Consultative Committee Report

December 2002

Prepared on behalf of:

The Consultative Committee for the Shuswap River Water Use Plan

Shuswap River Water Use Plan

A Project of BC Hydro

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This report was prepared for and by the Shuswap River 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 Shuswap River Water Use Plan that will be submitted to the Comptroller of Water Rights for review under the *Water Act*.

The technical data contained within the 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

Water Use Planning was announced in 1996 to ensure provincial water management decisions reflect changing public values and environmental priorities. A Water Use Plan (WUP) is a technical document that, once 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 strategy using a public participatory process.

Background

The Shuswap River hydroelectric facilities are located on the upper reaches of the Shuswap River, about 35 km east of Vernon and the Okanagan Valley. The hydroelectric system is linear, comprising a single dam (Sugar Lake Dam) impounding a reservoir (Sugar Lake Reservoir) and a smaller dam (Wilsey Dam) creating a headpond for a two-unit generating station, further downstream.

Issues

The Shuswap River hydroelectric system is relatively small from a power perspective, contributing about 37 GWh annually to total provincial generation, about enough energy to provide the annual needs of 4000 homes. However, the river system carries a large importance for fish, playing a role in the lifestages of chinook, coho, kokanee and many other species. By retaining some of the freshet and releasing it gradually over the remainder of the year until the following spring, the reservoir serves both to increase power production and to enhance spawning and incubation flows downstream of the facilities. Since power generation was constant over a wide variety of alternatives, the challenge for the Consultative Committee was to find an operating alternative that maximized what was best for these fish downstream of the powerplant during the fall and winter periods when flows could be augmented.

The impact of reservoir operations on recreation also played a role in discussions as the reservoir is valued for boating, camping, and fishing opportunities. The Consultative Committee (CC) ensured that impacts to these values were tracked when selecting among alternatives.

The influence of reservoir operations on erosion around the reservoir was also considered in discussions. The existence of private property and First Nations archaeological sites that are subject to erosion turned out to play a large role in decisions made among alternatives by the Consultative Committee.

The operation of the Sugar Lake Dam was the focus of those who are affected by flooding along the Shuswap River. A strong interest was expressed in finding ways to enhance flood control, both through the operations of the current facility and through physical changes to these facilities.

Finally, the impact of unplanned flow disruptions arising from outages at the generating station was a key issue for the Consultative Committee. Sudden changes in flows have the potential to harm fish downstream, their impacts are difficult to observe and to quantify, and the ability to address these impacts through operational changes is limited.

The Consultative Process

The Shuswap River Consultative Committee consisted of 20 members representing a variety of interests including: power generation, recreation, cultural use and heritage sites, fish, wildlife, and flooding. Consultative Committee members represented various levels of governments, a First Nation, local interest groups and private landowners. The consultative process began in March 2000 and concluded in April 2002. Sixteen committee meetings were held during this period to work through the steps outlined in the provincial government's *Water Use Plan Guidelines*.

Objectives and Performance Measures

The Shuswap River Water Use Plan Consultative Committee explored issues and interests affected by facility operations and agreed to the following objectives:

- Maximize the net value of power generated;
- Maintain dam safety through all operations;
- Minimize flooding and erosion to property around the reservoir and on the river;
- Maximize recreational opportunities around the reservoir and on the river;
- Maximize the protection of archaeological resources around the reservoir;
- Maximize opportunities for First Nations' access to archaeological sites around the reservoir;
- Maximize wildlife habitat around the reservoir and on the river;
- Maximize habitat conditions in the reservoirs to maximize resident fish populations;
- Maximize spawning and rearing success for fish in the river; and
- Minimize the impacts of unplanned outages on all the lifestages of fish below Wilsey Dam.

Performance measures were developed based on these objectives. Where possible, performance measures were modelled quantitatively. In other cases, impacts were described qualitatively for different alternatives.

Creating Alternatives

Operating alternatives were developed to meet various objectives. In total, 24 alternatives for Sugar Lake Dam operations were run through BC Hydro's operations model which is based on historic natural inflows and then assessed based on their impacts on the objectives. In addition, three alternative ways of routing water at Wilsey Dam were considered, as well as a physical change to the facility in lieu of these operational changes. To assess the alternatives and develop an accepted operating strategy for the system, the operations at Sugar Lake Dam were considered independently from those at Wilsey Dam. The results were then combined into a single package at the end of the process.

Lessons Learned Around Physical Impacts of Sugar Lake Dam Releases

A number of key conclusions arose once the impacts of the numerous alternatives were analyzed, highlighting the understanding that can arise from a structured approach to decision-making. Power generation was relatively unaffected across a wide range of alternatives pursued, making it irrelevant to the trade-off analysis. As well, given the existing dam structures, the ability to control floods downstream was unchanged across these alternatives, and maximized under what was referred to as the Status Quo operations.

Several important facts were learned when analyzing the effects on fish. The first was that there was no apparent trade-off among species; one alternative maximized fish performance measures across all species. Secondly, there was no trade-off between fish in the reservoir and fish in the river. Finally, the Status Quo alternative represented the most favourable one for fish in the river. None of this was obviously apparent at the beginning of this process.

For impacts on archaeological sites around the reservoir, the data showed there was a fundamental conflict for most alternatives between protecting archaeological sites against erosion and keeping them covered to protect them from unauthorized collection.

Finally, the analysis of the impact of the alternatives on the recreation and reservoir erosion performance measures showed that the Status Quo operations could be improved upon through minor changes in reservoir elevations during the summer.

Lessons Learned Around Committee Members' Values Regarding Operational Impacts of Sugar Lake Dam

In their final choice, Consultative Committee members faced two options: Alternative A2 which was better for paddle sports on the river, erosion around the reservoir, and the protection of archaeological sites around the reservoir, or Status Quo which provided a small advantage to fish in the river. In choosing the Status Quo over Alternative A2, Consultative Committee members showed the high value they placed on the fish resources in the Shuswap River and their risk averse approach to managing this resource.

Lessons Learned Around Physical Impacts of Routing Water at Wilsey Dam

Since the impacts of unplanned flow disruptions on fish in their various lifestages are very difficult to quantify, the performance measures used in measuring these impacts were qualitative in nature only, and subject to a wide level of interpretation amongst the Fish Technical Committee (FTC). Nevertheless, it was made clear that continuously re-routing water away from the generators and into the spillway to reduce the impact of unplanned flow reductions is a more expensive and less effective way to address these issues than through the use of a gated spillway. A gated spillway, if feasible, would represent the best available control technology to mitigate against downstream flow disruptions.

Lessons Learned Around Consultative Committee Members' Values Regarding Operational Changes and Capital Works at Wilsey Dam

Committee members showed a wide divergence in their willingness to forego provincial power revenues or invest provincial money to reduce the impact of unplanned flow disruptions below Wilsey Dam. Many were risk adverse in their approach to protect fish stocks from unquantified and infrequent negative impacts of unplanned flow disruptions. Others did not want to commit provincial funds towards a project with unquantified benefits and infrequent impacts.

On a process note, those Consultative Committee members impacted by flooding along the river expressed a great deal of frustration that changes to the Sugar Lake Dam to increase flood control (such as making it larger or constructing additional gates) were outside of the scope of water use planning and were not investigated by this process.

Recommendations for Operations at Sugar Lake Dam

The committee members agreed by consensus to recommend the operating alternative designated as Status Quo for Sugar Lake Dam. This operation was viewed as the best alternative by many of the Consultative Committee members, and was accepted with minor reservations by others. The general operating parameters for this alternative are stated below.

- Latter Part of Summer - fill the reservoir after freshet and maintain a minimum of 601.22 m throughout August and a minimum of 600.50 m during September;

- Fall and Early Winter - release stored water gradually over the fall months to conserve storage for winter flows. In dry years, maintain flows of at least 16 m^3/s below Wilsey Dam from 15 August to 31 December;

- Winter to Freshet - release stored water gradually so that the reservoir is not empty before 28 February, but empty by 1 April. In dry years, maintain flows of at least 13 m^3/s below Wilsey Dam from 1 January until 1 April;

- Freshet to late summer - maximize storage capacity of the reservoir by keeping gates open until freshet has passed and then follow the staged stoplog installation protocol set by Dam Safety to fill the reservoir by the end of the summer; and

- All year round - follow prescribed ramping rates.

Recommendations for Operations at Wilsey Dam

The Consultative Committee was unanimous in not supporting any alternative that diverted water from the generators to the spillway as a means for protecting fish downstream from sudden flow disruptions. Some of the Consultative Committee would have accepted such an alternative with reservations while others would have found this unacceptable.

However, there was no agreement as to whether a gated spillway should be installed as a means of protecting fish downstream from unexpected outages. Most of the Consultative Committee, including BC Hydro, accepted or supported such an alternative. However, one member of the Consultative Committee felt that this was unacceptable. Consequently, there was no consensus recommendation around operations at Wilsey Dam.

Recommendations for Monitoring

The Consultative Committee expressed a wide range of opinions around which outstanding issues would require monitoring. A large number of studies were considered, both within the sub-groups and around the Consultative Committee table. There was agreement that a number of these studies were of a low enough priority that they were not required. In addition, there was no agreement amongst the Consultative Committee on the support for some studies, however, they did reach consensus on three monitoring studies:

- Local Inflow Measurement for Sugar Lake Reservoir

  Uncertainty being addressed: whether inflow data for the reservoir has been accurately measured, and whether additional, real time information can add to operational flexibility in the spring.
  Cost: $7,000 per year.

- Estimation of the Extent of Future Erosion Around the Reservoir

  Uncertainty being addressed: whether the reservoir is close to achieving bank stability, or whether operations at full pool will continue to erode the shoreline around the reservoir causing extensive damage over time.
  Cost: $15,000 for a one time study.

- Local Stage Measurement for Shuswap River below Wilsey Dam

  Uncertainty being addressed: whether the performance measure for flooding accurately captures the point at which flooding starts downstream of Wilsey, and what the link is between these flows and the extent of flooding over farmers fields.
  Cost: $20,000 for installation of a data collection platform, and administrative costs of $1,000 to collate data.

Costs of Monitoring

The total cost of this monitoring package is $36,000 in one time expenses, and $7,000 per year.

There were also a number of studies focussed on fish interests that were supported by most of the Consultative Committee, including BC Hydro, but that were viewed as an unacceptable use of money by others around the table.

Review Period

The Consultative Committee recommended BC Hydro report monitoring information on an annual basis, and that an informal review of the monitoring data be conducted 5 years after the Water Use Plan is implemented. If the information reviewed at that time warrants, a request can be made to the Comptroller of Water Rights for a formal review of the Water Use Plan. In absence of this, the Consultative Committee agreed that a formal review of this Water Use Plan should be conducted 10 years after the Water Use Plan is implemented.

Conclusion

In summary, the majority of the Shuswap River Water Use Plan Consultative Committee members agreed on a recommended operating strategy for the Sugar Lake Dam, and elements of a recommended monitoring program for Sugar Lake Reservoir and the Shuswap River. However, there was no consensus on several additional elements of the monitoring program, nor was there consensus on operational changes or physical works at Wilsey Dam to mitigate against outage events.

The consultative process provided a forum to share information and promote understanding of various interests and perspectives, explore alternative ways to operate the facility, evaluate impacts in a structured way and thus make choices more explicit. This participatory form of 'decision-making' provides accountability and an assessment of current public values to make more informed water management decisions in the province.

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1 INTRODUCTION

Water Use Planning was announced in 1996 by the Minister of Employment and Investment and the Minister of Environment, Lands and Parks (MELP) to ensure provincial water management decisions reflect changing public values and environmental priorities. A Water Use Plan (WUP) is a technical document that, once accepted and ordered 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 understand the physical implications of various water use options, public values around these and to develop recommendations defining a preferred operating strategy using a participatory process.

Water Use Planning processes are intended to address issues related to the operation of facilities as they currently exist and incremental changes to operations to accommodate other water uses.[1] Water Use Plans are neither intended to be comprehensive watershed management plans, nor are they to deal with water management issues associated with other activities in the watershed. Treaty entitlements and historic grievances from facility construction are specifically excluded from Water Use Plans, but can be considered as part of other processes (Province of British Columbia, 2000).

This report documents the consultative process and presents the recommendations of the Shuswap Falls and Sugar Lake (Shuswap River) Water Use Plan Consultative Committee to BC Hydro and the Comptroller of Water Rights. The interests and values expressed in the recommendations will be used by BC Hydro to prepare a draft Water Use Plan for the Shuswap River hydroelectric facilities. Both this Shuswap River Consultative Committee report and BC Hydro's draft Water Use Plan will be submitted to the provincial government for review and approval by provincial and federal government agencies as outlined in the *Water Use Plan Guidelines* (Province of British Columbia, 1998).

This Consultative Report is a record of the water use issues and interests identified for the Shuswap River facilities and the analysis of trade-offs associated with operating alternatives. It ensures the Comptroller of Water Rights has complete information from participants for use in decision-making.

[1] The focus of a Water Use Plan is to determine how water could be stored and released at control facilities to accommodate different water uses interests. Although the primary focus is on operational changes, there may be opportunities to undertake physical works as a substitute for operational changes if the physical works can achieve the same outcome as changes in flow but at less cost.

2 DESCRIPTION OF THE SHUSWAP RIVER PROJECT

2.1 Location

BC Hydro's Shuswap River project is located on the Shuswap River, east of Vernon and the Okanagan Valley, in the southern interior of British Columbia. The facilities can be reached by a secondary road off Highway 6, which is the main transportation corridor across the Monashee Mountains linking the Okanagan and Arrow Valleys. The project consists of four key components centred around two locations: Sugar Lake (Peers) Dam and Sugar Lake Reservoir north of Cherryville, B.C.; and Wilsey Dam and Shuswap Falls Generating Station, located at Shuswap Falls, northeast of Lumby, B.C.

2.2 History of Facilities

The US-owned West Canadian Hydroelectric Corporation built and brought into service the Sugar Lake and Wilsey dams and a single-unit generating station in 1929. Upgrades in 1942 raised Sugar Lake Dam and added a second generator to the Shuswap Generating Station at Shuswap Falls. The BC Power Commission acquired the system in 1945 and BC Hydro assumed control in 1962. For many years, the facility served the entire North Okanagan and Kamloops areas. Today the facility is linked to the provincial power grid and the region is served through this grid system.

Recent project improvements include the replacement of the unit No. 2 woodstave penstock with a steel penstock in 1993. The steel penstock is equipped with a bypass valve to shunt flows downstream of Wilsey Dam to protect fish resources in the event that generation flows are interrupted due to an unplanned outage (see Section 4 for details on the bypass valve). Other major improvements include rebuilding the powerhouse in 1995, and a seismic upgrade for Sugar Lake Dam in 1999 and 2002.

2.3 Description of Facilities

2.3.1 Existing Works

The Shuswap River project consists of Wilsey Dam at Shuswap Falls and Sugar Lake Dam located 35 km and 70 km east of Vernon, respectively. The Sugar Lake Dam, Wilsey Dam and Shuswap Falls Generating Station are collectively referred to as the Shuswap River hydroelectric system.

- Sugar Lake Reservoir is impounded by Sugar Lake Dam at the upstream end of the system. All water releases discharge into the Shuswap River.

- Downstream from Sugar Lake Reservoir, local inflows, primarily from Cherry and Ferry Creeks, combine with the Sugar Lake discharges to provide inflow to Wilsey headpond and the powerhouse.
- Wilsey Dam, spillway and powerhouse are ~29 km downstream of the Sugar Lake Dam on the Shuswap River. All releases discharge into the Shuswap River which subsequently flows into Mabel Lake.

A schematic of the Shuswap River system components is provided in Figure 2-1.

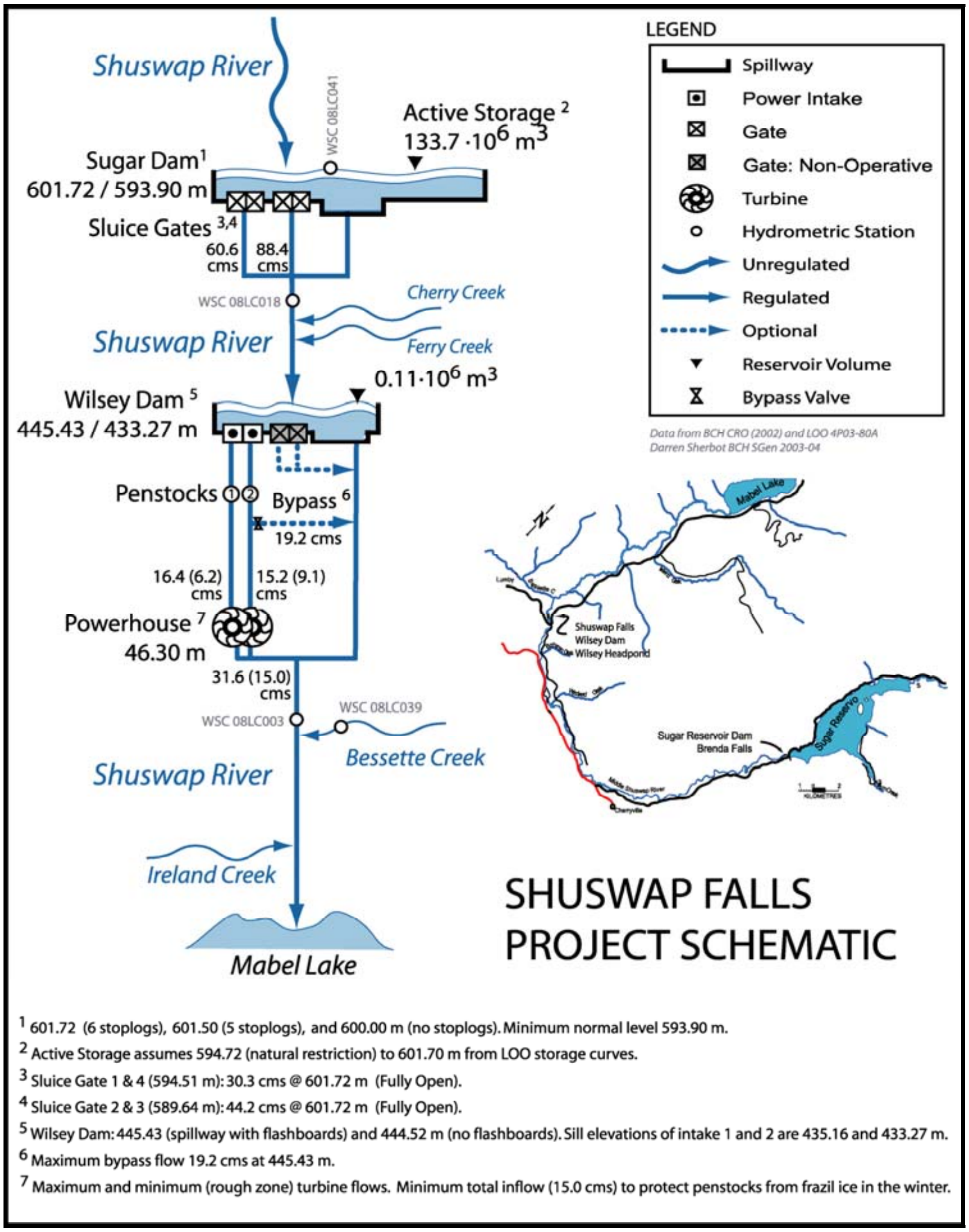

Figure 2-1 Schematic of Shuswap Falls and Sugar Lake Hydroelectric Facilities

All levels, volumes, and flows are approximate. Note the presence of the bypass valve on Unit 2. This valve is used to instantaneously divert flow from Penstocks 2 into the tailrace in the event of an unplanned plant outage

2.3.2 Sugar Lake Dam and Reservoir

Sugar Lake Dam is located on the Shuswap River, at the outlet of Sugar Lake. It is a 150 m long and 13 m high concrete buttress dam that provides storage and regulation for the Shuswap Falls Generating Station located 29 km downstream. The discharge facilities consist of four low level outlets and an overflow spillway with 14 bays. Following the freshet, the crest of each bay can be raised from El. 600.0 m to El. 601.72 m with the addition of up to 6 stoplogs in each bay.

The dam was originally constructed in 1929 as a 5.2 m high overflow dam. In 1942, the dam was raised to 13 m and the existing low level outlets were added. In 1975, timber facing on the spillway bays was replaced with precast concrete sections. In 1985 and 2002, the dam and abutments were upgraded to accommodate the Probable Maximum Flood.

Normal operating levels of Sugar Lake Reservoir are 594.7 m to 601.72 m. At the end of winter and prior to the onset of the freshet, the elevations at the Sugar Lake Dam may be lower than at the reservoir due to a natural outlet that restricts the reservoir upstream of the dam. Therefore the live storage is ~133.7 million m^3, as opposed to the expected 148 million m^3 noted in the original water licence.

2.3.3 Operating Variables at Sugar Lake Dam

By controlling gate openings and the number of installed stoplogs, BC Hydro has some influence over reservoir elevations in Sugar Lake Reservoir. This influence is minimal immediately before, during and immediately after freshet. There is more influence on reservoir levels when the reservoir and inflows are at an intermediate level. The variables under BC Hydro control and the range of operation are described in Table 2-1.

Table 2-1 Operating Variables of Sugar Lake Dam

Operating Variable	Operating Range	
	Minimum	Maximum
Reservoir Elevation at Lake	594.7 m	601.72[1]
Reservoir Elevation at Dam	589.6 m	601.72 m
Usable Storage[2]	0	133.7 million m^3
Discharge from Sugar Lake Dam gates[3]	149 m^3/s @ 601.72 m	

1. Represents top of 6th stoplog. Surcharging from high inflows or wind action can increase reservoir elevation. Elevation at Probable Maximum Flood (PMF) is 604.20 m.
2. Usable (or active) storage is measured between 594.70 m (level of natural lake restriction) and 601.72 m. (Source: Commercial Resource Optimization (CRO) Database (Version 4.6.1), BC Hydro, 2002). Note 2001 Water Use Plan reservoir mapping survey shows storage as 125.0 million m^3 at 601.72 m.
3. Discharge from all gates (fully open) at 601.72 m = 149 m^3/s.

The amount of inflows to the reservoir during freshet are far greater than the storage capacity of the reservoir. In an average year, freshet inflows are equivalent to 8 to 12 times the capacity of the reservoir. Once freshet fills the reservoir, typically by the end of May, the reservoir acts like a river and all additional inflows are free spilled on top of the controlled discharges. By this time, the stoplogs (metal beams that increase the effective height of the dam) have been removed and the four gates in the Sugar Lake Dam are left wide open so that the water can pass both through the gates and over the spillway. Once the freshet has passed, the height of the dam can be increased by installing the stoplogs. This changes the elevation of the top of the dam from 600 m (at its concrete sill) to 601.72 m. The exact limits on the timing of this placement during and after freshet is governed by dam safety requirements (Appendix A).

Following freshet, the stored water is released gradually through the year to augment natural inflows. This allows increased efficiency in energy generation, the avoidance of low flows (<15 m^3/s) which may damage the facilities due to frazil ice or excess cavitation, and the augmentation of spawning and incubation flows for salmon and other resident aquatic species below Wilsey Dam. The reservoir has historically been operated through one fill-empty cycle per year, using the spring freshet to refill the reservoir by July and to redistribute this volume, along with fall inflows, until the next spring freshet.

Sugar Lake Dam is not staffed on site and gate operations are done manually by personnel dispatched from Vernon, B.C. There is no generating capacity at Sugar Lake Dam.

2.3.4 Wilsey Dam and Shuswap Falls Generating Station

Wilsey Dam is located on the Shuswap River, 29 km downstream of Sugar Lake Dam. It is a 43 m long and 30 m high concrete arch dam constructed in 1929. A free overflow arch spillway is located to the right of Wilsey Dam. A concrete gravity plug dam was placed downstream of the arch dam after material at the base of the arch dam washed out.

The two low level outlets were closed in 1991 by bolting stainless steel plates over passages in the arch dam. This was done due to a lack of approval from resource agencies to use them to pass sediment as well as concerns with respect to ongoing maintenance.

The 6 MW powerhouse is located 140 m downstream of Wilsey Dam on the left bank of the Shuswap River. Two intakes on opposite sides of Wilsey Dam supply the generating unit. The unit 2 penstock has a hollow cone bypass valve.

Inflows to the generating station comprise the discharge from Sugar Lake Dam plus the local inflows, primarily supplied from Cherry and Ferry Creeks. Inflows above the maximum capacity of the units are spilled.

The Wilsey overflow spillway crest can be raised from El. 444.52 m to El. 445.43 m by installing flashboards. The flashboards are normally installed in the fall to raise the Wilsey headpond. This provides increased head for power production and reduces the risk of frazil ice build-up in the headpond. A headpond controller adjusts generation to ensure the headpond level remains within 2 cm of the spillway crest. This reduces the time it takes to restore downstream flows by spilling in the event of a unit failure or station trip. The flashboards are removed prior to the freshet to avoid damage caused by the high volume of spill during the freshet.

A map of the Wilsey headpond dam and trailrace is provided in Figure 2-2.

Water levels and flows on Sugar Lake Reservoir and Shuswap River depend on snowpack, weather during freshet and rainfall, all of which vary from year to year. These varying conditions combined with the limited storage in Sugar Lake Reservoir restrict BC Hydro's ability to manage the Shuswap River flows. Normally, Sugar Lake has lower winter levels, with increasing levels through spring and summer runoff and fall rainstorms. During the spring runoffs when flows are high, water bypasses the dam at Shuswap Falls.

The plant is operated as a base load plant, providing a relatively constant turbine discharge. This contrasts with peaking plants which respond to short-term fluctuations in electricity demand.

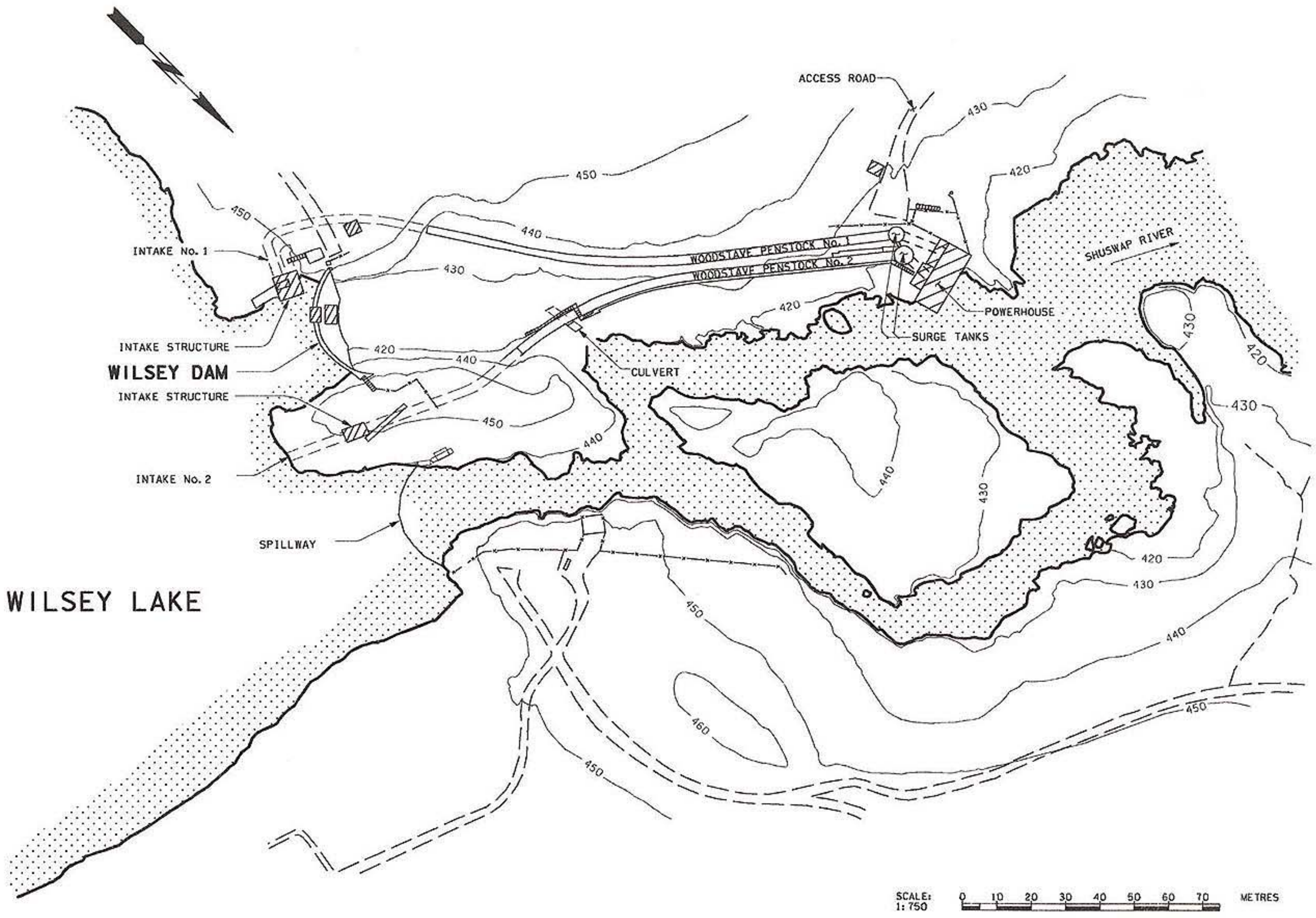

Figure 2-2 Wilsey Headpond, Dam, and Tailrace

Figure adapted from BC Hydro 310-C14-B343.

2.3.5 Operating Variables at Wilsey Dam

By controlling the amount of water entering the penstocks at Wilsey Dam, BC Hydro has some influence over the routing of the flows through the powerhouse and over the spillway. The variables under BC Hydro control and the range of operation are described in Table 2-2.

Table 2-2 Operating Variables at Wilsey Dam

Operating Variable		Operating Range	
		Minimum	**Maximum**
Diversion for generation (2 penstocks)	Unit 1	0 or 6.2 m^3/s	16.4 m^3/s
	Unit 2	0 or 9.1 m^3/s	15.2 m^3/s
Total		0, 6.2 m^3/s, 9.1 m^3/s or 15.3 m^3/s	31.6 m^3/s
Bypass Valve from Unit 2		0 m^3/s	19.2 m^3/s

2.4 Shuswap System Hydrology

The headwaters of the Shuswap River are in the Monashee Mountains east of the Okanagan Valley. The Sugar Lake drainage basin covers 1113 km^2 capturing water from the Upper Shuswap River and from creeks that drain into the reservoir. An additional 856 km^2 of drainage is associated with the river system between Sugar and Wilsey Dams and the mean annual discharge is ~52m^3/s.

Melting snowpack in spring and seasonal precipitation through the year provide inflows to the Shuswap River system. In the late fall, precipitation at higher elevations falls as snow. Inflows to the reservoir are lowest through the winter until temperatures warm in the spring. There is an annual spring flood (freshet) when the weather warms and the winter snow melts from the mountains. Spring runoff can begin as early as March and peaks in June (Figure 2-3), though there is some variation from year to year. Freshet (May-June), accounts for about 45% of the annual inflows to the system. Inflows to the reservoir can also increase if heavy rains occur at the same time as thaw. Summer and fall rainstorms can cause other smaller peak flows.

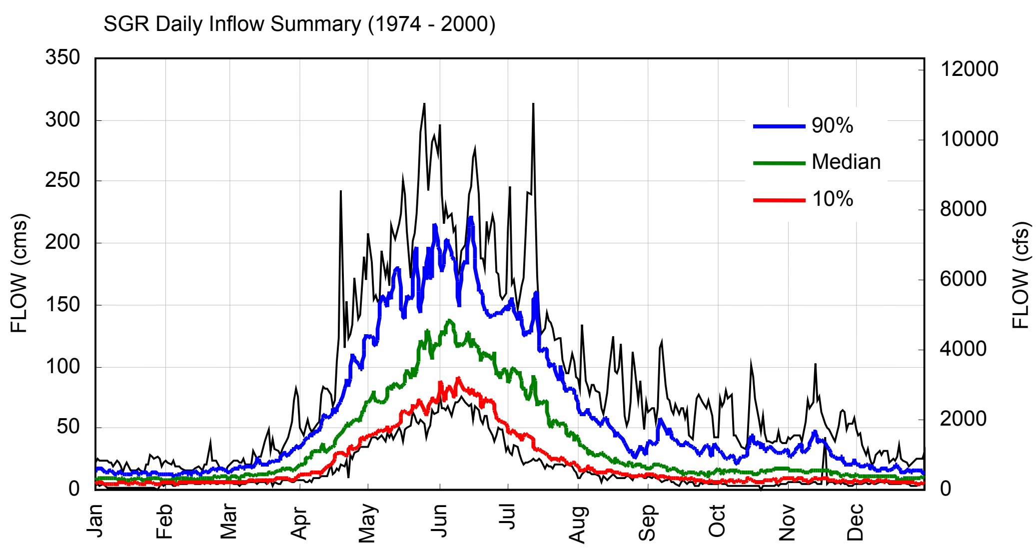

Figure 2-3 Inflow to Sugar Reservoir: 1974 - 2000

Minimum and maximum daily inflows bound 10th, 50th (median) and 90th flow percentiles. Daily inflow data from Water Use Plan Power Optimization Model (2001).

During freshet, Sugar Lake Dam has little influence over downstream discharge as water overtops the spillway. When inflows to the reservoir decline to the point that BC Hydro has some control over discharge from Sugar Lake Dam, the large increases to downstream flows are mainly from rainfall events and tributary inflows.

The small size of the drainage basin and the large role of rainstorms in annual precipitation make inflows highly variable and very difficult to predict in advance. The system operators rely on short-term weather forecasts, but even these are often unreliable. As a result, plans for running the Shuswap hydroelectric system are made on a very short timeline, sometimes even day-to-day, based on current reservoir storage, inflows, downstream flow constraints, and weather forecasts. In addition to lacking short-term predictability, there is no useful correlation between precipitation in one season and expected levels of precipitation in the next. As a result, it is never possible to speak of the current year as being a "wet" or "dry" year or even a "wet" or "dry" season, and operating plans cannot be made contingent on such a classification.[1]

Water from the reservoir flows past Sugar Lake Dam into the middle Shuswap River down to Wilsey Dam at Shuswap Falls. Downstream of Sugar Lake Dam, Cherry, Ferry, and Bessette creeks and numerous smaller creeks contribute additional flows to the middle Shuswap River.

The middle Shuswap River drains into the south end of Mabel Lake contributing about 48% of the inflows to Mabel Lake. The remainder of lake inflow is from the basin surrounding Mabel Lake. While the Middle Shuswap River contributes about half of the volume of water entering Mabel Lake, BC Hydro operations have little or no impact on the magnitude of these flows (Appendix B).

The lower Shuswap River begins on the west side of Mabel Lake and drains westward then northward towards Mara Lake, Shuswap Lake, and after 196 km, into the South Thompson River.

[1] Snowpack levels, collected by the Ministry of Water, Land, and Air Protection, do provide a predictive tool for estimating peak flow risks, but do not aid in informing on operations outside of the freshet period.

3 THE CONSULTATION PROCESS

The Shuswap River Water Use Plan (WUP) consultation process[1] followed the steps outlined in the provincial *Water Use Plan Guidelines* (Province of British Columbia, 1998). These steps represent an interest-based, structured approach to decision-making which was adapted for the water use planning process.

3.1 Initiation and Issues Scoping

The Shuswap water use planning process was publicly announced in a news release issued 1 March 2000. The news release, sent to media in Lumby, Vernon and Enderby, identified three upcoming open houses to introduce the planning process, obtain issues and interests and identify possible Consultative Committee members. Notification of the open houses was also provided through advertising in local papers (*Lake Shore News, Vernon Sun Review, Lumby Valley Times, Vernon Morning Star and Kingfisher News*), and faxing local elected officials and other groups and individuals who had been identified in earlier scoping discussions.

The open houses were attended by more than 100 people over a period of 3 days in March 2000:

- Mabel Lake Community Hall -14 March 2000
- Cherryville Community Hall - 15 March 2000
- Kingfisher Community Hall - 16 March 2000

In addition to group discussions, the attendees were encouraged to complete a questionnaire identifying their interests and issues associated with the operation of the Shuswap River hydroelectric facilities.

An Issues Scoping Workshop was held on 18 April 2000 in Cherryville to review the issues and interests collected during pre-scoping and to confirm the issues to be included as part of the water use planning process. The attendees included representatives from local organizations, government agencies, First Nations, and the general public who had expressed an interest in participating in the process.

[1] See the report *Proposed Consultation Process: Shuswap Falls and Sugar Lake Water Use Plan*. 26 October 2000, for details of the Shuswap Water Use Plan consultation process.

Information on the issues and interests raised at these scoping meetings, open houses, workshops, BC Hydro records and previous consultation processes (e.g. Electric System Operating Review), was compiled into the *Shuswap Falls and Sugar Lake Water Use Plan: Preliminary Issues* Report, dated 14 July 2000. This report was submitted to the Comptroller of Water Rights to complete Step 2 of the *Water Use Plan Guidelines*.

3.2 First Nations Involvement

In November 1999, as part of initiating the Shuswap River Water Use Plan, a First Nations orientation program was instituted. The goals of the orientation program were to identify First Nations with a territorial interest in the facilities, identify any issues pertaining to rights, orient them to the process and facilities, and engage them in meaningful dialogue toward their full participation. The orientation was also intended to make them aware, as early as possible, of the Water Use Plan, and allow them more time to determine their interests, working through any special needs and circumstances before deciding to participate. For this reason, First Nations initiation began ahead of the public initiation.

In November 1999, letters were sent to the:

- Shuswap Nation Tribal Council (SNTC);
- Okanagan Nation Alliance (ONA) Chief's Executive Council; and
- Spallumcheen Band.

The letters invited their participation and offered a presentation and discussion, on an individual First Nation basis, at their offices. These tribal organizations were chosen for the first round of discussion to determine whether their affiliated bands should be contacted. Spallumcheen Band was contacted because of their proximity to the facilities and because they are independent of the SNTC. Follow-up phone calls were made to ensure the letters were received and to establish a contact within each First Nation. See the separate report *Proposed Consultation Process: Shuswap Falls and Sugar Lake Water Use Plan* (BC Hydro, 26 October 2000).

Following the initial contact, the Okanagan Indian Band had planned to participate representing themselves and the Okanagan Nation Alliance. However, the Okanagan Indian Band decided to focus on other priorities and withdrew from the Shuswap River Water Use Plan process. The Shuswap Nation Tribal Council referred their participation to the Spallumcheen Band. A representative from the Spallumcheen Band attended Shuswap Consultative Committee (CC) meetings and the Band also attended some Fish Technical Committee (FTC) meetings. A summary of communications with First Nations is provided in Appendix C.

3.3 Consultative Committee Members

The Shuswap Consultative Committee (CC) was composed of 20 committee members and 9 alternates representing the range of interests (Table 3-1 and Table 3-2).[1] In addition, there were 26 observers (Appendix D) who received notices of upcoming meetings and notes from meetings. Two observers regularly attended Consultative Committee meetings. The BC Hydro Project Team of nine provided technical and logistical support to the Consultative Committee. Consultative Committee membership was relatively constant throughout the planning process. However, some members missed a series of meetings which resulted in fewer members participating in the trade-off discussions.

Table 3-1 Shuswap River Water Use Plan Consultative Committee Members

Committee Member	Affiliation	Primary Water Use Plan Interest
Ray Arlt	North Okanagan Naturalists Club (NONA)	Wildlife/Fish
Larry Arcand	Sugar Lake Resort (SLR)	Recreation/Fish
Don Brookes	Mabel Lake & Kingfisher Ratepayers Assoc., and the Kingfisher Environmental Interpretative Centre (MLKR)	Fish/Socio-economic
Alan Caverly	Water Land and Air Protection (WLAP) and Fish and Wildlife section ES Division	Fish/Secondary - Wildlife
Dave Couch	Landowner - Mara	Flooding
Loretta Eustache	Spallumcheen Band	Culture/Heritage
Brian Fast	BC Hydro (BCH)	Power
Rudi Gedaschke	Lumby & District Wildlife Association (LDWA)	Fish/Wildlife
Art Herbert	Shuswap Environmental Action Society (SEAS)	Environment
Lee Hesketh	Landowner	Fish
Joe Huwer	Landowner	Flooding
Tom (Pete) Huwer	Landowner	Flooding
Robin LeDrew	Local Resident	Socio-economic/Tourism
Kirk Mallette	Recreation (paddler)	Recreation
Tom Minor	White Valley Community Resources Centre (WVCRC)	Recreation/Environment
Hugh Smith	BC Hydro (BCH)	Power
Heather Stalberg	Fisheries and Oceans Canada (DFO)	Fish
Ron Trickett	Landowner	Flooding
Paul Wieringa	Crown Agencies Secretariat (CAS)	Socio-economic
Monty Willis	Kokanee Lodge & Resort (KLR)	Recreation/Fish

[1] The number of committee members and observers changed slightly throughout the Water Use Plan process. The figures show the number of participants at the completion of the Water Use Plan process.

The Consultative Committee adopted a Terms of Reference to guide the Committee's work (Appendix E). The terms of reference also described the responsibilities of participants and expectations for a collaborative working environment.

Table 3-2 List of Alternates for Water Use Plan Consultative Committee Members

Alternates	Alternates for	Affiliation
Cecil Rempel	Dave Couch	Landowner - Mara Lake
Dennis Roberts	Art Herbert	Shuswap Environmental Action Society
Erin Nelson	Ray Arlt	North Okanagan Naturalist Club
Hank Cameron	Larry Arcand	Landowner
Kevin Conlin	Alan Caverly	WLAP, Fish and Wildlife Branch
Len Foisy	Joe Huwer	Landowner
Michael Curd	Robin LeDrew	Local Resident
Neil Brookes	Don Brookes	Kingfisher Ratepayers
Steve Macfarlane	Heather Stalberg	Fisheries and Oceans Canada

3.4 Shuswap Subcommittees

The Consultative Committee created five subcommittees (Appendix F) to address specific issues and bring recommendations back to the main table.

- River Recreation
- Wildlife and Wildlife Habitat (Sugar Lake Reservoir, Mabel Lake, Shuswap River)
- Property Flooding and Bank Erosion (River and Sugar Lake Reservoir)
- First Nations Heritage and Archaeology Resources
- Fish and fish habitat (Reservoir and River) - Fish Technical Committee (FTC)

The Fish Technical Committee (FTC) met the most frequently with the wildlife, recreation, flood and erosion control, and First Nations heritage committee's meeting less frequently. The subcommittees were composed of members of the main Consultative Committee and others outside of the Consultative Committee, with support from the BC Hydro Project Team and consultants. In addition to subcommittee meetings, members carried on business by email. The wildlife subcommittee communicated exclusively by email and telephone.

3.5 Key Shuswap Water Use Plan Issues and Concerns

The Shuswap Consultative Committee identified nine key issues to address in the Water Use Plan consultative process. Identifying these key issues began with a preliminary scoping[1] of a larger number of issues. The Consultative Committee deliberated and refined the issues (Table 3-3) in Steps 4, 5, and 6. The issues, objectives, and performance measures are described in detail in Section 4.

Table 3-3 Shuswap Water Use Planning Issues

Interests	Issues[1]
Recreation	
Sugar Lake Reservoir	▪ Fishing, boating, visual aesthetics, boating safety, usable beach
Shuswap River	▪ Paddle sports, swimming, swimmer and paddling safety, fishing
Wildlife	
Sugar Lake Reservoir	▪ Wildlife habitat around Sugar Lake Reservoir
Shuswap River	▪ Wildlife habitat along the Shuswap River from Sugar Lake Reservoir to Mabel Lake
Power	▪ Power generation
	▪ Operating costs
Water quality	▪ Water temperature and Total Gas Pressure (TGP)
Flood and erosion control	
Sugar Lake Reservoir	▪ Property flooding and shoreline erosion around Sugar Lake Reservoir
Shuswap River	▪ Property flooding and bank erosion along the Shuswap River
Dam safety	▪ Safety and integrity of Sugar Lake Dam
Fish reservoir and river	
Sugar Lake Reservoir	▪ Fish productivity in the Shuswap River
Shuswap River	▪ Fish productivity in Sugar Lake Reservoir
First Nation heritage	
Sugar Lake Reservoir	▪ Protection of First Nations heritage, opportunities for study
Shuswap River	▪ Protection of First Nations heritage, opportunities for study
Protected areas and parks	▪ Protected areas and parks

1. No rank or priority is implied by the order of issues in the table.

[1] See the report *Shuswap Falls and Sugar Lake Water Use Plan: Preliminary Issues Report* for a detailed description of the preliminary issues and interests.

3.6 Geographic Scope of the Shuswap River Water Use Plan

Members of the Consultative Committee represented interests throughout the geographic scope of the Water Use Plan. However, the BC Hydro facilities are concentrated around two locations, at Sugar Lake Reservoir and 29 km downstream at Shuswap Falls where Wilsey Dam and the powerhouse are located. The influence of the hydroelectric facilities' operations is greatest closer to the facilities and diminishes with increasing distance from the facilities due to the attenuating effect of other water bodies such as Mabel Lake and inflows from tributaries supplementing flows in the Shuswap River.

The Consultative Committee deemed the upper extent of BC Hydro's operating influence to be the wetlands at the north end of Sugar Lake Reservoir and for a short distance up the upper Shuswap River and other tributaries to the reservoir. Any changes to operations would have no effect on conditions above the full pool mark upstream of the reservoir and so issues and interest beyond the full pool mark in the reservoir were not considered.

Downstream of Wilsey Dam and the powerhouse, the Consultative Committee had concerns that changes to BC Hydro operations could affect the degree of flooding and erosion and the quality and quantity of fish habitat downstream as far as Mara Lake. However, from a practical approach for conducting studies and modelling alternative operating regimes, the Consultative Committee focused on the downstream impacts as far as where the Middle Shuswap River joined Mabel Lake. This geographic area explicitly acknowledged the diminution of both the impact and the influence that BC Hydro operations had from Mabel Lake on downwards through the Shuswap River system. As well, the Consultative Committee adopted the working assumption that benefits from improved operations above Mabel Lake would also result in benefits from Mabel Lake and below.

In summary, the area of interest for the Shuswap Water Use Plan extended from the high water mark in Sugar Lake Reservoir downstream to where the Shuswap River joins Mara Lake. However, the studies and modelling focused on addressing impacts between the high water mark in Sugar Lake Reservoir down to but not including Mabel Lake.

3.7 Chronology of the Shuswap River Water Use Plan Process

The Shuswap River Water Use Plan was publicly announced in March 2000. Between June 2000 and April 2002, the Shuswap River Water Use Plan Consultative Committee met 16 times (Figure 3-1). In addition, the various Shuswap subcommittees met a total of 20 times during the consultative process.[1] Some of the Consultative Committee and subcommittee meetings spanned 2 days. In April 2002, BC Hydro reviewed the draft Consultative Committee report with the Consultative Committee and at that time a number of Consultative Committee members signed off on the report. Some Consultative Committee members requested an opportunity to review the revisions discussed at that meeting before signing off.

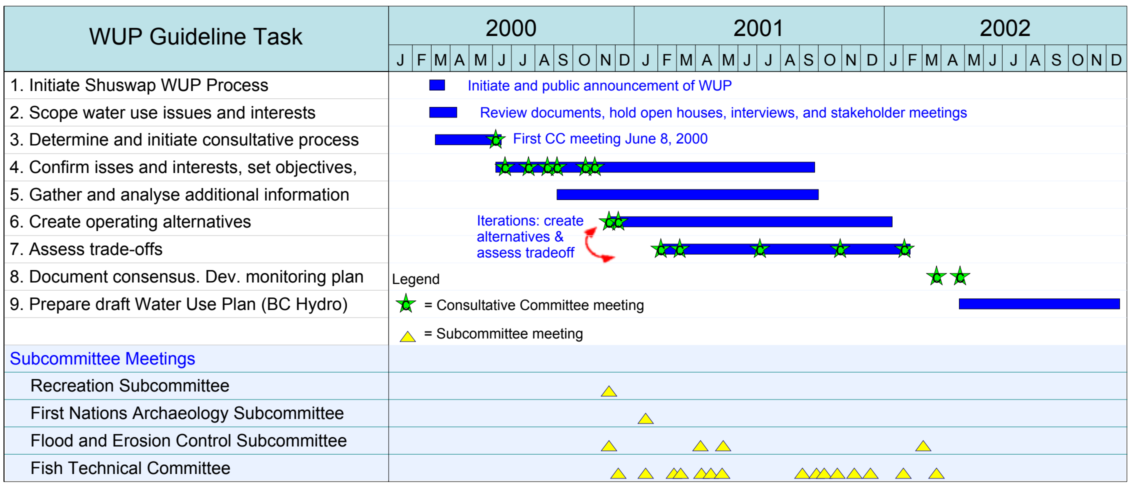

Figure 3-1 Shuswap Water Use Plan Schedule Showing Tasks and Meetings

3.8 External Communications

In addition to Consultative Committee members, alternates, and observers, BC Hydro provided information on the Water Use Plan process to other interested parties. The initial scoping meetings identified a number of agencies, groups and individuals who were not able to participate directly in the Consultative Committee but were interested in receiving updates on the process as recommendations were made. Other stakeholders were interested in providing input into the process but were unable to commit to being a Consultative Committee member. In these instances, the issue was brought to the attention of the Consultative Committee through written material and presentations or by referring the individual or group to a Consultative Committee member.

[1] See Appendix G for a detailed chronology of the Water Use Plan process and a list of key tasks. See Appendix H for a list of documents generated by the Water Use Plan process including a list of meeting notes.

BC Hydro communicated the progress and status of the Water Use Plan to area stakeholders who were not members of the Consultative Committee by means of website information, newsletters, fax updates, phone calls, email and news releases. In-depth information on the facilities and Water Use Plan process has also been made available in the reference section of the Lumby, Cherryville, Vernon and Enderby branches of the Okanagan Regional Library.

The first newsletter, issued in January 2001, provided an overview of the facilities, described the issues and interests identified for the Shuswap Water Use Plan, identified the Consultative Committee members and summarized the progress made during the first four steps of the process. The newsletter was sent to Consultative Committee members, alternatives and observers as well as local and regional government, MP and MLA offices, environmental organizations, business groups, media, property owners and water licence holders on the Shuswap River.

The second newsletter, issued in November 2001, described value-based decision-making and the development of operating alternatives, objectives and performance measures. This newsletter invited readers to contact the website, contact BC Hydro staff or attend a Consultative Committee meeting to observe the process.

Information was posted on the BC Hydro website regarding the Shuswap Water Use Plan status, newsletters, facility information, as well as upcoming meetings.

BC Hydro regularly reviewed the status of the Water Use Plan as part of other discussions with area stakeholders. For example, BC Hydro participated in community events at Cherryville and Lumby (July 2000) which provided an opportunity to share information and respond to questions regarding the Shuswap Water Use Plan process. When appropriate, information, questions and concerns were brought to the attention of the Consultative Committee.

The communication activities generally followed the consultation process proposed to the Comptroller of Water Rights in October 2000. The news releases proposed after Steps 7 and 8 were combined into a final news release on the project and the news release in Step 4 was advanced to the end of Step 3. The Open House proposed following Step 6 was not held although an introduction to operating alternatives was provided in the November 2001 newsletter. The newsletter proposed after Step 7 was combined into the final newsletter (November 2002). A chronology of the water use planning process and key achievements is provided in Appendix G.

4 ISSUES, OBJECTIVES AND PERFORMANCE MEASURES

To fulfil Step 4 of the *Water Use Planning Guidelines*, the Consultative Committee developed specific objectives for the new operating regime in order to address the key issues around the table. In defining the objectives, the participants articulated what they sought to achieve through a change in BC Hydro operations. For each objective, the Consultative Committee defined one or more performance measures that were used to compare the benefits or impacts of alternative operating regimes relative to the desired objectives. This section provides a summary of the issues, objectives, and performance measures. No priority or importance is implied by the order of interests or issues.

The following sections provide some descriptive context for the issue, a brief summary of the key concerns, and the objectives and performance measures adopted by the Consultative Committee. In the following tables, the **objective** states the most desired outcome for addressing a particular issue. In order to compare how well water use alternatives achieve each objective, the Consultative Committee has specified **performance measures**. The performance measure column specifies what will be measured, and in some cases when it will be measured if the issue is limited to certain seasons. Using power generation as an example, performance is measured by the value of energy produced. The third column specifies **the location** where the performance measure will be measured. For instance when dealing with flows, flows can be measured at Sugar Lake Dam, at Wilsey Dam, or at any other point of interest along the river.

