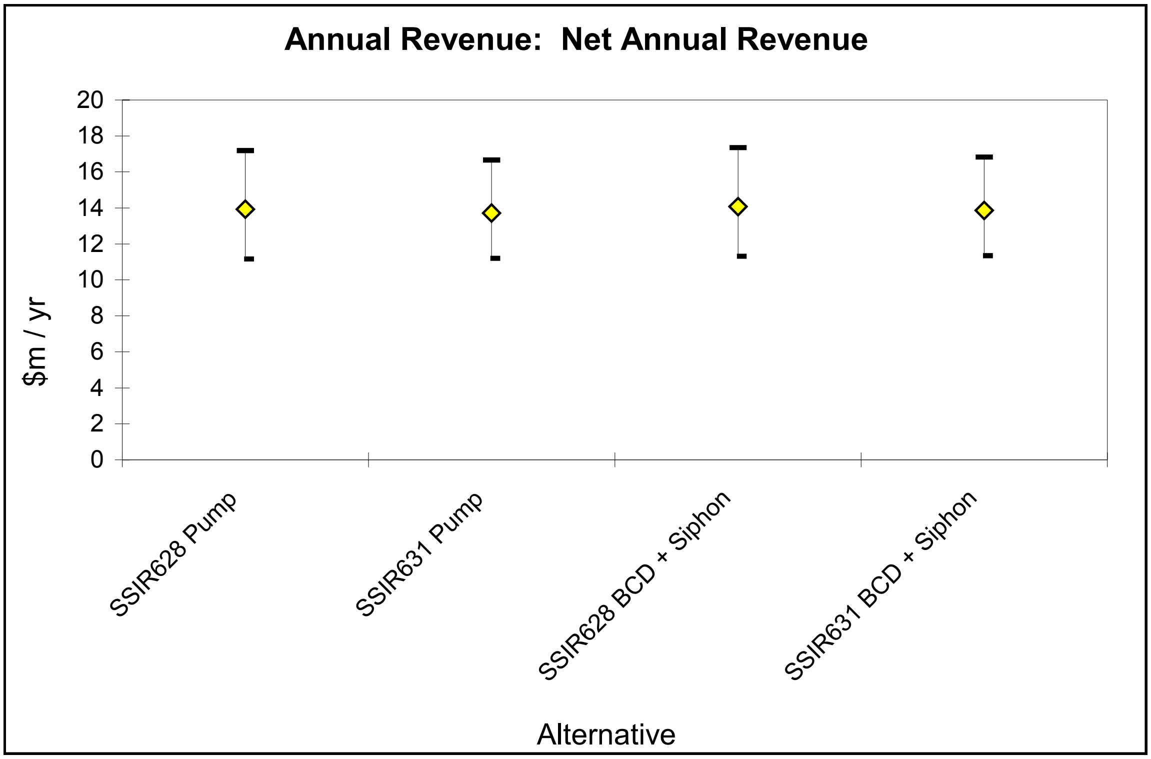
SKETCH 2: TYPICAL CONFIGURATION OF TYROLEAN WEIR WITH WEDGE WIRE SCREEN

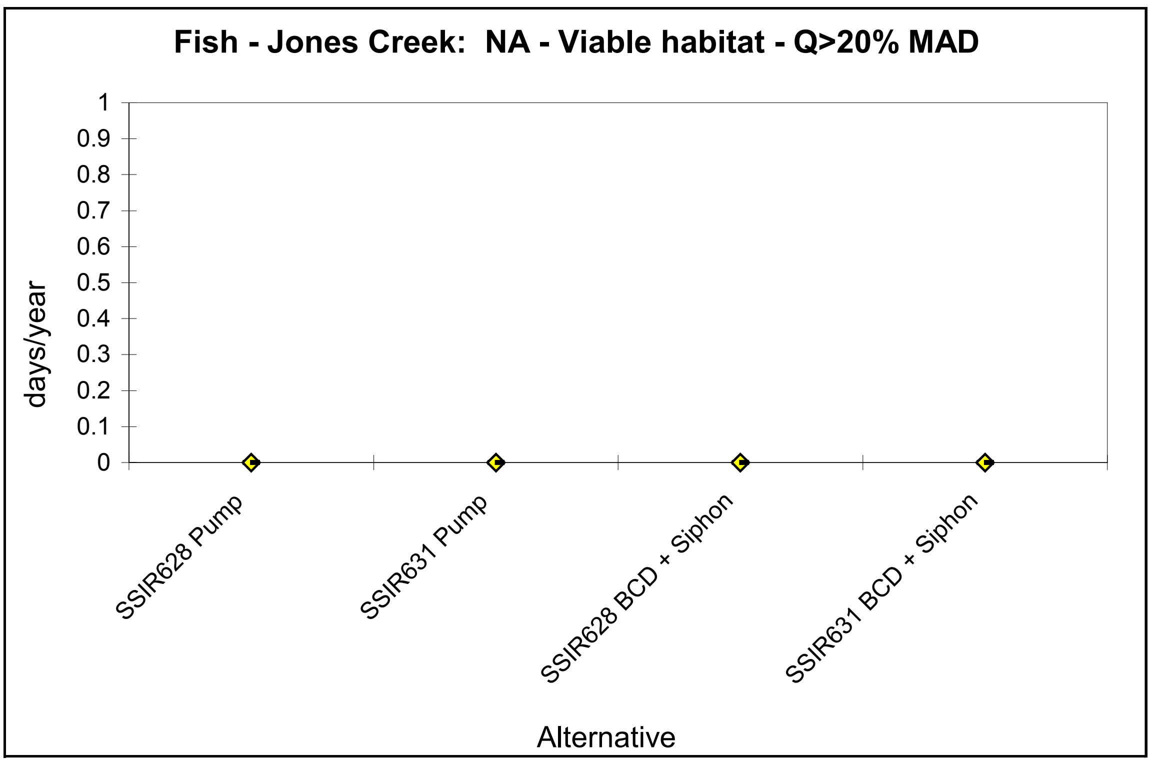


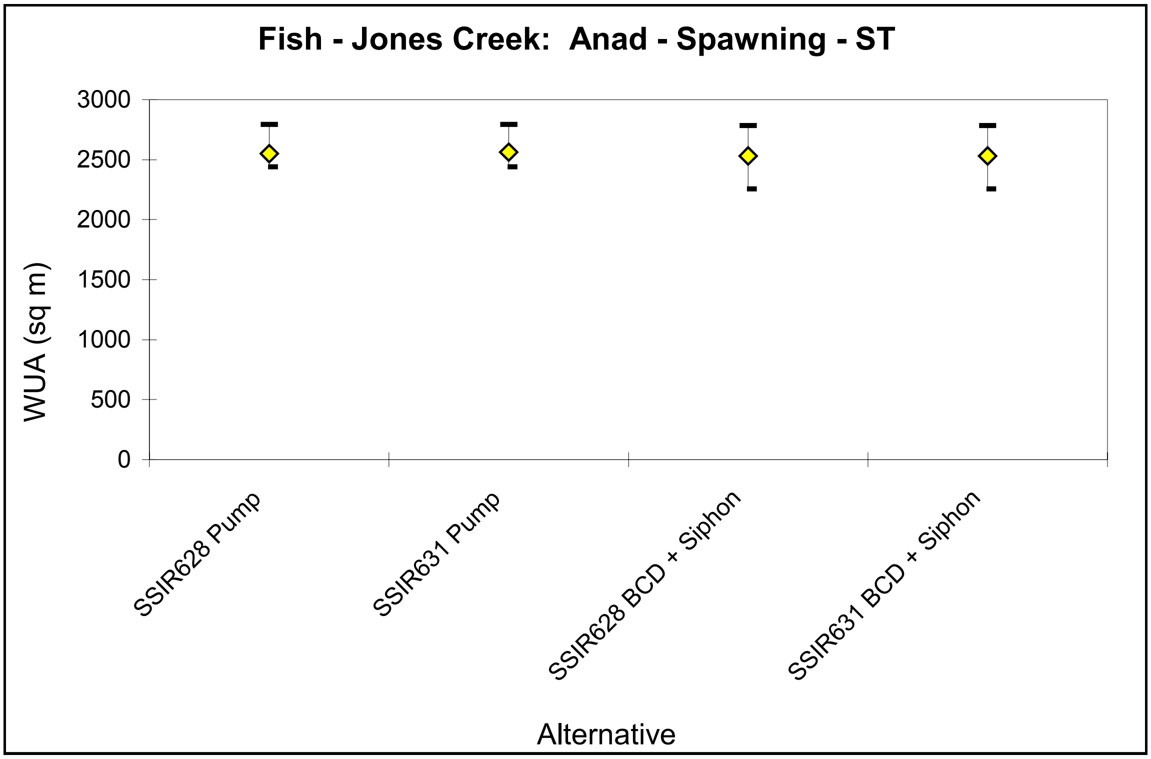
APPENDIX L ROUND 6 OPERATING ALTERNATIVES PERFORMANCE MEASURE CHARTS

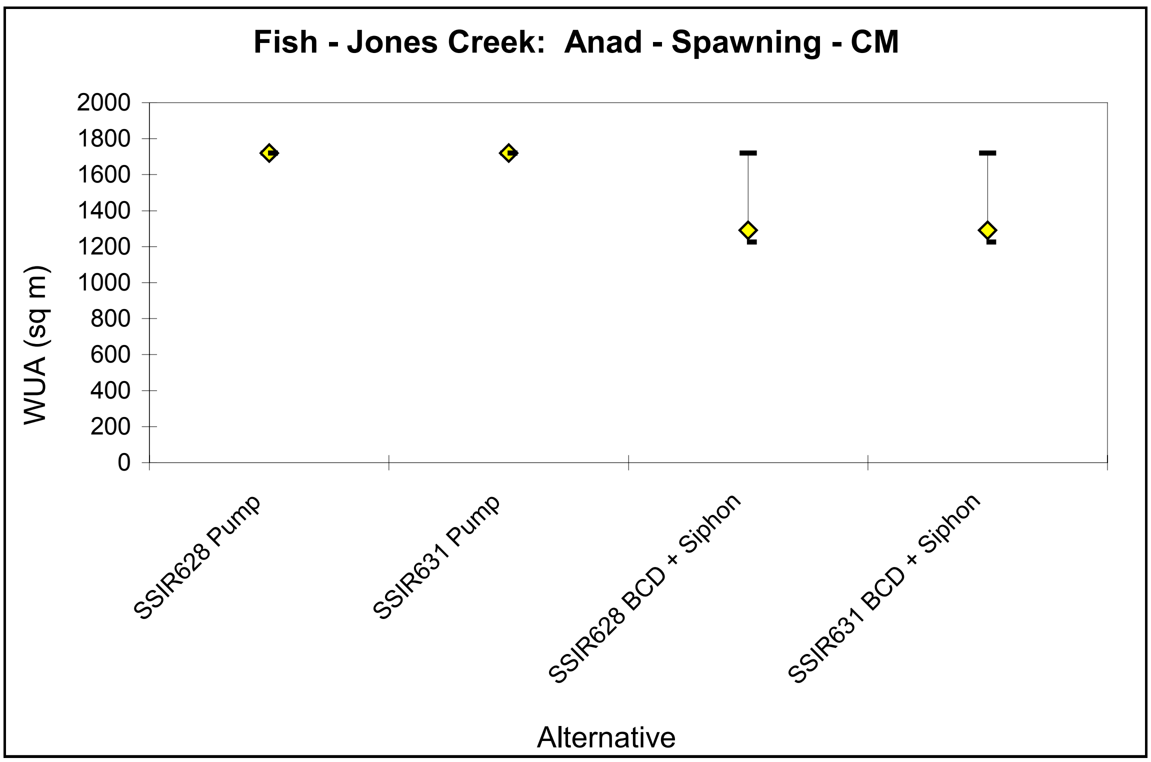


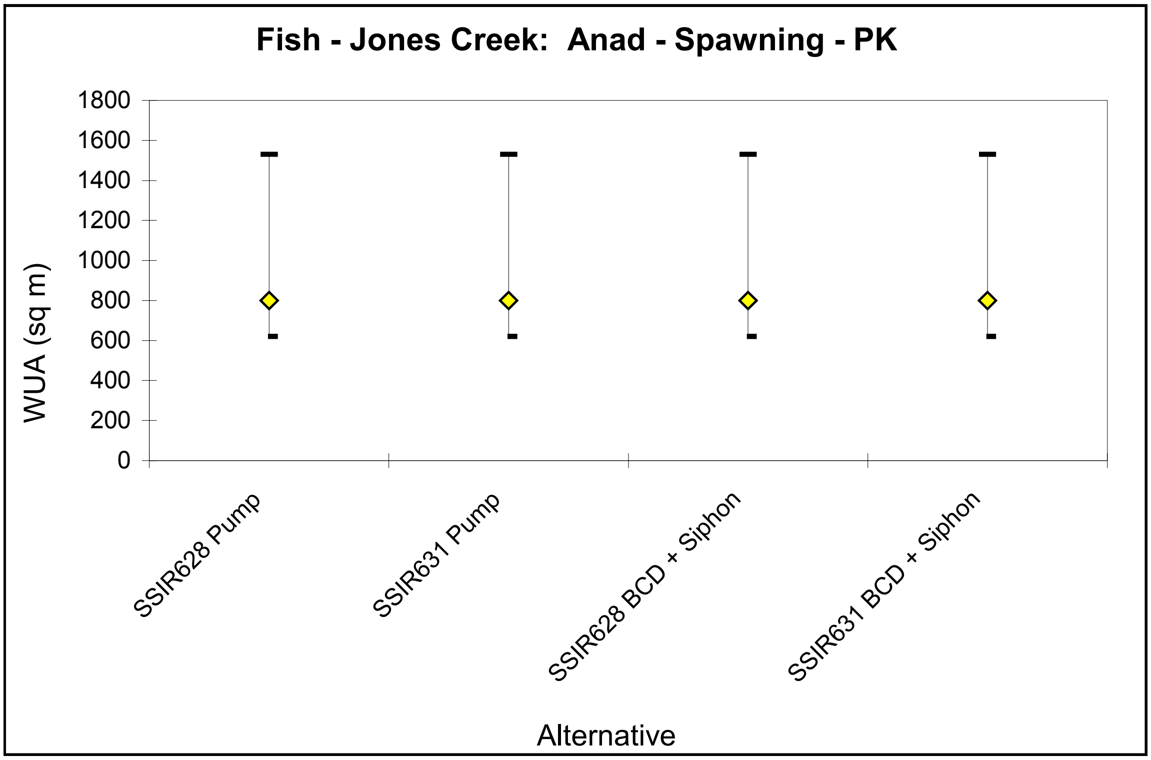


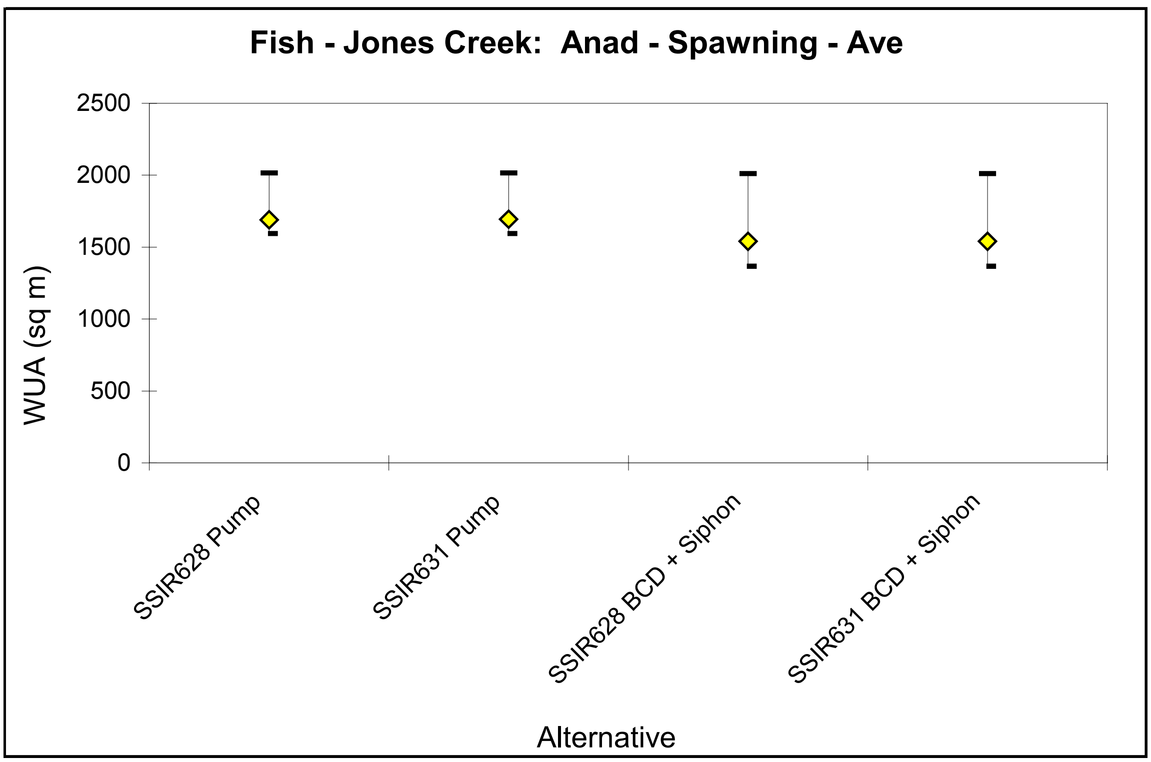

Annual Revenue: Net Annual Revenue
$m / yr
20
18
16
14
12
10
8
6
4
2
0
SSIR628 Pump
SSIR631 Pump