The fourth column in the tables is the **Least Significant Difference** (LSD). LSD is the amount by which a performance measure must differ between two alternatives, for one alternative to be considered a significantly better performer than the other. A difference less than the LSD means the two alternatives perform equally on that objective. This measure of a significant difference was taken to be the largest of the following sources of uncertainty:

- Statistical variation arising from annual fluctuations in inflows;
- Modelling error in the generation of flows and elevations;
- Modelling error in the calculation of performance measures;
- Uncertainty in the link between the performance measure and the fundamental objective;[1] and

[1] This definition was presented at all of the sub-group meetings (fish, flood, and recreation). In her review of the FTC meeting notes of 9 October 2001, Heather Stalberg (DFO) noted that she does not think that this source of uncertainty should be applied to ecological measures.

- Measurement error.

As an example, the value of energy generated could have been calculated to the nearest penny. From a practical point of view, the BC Hydro representatives felt that differences of less than $5,000 were not significant to the overall goal of maximizing net revenues. However, professional judgement by the BC Hydro modellers suggested that differences of less than $20,000 were within the range of modelling error. As a result, $20,000 was selected as the least significant difference for the power revenue performance measure. Alternatives that generated revenues that were within this range of each other were considered to be tied on this performance measure.

The Consultative Committee directed studies to better understand the relationship between BC Hydro operations and effects on resource values. Study results also helped the Consultative Committee scope down to the issues which could be addressed through changes in operations. The studies also provided information to assist the Consultative Committee in establishing and calculating performance measures. A summary of documents produced during the Shuswap Water Use Plan process is provided in Appendix H. Where there was uncertainty whether or not an issue fell within the scope of water use planning, the Committee sought direction from the Water Use Plan Management Committee, the interagency committee overseeing the implementation of water use planning. A letter written in the fall of 2000 and its response is provided in Appendices I and J.

4.1 Overall Water Use Plan Objective

The Consultative Committee agreed that the overall objective of the Water Use Plan should be to **maximize the value of the Shuswap River system to the local community**. There was no performance measure developed for this objective because it was used as an overarching objective which could be met by achieving other objectives.

4.2 Power Generation

4.2.1 Issues - Generation and Net Revenues

Maximizing the financial value of power generation has implications for both the generation of power revenues and the avoidance of operating costs. The Consultative Committee dealt with these issues separately.

Power Revenues

The Shuswap facility historically generates 37 GWh annually providing electricity to the provincial grid system. The value of this electricity is approximately $1.6 million annually. The net value in any given year would depend on maintenance and operating costs in that year.

Operating Costs

As well as maximizing the value of power generation, concerns were also raised about avoiding large financial costs. Current operations are designed to avoid low and zero flows past Wilsey Dam during the winter months. The combination of near freezing water temperatures and low flows can precipitate the build up of frazil ice on the trash racks on the penstock intakes. If the intakes become blocked and the generators continue to operate, negative pressure in the penstocks can cause a penstock to collapse. Currently, BC Hydro maintains a minimum of ~15 m^3/s inflow into the Wilsey headpond during November to March. This flow is sufficient to prevent frazil ice build-up. At flows below ~15 m^3/s (~530 cubic feet per second), the intake gates are closed and generation curtailed to protect the penstock. Damage caused by frazil ice build-up can be very costly and the Consultative Committee was interested in avoiding such situations.

4.2.2 Objectives and Performance Measures - Net Power Revenues

The Consultative Committee specified two power-related objectives with the corresponding performance measures. The power objectives and performance measures are outlined in Table 4-1. For a description of how power performance measures were calculated see the *BC Hydro Shuswap River Water Use Plan Hydro Operation Studies Report*.

Table 4-1 Power Objectives and Performance Measures

Objectives	Performance Measures	Location	Least Significant Difference
Maximize the value of power generated by the Shuswap facilities	Power Generation measured as $	Wilsey Dam powerhouse	Based on modelling error, measures that are within $20,000 of each other are tied.
Avoid costly damage to penstocks caused by frazil ice build-up on intakes	Number of years in which inflows do not drop below ~15 m^3/s (~530 cfs), 1 Nov to 1 Mar	Wilsey Dam	Based on difference between Historical and Status Quo operations, measures that are closer than 6 units are tied.

4.2.3 Studies - Power

A key precursor to calculating performance measures for power and other interests was data on inflows into the reservoir. BC Hydro Resource Management estimated inflows into the system from records on reservoir elevations and discharges from Sugar Lake Dam, and the 2 Water Survey of Canada (WSC) gauges downstream of Sugar Lake Dam. This process recreated 27 years of inflow data for modelling the outcome of various Water Use Plan alternatives. The details around the compilation of the inflow data set can be found in Appendix K. A description of the power modelling can be found in the *BC Hydro Shuswap River Water Use Plan Hydro Operation Studies Report*.

4.3 Dam Safety

4.3.1 Issues - Dam Safety

Dam safety relates to the structural integrity of Sugar Lake and Wilsey dams. Members of the Consultative Committee living downstream of the dam were very interested in this topic, and there was unanimous consent within the Consultative Committee that no operations should be considered that violated provincial standards and BC Hydro's dam safety guidelines.

There were no dam safety concerns raised around the way in which water was routed at Wilsey Dam. However, Consultative Committee members living along the Shuswap River took special interest in operations at Sugar Lake Dam during the freshet.

The number and timing of stoplog placement during the year is guided by a specific dam safety protocol. The exact description of the stoplog placement schedule can be found in Appendix A and is subject to change due to changing standards and guidelines. In brief, a maximum of two stoplogs can be installed before spring freshet has passed. Once freshest flows have passed, up to six stoplogs can be installed following the schedule in the operating orders. Installing six stoplogs increases the height of Sugar Lake Dam to 601.72 m from 600.00 m and increases storage capacity.

To ensure that the protocols around dam safety were adhered to, the Consultative Committee requested that each alternative be assessed as to whether or not it met the dam safety guidelines.

4.3.2 Objectives and Performance Measures - Dam Safety

The objective for dam safety was to ensure Sugar Lake and Wilsey dams **meet or exceed industry and provincial dam safety standards** (Table 4-2).

Table 4-2 Dam Safety Objectives and Performance Measures

Objectives	Performance Measures	Location	Least Significant Difference
Meet or exceed industry and provincial dam safety standards for Sugar Lake and Wilsey Dams	Yes or No	Both Sugar Lake Dam and Wilsey Dam	Yes versus No are significantly different

The Consultative Committee initially stated other objectives related to dam safety, however, these objectives were not used to distinguish between Water Use Plan alternatives. In order not to lose these concerns, they are presented in this report in Section 4.9.

4.4 Flooding and Erosion

Consultative Committee members identified concerns about property flooding and erosion along two parts of the Shuswap system: the shoreline of Sugar Lake Reservoir and on the Shuswap River flood plain. The two parts are treated separately here.

4.4.1 Issues - Reservoir Flooding and Erosion

Properties around the reservoir shoreline are susceptible to erosion and flood damage when the reservoir is at full pool (601.72 m). Heavy precipitation or snowmelt can surcharge the reservoir raising water levels above 601.72 m and aggravate shoreline erosion. Also, strong winds and wave action can raise local reservoir elevations increasing the risk of flooding and erosion of roads, property, and the shoreline.

Reservoir elevations are controlled by placement of stoplogs and by releasing water through gates at Sugar Lake Dam. Property owners around the reservoir noticed that the incidence of flooding and shoreline erosion is reduced when the reservoir is maintained at 601.52 m or lower (5 Stoplogs) as it was in the years 2000 and 2001 for a dam safety upgrade.

4.4.2 Objectives and Performance Measures - Reservoir Flooding and Erosion

Members of the Flooding and Erosion subcommittee considered numerous approaches for performance measures for flooding around the reservoir. They noted that with the reservoir at full pool (601.72 m) flooding and erosion was exacerbated by heavy inflows surcharging the reservoir and by high winds that locally increased water levels. However, they also observed that since recent operations (during the dam safety upgrade) when the reservoir was kept at 601.52 m, erosion and flooding was reduced. Thus the elevation of 601.52 m was selected as a threshold, below which flooding and erosion around the reservoir was not considered an issue. A summary of the objectives and performance measures for reservoir flooding and erosion is provided in Table 4-3.

Table 4-3 Reservoir Flooding and Erosion Objectives and Performance Measures

Objectives	Performance Measures	Location	Least Significant Difference
Reservoir			
Minimize negative effects of flooding on property (around the reservoir)	Number of days reservoir elevation is at or below 601.52 m	Sugar Lake Reservoir	Based on statistical significance, measures that are 7 days apart or less are to be considered tied.
Minimize the negative effects of erosion on reservoir shoreline	Number of days reservoir elevation is at or below 601.52 m	See above	See above

1. Modelling does not take into account surcharging (going above 601.72 m)

4.4.3 Issues - River Flooding and Erosion

Flooding is a major concern for individuals with property along the flood plain of the Shuswap River. Specific areas of concern for flooding and erosion include:

- The area west of Cherry Creek and where the river enters a narrow canyon 3 km upstream of Wilsey Dam.
- Mabel Lake community from north of Bessette Creek to Mabel Lake.
- The community of Mara, between Enderby and Mara Lake.

The flood plain area between Cherry Creek and Wilsey Dam supports agricultural activities with one farm and a golf course. From Wilsey Dam to Mabel Lake there are approximately 22 farms, and there are numerous homes and farms along the river from Mabel Lake to Mara Lake. These farms support livestock and crop production, and farmers face large monetary losses because of flooding from relocating animals and from degradation or loss of hay, corn, and other crops. Bank erosion causes loss of farmland. A published peer reviewed paper was submitted to the sub-committee documenting more severe erosion where riparian vegetation has been reduced or eliminated. When high flows cut new channels, areas of farmland become isolated and inaccessible.

Flooding is not an issue every year. The flood subcommittee estimated that flooding starts to occur when flows past Wilsey Dam reach 232 m^3/s. Mean peak freshet flows are about 199 m^3/s. Over the 27-year data set of historical flows, peak flows higher than 232 m^3/s occurred in only 6 years, for a total of 59 days. However, high flows can be damaging and flows of 375 m^3/s at Wilsey Dam are recorded in this data set.

4.4.4 Objectives and Performance Measures - River Flooding and Erosion

The objective for river flooding and erosion was to **maximize the number of flood-free days**. A number of flooding performance measures were considered, based on frequency of flood events, magnitude of peak flows, and duration of flood events. However, a reliable flood performance measure for the river was difficult to develop. The subcommittee finally agreed that the most appropriate performance measure was the **number of days flows at Wilsey Dam remained below 232 m^3/s**. Since flooding does not occur every year, averaging across years washed out large differences. As a result, this performance measure is a total across the 27-year data set.

This benchmark of 232 m^3/s reflects the Shuswap River staying within its banks as measured at the Trickett Farm west of Cherry Creek. It is assumed that any improvements to flood control for properties upstream of Mabel Lake would also benefit properties below Mabel Lake to Mara Lake. A summary of the objectives and performance measures is provided in Table 4-4.

Table 4-4 River Flooding and Erosion Control Objectives and Performance Measures

Objectives	Performance Measures	Location	Least Significant Difference
Maximize the number of flood-free days	Number of days that flows over the 27-year data set are less than 232 m^3/s downstream of Wilsey Dam.	Total discharge past Wilsey Dam	Based on estimates of modelling error, any measures that differ by 15 days or less are tied.

4.5 Recreation

Recreation interests in water use planning process focus on those activities that could be affected by BC Hydro operations. Recreation interests in the Shuswap River system are centred around three areas:

- Perimeter of Sugar Lake Reservoir
- Perimeter Mabel Lake
- Shuswap River

The overall recreation objective was to **maximize recreation opportunities.**

4.5.1 Issues - Sugar Lake Reservoir Recreation

Sugar Lake Reservoir is an important recreation area in the north Okanagan Valley. Around the reservoir there are five Ministry of Forests Recreation Sites[1], including campsites on east shore at Kate Creek, west shore at 1.61 km, 3.22 km, 4.83 km, and 5.63 km on Sugar Lake Forest Service Road, two private resorts, and one commercial resort and lodge.

Recreation occurs year round with peak use occurring from May to Labour Day. Activities include boating, fishing, swimming, camping, and sight seeing. Throughout winter, a small number of people ice fish.

Reservoir levels impact recreational values by affecting:

- Visual aesthetics by the amount of visible drawdown zone (higher reservoir elevations are preferred)
- Boating safety by the amount of woody debris refloated from the shoreline (less than full pool elevations are preferred to avoid refloating shoreline debris or creating new debris through eroding the base of trees by the shore)
- Ability of visitors to launch and take out boats (at 600.61 m boaters can use trailers to launch and take out boats at the resort site)

[1] The future of these sites is uncertain as the Ministry of Forests is withdrawing from providing recreational services.

- Property owners' use of docks (higher elevations preferred)
- Usable area of beach (full pool, 601.72 m, covers much of the usable beach)

4.5.2 Objectives and Performance Measures - Reservoir Recreation

The Consultative Committee recommended that a target reservoir elevation between 600.61 m and 601.22 m would balance between the reservoir recreation interests. This elevation is sufficiently high to submerge most of the drawdown zone, to allow boaters to launch and take out boats (above 600.61 m), and to allow use of floating docks. At the same time, the target elevations would reveal a usable amount of beach and minimize refloating shoreline debris. A summary of the objectives and performance measures is provided in Table 4-5.

Table 4-5 Reservoir Recreation Objectives and Performance Measures

Objectives	Performance Measures	Location	Least Significant Difference
Maximize the recreation experience of the reservoir	Number of days elevation between 600.61 and 601.22 m between 15 June to mid-October	Elevation measured at Sugar Lake Dam	Based on statistical significance, measures that are within 13 days of each other are considered to be tied.

4.5.3 Issues - Mabel Lake Recreation

Mabel Lake is heavily used for recreation. There are year round and seasonal dwellings, commercial campgrounds, resorts, and a growing year round community at Kingfisher near the outlet of Mabel Lake. Mabel Lake Provincial Park is located on the southeast shore.

The Consultative Committee investigated the degree of impact BC Hydro operations has on Mabel Lake. About 52% of the mean annual discharge (MAD) to Mabel Lake are from the Mabel Lake watershed and 48% from the Shuswap River. By attenuating some of freshet flows in the Shuswap River, the presence of Sugar Lake Dam structure reduces peak Mabel Lake elevations in early summer by about 27 cm and operational changes have an even smaller impact (Appendix B). Hence, there is little opportunity for changes in BC Hydro operations to influence recreation values in Mabel Lake. As such, the Consultative Committee did not address recreational issues at Mabel Lake.[1]

[1] A note provided by Terri Deuling suggested that there is a direct correlation between Mabel Lake elevations and tourism activity on Mabel Lake. This note was presented to Basil Stumborg at a flood group meeting in March 2002, but not forwarded to the Consultative Committee. It is attached in Appendix L.

4.5.4 Issues - River Recreation

Recreation in the Middle Shuswap River includes viewing (aesthetics), paddle sports, drift boating, swimming, and fishing. Currently, with the exception of summer fishing, water recreational use is low as there is limited public access into and out of the middle Shuswap River. BC Hydro provides a picnic area on the Middle Shuswap and a viewing area at Shuswap Falls.

The Lower Shuswap, from Mabel Lake to Mara Lake is more heavily used for river recreation. Skookumchuck Narrows downstream of Mabel Lake is a popular kayaking area and site of an annual kayaking rodeo in June. Further downstream towards Enderby and Mara Lake, the river is popular for swimming, fishing, and power boating. However, since the control that BC Hydro has on the river below Mabel Lake is negligible, the Consultative Committee did not pursue issues arising from recreation below Mabel Lake.

The Consultative Committee focused on river recreation in the Middle Shuswap between Sugar Lake Dam and Mabel Lake where changes to operations would have the most effect. Peak use in the Middle Shuswap is during summer months with the paddle sport period extending from June to mid-October. The three key issues were:

- Sufficient water for paddle sports (kayaking) and drift boating in the Middle Shuswap
- Sufficient flows in the Wilsey spillway to deter sunbathers and swimmers (flows in the spillway can suddenly increase if the generation plant shuts down)
- Sufficient flow in the Wilsey spillway to create a visually pleasing waterfall scene (achieved along with swimmer deterrence flows in the spillway)

The main river recreation issues that changes to BC Hydro operations could address were paddle sports and swimmer safety/visual aesthetics in the Wilsey spillway.

4.5.5 Objectives and Performance Measures - River Recreation

The first of four river recreation objectives focuses on paddle sports such as kayaking and drift boating as the depth of water in the river limits these activities. Based on observations of field crews studying fish, a release of approximately 20 m^3/s from Sugar Lake Dam was sufficient to allow a small boat to float down the river between Sugar Lake Dam to Wilsey Dam. In October 2002, a drift boat "grounded out" on shallow riffles in 2 to 3 locations at 20 cms but the river was passable. Hence the performance measure was based on the **number of days between 1 June and 9 September (to include the Labour Day weekend) that discharge from Sugar Lake Dam was 20 m^3/s or greater**. The Consultative Committee did not specify a maximum desired discharge. Different recreationists will use the river at different times depending on flows and personal skill. Experienced white water paddlers will use the river during high flows. Families will paddle during low water, safer periods in late summer.

The second river recreation objective was to **maximize personal safety in the spillway area**. The performance measure was the **number of days in August that there was 3 m^3/s or greater flow down the Wilsey spillway**. This measure was based on professional judgement as to a level of flow that would make access to the lower pools difficult.

The third river recreation objective was to **maximize the aesthetic impact of the river**, particularly in the Shuswap Falls area. The performance measure was the same as for personal safety: number of days in August with spillway flows of 3 m^3/s or greater.

The fourth objective, **maximize the quality of the fishing experience**, is partly covered by fish objectives. The Consultative Committee agreed that the number and size of fish was part of the fishing experience, however the Consultative Committee decided that maximizing fish productivity would also benefit the fishing experience. The Consultative Committee agreed that fish performance measures would be a surrogate for a fishing experience performance measure. However, accessibility to the river for wading anglers is limited at higher flows, but is popular with boating anglers. A summary of the river recreation objectives and performance measures is presented in Table 4-6.

Table 4-6 River Recreation Objectives and Performance Measures

Objectives	Performance Measures	Location	Least Significant Difference
Maximize opportunities for paddle sports on river	Number of days summer flows ≥20 m^3/s between 1 June and 9 Sept (inclusive)	Discharge from Sugar Lake Dam	Based on statistical significance, any differences of 5 days or less are tied.
Maximize safety and the aesthetic experience in the spillway	Number of days flows in August are above 3 m^3/s	Wilsey Dam	Not discussed
Maximize quality of the fishing experience	Covered by managing for fish and fish habitat below		

4.6 First Nations Heritage and Archaeological Resources

4.6.1 Issues - First Nations Heritage and Archaeology

Historically and in recent time, First Nations people have used the area around Sugar Lake Reservoir and the Shuswap River. Potential uses included seasonal camps for fishing, hunting, and berry picking. In addition, the original lake where Sugar Lake Reservoir sits may have been a starting point for an aboriginal trail reported to head north up the Shuswap River and east over the Monashee Mountains. The Spallumcheen Band has an interest in both pursuing further archaeological investigations in the area as well as protecting sites from unauthorized collection of artifacts.

Spallumcheen Band investigations by an archaeology team in late May 2001 revealed several sites in the vicinity of the reservoir with numerous First Nations artifacts dating from pre-European contact. Some items date from 7000 years before present (Spallumcheen Band and D. French, 2001).

The Consultative Committee addressed three heritage archaeology issues at the reservoir:

- Protecting Aboriginal heritage from unauthorized collection of artifacts
- Protecting soil layers from shoreline erosion (reduces ability to date artifacts from organic material in soil strata)
- Providing opportunity for archaeology study during low reservoir periods

4.6.2 Objectives and Performance Measures - First Nations Heritage and Archaeology

The Consultative Committee defined three objectives and accompanying performance measures (Table 4-7). The first objective, **maximize protection of archaeology resources from shoreline erosion,** sought to minimize disturbance of the substrates where artifacts can be found. An intact substrate provides historical context and possibilities for dating objects. The performance measure of **the number of days the reservoir elevation is below 601.22 m** followed from results of an archaeological survey around the reservoir.

The second objective was to **maximize protection of artifacts from unauthorized collectors.** The performance measure was **the number of days reservoir elevation is above 600.61 m between 15 June and 8 September.** This period reflects high summer use around the reservoir when more people are likely to find and remove artifacts.

The third objective was to **maximize opportunities for First Nations' study of reservoir archaeology sites.** Study opportunities are greatest when the reservoir is drawn down and the performance measure reflected the **number of years over the 27-year data set that the reservoir is below 598.59 m for 32 consecutive days**. The archaeologist recommended 32 days as the minimum period to carry out a meaningful archaeological investigation.

Table 4-7 First Nations Heritage and Archaeology Resources Objectives and Performance Measures

Objectives	Performance Measures	Location	Least Significant Difference
Maximize protection of archaeology resources from shoreline erosion	Number of days reservoir elevation below 601.22 m	Sugar Lake Reservoir	Based on statistical significance, any measure that differs by 7 days or less is tied.
Maximize protection of artifacts from unauthorized collectors	Number of days reservoir elevation is above 600.61 m between 15 June and 7 September	Sugar Lake Reservoir	Based on statistical significance, any measure that differs by 10 days or less is tied.
Maximize opportunities for First Nations study of reservoir archaeology sites	Number of years over the 27-year data set that the reservoir is below 598.59 m for 32 consecutive days	Sugar Lake Reservoir	None defined

4.6.3 Studies - First Nations Heritage and Archaeology

The Spallumcheen Band conducted a limited scale archaeological investigation of the drawdown zone of the reservoir in late May 2001. The investigation provided preliminary information on the location and nature of First Nations archaeology resources in the drawdown zone. The location of the sites in the drawdown zone helped establish the threshold elevations for the three archaeology performance measures above and guided development of the operating alternatives.

4.7 Wildlife and Wildlife Habitat

4.7.1 Issues - Wildlife and Wildlife Habitat

The riparian areas bordering lakes and rivers are important wildlife habitats. These riparian areas have a diversity of tree and plant species that offer cover, forage, and habitat for a wide range of species from mammals to amphibians. The BC Conservation database indicated the occurrence of several Red and Blue listed species in the Shuswap watershed, though the exact distribution of these species and plant communities is not known (Table 4-8). Some, such as the Western Grebe, are directly dependent on water bodies such as Sugar Lake Reservoir.

Approximately 40% of Shuswap River valley is cultivated and the remainder is a mixed second growth coniferous and deciduous riparian forest. There is a significant wetland area within the flood plain where the Middle Shuswap River joins the south end of Mabel Lake. Another area of interest for its significance to wildlife was the wetland meadows at the north end of Sugar Lake Reservoir that are inundated and dewatered annually.

Table 4-8 Species Observed in the Shuswap Water Use Plan Area (BC Conservation Data Centre)

	Amphibians	Reptiles	Birds	Mammals	Wetland Vegetation
Red-listed	None	Painted turtle, Rubber boa	Western grebe +5 other species not associated with water	None	Brown beak-rush, Giant Helleborine, Loesell's lipairs
Blue-listed	None	None	Blue heron +6 other species not associated with water	Grizzly bear, Townsend's big eared bat, caribou	None

BC Hydro operations may have an effect on the habitats of some of the species dependent on riparian and wetland areas around Sugar Lake Reservoir, Mabel Lake, or along the middle Shuswap River. Changes in river flows or elevations in the reservoir may impact food availability, cover, nest sites, and other critical aspects of habitat. However, given the small size of the reservoir in comparison to inflows, it was recognized early that the ability to affect wildlife through changes in operations was very limited.

4.7.2 Objectives and Performance Measures - Wildlife and Wildlife Habitat

The overall objective for wildlife was to **maintain biodiversity and ecological function in the Shuswap system**. In addition to this, an objective was established for wildlife around the reservoir and another for wildlife along the river (Table 4-9).

Riparian habitats are complex biological systems and it is difficult to quantify responses to changes in reservoir elevations and flows. The Consultative Committee's approach on a **wildlife performance measure** was to solicit a **professional wildlife biologist's qualitative opinion on the expected impact of Water Use Plan alternatives on wildlife habitat**. These opinions were originally offered for habitat around the reservoir and the river. However, the judgements regarding habitat around the river were very tentative and were dropped before the final round of trade-offs occurred (Round 3). This performance measure is not described below.

Note that some wildlife (such as otters, mink, osprey, etc.) depend on fish for food. The professional opinion of the wildlife biologist was that judgements regarding what is best for fish across both the reservoir and the river could serve as a proxy measure for benefits to wildlife dependent on fish for food. An overall scale measuring "what is good for fish" was developed by the Fish Technical Committee. This scale included both impacts on the river and the reservoir. A performance measure describing "what is good for wildlife that require fish for food" was based on this. A description of performance measures for fish is provided in Appendix M.

Table 4-9 Wildlife and Wildlife Habitat Objectives and Performance Measures

Objectives	Performance Measures	Location	Least Significant Difference
Overall			
Maintain biodiversity and ecological function in the Shuswap system	None, an overall objective		
Sugar Lake Reservoir			
Minimize negative impacts to wildlife around Sugar Lake Reservoir	Expert opinion on "Will this alternative have a significantly negative, positive or no impact on wildlife habitat around the reservoir"?	Professional opinion based on changes to Sugar Reservoir elevations	Performance measure formed by professional judgement, differences are significant where noted.
River			
Maximize benefits to wildlife dependent on fish for food	Based on index developed by Fish Technical Committee estimating what is best for fish.	Reservoir and river down to Mabel Lake	Performance measure formed by professional judgement, differences are significant where noted.

4.7.3 Studies - Wildlife and Wildlife Habitat

The wildlife consultant reviewed the literature on wildlife issues in the Water Use Plan project area and queried the BC Conservation Data Centre data base for Red- and Blue-listed species and habitats (Robertson Environmental Services, 2001). The wildlife review was conducted at an overview level. As such the performance measures were based on professional opinion of how wildlife would respond to operating alternatives. The Ministry of Water, Land and Air Protection have suggested that due to the high resource values present, more inventory work for this section of the basin would be beneficial.

4.8 Fish and Fish Habitat

While the Shuswap hydroelectric facilities generate a small amount of power relative to the total electricity generation in the province, the Shuswap River system contains an important fisheries resource. The attenuation of runoff and its gradual release over the winter months mean that BC Hydro operations have the potential to influence the early spring, late summer, fall and winter flows required for many aquatic species. Fish resources and interests are described here in two parts: fish in Sugar Lake Reservoir and fish in the Shuswap River (Sugar Dam to Mabel Lake). A summary of the fish resources in the reservoir and the river is provided in Appendices N and O.

4.8.1 Issues - Reservoir Fish

Of the species present in the reservoir, the Fish Technical Committee (FTC) focused on kokanee (*Oncorhynchus nerka*), rainbow trout (*O. mykiss*), and burbot (*Lota lota*) for the purposes of the Water Use Plan. These species are important to the reservoir sport fishery. Kokanee, in particular, are an important food source for rainbow trout and bull trout (*Salvelinus confluentus*). Little is known about the burbot population in Sugar Lake Reservoir. In addition to rainbow trout in the reservoir, there are reportedly surviving Gerrard rainbow trout from provincial lake stocking in the early 1990s. Whitefish and numerous other non-salmonid fish also inhabit the reservoir.

Past surveys for kokanee escapements[1] in the Middle Shuswap River for 5 years between 1991-2001 (Mabel Lake kokanee) ranged from 11 000 to 108 000 spawning adults. Escapement estimates for Kokanee were carried out in 1987 and 1999 and range from 5000 to 17 000 in the Upper Shuswap River and Sugar Lake Reservoir. The Upper Shuswap River from Sugar Lake Reservoir ranged from 5000 to 20 000 spawners. Year 2000 estimates were much lower at 4200 to 6400 in the Middle Shuswap and 1000 to 1500 in the Upper Shuswap. Meanwhile, year 2000 escapements in nearby systems such as the Eagle and the Lower Shuswap were at record numbers at 1 million spawners. The cause of the low escapements for the Middle and Upper Shuswap is unknown but posed a great concern to Consultative Committee members, and the potential for flow impacts and reservoir operations to affect kokanee abundance was recognized.

4.8.2 Objectives and Performance Measures - Reservoir Fish

The Consultative Committee focused on **maximizing littoral productivity** as a way of enhancing fish populations in the reservoir (Table 4-10). The littoral zone represents the shallow substrate of the reservoir extending to depth where sunlight can penetrate sufficiently to support photosynthesizing organisms. The Fish Technical Committee agreed that in Sugar Lake Reservoir, the littoral zone was an important component in primary productivity, a significant mechanism for nutrient cycling, and for providing habitat for aquatic life. The Consultative Committee's working assumption was that increasing littoral productivity would also enhance fish populations. Pelagic productivity may also play an important role in primary productivity and nutrient cycling, however, this was hypothesized to be secondary to littoral contributions in Sugar Lake Reservoir and not directly affected by operations.[2]

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[1] Escapement: the number of adult fish that escape the ocean, downstream, and in-river fisheries and return upstream to spawn.

[2] Indirect effects are possible, even likely, but were beyond the scope of the Water Use Plan and could not be altered to a large degree by operational changes.

In a reservoir, changes in water levels affect where the littoral zone can become established. Annual littoral production may be maximized when the reservoir is stable and the littoral ecology can develop in the same depth undisturbed year to year. When water levels fluctuate during reservoir operations, the ability for algae and associated aquatic communities to establish are limited by the duration that the zone is both wetted and receives sufficient sunlight. Both decreases in water levels (exposure and desiccation) and increases (too deep for light penetration) will limit littoral production. If the drawdown over the growing season exceeds the maximum depth of light penetration, no permanent littoral zone will be established.

The performance measure "**Effective Littoral Zone**" (ELZ) tracks the area and duration of suitable reservoir bottom that receives sunlight and is continuously wetted during the annual growing season (from late spring until fall). For details on the calculation of the ELZ performance measure see the *BC Hydro Shuswap River Water Use Plan Hydro Operation Studies Report* in Appendix M.

Table 4-10 Reservoir Fish Objectives and Performance Measures

Objectives	Performance Measures	Location	Least Significant Difference
Maximize productivity of littoral zone	Effective Littoral Zone (hectares)	Sugar Lake Reservoir	Based on discussions within the Fish Technical Committee (FTC), any measures that differ by 0.2 ha or less are tied.

4.8.3 Studies - Reservoir Fish

The first investigation involved remapping the reservoir basin to provide data for calculating the performance measure of effective littoral zone area. The new bathymetric map also provided a check on the relationship between reservoir elevation and reservoir storage (reservoir storage curve).

The second study addressed whether or not trout were able to access tributary streams to the reservoir for spawning. In May 2001, biologists from the Ministry of Environment, Lands, and Parks and the BC Conservation Foundation inspected tributaries for spawner access. The crews also assessed the potential that rainbow trout redds would be inundated after spawning as the reservoir rose to full elevation. The outcome was that under current operations for the 2001 survey, the reservoir was expected to be high enough in late May for spawning trout to move into the tributaries and that reservoir operations would not unduely inundate these spawning areas. The Fish Technical Committee did not pursue the topic of tributary access any further.

4.8.4 Issues - River Fish

Interest in riverine fish extended from Sugar Lake Dam to Mara Lake. However, recognizing the limited impact and control BC Hydro operations have on river flows below Mabel Lake, the Consultative Committee focused on habitat in the Middle Shuswap, Figure 4-1, between Sugar Lake Dam and Mabel Lake. Changes to operations benefiting fish in the Middle Shuswap were assumed to also benefit fish in the Lower Shuswap below Mabel Lake. Key indicator species for the Middle Shuswap River include chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), kokanee (*O. nerka*), and rainbow trout (*O. mykiss*).

Anadromous fish have access to the Middle Shuswap as far upstream as Wilsey Dam. Chinook salmon form an important part of the fishery resource. The area from Wilsey down to Mabel Lake typically has between 3500-4000 chinook spawners annually, which support a local sport fishery and First Nation uses. But while the chinook population has been increasing in the river below Mabel Lake, the number for the Middle Shuswap has been constant in the recent past. This lack of improvement in numbers made chinook a primary species of concern for the Consultative Committee. The Consultative Committee was also concerned about coho salmon. Annual returns are about 200 to 250 per year and therefore represent a conservation concern.

Other species of concern included Mabel Lake kokanee, for reasons listed in the previous section, and rainbow trout. The Consultative Committee thought that the rainbow trout populations would not be as sensitive to operations as the other species listed due to timing of spawning and rearing relative to freshet flows. However, the Consultative Committee was interested in knowing that any changes to operations would not adversely affect rainbow trout populations.

BC Hydro has negligible influence over river flows during freshet (mid-April to mid-June) and has only limited control over daily flows as freshet recedes (mid-June to August). Outside of freshet, BC Hydro has relatively more control over the rates of stage change in the river (i.e. ramping rates). The partial retention of runoff, and its gradual release until the next spring allows BC Hydro operations to influence the spawning and incubation of salmon and lifestages of other fish during the fall and winter months. Assessing different flows during salmon spawning, incubation, and rearing formed the major source of inquiry during this Water Use Plan. While outside the scope of Water Use Plans, other significant influences on anadromous and resident fish include active hatchery management for chinook and coho below Wilsey Dam and the construction and maintenance of spawning and rearing side channels in the river between Wilsey Dam and Mabel Lake.

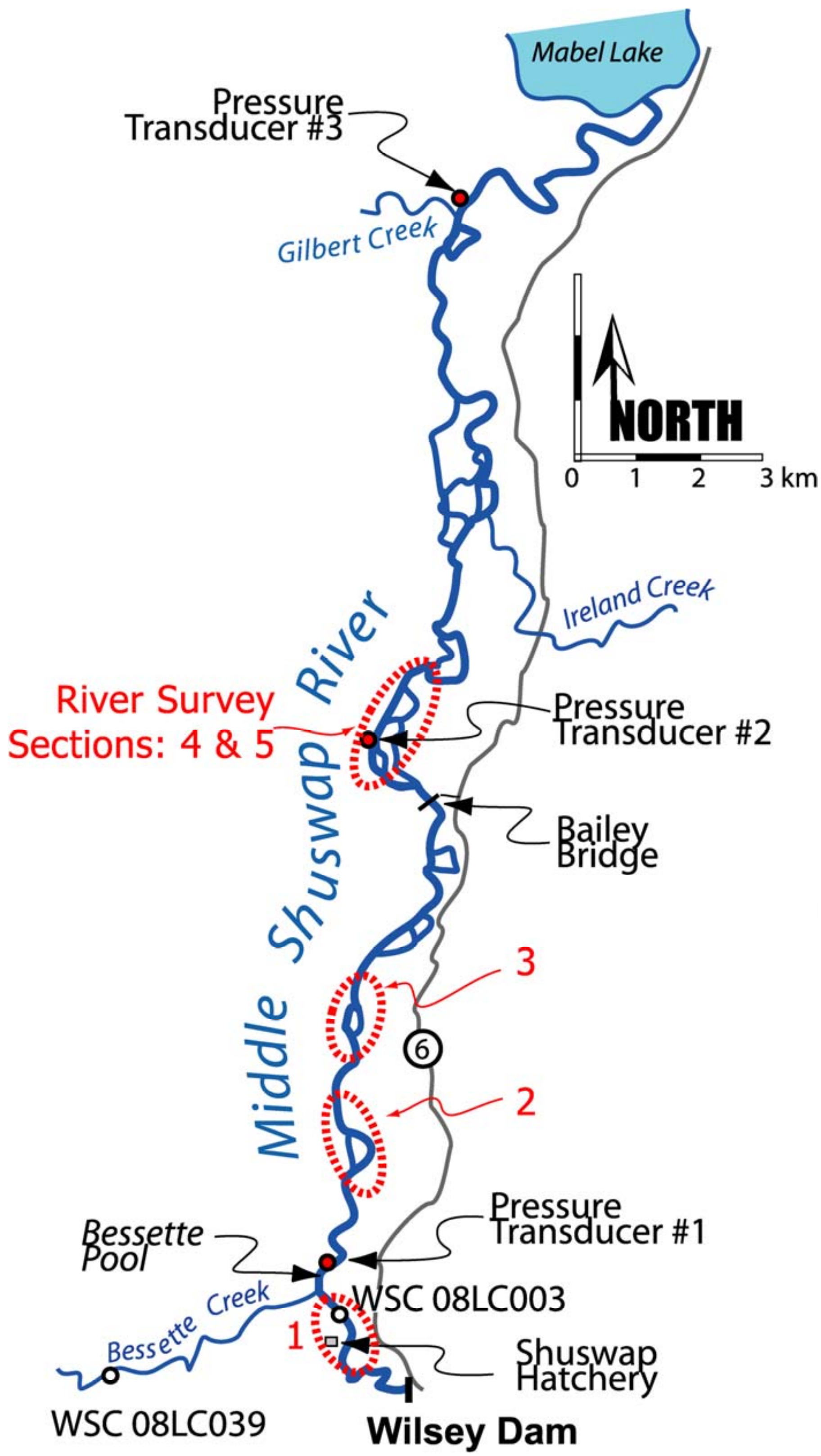

Figure 4-1 Map of Middle Shuswap

A final topic that the Consultative Committee examined in depth was the impact of sudden flow disruptions arising from unplanned outages at Wilsey Dam. Disruptions to power generation arising either at the plant itself or external disruptions in distribution system may trip off one or both generators. This temporarily disrupts the discharge below the Wilsey powerhouse and flows may take between 5 minutes to 1½ hours to be fully restored in the river below via spilling. Implications of the flow disruption include displacement and mortality for downstream aquatic life. However, the extent of impact and the species affected are highly dependent on the seasonal timing, the magnitude, and the duration of the flow disruption. Previous attempts to mitigate this through the installation of a bypass valve have only been partially successful and flow outages remained a specific concern for the Department of Fisheries and Oceans Canada. The Fish Technical Committee and the Consultative Committee explored at length ways in which changing the routing of water at Wilsey Dam could address this concern.

4.8.5 Objectives and Performance Measures - River Fish

The Fish Technical Committee developed four river-fish objectives and performance measures. All the performance measures focussed on the three fish species: coho, chinook, and kokanee. The first objective was to **maximize area of effective spawning habitat for the three species.** The Consultative Committee deemed these species the most susceptible to BC Hydro's operations. Given the different spawning needs (kokanee spawn in shallow margins of the river, coho at medium depths and velocities, and chinook in the mid-channel) and life history timing, these species would act as indicators for all fish in the system. This performance measure for this objective is a function of spawning habitat and successful incubation, both described below. Details regarding the calculation of this performance measure can be found in the *Shuswap Water Use Plan Performance Measure Summary* in Appendix M**.**

4.8.5.1 Spawning Habitat and Early Lifestage Survival

In the fall (mid-September to early December), salmon returning to the Shuswap River spawn in various areas as far upstream as Wilsey Dam. River discharge and the river substrate are important determinants of the quantity and quality of spawning habitat. At low flows, the width of the wetted channel is low and the available habitat with suitable water depth, velocity, and substrate (bottom composition) may be physically limited. Habitat modelling showed that spawning area does not increase linearly with increasing flows. Increasing flows from a low flow condition generally increases spawnable habitat, but these relationships peak and may decrease with increasing flows. At high flows, available spawning habitat tends to be low since fish that could spawn in the main channel substrate are now confined to the river margins with more suitable depth and velocity criteria. It should be noted, however, that these relations are highly site specific and vary significantly depending on which species are being investigated. Modelling also showed that maximum spawning habitat occurs at different flows for the five different sections sampled between Wilsey Dam and Mabel Lake. In addition, different species have different flow, depth, and substrate requirements.

Following spawning, the eggs/alevins in the redds must remain continuously wetted during the winter to ensure survival until emergence in the spring. Based on direct field observations and a literature review, the Fish Technical Committee, as a conservative measure, estimated that eggs required a minimum of 8.0 cm depth (measured relative to the river bed) to ensure successful incubation (a function of oxygen levels, temperature, and flows). The Consultative Committee recognized that the small storage capacity of the reservoir and the uncertainty of inflows through fall and winter would limit the available water to guarantee the survival of all the incubating eggs that were spawned in the fall. Consequently, there is a fundamental trade-off between providing high flows of water during the fall spawning season and retaining sufficient water to ensure continuous overwintering flows for the eggs in the redds.[1]

The Fish Technical Committee developed two performance measures to compare alternatives based on spawning success. These are described below. The actual scores for these performance measures were calculated using a method that incorporated river section surveys, estimated parameters describing fish spawning and incubation, preferences, and computer models for 2D flow dynamics in the river, and a model to post process incubation success. Further descriptions and details of the calculations can be found in the *Shuswap Water Use Plan Performance Measure Summary* in Appendix M.

Effective spawning performance measure

The first spawning performance measure of **hectares of effective spawning habitat** combined available habitat area during the spawning period along with the spawning area that remained wetted (to at least 8.0 cm depth) until fry emergence in the spring for each of the three species of interest. Areas were calculated in five representative reaches (Figure 4-1) and extrapolated over the river length to provide actual area estimates between Wilsey Dam and the Bailey bridge in the Middle Shuswap.

[1] Upon review of the draft Consultative Committee Report, Al Caverly (WLAP) asked for the following to be added: "Two situations developed in the winter/early spring of 2001. In the first situation, in February, declining flows and cold temperatures in February, caused some redd sites to freeze, even though they were still covered by shallow water. Many dead eggs were found. In the second situation, in late March/early April of 2001, when storage was almost exhausted, sustainable flows dropped to a level that left some spawning habitat sections uncovered by water. Mortality of the emerging alevins occurred. These two situations illustrate the validity behind the assumptions in the spawning and survival performance measures. The dead eggs/alevins examples refer to kokanee and chinook.

Per cent survival performance measure

The arrival of spawners is followed by a peak spawning period. Subsequently, while providing large areas of spawning is important for maximizing the quantity and quality of fish habitat, it is also important to provide this habitat at the correct time to coincide with the peak activity of spawners. The Fish Technical Committee used local knowledge and existing agency databases to document when the three species of interest (chinook, coho, and kokanee) arrive for spawning and the timing when the arrivals peak. For each day during the spawning period, the fraction of habitat that remained wetted during incubation was calculated and weighted by the number of spawners modelled to arrive on that day. The sum of the weighted fraction allowed calculation of a second spawning performance measure of **per cent survival of redds** based on redds that are effectively wetted during incubation. Table 4-11 provides a summary of the spawning habitat and egg survival objectives and performance measures.

Table 4-11 Fish Spawning and Egg Survival Objectives and Performance Measures

Objectives	Performance Measures	Location	Least Significant Difference
Maximize area of spawning habitat	Hectares of effective spawning habitat (habitat that provided suitable spawning and remained wetted until the spring)	Measured in five representative spawning areas between Mabel Lake and Wilsey Dam	Based on analyses of statistical significance, scores that are greater than what is listed below are considered to be different: Chinook - 1 ha Coho - 3 ha Kokanee - 0.3 ha
Maximize % survival of redds	% survival of redds	Measured in five critical areas between Mabel Lake and Wilsey Dam	Based on analyses of statistical significance, scores that are greater than what is listed below are considered to be different: Chinook - 2% Coho - 8% Kokanee - 10%

4.8.5.2 Rearing Habitat

The second river-fish objective was to **maximize available rearing habitat** for rainbow trout. Rainbow trout rear in the Middle Shuswap River from Sugar Lake Dam to Mabel Lake. Their spawning locations are unknown at present, but this lifestage coincides with increasing flows in the spring and are not susceptible to flow fluctuations arising from BC Hydro operations. The Fish Technical Committee and the Spallumcheen Band were interested in the impact of alternative operations on rainbow trout.

Using methods developed at other Water Use Plans (e.g. Cheakamus Water Use Plan), the Fish Technical Committee and the BC Hydro project team used the physical habitat model (River 2D) to estimate the impacts of flow alternatives on available rearing habitat for rainbow trout in the fall. The performance measure was expressed in **hectares (ha) of rainbow trout rearing habitat** (Table 4-12). The modelling was based on a surveyed river section immediately below Wilsey Dam (Figure 4-1). However, the Fish Technical Committee agreed the habitat in that section represented a significant portion of river above Wilsey Dam (about 50% of the habitat area).

Table 4-12 Rearing Habitat Objectives and Performance Measures

Objectives	Performance Measures	Location	Least Significant Difference
Maximize available rearing habitat	Area of rearing habitat (ha) (August to September)	Below Wilsey Dam (but performance measure primarily used to evaluate effects in confined sections of the river length above Wilsey Dam)	Based on an estimate of practical significance measures that are within 0.5 ha are considered tied.

4.8.5.3 Shape of the Hydrograph

The performance measures for fish in the river, outlined above, track the estimated impact of river flows for the objectives of spawning, incubation, and rearing. These models rely on measures of river depth, velocity and substrate in various reaches. Based on these measures, the Fish Technical Committee developed estimates of how combinations of depth, velocity and substrate would be needed for each species to spawn and incubate successfully.

While the depth, velocity, and substrate may be the most important, measurable determinants of fish habitat, fish respond to a wide variety of environmental indicators not taken into account in this model. A partial list might include temperature, increase in flow, and decrease in flow, to name a few. An important consideration for some members of the Consultative Committee was that this broad set of cues for fish in the river remain as close as possible to what fish would experience under "natural" conditions.

To guard against choosing an alternative that scored high on the above fish performance measures, but that was poor for fish for other reasons, the fish sub-group developed a "Shape of the Hydrograph" performance measure (Table 4-13). This qualitative, binary (0,1) performance measure looks at the shape of the hydrograph to determine whether each alternative poses risks to fish productivity that would not be picked up by the spawning, incubation, and rearing performance measures. These risks include departures from flows that have a single peak in freshet and/or running out of stored water in the late winter.

Table 4-13 Shape of the Hydrograph Objectives and Performance Measures

Objectives	Performance Measures	Location	Least Significant Difference
Avoid large deviations from an idealized hydrograph	0 for a poor shape 1 for a good shape	Measured below Wilsey Dam, but assumed to apply from Sugar Dam to Mabel Lake	Qualitative assessment placed alternatives into distinct categories

Characteristics of Hydrographs Scoring "0"

- Frequent and highly variable flow changes (e.g. short-term releases of extreme high flows in late winter, short-term extreme reductions of flows in the fall during spawning), incubation flows either unnaturally (extremely) higher or lower than spawning flows and/or frequently ran out of stored water in the spring.

Characteristics of Hydrographs Scoring "1"

- Any alternative that does not score a "0."
- Naturalized hydrograph shape (e.g. one major spring peak reducing trend through the fall to relatively stable overwinter flows). Does not run out of stored water frequently in the spring.[1,2,3]

[1] The fish sub-group recognized that running out of stored water, even once, could potentially have large negative consequences for fish downstream. However, for the purpose of this exercise, it may be that an alternative that runs out of water once or twice over twenty seven years still scores "1" on this measure.

[2] Darren Sherbot (BC Hydro) also noted that natural (i.e. unregulated) inflows have 'frequent and highly variable' flow changes and would not have been considered as a 'good' hydrograph under this scoring system.

[3] Heather Stalberg noted that the Wilsey Dam prevented fish migration into historical habitats, justifying attempts to create a better than natural hydrograph.

4.8.5.4 Minimize Adverse Impacts of Unplanned Flow Disruptions on Fish

On hydroelectric systems, unplanned external events (e.g. downed distribution line) and/or internal factors (e.g. frazil ice, human error, unanticipated events etc.) may cause a plant outage (or a "tripping event"). On the Shuswap River system, an outage may result in a sudden decrease in flow below Wilsey Dam when the electrical generators trip off and temporarily suspend flow through one or both penstocks. This causes an instantaneous loss of flow proportional to the amount no longer flowing through the penstocks (0-31.6 m^3/s). The frequency, timing and duration of such events influence the overall fish and habitat productivity. While a bypass valve has been installed on the Unit 2 penstock to prevent flow disruptions below 19.2 m^3/s, an outage may still cause impacts if the bypass valve is disabled, if the valve fails, and/or if the interrupted flow during an outage exceeds the capacity of the valve (19.2-31.6 m^3/s). Flow disruptions when the bypass valve operates and flows through the powerhouse are less than 19.2 m^3/s create no downstream flow impacts. When flows are at their maximum (31.6 m^3/s) and the bypass valve fails, downstream flows may require up to 1½ hours to be fully restored from spilling at Wilsey headpond alone.

Flow disruptions associated with an outage are greatest immediately below Wilsey Dam (estimated at about 50 cm in a worst case scenario) and are diminished in magnitude by the time the river reaches the Bailey bridge at Bigg Creek confluence (a section of the river, ~8 km below Wilsey Dam). Even if the bypass valve fails, stage changes at the Bailey bridge and below during a tripping event are less than ~3 cm.

The habitat between the Bailey bridge and Wilsey Dam experience high densities of spawning chinook, and is also used for spawning by coho, kokanee, and mountain whitefish. Coho and rainbow trout also have significant rearing life histories in this section of the Middle Shuswap River. Flow disruptions, if occurring during a critical lifestage, could have significant effects on the incubating population, rearing or overwintering fish.

BC Hydro has made progress in the last few years by reducing the major causes of outages, including improving bypass valve operation to route water around Unit 2 in the event flows through the turbine are stopped. Data from the revised operations suggest that unplanned outages will still cause major flow disruptions (where the flow through the generators is disrupted and the bypass valve fails) twice per year (post 1999 observed operations), and minor flow disruptions (where flow through the generators is disrupted and the bypass valve works) three times every 2 years. This represents a two-fold improvement from operations prior to 1999 where major flow disruptions from outages were observed four times a year. Operational improvements will continue to reduce both the frequency and magnitude of unplanned outages and the successful operation of the bypass valve. It is expected that the frequency of outages that cause flow disruptions will continue to decrease, but not be eliminated.

The rate of flow and stage change associated with a sudden decrease in flow from an outage is unnatural. Rapid changes in stage can cause mortality to juvenile and adult fish through stranding. Juvenile fish such as coho and rainbow trout that rear in the margins of the river are particularly susceptible. Impacts are also expected to be large when the relatively immobile alevins are exposed to air and/or freezing temperatures. For adult fish, marginal spawning species such as coho and kokanee are the most susceptible. What remains unknown, however, are the net impacts to river productivity. Measures of instantaneous impact remain unknown and difficult to study. Also the link between the magnitude of the flow change and the role of cumulative, long-term impacts on overall fish productivity is unknown. Moreover, given the brief duration of these events and their remote location, these events are difficult to assess when they happen. To date, the only data on the impacts of these events have been gathered by chance as researchers on other projects noted dramatic stage changes on the river and the associated impact to fish, as described above.

The Fish Technical Committee considered three separate approaches to calculating performance measures for this issue. One approach considered was the creation of a series of planned tripping events where actual biological impacts could be tied to flow changes under various background conditions and at various times of the year. Given the number of combinations of season and background flows, even several planned outages would only have given a partial picture of the link between flow changes and biological impacts; in a fish sub-group meeting, Heather Stalberg (DFO) said that potential risk of killing fish for such a study would not be authorized.

A second approach explored was to use quantified professional judgement. To effect an impact three conditional events must occur: an outage, a bypass valve failure, and failure timing that coincides with a susceptible aquatic lifestage. In formulating this method, various failure scenarios, their probabilities, and their estimated biological impacts were put into a fault tree to calculate the expected outcome of an outage. The fish agencies within the Fish Technical Committee (DFO and WLAP) were critical of this attempt at quantification, and so this line of inquiry was dropped.

The approach selected was to use qualitative professional judgement where a single, representative example of a flow disruption is used to illustrate impacts and the performance of different alternatives. The performance measures were then based on this single, illustrative flow disruption.

Table 4-14 Generation Tripping and Flow Interruptions Objectives and Performance Measures[1]

Objectives	**Performance Measures**	**Location**	**Least Significant Difference**
Minimize the impacts of Wilsey Dam tripping events on fish	Frequency of dewatering events arising from joint occurrence of an outage and a bypass valve (BPV) failure	Wilsey Dam and the Bailey bridge	Not discussed. Estimates based on recent historical records.
Minimize the impacts of Wilsey Dam tripping events on fish	Estimated typical stage change at WSC gauge during an outage when BPV fails	Wilsey Dam and Bailey bridge	Not discussed
Minimize the impacts of Wilsey Dam tripping events on fish	Estimated duration of stage change during an outage when the bypass valve fails	Below Wilsey Dam to Mabel Lake	Not discussed
Minimize the impacts of Wilsey Dam tripping events on eggs in the gravel	Estimated impact of flow disruption on eggs in gravel	Below Wilsey Dam to Mabel Lake	These qualitative measures are essentially for ranking information. No judgements about magnitude are possible.
Minimize the impacts of Wilsey Dam flow disruptions on alevins	Estimated impact of flow disruption on alevins	Below Wilsey Dam to Mabel Lake	These qualitative measures are essentially for ranking information. No judgements about magnitude are possible.
Minimize the impacts of Wilsey Dam flow disruptions on juvenile fish	Estimated impact of flow disruptions on juvenile fish	Below Wilsey Dam to Mabel Lake	These qualitative measures are essentially for ranking information. No judgements about magnitude are possible.
Minimize the impacts of Wilsey Dam flow disruptions on adult fish	Estimated impact of flow disruptions on adult fish	Below Wilsey Dam to Mabel Lake	These qualitative measures are essentially for ranking information. No judgements about magnitude are possible.