SSIR628 BCD + Siphon
SSIR631 BCD + Siphon
Alternative

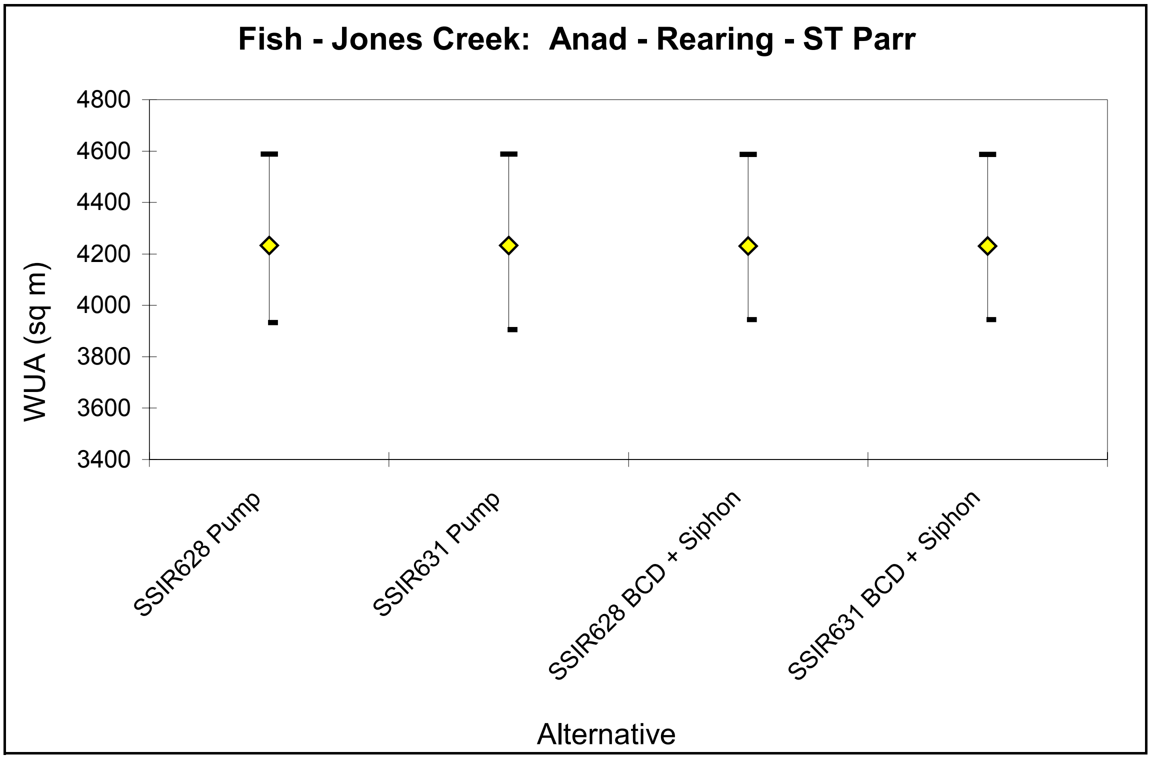

Fish - Jones Creek: NA - Viable habitat - Q>20% MAD
days/year
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
SSIR628 Pump
SSIR631 Pump
SSIR628 BCD + Siphon
SSIR631 BCD + Siphon
Alternative

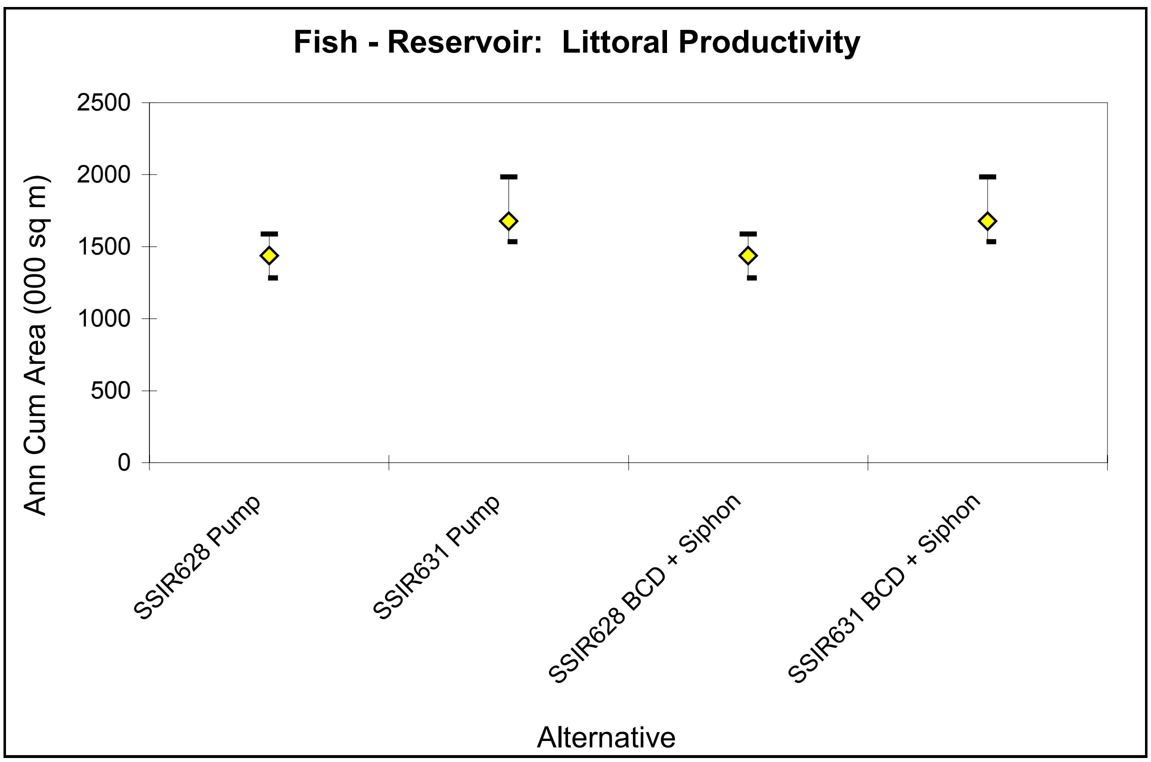

Fish - Jones Creek: Anad - Spawning - ST
WUA (sq m)
3000
2500
2000
1500
1000
500
0
SSIR628 Pump
SSIR631 Pump
SSIR628 BCD + Siphon
SSIR631 BCD + Siphon
Alternative

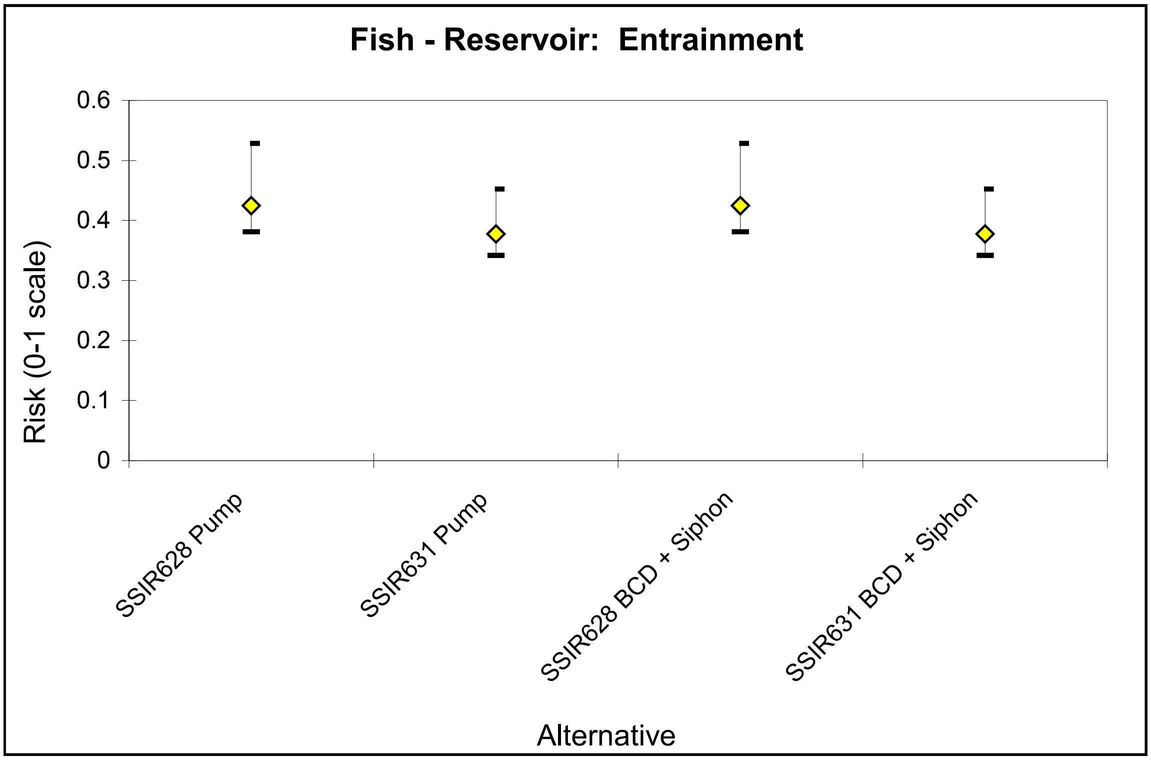

Fish - Jones Creek: Anad - Spawning - CM
WUA (sq m)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
SSIR628 Pump
SSIR631 Pump
SSIR628 BCD + Siphon
SSIR631 BCD + Siphon
Alternative

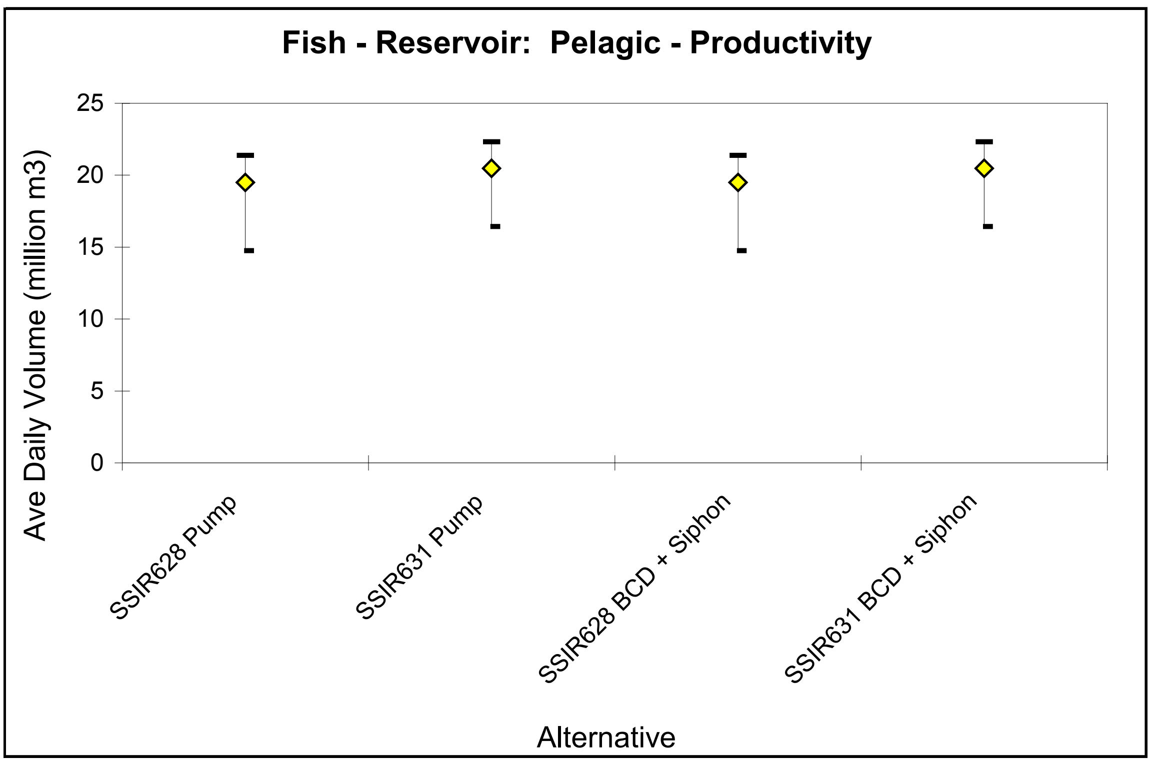

Fish - Jones Creek: Anad - Spawning - PK
WUA (sq m)
1800
1600
1400
1200
1000
800
600
400
200
0
SSIR628 Pump
SSIR631 Pump
SSIR628 BCD + Siphon
SSIR631 BCD + Siphon
Alternative

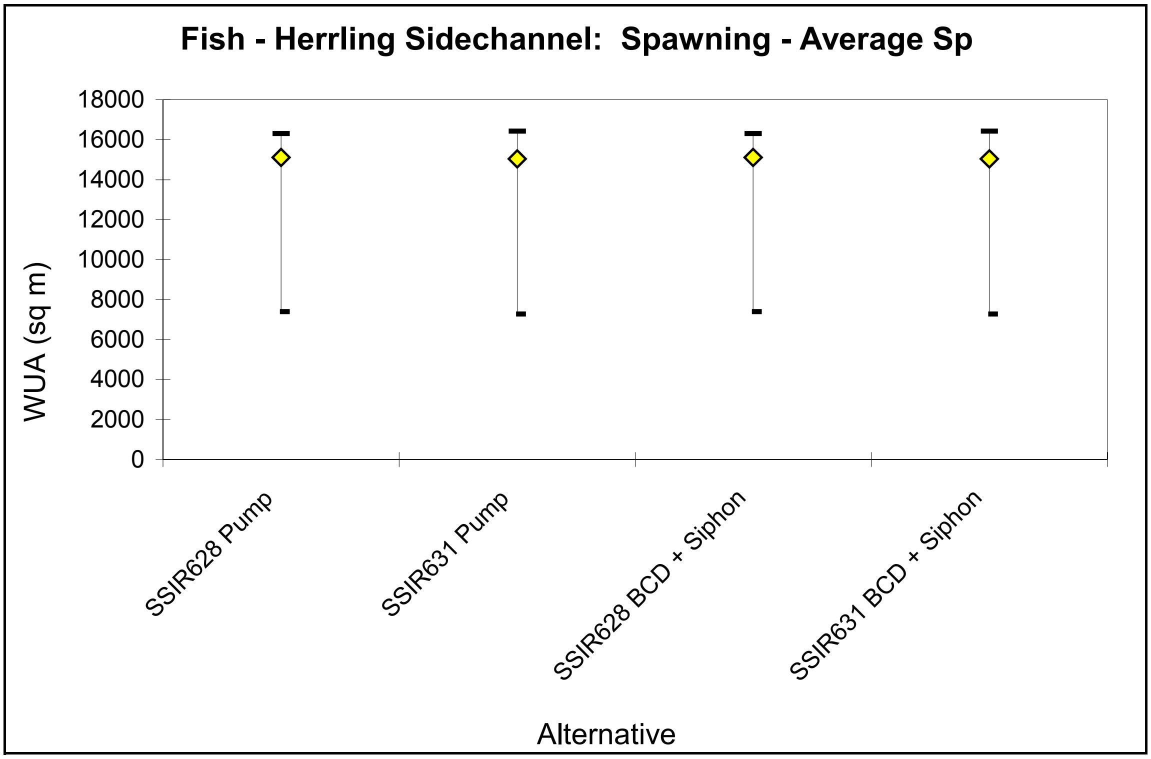

Fish - Jones Creek: Anad - Spawning - Ave
WUA (sq m)
2500
2000
1500
1000
500
0
SSIR628 Pump
SSIR631 Pump
SSIR628 BCD + Siphon
SSIR631 BCD + Siphon
Alternative

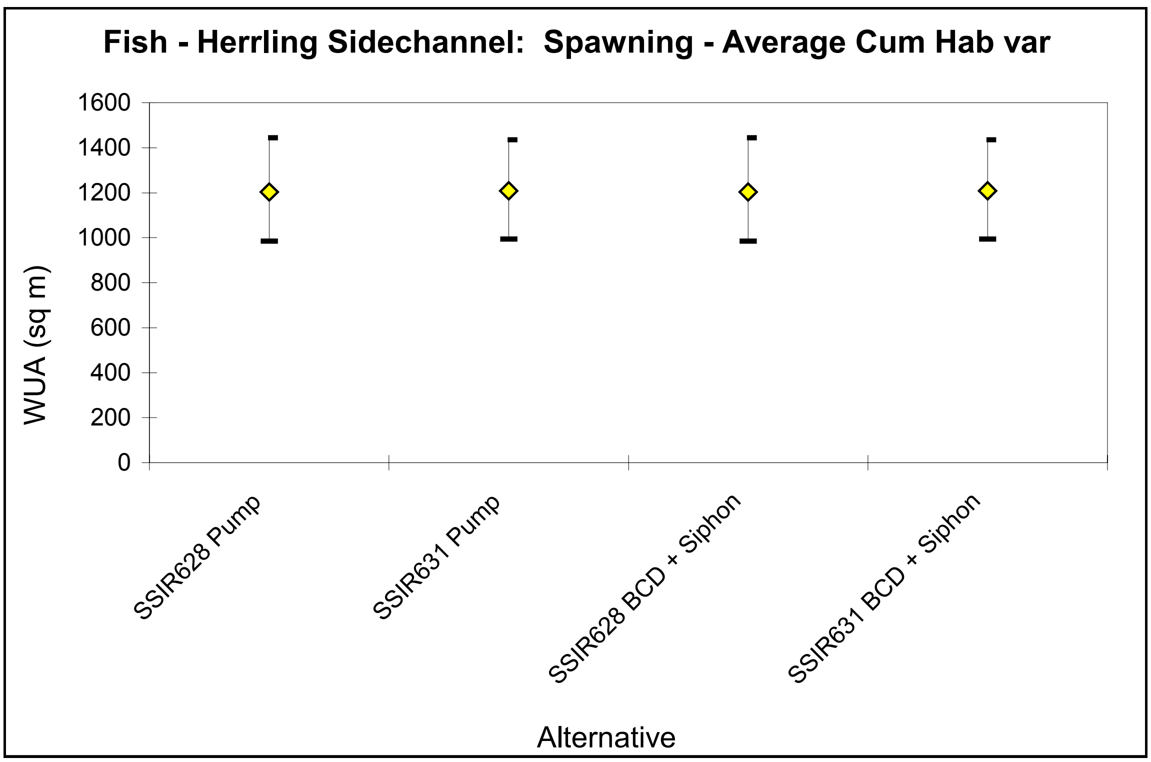

Fish - Jones Creek: Anad - Rearing - ST Parr
WUA (sq m)
4800
4600
4400
4200
4000
3800
3600
3400
SSIR628 Pump
SSIR631 Pump
SSIR628 BCD + Siphon
SSIR631 BCD + Siphon
Alternative