[1] These descriptions were derived from the consequence Table used for comparing operating alternatives at Wilsey Dam. The final minutes from FTC meetings in December 2001 and February 2002, and the Consultative Committee meeting of February 2002 have these measures identified as performance measures and record conversations around the meaning of these performance measures. In her review of the draft Consultative Committee report, Heather Stalberg (DFO) wrote that Table 4-14 "does not accurately represent our discussions as we didn't set performance measures for tripping. This should be deleted." In his review of the Consultative Committee report, Al Caverly (WLAP) also did not interpret these as performance measures when they were presented to the Consultative Committee. Darren Sherbot (BC Hydro) also maintains that without links between biological impacts and flow disruptions, the only useful performance measure would be an assessment of event occurrence using a fault tree analysis.

The performance measures used to compare alternative ways of routing water are described in Table 4-14. It was assumed that these impacts are independent of the operations chosen for Sugar Lake Reservoir, and so can be studied in isolation. The biological impacts are complex and can vary across season, temperature, and flow in the river. Moreover, these have not been studied to date. Consequently, performance measures associated with biological impacts are estimates based on professional opinion of what would happen in a "typical situation".

As additional information for the Consultative Committee, Heather Stalberg (DFO) provided anecdotal evidence around the impacts of sudden stage changes on the river based on experience by consultants who were working on the river when flows dropped suddenly (Appendix P). A summary of this evidence was provided to the Consultative Committee for the February 2002 Consultative Committee meeting and can be found in Appendix Q.

4.8.6 Studies - River Fish

The Fish Technical Committee collected information on fish in the river and the relationship between flows and fish habitat for the Consultative Committee. Some of the information was based on existing literature, past Shuswap River studies and new field studies. This information helped identify which species and lifestages were most at risk from operations. Study results on the expected response of fish habitat to different flows were used in environmental modelling to calculate fish performance measures. Study findings also guided the Consultative Committee on specifying flow regimes beneficial to fish. The fish related studies are summarized in Table 4-15 with a description of how the information was used in the Water Use Plan.

Table 4-15 Summary of Studies on Fish and Fish Habitat in the River

Study	Information Collected	Application of Information
1. Life history stages for fish in the Shuswap River	▪ Life history stages and timing for indicator species in the Shuswap system summarized from agency databases, local knowledge, and a field study into a periodicity chart.	▪ Identified times of year when changes to operations could avoid impacts and even improve fish habitat. ▪ Timing of life history stages used in calculating fish habitat performance measures.
2. Spawner distribution and habitat preference	▪ Map of spawner distribution. ▪ Estimated escapement levels. ▪ Measured flows at redds during spawning and depth of redd base and crests.	▪ Spawner information used in modelling fish habitat performance measures based on velocity, depth, and substrate preferences.

Table 4-15 Summary of Studies on Fish and Fish Habitat in the River - Cont'd

Study	Information Collected	Application of Information
3. Instream flow data at five transects between Wilsey Dam and Mabel Lake	▪ Survey four representative salmon spawning habitats between Wilsey Dam and Mabel Lake. ▪ Collect instream flow and substrate information as input to fish habitat models to calculate performance measures for effective spawning area and percent survival. ▪ Compared distribution of habitats surveyed in 1986, 1991, 1993, and 1994 prior to 1997 high flows.	▪ Instream flow data guided development of alternatives to maximize fish habitat. ▪ Instream flow data used in modelling fish habitat performance measures.
4. Water level monitoring	▪ Installed three water level transducers in Shuswap River to monitor stage changes following plant outages.	▪ Water level observations used to measure flow disruptions of plant outages and other flow changes on fish habitat.
5. Measurements of Total Gas Pressure (TGP)	▪ Sampling of TGP in spring, summer and fall. Analysis by Fisheries and Oceans determined that TGP was not an issue under current operating conditions at those times.	▪ Resolved that under those operating conditions, TGP was not an issue.
6. Measurements of water temperatures of water from Sugar Lake Reservoir	▪ Sampling of water temperatures at various depths in the channel leading from Sugar Lake Reservoir to Sugar Lake Dam on three occasions. ▪ Investigate opportunity to send cooler water from the lower gates at the reservoir down Shuswap River in summer. ▪ Temperature Sampling with continuous temperature loggers at Sugar Lake Outlet.	▪ The three samples collected in 2001 showed no significant difference in temperatures through the vertical profile of the channel, thus it was recommended, based on this information, that no opportunity to send cooler water from the reservoir down the Shuswap River existed. ▪ Continuous data loggers were placed in the outlet of the reservoir during the consultative process (2001). ▪ Temperature data loggers were recovered in April 2002, subsequent to Consultative Committee decision-making. The data indicate a temperature difference in late July and early August, suggesting opportunities may exist to provide cooler water.
7. Tributary access	▪ Site visits of potential spawning areas in streams around the reservoir in spring 2001. ▪ Visual check for access issues, evidence of spawning, potential for backwatering from high reservoir levels.	▪ Tributary access and inundation of spawning sites was not seen to be an issue under current water conditions. ▪ This issue was not listed as a high enough priority to be addressed through the creation of performance measures or alternatives.
8. Bathymetry	▪ GPS and depth-soundings of the reservoir at high pool, taken during the summer of 2001, were combined to produce a 3D model of the reservoir bottom.	▪ 3D model was used to assist in the calculation of the ELZ performance measures.
9. Assess water quality for fish habitat	▪ Sample water quality in river and assess for suitability for fish.	▪ Results showed water quality to be good with low levels of nutrients. ▪ The Consultative Committee did not pursue water quality as an issue for fish.

4.9 Other Water Use Issues Identified during Water Use Plan Process

During the course of the Water Use Plan, the Consultative Committee raised other issues and concerns related to BC Hydro operations on the Shuswap hydroelectric system. The Consultative Committee investigated these issues and decided either:

- The information showed the issue did not warrant further action at this time;
- There was insufficient information to address the concern in the Water Use Plan process;
- There were other means of addressing the issue; or
- The issue was not within the domain of water use planning but the Consultative Committee felt strongly that their concern should be noted here.

Summaries of the identified concerns are provided in this section.

4.9.1 Public Communication around Sugar Lake Operations

Members of the Consultative Committee living on the river flood plain were very interested in knowing the current state of the reservoir. This knowledge would allow them to form more accurate expectations about when flooding might occur on their properties, which would allow them to take more defensive actions such as moving equipment and livestock to higher ground. Communication protocols suggested in conversation included using the local newspapers, faxes, and web-based sources. The information desired included inflows (actual and predicted), reservoir levels, and the settings for gates and stoplogs.

In the final Consultative Committee meeting, several other points were raised regarding the intended operations at Sugar Lake Dam and how these might be communicated by BC Hydro. These points can be found in Section 8.3.

4.9.2 Adequacy of Sugar Lake Dam for Flood Control

Residents of the community of Mara Lake and those living along the river were concerned about the adequacy of Sugar Lake Dam in controlling flows during spring freshet. Property owners and farmers along the flood plain from Wilsey Dam to Mara are affected by flooding during high flows. Data suggest that the river overtops its banks about once every four years, but because of dam safety constraints governing the placement of stoplogs, no operations using the current structures can improve upon the Status Quo for controlling these flood events.

A large amount of time was spent at the Consultative Committee Table discussing flood control. Several ideas were put forward, including building a larger dam at Sugar Lake (which could contain more of the freshet flows) to building additional gates in the current structure (which would allow evacuation of more of the reservoir in anticipation of sudden floods).

The Consultative Committee recognized that changes to Sugar Lake Dam to address flooding impacts were outside of the scope of water use planning. However, it was important to those affected by flooding to have their perspective understood in this report that the current level of flood control is not considered to be adequate, and that solutions that include changing the facilities at Sugar Lake Dam need to be considered. In particular, a good deal of frustration was expressed at the scope of Water Use Plans, in that it allowed the consideration of a gated spillway at Wilsey Dam to address fish issues (since operational alternatives existed that addressed these interests), but did not allow the consideration of changing Sugar Lake Dam to improve flood control (since there existed no operational alternatives that could improve flood control with the current structures).

A letter was written to the Water Use Plan Management Committee to ask that the scope of Water Use Plans be relaxed to allow consideration of changing Sugar Dam to improve flood control. This letter can be found in Appendix R. The Water Use Plan Management Committee responded, saying the scope of Water Use Plans would not be relaxed to consider changes to Sugar Lake Dam to improve flood control. This response can be found in Appendix S.

Finally, members of the Consultative Committee that were affected by flooding along the river felt that it was important to have on record their feelings that "win/win" solutions exist for improving flood control and addressing some other objectives raised within this Water Use Plan process. In addition, if there were ever changes considered to the structure of the Sugar Lake Dam, then the consideration of adding extra gates to address the issues raised in this Water Use Plan need to be taken into account at that point.[1]

4.9.3 Dam Safety

Two issues related to the safety of Sugar Lake Dam were raised at the Consultative Committee Table but were not pursued in the course of water use planning: public communications around dam safety activities, and the impact of dam safety related maintenances on other interests. These are treated separately below.

[1] Details around the modelling of this fifth gate can be found in Appendix T.

4.9.3.1 Public Communication on Dam Safety Issues

BC Hydro systematically assesses its facilities against provincial and international dam safety standards that are continually evolving and improving. Consultative Committee members, especially those living downstream of the facilities, are particularly interested in these standards and the activities that BC Hydro undertakes to meet these standards. Recent examples include seismic upgrades to Sugar Lake Dam in 1999 and 2002.

The Consultative Committee recommended that there should be improved communication between BC Hydro and local communities on dam safety issues, including current standards, the current state of the facilities and protocols, and upgrades to the structures themselves.

4.9.3.2 Minimize Impacts of BC Hydro Operations on Other Resource Objectives

On occasion, BC Hydro carries out maintenance and safety inspections of the dams. Sometimes this work requires that reservoir levels be reduced resulting in a short-term, unseasonably high flow in the river. The timing of these releases can have an impact on other resource values such as fish. The Consultative Committee recognizes that in an emergency or dam safety situation, changes to flows and reservoir elevations may need to occur on short notice. However, where routine inspections and maintenance are being planned and can be scheduled with flexibility, the Consultative Committee recommends that BC Hydro should continue to seek information from the agencies and affected stakeholders to minimize any negative impacts to other resource values.

Where scheduling cannot avoid negative impacts, some Consultative Committee members pointed out that mitigative measures could be included as part of the BC Hydro activities. DFO suggested that this "could" should be changed to "should".

4.9.4 Decommissioning BC Hydro Facilities

Several Consultative Committee members on many occasions expressed interest in removing both dams from the river. Other Consultative Committee members expressed an interest in removing only Wilsey Dam. These suggestions were present from the start of the consultative process and addressed many issues: fish access beyond Wilsey Dam and Sugar Lake Dam, aesthetics, existence values for a free river, absence of sudden flow changes arising from tripping events, and a restoration of a natural hydrograph.

The Consultative Committee realized that the removal of the dams would also carry large costs: lost revenues, costs for decommissioning, environmental costs of silt release, lack of regulation of flows for fish species, and a loss of flood control on the river. Al Caverly (WLAP) pointed out that decommissioning Wilsey Dam alone but maintaining operations at Sugar Lake Dam would continue to provide flood control and fish flow regulation.

Since this topic was outside of the scope of Water Use Plans, the topic was not pursued.[1] One alternative, the almost run-of-river alternative, was modelled to give some insight as to the impacts of decommissioning. After considering this option, this Consultative Committee rejected it, eventually choosing the Status Quo alternative.

Some Consultative Committee members expressed frustration that the scope of Water Use Plans was constrained to examining operational changes only, and could not address decommissioning directly. The almost-run-of river alternative did not address all of the issues touched on by decommissioning the dams, and so was not seen as an adequate substitute by some.

4.9.5 Stumps and Boating Safety in the Reservoir

The Consultative Committee initially identified submerged and partly submerged stumps at the north end of Sugar Lake Reservoir as an issue of boating safety. Reservoir elevations affected whether or not these stumps were exposed and posed a danger to boaters. The Consultative Committee referred the issue to BC Hydro to address through improved warning signs at both ends of the reservoir.

4.9.6 River Recreation - Sugar Lake Dam to Wilsey Dam

There are limited public facilities to support river recreation between Sugar Lake Dam and Wilsey Dam. Members of the recreation sub-groups sought to enhance river recreation opportunities. Proposed outcomes included improving public access to the river (most of the riverside properties are privately owned) and improving a back eddy area above Wilsey Dam as a canoe take-out site. However, sections of the river between the canoe launch site and Wilsey Dam are challenging with the added danger of the spillway, headpond, and intake at Wilsey Dam. BC Hydro did not want to encourage inexperienced paddlers into this part of the river. Until 2001, BC Hydro operated a canoe launch site between Lumby and Cherryville accessible from Highway 6. Subsequently the signs have been changed and the former canoe launch site has been redesignated a picnic area. These changes should improve river safety upstream of Wilsey Dam by not encouraging entry a short distance upstream of the "chute" located at the upstream end of the canyon approaching Wilsey Dam.

[1] Upon review of the draft Consultative Committee report, Al Caverly noted that earlier discussions around decommissioning Wilsey Dam were supported by the Water Use Plan Management Committee only in the event that Wilsey Dam was no longer economically viable, and that the higher financial cost alternatives discussed in Table 5-5 could lead to this outcome.

4.9.7 Water Quality for Fish

The Fish Technical Committee discussed whether BC Hydro operations affected water quality related to fish habitat. The specific concerns were whether operations increased total gas pressure (TGP) or if operations could affect water temperatures in the river. Both TGP and changes in temperature may have lethal and sub-lethal effects on fish. DFO analysis of water samples from the Shuswap River showed that TGP below BC Hydro Shuswap facilities was not a concern under the current operating regime for those periods sampled. The fish group chose not to consider TGP when creating water use alternatives or to use TGP in comparing between alternatives and BC Hydro committed to collecting information during the winter months on this topic.

Spot water temperature samples collected in the channel in July and September between the reservoir and Sugar Lake Dam showed no significant difference in water temperature through the vertical water profile. There was therefore no obvious opportunity to use the lower gates on Sugar Lake Dam to release cool water into the Shuswap River during summer. Hence, as with TGP, the Fish Technical Committee did not develop objectives or performance measures for water temperature. Fish Technical Committee members noted that this temperature sampling was not continuous and was limited to a single season.

Data collected during the consultative process but analyzed after decisions were made showed that there was a difference in water temperature in July and August of 2001. Hence, an opportunity may exist in some years to release cooler water from the lower gates at Sugar Lake Dam that was not explored in this Water Use Plan process.

4.9.8 Water Quality and Quantity for Domestic Use and Irrigation

Some property owners along the Shuswap River hold water licences that confer rights to withdraw water for irrigation, domestic use, and dilution of effluent (e.g. City of Enderby). Early in the Water Use Plan, Consultative Committee members raised concerns about water quality and water quantity.

Generally, water quality in Sugar Lake and the Shuswap River is good and some residents apparently do not hesitate to drink the water. At times sediment load in the Middle Shuswap River (above Mabel Lake) is high during spring freshet. The main sources of sediment are from tributaries (Cherry and Ferry Creeks). However, for Water Use Plan purposes, Cherry and Ferry Creeks are outside the influence of BC Hydro operations. Farmers and ranchers currently deal with sediment by not pumping for irrigation during this period to avoid filling irrigation pipes with sediment. There were no issues with suspended material in the lower Shuswap River below Mabel Lake as sediments settle out in the lake. There was a concern raised that flood waters wash manure into the Shuswap River, however the Consultative Committee did not pursue this issue.

In addition to the question of water quality, the Consultative Committee investigated whether there was sufficient water to supply all existing water licences. An analysis by the BC Water Branch showed that during lowest annual flows in April, the average Shuswap River discharge is approximately 8 m^3/s measured at the Water Survey of Canada gauge (WSC No. 08LC018) just below Sugar Lake Dam. By the time flows reach Lumby, April low flows increase from local inflows to average 9.87 m^3/s. In comparison, if all existing water licence holders between Sugar Lake Dam and Mabel Lake withdrew water from the river to the maximum allowed by their licence, the combined withdrawal totalled 0.18 m^3/s or less than 2% of low flows. The Shuswap Consultative Committee decided water quantity to meet other licensed needs was not an issue at this time.

There was also concern about the impact of BC Hydro operations on shallow wells on properties along the river. In discussion, the Consultative Committee agreed that it was likely that the effect, if any, on shallow wells will not be different between the alternatives considered and impacts on shallow wells was not pursued.

4.9.9 Protected Areas and Parks

Early in the Water Use Plan process the Consultative Committee developed the objective to **minimize negative impacts to protected areas and parks.** There are numerous forest service recreation areas and the Mabel Lake Provincial Park in the Shuswap River watershed. On further analysis, as described in Appendix B, the opportunity to change the magnitude and timing of water levels in Mabel Lake with changes in BC Hydro operations was minimal. The Consultative Committee did not pursue an objective or performance measures for recreation on Mabel Lake. No issues emerged with respect to the forest service recreation areas.

At the time the Shuswap Water Use Plan process was initiated, the Okanagan-Shuswap Land Resource Management Plan (LRMP) had identified three candidate Goal Two protected areas in or adjacent to the Water Use Plan project area. One of the three areas would be designated a Class A park. On analysis, changes in BC Hydro operations would not affect biological, wildlife, or recreation values in any of the candidate protected areas. The Shuswap Water Use Plan Consultative Committee did not pursue issues related to protected areas or Mabel Lake Provincial Park.

4.9.10 Fish Access Past Wilsey Dam

At several points during the process, Consultative Committee members highlighted the fact that the presence of the Wilsey Dam blocked access of fish to the upper portion of the Shuswap River. Consultative Committee members reiterated this concern during the discussions around installing a gated spillway at Wilsey Dam. There was a large degree of support for BC Hydro to take into consideration the possibility of a fishway when designing a gated spillway at Wilsey Dam.

4.9.11 Continual Improvements to Reduce Unplanned Flow Disruptions

In the discussions around the issue of unintentional outages and unplanned flow disruptions at Wilsey Dam, a number of ideas were considered to reduce the frequency and/or the duration of unplanned flow disruptions below the dam. These included the installation of an auto-restart mechanism on the generators, some additional redundancies on the power lines to the Lumby substation, etc. While these were outside of the scope of Water Use Plans, the Consultative Committee wanted it to be clear that any changes that would reduce the frequency and duration of unplanned outages would be valued highly.

4.10 Summary of Information Collected and Reports Generated

In support of Water Use Planning deliberations, the Consultative Committee carried out various studies to fill gaps in existing data. The Consultative Committee conducted other studies to provide information for calculating performance measures. A number of studies were funded through the planning process and these were supplemented by studies completed by BC Hydro staff and in-kind support from DFO and MELP/WLAP staff. See Appendix H for a list of documents and reports generated by the Water Use Plan process.

5 OPERATING ALTERNATIVES

In Step 6 of the Water Use Plan process, the Consultative Committee created and evaluated various operating alternatives for achieving the Water Use Plan objectives. The project team modelled these operating alternatives using the BC Hydro Power Optimization Model[1]. The Consultative Committee then used the modelling results and performance measures to compare how well each alternative achieved the desired Water Use Plan outcomes.

5.1 Specifying Water Use Plan Alternatives

BC Hydro exerts limited control over the Shuswap River system at two points: Sugar Lake Dam and Wilsey Dam. Releases from Sugar Lake Dam can be used to influence reservoir levels and/or flows downstream. The control over the river and the reservoir is variable, and is a function of the current inflows to the reservoir, previous inflows, reservoir elevation, and recent operating decisions. The routing of the water at Wilsey Dam influences the proportion of water that is diverted to the generating units or passed over the spillway. The routing of water at Wilsey Dam is assumed to be independent of Sugar Lake Dam operations. Operations for Sugar Lake Dam and operations for Wilsey Dam will be treated separately below.

5.2 Water Use Modelling Process for Sugar Lake Dam Operations

Modelling Water Use Plan alternatives involves a number of steps and computer programs. First the alternative operating regimes are simulated using the BC Hydro Power Optimization Model. The power model optimizes for power generation subject to the operating constraints of the alternative being modelled. Operating constraints include the physical limitations of the system such as maximum penstock flow, minimum and maximum reservoir elevation, and generator capacity. Additional operating constraints include the target reservoir elevations and/or river flows specified by the Water Use Plan alternative to achieve the desired outcomes.

[1] The Power Optimization Model was sometimes referred to as the "AMPL" (A Mathematical Programming Language) model during the Water Use Plan process.

In describing alternatives, the Consultative Committee specified the target operating parameter in terms of constraints on reservoir levels and/or discharge from Sugar Lake Dam and when these constraints were to be in effect. As the operating variables were interrelated (e.g. flow constraints on the river affect reservoir levels and storage) the Consultative Committee also set priorities for each operating constraint (high, medium, low) which the Power Optimization Model considered when selecting which constraint to relax first (e.g. reservoir levels or river flows). See Appendix U for an example specification of a water use alternative.

The power model used 27 years of historic (1974 to 2000) Sugar Lake Reservoir inflow data to estimate how the system would respond to each Water Use Plan alternative. The power model has a resolution of one day. For each alternative, the model provides an estimate of the power production (MW), reservoir levels (metres above sea level), and averages for turbine discharges, dam releases and spills (m^3/s) for each day over 27 years. Average daily reservoir elevations and river discharges at Sugar Lake Dam and Wilsey Dam are used in environmental simulation models to calculate the performance measures for each alternative. Another model uses power production to calculate the value of energy (VOE) produced.

5.3 Creating Water Use Plan Alternatives for Sugar Lake Dam

The Consultative Committee carried out three rounds of developing and evaluating 24 distinct operating alternatives for Sugar Lake Dam:

- Round 1: Nine Trial Water Use Plan alternatives for operating Sugar Lake Dam.
- Round 2: Fourteen Water Use Plan alternatives for operating Sugar Lake Dam.
- Round 3: Eight Water Use Plan alternatives for operating Sugar Lake Dam, three alternatives for operating Wilsey Dam, and one plan of physical works at Wilsey Dam in lieu of operational changes.

In Round 1, the Consultative Committee developed trial alternatives which optimized for one or two objectives (e.g. reservoir recreation and power). The Consultative Committee used the trial alternatives to become familiar with the modelling process and the resulting performance measures. The trial alternatives also served to explore how the system responded when optimizing for a single objective which helped define the extreme boundaries of possible operating scenarios. Since these were not practical alternatives, the specifications and results are not presented here.[1]

[1] For details of the Round 1Trial Water Use Plan alternatives, see the 5 July 2001 Shuswap Water Use Plan meeting notes for alternative constraints and Shuswap Water Use Plan meeting notes of 1 November 2001 for modelling results.

Alternatives in Round 2 were created using the increased knowledge gained in Round 1, and represented more realistic options which addressed a wider range of Water Use Plan objectives. These Round 2 alternatives represented four fundamentally different ways to use water in the system. Within each of the four categories, variations were created to span a range of flows. Six alternatives from the Round 2 discussions were retained for further examination and refinement in Round 3.

The description of the 14 alternatives considered in Round 2 and the related trade-off analysis and lessons learned are summarized in Appendices V and W. The details of the Round 3 alternatives are presented below.

5.4 Details of Round 3 Alternatives

The Consultative Committee carried six alternatives into Round 3 from the alternatives evaluated in Round 2. In addition, the Consultative Committee added two new alternatives for a total of eight alternatives for operating Sugar Lake Dam.

In Round 3, the Consultative Committee also began evaluating alternatives for managing water use at Wilsey Dam. The Consultative Committee considered four alternatives for Wilsey plus one physical change to the Wilsey spillway. The alternatives for Sugar Lake Dam and for Wilsey Dam are described separately (see Section 5.5 for Wilsey Dam alternatives).

5.4.1 Alternatives for Operating Sugar Lake Dam

The eight Round 3 alternatives represented variations on three themes:

1. Modified fall flows to maximize fish spawning success.
2. Operate the reservoir on an annual fill-drain cycle for a suite of reservoir and river interests.
3. Stabilize the reservoir for mainly reservoir interests.

The three themes represent fundamentally different methods of managing Sugar Lake Dam, each method with emphasis on a different set of objectives. Table 5-1 summarizes the motivation behind each of the groups of alternatives.

There are two alternatives in the first theme. Both impose a specific stepped flow regime to maximize fall spawning success in the river. Alternative G1 represents a low-flow regime while F1 represents a median-flow regime based on the hydrograph of the past 27 years 1974 to 2000.

Table 5-1 Comparison of Interests Addressed by Round 3 Alternatives

	Theme		
	1. Modified Fall Flows	**2. Annual Fill-Drain Cycle**	**3. Stabilize the Reservoir**
Alternative names:	G1, F1	A, A2, B, SQ, SQ2	DS1
Interest addressed			
Net Power Revenues		✓	
Flood and Erosion Control			
Reservoir			✓
River		✓	
Recreation			
Reservoir			✓
River		✓	
First Nations Archaeology			✓
Fish			
Reservoir			✓
River	✓	✓	✓

Alternatives in the second theme represent variations on current Status Quo operations. These alternatives attempt to fill the reservoir by the late summer then gradually release water over the fall and winter months to provide fish habitat in the river. The target is to empty the reservoir before the next freshet arrives (target date of 1 April), but not before 1 March. There are five alternatives in this group: A, A2, B, SQ, and SQ2.

Alternative DS1[1] represents the third theme which maintains a high and stable reservoir throughout the littoral growing season and the summer recreation season. After Thanksgiving storage is released to provide fish habitat in the river and to reach empty by 1 April, but not sooner, to receive the next freshet.

[1] The alternatives were sequentially named as "A", "B", "C" etc. as the Consultative Committee developed them. Refinements and variations lead to additional letters and numbers being added to the names. Other than for identifying alternatives, the names do not convey any meaning except SQ for Status Quo which represented an alternative that was close to current operation.

5.4.2 Description of the Round 3 Alternatives for Sugar Lake Dam

This section briefly describes the eight Round 3 alternatives. For detailed specifications of the alternatives see Appendix X.

The number of alternatives and detail of the alternatives can become overwhelming from this point forward. Readers are directed to focus on alternatives **A2**, **SQ**, and **DS1** which the Consultative Committee regarded as having better performance measure scores and which the Consultative Committee carried into the final trade-off analysis. The lessons learned from considering this broad suite of alternatives for water use at Sugar Lake Dam are listed in Section 5.4.4. The trade-off process and outcome are described in Section 6.

5.4.2.1 Theme 1: Manage Modified Fall Flows for Fish

Modified flows in the fall to favour fish habitat:

- One reservoir fill-empty cycle annually with staged stoplog placement.
- Provide decreasing minimum flow constraints through the fall to encourage the spawning success of fish.
- Focus on river fish objectives only, no other objectives explicitly considered.
- **G1** has low-flow hydrograph**, F1** offers increased flows based on median-hydrograph Table 5-2.

Table 5-2 Low and Median High Fish Flow Hydrographs

	Date	Alternative G1		Alternative F1		Modelling Priority
		Low-flow Hydrograph		Median-flow Hydrograph		
Minimum Flows past Wilsey	1 Apr-Aug	29 m^3/s (1024 ft^3/s) if possible, but less to keep reservoir high in summer.		As required for freshet, 29 m^3/s (1024 ft^3/s) to keep reservoir high in summer.		Low
Minimum Flows past Wilsey Dam	1 Sept	29.0 m^3/s	1024 ft^3/s	29.0 m^3/s	1024 ft^3/s	Low
	15 Sept	25.5	900	28.3	1000	High
	1 Oct	24.1	850	26.9	950	High
	15 Oct	24.1	800	25.5	900	High
	1 Nov	24.1	800	25.5	900	High
	15 Nov	24.1	800	24.8	875	High
	1 Dec	24.1	800	24.1	850	Medium
	15 Dec	24.1	800	24.1	800	Medium
	15 Mar	24.1	800	24.1	800	Medium

5.4.2.2 Theme 2: Fill-Drain Reservoir

The fill-drain the reservoir alternatives:

- Fill the reservoir by capturing the end of freshet flows.
- Empty the reservoir by 1 April but not before 1 March. The model kept the gates open at least until mid-June. If the reservoir levels remained low in June because of dry conditions, discharge from Sugar Lake Dam was reduced to bring the reservoir up.

Alternative A

- Objectives: river flood control, river recreation, frazil ice protection, and power.
- Provided minimum of 20 m^3/s discharge 1 June to 15 October for river paddle sports. After 15 October, flows dropped to 15-20 m^3/s range if reservoir was below full pool. In some years, higher discharge from Sugar Lake Dam was necessary to keep reservoir below 601.7 m. Reservoir gradually drained from mid-November to 1 April to provide for fish habitat in the river.

Alternative A2

- Similar to Alternative A but conserves water released for fish through fall and winter by curtailing discharge for paddle sports after Labour Day instead of Thanksgiving as in Alternative A.
- Relative to A, reduces period to 1 June-7 September, from 1 June to 15 October, when 20 m^3/s is discharged from the reservoir for river paddling sports. Reduced period of release conserves water for fish in the fall and winter.

Alternative B

- Same as Alternative A with addition of discharge following low-flow fish hydrograph (Table 5-2). Whereas Alternative A allowed a gradual draining of the reservoir between November to 1 April, Alternative B provides higher spawning flows from September to April.

The Consultative Committee also modelled two variations of the Status Quo for comparison.

Alternative SQ - Status Quo[1,2]

- Model current operations using 1974 to 2000 inflow data as a baseline for comparing other alternatives.
- Reservoir allowed to fill to maximum 601.72 m, empty by 1 April but not before 28 February.
- Minimum 18 m^3/s discharge below Wilsey Dam from 15 August to 1 January for fish.[3]
- Minimum 15 m^3/s discharge below Wilsey Dam from 1 January to 1 April for fish.
- Gates and stoplogs operated according to current dam safety schedule (Appendix A).

Alternative SQ2 - Status Quo 2

- Based on Alternative SQ.
- Increase minimum discharge from reservoir in the fall slightly in an attempt to increase fall spawning success. The consequence is that this may lower winter incubation flows.

5.4.2.3 Theme 3: Stabilize the Reservoir

The stabilize the reservoir alternatives:

- Close the gates on Sugar Lake Dam earlier to achieve a higher reservoir elevation early in the summer months.
- Empty the reservoir by 1 April but not before 1 March.
- Provide flows that follow a fish friendly hydrograph in the fall.

Alternative DS1

- Objectives: Reservoir recreation, archaeology, reservoir fish, and river fish.

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[1] The Status Quo alternative represents the BC Hydro's dam operator's best effort at approximating what current operations look like. Given that there are no formal rule curves or dynamic decision rules guiding the modelling, it is expected that the output of this model is not an exact replica of what a current operator would do under any given scenario.

[2] Current operations include agency consultation and in season flow adjustments to match inflows/fish life history events.

[3] The minimum daily flows specified by the Consultative Committee in defining these alternatives were modelled as weekly minimum flows. The corresponding daily minimum flows consistent with these weekly minimum flows are about 2 m^3/s lower. So the numbers reported here and in Section 8.1, Table 8-1 and Table 8-2 differ by 2 m^3/s.

- Hold the reservoir below 601.22 m May through Thanksgiving. Hold the reservoir above 600.61 m from mid-July until Thanksgiving.
- Release fall flows according to low-flow fish hydrograph schedule (Table 5-2).

5.4.3 Consequence Table for Sugar Lake Dam Operations

The alternatives for Sugar Lake Dam operations can be organized into a consequence table, where an "impacts by alternatives" matrix is created. This allows a full comparison of the performance measures to be carried out, across all alternatives. This is reproduced below for the eight alternatives carried into the third round of trade-off analysis.

Notice that in this table, the performance measures are included, along with their units and their "least significant difference" (LSD). The LSD is an explicit measure of uncertainty generated by the technical sub-groups, and allows for a determination as to whether the score for a performance measure for an alternative is tied, less than, or greater than the score for another alternative.

Table 5-3 Consequence Table for Sugar Lake Dam Operations

Performance Measure - more is better *(least significant difference in parentheses)*	**Annual Fill-Drain Alts**					**Stabilize Reservoir**	**Fall Flow Management**	
	SQ	**SQ2**	**A**	**A2**	**B**	**DS1**	**G1**	**F1**
Recreation - Reservoir[1]								
Number of days elevation between 600.61 and 601.22 m 15 Jun to Thanksgiving. Max=122 (±13 days)	27	22	52	42	33	91	45	44
Recreation (Paddling)River								
Number of days flows ≥20 m^3/s June to Labour Day (paddle sports). Max=136 days (±5 days)	80	92	101	101	101	85	99	100
Wildlife								
Estimated impacts to wildlife depending on fish (4 is best, 1 is worst)	4	3	3	4	2	2	2	1
Estimated impacts to wildlife depending on reservoir riparian habitat (3 is best, 1 is worst)	3	3	3	3	3	1	2	2

[1] This performance measure was altered part way through the trade-off process. This will be detailed below in Section 6.2.

Table 5-3 Consequence Table for Sugar Lake Dam Operations - Cont'd

Performance Measure - more is better ***(least significant difference in parentheses)***	**Annual Fill-Drain Alts**					**Stabilize Reservoir**	**Fall Flow Management**	
	SQ	**SQ2**	**A**	**A2**	**B**	**DS1**	**G1**	**F1**
Power								
Value of Power $Millions (±$20,000[1])	1.61	1.60	1.58	1.59	1.58	1.59	1.59	1.59
Number of years inflows >14.2 m^3/s (500 cfs), 1 Nov to 1 Mar. Prevent cost of frazil ice damage (±6 years)	27	25	26	26	10	21	14	12
Flood and Erosion Control - Reservoir								
Number of days elevation ≤601.52 m (±7 days)	340	346	358	361	354	365	357	358
Flood and Erosion Control - River								
Number of days Wilsey discharge ≤232 m^3/s (±15 days)	9790	9790	9791	9789	9791	9792	9791	9791
Dam Safety								
Meet or exceed dam safety requirements 1=Yes	1	1	1	1	1	1	1	1
First Nations Archaeology - Reservoir								
Number of days elevation ≤601.22 m (protect from erosion) (±7 days)	287	307	332	323	340	352	340	343
Number of days elevation ≥600.61, 15 Jun to 7 Sept (prevent unauthorized collecting) Max=85 (±10 days)	56	49	44	57	32	56	43	42
Number of years reservoir ≤598.59 m for 32 days for archaeology study. Max=27	27	27	27	27	27	27	27	27
Fish - Reservoir								
Hectares of effective littoral zone (±0.2 ha)	4.4	4.3	4.3	4.3	4.0	4.3	4.2	4.1
Fish - River								
Chinook % survival (±2%)	99	97	97	98	94	98	92	86
Chinook ha Effective Spawning (±1)	25	26	24	25	24	22	24	23
Coho % survival (±8%)	86	74	86	84	70	68	62	60
Coho ha Effective Spawning (±3)	19	16	21	18	14	15	13	11
Kokanee % survival (±10%)	46	35	35	45	29	48	25	20
Kokanee ha Effective Spawning (±0.3)	1.9	1.3	1.5	2.1	1.1	1.8	0.9	0.6
Rainbow Trout m^2 of Rearing (±0.5 units)	9.9	8.9	9.6	9.6	7.4	9.6	9	9.2
Shape of Hydrograph (1 is good, 0 is bad)	1	1	0	1	0	0	0	0

[1] The Figure of ±$20,000 was used for the trade-off analysis during the Consultative Committee meeting. However, it was mistakenly identified as $5,000 in the pre-meeting readings sent to the Consultative Committee.

5.4.4 Lessons Learned from Creating Alternatives for Sugar Lake Dam

One set of lessons learned from the Consultative Committee's deliberations of alternatives is regarding individuals' values around various impacts. These insights will be described in Section 6.2.1. A second type of lesson is around the physical impacts themselves; how do the various elements in the system respond to changes in flows and elevations? These insights will be presented in this section, broken down by category.

Recreation on the Reservoir

The scores for this performance measure can be increased significantly above current levels (by a factor of 3) by stabilizing the reservoir during the summer months. Other operations can also increase recreation above current levels. Current operations are one of the worst alternatives for this measure.

Recreation (Paddle Sports) on the River

The scores for this performance measure can be increased significantly (25%) above the Status Quo by choosing A, A2, B, G1 or F1. There was an assumption that putting water down the river during the summer months would be at the cost of storing water in the reservoir to provide fish flows in the fall and winter. This was true for B, G1, and F1, but this conflict was not there for choosing between SQ and A or A2.

Wildlife

No opportunities were identified that improved scores above those for the Status Quo alternative. Several of the alternatives posed a deterioration of conditions for wildlife on the reservoir and wildlife that depended on fish for food.

Power Revenues and Costs

No opportunities were identified that increased power revenues over Status Quo alternative. However, these power revenues were roughly equal across the broad range of alternatives. Consequently, there were no trade-offs between power revenues and other interests. A number of alternatives (B, G1, F1) that drew the reservoir down in the late fall and winter significantly increased the risk of damage to the penstocks and generators from frazil ice.

Flood and Erosion Control on the Reservoir

The scores for this performance measure improved significantly for all departures from Status Quo except SQ2. Alternatives that kept less water in the reservoir decreased damage from surcharging and wave erosion. The Status Quo was the worst alternative for this measure since it maximized the amount of water stored in the reservoir.

Flood and Erosion Control on the River

No opportunities were found to improve on flood control beyond the levels found under the Status Quo alternative. However, the amount of flood control was equal across all of the alternatives considered. This is because flooding occurs during freshet when the reservoir has already been filled by spring runoff and because dam safety constraints preclude the addition of extra stoplogs to increase storage. Once the reservoir is full, it cannot buffer the inflows and passes out any flows that come in. This lack of control over flooding suggests that there will be no trade-offs between flood control on the river and other interests.

Protection of Archaeology From Erosion and Unauthorized Collecting

By keeping the reservoir high during the summer months, Status Quo and A2 represent the best way to use the reservoir to protect archaeological sites from unauthorized collecting. Several other alternatives that run the reservoir down lower had significantly lower scores on this measure. By keeping the reservoir down from its maximum elevation, B, G1 and F1 were the best ways to protect sensitive sites from erosion. These two measures moved in opposite ways to each other, suggesting a fundamental conflict between protecting archaeological sites from erosion and protecting archaeological sites from unauthorized collecting.

Fish in the Reservoir

No opportunities were found to increase the scores for reservoir productivity above the Status Quo alternative. Several alternatives (B, G1, and F1) decreased scores on this measure, and the ELZ scores were also the same over a broad number of alternatives (SQ, SQ2, A, A2, and DS1). One surprising result was that stabilizing the reservoir until Thanksgiving created no additional gains to ELZ measures over and above Status Quo.

Fish in the River

One surprise for this measure was that Status Quo yielded the highest scores across a broad range of measures (as did A2). In particular, a great deal of effort had gone into developing "fish friendly" alternatives (examples here are G1 and F1, more can be found in Appendix V) that increased fall flows to provide more spawning habitat. However, the performance measures indicated that these gains in spawning were more than offset by incubation losses, decreasing the overall scores.

A second surprise was that there were no significant inter-species trade-offs for the indicator species examined in the river. Moreover, at the start of the process, it was expected that a fish-in-the-reservoir vs. fish-in-the-river conflict would emerge. This trade-off did not materialize. SQ and A2 were best for fish in the river and fish in the reservoir for these performance measures.

As expected, the fish species varied in their responses to altered flow regimes. The species' scores that showed the largest changes among alternatives were kokanee and coho. Chinook and rainbow trout, while affected by the different alternatives, had much more stable scores. Overall, the measures demonstrated the boundaries imposed on changes to operations by limitations in storage.

Almost Run-of-River

One scenario that did not fit into categorization by performance measure is that of the alternative "Almost Run-of-River." This alternative was created to get as close as the scope of Water Use Plans allowed to decommissioning Sugar Lake Dam; the system was "run" with no stoplogs in place at Sugar Lake Dam and with the gates always wide open. The detailed results of this can be found in Appendix V. However, the consequences were very poor for fish in the reservoir, fish in the river, wildlife, prevention of damage to the penstocks, and reservoir recreation. As a result, the Consultative Committee decided that alternatives like this were not worth pursuing.

Several Consultative Committee members pointed out that this did not fully address the benefits from decommissioning the dam since the structures were still in place in this example. Leaving the structures in place blocked fish access upstream of Wilsey Dam, and leaving the structures in place meant that the river was not a truly free flowing river.

Note that this alternative, by keeping the reservoir as low as possible, also maximized available flood control at Sugar Lake Dam. This alternative provided the same level of flood control as the others, highlighting the lack of capacity the Sugar Lake Dam facility has over flooding on the Shuswap River.

5.5 Creating Water Use Plan Alternatives for Wilsey Dam

The Consultative Committee considered four operating alternatives for Wilsey Dam and one physical change to the Wilsey spillway. The alternatives became part of the Round 3 discussion and are described in this section.

5.5.1 Spilling Water to Reduce Impact of Flow Disruptions

As described in Section 4.8.5.4, unplanned outages at the generating units can disrupt flows through the powerhouse. In 1993, a bypass valve was installed to re-route flows in the case of an outage (Figure 2-1). However, the bypass valve may malfunction due to sediment build-up and/or gate closure upstream from the valve, and is smaller in capacity than the penstocks. During an outage when the bypass valve fails, the magnitude of disruption is proportional to the magnitude of the flows through the penstocks and over the spillway. During an outage when the bypass valve operates, the disruption is proportional to the difference between the magnitude of flows entering the penstocks and the amount of water re-routed through the bypass valve.

These unplanned flow disruptions are not large enough to impact any interests other than fish and the wildlife that depend on fish. As well, these flow disruptions can be thought of as independent from Sugar Lake Dam operations. Consequently, the alternatives developed to address unplanned outages were developed within the Fish Technical Committee and their focus is generated to address fish interests only, downstream of Wilsey Dam. The three alternative ways[1] of routing water at Wilsey Dam are described in Table 5-4.

Since the magnitude of the impacts is proportional to the disrupted flows through the penstocks, the goal of the alternatives was to divert flows around the powerhouse and down the spillway to attenuate downstream flow disruptions. The difference between the three alternatives was in the quantity of water diverted and the timing of this diversion.

Table 5-4 Alternative Operations for Wilsey Dam

<table>
<tr><th>Alternative</th><th colspan="3">Diversion Schedule</th><th>Motivation</th></tr>
<tr><td>Status Quo</td><td colspan="3">The first 31.6 m^3/s of flows are routed into the penstocks. All flows above that go down the spillway. (The capacity of the generators is 31.6 m^3/s).</td><td>Maximize net power revenues.</td></tr>
<tr><td>Alternative 1 - Divert 33% of flows</td><td colspan="3">Always</td><td>Reduce flow disruption downstream in case of an outage and a bypass valve (BPV) failure.</td></tr>
<tr><td>Alternative 2 - Divert all flows away from penstock No. 1</td><td colspan="3">Always</td><td>Reduce flow disruption downstream in case of an outage and a BPV failure.</td></tr>
<tr><td>Alternative 3 - Divert ~33% of flows in high flow periods and none in low flow periods</td><td>If inflows are:
▪ 0-15 m^3/s
▪ 15-20 m^3/s
▪ 20-27.5 m^3/s
▪ over 27.5 m^3/s</td><td>Penstocks:
▪ all inflows
▪ 15 m^3/s
▪ 15 m^3/s + 2/3*(inflows - 20 m^3/s)
▪ 20 m^3/s</td><td>Spillway:
▪ 0 m^3/s
▪ Inflows - 15 m^3/s
▪ Inflows - [15 m^3/s + 2/3*(inflows - 20 m^3/s)]
▪ inflows - 20 m^3/s</td><td>Reduce flow disruption downstream in case of an outage and a BPV failure. But protect penstocks from damage in cold, low flow periods.</td></tr>
</table>

It was recognized that diverting one third to one half of the water away from the penstocks would be expensive. As well, the fish group agreed that spilling water down the spillway was only a partial solution.

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[1] In his review of the draft Consultative Committee report, Al Caverly pointed out that a fourth alternative would be to route all water away from the powerhouse, all of the time. This would make decommissioning Wilsey Dam attractive, and Sugar Lake Dam could be run for fish interests and flood control interests only. Since this alternative was not introduced into the discussions leading up to the Consultative Committee recommending operations for Wilsey Dam, it is not included in Table 5-4.

In lieu of an expensive, partial solution, BC Hydro suggested that a gated spillway, controlled by a inflated bladder, would be a change in lieu of an operational alternative that fell within the scope of Water Use Plans. The main idea of this would be that a gate would be placed in the spillway to hold back flows from the Wilsey headpond. The gate would rest against an inflated bladder on the downstream side. In the case of an outage where the bypass valve did not restore flows (either through failing or through not re-routing enough water during an outage), the bladder would rapidly deflate and downstream flows would be restored quickly.

The impacts from spilling water and from the installation of the gated spillway are included in Table 5-5.

Table 5-5 Consequence Table for Alternative Operations at Wilsey Dam

Objectives/ Performance Measures	Status Quo (at Wilsey) (BPV in operation)	Alternative 1 - Divert 33% of all flows from penstocks	Alternative 2 - Divert all flows from Generator No. 1 (BPV in operation)	Alternative 3 - Divert ⅓ of water above low flows (15 m^3/s)	Gated Spillway (BPV in operation)
Change in Annual Net Revenue (excluding changes to maintenance costs)	$0	$653,000 per year	$700,000 per year	$614,000 per year	$100,000 to - $155,000 per year ($1-1.5 million cost, amortized at 8% over 20 years
Frequency of Outages	No change [3.6 (Outages/Yr)]	Increases [4.5 (Outages/Yr)]	Decreases [3.2 (Outage/Yr)]	No Change [3.6 (Outage/Yr)]	No change [3.6 (Outage/Yr)]
Frequency of Large, Unplanned Flow Disruptions (Outage and BPV failure)[1]	No change (2.0 per yr)	Increases slightly (3.1 per yr)	Decreases slightly (1.7 per yr)	No Change (2.0 per yr)	Significantly Less* (0.04 per yr) *Assumes 1/100 chance failure

[1] This performance measure was presented as "Frequency of Dewatering" in the December 2001 FTC meeting. This description was changed for the February 2002 Consultative Committee meeting to capture the idea that this performance measure only refers to events that are both a plant outage and a Bypass Valve Failure. Plant outages at high flows (above the 19 m^3/s capacity of the BPV) when the BPV works may cause smaller flow disruptions. These are not covered in this performance measure. While this was mentioned briefly in the February meeting, it is not recorded in the final meeting minutes.

Table 5-5 Consequence Table for Alternative Operations at Wilsey Dam - Cont'd

Objectives/ Performance Measures	**Status Quo (at Wilsey) (BPV in operation)**	**Alternative 1 - Divert 33% of all flows from penstocks**	**Alternative 2 - Divert all flows from Generator No. 1 (BPV in operation)**	**Alternative 3 - Divert ⅓ of water above low flows (15 m^3/s)**	**Gated Spillway (BPV in operation)**
Estimated Duration of Typical[1] Stage Change (Outage and BPV Failure)[2]					Within minutes. This may take longer, depending on considerations for safety.
▪ Wilsey	90	60	45	60	
▪ Bailey bridge	104, 270, 150	70, 80	52, 135	70, 180	
Estimated Typical Stage Change (Outage and BPV Failure)					Almost negligible if flows are restored quickly. Some stage change may take place if operations are slowed down for reasons of safety.
▪ Wilsey at WSC gauge	▪ 50 cm	▪ 33 cm	▪ 25 cm	▪ 33 cm	
▪ Bailey bridge	▪ 3.4, 25, 41 cm	▪ 2.3, 16 cm	▪ 1.7, 12 cm	▪ 2.3, 16 cm	
Estimated Impact on Eggs from a Typical Outage	Exact magnitude of damage is suspected to be minimal unless during extreme temperature events.	Exact magnitude of damage is suspected to be minimal unless during extreme temperature events.	Exact magnitude of damage is suspected to be minimal unless during extreme temperature events.	Exact magnitude of damage is suspected to be minimal unless during extreme temperature events.	Avoids most damage from unplanned outages, when in operation

1 For ease of analysis a "typical" outage was defined as a tripping event where both generators shut down and the bypass valve failed when background flows were roughly equal to the plant's capacity.

2 In using a "representative flow disruption" as a point of comparison, there were inconsistencies between meetings as to which numbers were used for impacts at the Bailey bridge. In this table, the first number for the duration of flow disruption and stage change at the Bailey bridge is one provided to the Consultative Committee for the February Consultative Committee meeting when the choice of alternatives at Wilsey Dam was made. The second number is the one used by the Fish Technical Committee in its December 2001 meeting. In the Fish Technical Committee discussions of November 2001, the group agreed that the third number in the first column would represent the duration and stage change of flow disruption at the Bailey bridge. These measures for duration from the November Fish Technical Committee meeting were not extrapolated to the other alternatvies and so a third number is not reported across the columns.

Table 5-5 Consequence Table for Alternative Operations at Wilsey Dam - Cont'd

Objectives/ Performance Measures	**Status Quo (at Wilsey) (BPV in operation)**	**Alternative 1 - Divert 33% of all flows from penstocks**	**Alternative 2 - Divert all flows from Generator No. 1 (BPV in operation)**	**Alternative 3 - Divert ⅓ of water above low flows (15 m^3/s)**	**Gated Spillway (BPV in operation)**
Estimated Impact on Alevins from a Typical Outage	Majority of impact occurs immediately and is compounded as flows continue to drop. Impacts are further compounded as delays continue over time.	Majority of impact occurs immediately and is compounded as flows continue to drop. Impacts are further compounded as delays continue over time. Some benefit (unknown) will reduce immediate and additional impacts.	Majority of impact occurs immediately and is compounded as flows continue to drop. Impacts are further compounded as delays continue over time. Some benefit (unknown) will reduce immediate and additional impacts more than the 33% alternative.	Majority of impact occurs immediately and is compounded as flows continue to drop. Impacts are further compounded as delays continue over time. Some benefit (unknown) will reduce immediate and additional impacts.	Avoids most damage from unplanned outages, when in operation
Estimated Impact on Outage from a Typical Juveniles[1]	Majority of impact occurs immediately and is compounded as flows continue to drop. Impacts are further compounded as delays continue over time	Majority of impact occurs immediately and is compounded as flows continue to drop. Impacts are further compounded as delays continue over time. Some benefit (unknown) will reduce immediate and additional impacts.)	Majority of impact occurs immediately and is compounded as flows continue to drop. Impacts are further compounded as delays continue over time. Some benefit (unknown) will reduce immediate and additional impacts more than the 33% alternative.	Majority of impact occurs immediately and is compounded as flows continue to drop. Impacts are further compounded as delays continue over time. Some benefit (unknown) will reduce immediate and additional impacts.	Avoids most damage from unplanned outages, when in operation

[1] This performance measure was presented as "Frequency of Dewatering" in the December 2001 FTC meeting. This description was changed for the February 2002 Consultative Committee meeting to capture the idea that this performance measure only refers to events that are both a plant outage and a Bypass Valve Failure. Plant outages at high flows (above the 19 m^3/s capacity of the BPV) when the BPV works may cause smaller flow disruptions. These are not covered in this performance measure. While this was mentioned briefly in the February meeting, it is not recorded in the final meeting minutes.

Table 5-5 Consequence Table for Alternative Operations at Wilsey Dam - Cont'd

Objectives/ Performance Measures	**Status Quo (at Wilsey) (BPV in operation)**	**Alternative 1 - Divert 33% of all flows from penstocks**	**Alternative 2 - Divert all flows from Generator No. 1 (BPV in operation)**	**Alternative 3 - Divert ⅓ of water above low flows (15 m^3/s)**	**Gated Spillway (BPV in operation)**
Estimated Impact on from a Typical Outage Adults	Impacts will increase as a function of time through predation, asphyxiation etc. Susceptibility to immediate impacts are less than alevins and juveniles.	Impacts will increase as a function of time through predation, asphyxiation etc.). Susceptibility to immediate impacts are less than alevins and juveniles. Some benefit (unknown) will reduce immediate and additional impacts.	Impacts will increase as a function of time through predation, asphyxiation etc.). Susceptibility to immediate impacts are less than alevins and juveniles. Some benefit (unknown) will reduce immediate and additional impacts more than the 33% alternative.	Impacts will increase as a function of time through predation, asphyxiation etc.). Susceptibility to immediate impacts are less than alevins and juveniles. Some benefit (unknown) will reduce immediate and additional impacts.	Avoids most damage from unplanned outages, when in operation

5.5.2 Lessons Learned from Creating Alternatives at Wilsey Dam

A number of lessons were learned during the Consultative Committee's discussions on operating alternatives for Wilsey Dam. These insights are presented below.