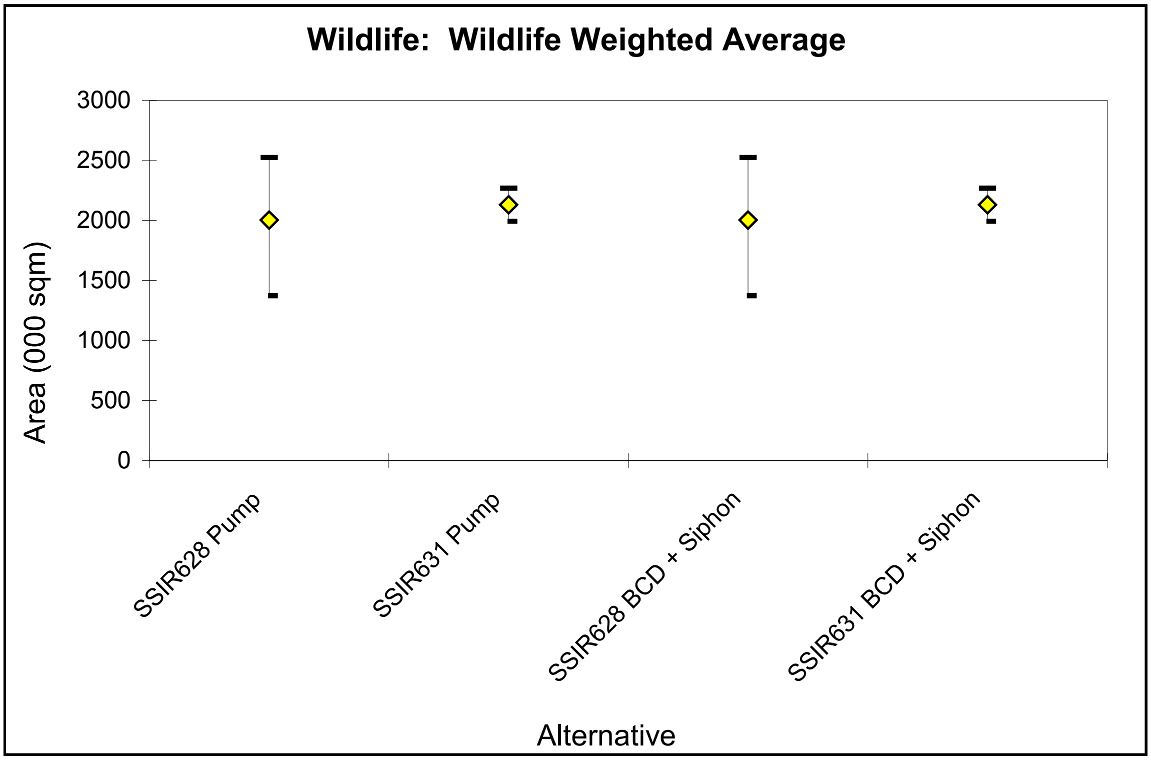

Fish - Reservoir: Littoral Productivity
Ann Cum Area (000 sq m)
2500
2000
1500
1000
500
0
SSIR628 Pump
SSIR631 Pump
SSIR628 BCD + Siphon
SSIR631 BCD + Siphon
Alternative

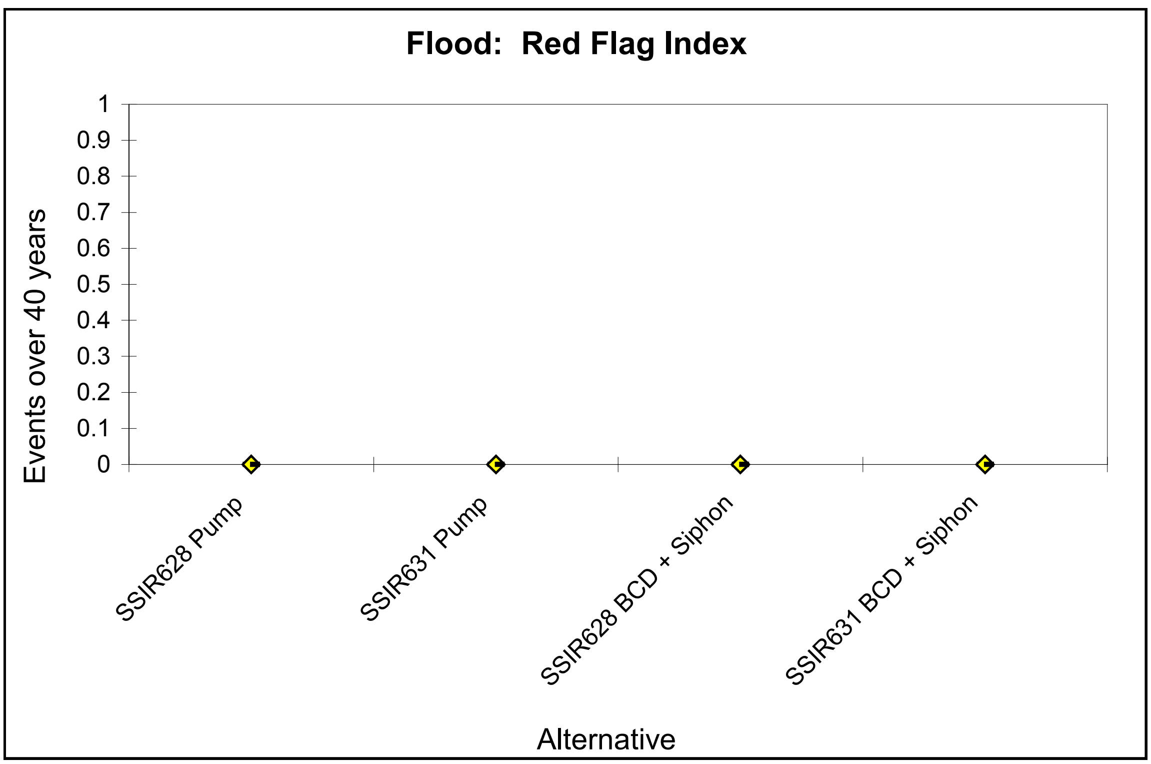

Fish - Reservoir: Entrainment
0.6
0.5
0.4
0.3
0.2
0.1
0
Risk (0-1 scale)
SSIR628 Pump
SSIR631 Pump
SSIR628 BCD + Siphon
SSIR631 BCD + Siphon
Alternative

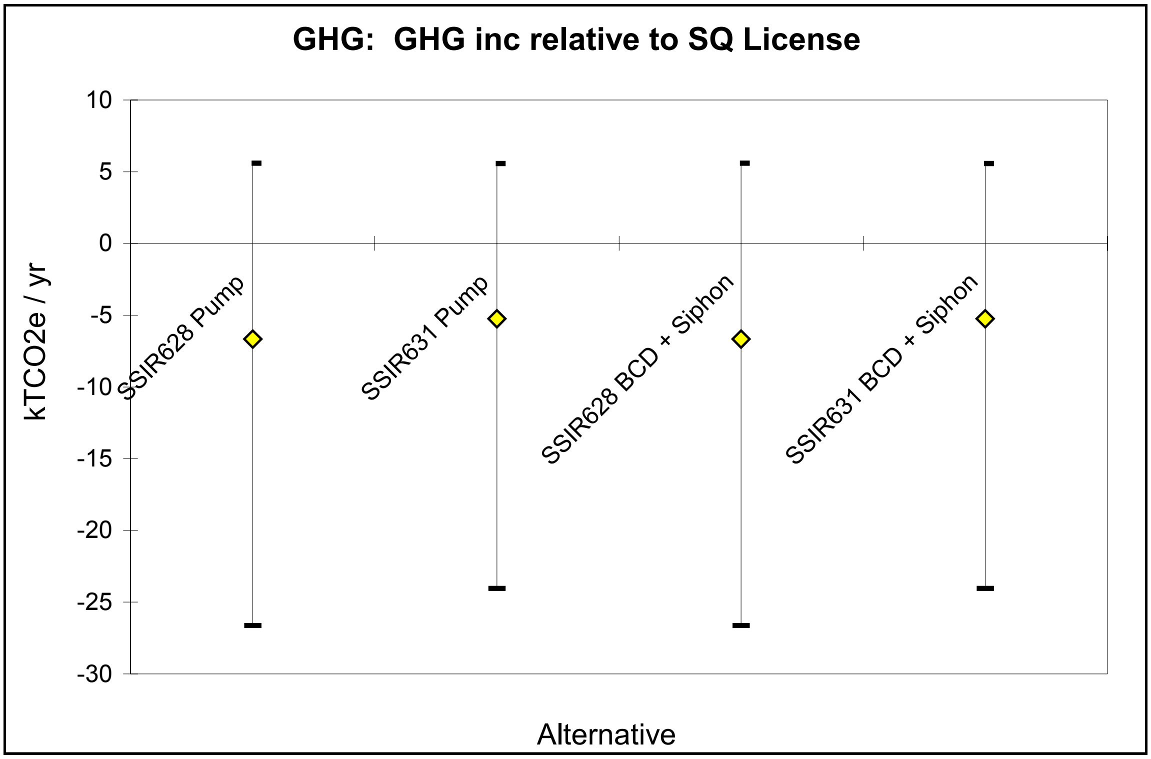

Fish - Reservoir: Pelagic - Productivity
25
20
15
10
5
0
Ave Daily Volume (million m3)
SSIR628 Pump
SSIR631 Pump
SSIR628 BCD + Siphon
SSIR631 BCD + Siphon
Alternative


Fish - Herrling Sidechannel: Spawning - Average Sp
WUA (sq m)
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
SSIR628 Pump
SSIR631 Pump
SSIR628 BCD + Siphon
SSIR631 BCD + Siphon
Alternative


Fish - Herrling Sidechannel: Spawning - Average Cum Hab var
WUA (sq m)
0
200
400
600
800
1000
1200
1400
1600
SSIR628 Pump
SSIR631 Pump
SSIR628 BCD + Siphon
SSIR631 BCD + Siphon
Alternative


Wildlife: Wildlife Weighted Average
Area (000 sqm)
3000
2500
2000
1500
1000
500
0
SSIR628 Pump
SSIR631 Pump
SSIR628 BCD + Siphon
SSIR631 BCD + Siphon
Alternative


Flood: Red Flag Index
Events over 40 years
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
SSIR628 Pump
SSIR631 Pump
SSIR628 BCD + Siphon
SSIR631 BCD + Siphon
Alternative


GHG: GHG inc relative to SQ License
10
5
0
-5
-10
-15
-20
-25
-30
kTCO2e / yr
SSIR628 Pump
SSIR631 Pump
SSIR628 BCD + Siphon
SSIR631 BCD + Siphon
Alternative

APPENDIX M ELIGIBILITY CRITERIA FOR WATER USE PLAN MONITORING STUDIES

DRAFT

Water Use Planning Monitoring Program: Principles,
Decision Tree, and Required Information

1.0 INTRODUCTION

The Water Use Plans for the BC Hydro facilities will contain recommended operational changes that are designed to address issues identified during the development of the Water Use Plans. However, in light of the 5-year time frame to develop these Water Use Plans, a significant amount of uncertainty may exist regarding the effectiveness of the recommended operational changes. This uncertainty is largely due to the difficulty in drawing scientifically defensible conclusions with a limited database. In some cases there will be a need, therefore, to verify the effectiveness of the recommendations put forward by the Water Use Plan Consultative Committees. These specific Water Use Plans will contain a post-Water Use Plan monitoring program that will provide additional data designed to measure the results/effectiveness of the operational changes specified by the Comptroller of Water Rights for each of the facilities.

Additional to this, the provincial water use planning Guidelines outline that the individual Water Use Plans will specify monitoring programs and reports for preparation by the licensee to enable provincial and federal regulatory authorities (Comptroller of Water Rights and Fisheries and Oceans Canada) to assess compliance with the authorized Water Use Plan. In order to address this aspect of the Water Use Plan, BC Hydro will provide the Comptroller of Water Rights the mechanisms and information detailing the actual implementation of the operational change. These may include flow measuring devices and regular reporting schedules of actual flow levels.

2.0 MONITORING PROGRAM ELEMENTS

The primary objectives of the post Water Use Plan Monitoring Program will be to assess whether the operational changes, as specified in the Water Use Plan, provide the expected results (in terms of the performance measures and/or the fundamental objectives), or whether the operations need further adjustment (which could include adjustment back to pre-Water Use Plan operations):

- In the case of Water Use Plans with passive adaptive management aspects (i.e., a single change in flow regime from the licensed flows), the studies will assess specific parameters related to performance measures and fundamental objectives.

- With respect to Water Use Plans with active adaptive management aspects (i.e., two or more significant changes to flow regimes during a set period of time), studies will assess the response of the selected flow regimes against expected performance measure response or its ability to address the objectives.

3.0 PRINCIPLES

The individual Water Use Plan Consultative Committees will be responsible for defining and prioritizing the recommended post-Water Use Plan monitoring studies. The recommendations for monitoring studies will be included in the Consultative Committee Report and the Water Use Plan presented to the Comptroller. Each monitoring study will be designed to meet the following principles:

- An expected result from each study must have the potential to change the way water is used at BC Hydro facilities.
- Each study must have the ability to distinguish between competing hypotheses. This can be assessed using a range of techniques, from a calculation of statistical power to professional judgment around the weight of evidence.
- Each study must be able to show results in a timely manner (e.g., by the next scheduled Water Use Plan period).
- Each study must show cost effectiveness by demonstrating that it is the least expensive way to generate that level of learning both within that Water Use Plan and across other Water Use Plan monitoring plans.

In order to ensure that the above principles are met, requests for monitoring studies should be described in sufficient detail to allow the evaluation of objectives, methodologies, deliverables, and estimated costs. This information will be collected by having the subgroups, and then the Consultative Committee, fill out the "Information Matrix for Water Use Plan Monitoring Requests" found on Page M-4.

4.0 DECISION TREE FOR EVALUATING WATER USE PLAN MONITORING REQUESTS

The following decision tree (Figure M-1) embodies the principles of monitoring laid out by the ad hoc Water Use Plan interagency committee developing monitoring protocol. This tree is to be used in conjunction with input from the Water Use Plan MC, RVAT and FAT and will be used by the facilitator to assist subgroups and the Consultative Committee in assessing monitoring requests. Note that this process does not address monitoring activities that are geared towards assessing compliance to the Water Use Plan. Step 1 starts at the subgroup level and this process is carried out for each proposed study.

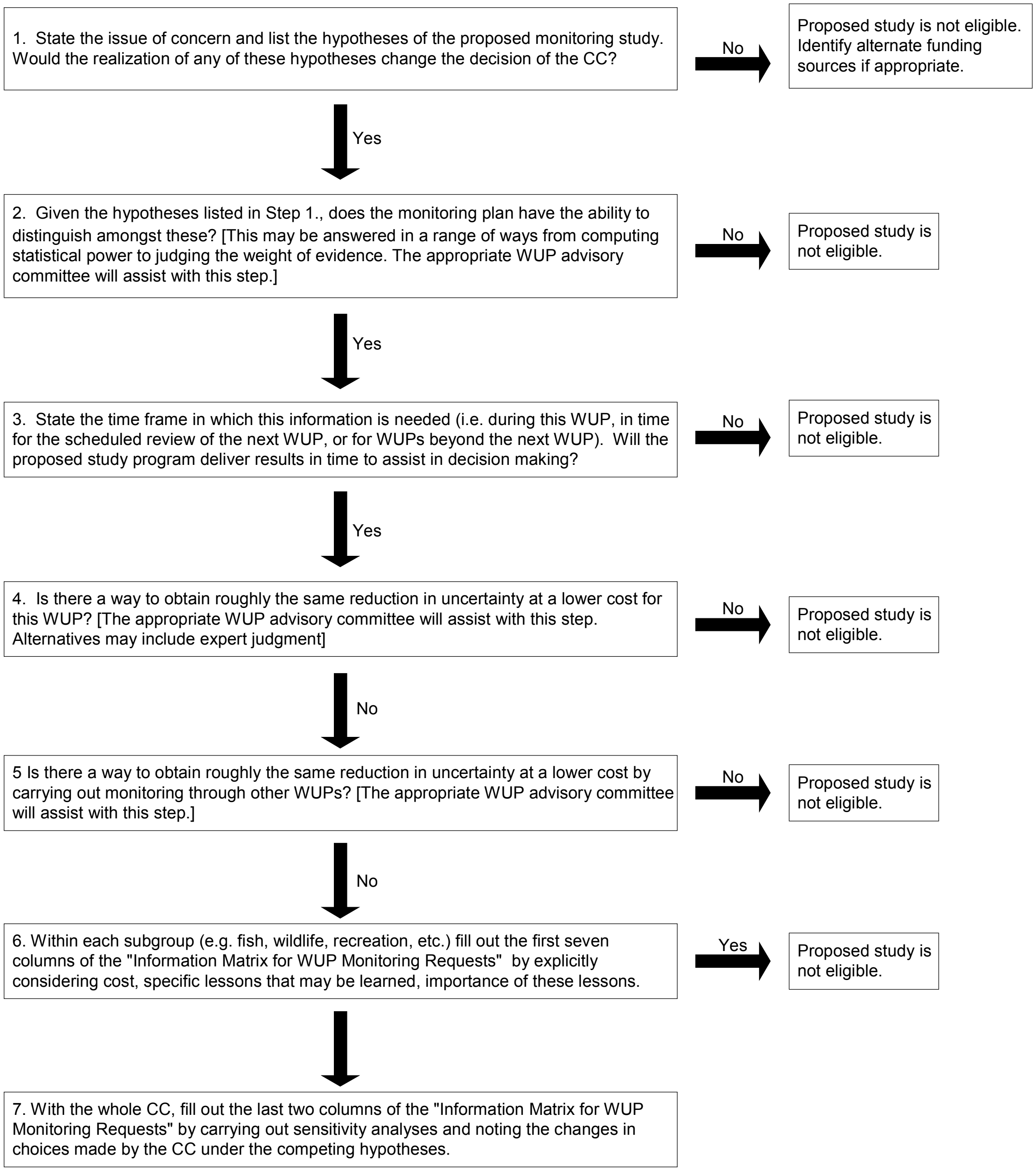


Figure M-1: Decision Tree for Evaluating Water Use Plan Monitoring Requests

Table M-1: Information Matrix for Water Use Plan Monitoring Requests (subgroups fill out the first seven columns, the last two are filled out at the Consultative Committee level)

I	II	III	IV	V	V1			
Study (Water Use Plan, Title of Study, Interest Area)	Description	Data Gap Addressed (list the issue, the competing hypotheses, and the estimates of the probability of these competing hypotheses being true.)	Amount of learning expected through monitoring (high, medium or low)	Estimated Duration of Study Program.	State the time frame in which this information will be used: before the next Water Use Plan, during the next Water Use Plan, after the next Water Use Plan.	Estimated Cost (including lost power values)	Willingness of Consultative Committee to change water allocation (high, medium, or low)	Rating of Study

5.0 "WILLINGNESS TO CHANGE WATER ALLOCATION" SCALE EXPLAINED

These scales will be developed once the final choice of the Consultative Committee has been made. At that time, key uncertainties about the Performance Measures and/or their link to fundamental objectives can be tested through sensitivity analyses, and the change in the support from the Consultative Committee for the various alternatives considered can be observed.

High Importance — It is *clear* that the Consultative Committee will change its final choice if one of the alternative hypotheses prevails. This change includes a shift in support *away* from the original choice made and the convergence of the Consultative Committee's support on another, *existing* alternative.

Medium Importance — A large shift in support away from the final choice of the Consultative Committee takes place under one of the competing hypotheses. This shift in support may include some people preferring to block the original choice of the Consultative Committee. However, it is not clear that another, existing alternative would be chosen by the Consultative Committee under this competing hypothesis.

Low Importance — A shift in support away from the final choice of the Consultative Committee may occur. However, *it is clear* that the final choice of the Consultative Committee will not be changed to another, existing alternative. This decision may be a non-consensus Water Use Plan.

6.0 LEARNING SCALES EXPLAINED

High — Monitoring study will definitely lead to quantitative discrimination among all of the competing hypotheses.

Medium — Monitoring study will likely lead to the ability to discriminate quantitatively among some of the competing hypotheses.

Low — Likely to allow only qualitative comparisons among a few competing hypotheses.

7.0 RATING OF STUDY EXPLAINED

High Importance It is clear that there is a consensus, or close to consensus, agreement that this monitoring program should be included as a request within the consultative report.

Medium Importance There is no clear consensus within the group as to whether this monitoring program should be included as a request within the consultative report.

Low Importance There is a consensus, or close to a consensus, agreement that this monitoring plan should not be included as a request within the consultative report.

APPENDIX N MONITORING PROGRAM AND NON-OPERATIONAL PHYSICAL WORKS

1.0 INTRODUCTION

A cornerstone of water use planning is determining the effectiveness of the recommended operating regimes to demonstrate benefits to the Province of British Columbia. The Wahleach Water Use Plan monitoring studies recommended by the Consultative Committee are intended to quantify the performance of an operational change (effectiveness monitoring), or collect additional information to inform assumptions made in the Wahleach water use planning process (hypothesis testing).

The following section describes the monitoring studies and non-operational physical works that were recommended by the Consultative Committee. Study results will be reviewed five years after implementing the Wahleach Water Use Plan.

2.0 FISH MONITORING STUDIES

2.1 Salmonid Productivity Monitoring: Jones Creek Anadromous

Hypothesis Addressed

H_0: The provision of minimum spawning, incubation and rearing flows do not affect the spawning and rearing success of salmonids utilizing Jones Creek anadromous.

The Wahleach water use planning process specified minimum flows that are expected to produce effective spawning habitat, along with increased rearing conditions. The key uncertainty associated with each performance measure is whether these habitat benefits will result in increased fish productivity in Jones Creek anadromous. Other questions to be addressed include:

- Habitat use: do steelhead utilize Jones Creek anadromous for spawning and rearing?
- Channel stability: will channel migration in Jones Creek anadromous impact spawning and rearing success?
- Hydrology: are there adequate inflows to provide the specified minimum flows, and/or are the flows provided adequate for enhancing salmonid productivity in Jones Creek anadromous?

Rationale

The Fisheries Technical Subcommittee utilized habitat suitability criteria and the results of an instream flow study (WAH FTC, 2000) to determine flow-habitat relationships for Jones Creek anadromous. Results from a fry enumeration study in 2000 (Greenbank) indicated poor survival for chum and pink eggs, and attributed this to poor gravel conditions and channel instability. This result raised questions about the benefits of minimum flow provisions. Results of the study will determine whether the minimum flows will increase salmonid productivity in Jones Creek anadromous.

Study Design

Annual assessments of adult escapement and fry outmigration will be conducted over the review period. Results will be compared against local and regional bio-standards, as well as assessments completed for pink runs in 1999/2000 and 2003/2004.

Methods

The field program will be conducted annually, with data reports issued after the fry outmigration data has been analyzed.

Salmon Adult Escapement

Every five days, spawner surveys will be conducted by visual observation. Discharge, water clarity, weather, and information on channel characteristics will be collected on the day of each survey. Spawner use and channel characteristic data will be noted on a map template of the 800 m Jones Creek anadromous. Index redds will be marked where possible, for evaluation in the spring. Hourly temperature and discharge data will be automatically logged at the Laidlaw Bridge data collection platform, to be installed by BC Hydro. Escapement will be estimated using area-under-the-curve approximations (Irvine and Nelson, 1995).

Salmon Fry Outmigration

A downstream trap(s) (modified fyke net and/or incline plane trap) will be installed above the confluence with Lorenzetta Creek from 15 March to 31 May each year. The trap(s) will be maintained daily and fish captured in live boxes will be enumerated (species ID and counted), and either held for mark-recapture trials (upstream release) or released downstream of the trap if mark-recapture is not required. There will be a minimum of seven mark-recapture trials over the outmigration period, to properly assess efficiencies with respect to flow and outmigration timing. Fry outmigrant population will be estimated using the Peterson estimate (Ricker, 1975), with confidence intervals defined by Pearson's formula for marks recaptured (Ricker, 1975).

Steelhead Assessments

Steelhead are currently not abundant in the Jones Creek system. Initially, spring adult assessments will be conducted in concert with the salmon fry enumeration, by visual observation. If numbers require a more rigorous approach, provisions are available to extend the escapement program. Smolt outmigration will be assessed during the fry enumeration. Steelhead fry and parr use in Jones Creek will be assessed in August of each year using the closed net multiple-pass electroshocking methodology and analysis described in Carle and Strub (1978). Summer assessments will resume until a smolt enumeration program is warranted.

Budget

The following budget assumes a full-scale smolt and fry enumeration program with steelhead and salmon escapement surveys each year.