Change in Annual Net Revenue

The costs of diverting water away from the penstocks is high because this water is no longer available for power generation. The costs of the alternatives that spilled water did not include any additional maintenance costs,[1] yet were still above the amortized cost of a gated spillway costing $1.5 million.

[1] These maintenance costs may be substantial. Diverting 33% of all flows may lead to cavitation or frazil ice damage in cold, low flow periods. The net cost to diverting all flows from penstock No. 1 is unclear; this may lead to decommissioning which represents a large, one-time cost, but it also saves on annual maintenance.

Frequency of Outages

Data from 1996 to the present indicate that the powerhouse has experienced almost four outages per year. Diverting water from the penstocks to the spillway, so that penstock flows are sometimes below 15 m^3/s, might actually increase outages as flows above 15 m^3/s protect the penstocks from frazil ice build-up. However, diverting all flows from one penstock was assumed to decrease outages, as this eliminates cross-tripping[1] between units. The other alternatives were assumed to have no impact on outages.

Frequency of Large, Unplanned Flow Disruptions

Based on data from 1996 to the present, the river has experienced large flow disruptions (where the plant trips off and the bypass valve (BPV) fails) roughly twice per year.[2] Again, diverting one-third of all flows from the penstocks in low flow periods (Alternative 1) increases this frequency, but diverting all flows from one penstock (Alternative 2) may decrease this slightly. The gated spillway was assumed to be used as a backup system to the BPV. So large flow disruptions were assumed to occur only when there was, simultaneously: an outage, a BPV failure, and a failure of the gated spillway mechanism. This essentially eliminates large flow disruptions from the river.[3]

Estimated Duration of a Typical Stage Change

There was enough data to estimate the relationship between flow disruptions and stage changes. However, this relationship varies, depending upon where the stage change is measured, what the background flows are, and how far from Wilsey Dam the measure is taken. To simplify the analysis, one set of data was used to represent a "typical" outage just below Wilsey Dam and 8 km downstream at a location called the Bailey bridge. It was estimated that the decrease in the duration of the flow disruption would be proportional to the amount of water diverted from the penstocks. The design and the operation of the gated spillway will be crucial to its ability to restore downstream flows quickly. It is estimated that flows could be fully restored in less than five minutes, but safety concerns may mean that in summer months, this might be delayed to ensure that the spillway is clear of people before flows are fully re-routed.

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1 A cross-trip is when one generator trips, and this trips the other generator off.

2 BC Hydro felt that the data included from 1996-1999 overstated the current frequency of tripping events since operational changes and equipment improvements have since eliminated the sources of these earlier failures. DFO is not sure that this is an accurate assessment due to human error and possible unanticipated events.

3 The BC Hydro project team was not able to find other instances of gated spillways being used to restore downstream flows during tripping events. Operators of gated spillways reported that they were very reliable, so a failure rate of 1/100 was assigned to its operations. Darren Sherbot (BC Hydro) in his review of the draft Consultative Committee report, noted that the gated spillway is untried technology. Its effectiveness or even feasibility should be subject to an engineering assessment prior to implementation.

Estimated Magnitude of Typical Stage Change

The area below Wilsey Dam is a confined canyon and so the measure of stage change is largest in that area when the BPV fails. This impact is lessened greatly downstream at the Bailey bridge, both due to its distance from Wilsey Dam (~8 km), the presence of other inflows, and to the shape of the channel. The example used in the consequence Table shows during an outage where the BPV fails, the river would experience a stage change of 50 cm immediately below Wilsey Dam, but a much smaller change 8 km downstream at the Bailey bridge.[1]

It was assumed that the magnitude of the flow disruption would be decreased in proportion to the amount of water diverted from the penstocks. The amount by which the gated spillway will reduce the stage change depends on its design and operation. Current assumptions are that it could operate so that there is little to no change in the river height. However, safety concerns may delay the restoration of flows. The working assumption is that, even if flows were delayed, the gated spillway would dampen the stage change from a BPV failure during an outage significantly.

Biological Impacts

The impacts on flows were simplified a great deal, and using a "typical" outage hid a lot of detail in favour of simplifying the impacts for the Consultative Committee. For example, the actual impact on any section of the river would vary with the shape of the riverbed. The biological impacts are based on this "typical" outage, and so carry along with them this uncertainty. Moreover, the biological impacts are derived from professional judgement and are not derived from any quantitative analysis or data collection. As a result, these biological measures are much less certain than the flow impacts. These measures may be used for ranking alternatives, but they do not convey any ability to judge the magnitude of impact.

The Fish Technical Committee spent a considerable amount of effort on discussing a "damage function" for each of the impacts listed below that would relate the amount of time that the water was low to the aggregate amount of damage done to that lifestage in the river**.** The Fish Technical Committee agreed that impact increased with time. However, there was little agreement beyond that. In particular, the group could not find common ground in deciding how long it would take before the majority of damage had occurred to each lifestage.

[1] Again, numbers presented around the magnitude of this stage change varied from 3.4 cm (February 2002 Consultative Committee meeting), 4 cm (November 2001 FTC meeting), and 25 cm (December 2001 FTC meeting).

Eggs

It was the opinion of the fish group that eggs in the gravel are the least susceptible to damage from short-term dewatering. There was little basis for differentiating among the alternatives that spilled water, but there was general agreement amongst the fish group that spilling more water provides some benefit of unknown magnitude. By avoiding most of the dewatering (stage and duration), it was assumed that the gated spillway would also avoid most of the damage.

Alevins

It was the judgement of the fish group that the majority of the damage to alevins occurs very quickly during dewatering due to their high oxygen demand. Much of this can be avoided through the use of a gated spillway, even if flows take up to 10 minutes to be restored. After that point, damage still occurs as the restoration of flows is delayed, but the incremental damage to further delays is small. This means that spilling more water provides some additional benefit of unknown magnitude.

Juveniles

It was the judgement of the fish group, backed by fisheries literature, that the majority of the damage to juvenile fish occurs very quickly during dewatering. This can be minimized through the use of a gated spillway, even if flows take up to 10 minutes to be restored. After that point, damage still occurs as the restoration of flows is delayed, but the incremental damage to further delays is less. This means that spilling more water provides some additional benefit of unknown magnitude. Juveniles and alevins are expected to be the most impacted by outages.

Adult Fish

Adult fish may be able to avoid stranding initially, but if they are trapped in small pools they will succumb rapidly to oxygen depletion and predation. So, as opposed to juveniles and alevins, the impacts to adult fish grow steadily and accumulate the longer the flows are reduced. Most damage can be avoided if flows are restored quickly (through the use of a gated spillway). Apart from that, spilling more water provides some additional benefits of unknown magnitude.

5.5.3 Spilling Water in August for Safety Reasons

A final type of alternative explored for Wilsey Dam was a 3 m^3/s spill in August. The main concern here was for safety of swimmers and sunbathers in the spillway. Consultative Committee members felt that, despite the signs and fencing around the spillway, people still used the spillway in the summer months as a place to recreate. In particular, isolated pools in the spillway provided attractive swimming locations.

In the case of an unplanned outage where the BPV failed, flows into the Wilsey headpond would increase the water elevation until water came down the spillway. The fear expressed by some at the Consultative Committee Table was that this introduction of flows down the spillway would pose a risk to those below. Although it has not been verified or tested, it was thought that a 3 m^3/s spill might provide an additional deterrent to those trying to get down into the spillway. As well, it would replenish the pools below the spillway with cold water, possibly making them less attractive to swimmers and sunbathers.

A second objective that is addressed by this 3 m^3/s spill is the aesthetic appeal of the Wilsey spillway. Originally, some members of the Consultative Committee felt that restoring natural flows to the system would recreate what was once a dramatic waterfall at the site of Wilsey Dam. The 3 m^3/s spill in August was not designed to address this, but some Consultative Committee members felt that this went part way towards improving the aesthetics of the area (Table 5-6).

This alternative was treated as a diversion of up to 3 m^3/s from the penstocks. As such, the only other interest that it would impact is the generation of power revenues. As a result, this alternative was not integrated into the other alternatives considered, but left for consideration on its own.

Table 5-6 Consequence Table for Considering August Spills to Address Safety Concerns Below Wilsey Dam

	Status Quo	**3 m^3/s spill during August**
Change in Revenues	$0	$18,000 annual cost (average)
Change in safety for individuals below dam	No change	Not quantified by Consultative Committee

6 TRADE-OFF ANALYSIS

The Consultative Committee discussed two separate issues during their deliberations: operations at Sugar Lake Dam and operations at Wilsey Dam. Since these are assumed to be independent, they will be analyzed separately below.

6.1 Method of Comparisons in Trade-off Analysis

For the discussions around Sugar Lake Dam operations and Wilsey Dam operations, the Consultative Committee's discussions were structured around the use of pairwise comparisons. The logic of pairwise comparisons requires that clear relationships of dominance can be established between the alternatives. As an example, if Alternative B is as good as, or better than, Alternative C on every measure from the Consultative Committee's perspective, then Alternative C can be dropped from discussion; the Consultative Committee would never choose Alternative C since it can always do better by choosing Alternative B. In this case, it is said that B dominates C. Note that in the case of dominance, no trade-offs are required. Each measure is as good as, or even better, under B than under C.

If there are several alternatives to be considered, then this process can be repeated until either a) there is only one alternative left, or b) some trade-offs need be made.[1]

6.2 Results of Trade-off Analysis for Sugar Lake Dam

The trade-off analysis was aided by the use of a dynamic spreadsheet analysis. For illustration here, Alternative A2 is the basis of comparison to all other alternatives. Based on the measures of Least Significant Difference (LSD), Performance Measure (PM) scores in the matrix are coloured yellow if they are tied with their counterpart in Alternative A2, green if they are better than the same measure in A2, and red if they are worse.

[1] If A is better than B on most (but not all) measures, then it is said that there is a relationship of "practical dominance." In this case, repeated pairwise comparisons must be made with care in a group setting. It is possible that the use of pairwise comparisons where dominance does not exist, choice can show intransitivity, where A is preferred to B by the group, B to C, but C to A. In such a case, pairwise comparisons are not appropriate. Refer to Table 6-1 to see that this is not the case for the Shuswap Water Use Plan.

Table 6-1 is different from its counterpart in the previous section (Table 5-3) in two respects: performance measures for archaeological interests and the performance measure for recreation on the reservoir. At the start of the discussions, it was clear that the performance measures measuring the erosion impact on archaeological sites and the ability of the reservoir to cover these sites from unauthorized collecting, were in conflict. However, not enough information had been collected during Step 5 of the Water Use Plan to help prioritize these impacts. As a result, Loretta Eustache, the representative for the Spallumcheen Band at the table, felt that these measures would not be useful helping to choose between these alternatives. The group agreed and suggested that the process of choosing could move ahead without these performance measures, but that this data should be addressed through a monitoring program to judge the location, susceptibility, and importance of these sites around the reservoir. As a result, the measures tracking impacts to archaeological sites were removed from the consequence table. Table 6-1 reflects this change.

With the removal of the performance measures tracking impacts to archaeological sites, it is clear that A2 dominates Alternatives A, B, G1 and F1. This is because A2 is tied with or better than these other alternatives on every measure. Since no trade-offs were required in choosing between these alternatives, the Consultative Committee dropped the inferior ones with unanimous consent.

In comparing A2 with DS1, there is not a relationship of clear dominance. A2 is tied with, or better than, DS1 on every measure except recreation on the reservoir. Here, DS1 has a much higher score than A2. Discussion around the Consultative Committee regarding this measure, however, led to the conclusion that the important part of the reservoir recreation measure was how long the reservoir was kept above 600.61 m, a key elevation that allowed launching from a specific boat ramp. This opinion was put forward by those living around the reservoir and so was accepted by the Consultative Committee. The performance measure was recalculated based on this measure, and this new measure is inserted on the second row of the performance measures. Using this new measure of "what is good for recreation in the reservoir," DS1 is dominated by A2 and can be dropped without considering any trade-offs. This left SQ, SQ2 and A2 as the remaining alternatives.

Table 6-1 Consequence Table for Sugar Lake Dam Operations

Performance Measure (least significant difference)	Fill-Drain Alts					Stabilize Reservoir	Fall Flow Management	
	SQ	SQ2	A	A2	B	DS1	G1	F1
Recreation – Reservoir								
Number of days elevation between 600.61 and 601.22 m 15 June to Thanksgiving. Max=122 (±13 days)	27	22	52	42	33	91	45	44
Number of days elevation is above 600.61 m 15 June to Thanksgiving. Max=122 (LSD assumed at 13 days)	87	N/A	N/A	74	N/A	58	N/A	N/A
Recreation (Paddling) River								
Number of days flows ≥20 m^3/s June to Labour Day (paddle sports). Max=136 days (±5 days)	80	92	101	101	101	85	99	100
Wildlife								
Estimated impacts to wildlife depending on fish (4 is best, 1 is worst)	4	3	3	4	2	2	2	1
Estimated impacts to wildlife depending on reservoir riparian habitat (3 is best, 1 is worst)	3	3	3	3	3	1	2	2
Power								
Value of Power $Millions (±$5,000)	1.61	1.60	1.58	1.59	1.58	1.59	1.59	1.59
Number of years inflows >14.2 m^3/s (500 cfs), 1 Nov to 1 Mar. Prevent cost of frazil ice damage (±6 years)	27	25	26	26	10	21	14	12
Flood and Erosion Control – Reservoir								
Number of days elevation ≤601.52 m (±7 days)	340	346	358	361	354	365	357	358
Number of days Wilsey discharge ≤232 m^3/s (±15 days)	9790	9790	9791	9789	9791	9792	9791	9791
Dam Safety								
Meet or exceed dam safety requirements	yes	yes	yes	yes	yes	yes	yes	yes
Fish – Reservoir								
Hectares of effective littoral zone (±0.2 ha)	4.4	4.3	4.3	4.3	4.0	4.3	4.2	4.1
Fish – River								
Chinook % survival (±2%)	99	97	97	98	94	98	92	86
Chinook ha Effective Spawning (±1)	25	26	24	25	24	22	24	23
Coho % survival (±8%)	86	74	86	84	70	68	62	60
Coho ha Effective Spawning (±3)	19	16	21	18	14	15	13	11
Kokanee % survival (±10%)	46	35	35	45	29	48	25	20
Kokanee ha Effective Spawning (±0.3)	1.9	1.3	1.5	2.1	1.1	1.8	0.9	0.6
Rainbow Trout m^2 of Rearing (±0.5 units)	9.9	8.9	9.6	9.6	7.4	9.6	9	9.2
Shape of Hydrograph (1 is good, 0 is bad)	1	1	0	1	0	0	0	0

Using SQ as the basis for comparison in Table 6-2, the scores for the other alternatives are now coloured in reference to those in SQ. Again, red means significantly lower than, green means significantly higher than, and yellow means tied with the scores in SQ.

In comparing SQ and SQ2, SQ is tied with or better than SQ2 on every measure except one: paddling days in the river. Upon discussion around the Consultative Committee, it was clear that many people put a very low weight on this objective in the context of this trade-off. In fact, several property owners along the river felt that more paddling opportunities would be a negative thing (e.g. more safety concerns, more vandalism of property).

Given this low to negative weight placed on paddling on the river, SQ practically dominates SQ2. That is, the group felt that the extra paddling days made available by choosing SQ2 were not worth the losses that would be experienced by fish and wildlife. As a result, the group dropped SQ2 from consideration.

The final comparison was between SQ and A2. On the face of it, A2 dominates SQ since the performance measure scores for A2 are equal to or higher than SQ on every measure and higher for paddling on the river and flood control on the reservoir. It was also pointed out that A2 represents a significant gain for the protection of archaeological sites from erosion, a performance measure that was set aside by the Consultative Committee for further monitoring. This performance measure was put back in front of the group during this discussion.

Table 6-2 Simplified Consequence Table for Sugar Lake Dam Operations

Performance Measure (least significant difference)	Fill- Drain		Alts
	SQ	SQ2	A2
Recreation-Reservoir			
Number of days elevation between 600.61 and 601.22 m 15 June to Thanksgiving. Max=122(±13 days)	27	22	42
Number of days elevation is above 600.61 m 15 June to Thanksgiving. Max=122 (LSD assumed at 13 days)	87	N/A	74
Recreation (Paddling) River			
Number of days flows ≥20 m^3/s June to Labour Day (paddle sports) Max=136 days (±5 days)	80	92	101
Wildlife			
Estimated impacts to wildlife depending on fish (4 is best, 1 is worst)	4	3	4
Estimated impacts to wildlife depending on reservoir riparian habitat (3 is best, 1 is worst)	3	3	3

Table 6-2 Simplified Consequence Table for Sugar Lake Dam Operations - Cont'd

Performance Measure (least significant difference)	**Fill- Drain**		**Alts**
	SQ	**SQ2**	**A2**
Power			
Value of Power $Millions (±$5000)	1.61	1.60	1.59
Number of years inflows >14.2 m^3/s (500cfs), 1 Nov-1 Mar Prevent cost of frazil ice damage (±6 years)	27	25	26
Flood and Erosion Control-Reservoir			
Number of days elevation ≤601.52 m (±7 days)	340	346	361
Flood and Erosion Control-River			
Number of days Wilsey discharge ≤232 m^3/s (±15 days)	9790	9790	9789
Dam Safety			
Meet or exceed dam safety requirements Yes/No	yes	yes	yes
First Nations Archaeology - Reservoir			
Number of days elevation ≤601.22 m (protect from erosion) (±7 days)	287	N/A	323
Number of days elevation ≥600.61 14 June to 7 Sept (prevent unauthorized collecting) Max=85 (±10 days)	56	49	57
Fish-Reservoir			
Hectares of effective littoral zone (±.2 ha)	4.4	4.3	4.3
Fish-River			
Chinook % survival (±2%)	99	97	98
Chinook ha Effective Spawning (±1)	25	26	25
Coho % survival (±8%)	86	74	84
Coho ha Effective Spawning (±3)	19	16	18
Kokanee % survival (±10%)	46	35	45
Kokanee ha Effective Spawning (±0.3)	1.9	1.3	2.1
Rainbow Trout m^2 of Rearing (±0.5 units)	9.9	8.9	9.6
Shape of Hydrograph (1 is good, 0 is bad)	1	1	1

The gains to protecting archaeological sites from erosion were not a factor in most peoples' decisions. The Consultative Committee asked that the magnitude of the impact from erosion and the significance of these impacts be studied through a monitoring program so that future decision-making could take these into account, but for the most part did not use this information (see comments in Section 6.2.1). Similarly, several people around the Consultative Committee did not know the extent of the damage that could arise through erosion to property around the reservoir. While the performance measures suggest that there is a significant difference between SQ and A2 in their impact on properties around the reservoir, Consultative Committee members were unsure whether these impacts would continue on year after year, or whether the reservoir would stabilize soon and further damage would not occur. Again, most Consultative Committee members did not refer to this impact in explaining their final decision.

The only fault with A2 is that, in two of the 27 years of the data set, the reservoir ran out of stored water. Although this does not show up on any of the performance measures for fish (the fish performance measures were all tied across the two alternatives), there was a strong feeling within the Consultative Committee that this posed a significant risk for fish in the river. The fear was that this might occur in a year when fish had spawned during normal to high flows, and the impact from dewatering these redds would be large.

The instructions given to the Consultative Committee for choosing operations were to pick one of three responses:

- S - I fully support this alternative.
- A - I accept this alternative with reservations, but I can live with it.
- B - I block - I cannot live with it.

In choosing between SQ and A2, Consultative Committee members were asked to note their initial choice and their rationale on a piece of paper. The group was told that this would be an initial scoping and that they could change their minds on this later. Then each member was canvassed; their final choice and their rationale is listed below.

The final tally for the two alternatives is shown in Table 6-3.

Table 6-3 Final Tally of Support Levels Between SQ and A2

	Support	Accept	Block
SQ	9	5	0
A2	5	5	4

Given these results, SQ was the only alternative that received high levels of support and met everyone's minimum needs. As a result, the Consultative Committee chose to recommend that Sugar Lake Dam be operated according to the constraints described by Alternative SQ.

Final Recommendation for Operations at Sugar Lake Dam: Sugar Lake Dam should be operated subject to the constraints described in Section 8 for the Status Quo alternative.

Discussions within the Fish Technical Committee also focused on ramping rates, and it was agreed that constraints on flow changes from gate operations should be based on the lower range of the current guidelines used by BC Hydro for ramping down limits. Restrictions on the rate at which flows can be ramped up were also agreed upon, and are included in Section 8.[1] Since these did not impact other interests across the Consultative Committee, these discussions were not pursued within the larger group. However, these constraints are listed as part of the general recommendations in Section 8.

6.2.1 Understanding Peoples' Values Regarding Sugar Lake Dam Operations

Individuals' choices, and their rationale for these choices, are listed in Table 6-4.

Recall that A2 dominated SQ. In particular, the fish performance measures for SQ and A2 were tied, and A2 had higher performance measure scores for recreation in the river, flood/erosion control in the reservoir, and protection of archaeological sites. Several insights can be derived from the choices and comments that people made during the trade-off process that led to the group choosing the dominated alternative.

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[1] In his review of the draft Consultative Committee report, Darren Sherbot (BC Hydro) noted that there was neither a qualitative basis for establishing an upramp rate nor have similar constraints been imposed on other facilities.

Table 6-4 Consultative Committee Choices and Comments for Sugar Lake Dam

Consultative Committee Member	SQ	A2	Comments
Lee Hesketh (Landowner)	A	A	Would prefer SQ but can live with both. River recreation is a very low priority because of negative impacts to shorefront property owners, this is outweighed by risks to fish from running out of stored water.
Al Caverly (WLAP)	S	A	Running out of stored water is a risk that is a large concern due to potential impact on fish. More certainty is needed around impacts to reservoir erosion (arch and property) before these could be given a higher weight in the decision.
BC Hydro (Brian Fast and Hugh Smith)	S	S	Recognized the trade-offs between providing benefits in the reservoir (erosion for property and arch sites) and more certainty around fish flows over the winter. Based on group conversation, little weight was given to the recreational performance measure. But the other concerns roughly balanced each other out.
Ray Arlt (NONA)	S	A	Felt that the reduction in risk to fish to be more important than the gains from A2.
Joe Huwer (Landowner)	S	B	Did not want to encourage greater use of the river by paddlers. Joe felt that protection from erosion around the reservoir was important, but that he put a greater emphasis on not running out of stored water for fish.
Tom Huwer (Landowner)	S	B	Did not want to encourage more paddling along the river. Tom also agreed with Al and Hugh that running out of water was a risk that he did not want to take.
Leroy Proctor (Landowner)	S	B	Felt that the impacts from changing away from status quo were not fully understood, and therefore change would not be practical. Leroy also felt that more recreation would be bad.
Heather Stalberg (DFO)	S	B	Protection from erosion to archaeological sites is not clear and can be studied in a monitoring proposal. The river recreation performance measure is weak. SQ has better performance measure scores on a cumulative basis, although they are tied on an individual basis. SQ does not run the reservoir out of stored water.
Rudi Gedaschke (LDWA)	S	A	Lean towards SQ but can live with A2. The priority is the reservoir.
Monty Willis (KLR)	S	A	There really is not the possibility of running out of water, the agencies would communicate and respond. Running out of water isn't as high a risk as people think and it should not direct decisions here.
Larry Arcand (SLR)	A	S	Larry pointed out that he felt strongly about erosion around the reservoir and preferred recent operations (since 1997) when the reservoir had been kept lower. But he could live with SQ.
Paul Wieringa (CCS)	A	S	Felt that the gains under A2 from protection from erosion to shorefront property and archaeological sites is important. Paul did not see a lot of value in river recreation expressed around the table.
Michael Curd (Landowner)	A	S	Felt that recreation along the river was important to him, and that A2 provided the best way to attain this important objective. Michael saw little difference between the two options for fish.
Loretta Eustache (Spallumcheen Band)	A	S	Felt that A2 is better overall for all interests. In particular, it is the better of the two alternatives in protecting archaeological sites around the reservoir from erosion.

Risk Averse for Fish Interests

One group of Consultative Committee members accepted the performance measures at face value, yet saw the dominated alternative of SQ as being as good as, or better than, A2. This included Al Caverly (WLAP), Brian Fast / Hugh Smith (BC Hydro), Ray Arlt (NONA), Heather Stalberg (DFO) and Rudi Gedashke (LDWA). Such a choice represents a highly risk averse attitude towards fish interests, and a high weight on fish interests compared to archaeological interests, recreation, and flood protection on the reservoir. The comments in Table 6-4 support this inference.

Risk Averse for Fish Interests and a Negative View of Paddle Sports

For several people, A2 did not dominate SQ. Rather, increasing the number of paddling days on the river was seen as a bad thing. As a result, choosing between A2 and SQ posed a trade-off between fish interests and (lower number of) paddling days (through choosing SQ) vs. archaeological protection and flood control in the reservoir (through choosing A2). Here, choosing SQ over A2 is interpreted as meaning that the gains available through A2 for flood control on the reservoir and protection of archaeological sites were outweighed by the gains from choosing SQ from avoiding the risk of running out of stored water for fish and keeping the number of paddlers on the river low. Lee Hesketh (Landowner), Joe Huwer (Landowner), Tom Huwer (Landowner), and Leroy Procter (Landowner) all felt that SQ was better than A2, and their comments in Table 6-4 reflect both their concern over the risks to salmon and their views of paddle sports in the river.

No Risk Aversion for Fish and a Positive View of Paddle Sports

A number of people chose A2 over SQ. This group included Larry Arcand (SLR), Paul Weiringa (CCS), Michael Curd (local resident), and Loretta Eustache (Spallumcheen Band). None of them mentioned that paddle sports were seen in a negative light, and Michael Curd (local resident) mentioned that he valued this positively. Comments from this group in Table 6-4 show that erosion impacts around the reservoir, both to archaeological sites and private land, carried a lot of the weight for their decisions. No concerns were expressed regarding an increase risk to fish from running out of stored water.

6.3 Result of Trade-off Analysis for Wilsey Dam

The Consultative Committee was presented with a choice between maintaining operations at Wilsey Dam as they currently are, or changing these operations. The first option was termed "Status Quo." Since operations at Sugar Lake Dam and Wilsey Dam were taken as independent, the Status Quo alternative at Wilsey Dam is distinct from the Status Quo alternative for Sugar Lake Dam.

At the outset of the trade-off discussion, it was pointed out that Alternative 1 (spilling 33% all of the time) was dominated by Alternative 3 (spilling 33%, but not during low flow periods). That is, Alternative 3 was as good as, or better than, Alternative 1 on every measure. As a result, the Consultative Committee agreed that Alternative 1 should be dropped from discussions. But, as opposed to the trade-off analysis for Sugar Lake Dam, no further pairwise comparisons were pursued with the Consultative Committee. This allowed a more complete exploration of individuals' level of support across all of the alternatives. These results are presented in Table 6-5.

The Consultative Committee was then presented with a choice between operations for Wilsey Dam: Status Quo, Alternative 2, Alternative 3, and Alternative 4 (the gated spillway). Paul Wieringa (CCS) objected to this process, stating that the logic inherent in determining what is in and out of Water Use Plans dictated that a choice must be made first about the best way to use water, and then changes in lieu of operations for that preferred choice could be entertained. This interpretation was not shared by all involved, and so the trade-off discussion proceeded, with Paul Wieringa (CCS) "agreeing to disagree" with the process.

After a discussions around the alternatives and the performance measures, the Consultative Committee was asked to note their level of support for the four alternatives proposed for Wilsey Dam (Status Quo, Alternative 2 (50% flow diversion), Alternative 3 (~33% flow diversion), and Alternative 4 (gated spillway) and write down their reasons for their choice.

The levels of support for each alternative were to fall into one of the three following categories:

- S - I fully support this alternative.
- A - I accept this alternative with reservations, but I can live with it.
- B - I block - I cannot live with it.

The responses were then collected from the Consultative Committee members and then revealed to the group as a whole. Consultative Committee members were given opportunities to change their responses. Three Consultative Committee members revised their choices at a subsequent meeting after gaining more information around the gated spillway option; two members switched from "block" to "support" for the gated spillway and one Consultative Committee member switched from "accept" to "support."

Table 6-5 Summary of Choices for Alternatives at Wilsey Dam

Alternative	Support	Accept	Block
SQ (Wilsey Dam)	3	5	4
Alternative 2	0	4	8
Alternative 3	0	3	9
Alternative 4 (Gated Spillway)	9	2	1

Given the tally in Table 6-5, it is clear that there is no consensus as to how to operate Wilsey Dam. The Consultative Committee as a whole put a very low value on the options that spilled water down the spillway to protect downstream interests. No one supported these options, and most people felt that these choices did not meet their minimum needs, and so they blocked them. However, some people did accept the alternatives that spilled water down the spillway since it met their minimum needs.

Both Status Quo and the gated spillway were fully supported by some, however both alternatives were also blocked by some, indicating that these alternatives did not meet their minimum needs.

Consultative Committee Recommendations for Operations at Wilsey Dam: The Consultative Committee could not reach consensus on operations at Wilsey Dam. As a result, no recommendations are being put forward.

The choices of individual Consultative Committee members, and their explanations for these choices, are noted in Table 6-6.

Table 6-6 Consultative Committee Members Choices and Rationales for Wilsey Dam Operations

Consultative Committee Member	SQ	Alt 2	Alt 3	Alt 4 (Gated Spillway)	Comments
Lee Hesketh (Landowner)	A	B	B	A	Lee could live with status quo, but cannot live with Alternatives 2 and 3. He was not sure that $1.5 million for a gated spillway is best use of money, especially given the uncertainty of the benefits.
Al Caverly (WLAP)	A or B	A	B	S	Alternative 3 is less than satisfactory and Al could not live with it, since gains to fish are not sufficient to offset financial costs and were highly uncertain. From Al's perspective, the probability of seeing gains under Alternative 2 was higher. SQ would be acceptable to Al only under two conditions: based on the confirmation that BC Hydro would continue to improve plant through other means to avoid/mitigate tripping, and based on the requirement that SQ will include a significant monitoring component. If there is not a significant monitoring component to SQ, then Al would have blocked this. Alternative 2 was preferred to Alternative 1 by Al; the loss in revenue was more than compensated by the gain in fish benefits.
BC Hydro (Hugh Smith and Brian Fast)	S	B	B	S	Gated option is the first choice for BC Hydro. Some evidence that outages are not having an impact at the population level (the Lister report), this is a low revenue plant, and outages will always occur on any system with a hydroelectric plant. However, the high fishery values and BC Hydro's commitment to avoiding impacts put this as the first choice. BC Hydro's commitment to public safety is also important, and spillway will only go ahead once public safety needs have been signed off on. Status Quo is also supported, recognizing that BC Hydro's commitment to improvements will continually improve performance. Alternatives 2 and 3 lose a lot of revenue. Given the current revenue of the plant, these fail to meet BC Hydro's minimum needs and are blocked.
Ray Arlt (NONA)					Absent
Tom Huwer (Landowner)	S	B	B	S	Tom was clear that he was frustrated with the process that allowed the consideration of a gated spillway, but not of changes to Sugar Dam. If the goal of the Water Use Plan process is to optimize the use of water, it was not clear to Tom why this should not include changing the structure of Sugar Lake Dam. Possible changes to Sugar Lake Dam may have benefits for many interests (e.g. fish, recreation on the reservoir, erosion on the reservoir, etc.). Tom also found that the fish interests carried too much power in this process, and other interests (such as flood protection) did not get the same consideration. Originally, Tom indicated that he would block Alternative 4 in protest to this. However, with more information around the benefits from the gated spillway, Tom decided he could support this. Status quo was fully supported, and Tom wrote that he cannot live with Alternatives 2 and 3.

Table 6-6 Consultative Committee Members Choices and Rationales for Wilsey Dam Operations - Cont'd

Consultative Committee Member	SQ	Alt 2	Alt 3	Alt 4 (Gated Spillway)	Comments
Joe Huwer (Landowner)	A	A	A	S	Joe originally indicated that he would block the gated spillway. However, at a subsequent meeting, he changed his vote to "support," in light of his increased understanding around the benefits from the gated spillway. Joe shared the sentiments of LeRoy P. and Tom H. in that he felt it was unfair that a gated spillway could be considered but changes to Sugar Lake Dam were outside of the scope of Water Use Plans.
Leroy Proctor[1,2] (Landowner)	S	B	B	A	Leroy felt that the gated spillway is the best option on the table, although he is not sure that it is the best use of the money. He could imagine other ways to spend the money that would yield larger benefits, but the group was not allowed to consider these. In particular, the group was not allowed to consider adding a fifth gate to Sugar Lake Dam. He protested that this definition of scope was not fair. Leroy said that he could live with SQ as well, but that he would block 2 and 3 since they were not reasonable.
Heather Stalberg (DFO)	B	A	A	S	Finding improvement to impacts from outages was one of the primary interests of DFO in this Water Use Plan. From DFO's perspective, Alternatives 2 and 3 provided enough improvement to outweigh the costs imposed. Alternative 4 would provide the largest improvement, and DFO felt that it would be money well spent even if the benefits at the population level are unknown. SQ does not provide any improvement and therefore does not meet the minimum needs of DFO.
Rudi Gedaschke (LDWA)	A	B	B	S	Rudi could live with SQ, but supported the gated spillway, because his interest is in protecting fish. He valued fish in this system so much that when he is away on a vacation, he dreams of these fish. Alternative 2 and 3 do not meet his minimum needs, and so he blocked them.

[1] The Consultative Committee made its choice around operational recommendations for Wilsey Dam in February 2002. At that time, LeRoy Proctor had indicated that he would accept the gated spillway option. Later in the same meeting, LeRoy noted that he wanted to block the whole process since the consideration of the gated spillway but not of any changes to Sugar Lake Dam was unfair. At the following Consultative Committee meeting, LeRoy indicated that he now understood more fully the reasoning that led to the consideration of the gated spillway and the benefits derived from the gated spillway, and changed his vote to "support."

[2] Leroy Proctor was listed as an observer to the process. However, he had attended Consultative Committee meetings and took part in the trade-off discussions and decisions.

Table 6-6 Consultative Committee Members Choices and Rationales for Wilsey Dam Operations - Cont'd

Consultative Committee Member	SQ	Alt 2	Alt 3	Alt 4 (Gated Spillway)	Comments
Monty Willis (KLR)	B	B	B	A	Monty felt that Alternatives 2 and 3 were not credible, given their cost. So these were blocked. The status quo causes damage to the environment, and if there is an outage, it could lead to a costly court battle between DFO and BC Hydro. Therefore, this is not acceptable either. Monty was concerned with the large uncertainty around what the spillway would look like, how it would operate, and how much it would cost. He felt that BC Hydro had not done its homework before presenting this option. But despite the uncertainty here, Monty felt that he could live with these reservations around the construction of the gated spillway.
Paul Wieringa (CCS)	S	B	B	B	Paul felt that the process leading to the consideration of the gated spillway was flawed. The options that spilled water are far too expensive when compared to the uncertain benefits. If given the choice between SQ and the gated spillway, Paul felt that SQ was the better choice. Moreover, he felt that he could not go to the government with a plan that committed to spending $1.5 million without a clear idea around what the province would be getting for this. Paul could imagine endorsing such a project on the river if the data supported it, but the performance measures were too qualitative and uncertain for him to be convinced in this case.
Larry Arcand (KLR)	B	B	B	S	Larry felt that outages would continue to be a problem at the plant, and so the only feasible option is the gated spillway. Therefore, the only option that he supported was the gated spillway option and that the benefits to the fish are worth the costs to the province.
Michael Curd (Landowner)	B	A	A	S	Michael felt that something had to be done for fish down the river, and SQ is not acceptable to him. Alternatives 2 and 3 he would accept, with some reservations, but Alternative 4 was, by far, the best option in his mind. He did not think that this was the best use of money on this river, but he supported it as an option.
Loretta Eustache (Spallumcheen Band)					Absent

6.3.1 Understanding People's Value Regarding Wilsey Dam Alternatives

Since all of the biological performance measures moved together, there were no trade-offs to be considered among adult fish, alevins, juveniles, and eggs. The only trade-offs were between biological impacts and financial impacts. This allows a measure of individuals' willingness to pay to achieve certain levels of protection from flow changes, and this measure can be recovered from individuals' levels of support for the four alternatives. This information is summed up in the tables below. In particular, three trade-offs are highlighted: spilling water vs. status quo operations (Table 6-7), installing a gated spillway vs. status quo operations (Table 6-8), and spilling water vs. building a gated spillway (Table 6-9).

Table 6-7 Individual Valuations of the Gains to Spilling Water Over Status Quo Operations

Diverting water from penstocks (Alternatives 2 and 3) vs. not diverting water from penstocks (Status Quo)	
The gains to protecting fish are not as great as the losses to power revenues.	Most Consultative Committee members rated Alternatives 2 and 3 below the Status Quo. In other words, they felt that the gains from diverting water from the penstocks to the spillway in order to protect fish were not worth the costs in terms of lost power revenue. These included: Lee H.(Landowner), Al C. (SQ vs. Alt 3) (WLAP), BC Hydro, Tom H. (Landowner), LeRoy P. (Landowner), Rudi G. (LDWA), and Paul W. (CCS)
The gains to protecting fish are about the same as the losses to power revenues.	Several Consultative Committee members rated Alternatives 2 and 3 as the same as SQ. This means that the gains from adopting Alternatives 2 or 3 were seen as roughly the same as the losses to power revenues in moving away from SQ. ▪ Larry A. (SLR) and Monty W. (KLR) blocked both the status quo and all options that diverted water from the penstocks to the spillway. ▪ Joe H. wrote that he accepted (with reservations) the status quo operations and the alternatives that divert water from the penstock to the spillway. ▪ Al C. accepted (with reservations) both the status quo operations and the alternative that shut down unit 1 (diverting about half the flows from the penstocks to the spillway). Notes from the meeting have Al C., ranking Alternative 2 higher than the status quo, meaning that the gains from diverting about ½ of the water from the penstocks deliver benefits that are worth more annually than the foregone revenues of $700,000.
The gains to protecting fish outweigh the losses to power revenues.	Two people stated a greater level of support for Alternatives 2 and 3 than for SQ. This means that they felt that the gains to protecting fish from diverting water away from the penstocks outweigh the losses to power revenues from doing so: Michael C. (Landowner) and Heather S. (DFO)

Table 6-8 Individual Valuations of the Gains from a Gated Spillway Over Status Quo Operations

Building a gated spillway vs. status quo	
The gains to protecting fish though building a gated spillway are not as great as the foregone financial costs	One person, Paul W. (CCS), rated the gated spillway lower than the status quo. That means that the expected gains to protecting fish from unplanned outages through building a gated spillway were not worth the financial costs of doing so for him.
The gains to protecting fish though building a gated spillway are about the same as the foregone financial costs	Three people rated SQ and the gated spillway as the same. This means that they felt the gains to protecting fish from unplanned outages through building a gated spillway were roughly equal to the financial costs of doing so. These included Lee H. (Landowner) (who accepted both alternatives with reservations), Tom H. (Landowner), and BC Hydro (both of whom supported both alternatives). Conversations from the meeting suggested that BC Hydro favoured the gated spillway over the status quo, indicating that the gains to the protection of fish were slightly more valuable than the cost to the province of the gated spillway.
The gains to protecting fish through building a gated spillway are worth more than the foregone financial costs.	About half of the Consultative Committee stating preferences rated the gated spillway higher than that of status quo operations at Wilsey Dam. This means that they valued the gains to fish protection from the gated spillway higher than the foregone costs borne by the province. These people included: Al C. (WLAP), Heather S. (DFO), Rudi G. (LDWA), Monty W. (SLR), Larry A. (KLR), Joe H. (Landowner), Michael C. (Landowner), and LeRoy P. (Landowner).

Table 6-9 Individual Valuations of the Gains to Spilling Water Over a Gated Spillway

Building a gated spillway vs. diverting water from the penstocks
The last comparison is between diverting water from the penstocks and building a gated spillway. Since the gated spillway delivered greater benefits across all measures at a lower cost, there was no trade-off to be considered here. All Consultative Committee members' final choices were consistent with this, showing equal or greater ratings for the gated spillway over the alternatives that diverted water from the penstocks.

6.4 Safety in the Wilsey Spillway

During an early Consultative Committee meeting, a concern was raised that individuals recreating in the spillway in the summer when it is dry may be at risk during an outage as water is re-routed from the penstocks. Initially, this concern was addressed through the use of a performance measure tracking the number of days in the summer where spills were greater than 3 m^3/s. But since this could be addressed as an alternative, maintaining a 3 m^3/s spill during August was presented as an alternative to the Consultative Committee

This 3 m^3/s spill was also felt by some Consultative Committee members to be a measure to improve the aesthetic appeal of the spillway. Early discussions around the aesthetics of the spillway led to the consideration of this 3 m^3/s spill as well for safety reasons.

BC Hydro estimated that it would cost up to $18,000 each August to maintain a minimum flow of 3 m^3/s down the spillway. However, discussions around the Consultative Committee revealed that the impact of this spill on safety was not clear. Some felt that it would deter people from the spillway, and some felt that it would entice them into the spillway. The cost seemed to most to be a high price to pay, and several people suggested that more cost-effective ways may be found to deter people from entering the spillway. Aesthetic considerations were not raised during this decision.

In the end, the Consultative Committee recommended that BC Hydro make safety a priority in designing and running the gated spillway. However, the means for achieving this (spills, gates, signs, sirens etc.) were to be left up to BC Hydro to decide upon.

Heather Stalberg (DFO) noted if the operating regime for the gated spillway, which was intended to address the impacts of unplanned outages and flow disruptions, was compromised to address public safety concerns, DFO would change its level of support for the gated spillway alternative at Wilsey Dam.

7 RECOMMENDATIONS FOR MONITORING

The Consultative Committee conducted four steps to reach its recommendations.

1. The Fisheries Technical Committee developed a list and rationale for sixteen proposed monitoring activities, totalling about $1 million in non-discounted costs across all years. Each proposal was initially screened using the decision tree provided by the Water Use Plan Management Committee to exclude proposals that were unlikely to contribute useful data for assessing the effectiveness of operating changes or provide basis for better decisions in the future. These sixteen preliminary proposals are summarized in Appendix Y.
2. Monitoring proposals were then evaluated using a simple qualitative ranking system to determine the overall value they would provide.

   - The *Importance Scale* reflects both: a) the importance of the resource and b) the extent to which the information is expected to influence a future decision. L indicates lowest importance; M indicates a medium importance, and H is highest. This first scale was an interpretation of the discussions, made by the BC Hydro facilitator (Basil Stumborg).

   - The *Statistical Power* Scale refers to the degree to which the study design can answer the questions posed. *High* means that the design will be able to make fine, quantitative comparisons, *medium* means that quantitative comparisons will be limited in number, *low* means that only qualitative comparisons are possible. *Baseline* means that this information is filling in data gaps, but is not being used in hypothesis testing. This information was generated by the Fish Technical Committee.

   - The *Overall Rank* reflects a) the importance of the resource b) the extent to which the information is expected to influence a future decision; c) inferential quality of the program, and d) cost-effectiveness. H indicates the highest priority and L is the lowest. This information was generated by the Fish Technical Committee.

Scores were used as a starting point for discussion at the sub-group level. There was a large divergence in opinions within the Fish Technical Committee regarding the technical assessments of these studies. In particular, there was a wide range of opinions within the sub-group regarding which studies had merit and which should be dropped from consideration. This range of opinion was brought forward to the Consultative Committee and formed a starting point for discussion at the Consultative Committee table.

3. This matrix was then presented to the Consultative Committee (see Appendix Z for the final list considered by the Consultative Committee), with the sub-group's overall rating of the study reported. Note that where there was no agreement, this rating was represented as a range of opinion. This matrix included proposals put forward from the sub-groups (all but two of these were related to fish, one was related to heritage issues around the reservoir and the other was related to flooding) and proposals generated through discussion at the Consultative Committee table. The Consultative Committee considered monitoring requests over two meetings, in light of the information contained in the matrix and criteria for monitoring proposals provided by the Water Use Plan Management Committee.

4. Each Consultative Committee member was then asked to indicate their level of support for each proposal. It was highlighted to Consultative Committee members that whether or not to recommend a monitoring proposal depended both on technical information (study design, statistical power, degree of uncertainty, etc.) but also individual values (willingness to have money spent to reduce uncertainty). Each Consultative Committee member could indicate their level of support for each study as:

   - Support
   - Block
   - Abstain (don't know)

The results of this poll are shown in Appendix AA.

There existed a wide range of support for a number of the proposals considered. Table 7-1 contains the list of the three study proposals that received unanimous support from the Consultative Committee. These will form the consensus recommendations for monitoring from this committee.

A number of other proposals considered received mixed levels of support. In particular, studies 1, 2, 6a, 7, and 10 received support from most of the Consultative Committee including BC Hydro, but not unanimous support (see Appendix Z for these details of these studies). Since the recommendations put forward by BC Hydro in the draft Water Use Plan to the Water Comptroller for monitoring may differ from Table 7-1, no further effort will be made to summarize the overall package of monitoring studies.

Table 7-1 Consensus Recommendations for Monitoring

Study ID	Study Area	Synopsis	Total Cost ($K)	Time frame	Duration (Yr)	Cost ($K/Yr)	Uncertainties	STAT POWER	Operational Implications	(Environmental) Implications	Notes
4	Sugar Inflow (SGR/SHU)	Provide flow gauging to assist estimation of instantaneous inflow into SGR.	$70	Next Water Use Plan	10	$7	Inflows to SGR are back calculated from uncertain reservoir level storage and discharge curves. These data were the basis for the power optimization model and all environment performance measures.	HIGH	Validating these data may change future decisions on water management and provide more accurate real-time estimates of inflows to SGR. In particular, these allow more predictability around the arrival of freshet, which may allow more operational options to be explored.	Under/over estimates inflow available during winter months when storage management decisions are critical.	Location of predictive inflow gauge was to be upstream Sugar Lake Reservoir or on Eagle Creek.
11	Shoreline Erosion around the Reservoir	Look for areas affected by reservoir operations. In particular, look at areas susceptible to erosion and estimate the potential amount of damage from operating up to 601.72.	$15	Next Water Use Plan	1	$15	Not sure the level of damage that will occur over time from erosion occurring at full pool level.		Consultative Committee could choose to keep reservoir 20 cm lower to achieve benefits.		
12	Monitoring Flood Interests	Install monitoring equipment so that flows below Wilsey and by Mara Lake are recorded on a daily basis.	$21	Next Water Use Plan		$21	Not sure what the actual relationship is between daily flows from Sugar Lake Dam, when flooding begins, and the magnitude of the flood.		Unclear whether BC Hydro can do anything to improve flood control.		DCP exists just below Wilsey Dam. Unclear whether BC Hydro can do anything to affect flooding during freshet or the summer.

8 SUMMARY OF RECOMMENDATIONS

These are the recommendations developed by the Shuswap Consultative Committee. This includes the modelling constraints defining the Status Quo option selected by consensus for Sugar Lake Dam Operations, the ramping restrictions selected by consensus for Sugar Lake Dam operations, the proposed monitoring program, and the review period.

8.1 Recommended Constraints for Sugar Lake Dam and Wilsey Dam Operations

BC Hydro reviewed this set of constraints recommended by Consultative Committee for operations at the Sugar Lake Dam in Table 8-1 and then provided a larger set of constraints that:

- Is fully consistent with the constraints chosen by the Consultative Committee.
- Is more complete, in that it is explicit in several areas where the constraints in Table 8-1 were silent.
- Will form the basis of the portion of the Water Use Plan that addresses Sugar Lake Dam operations.

Several examples where the constraints recommended in Table 8-1 are silent are:

- Minimum flows below Sugar Lake Dam
- Minimum flows below Wilsey Dam from 1 April to 14 August
- Minimum Spillway flow at Wilsey Dam

Table 8-1 Recommended Constraints for Sugar Lake Dam and Wilsey Dam Operations

Facility	Operating Variable	Target	When	Priority	Comments
Reservoir	Maximum Reservoir Level	601.72 m	Year round	Maximum normal operating level	
	Minimum Reservoir Level	Empty by 1 April (but do not empty to 594.7 m before 28 Feb)		High	
		601.22 m	1 Aug - 31 Aug 1 Sept - 1 Oct	Medium	Goal is to conserve water for spawning and incubation by keeping reservoir high
Sugar Dam	Minimum Sugar Discharge			High	
	Maximum Ramping Rate	See Table 8-4	Year Round	High	
Wilsey Dam	Maximum Discharge Below Wilsey	Gates open to maximize discharge during freshet, and staged stoplog installation as per dam safety.	1 May - 31 July	High	
	Minimum Spillway Flow	None required	Year round		
	Minimum Total Discharge Below Wilsey[1] [A] (minimum flow rates on a weekly basis in round brackets) [B] {minimum instantaneous flows on a daily basis in curly brackets}[2]	(18 m^3/s)[A] {16 m^3/s}[B]	15 Aug - 1 Jan	High	There is no direction to reduce flows to this. It is expected that flows will approach this minimum only during very dry years.
	(minimum flow rates on a weekly basis in round brackets) {minimum instantaneous flows on a daily basis in curly brackets}[42]	(15 m^3/s) {13 m^3/s}	1 Jan - 1 Apr	Medium	There is no direction to reduce flows to this. It is expected that flows will approach this minimum only during very dry years.[3]

The more comprehensive set of constraints can be found in Table 8-2 and Table 8-3

1 In expressing the constraints that constitute this alternative, the BC Hydro project team used minimum flow constraints that applied over a weekly timespan. For the 15 August to 1 January period, flows below Wilsey were to remain above 18 m^3/s. For the 1 January to 1 April period this restriction was 15 m^3/s. The BC Hydro project team pointed out that daily minimum flow restrictions that are consistent with these weekly restrictions are 16 m^3/s and 13 m^3/s, as noted in the Table above.

2 In his review of the draft Consultative Committee report, Al Caverly (WLAP) noted at this point the following: "we discussed this ±2 m^3/s as too high a variance," and "In practice, flows of 13 m^3/s may never occur except under extreme low flow circumstances." Al continued this thought at the last Consultative Committee meeting, noting that significant biological losses start to occur when flows go below 15 m^3/s.

3 In the winter to the start of the freshet, flows below Wilsey Dam are expected to be sustainable above the 15 m^3/s about 95% of the time, based on the 27 years of recorded inflow. Natural inflows downstream Wilsey during this the period may actually be 7.2 m^3/s.

Table 8-2 Recommended Constraints on Operations for the Shuswap Water Use Plan[1]

Facility	Operating Variable	Maximum Operating Limit	Minimum Operating Limit	Target	When	Priority	Comments
Sugar Reservoir[2]	Reservoir Level	601.72 m	594.7 m	None required	Year round	Normal operating levels	Incursions above the max. will occur while routing the freshet flows and summer and fall storms.
	Reservoir Level	601.72 m	601.22 m	None required	1 Aug - 31 Aug	Medium subject to: ▪ dam safety ▪ min flow down-stream of Wilsey	Goal is to conserve water for spawning and incubation by keeping the reservoir high.
	Reservoir Level	601.72 m		None required	1 Sept - 30 Sept	Medium subject to: ▪ dam safety ▪ min flow down-stream of Wilsey	Goal is to conserve water for spawning, rearing and incubation by keeping the reservoir high
	Reservoir Level	597.6 m		None required	1 Mar - 31 Mar	High	Goal is to evacuate storage prior to spring runoff for flood routing purposes, incubation power flows, and archaeological protection.

[1] Heather Stalberg (DFO) pointed out that there are some instances when BC Hydro should be directed to consult with regulatory agencies, even when it is not expecting to violate the constraints listed in this table. These instances are when BC Hydro anticipates approaching the lower flow constraints listed below Wilsey Dam. In such a case, Heather suggested that planning around flows needs to be made jointly between BC Hydro and the regulatory agencies. Al Caverly (WLAP) wanted information from BC Hydro when it anticipates approaching these low flow constraints, but was not seeking joint decision-making.

[2] Al Caverly (WLAP) noted that an objective for reservoir operations was also to maximize resident fish production. This goal does not match the time frames for the right hand column (the ice-free season).