Table N-1: Salmonid Productivity Monitoring Budget

Monitoring Objective	Study Proposal (Options)	Duration (Number of Assessments)	Annual Cost ($'000s)	Comments/ Considerations
Monitor the fish production response to flow/habitat changes in the anadromous reach of lower Jones Creek and the fish habitat enhancement site	a) Conduct fall (pink and chum) spawner enumerations	10 years	20	Pink spawning occurs every odd year
	b) Conduct spring (pink and chum) fry outmigrant enumerations	10 years	35	
	c) Conduct spring (steelhead) spawner enumerations	10 years	15	Overlap between salmon fry and steelhead adults enumeration periods should lead to cost savings
	d) Conduct summer (steelhead) fry outmigrant enumerations	10 years	35	Outmigration to coincide with Fraser River freshet.
	e) Map out spawning sites for spring and fall spawners and compare channel configurations for outmigrant periods	10 years	0	Assumed to be part of the report, data collected while conducting spawner survey and outmigrant information
	f) Report annual productivity assessments for both spawning periods, summarize monitoring work to date, and evaluate effectiveness of flow regime	10 years	15	

2.2 Channel Stability Assessment: Jones Creek Anadromous

Hypothesis Addressed

H_1: Flows in Jones Creek anadromous promote channel change.

H_2: Spawning success related to hydrology is further affected by changing channel structure.

The hydrology and channel stability analysis will compliment results from the fish productivity study.

Rationale

Several factors contribute to the spawning success of salmonids in Jones Creek anadromous. Due to the short duration of study (five to ten years) it is important to identify those factors to explain the results of the productivity study. Results of the study will attempt to identify how hydrology and channel migration can affect productivity.

Study Design

The transect and hydrological analysis will be conducted annually over a 10-year period, with a 5-year review of information to determine if further data is required.

Methods

Transect Analysis

Each transect defined in the original instream flow study conducted during the Wahleach water use planning process (FTC, 2001) will be re-surveyed before and after spawning and before outmigration (three surveys per year) as per the original survey methodology. In addition, two cross sections will be surveyed in Lorenzetta Creek for comparison. Photo-points will be established during the spawning survey, and a record of upstream channel changes will be photo-documented during each field visit. Transect surveys will be compared and results will summarize the extent of channel migration in comparison with index streams.

Hydrology Analysis

Flow logged at the data collection platform installed at the Laidlaw Bridge at the upper end of Jones Creek anadromous will be analyzed to identify extreme events that may influence fry productivity results. This will also be compared against channel survey results to determine any linkages between inflow magnitudes and channel migration.

Budget

Table N-2: Channel Stability Assessment Budget

Monitoring Objective	Study Proposal (Options)	Duration (Number of Assessments	Annual Cost ($'000s)	Comments/ Considerations
Monitor the effect of flow levels and channel migration on egg survival for chum, pink and steelhead	a) Review/update transect data collected to date where/when channel forming flows change the morphology of the channel	10 years (3 transect assessments)	3	Integrate information collected in 1(e)
	b) Analyze flow information from downstream gauge to determine the level of egg stranding predicted over the review period	10 years	5	Requires the installation of data collection platform in lower Jones Creek

2.3 Pink Salmon Genetic Composition Assessment: Jones Creek Anadromous

Hypothesis Addressed

H_0: The pink salmon spawning in Jones Creek biannually are not distinct to that watershed.

Rationale

The Jones Creek spawning channel originally supported over 4000 pink spawners on average, as well as healthy populations of chum and sockeye. Flow diversion and channel instability have limited the productivity of these species in the mainstem. To date, many species no longer utilize Jones Creek as a spawning ground. In comparison, the Herrling Island Sidechannel supports a large population of chum and pink spawners. Some of the reasons the Consultative Committee chose to focus on Jones Creek, to provide minimum flows and habitat enhancement, were:

- Herrling Island Sidechannel is already supporting a large population of salmon spawners.
- Jones Creek may still support a unique fishstock remnant to pre-impoundment.

By focusing on Jones Creek, there was limited opportunities for enhancing fish values in the Herrling Island Sidechannel. Therefore, it is important to ensure that the assumptions that went into this decision be validated for future water use planning decisions.

Methods

Fisheries and Oceans Canada has offered their technical services to analyze samples collected during pink salmon spawning. Several samples will be retrieved from the Fraser River local to the Jones Creek confluence, Jones Creek proper, and an unnamed adjacent tributary for reference. The details on the genetic analysis are not known at this point.

Budget

The costs for this analysis will be covered by Fisheries and Oceans Canada. Sampling will be done during spawner enumeration.

2.4 Entrainment Monitoring: Jones Lake Reservoir

Hypothesis Addressed

H_0: Reservoir spill and penstock diversion do not affect fish abundance at the population level by entraining fish.

Rationale

During the Wahleach water use planning process, the Consultative Committee considered entrainment risk, but the risk was unknown and was thought to be minimal. This study assesses the spillway plunge pools and tunnel maintenance areas opportunistically to enumerate fish in each area.

Methods

Two areas are to be assessed opportunistically over a 10-year period:

Spillway Plunge-pool

After a spill event, crews will electroshock the plunge-pool below the spillway and enumerate fish to gain insight into the instantaneous number of fish entrained. During years where spilling occurs, there will be an assessment of population levels as part of the fertilization program from which to infer changes due to spill entrainment.

Scroll-case Inspections

Two types of maintenance activities can help define instantaneous entrainment through the tunnel:

- Penstock/scroll-case dewatering: annual assessments during maintenance of the scroll case will take place to assess the number of fish that remain.

- Tunnel dewatering: every 10 years, the tunnel is dewatered and fish are collected in the scroll case. Fish will be enumerated when and if this event occurs within the review period.

Both assessments may shed light on the issue of entrainment through power generation.

Budget

There are no costs to the Wahleach Water Use Plan for these inspections, as they are requirements of the BC Hydro facility operators. The Wahleach Water Use Plan monitoring program will ensure that the data collected are archived in their database and provided in updates to the Comptroller of Water Rights.

2.5 Chum Salmon Spawning Behaviour Observations: Herrling Island Sidechannel

Hypothesis Tested

H_0: Chum salmon spawning behaviour is not affected by operations of the Wahleach Generating Station.

Rationale

Chum and pink salmon spawners in the Herrling Island Sidechannel can be subjected to changes in flow releases from the Wahleach Generating Station upstream, which may limit their spawning success by creating ephemeral spawning habitat in marginal areas. Curtailing generation to zero for a two-hour period every twenty-four hours is expected to reduce the quality of spawning in marginal areas (areas subject to dewatering). This study will determine if this operation will lead to a reduction in spawning in those areas and an overall increase in spawning success.

Methods

This study will build on a similar study being conducted on the Stave River below Ruskin, where flow disruption is being used to ensure spawning habitat can be maintained by operations. It has two phases:

Water Level Monitoring

Three staff gauge and water level logging units will be installed at representative sites along the Herrling Island Sidechannel to monitor changes in flow that can be linked to spawning habitat. The annual analysis of this data will be linked to spawner observations to determine the effectiveness of the daily shutdowns, and document the attenuation effects through the system.

Spawning Behaviour Assessment

Behavioural observations will take place over five 3-day periods at each of the three index sites where water level monitoring will occur through the spawning season. Spawning will be documented where observed and spawning extents will be marked before, during and after flow changes from the facility. Observations will fit a template to ensure consistency of observations are maintained between observers, and photo points will be established to capture all changes and spawning conditions.

The review and analysis will compare site and flow conditions to determine the effectiveness of the operation.

Budget

Table N-3: Chum Spawning Behaviour Observations Budget

Monitoring Objective	Study Proposal (Options)	Duration (Number of Assessments	Annual Cost ($'000s)	Comments/ Considerations
Monitor spawning habitat use to determine a) the extent and success of spawners in the Sidechannel, and b) the effectiveness of plant operations in mitigating egg stranding via spawner disruption in margins	a) Install and service 3 monitoring stations or below tailrace "pool" to translate operational changes to real-time flow changes downstream	5–10 years	15	One time cost
	b) Conduct spawner observations in addition to document spawner behaviour patterns in connection to plant operations	5–10 years	20	May only require observations for short period if initial trials are successful

2.6 Summary of Monitoring Program Costs

Table N-4 summarizes the Wahleach Water Use Plan monitoring program costs.

Table N-4: Monitoring Program Summary of Costs

Area	Study	Study Component	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Jones Creek Anadromous	Salmonid Productivity Monitoring	Fall Spawner Enumerations[1]	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20
		Fry Outmigration Enumeration[1]	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35
		Spring Spawner Enumeration[2]	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15
		Smolt Enumeration[2]	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35
		Annual Productivity Reporting	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15
	Channel Stability Assessment	Transect Resurveying	$ –	$ –	$ 10	$ –	$ –	$ 10	$ –	$ –	$ 10	$ –
		Egg Stranding/Flow Analysis	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5
	Pink Salmon Genetic Composition Assessment		$ –	$ –	$ –	$ –	$ –	$ –	$ –	$ –	$ –	$ –
Jones Lake Reservoir	Entrainment Monitoring		$ –	$ –	$ –	$ –	$ –	$ –	$ –	$ –	$ –	$ –
Herrling Island	Chum Spawning Behaviour	Flow monitoring and analysis	$ 15	$ –	$ –	$ –	$ –	$ –	$ –	$ –	$ –	$ –
		Spawning Observations[3]	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20
Total			**$ 160**	**$ 145**	**$ 155**	**$ 145**	**$ 145**	**$ 155**	**$ 145**	**$ 145**	**$ 155**	**$ 145**

1. Most effort spent on pink (odd-year) runs.
2. Costs and approach will depend on steelhead abundance and habitat use.
3. Data collected up to year five will be used to evaluate the Wahleach Operating Protocol, and a decision will be made to test a new protocol or not.

3.0 NON-OPERATIONAL PHYSICAL WORKS

3.1 Fertilization Program: Jones Lake Reservoir

Rationale

This fertilization program is recommended in lieu of an operating alternative that would have provided a stable reservoir. This program will include the fertilizer with an in-depth analysis of benefits in terms of water nutrient balance, and fish and benthic abundance. The main metric of the program will be kokanee abundance.

Program Components

It is recommended that two years of full fertilization assessment be completed, prior to conducting a review every two years of fisheries and zooplankton production in the reservoir. There will be three levels of reporting over the review period:

- Annual Data Summary: study results will be summarized for each performance measure on an annual basis.
- Biannual Review: study results are summarized for entire program period; program performance reviewed and recommendations provided.
- Full Analysis and Review: after the first four years of study, a comprehensive evaluation of the program's performance as per above, peer reviewed and published.

Table N-5: Fertilization Program Components

Component	Frequency	Description
Fertilizer addition	Annual	Purchase of fertilizer; application; project management
Limnology sampling	Biannual	Zooplankton and phytoplankton analysis
Hydro-acoustic study and fish sampling	Biannual (and first 2 years)	Hydro-acoustic sampling for density distribution and population estimates; trawling and gill netting required as calibration for the hydro-acoustic work
Spawner survey	Annual	8 weekly surveys of tributary spawners
Report	Annual	Data report
	Biannual	Review and data report
	5 Year Review	Comprehensive evaluation of methods and performance
Equipment	One-time	Capital investment of boat ($20,000) and facility roof ($25,000)

Budget and Project Plan

The fertilization program recommended by the Consultative Committee is budgeted at $78,200 (2002 dollars) annually (this includes $45,000 in equipment annualized at $6,000). This program will be delivered by the Ministry of Water, Land and Air Protection staff in conjunction with a similar program on BC Hydro's Alouette Reservoir. The Ministry of Water, Land and Air Protection staff contribution to this program will be $78,500 annually, making the total cost $156,700. After five years, the Wahleach Monitoring Advisory Committee will review the program results and revise the expenditures as required.

Table N-6: Fertilization Program Budget

Funding Source	Component	Annual Cost ($)	Sub-total ($)
Water Use Plan Program Funding	Fertilizer	17.1	
	Limnology Sampling	6.8	
	Fish Sampling	10.5	
	Spawner Survey	3.0	
	Equipment ($45,000 Annualized)	6.0	
	Reporting and Staff	28.2	
	Expenses	6.6	78.2
Ministry of Water, Land and Air Protection Funding	Project Biologist Support	56.5	
	Senior Management Staff (Regional Office)	12.0	
	Senior Scientific Staff	10.0	78.5
Total			156.7

3.2 Fish Habitat Enhancement Project: Jones Creek Anadromous

Rationale

The spawning channel destroyed in 1995 was a cultural attraction and compensation for expected losses in salmon production due to the diversion of Jones Creek during its operation. While the flow provisions in the recommended operating alternative are intended to address these issues, the Consultative Committee wished to see further improvements in Jones Creek while the watershed restored itself after devastating logging impacts (Miles, 1997). The Consultative Committee agreed to the establishment of a temporary fish habitat enhancement that would be maintained biannually and promote spawning and rearing production.