Table 8-3 Recommended Constraints on Operations for the Shuswap Water Use Plan

Facility	Operating Variable	Maximum Operating Limit	Minimum Operating Limit	Target	When	Priority	Comments
Sugar Dam	Sugar Discharge	None required	5 m^3/s [1]	None required	1 May - 28 Feb	High subject to water available from storage	Use Sugar release to assist in meeting min flow downstream of Wilsey
	Sugar Discharge	None required	Min of: 5 m^3/s or [2] Sugar inflows	None required	1 Mar - 30 Apr	Subject to water available from storage	Use Sugar inflow to assist in meeting min flow downstream of Wilsey
	Sugar Discharge	None required	None required	Maximize discharge during freshet	1 May - 31 July	High subject to filling reservoir for summer	Gates and stoplog operation as required for dam safety and minimizing flood
	Ramping Rate		See Table 8-4				
Wilsey Dam	Minimum Spillway Flow	None required	None required	None required	Year round		
	Total Discharge Below Wilsey	None required	16 m^3/s min instantaneous minimum	None required	15 Aug - 31 Dec	High subject to water available from storage	There is no direction to reduce flows to this. It is expected that flows will approach this minimum only during very dry years.[3]
	Total Discharge Below Wilsey	None required	13 m^3/s instantaneous minimum	None required	1 Jan - 31 Mar	Medium subject to water available from storage	There is no direction to reduce flows to this. It is expected that flows will approach this minimum only during very dry years.
	Total Discharge Below Wilsey	None required	13 m^3/s instantaneous minimum		1 April - 14 Aug	Subject to water available from storage	
	Elevation	None required	None required	None required	All year		

1. Dry years are associated with low flows expected 5% of the time. In an unregulated system, these flows in a very dry year downstream of Wilsey Dam could be as low as 7.1 m^3/s.

[1] This constraint was not seen as acceptable to the DFO and the WLAP representatives, but time did not permit further discussion of this issue to discover more appropriate wording or more appropriate flows. Phrasing around fish conservation flows below Sugar Lake Dam was agreeable to BC Hydro, WLAP and DFO representatives.

[2] See footnote for Sugar Minimum Discharge, 1 May - 28 February.

[3] BC Hydro is confident that it can maintain these flows 95% of the time, based on the 27 years of recorded inflow.

In addition to the constraints in Table 8-2, BC Hydro suggested that the following paragraph accompany these operating constraints:

> BC Hydro shall operate Sugar Lake Dam within the stated minimum flows, minimum elevations, ramping rates and maximum elevations when ever possible under normal conditions. During emergency situations[1], outages, and in extreme low water conditions[2], BC Hydro may have to operate outside the above constraints. When it is anticipated that the above constraints will be violated for whatever reason, and when time permits, BC Hydro will review[3] with the appropriate federal and provincial agencies and seek direction from the Comptroller of Water Rights in selecting a flow regime that differs from the constraints listed above.

8.2 Recommendations Regarding Constraints on Ramping Rates

The set of recommended ramping restrictions developed through discussions between BC Hydro, DFO and WLAP are found in Table 8-4.

Table 8-4 Sugar Dam Discharge - Maximum Ramp Rates[4]

Time of Year	Life History Stage	Down Ramp Rate (cm/h)		Up Ramp[5] Rate (cm/h)	Maximum Daily Change	
		Day	Night[6]	Day/Night	Down	Up
1 April - 31 July	Fry Emergence	2.5[7]	2.5	5	15 cm	15 cm
1 August - 1 October	Rearing	2.5[8]	5	5	15 cm	15 cm
2 October – 31 March	Winter Rearing[9]	0	<5	5	15 cm	25% of current flow

1 Emergency: Emergencies include those required to address dam safety, actual or potential loss of system-wide power supply to customers, dam breach or potential dam breach, extreme flood flows, fire or explosion, environmental incidents, major equipment failure, or threat to employee or public safety. Notification will occur as outlined in emergency procedures. Heather Stalberg (DFO) and Al Caverly (WLAP) noted that this definition was not satisfactory since it was too broad. Time did not permit a full discussion of this definition, nor were the emergency procedures for BC Hydro made available.

2 BC Hydro is confident that the constraints on flows and reservoir elevations can be maintained for most conditions similar to those found in the 27-year inflow data set. Water conditions that are significantly different from those found in the 27-year data set are referred to here as extreme water conditions.

3 "Review," in this context, implies joint decision-making between BC Hydro and DFO and the appropriate provincial agencies.

4 The ramping rate is measured at WSC Gauging Station immediately downstream of Sugar Lake Dam.

5 Up ramp rates are specified for gate changes under normal operation. They are not intended to hinder flood routing, dam safety releases, or discharges during the spring freshet. The biological benefits of up ramping rates in this system have not been quantified by DFO, WLAP, or BC Hydro.

6 "Night" ramping to be initiated no earlier than 2 hours before sunset.

7 BC Hydro suggested that these are target restrictions due to equipment limitations. DFO wanted these as maximums.

8 BC Hydro suggested that these are target restrictions due to equipment limitations. DFO wanted these as maximums.

9 The Winter rearing period is intended to cover the period when water temperature is less than 7°C.

The constraints listed in Table 8-2 and Table 8-4 will form the recommendations for the Water Use Plan. BC Hydro has drafted a rough set of descriptors for how it anticipates that it will act within these constraints. These can be found in Appendix BB.

8.3 Additional Recommendations Made by DFO Regarding Communications Protocol

Heather Stalberg (DFO), upon her review of the draft Consultative Committee report, suggested that some additional communications protocol be implemented. These were presented to the Consultative Committee during the last Consultative Committee meeting and are attached below in the following eight points:

1. DFO requested a current posting of the data that is sent to them now (e.g. reservoir elevations, gate changes, discharges), perhaps on a BC Hydro website. Some Consultative Committee members wanted this updated daily. BC Hydro could not be specific about what they could post and when.
2. DFO requested that BC Hydro provide this information in graph form, similar to the graphs found in Appendix BB to track Sugar elevation and Wilsey discharge. It was suggested that this can also be on the BC Hydro website.
3. DFO requested sufficient notice prior to (e.g. dam safety release, large planned changes in releases) or concurrent (e.g. outage) of flow perturbation outside of normal operations. Notice should include why perturbation occurring, when it will occur, how it will be managed e.g. duration.
4. DFO requested that proposed maintenance or other works that may affect flows will be forwarded to the appropriate agencies for review (e.g. Wilsey forebay dredging).
5. DFO requested that a mid-April summary of snowpack and long-term weather forecasting could be communicated by BC Hydro. Hydro should then also communicate the projected flow regime (e.g. 15 September) and then if there are any changes upon receiving, or not, the "fall rains" further updated 15 November. The data communicated would include reservoir level, and other flow forecasting information communicated in a graphic format where useful.
6. DFO requested an annual summary of Wilsey discharge (which can be met via No. 2).
7. DFO requested an initiation of discussions when flows are first projected to drop down to18.4 m^3/s (650 cfs) during 15 August to 31 December.[1]

[1] Heather Stalberg (DFO) further requested that flows dropping below 18.4 m^3/s should initiate consultation with this threshold holding across all months. BC Hydro suggested that the threshold of 15 m^3/s should apply only from

These discussions would be initiated to assess availability of stored water until freshet and the options and the risks of various future flow regimes These discussions would also determine the planned flows, the reduction of range in gate settings to reduce variability (e.g. too high above base flow or too much variation on the low side sets productivity even lower), and situations for further consultations.

8. DFO requested access to the flow data from previous years or months.

8.4 Comments on BC Hydro's Likely Operations Within the Recommended Constraints

The constraints listed above for longer term operations at Sugar Lake Dam and for ramping restrictions at Sugar Lake Dam will form the recommendations for the Water Use Plan. BC Hydro has drafted a rough set of descriptors for how it anticipates that it will act within these constraints. These can be found in Appendix BB. These descriptors were provided to the Consultative Committee for their information. Some Consultative Committee members had some concerns about BC Hydro's stated intentions. Comments around these descriptors can be found as footnotes in Appendix BB.

8.5 Monitoring Recommendations

The Shuswap Water Use Plan Consultative Committee recommended that monitoring studies be carried out. A summary of these studies, including the estimated costs, time frame, duration, uncertainties and operational and environmental implications, is provided in Table 8-5.

1 January to 31 March. Al Caverly (WLAP) noted that the communication triggers suggested by BC Hydro are acceptable.

Table 8-5 Monitoring Studies Receiving Consensus Recommendation[1]

Study ID	Study Area	Synopsis	Total Cost ($K)	Time frame	Duration (Yr)	Cost ($K/Yr)	Uncertainties	STAT POWER	Operational Implications	(Environmental) Implications	Notes
4	Sugar Inflow (SGR/SHU)	Provide flow gauging to assist estimation of instantaneous inflow into SGR.	$70	for next Water Use Plan	10	$7	Inflows to SGR are back calculated from uncertain reservoir level storage and discharge curves. These data were the basis for the power optimization model and all environment performance measures.	HIGH	Validating these data may change future decisions on water management and provide more accurate real-time estimates of inflows to SGR. In particular, these allow more predictability around the arrival of freshet, which may allow more operational options to be explored.	Under/over estimates inflow available during winter months when storage management decisions are critical.	
11	Shoreline erosion around the reservoir	Look for areas affected by reservoir operations. In particular, look at areas susceptible to erosion and estimate the potential amount of damage from operating up to 601.72	$15	for next Water Use Plan	1	$15	Not sure the level of damage that will occur over time from erosion occurring at full pool level.	BASE	Consultative Committee could have chosen to keep reservoir 20 cm lower to achieve benefits.		
12	Monitoring flood interests	Install monitoring equipment so that flows below Wilsey and by Mara Lake are recorded on a daily basis.	$21	for next Water Use Plan		$21	Not sure what the actual relationship is between daily flows from Sugar Lake Dam, when flooding begins, and the magnitude of the flood.	BASE	Unclear whether BC Hydro can do anything to improve flood control.		DCP exists just below Wilsey Dam. Unclear whether BC Hydro can do anything to affect flooding during freshet or the summer.

[1] Of the three studies reported here, one was copied from the final Consultative Committee meeting notes of February 2002, and two were developed in the March 2002 meeting. Upon her review of this Table in the March 2002 Consultative Committee meeting notes, Heather Stalberg (DFO) noted the following at this point: "I have reviewed the monitoring Table two or three times and made suggested revisions throughout which I see are still not incorporated and the Table remains inaccurate as a result. Please refer to my review comments of the last meeting minutes in which we reviewed monitoring for these comments and edit as appropriate."

8.6 Review Period[1]

BC Hydro will report out annually on flows and elevations from that year, and on monitoring data collected. At the end of the monitoring program (which is expected to take about 5 years after Water Use Plan approval), BC Hydro will conduct a complete, informal review of the data collected.[2]

Participants in this informal review of the monitoring data will include:

- BC Hydro
- Federal Fisheries Agency
- Provincial Environmental Agency (as appropriate)
- Spallumcheen Band
- An individual representing each of the other interests at this table: flooding, recreation, reservoir interests (from the Consultative Committee, if possible)

At this informal review, information collected will be used to reassess the choice of the Consultative Committee in recommending the Alternative SQ. If the updated information suggests that the SQ alternative[3] is being outperformed by other alternative uses of water, then a formal review of the Water Use Plan can be requested from the Comptroller of Water Rights.

If an analysis of the information collected indicates that SQ is still outperforming the other alternatives, then a formal review is recommended to occur 10 years after the Water Use Plan has received approval from the Water Comptroller.

[1] This section is not to address monitoring around compliance.

[2] Upon review of this passage, Heather Stalberg (DFO) noted at this point, "Currently we don't know what will even be in the monitoring program. It could be very thin on the fisheries side and thus provide little insight into the impacts of the operations. This provides further support to the need to also include the operational data e.g. hydrographs delivered, installation date of collapsible dam, exceedences of constraints in an annual review and in the 5-year time."

[3] Upon review of this passage, Heather Stalberg (DFO) noted at this point, "is this just limited to the existing set of alternatives? Also, there may be opportunity to "tweak" the alternative and this needs to be captured in the wording here. Also, how will we know that it is being outperformed by other alternatives? Is there going to be model runs of our performance measures for the annual hydrographs? Given the uncertainties within the models and uncertainties about what monitoring is going to be done, field observations from agencies doing their own monitoring need to somehow be incorporated into this."

As outlined in Step 13 of the *Water Use Plan Guidelines*, a review may also occur at any time if a) the licensee (BC Hydro) requests one, or b) if a new water use or conflict arises, then a review can be ordered by the Water Comptroller. The above recommendations are not meant to supersede these additional guidelines.

9 REFERENCES

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APPENDIX A: DAM SAFETY SCHEDULE FOR STOPLOG AND GATE OPERATION FOR SUGAR LAKE DAM

Current Stoplog Operation Guidelines [1]

Date	Maximum Stoplogs	Determining Factors	Sugar Reservoir Free-Spill Elevation	Why
15 April - 15 June	0-2	depending on snowpack	El. 600.00 - 600.61 m	To ensure a Max flood level of 604.20 m due to max PMP [2] (rain) and snowpack
15 June - 30 June	3	install after peak of freshet has passed	El. 600.91 m	To ensure a Max flood level of 604.20 m due to max PMP (rain) and snowpack
After 1 July	4	provided daily inflows are <85 m^3/s due to snowpack depletion	El. 601.21 m	To ensure a Max flood level of 604.20 m due to max PMP (rain) and partial snowpack
After 1 July	6	Provided daily inflows are <50 m^3/s due to snowpack depletion	El. 601.72 m No requirement to pull stoplogs, but gates would be operated to limit reservoir level.	To ensure a Max flood level of 604.20 m due to max PMP (rain) and little or no snowpack

1. BC Hydro carried out upgrades to Sugar Dam in 2000 to 2002. Until completion of the upgrade the maximum number of stoplogs installed after 1 July was limited to 5. The table above reflects the stoplog operating guide for Sugar Lake Dam once the work is complete.
2. PMP = Probable Maximum Precipitation.

APPENDIX B: THE INFLUENCE OF BC HYDRO OPERATIONS ON MABEL LAKE ELEVATIONS

The following memo was distributed to the Consultative Committee in the fall of 2000:

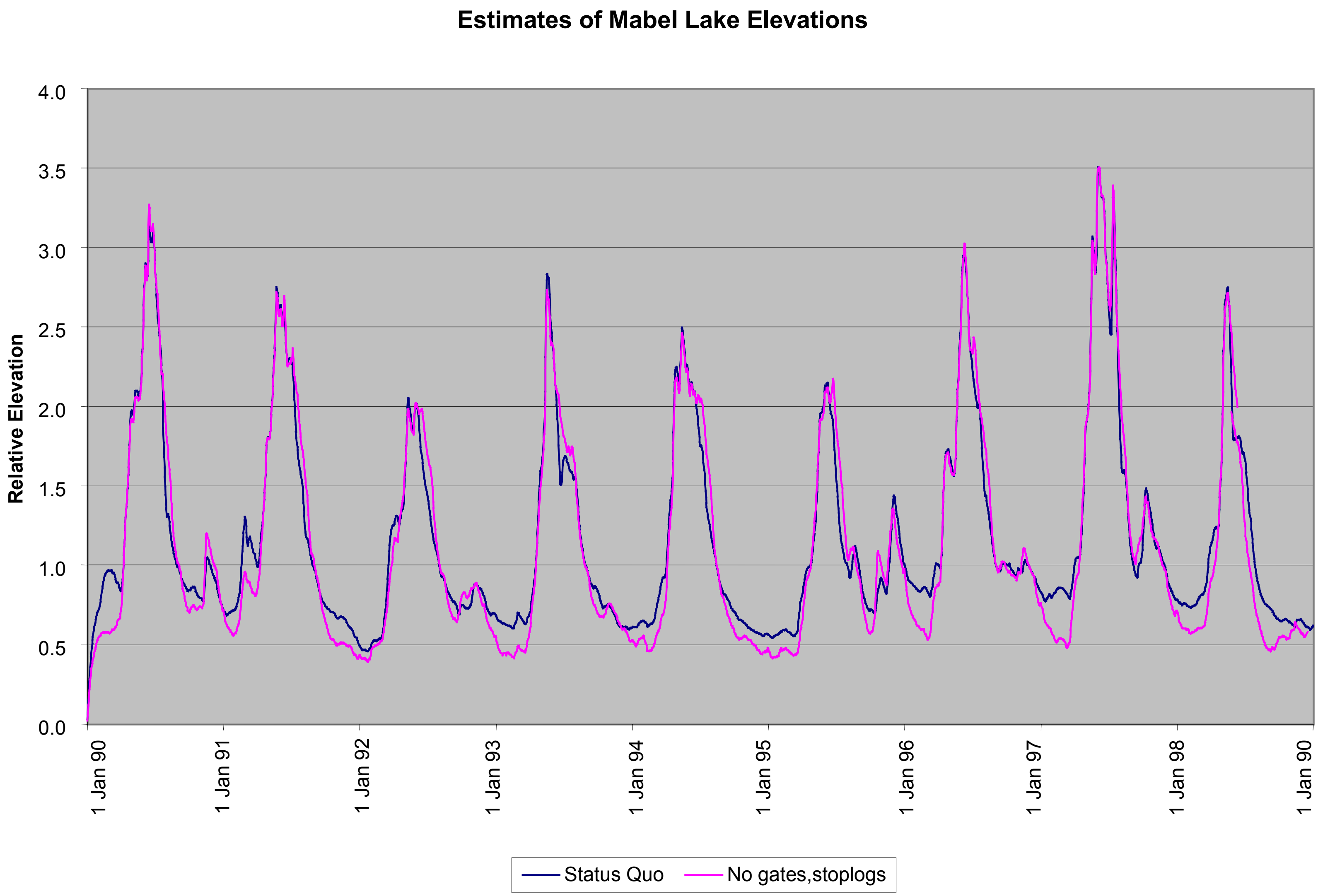
To: Consultative Committee Members

The Shuswap Water Use Planning Committee has requested that the BC Hydro project team provide some estimates as to the influence of Hydro operations on the elevation of Mabel Lake. This information has been requested in several instances, most recently in trying to determine the impact of possible changes in operations on wildlife in that area.

To answer this question, an extreme alternative was assumed for the basis of comparison. In this case, historical operations were compared against an operation where no stoplogs were used and the gates on the Sugar Lake dam were kept open all year round. It is assumed here that any actual changes arising from in the Shuswap Water Use Plan will lie somewhere between historical operations and this extreme alternative. Therefore, *this example most likely overstates the impact of changes in operations on elevations in Mabel Lake.*

The graph on the following page compares elevations resulting from historical operations (labelled 'status quo' and in blue) with the extreme alternative of no stoplogs and gates always open (in pink) over several years. To aid in this comparison, a year was broken into three seasons, and average elevations were computed across the years. The results are shown in the table below:

	Gates open, no stoplogs	**Historical Operations**
Summer (16 April - 15 August)	2.0 m	1.9 m
Fall (16 August - 31 December)	0.8 m	0.8 m
Winter (1 January - 15 April)	0.6 m	0.8 m


Estimates of Mabel Lake Elevations
Relative Elevation
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1 Jan 90
1 Jan 91
1 Jan 92
1 Jan 93
1 Jan 94
1 Jan 95
1 Jan 96
1 Jan 97
1 Jan 98
1 Jan 90
Status Quo
No gates,stoplogs

APPENDIX C: SUMMARY OF COMMUNICATIONS WITH FIRST NATIONS

Spallumcheen Band

On 15 November 1999, BC Hydro met with the Natural Resources Coordinator for the Spallumcheen Band. During a 2-hour meeting the steps in the Water Use Plan guidelines were discussed in detail and the band's participation, and capacity funding, were covered. The band was in the midst of electing a new chief and council, and was therefore unable to determine its interest in participating until the New Year. On 28 February 2000, BC Hydro made a formal presentation to the new chief and council regarding Water Use Planning in general, and the Shuswap Water Use Plan in particular. Also in attendance were Fred Fortier of the BC Aboriginal Fisheries Commission, and Keith Matthew of the First Nations Water Use Planning Committee. At the time the band was unclear about their intention to participate and remained that way over the following months.

During this time, the Natural Resources Coordinator was added to the Water Use Plan contact list and was sent all meeting notifications, materials and notes. During the scoping phase, and facility tours, the band sent a number of different representatives, including, on one occasion, the chief. After the 8 June Consultative Committee meeting they then settled on one representative and formally committed to participate in the process, at the main table.

Shuswap Nation Tribal Council

After the formal notification and invitation was sent to the Shuswap Nation Tribal Council (SNTC), telephone discussions eventually took place, in November 1999, with the director of the Shuswap Nation Fisheries Commission (SNFC). Through discussion he informed BC Hydro that the SNTC would prefer to let the Spallumcheen Band take the lead for the Shuswap Nation. However, the SNFC would monitor the progress of the Water Use Plan and, when invited by the Spallumcheen Band, take part in any technical committees or reviews, particularly those related to fish. The director did confirm that the Spallumcheen Band would have the primary interest of all the bands within the Shuswap Nation. In June 2000, BC Hydro spoke to the interim director of the SNFC, who confirmed they would follow this course, set out by his predecessor. An invitation to attend meetings as an observer or to contact BC Hydro with concerns or questions was extended.

Okanagan Nation Alliance and Okanagan Band

The Chief's Executive Committee for the Okanagan Nation Alliance (ONA) in compliance with the ONA consultation guidelines was sent formal notification and invitation to participate in the process in November 2000. This committee and many of the Nation's bands were in the midst of electing new councils, and therefore actual discussion was not possible before the New Year. They did, however direct us to formally invite a member band, the Okanagan Band, who might have a territorial interest in the Water Use Plan. The letter of invitation was sent on 17 December 1999.

Early in the New Year, follow–up discussions took place with Natural Resources coordinators for the ONA and Okanagan Band. In February the ONA and Okanagan Band together appointed one representative, an Okanagan Band councillor and chairman of the Okanagan Fisheries Commission. He and his alternate were then placed on the contact list and sent all subsequent materials, including meeting notifications. On 15 March 2000, at the request of the ONA staff, BC Hydro provided a formal Water Use Plan presentation to the ONA Natural Resources Committee. The ONA representative and his alternate were sent invitations to the pre-scoping meetings and the Consultative Committee meetings accompanied by personal phone calls. Despite all efforts to have them attend these meetings, even after their assurances that they would attend, neither attended any meetings.

On 30 May 2000 the ONA representative, via e-mail and a subsequent telephone conversation, informed BC Hydro that the ONA would suspend their participation because of what he said were unresolved differences with DFO and MELP. He did not consider BC Hydro to be a government agency and therefore, these matters were to be resolved between those agencies only. BC Hydro left the door open for their return, with a caution that it would be difficult to re-engage in the process with the passage of too much time. BC Hydro also committed to keep the ONA and Okanagan Bands informed of progress by continuing to send Water Use Plan materials in the fashion they previously requested.[1]

[1] Heather Stalberg (DFO) noted upon review of this report that the details of the consultation process outlined above were not provided to DFO during the process.

APPENDIX D: OBSERVERS OF THE SHUSWAP WATER USE PLANNING PROCESS

Observer	Representing
George Abbott	Member Legislative Assembly
Marc Angelo	Outdoor Recreation Council of B.C.
Wes Barton	Resident
Pieter Bekker[1]	MSRM - Water Management Branch[2]
Tom Christensen	Member Legislative Assembly
Les Deuling	NORD Director, Area D
Terry Deuling	Resident
Eugene Foisy	NORD Director, Area E
Miles Hopkins	Kal Lake Fly Fishers
Bill Huwer	Resident
James Huwer	Resident
Brian Jones	Mabel Lake Community Club
Jim Johnson	Resident
Frank Kelsey	Resident
Joanne Kineshanko	Mayor - Lumby
Roger Lucas	Local Resident
Bill McGiverin	Councillor - Village of Lumby
Barry Moore	Kal Lake Fly Fishers
LeRoy Procter	Resident
Dennis Roberts	Shuswap Environmental Action Society
Rob Smailes[3]	North Okanagan Regional District
Ian & Charmaine Templeton	Residents
Jean Tuominen	NORD Director, Area F
Joseph Werner	Landowner – Mara
Ted White	MSRM, Water Management Branch
Stephan Wolski	Shuswap Fish Hatchery

1. Changed from Consultative Committee Member to Observer.
2. Ministry of Sustainable Resource Management, formerly Ministry of Environment, Lands, and Parks.
3. Changed from Consultative Committee Member to Observer.

APPENDIX E: TERMS OF REFERENCE FOR THE SHUSWAP WATER USE PLAN CONSULTATIVE COMMITTEE

Introduction

The purpose of this Terms of Reference (ToR) is to outline our mandate and describe guidelines for the Shuswap River Water Use Plan Consultative Committee (CC).

Mandate

The mandate of the Shuswap River Water Use Plan Consultative Committee (CC) is to collaboratively develop a recommended operating regime for the BC Hydro facilities on the Shuswap River. This operating regime will consider the needs and interests of all participants on the Consultative Committee.

The BC Hydro facilities include the Sugar Lake Reservoir, the Sugar Lake (Peers) Dam, the Wilsey Dam, and the Shuswap Falls Generating Station. Specifically, the Water Use Plan will define the operation of the gates, spillways, bypasses, and related emergency equipment and procedures that control the flows of the water in Shuswap River.

Resource values include, but are not limited to:

- Fish and wildlife
- Agriculture
- Property
- Recreation
- Heritage and cultural conservation
- Water licences
- Power generation

Scope

The scope of the Consultative Committee's deliberations will include those issues and values within BC Hydro's control (e.g. water flows, rate of change in flows, and water levels in the Sugar Lake Reservoir and in the Shuswap River). Geographically, the scope will include Sugar Lake Reservoir, the Shuswap River from Sugar Lake Reservoir to Mabel Lake, Mabel Lake, and the Shuswap River from Mabel Lake to Mara Lake.

As a general guideline, on-topic issues are those that are affected by BC Hydro's influence on water levels or flows in the Sugar Lake Reservoir/Shuswap River system. If the Consultative Committee is uncertain whether or not an issue is Water Use Plan related, it may seek clarification from the Water Use Plan Management Committee.

The decision-making process will follow the steps described in the provincial government's Water Use Planning Guidelines.

At times, the Consultative Committee may decide that an issue raised by a participant is related to the Shuswap River, but is outside our mandate. For these, the Consultative Committee will note the issue and refer the issue to the appropriate agency.

Membership

Participation on the Shuswap River Water Use Plan Consultative Committee is open to individuals and organizations with an interest in the operations of the BC Hydro facilities on the Shuswap system. Participants will be invited from federal, provincial, and community governments, First Nations, non-government organizations, the general public, BC Hydro, and other groups with an interest in Sugar Lake Reservoir or the Shuswap River. BC Hydro will have two Corporate representatives at the Table.

Member's responsibility

For the efficient and smooth functioning of the Consultative Committee, as a participant you are responsible for:

- Attending each meeting of the Consultative Committee and any meetings of subcommittees or working groups to which you belong.
- Communicating with members of your organization by relaying proceedings of the Consultative Committee to your constituents and bringing constituents' concerns to the Consultative Committee.
- Preparing for each meeting by reading meeting minutes, studies, subcommittee reports and other material distributed as part of this consultative process.
- Designating an alternate representative to attend in your place if you cannot attend.
- The designated alternate should be familiar with the discussions, past minutes, and other material distributed by the Consultative Committee. The alternate should become familiar with these Terms of Reference.
- If the main representative and the alternate are both present at a meeting, only one can be the spokesperson for the organization at the meeting.
- Indicating to the other members of the Consultative Committee if your agreement is subject to approval from your constituents or superiors.

New Members

The final membership of the Consultative Committee will be established upon adoption of these Terms of Reference. However, new members may apply to join the Consultative Committee:

- By submitting a written request for membership to the Committee[1]; and
- By appearing before the Consultative Committee at a regular meeting to describe what issue they represent and why their interests are not already adequately represented at the Table.

The Consultative Committee will consider the request for membership and decide on the merits of the application. If the applicant is successful, she/he must:

- Agree to abide by these Terms of Reference.
- Accept agreements made previously by the Consultative Committee.
- Become familiar with the past work of the Consultative Committee including reviewing meeting minutes and material distributed by the Consultative Committee.

ROLES

Members of the Consultative Committee

Members of the Consultative Committee have the task of listening to and understanding the various interests around the Table. The Consultative Committee will collaboratively develop recommendations for a water use plan that best meets the needs of all those interests.

Subcommittees or Working Groups

At times, the Committee may find it useful to form subcommittees or working groups to tackle specific or technical issues. These subcommittees will be guided by instructions from the Consultative Committee and report back findings and results to the Consultative Committee. Subcommittees and working groups need to remain cognizant of the key questions being asked at the Consultative Committee main table.

These Terms of Reference and guidelines for discussions also apply to subcommittees and working groups.

[1] Prospective applicants can contact Mary Algar (Tel: 250 549-8531) at BC Hydro, Vernon.

Facilitator/Analyst

The facilitator/analyst serves the Consultative Committee by helping the Table progress through the Water Use Planning process by:

- Creating a collaborative problem solving environment for the Consultative Committee.
- Promoting creative thinking to overcome road blocks and obstacles.
- Being respectful of participant's time and making the best use of meeting Committee time.
- Coordinating the consultative process with the BC Hydro Project Team.
- Remaining objective and impartial between the parties at the Table.
- Remaining open to suggestions on process and procedures.
- Providing written notes of meeting discussions with the objective of delivering the notes within 1 week of the meeting.
- Providing a final Consultative Report with sign-off by the process participants which will document, at a minimum: objectives & measures, alternative operating parameters and implications (i.e., objectives by alternatives matrix), areas of agreement and disagreement (with rationale) across alternatives.

BC Hydro

BC Hydro has two Corporate Representatives at the Table representing corporate interests and participating in Consultative Committee decision-making. In addition, the BC Hydro Project Team provide logistical and technical support to the consultative process, however, the project team does not participate in decision-making at the Table. The BC Hydro Project Team will provide support to the consultation process by:

- Providing technical advice and support on resource valuation, power studies, operations, and the environment, among other topics.
- Arranging facilities and notice for meetings, open houses, and other venues to complete the Water Use Planning process.
- Arranging for an independent facilitator/analyst to support the Consultative Committee in its work.
- Maintaining communications with interested parties.
- Reproducing and distributing materials to members of the Consultative Committee and other interested parties.

- Assisting with preparation of the Consultation Report.

Observers and Guests

Members of the public and the media are welcome to observe at Consultative Committee meetings[1]. Upon request, and preferably with advance notice to adjust the agenda, there will be opportunities for observers to make comments to the Consultative Committee.

The Consultative Committee may invite guest speakers to provide a technical presentation, or to respond to questions, on a subject relevant to the Shuswap Water Use Plan. The guest presentation will be scheduled as an agenda item at an upcoming meeting.

Note: Observers and guests will not be able to participate in decision-making during a meeting.

Communications

The Consultative process is intended to be an open, transparent process. As such, communications with people and organizations outside the Table are encouraged. Guidelines for communications:

- Consultative Committee meetings are open to the public and media (see above).
- BC Hydro, as the licensee, will be the spokesperson (Vesta Filipchuk - Project Manager, Mary Algar or Bob Gammer - Communications) for information on BC Hydro's operations, facilities, and the Water Use Planning Process. BC Hydro can direct the media to specific members of the Consultative Committee depending on the topic.
- The Consultative Committee may request the facilitator to be the spokesperson on the progress of the water use planning process. The facilitator may direct the media to specific members of the Consultative Committee depending on the topic. The facilitator and members will be supported by BC Hydro's community relations/communications task manager
- Consultative Committee members making statements to the media or the public should be respectful of others at the Table and the process. Unless authorized by the Consultative Committee to be a spokesperson, individual members will not represent themselves as spokespersons for the committee.
- BC Hydro will periodically release newsletters, news releases, or media updates describing the Water Use Planning Process and the Committee's progress.

[1] Interested observers are asked to contact Mary Algar (Tel: 250 549-8531) or Bob Gammer (Tel: 250 549-8553) at BC Hydro, Vernon for information about attending a Consultative Committee meeting or to make comments to the Committee.

GUIDELINES FOR COMMITTEE DISCUSSIONS

Interest Based Discussions

Committee members will focus on interests and needs rather than positions. Focusing on interests and needs creates more opportunities for an all-inclusive, long-lasting solution than does focusing on positions. Positions are predetermined solutions that do not necessarily consider the needs of others. Interest based decision-making includes:

- Focusing on interests, not positions
- Focusing on the issues, not the messengers
- Generating criteria (objectives) for what we want the solution to achieve
- Generating a variety of possible solutions
- Evaluating the solutions against the criteria/objectives
- Selecting the solution that best meets everyone's needs

Guidelines for discussions

- Focus on interests and needs, not positions.
- Separate the problem from the person; focus on the issue, not the individual.
- Listen to understand before speaking.
- Explore other points of view, ask questions.
- Contribute to and participate in collaborative learning.
- Differences of opinion are okay.
- Accept that concerns and interests of others are legitimate and real.
- Respect each other.
- One speaker at a time, let others finish speaking before speaking.
- Respect the Committee's time; recognize when discussions drift off-topic
- Work cooperatively towards solutions that best meet as many interests and needs as possible.

Consensus Decision-making

Consensus building is the process of tackling problems together and to collaboratively develop solutions that takes into account all stated needs. When the Consultative Committee agrees that a particular solution is the best and that all members are able to live with the decision, we will have reached an agreement by consensus.

When a solution involves many parts, consensus agreement is agreement on the whole package. There may be some parts that do not entirely satisfy a stakeholder's interests, but on the whole, we are in agreement on the entire package.

An agreement need not be a final decision. The Consultative Committee may decide to revisit an agreement:

- if new information becomes available relevant to a past decision.
- if by consensus, the Consultative Committee decides it needs to review specific agreements that are part of a larger, final package of agreements.

Non-Consensus

If the Consultative Committee is unable to reach an unanimous agreement, then dissenting members will be responsible for describing what part(s) of the agreement does not meet their needs and what are possible alternative and acceptable solutions?

Consensus on the Final Consultative Committee report

At the end of the consultation process, the Committee will sign-off on a report describing the Water Use Plan consultation process and the preferred recommendation for an operating regime. In the event that we are unable to reach an unanimous agreement on a preferred operating regime, the report will tally the three levels of agreement on the solution:

- **Endorse**: endorse fully or with minor reservations
- **Accept**: Support the Consultative Committee's decision and minimum needs are met, but disagree that the solution is the best.
- **Block**: Minimum needs are not met and cannot support the decision

COMMITTEE BUDGET

Data Gap Studies

BC Hydro has allotted a budget for undertaking studies to answer questions relevant to water use planning for the Shuswap River. The Consultative Committee will decide how this budget is to be allocated among the candidate studies proposed by members of the Consultative Committee, subcommittees, and working groups.

Reimbursement guidelines

BC Hydro will arrange for meeting facilities and refreshments, communications, photocopying, and similar support to the Consultative Committee. Committee members are not expected to incur or absorb such costs. At the same time, there will be no reimbursement to Consultative Committee members for minor expenses associated with attending meetings.

Revisions

These Terms of Reference may be revised by a consensus of a quorum of 2/3 of active members of the Consultative Committee.

APPENDIX F: SHUSWAP WATER USE PLANNING: SUBCOMMITTEES' MEMBERSHIP

Individuals who attended one or more subcommittee meetings

A. RECREATION SUBCOMMITTEE

Subcommittee Member	Affiliation
Larry Arcand	Sugar Lake Resort
Pieter Bekker	Ministry of Sustainable Resource Management - Water Branch
Alan Caverly	Ministry of Water, Land, and Air Protection
Michael Curd	Resident
Robin LeDrew	Resident
Kirk Mallette	Recreation (Paddling)
Basil Stumborg	BC Hydro (Facilitation)
Bob Westcott	BC Hydro
Monty Willis	Kokanee Lodge and Resort
Tony Wong	Facilitation

B. Property Flooding and Bank Erosion (River and Sugar Lake Reservoir) Subcommittee

Subcommittee Member	Affiliation
Alan Caverly	Ministry of Water, Land, and Air Protection - Fish and Wildlife Section
Dave Couch	Resident – Mara
Lee Hesketh	Landowner
Joe Huwer	Landowner
Tom Huwer	Landowner
Kim Meidal	BC Hydro (Power Studies)
Erin Nelson	North Okanagan Naturalists Club
Dave Percell	BC Hydro
LeRoy Procter	Landowner
Basil Stumborg	BC Hydro (Facilitation)
Ron Trickett	Landowner
Tony Wong	Facilitation

C. First Nations Heritage and Archaeology Resources Subcommittee

Subcommittee Member	Affiliation
Loretta Eustache	Spallumcheen Indian Band
Lorrie MacGregor	BC Hydro Aboriginal Relations Department
Basil Stumborg	BC Hydro (Facilitation)
Bob Westcott	BC Hydro
Tony Wong	Facilitation

D. Fish and fish habitat (Reservoir and River) - Fish Technical Committee FTC

Subcommittee Member	Affiliation
Larry Arcand	Sugar Lake Resort
Ray Arlt	North Okanagan Naturalists Club
Neil Brookes	Mabel Lake & Kingfisher Ratepayers Assoc., and the Kingfisher Environmental Interpretative Centre
Alan Caverly	Ministry of Water, Land, and Air Protection - Fisheries Branch
Loretta Eustache	Spallumcheen Indian Band
Lee Hesketh	Landowner
Vic Lewynsky	BC Hydro (Environment)
Tom Minor	White Valley Community Resources Centre
Darren Sherbot	BC Hydro (Environment)
Basil Stumborg	BC Hydro (Facilitation)
Heather Stalberg	Fisheries and Oceans Canadaa
Hugh Smith	BC Hydro (Corporate Representation)
Bob Westcott	BC Hydro (Environment)
Monty Willis	Kokanee Lodge and Resort
Tony Wong	Facilitation

APPENDIX G: SHUSWAP WATER USE PLAN CHRONOLOGY AND KEY ACHIEVEMENTS

Water Use Plan Guideline Step	Key Activities and Consultative Committee Meetings
Step 1: Initiate Water Use Plan	**Fall 1999** ▪ Review 1994 Electrical System Overview Review for Shuswap Facilities for potential issues ▪ Make contact with local, regional, and provincial government representatives and First Nations; solicit potential Water Use Plan issues **Initiate Shuswap Water Use Plan March 2000**
Step 2: Issues Scoping	**March 2000** ▪ Invite environmental, recreation, and business interest groups to participate ▪ Issue public announcement of Water Use Plan process with invitation to open houses ▪ Hold three open houses, one each in Lumby, Cherryville, Kingfisher **April 2000** ▪ Meet with stakeholders to complete list of potential Water Use Plan issues and identify potential Water Use Plan committee members **May 2000** ▪ Hold facilities tour to reservoirs and powerhouse for committee members
Step 3: Determine the Consultative Process Step 4: Develop objectives and performance measures	**Begin Consultative Committee meetings 8 June 2000** ▪ Confirm committee members (main representative and alternates, observers) ▪ Presentation on structured decision-making process (Water Use Plan Guideline steps) ▪ Begin exploring interests around Consultative Committee table and developing objectives ▪ Draft letter to Water Comptroller outlining proposed Shuswap Water Use Plan consultative process **22 June 2000** ▪ Presentation of Bridge Coastal Restoration Program ▪ Continue exploring stakeholder interests **27 July 2000** ▪ Complete review of issues and interests ▪ Presentation on geographic extent of impacts of facilities ▪ Presentation on water licence allocations on the Shuswap River ▪ Presentation of literature review on fish and aquatic resources ▪ Begin setting Water Use Plan objectives and performance measures **24 August 2000** ▪ Continue setting Water Use Plan objectives and performance measures

Water Use Plan Guideline Step	Key Activities and Consultative Committee Meetings
Step 5: Additional Information Gathering	**7 September 2000** ▪ Presentation on hydrology of the Shuswap system ▪ Continue setting Water Use Plan objectives and performance measures ▪ Begin fish studies **19 October 2000** ▪ Adopt Consultative Committee terms of reference ▪ Presentation on Dam Safety ▪ Review and refine Water Use Plan objectives and performance measures **2 November 2000** ▪ Complete refinement of Water Use Plan objectives and performance measures
Step 6: Creating Alternatives	**23 November 2000** ▪ Presentation on wildlife and wildlife habitat resources ▪ Begin developing trial Water Use Plan alternatives (optimizing for single objectives) **7 December 2000** ▪ Presentation on economic profile of the Shuswap facilities ▪ Presentation on Water Use Plan modelling process ▪ Specify Round 1 alternatives
Step 7: Assess trade-offs	**8 February 2001** ▪ Present and discuss preliminary results from modelling Round 1 alternatives ▪ Use direct ranking, paired comparisons, and swing weighting to assist trade-off discussions **8 March 2001** ▪ Review performance measures of nine Round 1 alternatives ▪ Use direct ranking and swing weighting to assist discussions **5 July 2001** ▪ Present findings from First Nations archaeology study, Sugar Reservoir ▪ Specify Round 2 Water Use Plan alternatives **1 November 2001** ▪ Review performance of fourteen Round 2 alternatives ▪ Perform trade-off analysis and eliminate nine alternatives ▪ Specify Round 3 Water Use Plan alternatives

Water Use Plan Guideline Step	Key Activities and Consultative Committee Meetings
Step 8: Document areas of agreement and disagreement	**5-6 February 2002** ▪ Review performance of eight Round 3 alternatives ▪ Document areas and extent of consensus on preferred Water Use Plan alternative(s) **25 March 2002** ▪ Discuss monitoring plan ▪ Review consultation report ▪ Complete decision-making for preferred operation at Wilsey Dam **29-30 April 2002** ▪ Sign-off on consultation report ▪ Close Shuswap Water Use Plan consultative process

APPENDIX H: DOCUMENTS GENERATED BY THE SHUSWAP WATER USE PLAN PROCESS

A. BC Hydro Shuswap Water Use Planning Interim Reports

BC Hydro. (2000). *Proposed Consultation Process: Shuswap Falls and Sugar Lake Water Use Plan*. BC Hydro, Burnaby, B.C. 26 October 2000

BC Hydro. (2001). *Shuswap Falls and Sugar Lake Water Use Plan: Preliminary Issues Report*. BC Hydro, Burnaby, B.C. 14 July 2000.

B. Literature Reviews and Study Reports

Arc Environmental. (2001). *Shuswap River Fish and Aquatic Information Review*. Prepared for B.C Hydro by Arc Environmental, Kamloops, B.C. 2 February 2001.

Nielson, Lori. (2000) *Shuswap WUP Reference Database*. Kator Research Services. Surrey, B.C.

Robertson Environmental Services. (2001). *Shuswap River Water Use Plan: Wildlife Overview*. Prepared for BC Hydro by Robertson Environmental Services Ltd. 27 July 2001.

Spallumcheen Indian Band and Diana French. (2001). *Archaeological Site Inventory: Sugar Lake Reservoir*. Kelowna, B.C. 4 July 2001.

C. BC Hydro Shuswap Water Use Plan Reports on Performance Measure Calculations

BC Hydro. (2002). *Shuswap Water Use Plan Hydro Operations Studies Report*. BC Hydro, Burnaby, B.C. Report No. PSE 464.

BC Hydro. (2001). *Shuswap Water Use Plan Performance Measure Study*. Draft Overview Prepared by Darren Sherbot for the Shuswap Water Use Plan Consultative Committee. BC Hydro, Burnaby, B.C.

APPENDIX I: LETTER FROM THE SHUSWAP CONSULTATIVE COMMITTEE TO THE WATER USE PLAN MANAGEMENT COMMITTEE REGARDING THE SCOPE OF WATER USE PLANS

September 18, 2000

Water Use Planning Management Committee
c/o Mr. Steve Macfarlane
Department of Fisheries and Oceans
300 - 555 Hastings Street
Vancouver, BC V6B 5G3

Attention: Water Use Planning Management Committee

The members of the Consultative Committee for the Shuswap WUP seek direction from the WUP Management Committee on whether structural modifications to BC Hydro facilities are a valid WUP issues or not.

Currently, we are finalizing our WUP objectives and performance measures. Soon we will be developing WUP alternatives. In developing alternatives, it would be helpful to know what are the bounds to our discussions with regards to the extent that we can consider modifications to the structures. Examples that have come up in our discussions so far include changing the size of the gates, changing the height of the dam, and in particular, building a fish ladder.

We recognize some of these modifications are solutions and at this time we do not know if they will be part of the alternatives we develop. However, it would be helpful in guiding the committee's discussions to know what are the bounds for alternatives in achieving our WUP objectives.

Sincerely,

Tony Wong
Facilitator and Analyst, Shuswap Falls/Sugar Lake WUP

APPENDIX J: LETTER FROM WATER USE MANAGEMENT COMMITTEE TO THE SHUSWAP CONSULTATIVE COMMITTEE REGARDING THE SCOPE OF WATER USE PLANS

November 8, 2000 (text of letter)

Mr. Tony Wong
Facilitator and Analyst
Shuswap Falls/Sugar Lake Water Use Plan
4837 Westlawn Drive
Burnaby, BC VSC 3R4

Dear Tony:

Thank you for your letter of September 18, 2000 on behalf of the Shuswap Falls/Sugar Lake Water Use Plan (WUP) Consultative Committee requesting advice from the WUP Management Committee (CC) on whether "structural modifications to BC Hydro facilities" are valid items that can be considered in the development of a WUP. In particular, we understand your specific questions to be whether structural modifications such as changing height of the dam or size of the gates and building fish ladders are appropriate. In addition, we are aware that decommissioning has been raised by the CC.

The Management Committee is considering how best articulate the scope of WUPs. We have developed a draft framework that can be used for this purpose and as one test case ran the Shuswap examples through the model.

The framework focuses on the management of the water through changes in operations given the current physical plant. Note that "changes in operations" is intended to be broad in scope. Changes in physical structures can be considered where they offer more effective or cost-effective options to an operational change.

Based on these guidelines and the specifics of the Shuswap system the Management Committee concludes that the answer to raising the height of the dam and building fish ladders is "no", since these actions would be addressing impacts related to the dam being in place rather than cause by ongoing operations. Adjustments or additions to gates may be acceptable if these changes do not impede dam safety or probably maximum flood.

In response to comments around decommissioning, the Management Committee agrees that, if after a full exploration of possible operating alternatives, an operations mode is selected such that decommissioning could be done in lieu of changes to in water flows or reservoir levels then this is an acceptable BC Hydro decision. However, this decision would be made later in the process. At this point, CC discussions should focus on the objective or outcomes desired, in terms of what is important, and exploring possible operational changes rather than specific technical fixes.

In terms of next steps, the Management Committee would like to test the framework on a broader set of examples with both a select number of BC Hydro Project Managers and external Consultative Committee facilitators. Would you be interested in participating in this exercise? If so, please let me know as soon as possible so that we can organize a workshop within the next few weeks. I can be reached at 250-952-0264 or <denise.mullendalmer@gems 1.gov . bc.ca> .

Yours sincerely,

Denise Mullen-Dalmer
Chairperson WUP Management Committee

cc: WUP MC

APPENDIX K: STUDIES SUPPORTING POWER MODELLING

A key precursor to calculating performance measures for power and other interests was data on inflows into the reservoir and local inflows between Sugar and Wilsey dams. This process recreated 27 years of inflow data for modelling the outcome of various Water Use Plan alternatives.

BC Hydro reviewed local inflow records available from its operations data archive. Two quality-control procedures developed for Water Use Planning requirements were used to adjust data, where required. The first method reduced "noise" in inflow data records that results from the nature of the inflow calculations. The second method verified that computed inflows per unit area (in units of $L/s/km^2$) were consistent with flows per unit area computed for nearby natural, unregulated streams. This second method was also used to fill gaps in or extend data records.

Water management alternatives or operating scenarios were analyzed by means of computer simulations. The main components of the general computer model are:

- Operating and physical constraints within which the facility(s) operate (includes facility functional constraints, licensing constraints, systems constraints, treaty/agreements),
- Basin (watershed) historical inflow data,
- Electricity marked demand profile over the year,
- Model of hydro operations to calculate reservoir trajectories, discharges, and resulting generation under specific operating scenarios,
- Valuing the generation achieved under the specific operating scenarios.

The reservoir elevation and flow results from each operating scenario of the model could be used as input to habitat models or used directly in the calculation of a performance measure, e.g. the number of days a reservoir is maintained in a recreation desired range.

APPENDIX L: NOTE FROM TERRI DEULING TO THE FLOOD GROUP (PRESENTED AT FLOOD WORKING GROUP MEETING, MARCH 2002)

To whom it may concern,

I have heard the WUP for the Shuswap River System is winding up and would like to express my concern that flood control is addressed. I have been the Park Facility Operator at Mabel Lake Provincial Park since 1993 and have seen a definite correlation between lake levels, mosquito counts and camper visits. In the years when the lake level rises and mosquito counts are high the campers stay away. I understand that snowpack and weather during the run-off season are a factor but if flooding could be managed it would lessen the impact. I have, for comparison, three years of statistics that show the correlation between water levels and camper visits.

1997 - 1,728,000 m^3 - 6419 camper nights

1998 - 900,000 m^3 - 8328 camper nights

1999 - 1,650,000 m^3 - 5897 camper nights

If the goal of the WUP is to maximize the value of the Shuswap River system to the local economy, I think this is a clear example of how high water negatively affects the tourist industry in the valley. Mabel Lake Park directly employs four locals in full-time seasonal jobs and indirectly provides business for many local companies. It would be nice to see the camper nights consistently high and that will only happen if the mosquito count can be modified by controlling water levels in the lake.

Terri Deuling

APPENDIX M: SHUSWAP WATER USE PLAN PERFORMANCE MEASURE SUMMARY

Overview Prepared for the Consultative Committee

SHUSWAP WUP
Fisheries Performance Measure Summary

Report No. SHU WUP FTC 03

Prepared for:
SHU WUP CC and FTC
Prepared by:

Darren Sherbot BE BSc MRM (PEng)
Watershed Management, BC Hydro
6911 Southpoint Drive, Burnaby, BC V3N 4X8

P (604) 528 1556 F (604) 528 2905 C (604) 761 3428
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Nov 26, 2002

AQUATIC LIFE AND FISHERY INTERESTS

BC Hydro (BCH) developed a Water Use Plan (WUP) for Shuswap River (SHU) operations in consultation with government and non-government representatives for environment, social, and economic issues. Ultimately, the WUP reviewed and made recommendations on a series of operational flow alternatives created by the Consultative Committee (CC) to meet broad and specific objectives set for the aforementioned issues. In order to effectively address potential conflicts between competing objectives, a suite of performance measures (PMs) were defined to illustrate differences between flow alternatives.

The Fisheries Technical Committee (FTC) addressed aquatic ecosystem integrity and specific fisheries interests for Sugar Reservoirs and for the Shuswap River between Sugar and Wilsey Dam and from Wilsey Dam to Mabel Lake (Figure M-1 and Figure M-2). The SHU CC identified "maximizing fisheries productivity" in the Middle Shuswap as one broad environmental objective. Specific objectives, focused on maximizing both spawning success and rearing fitness for several indicator species such as chinook, coho, and kokanee. Another key area of interest was increasing littoral productivity in Sugar Reservoir. While the FTC acknowledged that operational changes at Wilsey and Sugar could not directly influence ocean survival of salmonids, it was noted that hourly, daily, and seasonal changes in downstream discharges could affect the quality and quantity of habitat for spawning, incubation, and rearing in both the river and reservoir.

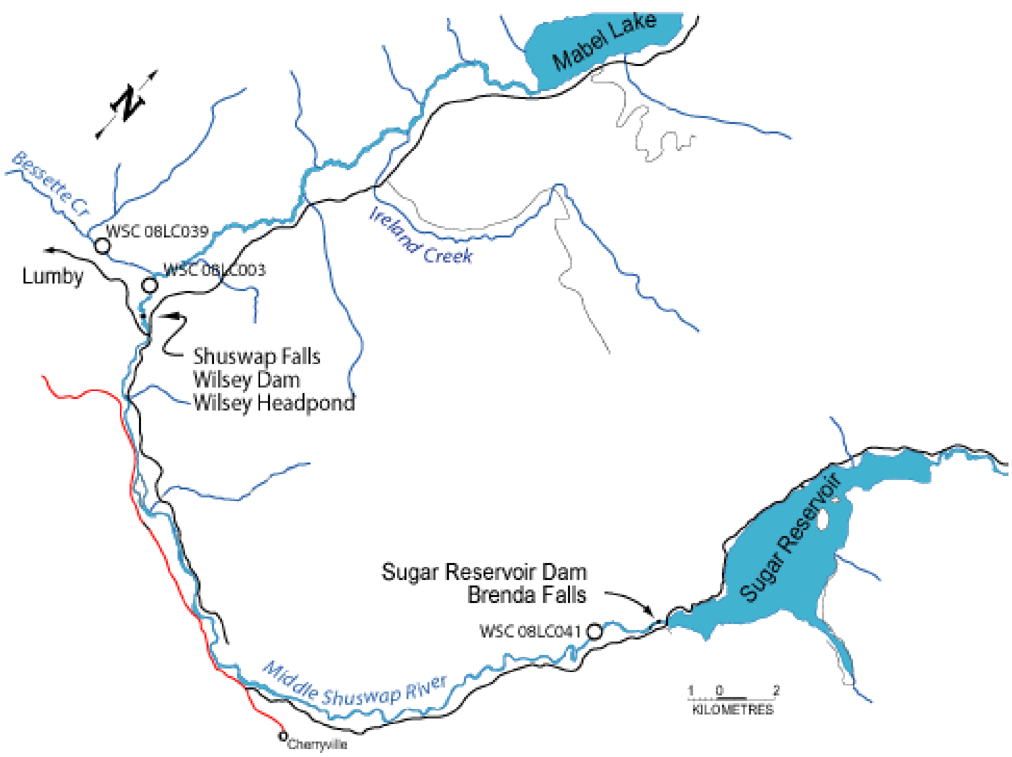


Figure M-1 Shuswap Falls Projects

Approximate location of Wilsey and Sugar dams. Water Survey Canada (WSC) stations listed. Shuswap upstream of Sugar Reservoir: Upper Shuswap. Shuswap between Sugar Reservoir and Mabel Lake: Middle Shuswap.

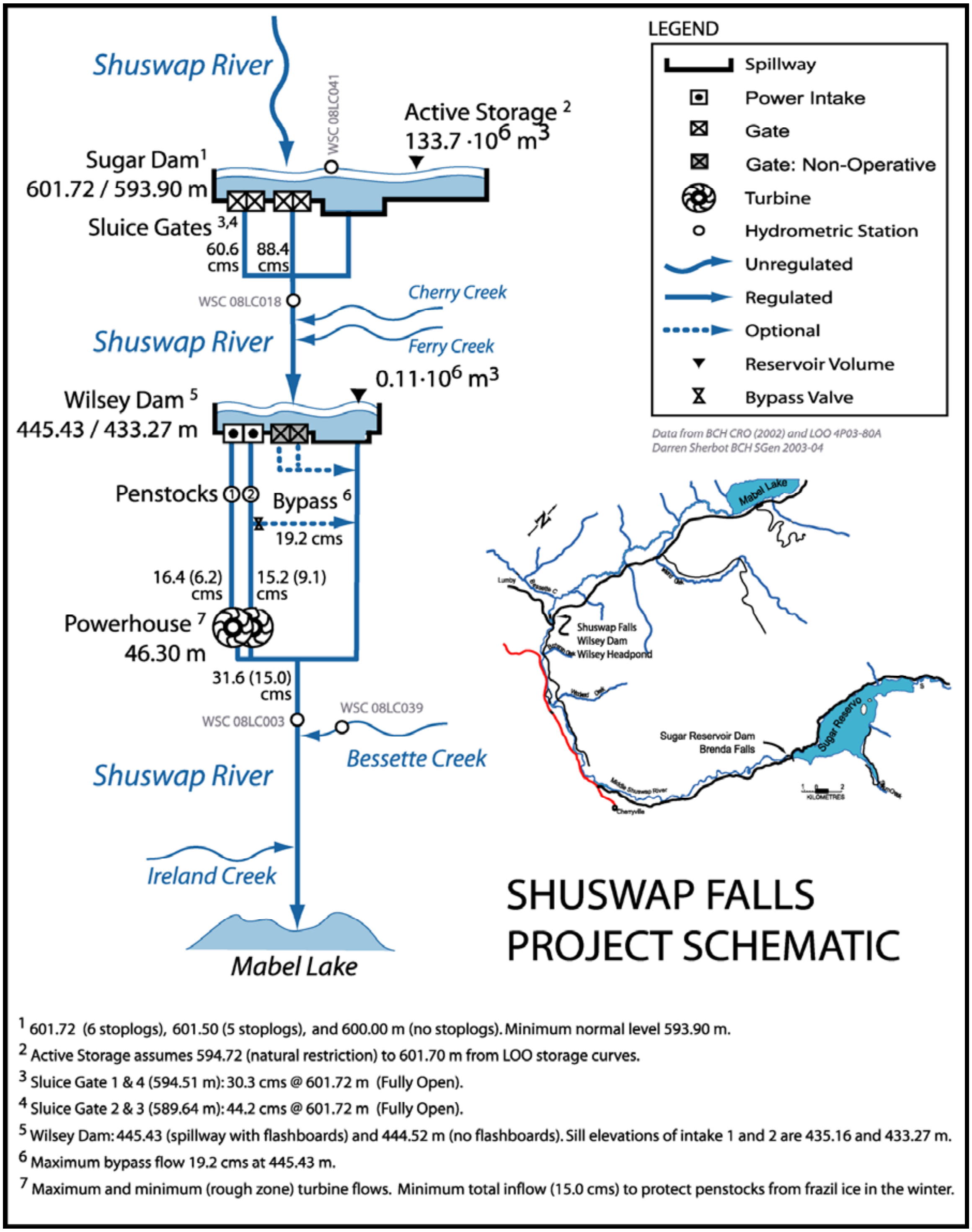


Figure M-2 Shuswap Project Flow Schematic

All levels, volumes, and flows are approximate. Note the presence of the bypass valve on Unit 2. This valve is used to instantaneously divert flow from Penstocks 2 into the tailrace in the event of an unplanned plant outage.

PERFORMANCE MEASURE DESCRIPTIONS

EFFECTIVE LITTORAL ZONE

ELZ Background Information

A digital elevation model (DEM) was generated to calculate the effective littoral zone (ELZ PM) for Sugar Reservoir (Figure M-3) for a series of operational alternatives. Several alternatives that involved conservation flows, maximizing power generation, and/or stabilizing reservoir levels all significantly influenced Sugar Reservoir levels. Many preferred scenarios, however, were subject to revision because of dam safety issues associated with stop log removal.

Impacts on resident fish with reservoir tributary access at Sugar were not tabled as it was acknowledged that current access was not a problem and any proposed alternatives would not create novel unfavorable conditions. Subsequently, the performance measure for the reservoir was ultimately pursued to address the environmental implications of operational changes that restricted the seasonal timing of full pool and reservoir stability. Critical areas in the marginal inlet areas were of particular focus (Table M-1).

Table M-1 Reservoir objective and performance measure summaries.

Broad and specific objectives jointly created by the SHU FTC and approved by the CC. Impact hypotheses and initial performance measures approved by the FTC.

Broad Fisheries Objective	Maximize resident fisheries populations in the Sugar Reservoir.
Specific Fisheries Objective	Increase littoral productivity of the reservoir.
Impact Hypotheses	(A) Seasonal and daily changes in reservoir levels may preclude the establishment of an effective littoral zone in 3 marginal inlet areas. This impact may reduce productivity at upper trophic levels by restricting primary production in the littoral zone. The potential for littoral production is assumed to be significant relative to pelagic production alone.
Means Objective	(A) Maximize growing length and area of reservoir littoral zones.
Performance Measure	**(A) Effective Littoral Zone**
Critical Uncertainties	Importance of littoral to pelagic productivity. Duration of effective littoral habitat necessary to increase littoral productivity.

Reservoir Performance Measure Development

During reservoir operations, wetted areas exposed to sunlight have the potential for plant growth (periphyton and macrophytes). This in turn, augments higher trophic levels (invertebrates, fish, etc.) as continued growth contributes to increasing biomass available for retention of pelagic nutrients. The extent of the littoral zone and the associated biomass will be a function of the area wetted, the subset of this area that is exposed to light, and duration this area remains wetted. In a natural lake system the extent of the littoral zone changes only as a function of induced storage and depth of light penetration associated with natural inflows. Depending on outlet restrictions, this should not vary more that 1 m for lakes with geometry similar to Sugar Reservoir.

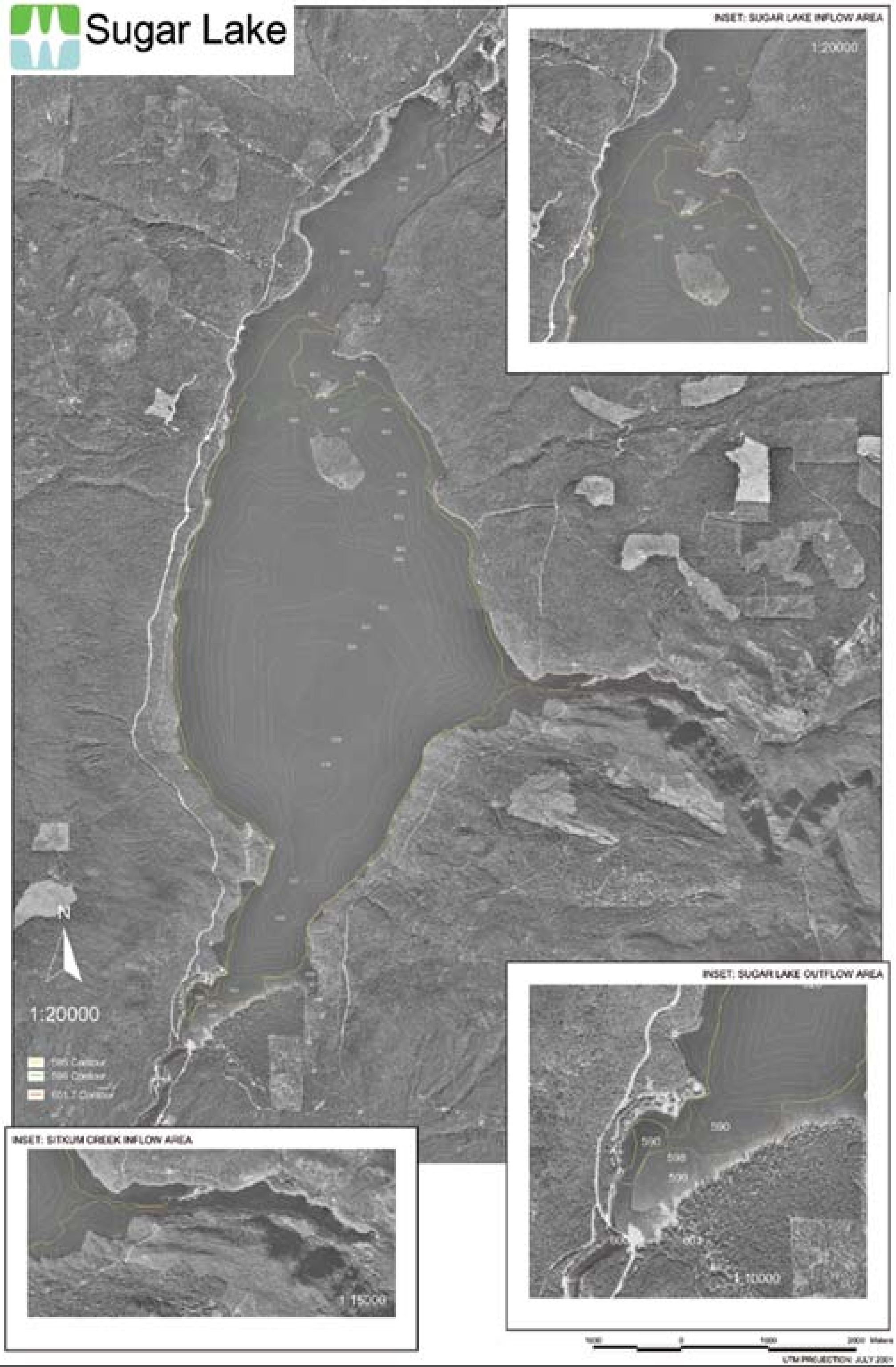


Figure M-3 Sugar Reservoir: Draft Bathymetry

Schematic depth profile of Sugar Reservoir. Mesh used to generate digital elevation model (DEM) for depth area (planar and surface) relationships at 0.1 m resolution. Insets provided for inlet margins. Data from Latitude Geographics (2001).

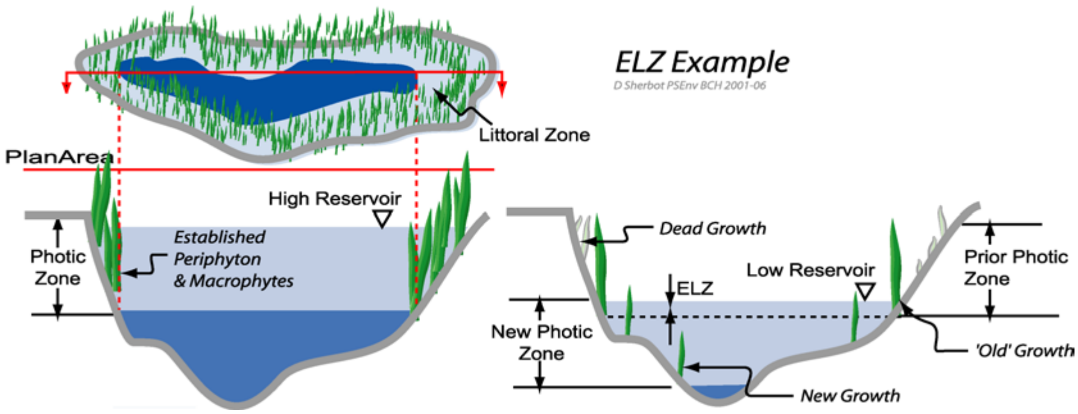


Figure M-4 Littoral Zone and Effective Littoral Zone

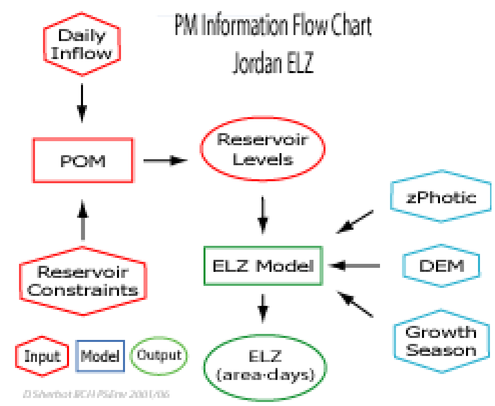
Established littoral zone in a natural lake system (left) or a reservoir at a static head. Area associated with an effective littoral zone (ELZ) in a reservoir (right) after a marginal drawdown. Note if the drawdown depth generally exceeds total light penetration depth, no ELZ will establish. Photic zone is defined as the depth of light penetration at an intensity sufficient to promote algae and/or macrophyte growth.

In a reservoir, the establishment of a littoral zone is dependent on the timing and drawdown depth. If sufficient duration of light and wetted area is observed, an Effective Littoral Zone may be established. For the SHU WUP, Effective Littoral Zone (ELZ), was defined as the wetted area of the reservoir that had sufficient sunlight penetration to allow for the growth of algae (periphyton) and vascular plants (macrophytes) **weighted by mean duration of growth**. ELZ has equivalent units of area·days. In a reservoir, both the littoral area and growth duration will vary as a function of depth. The design for the ELZ performance measure was adapted from the Stave WUP (Bruce 1999) and requires the following information for computation:

- Depth of light penetration during peak productivity periods.
- Location and surface elevation of critical shoreline habitats from a digital elevation model.
- Start and end dates of peak productivity periods.

Table M-2 MetaCode for ELZ Calculation.

Indents represent looping hierarchy. Italicized data indicates program calculation and/or output. Bolded values indicate alternative specific performance measure output. Year (yr), day (d), and alternative (Alt).

<table>
<tr>
<td>
Alternative = Alt A, B, C… to n
  Simulation Year = 1974 to 2000
    Day = May 1 to Oct 31
      ·Daily Reservoir Level (Alt, yr, d)
      ·Daily Littoral Area (Alt, yr, d)
    Next Day
      ·Annual ELZ (Alt, d)
  Next Simulation Year
    ·Median ELZ (Alt)
    ·Lower 10th Percentile ELZ (Alt)
Next Alternative
</td>
<td>


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Reservoir Data Collection:

To quantify the reservoir PM, baseline environmental data and information specific for the calculation of the ELZ PM was collected for Sugar Reservoir. These studies and surveys included:

- Bathymetry mapping and digital elevation models of Sugar Reservoir.
- Summary of drawdown frequency and seasonal timing for Sugar Reservoir.
- Light penetration and photic depth information.

The digital elevation map (DEM) developed for Sugar Reservoir was surveyed and post processed at a resolution sufficient to define both change in planimetric area and slope as a function of 0.1 m depth intervals.

ELZ Recommendations

The ELZ data could be improved by incorporating additional information such as light extinction data. In addition, model validation of inundation areas in the three critical inlets could be observed by noting extent of wetted perimeter as a function of set reservoir levels. Finally, all ELZ operations are based on the assumption that littoral productivity plays an important role in the reservoir limnology. No baseline data exists to either prove or disprove this hypothesis. If operational alternatives implemented severely restrict reservoir flexibility, validating this assumption would be worthwhile.

EFFECTIVE SPAWNING

Effective Spawning Background Information

Regulated changes in spawning flows below hydroelectric projects may facilitate spawning in areas that are not effectively watered during incubation and/or increase redd density in suitable areas to levels that may adversely affect incubation survival. The overall incubation success rate has been defined as *Effective Spawning* and can be represented by combined or separate measures of *%Effective Spawning Survival* (*%nESpawn*) and the Effective Spawning Area (*AESpawn*). Combined, the measures give information on the numbers that survive, the area that they survived in, and, hence, a density estimate (Table M-3).

In order to address the full suite of spawning options on the Shuswap below Wilsey, the FTC decided to examine the spawning performance for chinook, coho, and kokanee with the assumption that what is optimized for these species will also other resident species (rainbow trout) and sockeye during peak spawning years. Site selection for PM evaluation was jointly confirmed by DFO, MELP, and BC Hydro. It was the intention of the FTC to choose sites that were representative of spawning grounds for chinook, coho, and kokanee (Photo M-1 and Figure M-5).

Photo M-1 Middle Shuswap Chinook Redds

Mainstem Distribution Of Chinook Redds in 2001. Photo ~2 km downstream of Wilsey Dam.

Table M-3 Effective Spawning PMs: River objective and performance measure summary.

Broad and specific objectives jointly created by the SHU FTC and approved by the CC. Impact hypotheses and initial performance measures approved by the FTC.

Broad Fisheries Objective	**(A) Maximize resident and anadromous fisheries populations in the Middle Shuswap River.** (B) Maximize resident fish populations in Sugar Reservoir.
Specific Fisheries Objective	(A) Maximize emerging fry per spawning pair for chinook, coho, and kokanee.
Impact Hypotheses	Regulated changes in spawning flows below Wilsey dam may facilitate spawning in areas that are not effectively watered during incubation . Regulated changes in spawning flows below Wilsey may increase redd density in suitable areas to levels that may adversely affect incubation survival.
Means Objective	(A) Minimize redd stranding during incubation for chinook, coho, and kokanee by balancing minimum flow enhancement against winter inflows, reservoir storage, and spawning flows. (B) Minimize redd density to avoid bimodal spawning super imposition and decrease risk of adverse incubation for chinook, coho, and kokanee by regulating spawning flows.
Operational Implications	▪ Reduce discharge flexibility for power operations. ▪ Restrict storage capacity of Sugar Reservoir.
Performance Measure	(A) Percent redds that are effectively watered during incubation: Effective Spawning Survival (%nESpawn). (B) Spawning area that is effectively watered during incubation: Effective Spawning Area (AESpawn).
Critical Uncertainties	▪ Smolt and Ko fry survival is significantly dependent on incubation success. ▪ HSI data for the system adequately reflects spatial spawning preferences based on substrate, depth, and velocity alone. ▪ Sample survey sections are representative of known river reaches. ▪ Incubation success is significantly impacted by critical exposure depths ≤ 8 cm.
Data Acquisition Costs	▪ Survey ~5x500m sections: \$20,000. ▪ Post Hydrology Modeling: \$10,000. ▪ Post Processing PM Development and Modeling: \$5000. ▪ *In situ* HSI Data: \$5000 – \$50,000. ▪ Winter Redd Survival: \$5000/Survey.

PM Development

To quantify and, perhaps optimize, downstream flow regulation from Wilsey Dam for effective spawning, the FTC considered measure of %Effective Spawning Survival *(%n_{ESpawn})* and Area of Effective Spawning (*A_{ESpawn}*) (

Table M-4). Section summary statistics for area measures (ASpawn and AESpawn) are scaled by the representative length (RLength) each section (Length) is associated with:

- Total Area = A(Sctn) · RLength / Length

Section summary statistics for %nESpawn and pSpawn are expressed as a weighted average by representative lengths:

- %nESpawn = Σ [%nESpawn(Sctn) · RLength] / Σ (RLength)

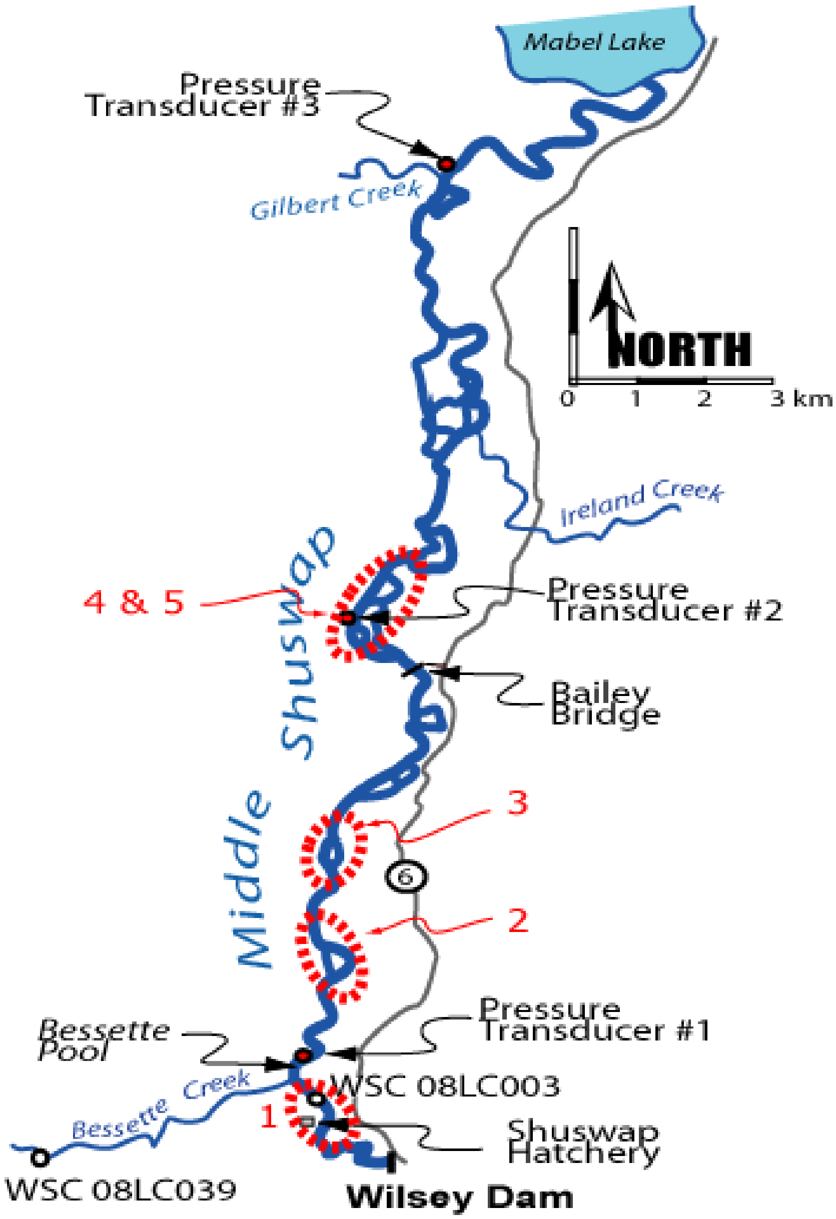

Figure M-5 Middle Shuswap River survey sites.

Sites 1 to 5 labeled in red. Site 5 is immediately downstream of Site 4. Site locations are approximate. Water Survey Canada (WSC) gauges. Locations of additional pressure transducers are also illustrated.

Table M-4 General Definitions for Effective Spawning.

Created from model development on CMS, SHU, and JHT WUPs (BCH 2001).

Effective Spawning (ESpawn)	Combined measure of spawning success that considers the percent of redds that remain effectively wetted during incubation and associated effective area. These parameters should implicitly consider initial spawning area, redd density, minimum incubation flow(s), and a dynamic distribution of spawners over the spawning period in both numbers and spatial habitat preference.
Effective Incubation (EIncb, zEIncb, vEIncb)	Redds that are effectively wetted during incubation. This is represented by minimum water depth (zEIncb) and velocity (vEIncb) criteria. As spawning may occur in areas that are not subsequently wetted during incubation, spawning area may be greater than effective incubation area. Effective incubation depths (Ch) have been estimated on CMS, LBR, and SHU between 15 and 8 cm.
Habitat Suitability Indices (HSI)	Data that describes preference (0 – 1) for a particular parameter range (ie velocity, depth) or parameter type (substrate). Used to calculate weighed usable area measurements.
Weighted Usable Area (WUA)	Area associated with particular species and life history stage weighted by preference for each variable associated with that area. Weighting is typically geometric: WUA = Area · Π (prf_i)
Spawning Area (ASpawn)	Weighted usable spawning area available for a species. Summarized as the mean or median area over the spawning period. Spawning area will always be ≤ total wetted area. If habitat suitability indices are used to define spawning preference, spawning area will change as a function of flow (ie depth and velocity) and constrained substrate type.
Effective Spawning Area (AESpawn)	Spawning area that is effectively incubated during the incubation time period. Effective spawning area will always be ≤ spawning area. Requires spatial analysis of original spawning area and subsequent area associated with the effective incubation depth. While spawning area may vary each day as a function of observed flows, effective spawning area is set by the minimum observed flow for the incubation period.
Effective Spawning Survival (% nESpawn)	Effective spawning survival is the % of total spawners that spawn in areas that are subsequently effectively incubated. Calculated as the daily ratio between spawning area and subsequent effective spawning area. For each day in the spawning period, this can then be weighted by the distribution of spawner arrivals expected each day. This measure indicates overall survival and considers both spatial and temporal distribution of spawners.
Spawning Density (pSpawn)	Summary statistic of the ratio spawner distribution (daily) and spawning area. Holding all other performance parameters constant, a lower pSpawn measure indicates a lower initial spawning density. Measures of nESpawn and AESpawn implicitly consider pSpawn.

Table M-5 Representative River Lengths

River section ID (nSctn) and representative lengths (RLength). Data provided by Summit (2001-08).

ID	Name	nSctn	Length (m)	RLength (m)
1	S1	1	450	2600
2	S2	2	560	3160
3	S3	3	418	3160
4	S45	4	1622	6920
6	S6	6	466	15840

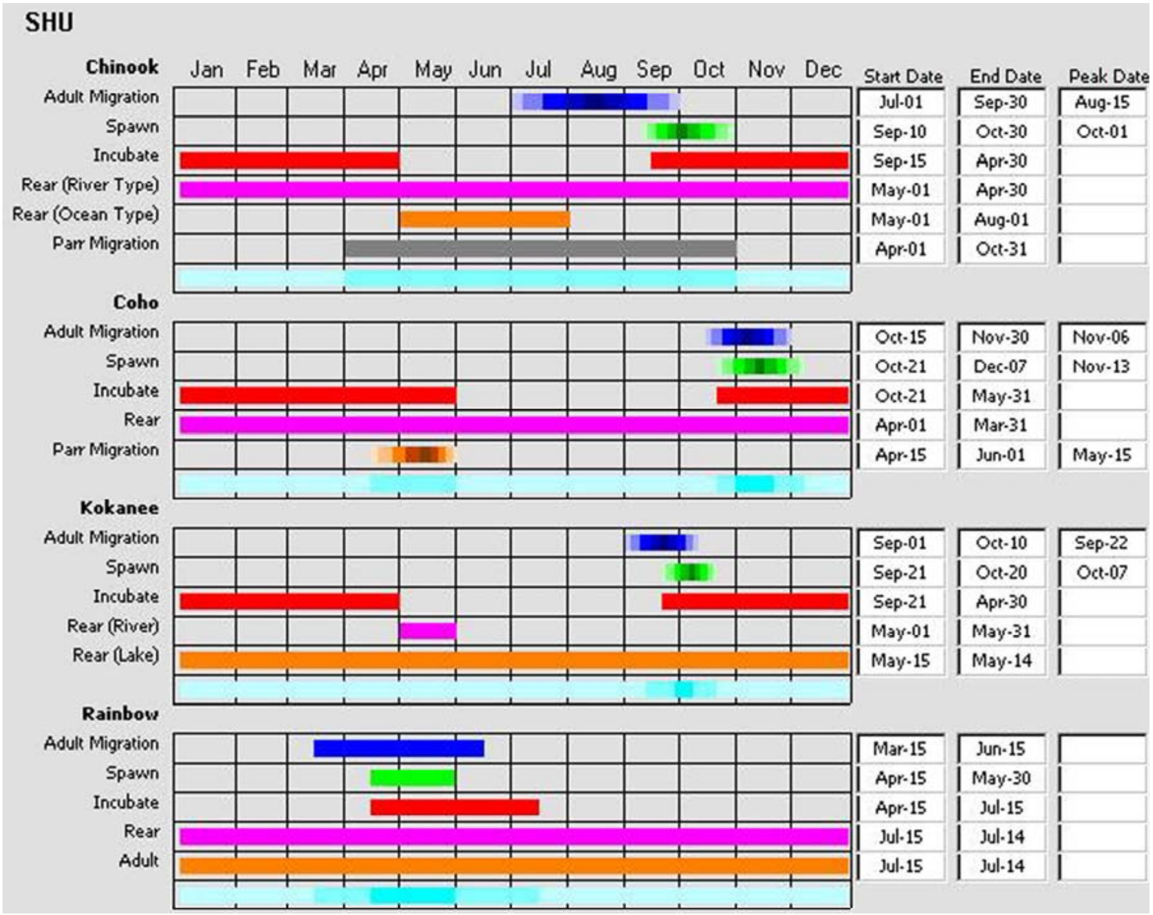

Figure M-6 Fish Periodicity Information: Middle Shuswap

Data complied from SHU FTC 2001-09.

Effective Spawning Data Collection

Habitat suitability indices specific to the Shuswap River were collected for Chinook, coho, and kokanee. Survey data was also collected for 5 river sections of known spawning to provide representative information on substrate quality and hydraulic suitability. An additional survey was conducted in the spring to answer a critical uncertainty associated with the effective depth necessary for successful redd incubation associated with dewatering and/or ice formation. All data were reviewed by the FTC prior to use in the performance measure model. Finally, information from different sources were pulled together and reviewed for the life history timing of chinook, coho, kokanee, and rainbow trout specific to the middle Shuswap.

Table M-6 MetaCode for ESpawn Calculations.

Indents represent looping hierarchy. Italicized data indicates program calculation and/or output. Bolded values indicate alternative specific performance measure output. Year (yr), day (d), species (Sp), section (Sctn), and alternative (Alt).

```
Alternative = Alt A, B, C… to n
  Section = 1 to 5
    Simulation Year = 1974 to 2000
      Species = Rb, Co, Ch, and Ko
        Day = IncbStart to IncbEnd
          ·Daily Inflow (Alt, Sctn, yr, d)
          ·Min IncbFlow (Alt,Sctn,yr,d,Sp)
        Next Day
        Day = SpawnStart to SpawnEnd
          ·Daily nSpawn (Alt,Sctn,yr,d,Sp)
          ·Daily Inflow (Alt,Sctn,yr,d)
          ·Daily ASpawn (Alt,Sctn,yr,d,Sp)
          ·Daily nESpawn (Alt,Sctn,yr,d,Sp)
        Next Day
          ·Mdn Annual ASpawn(Alt,Sctn,yr,Sp)
          ·Mdn Annual AESpawn(Alt,Sctn,yr,Sp)
          ·Mdn Annual pESpawn(Alt,Sctn,yr,Sp)
          ·Mdn Annual %nESpawn(Alt,Sctn,yr,Sp)
      Next Species
    Next Simulation Year
      ·Stat Sctn ASpawn(Alt,Sctn,Sp)
      ·Stat Sctn AESpawn(Alt,Sctn,Sp)
      ·Stat Sctn pESpawn(Alt,Sctn,Sp)
      ·Stat Sctn %nESpawn(Alt,Sctn,Sp)
  Next Section
    ·Stat Alt AESpawn(Alt,Sp)
    ·Stat Alt %nESpawn(Alt,Sp)
Next Alternative
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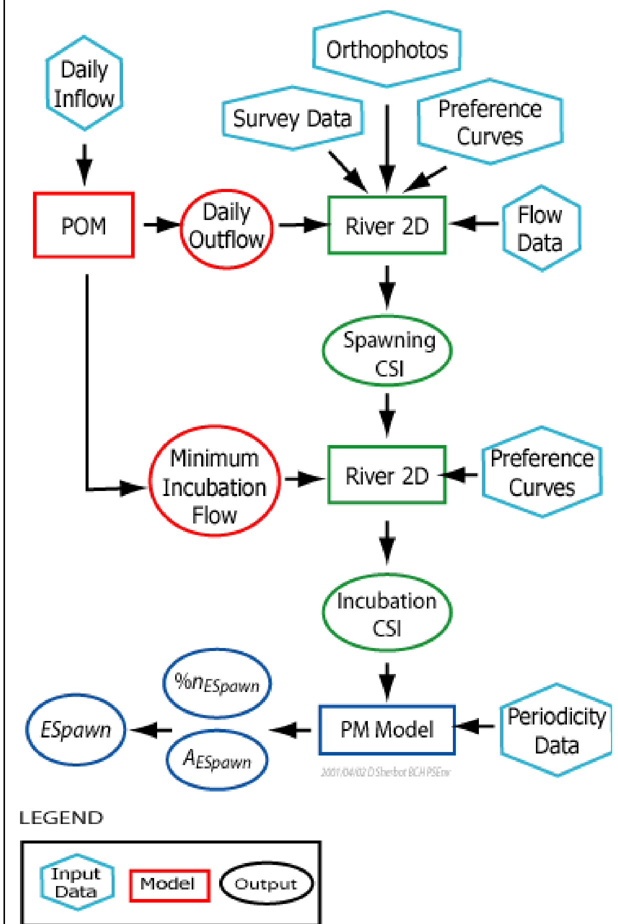


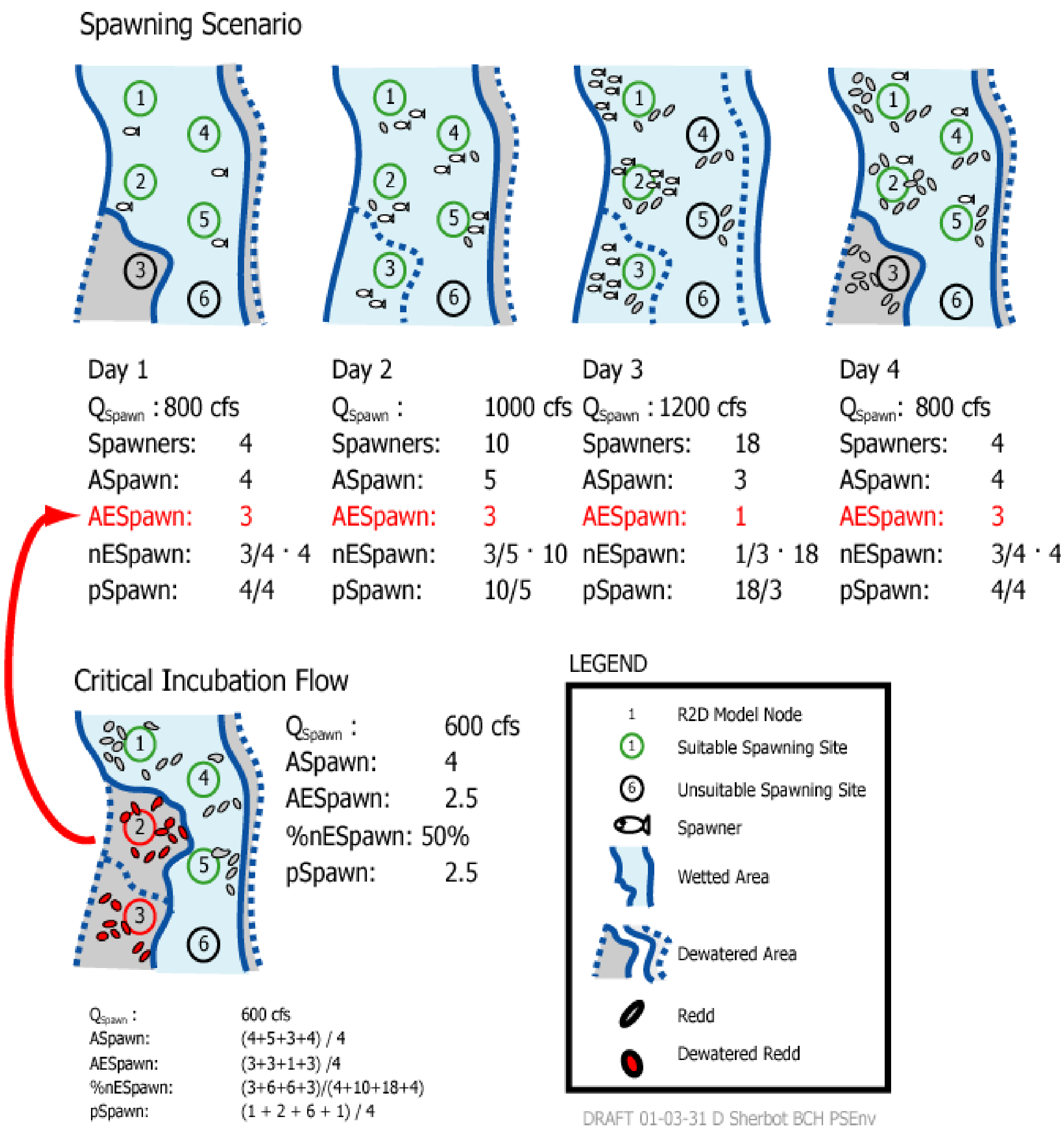


Figure M-7 Simplified Effective Spawning Model

Example based on 4 day spawning period. Summary statistics calculated as means.

Recommendations

The Effective Spawning PM has been used on several other WUPs. In all cases, model validation for habitat use and successful incubation remains a key outstanding question. Another uncertainty that will remain unapprised until operational changes are made (if any) is the relation between gains in effective incubation and subsequent populations of salmonid smolts. Out migration information coupled with model predictions and spawner count estimates may establish a critical effect size and help future management decisions.

REARING HABITAT

Rearing Habitat Background

Regulated changes in spawning flows below hydroelectric projects may facilitate different levels of suitable rearing habitat. For anadromous species, such as coho and chinook, maintaining good summer rearing and wintering habitat all year round may be the most important step in maximizing smolt numbers. While storage levels and operational restrictions prevent significant influence of river discharge with respect to an unregulated system, Wilsey and Sugar may be operated in a way during the fall months that could effect overall rearing area. As a comprehensive measure, the FTC decided to look at changes in rearing habitat for rainbow trout below Wilsey to ensure that any recommendations designed to enhance spawning success for chinook, coho, and kokanee would not be at the determent of a resident fish indicator species. Site selection for PM evaluation was jointly confirmed by DFO, MELP, and BC Hydro as the first river section below Wilsey Dam. This area was assumed to be representative of a large portion of the area between Sugar and Wilsey as well. Additional survey data was collected upstream of Wilsey dam but this was never processed in time for use with the decision making process (Figure M-5).

Rearing Performance Measure Development

Riffles are assumed to be surrogate measures of both lotic productivity and preferred rearing habitat for juvenile trout, steelhead, and certain salmonids (ie. coho). The FTC decided that measures of change in associated habitat would provide an integrated indicator of how different flow alternatives might increase habitat and productivity for resident fish, specifically rainbow trout, and other salmonids. Habitat suitability indices developed for steelhead were used in approximation of *in situ* curves for rainbow trout. Given the similarity of the early life history patterns between steelhead and rainbow trout, the FTC noted that this was not an unreasonable application. Weighting used in this application was geometric: $WUA = Area \cdot \prod (prf_i)$ where pfr curves were given for depth and velocity.

These data provide an integrated measurement of habitat as a function of flow. For any given flow, the product of wetted width and the estimated length of the riffle run provides an area estimate of riffle habitat. Furthermore, the sum of these areas over the river length below Elliott Dam yield a total habitat indicator. Reach specific summary statistics for area measures were scaled by the representative length (RLength) each sample section (Length) was associated with: Total Area = A(Sctn) · RLength / Length.

The Rearing WUA performance measure required the following information for computation:

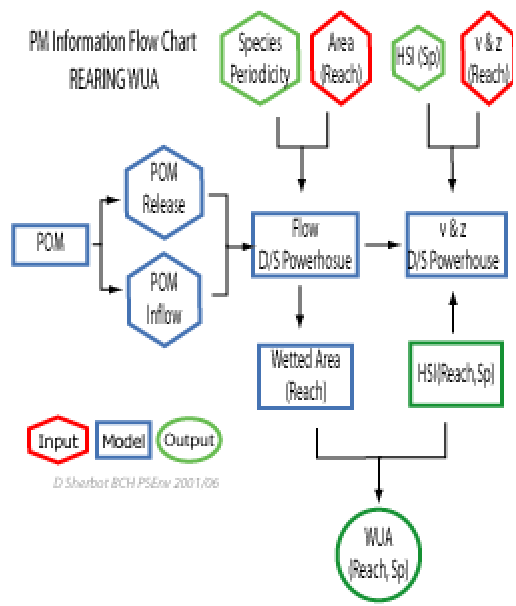
- For each flow alternative (*Alt*), daily (*d*) discharge releases from Wilsey into the Middle Shuswap from the power optimization model for each year (*yr*), river reach (rch), and species (*Sp*).
- Instream flow contribution for each river reach. Calculated from contribution for Bessette for reaches downstream.
- Periodicity data for each species to determine if daily flows benefited fry and parr habitat.
- Habitat Suitability Indices (HSI) for each species and lifestage.

There was some discussion amongst the FTC regarding what time interval to use to examine the rearing habitat for rainbow trout. While it was noted that Rb are actively rearing (vs. over wintering) between May and Sep (function of instream temperature), control of plant operations following freshet really begins after August. Running the PM between August and September would make the measure more sensitive to changes associated with proposed alternatives. An exception to this assumption was noted. An alternative that allowed free flow of water through the system with no regulation changed rearing habitat significantly during the early months.

Table M-7 MetaCode for WUA Calculation.

Indents represent looping hierarchy. *Italicized data indicates program calculation and/or output.* **Bolded values indicate alternative specific performance measure output.** Year (yr), day (d), species (Sp), section (Sctn), alternative (Alt), median (Mdn), and lower 10th percentile of data (L10).