Program Components

The sidechannel portion of the enhancement site would differ from the original spawning channel design in several ways:

- The design of the channel will allow for regular maintenance and reconstruction expected in the floodplain.
- The sidechannel will be operated year-round to serve the requirements of fall spawners and year-round rearing species, through spawning platforms and rearing pools.
- The sidechannel development will not pursue the level of productivity achieved by the original spawning channel – instead, the focus will be on maintaining a year-round stable habitat for mainstem refugia and stock preservation.
- The intake works will be designed to percolate flows such that storm events will not require repeated maintenance of the facilities.
- The lack of fish diversion structures on the mainstem will allow returning adults access to both parts of the system, affecting the overall productivity of the system, but maintaining the restorative principles implicit in the decommissioning agreement.

Budget and Project Plan

The initial cost of the project is estimated to be approximately $75,000. The annual maintenance on this project will be approximately $20,000 per year, or $50,000 every three years. After five years, the Wahleach Monitoring Advisory Committee will review the results of the project.

Table N-7: Fish Habitat Enhancement Channel Budget

Component	Annual Cost ($)
Channel Construction ($75,000 annualized over 10 years)	10
Habitat Maintenance	10
Channel Maintenance	10
Total	30

3.3 Summary of Non-Operational Physical Works

Table N-8 summarizes the Wahleach Water Use Plan non-operational physical works.

Table N-8: Summary of Non-Operational Physical Works

Area	Non-Operational Physical Works	Component	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Jones Creek Anadromous	Fish Habitat Enhancement	Construction	$ 75	$ –	$ –	$ –	$ –	$ –	$ –	$ –	$ –	$ –
		Maintenance[1]	$ –	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20
Jones Lake Reservoir	Fertilization Program	Fertilizer Application	$ 40	$ 40	$ 40	$ 40	$ 40	$ 40	$ 40	$ 40	$ 40	$ 40
		Reporting and Analysis	$ 40	$ 40	$ 40	$ 40	$ 40	$ 40	$ 40	$ 40	$ 40	$ 40
Boulder Creek Diversion Dam	Bypass: Tyrolean Weir[2]	Interim Construction	$ 100	$ 100	$ 100	$ 100	$ 100	$ –	$ –	$ –	$ –	$ –
		Feasibility Study and Design	$ –	$ –	$ –	$ –	$ 150	$ –	$ –	$ –	$ –	$ –
		Final Construction	$ –	$ –	$ –	$ –	$ –	$ 710	$ –	$ –	$ –	$ –
		Maintenance	$ –	$ –	$ –	$ –	$ –	$ –	$ 10	$ 10	$ 10	$ 10
Total			**$ 255**	**$ 200**	**$ 200**	**$ 200**	**$ 350**	**$ 810**	**$ 110**	**$ 110**	**$ 110**	**$ 110**

1. Maintenance and interim construction costs beyond first year may be less than budgeted, depending on extent of annual degradation.
2. After year 5, applicable programs will be reviewed to determine if plans are appropriate and costs will be scaled according to revisions suggested by review committee.

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APPENDIX O HYDROGRAPHS FOR ALTERNATIVE SALMONSIR628BCD+SIPHON

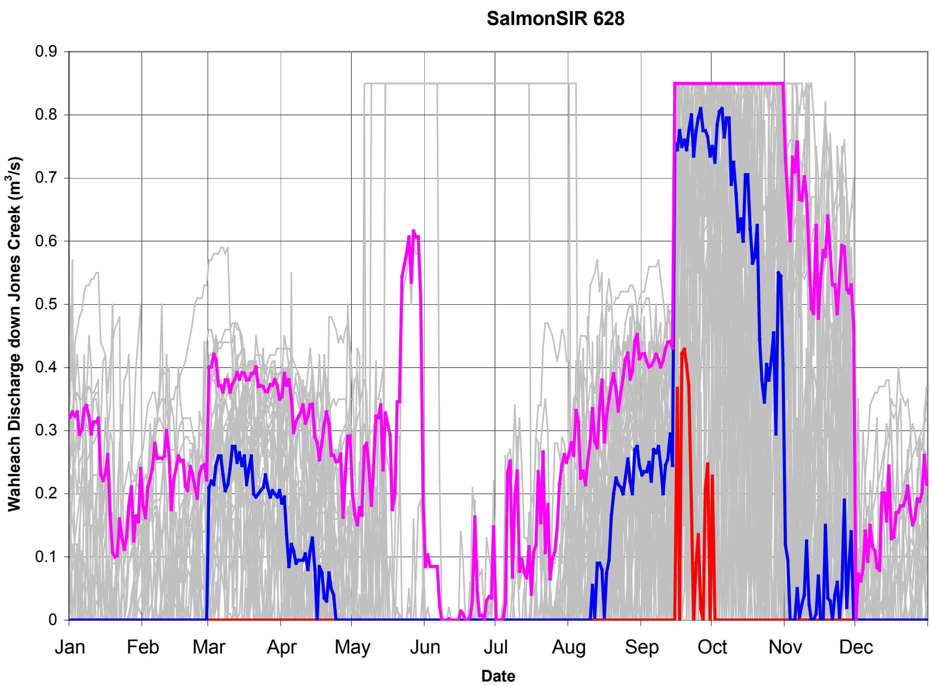

Figure O-1: Release into Jones Creek

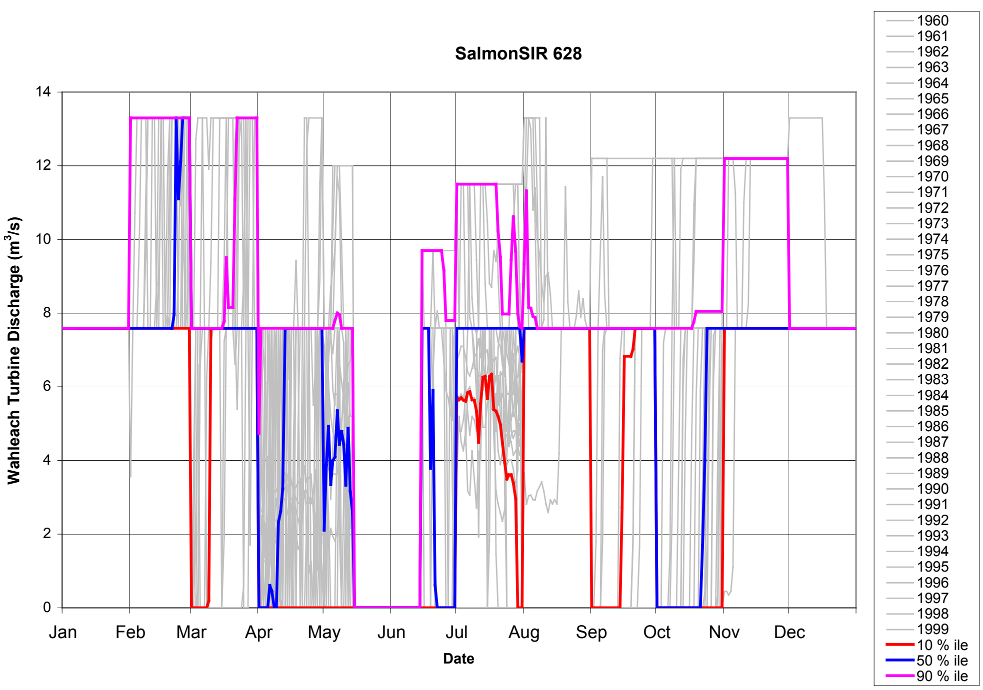

Figure O-2: Turbine Discharge

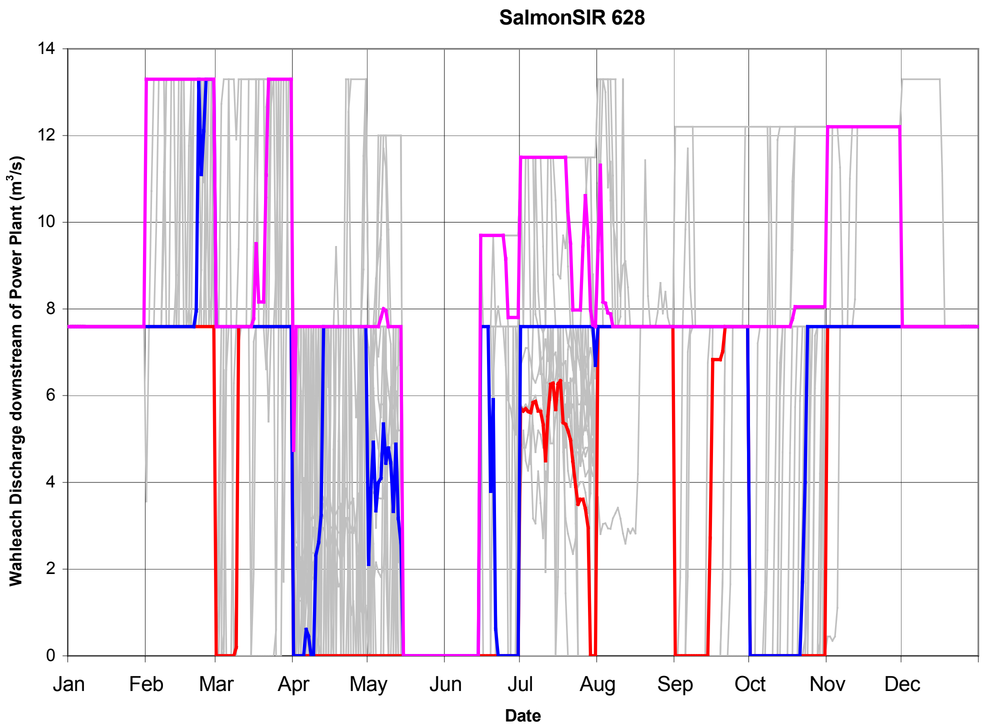

Figure O-3: Release into Herrling Island Sidechannel

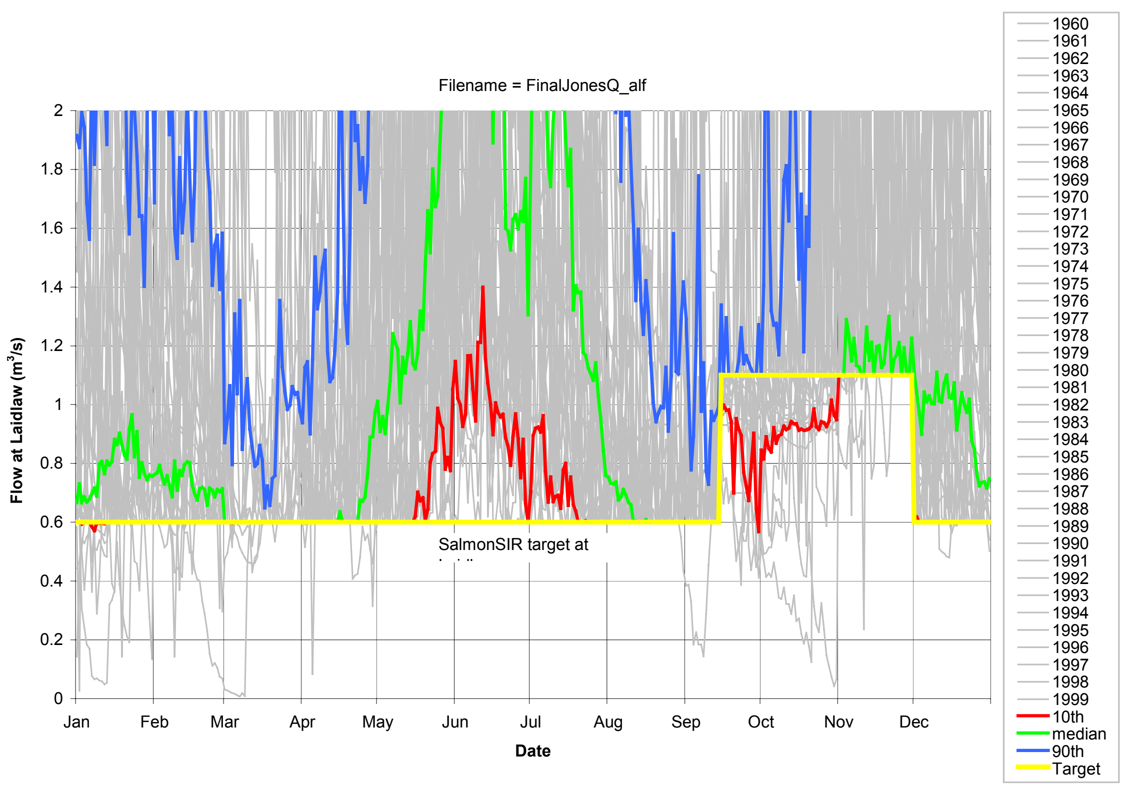

Figure O-4: Flow at Laidlaw

APPENDIX P CONSULTATIVE COMMITTEE SIGN-OFF OF CONSULTATIVE REPORT

AUG 01 2003 13:00 FR MOF CHWK MAIN 604 702 5711 TO 816045282905 P.01/01

Faxed Aug. 1, 2003.
@ 11:50. A.M.

- 3 -

To:

Sue Foster
Project Manager
Wahleach Water Use Plan

Fax: 604 528 2737
Phone: 604 528 2905

From:

MINISTRY OF FORESTS - CHILLIWACK FOREST DISTRICT.

46360 AIRPORT ROAD.

CHILLIWACK, B.C. V2P 1A5.

Wahleach Water Use Plan Consultative Committee Report

This Wahleach Water Use Plan Consultation Report records the deliberations of the Wahleach Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the Wahleach hydroelectric facility.

The undersigned confirm that this Consultative Report captures the water use interests, objectives and associated values expressed by the Consultative Committee members during the Wahleach water use planning process.

Name & Organization: RUSS KNUTSON - MINISTRY OF FORESTS CHILLIWACK FOREST DISTRICT.

Signature: [signature]

British Columbia Hydro and Power Authority, 6911 Southpoint Drive, Edmond 09, Burnaby, B.C. V3N 4X8

** TOTAL PAGE.01 **

To:

Sue Foster
Project Manager
Wahleach Water Use Plan

Fax: 604 528 2737
Phone: 604 528 2905

From:

Frank Kwak
2302 - 8485 Young Rd.
Chilliwack B.C. V2P7Y7

Wahleach Water Use Plan Consultative Committee Report

This Wahleach Water Use Plan Consultation Report records the deliberations of the Wahleach Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the Wahleach hydroelectric facility.

The undersigned confirm that this Consultative Report captures the water use interests, objectives and associated values expressed by the Consultative Committee members during the Wahleach water use planning process.

Name & Organization: Frazer Valley Salmon Society

Signature: Frank Kwak

over

Due to finacial pressures I continue to believe that this process - this time - was slanted towards dollars - big time. Fishing or anything else was a smoke screen. It was all about how many dollars could be added to the governments (BC. Hydro) pockets.

Frank Kwak

For me to think that some of the original propsals could fly was totally ignorant on my part. Example JCA Gen or JCA ~~Gen~~ mod B. Dollars not fishing quality was all that mattered

To:

Sue Foster
Project Manager
Wahleach Water Use Plan

Fax: 604 528 2737
Phone: 604 528 2905

From:

Dean Jones

Wahleach Water Use Plan Consultative Committee Report

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Name & Organization: Shxw'owhámel First Nation

Signature: Dean Jones

British Columbia Hydro and Power Authority, 6911 Southpoint Drive, Edmond 09, Burnaby, B.C. V3N 4X8

- 3 -

To:

Sue Foster
Project Manager
Wahleach Water Use Plan

Fax: 604 528 2737
Phone: 604 528 2905

From:

Edith M. Grainger
#7-7610 EVANS Rd
CHILLIWACK, BC. V2R 2T4

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Name & Organization: Chilliwack Citizen

Signature: Edith M. Grainger

British Columbia Hydro and Power Authority, 6911 Southpoint Drive, Edmond 09, Burnaby, B.C. V3N 4X8

#7 7610 Evans Road
Chilliwack, B.C. V2R 2T4
September 8, 2003

Sue Foster, Project Manager
Wahleach Water Use Plan Project TEam
B.C. Hydro and Power Authority
6911 Southpoint Drive,
Edmond 09
Burnaby, B.C. V3N 4X8

Dear Sue,

Being welcomed as a member of the Wahleach Consultative Committee was interesting and enjoyable. I appreciated the attention which was paid to my occasional input, and I value the many facts which I learned from the other members. Some of these facts I have already had the opportunity to share, verbally, with other local Fraser Valley Leaders.

I have read the Draft Consultative Committee Report July 2003. I found the report to be factual, comprehensive and explanatory. Two facts which were especially important to me:

1. Fish enhancement in Jones Lake or Jones Creek (especially) should not result in a negative impact on power generation.

The Consultative Committee recognized the value of enhancement of the fish habitat in the Herrling Sidechannel, particularly during th winter months.

2. Water diversion from Jones Lake Resevoir should be dictated by both the supply of water and the demand for power; license restrictions should NOT have governance as the original restrictions were no doubt an error.

As a Chilliwack citizen my opinion is "general", and not of a special interest (ie: recreation, fishing,First Nation). I was disappointed that neither members of the Chilliwack City Council, Chamber of Commerce Representatives nor members of Fraser Cheam REgional District chose to have input into the discussions concerning the Wahleach Water Use Plan. I will share the final report with them.

Yours truly,

Edith M. Grainger, Chilliwack Citiazen

- 3 -

To:

Sue Foster
Project Manager
Wahleach Water Use Plan

Fax: 604 528 2737
Phone: 604 528 2905

From:

FAN OUT SYSTEM CO ORDINATOR
ERIC ISAACSON
58051 LAIDLAW RD
RR2 HOPE BC

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Name & Organization: FAN OUT SYSTEM CO-ORDINATOR

Signature: Eric E Isaacson

British Columbia Hydro and Power Authority, 6911 Southpoint Drive, Edmond 09, Burnaby, B.C. V3N 4X8

- 3 -

To:

Sue Foster
Project Manager
Wahleach Water Use Plan

Fax: 604 528 2737
Phone: 604 528 2905

From:

Mike Lewis

Ruskin G.S.

Wahleach Water Use Plan Consultative Committee Report

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Name & Organization: Mike Lewis B.C. Hydro

Signature: [signature]

British Columbia Hydro and Power Authority, 6911 Southpoint Drive, Edmond 09, Burnaby, B.C. V3N 4X8

To:

Sue Foster
Project Manager
Wahleach Water Use Plan

Fax: 604 528 2737
Phone: 604 528 2905

From:

Dan Sneep
Fisheries and Oceans Canada

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Name & Organization: Dan Sneep, Fisheries and Oceans Canada

Signature:

British Columbia Hydro and Power Authority, 6911 Southpoint Drive, Edmond 09, Burnaby, B.C. V3N 4X8

- 3 -

To:

Sue Foster
Project Manager
Wahleach Water Use Plan

Fax: 604 528 2737
Phone: 604 528 2905

From:

Dorell Carlson
BC Hydro

Wahleach Water Use Plan Consultative Committee Report

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Name & Organization: Dorell Carlson ; BC Hydro

Signature: Dorell Carlson

British Columbia Hydro and Power Authority, 6911 Southpoint Drive, Edmond 09, Burnaby, B.C. V3N 4X8

NOV-24-2003 15:19 STOLO NAT BLD 1 FL 2 604 824 5226 P.02

To:

Sue Foster
Project Manager
Wahleach Water Use Plan

Fax: 604 528 2737
Phone: 604 528 2905

From:

Tim Peters
Enviro. Research Technician
Sto:lo Nation

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Name & Organization: Tim Peters, Sto:lo Nation

Signature: Tim Peters

TOTAL P.02

12/04/2003 16:13 FAX 604 582 5305 MELP - SURREY 002

- 3 -

To:

Sue Foster
Project Manager
Wahleach Water Use Plan

Fax: 604 528 ~~2737~~
Phone: ~~604~~ 528 2905

From:

ROSS NEUMAN

MINISTRY OF WATER, LAND + AIR PROTECTION

Wahleach Water Use Plan Consultative Committee Report

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Name & Organization: B.C. Ministry of Water, Land & Air Protection.

Signature: [signature]

British Columbia Hydro and Power Authority, 6911 Southpoint Drive, Edmond 09, Burnaby, B.C. V3N 4X8

GLOSSARY OF ELECTRICAL TERMS

Ancillary service:

The services needed to maintain system reliability and meet WECC/NERC operating criteria, including spinning, non-spinning, and replacement reserves, regulation, voltage control and black start capability. WECC is the Western Electrical System Co-ordinating Council. NERC is the North American Electricity Reliability Council.

Amper (amp):

The unit of measurement of electric current. It is proportional to the quantity of electrons flowing through a conductor past a given point in one second.

Capability:

The energy output of a generating station or the integrated system under specific conditions for a given time interval (usually one year).

Capacity:

Pertaining to the rating of the output from a generating station or the system.

- Maximum – the maximum output which can be achieved
- Nameplate – the maximum output specified by the manufacturer
- Dependable – the maximum output that can be supplied during the peak load months (December and January) on a reliable basis
- Firm – based on dependable capacity, unit availability and system characteristics: computed from reliability analysis

Capacitor:

A system of conductors and dielectrics so arranged that a large electric charge is stored in a small volume.

Circuit:

A system of conductors through which electric current passes.

Circuit breaker:

A mechanical device designed to open or close electric circuits.

Cogeneration:

The simultaneous production of mechanical or electrical energy and useful thermal energy in the form of steam or hot water from a single fuel source.

Critical water conditions or Critical Period:

A period of adverse streamflows which actually occurred in the past. Critical water conditions serve as a design test of the capability of a hydro electric system to meet forecast electric loads under adverse reservoir inflows. During a critical period all hydroelectric reservoirs would be drawn to minimum levels in order to sustain service.

Demand side management:

Actions that influence energy demands to better match energy supply. In BC Hydro's case, Power Smart customer programs promote efficient energy consumption to reduce future demand so that construction of power plants can be delayed. In this way the cost of electricity is kept in check.

Distribution system:

Refers to the facilities (i.e., lines, transformers, and switches) used to distribute electricity over short distances from the Transmission System to the customer. Distribution is generally at low voltage (below 69 kV).

Firm energy:

The assured energy contribution (kWh) of generating plants over the year. For the BC Hydro system, the firm energy is based on the energy available during an extended period of adverse stramflows (the critical period).

Gigawatt hour (GWh):

One million kWh . BC Hydro measures the energy output of the generating stations in gigawatt hours.

- City of Vancouver uses 4000 GWh each year.
- Prince George uses 2000 GWh each year, half of which goes to industrial customers.
- Victoria uses approximately 690 GWh per year.
- Vernon uses 180 GWh per year.

Integrated system:

The interconnected network of transmission lines and substations linking generating stations to one another and to customers. Also representing that portion of the BC Hydro electric system capable of being operated on a coordinated basis.

Kilowatt – hour (kWh):

A unit of work or energy equal to that expended at the rate of one kilowatt for one hour.

Load:
: The amount of energy required by a customer or group of customers.

Megawatt:
: 1000 kW, commonly used to measure the capacity of generating stations.

Peak demand:
: The maximum amount of electricity required by the system or by the customers, averaged over one hour, usually in the evening.

Penstock:
: A tube through which water flows from the reservoir to the turbines in a hydroelectric generation station.

Potential energy:
: The energy that a piece of matter has because of its position or because of the arrangement of parts.

Power:
: The instantaneous rate at which energy is used, measured in watts, kilowatts or horsepower: often used in the broader sense as a synonym for electricity.

Resistance:
: The opposition offered by any conducting material to the flow of a direct current of electricity.

Secondary energy:
: The additional energy available from a hydroelectric system in water conditions other than the critical period. Secondary is energy is not guaranteed to always be available.

Supply-side options:
: Generic denominations including all alternatives that increase generation output, such as new generation projects, market purchases, and improvements to existing facilities.

Transmission losses:
: Losses of electricity caused by line resistance, transformation, etc.

Transmission system:
: This refers to those facilities (i.e., lines, transformers, and switches) used to transport electricity in bulk from sources of supply to the Distribution System. Transmission is generally at high voltage (69 kV and above).

Transformer:

An electromagnetic device for raising or lowering the voltage of alternating current electricity.

V (Volt):

The basic unit of electric force or pressure.

W (Watt):

The basic unit of electric power expressing the rate of which electricity is expended. The amount of electricity a device consumes.