```
Alternative = Alt A, B, C… to n
  Section = 1 to n
    Simulation Year = 1974 to 2000
      Day = Aug 1 to Sep 30
        ·Daily Inflow (Alt, Sctn, yr, d)
        Species = Rb
          ·Daily Section WUA(Alt,Sctn,yr,d,Sp)
        Next Species
      Next Day
        ·Mdn Annual Sctn WUA(Alt,Sctn,yr,Sp)
      Next Simulation Year
        ·Median Section WUA (Alt, Sctn, Sp)
        ·L10 Section WUA (Alt, Sctn, Sp)
    Next Section
      ·Median River WUA (Alt, Sp)
      ·L10 River WUA (Alt, Sp)
Next Alternative
```



Rearing PM Data Collection

Data collection, such as survey information, used for the effective spawning PM were also utilized to address this measure. As noted, habitat suitability indices for steelhead doubled as generic curves to characterize rainbow trout.

Recommendations

As the FTC originally intended this measure as a cautionary check against other preferred alternatives, the expansion of this measure to other species and other survey areas was not viewed as critical as in the effective spawning performance measure. Subsequently, the rearing PM application was limited to rainbow trout in one section of the river. However, it is clear that exploration of the response of the system in other sections (i.e. braided channels) that are representative of the other channel types between Sugar and Wilsey would make the subsequent decisions more certain.

FLOW DISRUPTIONS (OUTAGES)

Background Information

The powerhouse at Shuswap Falls is fed by two penstocks from Wilsey headpond. During the months April through August, inflows generally exceed the maximum diversion of the penstocks and the headpond spills. Alternatively, the limited storage capacity at Sugar Reservoir prevents both turbines from operating at maximum capacity during the winter months: 100% of the inflow is typically routed through the penstocks September through March.

When an outage event occurs, one or both of the turbines shut down and immediately suspend the contribution of flow diverted by their respective penstocks (). Depending on inflow rates this can represent 10% (Freshet) to 100% (Winter) of the current downstream flow. If the suspended flow exceeds the capacity of the bypass value or the bypass valve does not operate, a flow reduction is observed downstream. The magnitude of the flow reduction is equal to the amount of flow suspended. The duration of the reduction is a function of the time required to surcharge the headpond (t_{fill})and reroute the suspended flow (t_{spill}) down the spillway. When 100% of the water is routed through the penstocks, time to fully recover flow immediately downstream is ~45 minutes at the WSC gauge (Figure M-8). If Wilsey Dam is spilling, the duration of the flow reduction can be reduced to 15 minutes. If the bypass valve functions and is able to divert a volume of water equal to that of the suspended flow, both flow reduction and duration are negligible (Figure M-9).

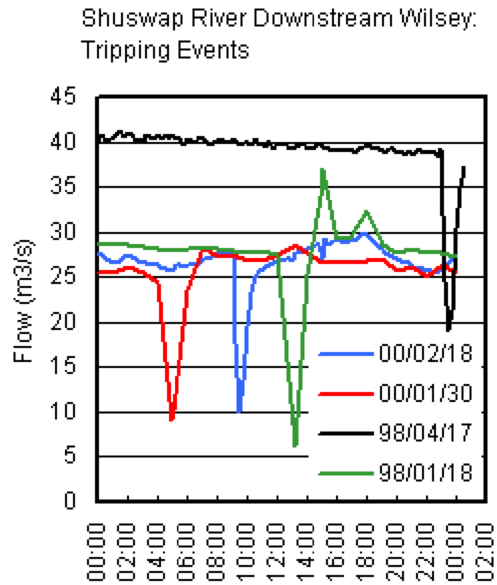


Figure M-8 Flow change below Wilsey Dam following an outage.

Examples of discharge reduction observed at the WSC gauge immediately downstream of Wilsey when 100% of the flow is suspended (00/02/18) and 35% is suspended (90/04/17).

An outage event will create unfavorable downstream flow conditions for aquatic life. The high rate of stage change associated with the sudden loss of 1 or 2 units, coupled with extended dewatering (>5 minutes) of habitat may contribute to mortality of fish through stranding. It is suspected that salmonid and resident fry that frequent the margins of the river are particularly susceptible to this type of impact. In addition, less mobile lifestages (alevins) and invertebrates in the dewatered area are significantly at risk from exposure. These effects are further exacerbated during winter months when freezing conditions occur, loss of wetted perimeter is maximized, and temporal delays are maximized because all local inflow is routed through the turbine(s).

Two key factors must be considered in estimating impacts: Duration and extant of dewatered habitat. It should be noted that stranding impacts will be the same regardless of duration, if the flow reduction is greater than 5 minutes: All exposure impacts having already occurred within the first 5 minutes. This implies that operational changes that reduce duration of a flow reduction from 20 minutes to 10 minutes will not change the associated impact. Conversely, the extent of dewatered habitat will be related to the percentage of rerouted flow, the base flow in the river, and the channel morphology (steep vs. gradual slopes). This relation is not linear. Extent of dewatered habitat assuming at 5% flow reduction at 1200 cfs could be greater than a 50% flow reduction at 700 cfs. Further confounding impacts estimates is the seasonal and diel habitat preferences of the aquatic life during the flow reduction.

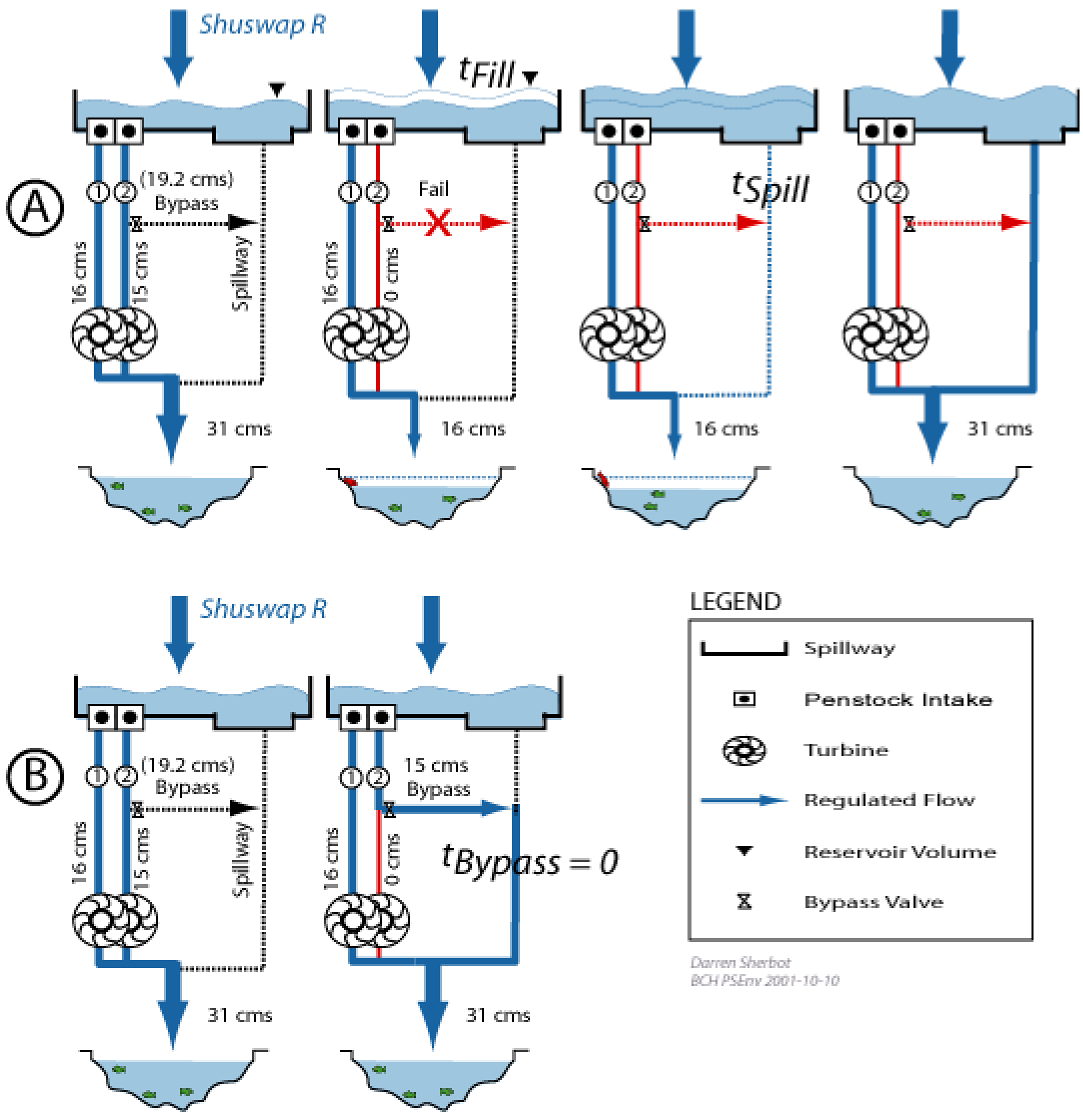


Figure M-9 Outage Flow Reduction Scenarios.

(A) Outage with bypass valve failure and (B) operation. Time associated with flow reduction downstream if the bypass valve does not operate or if suspended flow exceeds the bypass valve capacity is a function of the time required to surcharge the headpond (tFill) and the time required to 'wet" the spillway (tSpill). If the system is already spilling, tSpill is reduced, however, the duration of tFill is still sufficient to elicit potential impacts downstream. At risk is aquatic life exposed in the dewatered perimeter. Time required to divert water via the bypass valve (tBypass) is negligible: No significant impacts are associated with scenario B.

To minimize potential impacts associated with sudden downstream flow reductions, a bypass valve on Unit 2 penstock was added in 1993. The bypass valve was installed to provide an immediate downstream diversion up to 19.45 m^3/s in the eventuality of tripping Unit 1 and/or Unit 2. Effective operation of the valve would "bypass" the time lag associated with raising the induced storage level of Wisely headpond sufficient to spill and re-inundate the river below the tailrace.

In practice, the bypass valve has worked in only ~22% of the outages events during the last 7 years. Operational and mechanical problems have limited its effective use until cumulative operational improvements were effected in 1999. Since 1999, however, unless precluded from operating during certain protective conditions, the bypass valve is now expected to operate 96% of the time. Though dewatering and high change in stage continue to be a concern for downstream fishery impacts, its likelihood has now been significantly reduced. Furthermore, operational changes are also expected to reduce the frequencies of an outage event, itself, from ~3/yr to ~1.6/yr. When a fault tree analysis is used to predict the chance that an outage will result in a significant flow disruption, impacts from outages have been decreased from ~3 events per year to ~0.5 events per year (ie ~ once every 2 years) (Figure M-10).

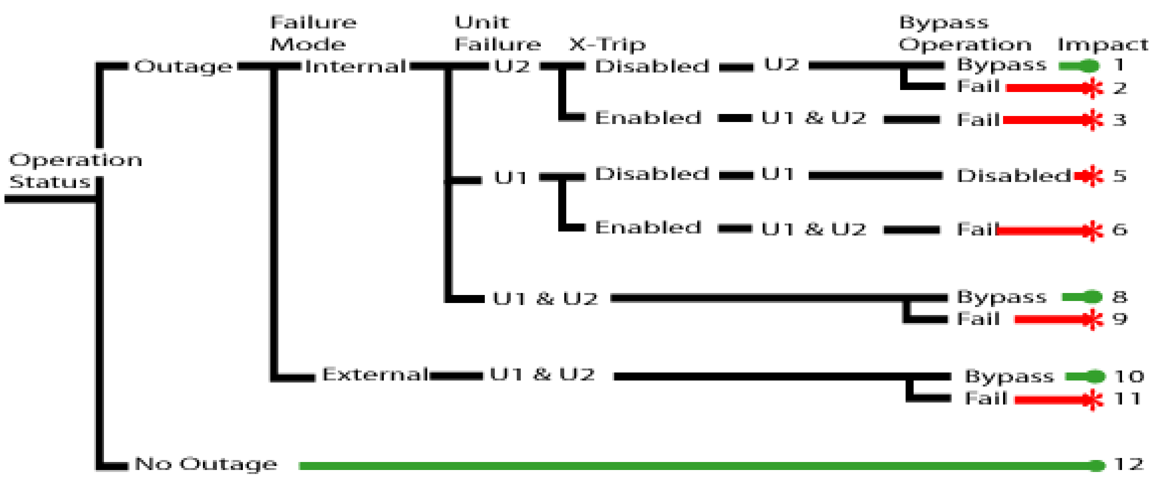


Figure M-10Outage Event Tree

Possible outage modes and conditional events used to calculate the expected frequency of outages that may impact aquatic life.

PM Development

To address potential mitigation of the cumulative effects associated with outage events, the FTC considered a qualitative scale to rank alternatives and a quantitative measure of how often impacts were expected to occur (Table M-8).

Table M-8 Outage PM: River Objective and Performance Measure Summary.

Broad and specific objectives jointly created by the SHU FTC and approved by the CC. Impact hypotheses and initial performance measures approved by the FTC.

Broad Fisheries Objective	**(A) Maximize resident and anadromous fisheries populations in the Middle Shuswap River.** (B) Maximize resident fish populations in Sugar Reservoir.
Specific Fisheries Objective	(A) Minimize impacts from outages to Chinook, Coho, Rainbow, and Kokanee downstream Wilsey Dam. (B) Minimize impacts from outages to riverine productivity.
Impact Hypotheses	A portion of salmonid fry and resident fish in the river margins are at risk from stranding during an outage. A portion of alevins are at risk when exposed during outages. Cumulative impacts from outages reduces the productivity capacity of the river at all trophic levels.
Means Objective	Reduce frequency of outages and bypass valve failure. Potential mitigation associated with constant bypass flow.
Operation Implications	Increased plant performance and revenue by reducing outages. Significant decreased revenue associated with baseline bypass.
Performance Measure	(A) Return frequency of outages with bypass valve failure. (B) FTC scale of potential benefits.
Critical Uncertainties	Magnitude of impact associated with outage event(s). Magnitude of ecosystem response to current operational improvements. Relationship between bypass flow (or spill) and outage impact.
Data Acquisition Costs	Multiple stage gauges to quantify flow disruption and attenuation downstream: ~$15, 000. Post processing of flow disruption frequency and risk: ~$5000. Controlled measures of biological impact: $50,000 – $500, 000.

Recommendations

The FTC agreed that BC Hydro should continue to seek improvements in both reducing the frequency of outages and bypass valve failure and, where possible, lessen the impact associated with outage flow disruptions. This can be accomplished though continued improved maintenance and operating procedures and, perhaps, with other physical works or flow operations if the benefits warrant the effort. What remains highly uncertain is what the current impacts from flow outages are on river productivity and what the response (if any) will be as the frequency of outages are reduced and/or operational changes are made to reduce potential impacts.

To date, no quantitative and/or qualitative data has been collected to assess the cumulative impacts of outages on any BC Hydro systems. Assuming, however, the impact hypothesis that "outages reduce the productive capacity of the river" is indeed significant, the Shuswap provides a unique opportunity to investigate this. In the last two years, the expected return of outages impacts has been reduced from 6 events every 2 years to 1 event every 2 years. This represents a 6x reduction in expected impact. If continued operation improvement further reduces the frequency of outages and the impact hypothesis is true, a measurable effect in the Shuswap system should be apparent over the next 4 years. The magnitude of this change will provide valuable information in assess additional operational efforts and/or flow strategies should they be warranted.

APPENDIX N: SUMMARY OF ANADROMOUS FISH INFORMATION FOR THE SHUSWAP RIVER

The following information was presented to the FTC and to the Consultative Committee by Heather Stalberg (DFO) as background reading, and was summed up into the information sheets to assist Consultative Committee members in thinking through the trade-off analysis.

SHUSWAP ANADROMOUS FISHERIES INFORMATION

26 November 2001

Fisheries and Oceans Canada manages chinook, coho and sockeye salmon resources on both the lower and middle Shuswap River. The following provides information pertaining to the status of and fisheries on these stocks.

Lower Shuswap River

(i) Chinook

In addition to fisheries within the Shuswap River, the chinook stocks in both the lower and middle Shuswap River are caught in commercial and sport ocean fisheries and first nations food, social and ceremonial fisheries in rivers downstream. The chinook stock in this section of the river is used as an indicator for exploitation (fishing pressure) and ocean survival in the Canada-U.S. Pacific Salmon Treaty process. It is monitored on an annual basis through counting the number of fish which return to the spawning grounds (escapement), assessing the age of the fish and analysing coded wire tag group information. This stock is used as an index for others in the same run timing grouping e.g. middle Shuswap, South Thompson and lower Adams River. In the last two years the estimated escapement to the river has been 24 000 and 28 000. The lower Shuswap chinook population is positively tracking the rebuilding efforts reflected in this run-timing grouping, unlike the middle Shuswap population which is described below. There is a sport fishery on chinook in the lower Shuswap, which includes Mable Lake, where the catch can reach 1500 fish per year. In addition, there is generally an annual provision of about 5-10% of the brood year for a First Nations food, social and ceremonial fishery on the lower and middle Shuswap. The Spallumcheen band fishes in both areas and for the period between 1994-2000, their total harvests ranged from 150-350 fish annually.

(ii) Coho

This stock is part of the South Thompson coho group which continues to remain a conservation concern. The escapement is only about 200 per year. Given the low numbers of this stock, there are no fisheries directed upon it and there have been significant changes in the ocean fisheries upon other salmon species to reduce the number of these fish caught incidentally.

(iii) Sockeye

The lower and middle Shuswap River sockeye are considered part of the late-run timing stock group which includes the S. Thompson and Adams River sockeye. In addition to fisheries within the river, these sockeye are caught in commercial and sport ocean fisheries as well as first nations food, social and ceremonial fisheries in rivers downstream. In 1987 higher escapement goals were established after the Pacific Salmon Treaty was signed in 1985 resulting in much greater returns of this stock group through the late eighties and nineties. Recent mortalities of the early arriving part of this group has resulted in a reduction of all fisheries. This stock has a four year cycle, with the dominant year being 1998, 2002, etc. In 1990, 1994, and 1998 there were approximately 1 million, 367 000 and 291 000 sockeye respectively in the lower Shuswap. There are typically about six times as many fish in the lower Shuswap as in the middle. The year after the dominant year, the run decreases significantly to a few thousand fish total in both the lower and the middle Shuswap and then in the remaining 2 years of the four year cycle there can be less than 1000 fish in the entire system.

Middle Shuswap River

(i) Chinook

Again, in addition to the fisheries within the river, the chinook stocks in both the lower and middle Shuswap River are caught in commercial and sport ocean fisheries as well as first nations food, social and ceremonial fisheries in rivers downstream. This population has remained steady at about 3500-4000 spawners per year and is not tracking the increasing trend in escapement as are the others within this run timing grouping. There is a sport fishery for chinook in the middle Shuswap wherein about 150-300 fish are caught annually. As per the lower Shuswap River, there is generally an annual provision of about 5-10% of the brood year for a First Nations food, social and ceremonial fishery. See the lower Shuswap River above for the Spallumcheen band harvest information. The Okanagan band occasionally fishes in the middle Shuswap with the catch seldom exceeding 25 fish per year.

(ii) Coho

Again, this stock is part of the South Thompson coho group which remain a conservation concern. The escapement is only about 200-250 per year. Given the low numbers of this stock, there are no fisheries directed upon it and there have been significant changes in the ocean fisheries on other salmon species to reduce the number of these fish caught incidentally.

(iii) Sockeye

As per the lower Shuswap River discussion.

Heather Stalberg
Senior Habitat Biologist
Fisheries and Oceans Canada

APPENDIX O: SUMMARY OF RESIDENT FISH INFORMATION FOR THE SHUSWAP

Shuswap Resident Fisheries Information

The Ministry of Water, Land and Air manages resident fish species including the following species found in the Shuswap Water Use Plan area.

Kokanee

Kokanee are native to Mabel Lake and are also present in Sugar Lake. Both stocks are small fish, from 21 to 26 cm in size and are at least three years old at time of spawning in early October. Spawning escapement counts of Mabel Lake kokanee were completed in 1986, 1991, 1993, 1994, 1999, 2000 and 2001 kokanee. Only three counts are on file for the Upper Shuswap. The lowest escapement estimates on record were in 2000, only 4200-6400 in the Middle Shuswap from Mabel Lake and 1000-1500 in the Upper Shuswap. Past escapements in the Middle Shuswap had escapement ranges from 11,000 to 108,000 and in the Upper Shuswap from 5000 – 20,000 adult spawners. In contrast, in 2000 kokanee runs in other parts of the Shuswap drainage were at record highs (i.e. Eagle, Lower Shuswap over 1 million fish each). Fall spawning kokanee sustain a portion of the lake recreational fishery and are key forage fish for other species such as bull trout and rainbow. Kokanee fry depend on shallow, littoral habitats. Older fish typically move into deep water (pelagic).

Rainbow

Rainbow trout from Mabel Lake are sometimes large in size and feed on other fish including young salmon and kokanee. Kokanee provide a year-round food source. Rainbow are caught in both Mabel and Sugar Lake. Smaller resident rainbows reside in the river and tributary creeks. Spawning rainbows (adfluvial migrants from Mabel) have been observed in May in Bessette Creek but spawning escapement and distribution in the Middle Shuswap and Upper Shuswap is unknown. In Sugar Lake, native rainbow are present and residual "Gerrards" left over from early 1990's stocking. The Gerrards grow to large size and feed on kokanee. Spawning location and population abundance is unknown.

Bull Trout

Bull trout are occasionally found in the Middle Shuswap below Wilsey but current spawning distribution, (with no access to cold water tributaries above Wilsey Dam) is thought to be in other tributary drainages to Mabel (i.e. Wap). Above Wilsey, a small, isolated population (under 100 fish) exists between the dams. In the Upper Shuswap, bull trout are fairly common and are suspected to be spawning in several key tributaries (i.e. Gates Creek). Bull trout, including large specimens, are caught in Sugar Lake by recreational anglers. Total escapement is unknown. Bull trout are long-lived species and may not spawn until seven years age.

Burbot

Burbot, or freshwater "ling" are present in Sugar Lake and attract some winter anglers. Spawning occurs in late winter in shallow areas of the lake. After the eggs hatch , juveniles live in shallow water for the first few weeks. Some anglers report late winter angling success for burbot in deep water near shoreline areas. This activity may coincide with spawning aggregations in nearby shallower habitats. No biological information exists about the Sugar Lake burbot population.

Mountain Whitefish

Mountain whitefish are present in large numbers in all sections of the Middle Shuswap (and in the Upper Shuswap). Whitefish are suspected to reside in the river at all life stages. In late fall or early winter, whitefish congregate in large schools and broadcast (no redds dug) spawn in cobble habitats. Spawning locations and population numbers have not been documented but whitefish are abundant in the watershed and are the largest proportion of resident fish biomass in river habitats.

Prepared by: Alan Caverly (WLAP Fisheries Biologist)

APPENDIX P: SUMMARY OF FIRST HAND OBSERVATIONS OF SUDDEN FLOW CHANGES ON THE RIVER, PROVIDED TO THE SHUSWAP WATER USE PLAN FISH TECHNICAL COMMITTEE IN OCTOBER 2001

The following is a summary of two first hand accounts of sudden stage changes on the Shuswap River, provided by Heather Stalberg (DFO). This information was presented to the FTC, and was summarized for the Consultative Committee to assist in the their decision-making.

Impacts of Plant Outages on Fish

Electrical generators in the Wilsey powerplant can "trip" off as a result of external (e.g. a downed transmission line) or internal (e.g. frazil ice) causes. Sudden changes to flows in the river below Wilsey Dam can occur when there is a trip, or outage, and the flows through the penstocks are suspended. This results in an instantaneous loss of some or all of the flow in the river, which negatively impacts fish productivity. The impact increases as the physical disruption increases. The magnitude, duration, timing and frequency of such events contribute to the degree of impact.

The magnitude of change in the river flow is greatest immediately below Wilsey Dam, and gradually reduces as one progresses downstream. The four kilometre length of river immediately downstream of Wilsey Dam is where the majority of chinook spawn, with a high density spawning area just downstream of the dam. Coho and kokanee also spawn in this area and rainbow trout and mountain whitefish utilize the area as well for rearing.

Unlike the magnitude, the duration of the flow change increases as one progresses downstream. There are fish present within the system year round and the seasonal timing of the outages will affect various lifestages of these fish. With respect to frequency, it is expected that there will be three outages per year, with no temporal distribution pattern.

BC Hydro has made some progress in the last few years in removing what they consider to be the major causes of dewatering arising from tripping, including installing and improving a bypass valve in Penstock No. 2 to re-route water around this tripped generator. However, an outage can still cause impacts if the bypass valve is disabled, if the valve fails and/or if suspended flow during an outage exceeds the capacity of the valve.

These sudden changes to flows are unnatural and can cause mortality to alevins, juvenile and adult fish directly through freezing, asphyxiation and predation and indirectly through stress. Eggs also dewatered during outages can be killed if temperatures are extreme. The degree of impact has rarely been assessed as the outages are unplanned and the site is isolated; typically when monitors have attended the site they arrive hours after flows have returned to pre-tripping levels.

There have been two outages where limited observations were opportunistically gained by consultants and agency staff working on the river. One event happened on 24 October 1994 where a fisheries consultant metering flows on a gravel bar approximately one kilometre downstream of the hatchery observed the water elevation drop about 30 cm in 10 minutes. He observed stranded red sided shiners and long nose dace on the gravel bar and expected that they had died. Numerous salmonid redds were partially dewatered. In the area that he was working there was no stranding of adult salmon. The river level was down for about 10-15 minutes after which it returned to pre-reduction levels in approximately 30 minutes.

The second event occurred a few years ago and was observed by hatchery and provincial fisheries staff in October during mapping work of coho and kokanee spawning areas. The crew was working about 3 to 4 km downstream of the hatchery where the river level was seen to drop about 15 cm. Kokanee redds were dewatered and numerous stoneflies moved out of the dewatered substrate. The total time for the reduction and resumption of river levels was approximately 30 minutes.

Further insight as to the potential impact of an outage can be gained when a comparison is made between the rate of river level drops associated with outages versus the science based guidelines developed to limit the potential to strand juvenile fish during planned flow reductions. The guidelines range from a 0-10 cm drop per hour depending upon the time of year and day, with 2.5cm being the typical target. Plus, there is a threshold of 15 cm for the total daily elevation drop. These guidelines are currently implemented at the facility for planned flow changes. As demonstrated through the previous examples, the rate and often magnitude of the river level reductions during an outage far exceeds the guidelines.

Heather Stalberg
Senior Habitat Biologist
Habitat and Enhancement Branch
Fisheries and Oceans Canada

18 January 2002

APPENDIX Q: IMPACTS OF SUDDEN FLOW DECREASES ON THE SHUSWAP RIVER

The following is a summary of first hand accounts of impacts of sudden flow decreases on the Shuswap River below Wilsey Dam. This information was presented to the Consultative Committee as pre-reading material for its February 2002 meeting.

There have been two outages where limited observations were opportunistically gained by consultants and agency staff working on the river. One event happened on 24 October 1994 where a fisheries consultant metering flows on a gravel bar approximately one kilometre downstream of the hatchery observed the water elevation drop about 30 cm in 10 minutes.[1] He observed stranded red sided shiners and long nose dace on the gravel bar and expected that they had died. Numerous salmonid redds were partially dewatered. In the area that he was working there was no stranding of adult salmon. The river level was down for about 10-15 minutes after which it returned to pre-reduction levels in approximately 30 minutes.

The second event occurred a few years ago and was observed by hatchery and provincial fisheries staff in October during mapping work of coho and kokanee spawning areas.[2] The crew was working about 3 to 4 km downstream of the hatchery where the river level was seen to drop about 15 cm. Kokanee redds were dewatered and numerous stoneflies moved out of the dewatered substrate. The total time for the reduction and resumption of river levels was approximately 30 minutes.

The DFO representative also pointed out that the stage changes mentioned above are in excess of previously established ramping restriction guidelines.

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1 Information provided to Heather Stalberg by Shuswap Hatchery Manager, Szcezpan Wolski during telephone conversation on 22 October 2001.

2 Information provided to Heather Stalberg by consultant, Dave Gordon, during telephone conversation on 22 October 2001. Information then summarised via e-mail and then approved by Dave Gordon on 22 October 2001.

APPENDIX R: LETTER TO THE WATER USE PLAN MANAGEMENT COMMITTEE REGARDING THE SCOPE OF WATER USE PLANS

4837 Westlawn Drive Office & Mobile: 604-839-9562
Burnaby BC, Canada V5C 3R4 Fax: 604-608-3589
Email: tonywong@uniserve.com

March 28, 2002

Ms. Denise Mullen-Dalmer
Chairperson - Water Use Planning Management Committee
1810 Blanshard Street, 4th Floor
Victoria, BC V8W 9N3

RE: Shuswap Water Use Plan and Structural Changes to Sugar Dam

Dear Denise Mullen-Dalmer,

I am writing to you on behalf of several CC members interested in flood control in the Shuswap Water Use Plan. As you are aware, the desire to see more flood control along the river has led to a large amount of discussion around whether changing the existing infrastructure at Sugar Lake Dam falls within the scope of WUPs. This question was touched upon in a previous letter sent to you and in your response of November 8th, 2000. At that time, the principles around the scope of WUPs were under development and it was unclear to the committee what could and could not be considered. While these principles have now been finalized, this group would like the WUP MC to reconsider the following issue one more time.

The current structure at Sugar Lake Dam has four gates. The flood sub-committee and its members that sit on the CC feel that the gates are too small. The existing gates cannot pass sufficient flows during the freshet and periods of high inflows (i.e. rainstorm events) even though the river has the capacity to carry higher flows without flooding. When high inflows are predicted, BC Hydro cannot drain the reservoir fast enough to create space to capture new inflows. Analysis provided by BC Hydro at the request of the flood sub-committee shows that the addition of a fifth gate at Sugar Lake Dam would enhance the ability to lower the reservoir faster, thus capturing a greater portion of high inflows and increasing flood control along the river. This reduces the number of days and magnitude of flooding.

In addition to improving flood control, the ability to evacuate the reservoir faster with an extra gate(s) would potentially allow for higher reservoir elevations earlier in the summer as long as dam safety criteria are met. Discussions around the CC table suggest that this would have no impact on power production and may benefit recreation and fish interests in the reservoir. The CC did not consider the effect this operation may have on fish downstream. In short, some of the members of the CC feel that the extra gate(s) may provide a win-win situation and would like the opportunity to evaluate this alternative. None of the thirteen operational alternatives evaluated during the WUP, using the existing four gates, improved the flooding Performance Measures. Moreover, it is the opinion of the BC Hydro project team that additional flood control is not possible, given the current structures. By following the logic that determines what is in and out of the scope of WUPs, physical changes at Sugar Lake Dam to improve flood control are outside of the scope of WUPs. The CC is not disputing this interpretation of the scope of WUPs. Rather, the individuals around the CC who are affected by flooding on the river are appealing to the WUP Management Committee to reconsider the boundary between in and out.

Given that the extra gate(s) at the Sugar Lake Dam may pose a win-win solution for flooding, recreation, and fish interests, it only seems reasonable that this option be explored within Water Use Planning. There are 22 farms between Wilsey Dam and Mabel Lake. Damage from flooding can be expensive. For example in 1997, one farmer estimated his losses at about $100,000 in degraded hay and in extra costs to relocate livestock during flooding. Three other farmers at CC meetings each reported losses of about $20,000. While the feasibility and costs of changing the dam have not been studied, it is the opinion of the SHU WUP flood sub committee that avoiding periodic damage to farmlands along the Shuswap River would almost certainly outweigh the costs of adding an extra gate or two to Sugar Lake Dam. It is for these reasons that this request for the scope of WUPs be reconsidered so that discussions considering an extra gate (or two) at Sugar Lake Dam can be undertaken.

On behalf of these members of the SHU WUP CC, I would like to thank you for considering this request.

Sincerely,

Tony Wong, Facilitator
Shuswap Water Use Planning
(CC: WUP MC, Vesta Filipchuk (BCH), Daryl Fields (BCH), SHU WUP CC)

APPENDIX S: REPLY FROM THE WATER USE PLAN MANAGEMENT COMMITTEE TO CONSULTATIVE COMMITTEE MEMBERS REGARDING THE SCOPE OF WATER USE PLANS

April 26, 2002

Mr. Tony Wong
Quintry Management Consulting Inc.
4837 Westlawn Drive
Burnaby, B.C.
V5C 3R4

Dear Mr. Wong:

Re: Shuswap Water Use Plan and Structural Changes to Sugar Dam

On behalf of the WUP Management Committee (MC), I am responding to your letter dated March 28^{th}, 2002 which was sent to us on behalf of the Shuswap WUP Consultative Committee members interested in improving flood control conditions on the Shuswap River. Specifically, your letter requested that the WUP MC reconsider the scope of WUPs in order to allow the flood group and the Consultative Committee to consider structural changes to the Sugar Dam. It is our understanding that the flood group believes that if additional gate(s) are installed in the dam, there may be an opportunity to reduce the frequency and magnitude of flooding on the Shuswap River.

Water use planning focuses on the operational changes at water control facilities as they currently exist. The premise of this review is to look at how the existing structures can store and release water in order to address a range of water related issues and interests. If there is an operational change that provides a benefit or improvements to a particular interest, these operational changes can be brought forward for trade-off and discussion by the CC in Step 7 of the *Water Use Plan Guidelines*. The ability of the CC to consider structural changes to existing facilities only comes into play when a structural change is a cheaper alternative to implementing an operational change. In the case of Sugar Dam, it is our understanding that the existing structure and dam safety considerations are such that there is not an operational change that can improve the flood control condition. If no operational change is available in which to trade-off a structural change, then a structural change to the facility cannot be contemplated.

While we appreciate the desire and interest of the flood group and members of the Consultative Committee to maximize flood control conditions on the Shuswap River, the balance of these issues and interests amongst all others must be done within the existing scope of Water Use Plans. The WUP Management Committee cannot extend beyond its mandate to broaden the scope of WUPs as it would set a precedent for ongoing and future WUP processes which could pose a risk to the success of the entire WUP programme.

Your interests in improving flood control on the Shuswap River have been noted. One of the purposes of Water Use Planning is to allow the government to have a more accurate assessment of public values around the use of water. To this end, please ensure your interests are expressed in the report of the Consultative Committee for the Shuswap WUP so that it will help to guide future water management policy and decision-making.

Sincerely,

Denise Mullen-Dalmer
Water Use Plan Program

APPENDIX T: ANALYSIS OF FLOWS AND ELEVATIONS IN THE SHUSWAP RIVER SYSTEM WITH FIVE GATES AT SUGAR LAKE DAM

Introduction

This note has been put together by the BC Hydro project team for the Shuswap Water Use Planning process at the request of the flooding subcommittee.

During the Shuswap Water Use Plan process, analysis provided by the BC Hydro project team has indicated that current operations at Sugar Lake Dam provide the greatest degree of flood control possible, given the current structures. Given this result, and given the definition of the scope of Water Use Plans as outlined in the interagency document, "Creating Alternatives Within Water Use Planning," the BC Hydro project team has concluded that any changes to Sugar Lake Dam to improve its flood control capacity is not within the scope of Water Use Plans.

With the configuration of Sugar Lake Dam, periodic flooding is expected to continue in about one of every 4 years along the Shuswap River. The flooding subcommittee has expressed interest in the impacts of having a fifth gate installed at Sugar Lake Dam. This analysis has been provided by the BC Hydro project team to assist those who are interested in pursuing these changes to the dam outside of the Water Use Plan process. However, it is important to highlight that this analysis is for informational purposes only. It does not represent support by BC Hydro for this project; no effort was expended to see whether this extra gate was of an optimal size, there is no analysis of all of the costs and benefits of these changes, nor is this analysis to be interpreted to say that the addition of a fifth gate is even feasible. This is only a hypothetical example to illustrate what flows might look like *if* a fifth gate was used.

Description of Analysis

The calculation of some performance measures is easier than others. For this reason, this analysis has been limited to performance measures that measure flooding on the reservoir and the river. For the sake of comparison, the other alternatives considered by the Consultative Committee are also presented below.

	SQ	SQ2	A	A2	B	DS1	G1	F1	5th gate
Reservoir flooding Number of days below 601.52 (accurate to +/-7 days)	340	346	358	361	354	365	357	358	345
River Flooding Number of days over 27 years flows are below 232 m^3/s (accurate to +/-15 days)	9790	9790	9791	9789	9791	9792	9791	9791	9814

From this analysis, it is clear that having a fifth gate will reduce this measure of flooding along the river compared to the other alternatives considered in the Water Use Plan process. Moreover, a fifth gate represents an improvement over the best that Hydro can do for flood control, given the existing facilities at Sugar Lake Dam. This physical change to the structure reduces flooding by about 24 days over 27 year data set.

Some other comparisons might also be of interest. A hardcopy printout of flows comparing status quo operations against this fifth gate option can show this in more detail, but the summary of these is given below.

	Status Quo (2)	**5th gate**
Number of flood free years (out of 27) (where flows were always below 232 m^3/s at Wilsey Dam)	20	24
% shaved off 1997 July flood	0%	2.3%
% reduction of largest flow (1 June 1997)	0%	25%

The addition of the fifth gate does not change, to a significant degree, the ability to keep the reservoir from surcharging. So, from perspective of the people living around the reservoir, the fifth gate is neither positive nor negative in terms of flooding.

No fish performance measures are included in this analysis. The main reason for this is that they are difficult to calculate with new flow data sets, and the project team cannot justify spending these resources on an issue outside of the scope of Water Use Plans. However, operations between SQ2 and the fifth gate alternative only differ during freshet. Therefore, it is assumed that the flows and elevations will be the same in the river and reservoir from the start of fall to freshet, leaving the fish performance measure scores unchanged.

Next Steps

The BC Hydro project team feels that discussions around a fifth gate are not within the scope of Water Use Plans, since no alternatives can do better for flood control than the one chosen, SQ. If the opinion of the flood group is different from this, a letter can be sent to the Water Use Plan Management Committee, the interagency dispute resolution body, for a ruling as to whether changes to Sugar Lake Dam are in or out of the scope of Water Use Plans. If changes to Sugar Lake Dam are ruled by the Water Use Plan MC to be within the scope of Water Use Plans, a more complete analysis of this option including the fifth gate can be undertaken, including performance measures for other interests. If the Water Use Plan MC rules this discussion to be outside of the bounds of Water Use Plans, then these concerns and discussions will still be highlighted in the Consultative Committee report, which will be forwarded to the Comptroller of Water Rights, but with the recognition that action on these suggestions are to be pursued outside of Water Use Planning.

APPENDIX U: EXAMPLE SPECIFICATION OF A WATER USE PLAN ALTERNATIVE

Alternative A Description: Power, Flood, Reservoir Recreation and Fish, Frazil Ice Protection

Facility	Operating Variable	Target	When	Modelling Priority	Comments
Reservoir	Maximum Reservoir Level	601.7	Year round		
	Minimum Reservoir Level	Empty by 1 Apr (but not before 28 Feb) Target 600 m between 15 Jun - 31 Dec		High priority Lower priority	
Sugar Lake Dam	Minimum Sugar Discharge	20 m^3/s	June - 15 Oct	High priority	
	Maximum Ramping Rate	N/a			Use current ramping rates in all alternatives
Wilsey Dam	Maximum Discharge Below Wilsey	Gates open to maximize discharge during freshet, and staged stoplog installation as per dam safety	1 May - 31 July		
	Minimum Spillway Flow	None required	Year round		
	Minimum Total Discharge Below Wilsey	15 m^3/s	1 Dec to 28 Feb		Prevent frazil ice (535 cfs equivalent)

Notes from Kim Meidal, Resource Management, BC Hydro, to Consultative Committee on Alt A - Flood, River Recreation and Fish, Frazil Ice protection, Power

1. The reservoir is emptied by 1 April but not before 1 March, and the gates forced open at least until mid-June to minimize floods. If the reservoir was still really low in June due to dry conditions, I allowed the discharge to reduce to bring it up.
2. Respected the minimum 20 m^3/s discharge until 15 October, but then dropped the flows to 15-20 m^3/s range if reservoir was below full pool. In some years, higher flows were necessary to keep reservoir below 601.7 m, and then I forced a gradual draft of the reservoir from mid-Nov to 1 April.
3. The 15 m^3/s min for penstock protections was achieved in all but 1 year to the end of February, but required dropping to 15 m^3/s immediately in October. Flows dropped lower in March. I was also trying to achieve a bit of a balance between fall and winter flows. In the 10^{th} percentile, the flows don't change dramatically from fall to winter. Further adjustment could have achieved similar for the median, but Alt B did that, so is a good comparison for what happens to the reservoir.
4. The gates are wide open and 0 stoplogs in for the freshet, then allows 4 stoplogs to go in towards the end of July and 6 stoplogs in August. I picked dates where the majority of the years would allow these levels. In drier or early freshet years, the stoplogs could go in earlier in July, so in reality, the reservoir may be up higher in some years earlier; however, I cannot model the stoplog installation in individual years, and wanted to ensure that the late, wet freshets were modelled well.

5. In Alt A, once the 20 m3/s discharge requirement period was over, I let the flows back-off to the 15 m^3/s min. In the driest years, this enabled the reservoir to draft gradually and we almost made it to April without emptying the reservoir. In the majority of years, this was too drastic, in the 10% for example, flows had to come back up to about 19 m3/s to draft the reservoir. For average years, it was also too drastic and required much higher flows in January - March. Alt B gives a good picture of staying around 23-25 m^3/s and the effect on average years. In Mid-October, some years go up again but almost 50% just continue drafting.

APPENDIX V: SHUSWAP WATER USE PLANNING ROUND 2 ALTERNATIVES AND TRADE-OFF ANALYSIS

This appendix describes the 14 alternatives evaluated in Round 2 of the Shuswap Water Use Plan process. The following appendix then describes the results of the trade-off analysis resulting in six of the alternatives being carried into Round 3 of alternative evaluation.

These alternatives can be grouped roughly into "themes." Within each theme, the alternatives are variations on a similar theme with the variations mainly being different fall flows designed to address fish interests (low, median, and high flow fish hydrograph—see Table V-1 and Table V-2 for the minimum flows defining these hydrographs). The four themes of alternatives represent different ways to manage flows from Sugar Lake Dam.

Theme 1: Manage Modified Fall Flows for Fish

- Modified flows in the fall to favour fish habitat.
- One reservoir fill-empty cycle annually with staged stoplog placement.
- Provide decreasing minimum flow constraints through the fall to encourage the spawning success of fish.
- Focus on river fish objectives only, no other objectives explicitly considered.
- Increasingly greater fall flows represented by Alternatives **M2**, **K1, G1, F1** through **H1**.

Alternative K1 and M2

- Objectives: River fish
- Managed fall flows (Table V-1) to provide spawning and incubation habitat for fish
- M2 same as K1, except M2 has actively managed releases from Sugar Lake Dam starting in December to empty reservoir by 1 April (but not before 1 March). K1 has a fixed flow regime December through April.

Table V-1 Fall Flows for Alternatives K1 and M2

		Alternative K1		**Alternative M2**	
	Date				
Minimum Flows	1 Apr – Aug	As required for freshet, 953 ft^3/s to keep reservoir high in summer.		As required for freshet, 953 ft^3/s to keep reservoir high in summer.	
Target Min Overwintering Flows.	1 Sep	27.0 m^3/s	953 ft^3/s	27.0 m^3/s	953 ft^3/s
	15 Sep	25.5	900	25.5	900
	1 Oct	24.1	850	25.5	800
	15 Oct	24.1	800	25.5	800
	1 Nov	24.1	800	25.5	800
	15 Nov	24.1	800	25.5	800
	1 Dec	24.1	800	Active management to 1 Apr	
	15 Dec	19.8	700	Active management to 1 Apr	
	15 Mar	19.8	700	Active management to 1 Apr	

Alternative G1, F1, and H1

- **G1**, **F1**, and **H1** modelled the low, median, and high fall fish-flow regimes in Table V-2. Each alternative represents progressively higher fall flows.
- Manage for fish interests only.

Table V-2 Low, Median, and High Fish Flow Hydrographs

	Date	Low-flow Hydrograph	Median-flow Hydrograph	High Flow Hydrograph	Priority
Minimum Flows past Wilsey Dam	1 Apr - Aug	1024 ft^3/s (29 m^3/s) (if possible, but less to keep reservoir high in summer)	As required for freshet, 1024 ft^3/s (29 m^3/s) to keep reservoir high in summer.	As required for freshet, 1200 ft^3/s (34 m^3/s) to keep reservoir high in summer.	Low
Minimum Flows past Wilsey Dam	1 Sep	1024 ft^3/s (29 m^3/s)	1024 ft^3/s (29 m^3/s)	1200 ft^3/s (34 m^3/s)	low
	15 Sep	900 (25 m^3/s)	1000 (28 m^3/s)	1200 (34 m^3/s)	High
	1 Oct	850 (24 m^3/s)	950 (27 m^3/s)	1200 (34 m^3/s)	High
	15 Oct	800 (23 m^3/s)	900 (25 m^3/s)	900 (25 m^3/s)	High
	1 Nov	800 (23 m^3/s)	900 (25 m^3/s)	900 (25 m^3/s)	High
	15 Nov	800 (23 m^3/s)	875 (25 m^3/s)	900 (25 m^3/s)	High
	1 Dec	800 (23 m^3/s)	850 (24 m^3/s)	900 (25 m^3/s)	Medium
	15 Dec	800 (23 m^3/s)	800 (23 m^3/s)	900 (25 m^3/s)	Medium
	15 Mar	800 (23 m^3/s)	800 (23 m^3/s)	900 (25 m^3/s)	Medium

Theme 2: Fill-Drain Reservoir

The fill-drain the reservoir alternatives:

- Fill the reservoir by capturing the end of freshet flows.
- Empty the reservoir by 1 April but not before 1 March. The model kept the gates open at least until mid-June. If the reservoir levels remained low in June because of dry conditions, discharge from Sugar Lake Dam was reduced to bring the reservoir up.

Alternative A

- Objectives: **River flood control, River recreation, Frazil ice protection, Power**

- Provided minimum of 20 m^3/s discharge 1 June to 15 October for river paddle sports. After 15 October, flows dropped to 15-20 m^3/s range if reservoir was below full pool. In some years, higher discharge from Sugar Lake Dam was necessary to keep reservoir below 601.7 m. Reservoir gradually drained from mid-November to 1 April to provide for fish habitat in the river.

Alternative B

- Same as Alternative A with a low-flow fish hydrograph added (Table V-2). Whereas Alternative A allowed a gradual draining of the reservoir between November to 1 April, Alternative B imposed higher spawning flows from September to April.

Alternative I

- Same as Alternative A with a median-flow fish hydrograph added (Table V-2). Compared to Alternative B, Alternative I provides higher spawning flows in the fall.

Alternative C

- Same as Alternative A with a high -flow fish hydrograph added (Table V-2). Alternative C provides higher spawning flows year round in the river for fish than Alternatives A, B, or I.

In addition to the Water Use Plan alternatives above, the committee modelled two other alternatives for comparison. Both the Status quo and Historical alternatives are "fill-empty" type operations.

Alternative "Status Quo"

- Model current operations using 1974 to 2000 inflow data as a baseline for comparing other alternatives

- Reservoir allowed to fill to maximum 601.72 m, empty by 1 April but not before 28 February

- Minimum 15 m^3/s discharge below Wilsey Dam from 1 December to 28 February for fish[1]
- Gates and stoplogs operated according to current dam safety schedule (Appendix A)

Alternative "Historical operations"

- Show the system "as-operated' in the past using recorded reservoir elevations and river discharge.
- Historical operating procedures changed over the years and resulting reservoir behaviour and river discharges reflect this change in operating practices.
- Generally, historical practice did not always draft the reservoir to empty and typically all six stoplogs were installed around mid-June (now delayed until July after freshet has passed).
- Does not conform to current dam safety practices.

Theme 3. Stabilize the Reservoir

The stabilize the reservoir alternatives:

- Close the gates on Sugar Lake Dam earlier to achieve a higher reservoir elevation early in the summer months.
- Empty the reservoir by 1 April but not before March 1.
- Provide flows that follow a fish friendly hydrograph in the fall

Alternative DS1

- Objectives: **Reservoir recreation, Archaeology, Reservoir fish, and River fish**
- Hold the reservoir below 601.22 m May through Thanksgiving. Hold the reservoir above 600.61 from mid-July until Thanksgiving.
- Release fall flows according to low-flow fish hydrograph schedule.

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[1] As explained in more detail in Section 8, the modelled constraint of 15 m^3/s translates into an instantaneous minimum constraint of 2 m^3/s lower.

FAlternative E

- Objectives: **Reservoir recreation, Archaeology, Reservoir fish, and River fish**
- Same as DS1 but with median-flow fish hydrograph

Note that operating according to Alternative E did not meet dam safety requirements for gate and stoplog operations. Alternative E was disqualified as a valid alternative.

Theme 4: Almost Run-of-River

This alternative represents the closest to letting the river run naturally. Even though the dams are in place in this alternative, there is no active operation of Sugar Lake Dam. The stoplogs are removed and the gates are wide open. Wilsey normally operates as a run-of-river dam.

- No stoplogs in place

Gates wide open year round

APPENDIX W: ROUND 2 TRADE-OFF ANALYSIS

From Shuswap Water Use Plan meeting minutes. 1 November 2001

EXAMINE TRADE-OFFS BETWEEN ALTERNATIVES SQ, A, B, C, DS1, M2, K, F1, G1, H.

The committee examined the performance measure scores and narrowed down to the most promising alternatives, then revise and refine most promising Water Use Plan alternatives for next time.

Comparing and looking for dominant alternatives

In comparing alternatives, we are looking for the alternatives that give us the most benefits (green cells) with the fewest trade-offs (red cells). Where the performance measures are the same (yellow cells), the alternatives are deemed to be the same within the range defined by the least significant difference.

Steps

1. Eliminate the alternatives that do not meet dam safety requirements: Historical and E

2. We have the added performance measure of Fish Hydrograph introduced by Heather and Al. Since the fish group "agreed to disagree" about how to choose between options that score "0" and options that score "1," the alternatives then fell into two main groups: alternatives scoring "0": A, M2, C, H1, and DS1, and alternatives scoring "1": B, I, SQ, G1, K1, F1, and RoR.

3. Looking at the "0" group first, It is clear that A dominates M2. This is because the two alternatives are tied on every measure except River Recreation, Wildlife, and the percent success of coho spawners. For those three, A is strictly better. The Consultative Committee would never choose M2 because A is equal to or better than it on every measure, so we can eliminate M2.

4. A vs. H1. A is better than H1 to a large degree on all fish measures, for wildlife depending on fish, and for power values. But H1 is better than A at protecting erosion of archaeological sites and against flooding around the reservoir. The group unanimously preferred H1 to A. Al C. said he would prefer to value living things over objects in reference to choosing to put a high weight on the fish performance measures.

5. A vs. C. The comparisons to H1 are the same, except that C was also better than A for putting the 3 m^3/s spill down the spillway. Robin felt that the extra 8 days of protection that Alternative C provided was well worth the cost to losses in fish and fish incubation. A number of Consultative Committee members felt that A was better than C. After some discussion, it became clear that this 3 m^3/s spill was more of an alternative than a performance measure, so it was dropped as a performance measure, and Kim will look at modelling the diversion of 3 m^3/s down the spillway in August. Without this safety performance measure, the Consultative Committee unanimously felt that the gains in fish incubation and spawning success outweighed the loss in archaeological protection arising from choosing A over C.

6. A vs. DS1 - no clear dominance pattern between the two, and so this choice was not pursued. A vs. DS1 was left unresolved, and to be addressed at the next cc meeting.

7. Group "1" - choices. B is tied to I on every measure except two, where it is better. By strict dominance, B is preferred to I.

8. G1 vs. K1 - G1 dominates K1 since it is tied on all measures except for three, where it is strictly better than K1.

9. F1 vs. G1. - F1 scores higher than G1 on the river recreation measure (130 days vs. 119 days), but worse on spawning and incubation measures for coho and kokanee. The Consultative Committee was not unanimous on their opinion here. The group supporting F1 felt that the gain in recreation numbers (11 days) outweighed the losses to coho and kokanee spawning and incubation success. However, the group supporting G1 felt that the gains in coho and kokanee spawning and incubation success in supporting G1 were more important than the gains of 11 days in river recreation. This choice was left as unresolved and will be addressed at the next meeting.

G1	F1
Tom Minor	Monty Willis
Dave Couch	Art Herbert
Tom Huwer	Larry Arcand
Heather Stalberg	Rudi Gedaschke
Leroy Proctor	
Al Caverly	
Brian Fast	
Ray Arlt	
Joe Huwer	
Lee Hesketh	
Robin Ledrew	

Comparing G1 to Run-of-River

The committee agreed that G1 dominated Run-of-River. RoR was dropped.

Bring back M2 for a comparison

Basil asked the group to reconsider alternative M2 (from the group with the "undesirable hydrograph." It was pointed out that the spawning and successful incubation performance measures suggested that M2 was a superior alternative to F1 for fish interests. But the fish performance measure for "hydrograph shape" suggested that F1 was better than M2 for fish. Heather was asked which performance measure carried more weight. In the ensuing discussion it was agreed that favouring G1 over M2 meant that the "hydrograph shape" performance measure was being used, at this point in the process, as a "trump card," outweighing any measure of successful spawning and incubation in this discussion. M2 was dropped and G1 remained.

SQ vs. B - difficult decision, since one is not clearly superior to the other across all or most performance measures. This choice was deferred until next meeting.

REDUCED SET OF ALTERNATIVES - 1 NOVEMBER 2001

Based on the performance measures, including fish hydrograph, these are the remaining contenders for further refinement.

1. Of the alternatives that meet Heather and Al's desirable hydrograph criteria, SQ, B, G1, and F1 remain.

2. Of the alternatives that otherwise do not meet Heather and Al's desirable hydrograph criteria, A and DS1 remain.

APPENDIX X: DETAILED SPECIFICATIONS OF SHUSWAP WATER USE PLANNING ROUND 3 ALTERNATIVES

ALTERNATIVE A - DESCRIPTION: POWER, FLOOD, RIVER RECREATION AND FISH, FRAZIL ICE PROTECTION

Facility	Operating Variable	Target	When	Modelling Priority	Comments
Reservoir	Maximum Reservoir Level	601.52 m	Maximum normal operating level	High	
	Minimum Reservoir Level	Empty by 1 April (but not before 28 Feb)		High	
		Target 600 m between 15 Jun - 31 Dec		Low	
Sugar Dam	Minimum Sugar Discharge (target minimum in parentheses)	18 m^3/s (20 m3/s)	June - 15 Oct	High	
	Maximum Ramping Rate	Under discussion	Year round	High	Use current ramping rates in all alternatives
Wilsey Dam	Maximum Discharge Below Wilsey	Gates open to maximize discharge during freshet, and staged stoplog installation as per dam safety	1 May ~31 July (timing dependent on freshet peak)	High	
	Minimum Spillway Flow	None required	Year round		
	Minimum Total Discharge Below Wilsey (target minimum in parentheses)	13 m^3/s (15 m^3/s)	15 Oct - 1 June	High	Prevent frazil ice (535 cfs equivalent) and to distribute remaining storage until 1 Apr

Alt A - Flood, River Recreation and Fish, Frazil Ice protection, Power Modelling Notes from Kim M. (BC Hydro)

1. The reservoir is emptied by 1 April but not before 1 March, and forced the gates open at least until mid-June to minimize floods. If the reservoir was still really low in June due to dry conditions, I allowed the discharge to reduce to bring it up.
2. Respected the minimum 20 m^3/s discharge until 15 Oct, but then dropped the flows to 15-20 m^3/s range if reservoir was below full pool. In some years, higher flows were necessary to keep reservoir below 601.7 m, and then I forced a gradual draft of the reservoir from mid-Nov to 1 April.
3. The 15 m^3/s min for penstock protections was achieved in all but 1 year to the end of February, but required dropping to 15 m^3/s immediately in October. Flows dropped lower in March. I was also trying to achieve a bit of a balance between fall and winter flows. In the 10th percentile, the flows don't change dramatically from fall to winter. Further fiddling could have achieved similar for the median, but Alt B did that, so is a good comparison for what happens to the reservoir.
4. The gates are wide open and 0 stoplogs in for the freshet, then allows 4 stoplogs to go in towards the end of July and 6 stoplogs in August. I picked dates where the majority of the years would allow these levels. In drier or early freshet years, the stoplogs could go in earlier in July, so in reality, the reservoir may be up higher in some years earlier; however, I cannot model the stoplog installation in individual years, and wanted to ensure that the late, wet freshets were modelled well.
5. In Alt A, once the 20 m^3/s discharge requirement period was over, I let the flows back-off to the 15 m^3/s min. In the driest years, this enabled the reservoir to draft gradually and we almost made it April without emptying the reservoir. In the majority of years, this was too drastic, in the 10% for example, flows had to come back up to about 19 m3/s to draft the reservoir. For average years, it was also too drastic and required much higher flows in Jan-Mar. Alt B gives a good picture of staying around 23-25 m3/s and the effect on average years. In Mid-Oct, some years go up again but almost 50% just merrily continue drafting.

ALTERNATIVE A2 - DESCRIPTION:

Facility	Operating Variable	Target	When	Modelling Priority	Comments
Reservoir	Maximum Reservoir Level	601.52 m	Maximum normal operating level	High	
	Minimum Reservoir Level	Empty by 1 April		High	
		Do not empty before 28 Feb		Low	
Sugar Dam	Minimum Sugar Discharge (target minimum in parentheses)	18 m^3/s (20 m^3/s)	1 Jun to 7 Sept	High	
	Maximum Ramping Rate	Max daily discharge reduction of 14 m^3/s (as per current practice)	Year round	High	Use current ramping rates in all alternatives
Wilsey Dam	Maximum Discharge Below Wilsey	Gates open to maximize discharge during freshet, and staged stoplog installation as per dam safety	1 May - 31 Jul (timing dependent on freshet)	High	
	Minimum Spillway Flow	None required	Year round		
	Minimum Total Discharge Below Wilsey (target minimum in parentheses)	16 m^3/s (18 m^3/s) 15 m^3/s (17 m^3/s) 14 m^3/s (16 m^3/s)	7 Sept - 14 Sept 15 Sept - 30 Sept 1 Oct - 31 Dec	High	
		13 m^3/s (15 m^3/s) no less than inflows	1 Jan to 28 Feb 1 Mar – freshet	Medium	

1. Alt A2 - Based on the modelling in Alt A, but with the flow restriction from Sugar Reservoir relaxed in early September.

ALTERNATIVE B - DESCRIPTION: SAME AS "A" EXCEPT WITH LOW-FLOW FISH HYDROGRAPH ADDED

Facility	Operating Variable	Target	When	Modelling Priority	Comments
Reservoir	Maximum Reservoir Level	601.7 m	Maximum normal operating level	High	
	Minimum Reservoir Level	Empty by 1 April		High	
		do not empty before 28 Feb		Low	
Sugar Dam	Minimum Sugar Discharge (target minimum in parentheses)	18 m^3/s (20 m^3/s)	June - 15 Oct	Covered by fish hydrograph	
	Maximum Ramping Rate	Under discussion	Year round	High	Use current ramping rates in all alternatives
Wilsey Dam	Maximum Discharge Below Wilsey	Gates open to maximize discharge during freshet, and staged stoplog installation as per dam safety	1 May - 31 July	High	
	Minimum Spillway Flow	None required	Year round		
	Minimum Total Discharge Below Wilsey	**Low-flow** Fish hydrograph (Table 1)	after 1 Sept	High	
Other					

ALTERNATIVE DS1 - DESCRIPTION: RESERVOIR RECREATION, ARCHAEOLOGY, FISH, AND RIVER FISH WITH LOW-FLOW FISH HYDROGRAPH

Facility	Operating Variable	Target	When	Modelling Priority	Comments
Reservoir	Maximum Reservoir Level	601.22 m	1 May – Thanksgiving	Maximum normal operating level	
		601.52 m	Thanksgiving - 30 Apr	Low	Winter, allow more storage, but minimize shoreline erosion
	Minimum Reservoir Level	600.61 m	mid-July – Thanksgiving	High	
		empty res. By 1 April		High	
Sugar Dam	Minimum Sugar Discharge	As required to meet min Wilsey discharge	Year round	high	
	Maximum Ramping Rate	Under discussion			
Wilsey Dam	Maximum Discharge Below Wilsey	Gates open to maximize discharge during freshet, and staged stoplog installation as per dam safety	1 May - 31 July (timing dependent on peak of freshet)	High	
	Minimum Spillway Flow				*20 m^3/s to protect penstocks, spill above Post-processed for Value comparison.
	Minimum Total Discharge Below Wilsey	**Low-flow** Fish hydrograph (Table 1)	After 15 Oct - 1 Apr	High after 15 Oct	

ALTERNATIVES F AND G - DESCRIPTION: STAND-ALONE FISH HYDROGRAPHS, EMPTYING RESERVOIR AND STAGED STOP-LOG INSTALLATION

Table 1 Fish Hydrographs (Target Minimums[1])

Alternative		F	G	Modeling Priority
Minimum Flows past Wilsey Dam	1 Apr - Aug	1024 ft^3/s (29 m^3/s) (if possible, but less to keep reservoir high in summer)	As required for freshet, 1024 ft^3/s (29 m^3/s) to keep reservoir high in summer	Low
Minimum Flows past Wilsey Dam.	1 Sept	1024 ft^3/s (29 m^3/s)	1024 ft^3/s (29 m^3/s)	low
	15 Sept	900 ft^3/s (25 m^3/s)	1000 ft^3/s (28 m^3/s)	High
	1 Oct	850 ft^3/s (24 m^3/s)	950 ft^3/s (27 m^3/s)	High
	15 Oct	800 ft^3/s (23 m^3/s)	900 ft^3/s (25 m^3/s)	High
	1 Nov	800 ft^3/s (23 m^3/s)	900 ft^3/s (25 m^3/s)	High
	15 Nov	800 ft^3/s (23 m^3/s)	875 ft^3/s (25 m^3/s)	High
	1 Dec	800 ft^3/s (23 m^3/s)	850 ft^3/s (24 m^3/s)	Medium
	15 Dec	800 ft^3/s (23 m^3/s)	800 ft^3/s (23 m^3/s)	Medium
	15 Mar	800 ft^3/s (23 m^3/s)	800 ft^3/s (23 m^3/s)	Medium

1. strict minimums are 2 m^3/s less

Ramping Rates: Under discussion

Maximum Discharge Below Wilsey: Gates open to maximize discharge during freshet, and staged stoplog installation as per dam safety instructions.

ALTERNATIVE SQ[1] - DESCRIPTION: MODELLING HISTORICAL INFLOWS TO CURRENT PRACTICES

Facility	Operating Variable	Target	When	Modelling Priority	Comments
Reservoir	Maximum Reservoir Level	601.7 m	Year round	Maximum normal operating level	
	Minimum Reservoir Level	Empty by 1 Apr (but do not empty before 28 Feb)		High	
		601.22 m 600.5 m	1 Aug - 31 Aug 1 Sept - 1 Oct	Medium	Goal is to conserve water for spawning and incubation by keep reservoir high
Sugar Dam	Minimum Sugar Discharge			High	
	Maximum Ramping Rate	Under discussion	Year Round	High	Use current ramping rates in all alternatives
Wilsey Dam	Maximum Discharge Below Wilsey	Gates open to maximize discharge during freshet, and staged stoplog installation as per dam safety	1 May - 31 July	High	
	Minimum Spillway Flow	None required	Year round		
	Minimum Total Discharge Below Wilsey	16 m^3/s	15 Aug - 1 Jan	High	
		13 m^3/s	1 Jan to 1 Apr	Medium	Prevent frazil ice (535 cfs equivalent)

Alt SQ - attempting to model Status Quo operations

1. Uses the same freshet configuration as Alt A, but doesn't have the 20 m^3/s min from Sugar. I used the historical median and 10th percentile fall and winter flows as a guideline to drafting the reservoir gradually to empty by April and not before 1 March.

[1] Note: This description of the Status Quo alternative is for illustration only. Please refer to Chapter 11 for the recommended operating constraints for Sugar Lake Dam.

ALTERNATIVE SQ2 - DESCRIPTION:

Facility	Operating Variable	Target	When	Modelling Priority	Comments
Reservoir	Maximum Reservoir Level	601.7 m	Year round	Maximum normal operating level	
	Minimum Reservoir Level	Empty by 1 Apr		High	
		Do not empty before 28 Feb		Low	
Sugar Dam	Minimum Sugar Discharge			Low	
	Maximum Ramping Rate	Under discussion	Year round	High	Use current ramping rates in all alternatives
Wilsey Dam	Maximum Discharge Below Wilsey	Gates open to maximize discharge during freshet, and staged stoplog installation as per dam safety	May 1 - July 31	High	
	Minimum Spillway Flow	None required	Year round		
	Minimum Total Discharge Below Wilsey (target minimums in parentheses)	23 m^3/s (25 m^3/s) 21 m^3/s (23 m^3/s) 19 m^3/s (21 m^3/s) 17 m^3/s (19 m^3/s) 17 m^3/s (19 m^3/s) 16 m^3/s (18 m^3/s) 14 m^3/s (16 m^3/s) 14 m^3/s (16 m^3/s)	1 Aug - 6 Sept 7 Sept - 14 Sept 15 Sept - 30 Sept 1 Oct - 14 Oct 15 Oct - 14 Nov 15 Nov - 30 Nov 1 Dec - 31 Dec 1 Jan - 15 Apr	High	

Alt SQ2 - Represents an attempt to put more water down the river in the fall months at the expense of having less water available in the winter months.

APPENDIX Y: INITIAL LIST OF MONITORING REQUESTS[1]

Study ID	Importance	Value	Overall Rank	Study Area	Synopsis	Total Cost ($K)	Duration (Yr)	Cost ($K/Yr)	Uncertainties	STAT POWER	Operational Implications	Environmental Implications	Notes
					TOTAL PROGRAM COST	995	5	199					
				Monitoring Terms of Reference	Prepare detailed TOR for the aforementioned monitoring plans and manage proposal and contract implementation	125	1	125	N/A	N/A			
A	N/A	N/A	N/A	Sugar Reservoir gate calibration (SGR)	Calibrate SGR gate changes to WSC (08LC041) downstream to establish flow and stage change curves as a function of gate opening(s).	40	5	8	Addresses error associated with assumed ramping rate determination vs. actual ramping rates.	HIGH	Revisit ramping rate protocol. More/less frequent gate management.	Revisit environment effects associated with exceeding/failing to meet current ramping rate protocol.	Would improve BC Hydro operations.

[1] This matrix was taken from a working sheet provided by an FTC member during early discussions around monitoring. Since these were working documents in the early part of discussions, this is not meant to indicate any agreement on the part of the group on the studies or their descriptions contained here.

Study ID	Importance	Value	Overall Rank	Study Area	Synopsis	Total Cost ($K)	Duration (Yr)	Cost ($K/Yr)	Uncertainties	STAT POWER	Operational Implications	Environmental Implications	Notes
B	5	5	5	Sugar Reservoir limnology (SGR)	Measure seasonal limnology, littoral productivity, and assess KO YOY survival.	50	1	50	Provides baseline information for future reservoir management decisions. Minimal baseline data exists, so this information <u>alone</u> will not inform us if immediate changes to reservoir operations under the Water Use Plan have changed productivity.	BASELINE	Limited, <u>however reservoir levels are quite varied under different alternatives and ELZ has not been measured or tested in the field.</u>	Affects management decisions between reservoir levels and recreation targets (storage) and downstream flows for salmonids if **significant** changes in storage management are proposed.	<u>No stocking of kokanee or any fish since 1994,</u> <u>N</u>o means to measure natural variability unless study is extended beyond 1 year, <u>however seasonal variability can be measured and annual Ko YOY survival compared to overall productivity for correlation.</u>
C	5	5	5	Sugar Inflow (SGR/SHU)	Provide flow gauging on the Upper Shuswap River to accurately measure instantaneous inflow into SGR. Combine data with revised storage elevation curves.	35	5	7	Inflows to SGR are back calculated from uncertain reservoir level storage and discharge curves. These data were the basis for the POM and all environment performance measures	HIGH	Validating these data may change future decisions on water management and provide more accurate real-time estimates of inflows to SGR.	Under/over estimates inflow available during winter months when storage management decisions are critical.	Would improve BC Hydro operations.
D	5	5	5	SGR /Upper SHU Kokanee Spawner Enumeration (SGR/ Upper SHU)	Annual count of spawners in Upper Shuswap (Upstream of SGR) to provide population trend data.	90	5	18	Provides <u>trend</u> information to assist future reservoir management decisions. <u>2 years</u> baseline data exists, so this information will not inform us if immediate changes to reservoir operations under the Water Use Plan have changed productivity.	<u>**Med-High**</u>	Limited <u>unless it supports an alternative that changes reservoir storage (i.e. more stability later in the year)</u>	Adds weight of evidence to productivity/reservoir operational links (See Study B) if **significant** changes in storage management are proposed.	<u>Kokanee as indicator species and overall indicator of fish production in reservoir. Direct comparison with YOY survival.</u>

Study ID	Importance	Value	Overall Rank	Study Area	Synopsis	Total Cost ($K)	Duration (Yr)	Cost ($K/Yr)	Uncertainties	STAT POWER	Operational Implications	Environmental Implications	Notes
E	4	4	4	Ramping Rates (SHU)	Monitor river stage change in relation potential stranding. Examine efficacy of current guidelines for prevention of stranding fish during flow reductions at SGR.	150	5	30	Current ramping protocol has not been validated against actual environmental effects. Current protocol may over/under estimate ramping rates.	MED	Revisit ramping rate protocol. More/less frequent gate management.	Quantify environment effects associated with exceeding/failing to meet current ramping rate protocol.	Site specific results and criteria.
F	5	5	5	POM Assessment (SHU)	Examine accuracy of POM predictions through annually comparing how system was operated vs. how ample predicted it should operate.	50	5	10	Large component of decision for selecting alternative based on ample output. Need to ensure it is accurate and if not, refine and review alternative selected.	HIGH	Revisit all calculations based on POM outflow data. Alternative estimates of generation.	Revisit all decisions based on environmental performance measures that used POM outflow data.	Accuracy function of improved inflow data. <u>Costs should decline after Year 1.</u>
G	4	3	3	Coho Side Channel Access (SHU)	Monitor invert elevations of side channels in relation to discharge. Undertake field surveys during spawning to confirm or revise spawning depths and velocities for coho and chinook.	25	2	12.5	Examine efficacy of hydrograph (timing and magnitude) for providing access to natural side channels for spawning.	MED	Alter operation discharges during coho spawning to provide/restrict "critical" access flows.	Optimize coho spawning flows to increase habitat relative to constructed side channels.	Required elevations may change as a function of changes in river morphology.
H	4	3	3	Validate HIS curves (SHU)	Increase data base of in situ HSI data for Ch, Ko, and Co under different flow regimes.	25	5	5	HIS information significantly influences WUA calculations used in Effective Spawning performance measure and Rearing Habitat.	MED	Re assess operational timing of the water to optimize spawning and incubation.	Re assess operational timing of the water to optimize spawning and incubation.	Ignores other factors that influence spawning distribution. Costs should decline after Year 1, intent to capture high/low flow
I	3	4	3	Validate Incubation Depth (SHU)	Investigate survival of redds with range of depth coverage, including 7.5cm.	30	5	6	Spawning performance measure used 7.5 cm as critical incubation depth for all species. Needs field testing under various conditions.	MED	Re assess operational timing of the water to optimize spawning and incubation.	Re assess operational timing of the water to optimize spawning and incubation.	Information applicable to other systems.

Study ID	Importance	Value	Overall Rank	Study Area	Synopsis	Total Cost ($K)	Duration (Yr)	Cost ($K/Yr)	Uncertainties	STAT POWER	Operational Implications	Environmental Implications	Notes
J	4	3	4	Super-imposition (SHU)	Examine magnitude of Ch superimposition and if influenced by available spawning habitat. Study would require reference data.	50	5	10	Addresses relation between spawning flows and redd superimposition.	LOW	Re assess operational timing of the water to optimize spawning and incubation.	Re assess operational timing of the water to optimize spawning and incubation.	Limited opportunity to 'increase' spawning habitat above natural inflows.
K	4	4	4	Outages (SHU)	Opportunistically monitor stranding impacts of flow disruptions from plant outages. Refine approach currently implemented to monitor impacts to ensure as much data as possible is gained relative to outages and possible mitigate bypass flows on fish stranding, redd dewatering, and predation.	50	5	10	Baseline information on magnitude of impacts associated with different flow disruptions (0-30 m^3/s) following a plant outage. Baseline information on proportion of impact relative to duration of event.	LOW	Refine approach currently implemented to monitor impacts to ensure as much data as possible is gained relative to outages and possible mitigate bypass flows on fish stranding, redd dewatering, and predation.	Increased/decreased effort to reduce frequency and magnitude of flow disruptions from outages.	Under/over estimate environmental impact associated with flow disruptions. Information may be applicable to other systems.
L	2	2	2	Total Gas Pressure (SHU)	Monitor operations not previously monitored.	10	1	10	TGP not a concern under current and/or proposed operating alternatives. Impacts associated with novel operation changes and/or infrastructure should be investigated.	HIGH	Non Applicable under current and all proposed operating alternatives.	Non Applicable under current and all proposed operating alternatives.	
M	2	2	2	Adult Holding in Bypass Area (SHU)	Perceived acute impacts during operation of bypass valve when Chinook are holding.	25	5	5	Uncertainty associated with impacts (significant/ insignificant) on Ch spawner if the bypass valve operates.	LOW	Potential to restrict bypass valve use.	Reduced(?) expected impact to Ch spawners. Increased risk to all other aquatic life in river.	Restriction of bypass valve operation increases expected risk of downstream flow disruption.

Study ID	Importance	Value	Overall Rank	Study Area	Synopsis	Total Cost ($K)	Duration (Yr)	Cost ($K/Yr)	Uncertainties	STAT POWER	Operational Implications	Environmental Implications	Notes
N	3	3	3	Middle Shuswap Rearing Habitat (SHU)	Estimate WUA for Rb rearing in Middle SHU.	15	1	15	Addresses uncertainty of operational alternatives on Rb upstream of Wilsey.	MED	Re assess operational timing of the water to optimize spawning and incubation.	Increase/decrease Rb habitat upstream of Wilsey against increase/decrease in Salmonid habitat downstream of Wilsey.	
O	5	5	5	Middle Shu River Survival Monitoring (SHU)	Collect annual distribution and survival of Ko, Co, and Ch spawners in the Middle Shuswap including mainstem/side-channel use and area dewatered **in winter.**	100	5	20	Assess predictive capability of Effective Spawning performance measure against previous spawner information. Baseline data useful for subsequent Water Use Plans.	**<u>Med</u>**	Re assess operational timing of the water to optimize spawning and incubation.	Re assess operational timing of the water to optimize spawning and incubation for Ch, Ko, and Co individually and as a group.	Numerous confounding factors (i.e. Ocean Survival, Enhancement, Hatchery). Time lag associated with cause and effects (~3 year life cycle). Limited opportunity to 'increase' spawning habitat above natural inflows. <u>Alternative for kokanee is to examine YOY abundance in Mabel or do smolt/fry for all salmon but no baseline.</u>
P	1	1	1	Middle Shu Regulated Constructed Side Channels (SHU)	Evaluate fry/smolt production from constructed/flow control channels	125	5	25	Proportion of fry/smolt production from constructed/flow control channels (and hatchery?). Adds weight of evidence to value of enhancing natural habitat.	LOW	Re assess operational timing of the water to optimize spawning and incubation.	Re assess operational timing of the water to optimize rearing for Ch, Co, and Rb individually and as a group.	Constructed channels outside the scope of Water Use Plans? <u>This is BCRP although channels have been funded in the past pre-BCRP.</u>

Study ID	Importance	Value	Overall Rank	Study Area	Synopsis	Total Cost ($K)	Duration (Yr)	Cost ($K/Yr)	Uncertainties	STAT POWER	Operational Implications	Environmental Implications	Notes
I	3	4	3	Validate Incubation Depth (SHU)	Investigate survival of redds with range of depth coverage, including 7.5cm.	30	5	6	Spawning performance measure used 7.5 cm as critical incubation depth for all species. Needs field testing under various conditions.	MED	Re assess operational timing of the water to optimize spawning and incubation.	Re assess operational timing of the water to optimize spawning and incubation.	Information applicable to other systems.
J	4	3	4	Super-imposition (SHU)	Examine magnitude of Ch superimposition and if influenced by available spawning habitat. Study would require reference data.	50	5	10	Addresses relation between spawning flows and redd superimposition.	LOW	Re assess operational timing of the water to optimize spawning and incubation.	Re assess operational timing of the water to optimize spawning and incubation.	Limited opportunity to 'increase' spawning habitat above natural inflows.
K	4	4	4	Outages (SHU)	Opportunistically monitor stranding impacts of flow disruptions from plant outages. Refine approach currently implemented to monitor impacts to ensure as much data as possible is gained relative to outages and possible mitigate bypass flows on fish stranding, redd dewatering, and predation.	50	5	10	Baseline information on magnitude of impacts associated with different flow disruptions (0-30 m^3/s) following a plant outage. Baseline information on proportion of impact relative to duration of event.	LOW	Refine approach currently implemented to monitor impacts to ensure as much data as possible is gained relative to outages and possible mitigate bypass flows on fish stranding, redd dewatering, and predation.	Increased/decreased effort to reduce frequency and magnitude of flow disruptions from outages.	Under/over estimate environmental impact associated with flow disruptions. Information may be applicable to other systems.

Study ID	Importance	Value	Overall Rank	Study Area	Synopsis	Total Cost ($K)	Duration (Yr)	Cost ($K/Yr)	Uncertainties	STAT POWER	Operational Implications	Environmental Implications	Notes
L	2	2	2	Total Gas Pressure (SHU)	Monitor operations not previously monitored.	10	1	10	TGP not a concern under current and/or proposed operating alternatives. Impacts associated with novel operation changes and/or infrastructure should be investigated.	HIGH	Non Applicable under current and all proposed operating alternatives.	Non Applicable under current and all proposed operating alternatives.	
M	2	2	2	Adult Holding in Bypass Area (SHU)	Perceived acute impacts during operation of bypass valve when Chinook are holding.	25	5	5	Uncertainty associated with impacts (significant/ insignificant) on Ch spawner if the bypass valve operates.	LOW	Potential to restrict bypass valve use.	Reduced(?) expected impact to Ch spawners. Increased risk to all other aquatic life in river.	Restriction of bypass valve operation increases expected risk of downstream flow disruption.
N	3	3	3	Middle Shuswap Rearing Habitat (SHU)	Estimate WUA for Rb rearing in Middle SHU.	15	1	15	Addresses uncertainty of operational alternatives on Rb upstream of Wilsey.	MED	Re assess operational timing of the water to optimize spawning and incubation.	Increase/decrease Rb habitat upstream of Wilsey against increase/decrease in Salmonid habitat downstream of Wilsey.	
O	5	5	5	Middle Shu River Survival Monitoring (SHU)	Collect annual distribution and survival of Ko, Co, and Ch spawners in the Middle Shuswap including mainstem/side-channel use and area dewatered **in winter.**	100	5	20	Assess predictive capability of Effective Spawning performance measure against previous spawner information. Baseline data useful for subsequent Water Use Plans.	**<u>Med</u>**	Re assess operational timing of the water to optimize spawning and incubation.	Re assess operational timing of the water to optimize spawning and incubation for Ch, Ko, and Co individually and as a group.	Numerous confounding factors (i.e. Ocean Survival, Enhancement, Hatchery). Time lag associated with cause and effects (~3 year life cycle). Limited opportunity to 'increase' spawning habitat above natural inflows. <u>Alternative for kokanee is to examine YOY abundance in Mabel or do smolt/fry for all salmon but no baseline.</u>

Study ID	Importance	Value	Overall Rank	Study Area	Synopsis	Total Cost ($K)	Duration (Yr)	Cost ($K/Yr)	Uncertainties	STAT POWER	Operational Implications	Environmental Implications	Notes
P	1	1	1	Middle Shu Regulated Constructed Side Channels (SHU)	Evaluate fry/smolt production from constructed/flow control channels	125	5	25	Proportion of fry/smolt production from constructed/flow control channels (and hatchery?). Adds weight of evidence to value of enhancing natural habitat.	LOW	Re assess operational timing of the water to optimize spawning and incubation.	Re assess operational timing of the water to optimize rearing for Ch, Co, and Rb individually and as a group.	Constructed channels outside the scope of Water Use Plans? This is BCRP although channels have been funded in the past pre-BCRP.

APPENDIX Z: FINAL LIST OF MONITORING PROPOSALS PRESENTED TO THE CONSULTATIVE COMMITTEE FOR THE MARCH 2002 MEETING

Study ID	Willingness to change decision	Rating of Study	Study Area	Synopsis	Total Cost ($K)	Time frame	Duration (Yr)	Cost ($K/Yr)	Uncertainties	STAT POWER	Operational Implications	(Environmental) Implications	Notes
				TOTAL PROGRAM COST	$611		5	$122					
1	low to medium	low to high	Sugar Reservoir (SGR)	Kokanee juvenile survival	$100	next Water Use Plan	5	$20	Current assumption is that chosen reservoir operations are ok for kokanee, but no research to establish link from performance measure to this objective.	Low to medium - attempts to tie populations changes to reservoir operations. Time frame and confounding factors limit this ability.	Potential changes most likely in early spring. Empty reservoir earlier or do not empty reservoir. Currently no ability to change operations once freshet starts.	Affects management decisions between reservoir levels and recreation targets (storage) and downstream flows for salmonids if **significant** changes in storage management are proposed.	Studies 1and 2 are to be used as a package

Study ID	Willingness to change decision	Rating of Study	Study Area	Synopsis	Total Cost ($K)	Time frame	Duration (Yr)	Cost ($K/Yr)	Uncertainties	STAT POWER	Operational Implications	(Environmental) Implications	Notes
2	low to medium	low to high	SGR /Upper SHU Kokanee Spawner Enumeration (SGR/ Upper SHU)	Annual count of spawners in Upper Shuswap (Upstream of SGR) to provide population trend data.	90	next Water Use Plan	5	18	Current assumption is that chosen reservoir operations are ok for kokanee, but no research to establish link from performance measure to this objective. Alternative hypothesis is that chosen reservoir operations are poor for kokanee.	LOW - only gives "better or worse" information	Potential changes most likely in early spring. Empty reservoir earlier (before freshet) or do not empty reservoir. Currently no ability to change operations once freshet starts.	Acts as a flag if kokanee populations are declining, stable, or are rising. May lead to consideration of significant changes to operations in reservoir.	1 and 2 are a package
3		low to high	Burbot	Low level reconnaissance survey during reservoir drawdown	$20	for next Water Use Plan	2 (5 years apart)		Current assumption is that chosen reservoir operations are ok for burbot, but no research to establish link from performance measure to this objective. Alternative hypothesis is that chosen reservoir operations are poor for burbot.	LOW - only gives "better or worse" information	Potential changes most likely in early spring. Empty reservoir earlier (before freshet) or do not empty reservoir. Currently no ability to change operations once freshet starts.	Acts as a flag if burbot populations are declining, stable, or are rising. May lead to consideration of significant changes to operations in reservoir.	
4		high	Sugar Inflow (SGR/SHU)	Provide flow gauging to assist estimation of instantaneous inflow into SGR.	$50	for next Water Use Plan	1	50	Inflows to SGR are back calculated from uncertain reservoir level storage and discharge curves. These data were the basis for the POM and all environment performance measures	HIGH	Validating these data may change future decisions on water management and provide more accurate real-time estimates of inflows to SGR. In particular, these allow more predictability around the arrival of freshet, which may allow more operational options to be explored (see burbot and kokanee studies above).	Under/over estimates inflow available during winter months when storage management decisions are critical.	

Study ID	Willingness to change decision	Rating of Study	Study Area	Synopsis	Total Cost ($K)	Time frame	Duration (Yr)	Cost ($K/Yr)	Uncertainties	STAT POWER	Operational Implications	(Environmental) Implications	Notes
5	med to low (would only change if changes to other PMs reduced the downside to trade-offs)	med to low		Super-imposition	$60	for next Water Use Plan	3	$20		low	If maximizing the number of chinook redds remaining wetted is no longer a priority, then SQ looks less attractive as the chosen alternative and other alternatives may be chosen.	With a new performance measure for "what is good for chinook," other alternatives may be chosen. This will have impacts on all other interests, both fish and non-fish.	SQ is the alternative that maximizes scores for the other fish performance measures (coho, rainbow trout, kokanee, ELZ), but superimposition under SQ may make some other alternative the best for Chinook.
6a			Outages (SHU)	Contingent on the gated spillway not being installed.	$70	2	2	35	At the moment, there no clear understanding about the link between sudden flow changes in the river and its biological impact on fish.	MED	If outages are having a quantifiable impact on various life stages of fish, then a stronger argument for a gated spillway can be put forward. In particular, outages during certain parts of the year and of certain magnitudes can be tied to specific biological impacts (species, lifestages).	Increased/decreased effort to reduce frequency and magnitude of flow disruptions from outages.	Options 6a and 6b are exclusive of each other. Limited sampling will give some idea about the relationship between sudden flow changes and biological impacts. But given the complexity of the problem, a negative result would probably not satisfy people that no damage is occurring.

Study ID	Willingness to change decision	Rating of Study	Study Area	Synopsis	Total Cost ($K)	Time frame	Duration (Yr)	Cost ($K/Yr)	Uncertainties	STAT POWER	Operational Implications	(Environmental) Implications	Notes
6b			Outages (SHU)	Contingent on the gated spillway not being installed.	$50	5	5	10	Baseline information exists on magnitude of impacts associated with different flow disruptions (0-30 m^3/s) following a plant outage, given current facilities. Baseline information also exists on proportion of impact relative to duration of event. Impact of gated spillway on flow changes, and impact on flow changes on bilogical indicators (for any structure at Wilsey) is unknown.	LOW	If outages are having a quantifiable impact on various life stages of fish, then a stronger argument for a gated spillway can be put forward.	Increased/decreased effort to reduce frequency and magnitude of flow disruptions from outages.	Options 7a and 7b are exclusive of each other. Given the transitory nature of the evidence, the chances of collecting sufficient information from this method are low.
7		low to med	Validate HSI curves (SHU)	Increase data base of in situ HSI data for Ch, Ko, and Co under different flow regimes.	$5	for next Water Use Plan	1	5	HIS information significantly influences WUA calculations used in Effective Spawning performance measure and Rearing Habitat. In situ measurements were collected for these species for most flows, but these have not been refined.	MED	Re assess operational timing of the water to optimize spawning and incubation.	Re assess operational timing of the water to optimize spawning and incubation.	Ignores other factors that influence spawning distribution.

Study ID	Willingness to change decision	Rating of Study	Study Area	Synopsis	Total Cost ($K)	Time frame	Duration (Yr)	Cost ($K/Yr)	Uncertainties	STAT POWER	Operational Implications	(Environmental) Implications	Notes
8		low to high	Middle Shu River Survival Monitoring - Kok escapement and enumeration (SHU)	Collect annual distribution and survival of Ko, Co, and Ch spawners in the Middle Shuswap including mainstem/side -channel use and area dewatered. In particular, with attention paid to invert elevations of side channels.	$50	for next Water Use Plan	5	10	Assess the link between the performance measure and the fundamental objective. The working assumption is that as performance measure scores for kokanee increase, then "what is good for kokanee" increases as well. The alternative hypothesis is that the performance measure does not pick out operations that are good for kokanee.	LOW	Currently, SQ maximizes kokanee spawning indicators. If this performance measure is incorrectly measured, then some other alternative may be best for kokanee and, therefore, picked by the Consultative Committee.	If the current performance measure is incorrect, then the alternative chosen may not be the best one for kokanee (although it is still the one that maximizes performance measure scores for other fish measures).	Numerous confounding factors (i.e. Enhancement, Hatchery). Time lag associated with cause and effects (~3 year life cycle).
9		med to high	Middle Shu River Survival Monitoring - access to side channel/invert elevations and winter survival (kokanee and coho) (SHU)		$50	for next Water Use Plan	5	$10	Assess predictive capability of Effective Spawning performance measure against spawner information. The current hypothesis is that the model was predicting correctly the location of spawning at different flows. The model was tested out against recollection and professional experience, but has not been assessed through detailed observations.	MED	Currently, SQ maximizes kokanee spawning indicators. If this performance measure is incorrectly measured, then some other alternative may be best for kokanee and, therefore, picked by the Consultative Committee.	If the current performance measure is incorrect, then the alternative chosen may not be the best one for kokanee (although it is still the one that maximizes performance measure scores for other fish measures).	

Study ID	Willingness to change decision	Rating of Study	Study Area	Synopsis	Total Cost ($K)	Time frame	Duration (Yr)	Cost ($K/Yr)	Uncertainties	STAT POWER	Operational Implications	(Environmental) Implications	Notes
10			Archeological Erosion Survey	Look for areas affected by reservoir operations. Determine the number, location, influence of erosion	14.5	for next Water Use Plan	1	14.5	Not sure whether using the top 20 cm of reservoir storage negatively affects arch sites, and to what extend		Consultative Committee could choose to keep reservoir 20 cm lower to achieve benefits		Two cc members mentioned that their choices were contingent on the assumption that no great damage was occurring to arch sites
11			Shoreline erosion around the reservoir	Look for areas affected by reservoir operations. In particular, look at areas susceptible to erosion and estimate the potential amount of damage from operating up to 601.72	15	for next Water Use Plan	1	15	Not sure the level of damage that will occur over time from erosion occurring at full pool level		Consultative Committee could choose to keep reservoir 20 cm lower to achieve benefits		
12			monitoring flood interests	Install monitoring equipment so that flows below Wilsey and by Mara Lake are recorded on a daily basis	21	for next Water Use Plan		21	Not sure what the actual relationship is between daily flows from Sugar Lake Dam, when flooding begins, and the magnitude of the flood		Unclear whether BC Hydro can do anything to improve flood control		DCP exists just below Wilsey Dam. Unclear whether BC Hydro can do anything to affect flooding during freshet or the summer.

APPENDIX AA: LEVEL OF SUPPORT FOR MONITORING REQUESTS

Study Proposal	Ron	Hugh	Ray	Tom m.	LeRoy	Heather	Al	Tom H.	Joe	Dave	Rudy	Larry	Art	Cecil	Paul	Support	Block	DK
1. SGR reservoir (Kokanee juvenile survival)	B	S	S	S	S	B	S	S	B	Dk	S	S	-	-	B	8	4	1
2. SGR Upper SHU (Kokanee Spawner Enumeration)	B	S	S	S	S	B	S	S	B	Dk	S	S	-	-	B	8	4	1
3. Burbot	B	B	S	S	S	S	S	Dk	Dk	Dk	Dk	S	-	-	B	6	3	4
4. Sugar Inflow at Eagle River	S	S	S	S	S	S	S	S	S	S	S For Sugar	S	-	-	DK	12	0	1
5. Superimposition	B	B	S	dk	B	S	Abstain	B	dk	Dk	S	dk	-	-	B	3	5	5
6a. Outages (if rubber dam does not go in) Plan A Planned outage	B	S Prefer	S	S	B	dk	S	B	S	B	S	B	-	-	B	7	6	0
6b. Outages (if rubber dam noes not go in) Opportunistic Data Collection	B	S	B	B	B	Dk	S	B	B	B	B	B	B	B	B	3	10	0
7. HIS data	S	S	S	S	S	S	S	S	S	Dk	S	S	-	-	B	11	1	1
8. Survival monitoring - middle Shuswap	B	B	B	dk	B	S	S	B	dk	Dk	S	A/dk	-	-	B	3	6	4
9. Survival monitoring - side channels	B	B	S	S	B	S	S	B	A	Dk	S	A/dk	-	-	B	5	5	2

Study Proposal	Ron	Hugh	Ray	Tom m.	LeRoy	Heather	Al	Tom H.	Joe	Dave	Rudy	Larry	Art	Cecil	Paul	Support	Block	DK
10. Arch. erosion[1]	-	S	S	-	S	S	S	S	S	B	S	S	S	DK	-	12	1	0
11. Shoreline Erosion	S -less $ from 15 to 20K	S	S -want lower cost	S	Dk	S	S at 15K B at 30	A/dk -less $, ask people who live there (could support if condi-tions met)	S -less$, ask people around reservoir	S	S	S			dk	10	0	3
12. Monitoring flood interests	S	S	S	S	S	S	dk	S	S	S	S	S			Dk	11	0	2

[1] This monitoring topic was not discussed during the March Consultative Committee meeting addressing monitoring requests, but was addressed at the final Consultative Committee meeting in April. Ron Tricket, Tom Minor, and Paul Weiringa were not present for this conversation, and Art Hubert and Cecil Remple were present only for this monitoring discussion.

APPENDIX BB: SUMMARY OF LIKELY HYDRO OPERATIONS FOR THE STATUS QUO ALTERNATIVE[1]

Introduction

The following is a description of what BC Hydro envisions for future operation of the Sugar/Shuswap facilities within the constraints selected by the Shuswap Water Use Plan Consultative Committee (Section 8).

The Shuswap Water Use Plan Consultative Committee selected a set of operating constraints on BC Hydro operations at the Sugar Lake Dam facilities (see Section 8). These constraints represent an attempt to find a balanced way to use water that addresses multiple interests and objectives. If ordered by the Comptroller of Water Rights, these constraints will help set the measurements against which compliance will be measured.

This note gives a general description of how BC Hydro will endeavour to operate the Sugar/Shuswap facilities within these constraints. Natural variations in inflows resulting from snow melt cycles and storm events, for example, may influence the actual operation. This description of general operations is only a guideline, and will not be used for measuring compliance with the constraints ordered by the Comptroller of Water Rights.

Description

Operations planning at any time of the year for the Shuswap system takes into account the operating constraints ordered by the Comptroller of Water Rights based on the Water Use Plan, relative preferences of competing objectives, prevailing inflow trends, and short-term weather forecasts. The behaviour of the basin under this mode of operation is expected to be similar to the results from the computer model studies conducted for the selected alternative during the Water Use Plan process. The operating guidelines were derived from the operating ranges of Sugar Lake Reservoir Elevations (Figure BB-1), discharges from Sugar Lake Dam (Figure BB-2) and discharges below Wilsey Dam (Figure BB-3) that can be expected at different times of the year with the selected alternative.

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[1] Heather Stalberg (DFO) noted on several occasions that the development of an envelope for operations, within which Hydro could operate without guidance from other agencies, was not acceptable. Heather noted in her review of Appendix BB that this isn't sufficient, there needs to be something within the constraints that makes BC Hydro accountable for not simply providing the minimum flows set forward in the constraints.

Al Caverly (MWLAP), in his review of the portion of Appendix BB that addresses the minimum flow constraints below Wilsey Dam, noted, "As an FTC member, I cannot recommend 13 m^3/s below Wilsey Dam as a constraint. Fall drought may force BC Hydro to reduce flows to 13 m^3/s in order to conserve water, after notification to agencies. I advise BC Hydro to seek agreement with the rationale for the decision to reduce flows that low."

Freshet to early-August Operations

Objectives:

- primarily driven by dam safety needs until inflows and snowpack have decreased to manageable levels
- to maximize discharge from Sugar Dam's gates until the peak of freshet is deemed to have passed
- to reduce risk of flooding downstream of the dam by maximizing available storage

From freshet to early August, stoplogs are installed when snowpack and inflows have decreased below the critical levels specified by the Director of Dam Safety (Appendix A). These criteria are subject to change under the direction of the Director of Dam Safety. The computer studies modelled a conservative operation for this period by prescribing a stoplog installation schedule which satisfies the dam safety criteria for the majority of the flow years on record. Under normal operations the stoplog installation schedule will be specific for specific conditions and it is expected that the stoplogs may be installed earlier in many years than indicated in the modelling results. This may result in the reservoir rising earlier in the year than depicted in Figure BB-1.[1]

The discharge from Sugar Dam is maximized by leaving the four sluice gates fully open until the peak of freshet has passed to reduce the risk of flooding downstream. Once the peak has passed, the discharges can be reduced to fill the reservoir as per the stoplog installation schedule.

The boat ramp at the Kokanee Resort Lodge becomes accessible at elevations above 600.61 m. The reservoir should rise to this level soon after stoplogs are installed. As noted above, we expect to achieve this elevation earlier in some years than indicated by the Water Use Plan study results.

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[1] Members of the Consultative Committee who were impacted by flooding on the river wanted to see an emphasis on flood control in BC Hydro operations. Suggestions were to use stoplog placement to maximize the flood control capabilities whenever possible, as long as dam safety was not compromised. In Appendix BB, BC Hydro's suggestion that the reservoir may be brought up quickly in drier years contradicts this desire to maximize flood control. Members of the Consultative Committee affected by flooding on the river also noted that if the stoplogs are installed "earlier in many years…result[ing] in the reservoir rising earlier in the year," then this too seems to work contrary to maximizing flood control. They are concerned about any operations that would decrease the storage of the reservoir available for flood control.

Summer Operations (~June - August)

Objectives:

- target high reservoir level
    - to retain more stored water for release during the fall and winter to provide adequate spawning and overwinter flows for fish
    - to retain more stored water for release during the fall and winter to minimize the risk of frazil ice build-up and to protect the water passages (penstocks, etc.) from freezing
    - to provide for recreational use of the reservoir
    - to provide for biological productivity in the annually wetted littoral zone
    - to maintain access to the boat ramp at Kokanee Resort Lodge above elevation 600.61 m

The computer model simulated this operation with a soft 601.22 m minimum operating elevation in August to retain water in the reservoir. In actual operation, reservoir levels could be lower than 601.22 m in August to maintain the minimum flow (18 m^3/s) below Wilsey Dam or to accommodate other operational needs during the summer. Less than desired stored water in the summer can result in less water available for release during the fall and winter period.

Fall (September - December) and Winter Operations (January - March)

Objectives:

- target an empty reservoir by 1 April
    - to provide the most supplemental spawning and incubation flows
    - to provide the best risk against flooding in the spring
    - to use the available stored water for power generation
    - to facilitate access to archaeological sites

The operating plan is to draft the reservoir over the fall and winter in a gradual manner to reduce the risk of needing to implement a dramatic flow adjustment in mid to late winter. Actual operation is expected to mimic the computer simulations except for uncertainties introduced by the natural variability in inflows encountered during the fall and winter, equipment availability and the uncertainty in projecting when the freshet is likely to commence. Actual operations will require over winter flow adjustments both upward and downwards and in the worst case can result in low releases equal to inflow if the spring runoff starts later than forecast or excess retained storage if the spring runoff is earlier than forecast.

Alternatives that release a larger amount of storage in the fall to provide higher spawning to incubation flows were deemed unacceptable when faced with the risk of not having adequate overwinter incubation and power flows.

Maximum Normal Operating Elevation

Computer simulations were operated to a maximum normal operating level of elevation 601.72 m. In actual operations there will be unavoidable incursions above the maximum normal operating level while routing the freshet flows and summer and fall storms.

Minimum Flows Below Wilsey Dam

The computer simulations conducted during the Water Use Plan indicated that from the onset of freshet through the fall, flows below Wilsey Dam are expected to be sustained at or above 18 m^3/s in about 9 out of every 10 years. In 3 years (1974, 1977, and 1987) of the 27-year record, the flows were at the minimum. The flows are expected to be in the 20-30 m^3/s range about 1 year in 2. In actual operation, the inflow encountered could alter the statistic derived from the 27-year database.

In the winter to the start of freshet, flows below Wilsey Dam are expected to be sustainable above 15 m^3/s about 19 years out of 20. In the 27-year data set, one half of the years had both daily minimum and daily maximum flows that were between 15.5 m^3/s and 42 m^3/s. Extreme low inflows in 2 years (1975 and 1985) of the 27 year record, resulted in flows below 15 m^3/s. In actual operation, the inflow encountered could alter the statistic derived from the 27-year database.

Between gate setting changes at Sugar Lake Dam, flows below Wilsey Dam will vary as a function of the reservoir elevation and the local inflows. BC Hydro will set the gate openings at Sugar Lake Dam to provide a release to meet the target flow averaged over a one to two week period. This will provide a cushion against reductions in gate releases as the reservoir level decreases. In actual operation, the flow will likely drop below the target before the gate openings are re-set.

During low water conditions, flow under actual operation might drop below the target summer-fall/winter minimum (18/15 m^3/s). This is recognized as unavoidable and BC Hydro will endeavour to not reduce the flow beyond 2 m^3/s below the target minimum. The relevant constraints recommended by the Consultative Committee for the summer-fall/winter time periods are 16/13 m^3/s. Forced outages on the units or equipment failure may also result in discharges below the minimum constraints as highlighted in the discussions around tripping.

Ramping Rates[1]

When a flow change is planned, the WSC gauge just downstream of Sugar Lake Dam is used to determine the expected stage change and the duration of the gate change as per Table 8-3. The gate discharge tables are used to determine the gate positions required to achieve the targeted flow. For example, if the expected stage change is 10 cm and the ramp rate is 2.5 cm/hr, the gate change will take place over 4 hours. Due to uncertainties around the discharge relationships of the WSC gauge and the gates, measured ramp rates or total actual stage change may be higher or lower than expected.

[1] Heather Stalberg (DFO) noted in her review of Appendix BB some concern around the uncertainty regarding what the expected ramp rate would be from a planned operation compared to what the actual ramp rate would be. She wrote, "This [level of uncertainty] isn't O.K. During our FTC monitoring discussions, I proposed that better calibration between the gate changes and the WSC gauge be undertaken. BC Hydro convinced me that they had an accurate system in place, thus the monitoring was not necessary and dropped. If there remains uncertainty, then gate changes should be done so that they are conservative i.e. they don't exceed the ramping rates. BCH may wish to track the gate over time so that the gate changes become more accurate."

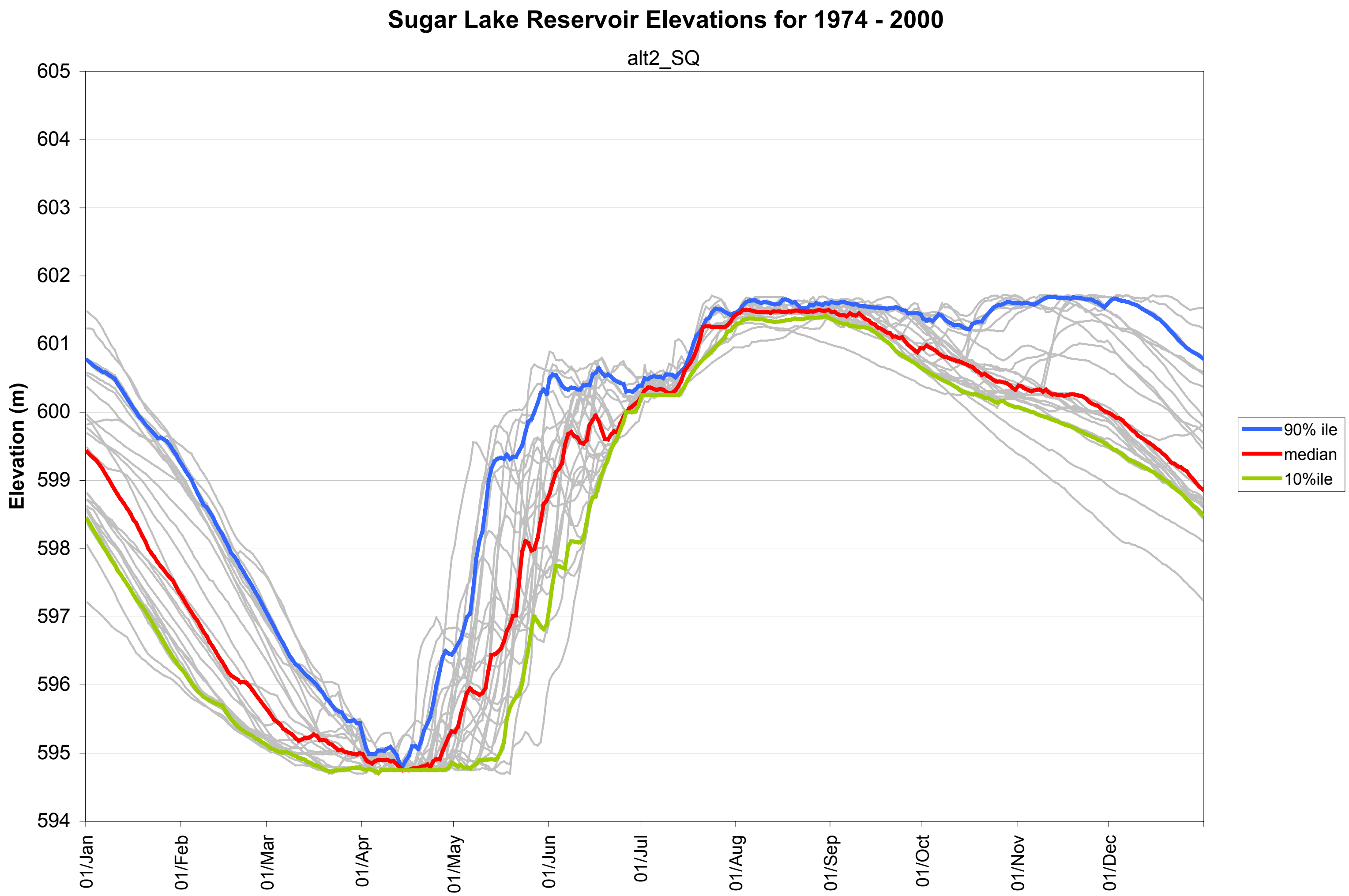

Figure BB-1 Sugar Lake Reservoir Elevations

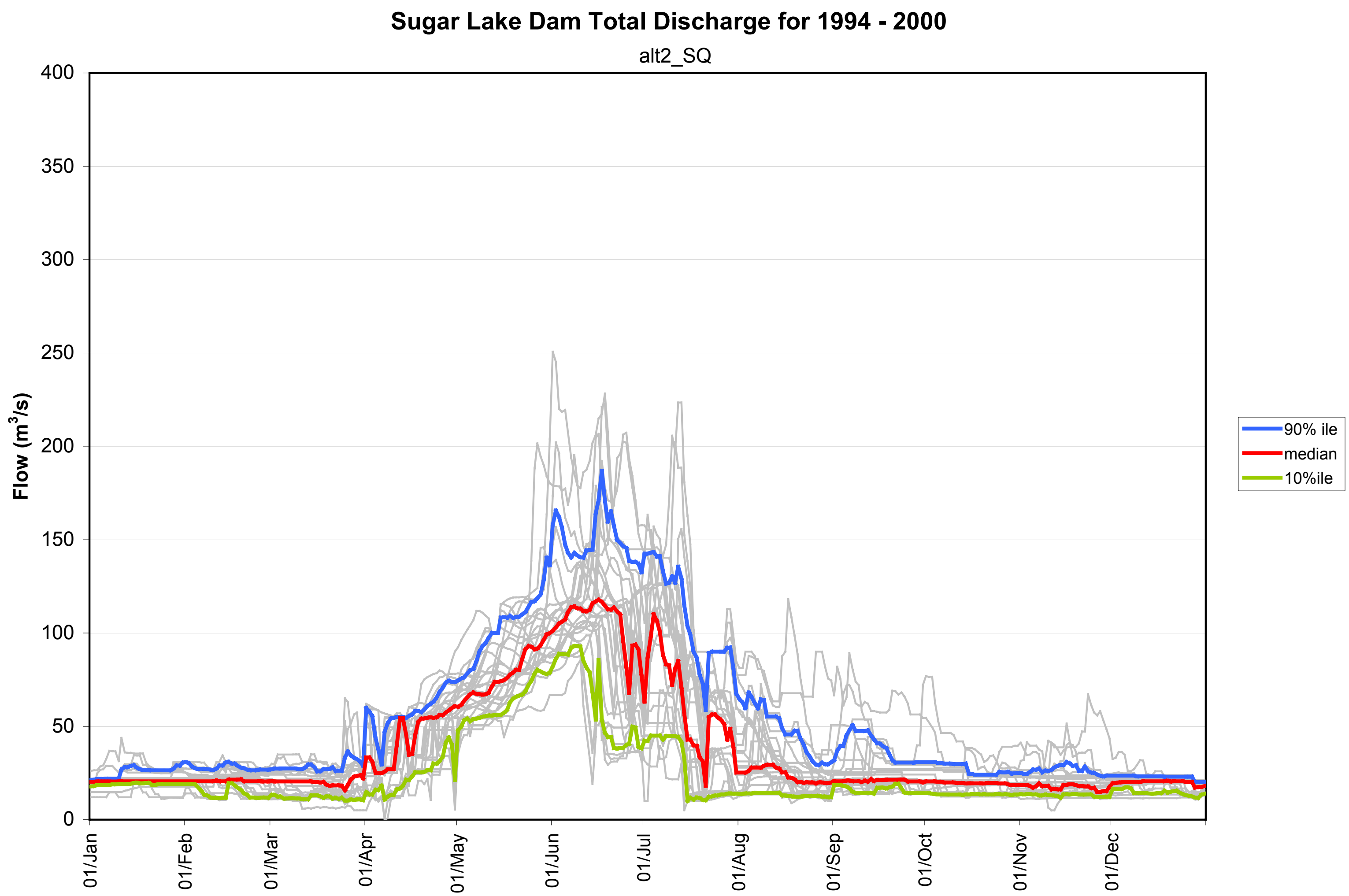

Figure BB-2 Sugar Lake Total Discharge

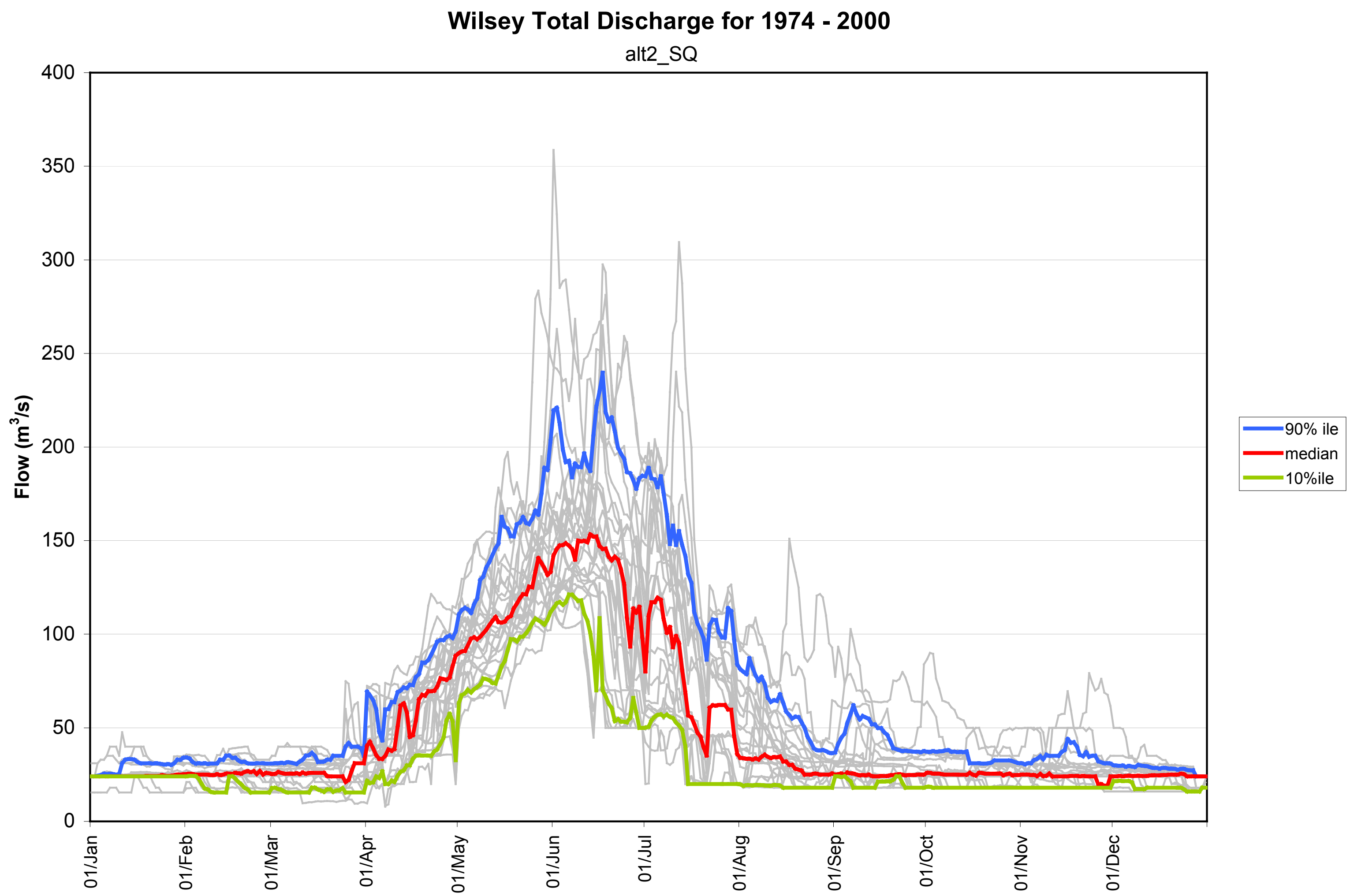

Figure BB-3 Wilsey Total Discharge

APPENDIX CC: COMMENTS ON SHUSWAP RIVER CONSULTATIVE PROCESS OFFERED AFTER 30 APRIL 2002

At the 29/30 April Consultative Committee meeting, members present were informed that the consultative portion of the Shuswap River Water Use Planning process was completed. No additional opportunities would be available for comments on the process to be made in the presence of the full Consultative Committee. However, the BC Hydro project team said that they would try to record individual comments made after 30 April, if possible. These comments have been added to text where appropriate and additional comments have been captured in footnotes.

After the final meeting, the following comments were received by the BC Hydro project team.

Alan Caverly, Ministry of Water, Land and Air Protection, 30 October 2002 (see attached letter).

BRITISH COLUMBIA

File: 441000-35
BCH-ShuWup

October 30, 2002

Vesta Filipchuk
BC Hydro-Water use Plan
6911 Southpoint Drive,
Burnaby, B.C. V3N 4X8

Dear Vesta,

RE: Shuswap River WUP CC Report
I have completed review of the CC report draft dated October 2, 2002. This version is superior to the last draft. I made several suggestions for edits in pencil and each page marked is folded over at the corner. Some of the edits are minor, a very few are key points so I encourage you to review them and include revisions in the final.

One omission at the end of the report is the summary of resident fish information I forwarded to Basil previously. An anadromous fish summary was provided by Heather Stalberg. Please include the resident fish summary (attached) in the final.

I do not need any further reviews and agree to sign off for WLAP Fish and Wildlife if the final includes everything in this latest CC report version and the minor edits. If you have any specific questions I can be contacted at the Kamloops WLAP office at (250) 371-6321 or by Email at alan.caverly@gems2.gov.bc.ca.

Sincerely,

Alan Caverly
Fisheries Biologist
WLAP

cc. Heather Stalberg, DFO